HVAC DUCT SYSTEMS INSPECTION GUIDE

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION, INC.

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SECOND EDITION — JUNE 2000

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FOREWORD

One definition of inspect is "to view closely and critically." In building construction the term "inspection" brings to mind many other terms: completeness, compliance, conformance, quality assurance, design deficiency, oversight, neglect, unauthorized substitution, defects and omissions, punch list, responsible party, call back, and payment retention. In any case the mechanical systems inspector plays an important role in contract compliance or code compliance verification. Knowledge and reasonableness are prerequisites for employment in this capacity. This guide is based on the assumption that SMACNA duct construction standards and installation recommendations are linked to contract or code compliance. It is an administrative guide to the inspection of duct systems. It can serve as a study guide for those needing an introduction to the functions of duct systems, to the nature of ductwork, and to the SMACNA documents it previews. Study of the complete texts of the excerpted editions is necessary and encouraged. Familiarity with all of the documents that regulate duct system installation will enable inspectors to develop their own checklists and to establish scales of importance that are consistent with their duties.

NOTE: The provisions herein are not intended to constitute contract requirements in and of themselves. The SMACNA manuals to which this guide refer contain many alternative constructions. They also contain many details that are obligatory. Other details are left to the prudent judgement of the contractor. Thus, this document is no substitute for familiarity with all of the provisions in the other manuals.

The following SMACNA manuals are excerpted within this guide:

- *HVAC Duct Construction Standards, Second Edition, 1995*
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- *Fire, Smoke, and Radiation Damper Installation Guide for HVAC Systems, Fourth Edition, 1992*

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CHAPTER 1

INTRODUCTION

1.1 SCOPE

This document gives reasons for doing inspections of air handling systems, provides outlines that can be used to organize and conduct inspections, and sets forth checklists that call attention to the basic features of ductwork and items placed in duct systems.

It presumes that *SMACNA's construction standards are used as the basis of compliance*, whether they are explicitly invoked in contract documents or in codes. No attempt is made to segregate designer's inspection obligations from those of code officials.

It is primarily prepared for commercial HVAC systems; however, similar principles would apply for residential or industrial work inspection. Furthermore, it assumes that prescription specifications apply rather than performance specifications. Performance specifications typically call for HVAC systems to maintain control of the environmental within certain tolerances. Whether the duct system has the specified airflow rate, maintains air temperature, humidity, degree of cleanliness, etc., or whether it controls room air motion and pressure differentials in relation to adjacent spaces are separate matters of design and testing and balancing that are already dealt with in numerous handbooks and standards. An overview of the functions of duct systems is given in Appendix A.

Finally, although this document covers some items that are safety related, this document is not a safety inspection guide. It is presumed that the applicable codes and system designs that are allowing use of the SMACNA standards and manuals address safety issues independently.

1.2 WHAT IS THE *PURPOSE* OF INSPECTION?

The purpose of inspection is to determine if the construction and installation comply with the documents for which the inspector is responsible.

1.3 WHAT IS THE *VALUE* OF INSPECTION?

The value of inspection is the assurance that the materials and assemblies purchased are either provided and available or that defects and omissions are documented.

1.4 WHAT IS THE *COST* OF INSPECTION?

The cost of inspection includes the expense for the manpower, travel, tools, tests, and report preparations necessary to conduct adequate investigations of construction that is in progress or presumably completed.

1.5 DOES THE *TIMING* OF INSPECTIONS AFFECT CONSTRUCTION COSTS?

The timing of inspections has a definitive impact on construction costs. The work that will be concealed or inaccessible for inspection after installation should be inspected while work is in progress. Delay in construction progress may occur if further work has to be suspended pending inspection. Correcting deficiencies after installations are complete is expensive and time consuming; it may affect the work of several trades; it may result in delays in payment or in contract closeout; it can even result in delayed occupancy or delayed use of the facilities.

1.6 WHAT *RISKS* ARE INVOLVED WHEN INSPECTIONS ARE NOT DONE OR ARE NOT DONE PROPERLY?

Some of the risks involved when inspections are not done or not done properly are:

a. Less qualified or less scrupulous contractors will gamble that omissions and defects will go undetected and will under-price the work or make excessive profits

b. Owner dissatisfaction will lead to litigation

c. Occupant dissatisfaction with indoor air quality and safety can result

d. Disruptive delays in occupancy and use can occur

e. Expensive corrective work at a later date will be required

f. Hazards that should be detected are not

g. The inspector's employer will have liability for consequences of delay and damage or loss

h. Adverse publicity can disrupt normal business practices

i. Bonding companies may have to complete the project

j. Different insurance will be needed than was anticipated.

1.7 WHAT *QUALIFICATIONS* ARE NEEDED BY INSPECTORS?

Some of the qualifications needed to inspect are:

a. Knowledge

b. Experience

c. Respect for limits of authority

d. Reasonableness.

1.8 HOW DO I USE THIS GUIDE?

This guide is intended to acquaint inspection officials, designers, and contractors with the basic features of duct construction, equipment connections to ducts and items inserted in ducts as they are found in the SMACNA manuals.

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However, this guide does provide a framework of knowledge and perspective that should provide a "feel" for construction that complies with SMACNA standards. When something is found on a job site that doesn't "look like" what is described herein, the inspector should examine a specific submittal, shop drawing, coordinated drawing, standard, or code to ascertain whether the installation is or is not in compliance. Otherwise, the checklists are useful in surveying the contract documents to find the subjects that are actually in a specific project. Edited versions of them can be created in the office environment so that they, along with any necessary documents, can be taken to a construction site to perform inspections.

Inspection plays a vital role in contract compliance and it assures that quality and performance are consistent with the design. It has recognizable dollar value that owners and citizens can recognize and appreciate.

1.9 DUCT INSPECTIONS OVERVIEW

Some guidelines for a duct inspection are presented below:

a. Prerequisites for conducting inspections:

1. Possess *general knowledge* of the craftsmanship of ducts
2. As applicable, conduct thorough examination of contract *plans, specifications, change orders, submittals, code requirements, and standards* invoked by these documents
3. Identify *framing* requirements and *fire stopping* for ducted penetrations of building structures and review *clearances* to combustible materials
4. Prepare *lists* of items to be inspected
5. Anticipate *work progress schedules,* particularly for ductwork that will be inaccessible after concealment or invisible after insulation is applied
6. Clarify *authority* to approve, inspect, reject, and suspend work and to withhold occupancy permits.

b. Arrange a meeting when possible between Inspector(s) and Job Supervisors prior to beginning installation to review the complete requirements for ductwork.

1. **Materials**
Review requirements
2. **Duct Construction Schedules**
Review wall thickness, reinforcements, joints and seams, and pressure classification as applicable to each system
3. **Duct System Supports**
Review support methods for ducts and apparatus to which they connect
4. **Flexible Duct/Connector**
Review length, type, configuration, support, and requirements for listing and labelling of flexible ducts and flexible connectors
5. **Sealants**
Review types and required use of seal-

ants, as needed, for ducts, fittings, connections, and casing

6. **Barrier Penetrations**
   Review methods of penetrating fire and smoke barriers

7. **Access**
   Review maintenance access requirements and size and location of access doors

8. **Air Terminals**
   Review provisions for locating and supporting grilles, diffusers, and registers

9. **Volume Control Devices**
   Examine methods of automatic or manual balancing of airflow in systems

10. **Building Compartment Leakage**
    Investigate the airtightness of building compartments to be pressurized under emergency mode situations

11. **Plenums**
    Review construction of field erected plenums and casings and clearances for maintenance and operation within these

12. **Special Duty Systems**
    Give due attention to special duty systems such as grease hood and fume hood exhausts, dishwasher and shower room exhausts, engineered smoke control systems, etc.

13. **Insulation**
    Review the types and methods of insulation

14. **Tests**
    Determine what tests are required, any concealment contingencies, what reports are to be filed, and what witnessing, if any, is required.

c. Conduct appropriate periodic inspections using checklists.

1. Visually inspect the installation

2. Witness qualification and operating tests as required

3. Look for labels and imprintings that are required for factory-made products

d. Give contractors appropriate and timely notice of deficiencies and omissions.

e. Special Notices:

1. The designer of an air system is required to *show the locations and mounting arrangement* of all fire dampers, smoke dampers, through-penetration firestops, and similar protection means *on the contract drawings.* This is usually required in codes as a prerequisite for construction permit issuance. Likewise, he is required to show on the contract drawings all air volume regulating devices required to balance the system. SMACNA strongly endorses a contractor's right to an equitable contract adjustment for all such devices not shown on the contract drawings.

2. The use of gypsum wallboard as duct material is relatively rare. Construction standards for such use, except as air shafts, do not exist. Temperature, humidity, leakage, and damage susceptibility are all factors that limit its use in applications other than ceiling plenums and air shafts. Limitations in the specific code should be checked.

3. The duct may be only designated to be "reasonably airtight." This terminology is commonly found in mechanical codes and in fire protection related standards such as NFPA 90A. Since it has no quantitative evaluation criteria it means that whatever leakage results from using the prescribed duct construction methods and good workmanship is acceptable. Good workmanship would be that perceived to be such in the trade.

   SMACNA manuals do not set allowable leakage rates or require leakage tests. It is the system designer's duty to prescribe these if needed. Comprehensive analysis of leakage, leakage rates expected in sealed and unsealed ducts, leakage classifications, and test procedures are in the SMACNA *HVAC Air Duct Leakage Test Manual*. SMACNA does not designate specific methods of sealing.

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CHAPTER 2

COMPLIANCE AND QUALITY CONTROL

2.1 COMPLIANCE AND QUALITY CONTROL

Although knowledge of the details in the construction standards is the ultimate basis of quality control, installations should also be checked by routinely looking for the presence or absence of general features that reflect the level of quality.

2.2 CHECKLISTS

The following checklists provide information and compliance and quality control. Not all projects will have all items listed in the checklist.

SPECIAL CONDITIONS REVIEW CHECKLIST

☐ Duct pressure classes are clearly given on the drawings or in the specifications for each system.

☐ The amount of sealing is specified or an allowable leakage rate is given.

☐ Field tests other than testing and balancing are required.

☐ The configuration of duct fittings is specified. It is determined by:

- ☐ design documents
- ☐ clarification by submittals
- ☐ contractor's choice of options in the SMACNA manuals.

☐ As-built ductwork deviates from the design documents. It was influenced by:

- ☐ obstructions
- ☐ crowded conditions
- ☐ equipment that was relocated
- ☐ approved submittals
- ☐ change orders.

☐ Ducts are not penetrated by anything other than piping, wiring, or tubing that is a necessary part of the HVAC system.

☐ The project requires seismic restraints on mechanical systems.

☐ Ductwork is not supporting items that are not of the sheet metal trade.

☐ Air passageways in return air ceilings and in shafts are not blocked.

☐ There is sufficient space in and behind access doors or panels in ceilings, walls, and shafts to allow a person to perform maintenance on the HVAC system devices that require it.

☐ Maintenance access in ducts is provided. Its form is:

- ☐ hinged panels
- ☐ lift off panels
- ☐ removable sections of ducts.

☐ Automatic monitoring devices to be mounted in or on ducts are present and operable:

- ☐ fire stats
- ☐ freeze stats
- ☐ smoke detectors
- ☐ fail-safe air flow switches
- ☐ damper position indicators.

☐ Early occupancy and warranty period adjustments.

☐ Owner's operating and maintenance instructions:

- ☐ by designers
- ☐ by contractors.

DUCT SYSTEM INSPECTION CHECKLIST

ACCEPTABLE ☒ **DEFICIENT** **REASON:**

T = Type	S = Size		
A = Attachment	L = Location		
I = Incomplete	C = Corrosion		
SP = Spacing	U = Unclean		
M = Material	D = Damage		
R = Rating			

RIGID DUCTWORK

- ☐ Pressure Class
- ☐ Duct Wall
- ☐ Joints
- ☐ Seams
- ☐ Reinforcements
- ☐ Tie Rods
- ☐ Crossbreak/Bead
- ☐ Sealing
- ☐ Hanger/Support
- ☐ Insert/Anchors
- ☐ Duct Liner
- ☐ Liner Adhesive
- ☐ Liner Pins
- ☐ Hangers
- ☐ Elbows
- ☐ Turning Vanes
- ☐ Transitions
- ☐ Trunk-Branch Fitting
- ☐ Branch Connection
- ☐ Extractors
- ☐ Splitters
- ☐ Volume Dampers
- ☐ Tap Collars
- ☐ Terminal Connection
- ☐ Equipment Connection
- ☐ Access Doors
- ☐ Fan Inlet
- ☐ Fan Outlet
- ☐ Belt Guards
- ☐ Vibration Connection
- ☐ Air Intake
- ☐ Louvers
- ☐ Air Exhaust
- ☐ Curbs
- ☐ Flashing
- ☐ Casing
- ☐ Plenum
- ☐ In Slab
- ☐ Underground
- ☐ Paint/Coatings
- ☐ Weatherproofing

DEFECT LOCATION AND
COMMENT (write in)

FIRE/SMOKE DAMPERS

- ☐ Location
- ☐ Sleeves
- ☐ Connections
- ☐ Retaining Angles
- ☐ Clearances
- ☐ Control Means
- ☐ Access

FLEXIBLE DUCT

- ☐ Duct Grade/Class
- ☐ Connector Grade
- ☐ UL/Other Label
- ☐ Excess Tension
- ☐ Excess Sag
- ☐ Supports
- ☐ Bend Radius
- ☐ 2 in. (51 mm) Metal Collars
- ☐ Damage

MISCELLANEOUS

- ☐ Grease Duct
- ☐ Range Hood
- ☐ Breeching
- ☐ Furnace Vent
- ☐ Chimney
- ☐ Fume Hood
- ☐ Dishwasher Exhaust Duct
- ☐ Air Shaft
- ☐ Through-penetration Firestop
- ☐ Insulation
- ☐ Ceiling Plenum Contents
- ☐ Pressurized Exit
- ☐ PVC Duct
- ☐ FRP Duct
- ☐ Maintenance Access

JOB ______________________________

____

CONTRACTOR ______________________________

____

INSPECTOR ______________________________

____

FOR ____________________ **DATE** __________

INSPECTION CHECKLIST FOR FIBROUS GLASS DUCT SYSTEM INSTALLATION

References
SMACNA Standards
North American Installation Manufacturers Association (NAIMA)
Board Manufacturer's Standards

General	**Yes**	**No**
1. Is the duct used within its service limitations?	☐	☐
2. Is system operating within the design limitations for which it was built?	☐	☐
3. Are all sheet metal accessory items galvanized?	☐	☐
4. Is the EI rating printed on the board facing?	☐	☐
5. Is the UL label present on much of the duct surface?	☐	☐
6. Is the system free from visual signs of duct board facing delamination?	☐	☐
Fabrication and Installation		
7. Are turning vanes installed in accordance with the Standards? (Pressing your hand into the cheek of the ell will reveal if specified vanes are being used.)	☐	☐
8. When metal parts are attached, are 2½ in. (63.5 mm) (minimum) square steel washers used on 16 in. (405 mm) (maximum) centers?	☐	☐
9. When staples can't be used, are 8 in. (203 mm) cross tabs of approved closure being used in place of staples? (Tab spacing requirements are 12 in. (305 mm) OC, minimum one per side)	☐	☐
10. Is the system completely free from tears or punctures in the facing?	☐	☐
11. Is the system free from areas where excessive amounts of closure materials, such as	☐	☐
several wraps around a joint, may have been used to conceal potential problem areas?	☐	☐
12. Are all system joints tight, free from bulges, with taped joints showing good workmanship?	☐	☐
13. Are all fittings fabricated in accordance with the Standards and do they demonstrate good workmanship?	☐	☐
14. Have offsets been installed so duct sections aren't forced to bend around obstructions?	☐	☐
15. Are all panels in any fitting at least 4 in. (102 mm) long, including male or female joints?	☐	☐
Electric Heaters		
16. Is interior sleeve present, properly attached with screws and washers 16 in. (405 mm) on centers?	☐	☐
17. Is heater separately supported?	☐	☐
18. Are all listed clearances to combustibles and radiation protections in place?	☐	☐
Dampers		
19. If a motorized damper operator is being used, is the sheet metal sleeve extended so the operator is mounted on the same sleeve with the damper?	☐	☐
20. On a manual volume damper, does the quadrant move a full 90 degrees?	☐	☐
Fire Dampers		
21. Is sheet metal sleeve present? (Fibrous duct stops at barrier)	☐	☐
22. Is duct properly attached to sleeve with screws and washers 16 in. (405 mm) on centers and sealed?	☐	☐
Access Doors		
23. Is installation in accordance with the Standards?	☐	☐
Grilles, Diffusers, Registers		
24. Is the extra weight of the item being separately supported and not dependent on the duct alone for support? (*EXCEPTION*: Registers not greater than 150 in^2 (0.097 m^2) in area may be attached to the duct with metal channel without other support.)	☐	☐

Equipment Unit Connection	**Yes**	**No**
25. Are sheet metal screws and washers used to secure duct system to flange extensions? (Mechanical fasteners must be used!)	☐	☐

Closure	**Yes**	**No**
26. Are all joints in the system properly sealed?	☐	☐
27. Are closure materials of a listed type as evidenced by presence of UL instruction sheet in duct board carton? Is tape imprinted?	☐	☐
28. Are there staples or cross tabs, properly spaced, on circumferential joints?	☐	☐
29. Are staples, if used, of the correct type and size, and spaced in proper intervals as recommended by the duct board manufacturer?	☐	☐
30. Are all pressure-sensitive tape closures rubbed down adequately, with staples or scrim in facing clearly visible through the tape?	☐	☐
31. If heat-sealable tape closure was used, was it applied correctly, as evidenced by dot color change?	☐	☐
32. If glass fabric and mastic are used, is the mesh of the glass fabric completely filled with mastic?	☐	☐

Reinforcement	**Yes**	**No**
33. Is reinforcement system of recommended type (formed metal, tie rod, or combination)?	☐	☐
34. Is tie rod wire 12 gage (0.18 mm) or heavier?	☐	☐
35. Is tie rod spacing correct according to duct span, board type, and static pressure?	☐	☐
36. Are tie rod washers 2½ in. (63.5 mm) square and proper gage by type?	☐	☐
37. Do tie rod washers have turned edges facing away from duct board so they won’t cut into it?	☐	☐
38. If tie rods reinforce a butt joint, are rods used on both sides of butt joint?	☐	☐
39. Is wire termination one of those in the Standards?	☐	☐
40. Are anti-sag devices used on ducts 48 in. (1220 mm) span or greater, to support top panel of ducts?	☐	☐
41. Do tie rods run straight through ducts and not at angles?	☐	☐
42. Are heels of tees, elbows, and end caps reinforced (formed sheet metal channel, tie rod, or combination)?	☐	☐
43. When formed sheet metal channel reinforcement is used, are sheet metal gages, dimensions, and spacing correct?	☐	☐
44. On supply ducts, is reinforcing member on the female side of the shiplap?	☐	☐
45. On return ducts, are sheet metal channel reinforcements attached to ducts with screws and 2½ in. (63.5 mm) square washers or 2 × 6 in. (51 × 150 mm) clips?	☐	☐
46. On return ducts, is the reinforcing member attached to the male shiplap side of the joint?	☐	☐
47. For the heels of tees, elbows, end caps, and any other fittings where a panel faces an opening on the opposite side, is correct reinforcing member (type: sheet metal channel, tie rod, or combination) applied?	☐	☐

Hangers and Supports	**Yes**	**No**
48. Are hangers installed in accordance with the Standards?	☐	☐
49. Are hanger designs in accordance with the Standards?	☐	☐
50. Are accessories that add weight to the duct system separately supported so as not to stress the system? (consult the standards)	☐	☐
51. Are vertical risers limited to two stories and supported on 12 ft (3650 mm) (maximum) centers?	☐	☐
52. If formed sheet metal reinforcements are used as hangers, are attachments within 6 in. (150 mm) of duct sides?	☐	☐
53. Are all fittings supported by hangers in accordance with the standards?	☐	☐

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APPENDIX A

FUNCTIONS OF DUCTED AIR HANDLING SYSTEMS

A.1 VENTILATION AND AIR CONDITIONING

Air is a gas that contains oxygen. It envelops the planet and fills all open spaces within buildings. The breathing function of human beings removes oxygen from air. Thus, a replacement supply of oxygen is needed to sustain life. Oxygen is also used up in burning fuels such as coal, oil, or gas to provide heat for human comfort. Replacement of oxygenated air is needed for the heating process as well.

The process of providing a fresh supply of air for human need in buildings and comfort is called ventilation. Sometimes the removal of odorous or contaminated air is called ventilation as well. Building codes prescribe minimum amounts of ventilation.

The process of treating air by filtering, cooling, and adding or removing moisture from it is called air conditioning.

Motor driven fans move air from one space to another (through ducts) to control it or to create desirable air motion within occupied spaces. Fans do this by creating enough pressure to overcome the resistance to flow that naturally occurs when air molecules bump into objects or have their direction changed.

A.2 CENTRAL AIR HANDLING SYSTEM

Central air handling systems are relatively large networks of air ducts that have fans located in an equipment room somewhere in a building or on the roof of the building. Air ducts on the outlet side of the fan unit are called supply air ducts. They convey outdoor or "treated" air to multiple rooms in selected zones. Zones may cover part of a floor or all of a floor. They may also cover parts of, or all of, several floors. Supply ducts operate with a positive pressure; that is, the pressure in them is higher than the atmospheric pressure in the spaces they pass through.

In a central supply-return system other ducts called return air ducts will collect air from the same rooms or zones that the associated supply ducts serve and bring it back to the heating, cooling, filtering, etc., apparatus, for reconditioning before being sent back through the supply fan. The supply fan may serve both functions (supply and return) or a separate return air will mix with outdoor air in a fresh air intake plenum located on the suction side of the supply limit. Alternatively, it may be exhausted to the outdoors. The system arrangement is diagrammed in Figure A-7. Several forms of "central" systems can be used. In some of them, not all of the return air is sent back to the central station fan unit. Instead, it is returned to a satellite unit that is located in its own zone where it is mixed with air coming from a central station unit and is then sent back to occupied spaces.

Air handling systems may be of constant volume or variable volume type. These terms refer to the quantity of air that is being circulated by the central station fan unit. Varying the volume permits conserving energy spent in circulating and treating air since in many cases the demand for heating or cooling varies over day-night and occupancy-use cycles.

A.3 DEDICATED EXHAUST SYSTEMS

Air removal from toilet rooms, potentially contaminated areas of hospitals and laboratories, cooling range areas, dishwashers, and boiler furnaces is normally exhausted directly to the outdoors by systems dedicated for the specific service. The expense or difficulty of reconditioning air from such operations to make it acceptable for occupant exposure is not considered worthwhile. In some cases, the thermal energy in exhaust air is saved by using heat recovery apparatus in the exhaust ducts. In industrial plants, dedicated exhaust systems collect and transport vapors, fumes, and particles that would cause health problems or interfere with work activity.

Another form of dedicated exhaust is smoke control. For a fire emergency, a separate smoke removal system can be activated or systems that would normally be operating in return/recirculation mode can be converted to exhaust mode.

The term "local exhaust" usually refers to air extraction from a specific work operation site within a room. This contrasts with general exhaust which will apply to area wide or an entire room.

All exhaust systems require a source of replacement or makeup air. The source may be a supply system, cracks or pores in the enclosure of exhausted space, open doors or windows, undercut doors, or louvered or dampered openings. Fan powered makeup air units are common in industrial facilities.

A.4 ROOM AIR DISTRIBUTION

Air velocity level and the pattern of air movement from a supply point to an exhaust point in a room affect occupant health, occupant comfort, and the efficiency of temperature control. Velocities under 15 feet per minute (fpm)(0.08 m/s) seem stagnant. Those over 65 fpm (0.33 m/s) seem drafty. The term “throw” designates the horizontal distance a supply air terminal directs air before it reaches minimum velocity. “Drop” pertains to vertical fall before reaching low velocity. Air terminals that have volume dampers are called registers. Special forms of supply terminals are called diffusers.

A.5 ROOM PRESSURE CONTROL

Rooms are designed to have positive pressure or negative pressure. In general those that have more fan powered supply air than fan powered exhaust will have positive pressure. When the opposite situation exists, the room will have negative pressure. The intended balance can be upset by unplanned opening of doors or windows, the wrong position of dampers, failure of interacting controls, unanticipated wind pressure on the building exterior, and other circumstances. Pressure control is critical in a fire situation and in chemically or biologically contaminated zones. Normal and emergency states of operation of fan systems must be understood in order to preserve health and safety.

A.6 INFILTRATION AND EXFILTRATION

Infiltration is unintentional air leakage into buildings. Exfiltration is uncontrolled air leakage out of buildings. These terms may also be applied to specific compartments within buildings. Typical rates of leakage for building components are given in the ASHRAE *Fundamentals Handbook* chapter on infiltration and exfiltration. The temperature, humidity, and cleanliness of air from these sources can significantly affect energy consumption costs as well as affect the control of indoor environment for health and safety reasons.

A.7 CENTRAL ALARM CONTROL STATIONS

Modern buildings often have central control/alarm stations that visually display and permit diagnosis of the operating condition of fire alarm, smoke detector, sprinkler, and air handling systems. They also have stop-start controls that allow change of the operating state of the air handling systems. The functions of these interdependent controls and systems are vital for the safety of building occupants and they must be understood by those responsible for verifying their condition.

A.8 TESTING AND BALANCING

The operations of measuring and adjusting the quantity of air at fans, in ducts and at air terminals are designated “testing and balancing.” The shorthand term for this is TAB. Testing often involves measuring air pressures in ducts. Static pressure is force exerted on a duct wall in a manner similar to that in an inflated balloon. Velocity pressure is a force acting in the direction of flowing air as in wind pressure. The sum of static pressure and velocity pressure is called total pressure. Standard procedures for TAB are published by several respected organizations, including SMACNA.

A.9 SYMBOLS

Standardized terminology and illustrations of duct system components are given in Figures A-1 and A-1M.

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SYMBOL MEANING	SYMBOL
POINT OF CHANGE IN DUCT CONSTRUCTION (BY STATIC PRESSURE CLASS)	
DUCT (1ST FIGURE, SIDE SHOWN 2ND FIGURE, SIDE NOT SHOWN)	20 x 12
ACOUSTICAL LINING DUCT DIMENSIONS FOR NET FREE AREA	
DIRECTION OF FLOW	
DUCT SECTION (SUPPLY)	S 30 x 12
DUCT SECTION (EXHAUST OR RETURN)	E OR R 20 x 12
INCLINED RISE (R) OR DROP (D) ARROW IN DIRECTION OF AIR FLOW	R
TRANSITIONS: GIVE SIZES. NOTE F.O.T. FLAT ON TOP OR F.O.B. FLAT ON BOTTOM IF APPLICABLE	
STANDARD BRANCH FOR SUPPLY & RETURN (NO SPLITTER) 45° INLET	S R
WYE JUNCTION	
VOLUME DAMPER MANUAL OPERATION	VD
AUTOMATIC DAMPERS MOTOR OPERATED	SEC MOD
ACCESS DOOR (AD) ACCESS PANEL (AP)	OR AD
FIRE DAMPER: SHOW ◄ VERTICAL POS. SHOW ◆ HORIZ. POS.	FD AD
SMOKE DAMPER (S)	AD S
HEAT STOP – CEILING DAMPER – (C) RADIATION DAMPER – (R)	
TURNING VANES (TYPE AS SPECIFIED)	
FLEXIBLE DUCT FLEXIBLE CONNECTION	
GOOSENECK HOOD (COWL)	
BACK DRAFT DAMPER	BDD

SYMBOL MEANING	SYMBOL
SUPPLY GRILLE (SG)	20 x 12 SG 700 CFM
RETURN (RG) OR EXHAUST (EG) GRILLE (NOTE AT FLR OR CLG)	20 x 12 RG 700 CFM
SUPPLY REGISTER (SR) (A GRILLE + INTEGRAL VOL. CONTROL)	20 x 12 SR 700 CFM
EXHAUST OR RETURN AIR INLET CEILING (INDICATE TYPE)	20 x 20 GR 700 CFM
SUPPLY OUTLET. CEILING, ROUND (TYPE AS SPECIFIED) INDICATE FLOW DIRECTION	20 700 CFM
SUPPLY OUTLET. CEILING, SQUARE (TYPE AS SPECIFIED) INDICATE FLOW DIRECTION	12 x 12 700 CFM
TERMINAL UNIT. (GIVE TYPE AND OR SCHEDULE)	T.U.
COMBINATION DIFFUSER AND LIGHT FIXTURE	
DOOR GRILLE	DG 12 x 6
SOUND TRAP	ST
FAN & MOTOR WITH BELT GUARD & FLEXIBLE CONNECTIONS	
VENTILATING UNIT (TYPE AS SPECIFIED)	
UNIT HEATER (DOWNBLAST)	
UNIT HEATER (HORIZONTAL)	
UNIT HEATER (CENTRIFUGAL FAN) PLAN	
THERMOSTAT	T
POWER OR GRAVITY ROOF VENTILATOR – EXHAUST (ERV)	
POWER OR GRAVITY ROOF VENTILATOR – INTAKE (SRV)	
POWER OR GRAVITY ROOF VENTILATOR – LOUVERED	
LOUVERS & SCREEN	36 H x 24 L

FIGURE A-1 SYMBOLS FOR HVAC SYSTEMS

SYMBOL MEANING	SYMBOL
POINT OF CHANGE IN DUCT CONSTRUCTION (BY STATIC PRESSURE CLASS)	
DUCT (1ST FIGURE, SIDE SHOWN 2ND FIGURE, SIDE NOT SHOWN)	508 x 305
ACOUSTICAL LINING DUCT DIMENSIONS FOR NET FREE AREA	
DIRECTION OF FLOW	
DUCT SECTION (SUPPLY)	S 762 x 305
DUCT SECTION (EXHAUST OR RETURN)	E OR R 762 x 305
INCLINED RISE (R) OR DROP (D) ARROW IN DIRECTION OF AIR FLOW	R
TRANSITIONS: GIVE SIZES. NOTE F.O.T. FLAT ON TOP OR F.O.B. FLAT ON BOTTOM IF APPLICABLE	
STANDARD BRANCH FOR SUPPLY & RETURN (NO SPLITTER) 45° INLET	S R
WYE JUNCTION	
VOLUME DAMPER MANUAL OPERATION	VD
AUTOMATIC DAMPERS MOTOR OPERATED	SEC MOD
ACCESS DOOR (AD) ACCESS PANEL (AP)	OR AD
FIRE DAMPER: SHOW ◀ VERTICAL POS. SHOW ◆ HORIZ. POS.	FD AD
SMOKE DAMPER (S)	AD S
HEAT STOP – CEILING DAMPER – C RADIATION DAMPER – R	
TURNING VANES (TYPE AS SPECIFIED)	
FLEXIBLE DUCT FLEXIBLE CONNECTION	
GOOSENECK HOOD (COWL)	
BACK DRAFT DAMPER	BDD
SUPPLY GRILLE (SG)	508 x 305 SG 330 LPS
RETURN (RG) OR EXHAUST (EG) GRILLE (NOTE AT FLR OR CLG)	508 x 305 RG 330 LPS
SUPPLY REGISTER (SR) (A GRILLE + INTEGRAL VOL. CONTROL)	508 x 305 SR 330 LPS
EXHAUST OR RETURN AIR INLET CEILING (INDICATE TYPE)	508 x 305 GR 330 LPS
SUPPLY OUTLET. CEILING, ROUND (TYPE AS SPECIFIED) INDICATE FLOW DIRECTION	508 x 508 330 LPS
SUPPLY OUTLET. CEILING, SQUARE (TYPE AS SPECIFIED) INDICATE FLOW DIRECTION	508 700 CFM
TERMINAL UNIT. (GIVE TYPE AND OR SCHEDULE)	T.U.
COMBINATION DIFFUSER AND LIGHT FIXTURE	
DOOR GRILLE	DG 305 x 152
SOUND TRAP	ST
FAN & MOTOR WITH BELT GUARD & FLEXIBLE CONNECTIONS	
VENTILATING UNIT (TYPE AS SPECIFIED)	
UNIT HEATER (DOWNBLAST)	
UNIT HEATER (HORIZONTAL)	
UNIT HEATER (CENTRIFUGAL FAN) PLAN	
THERMOSTAT	T
POWER OR GRAVITY ROOF VENTILATOR – EXHAUST (ERV)	
POWER OR GRAVITY ROOF VENTILATOR – INTAKE (SRV)	
POWER OR GRAVITY ROOF VENTILATOR – LOUVERED	
LOUVERS & SCREEN	914 H x 610 L

FIGURE A-1M SYMBOLS FOR HVAC SYSTEMS (METRIC)

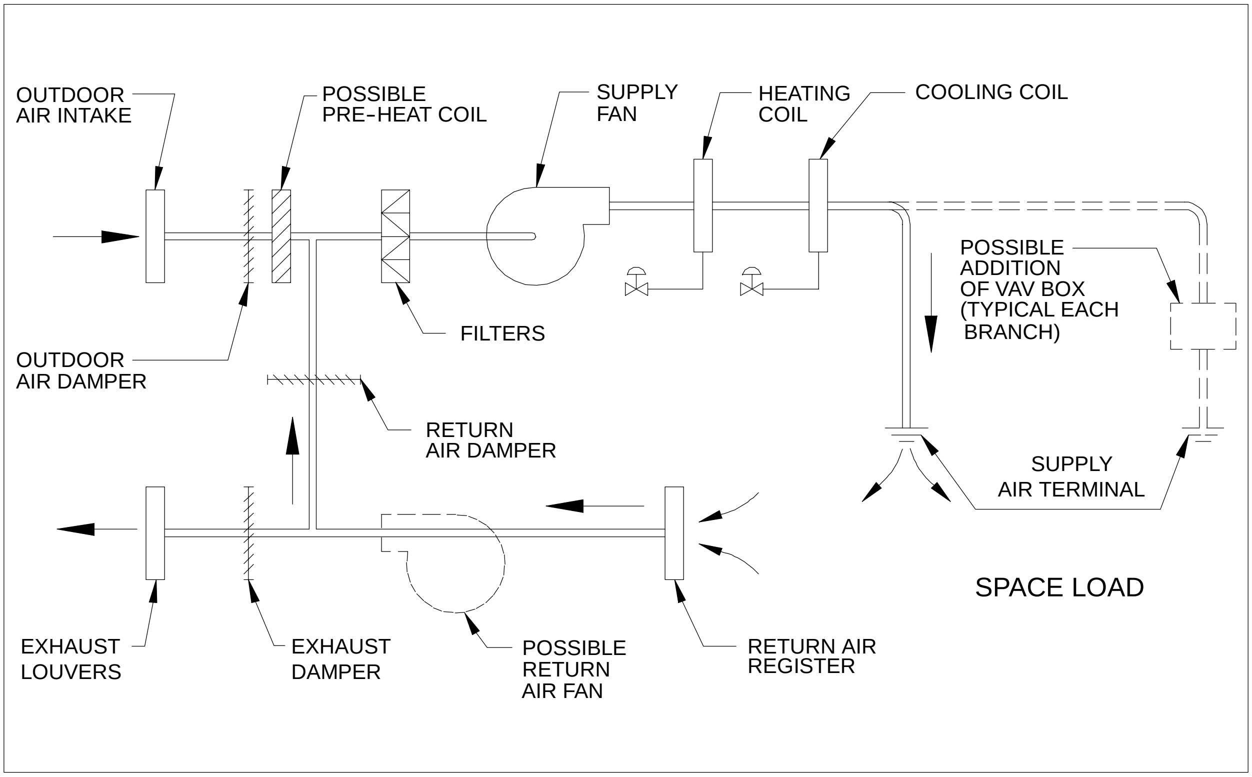


FIGURE A-2 SINGLE DUCT SYSTEM

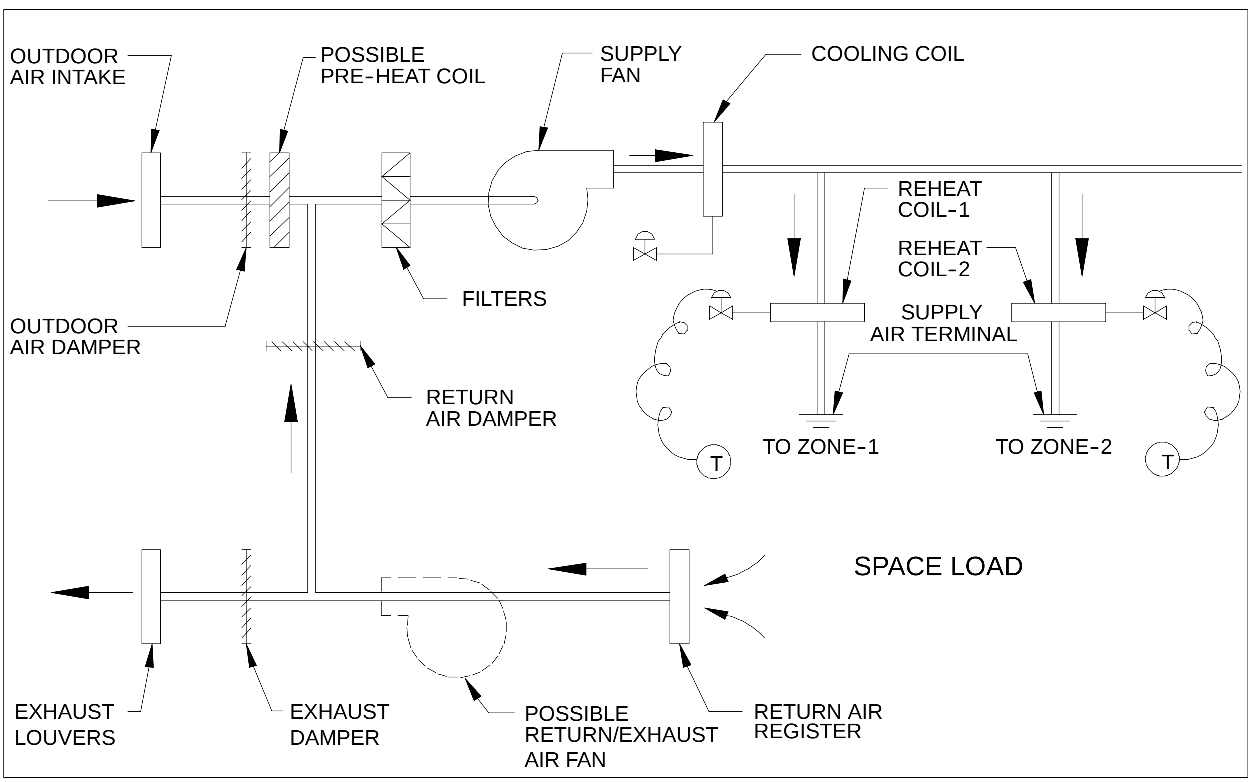


FIGURE A-3 TERMINAL REHEAT SYSTEM

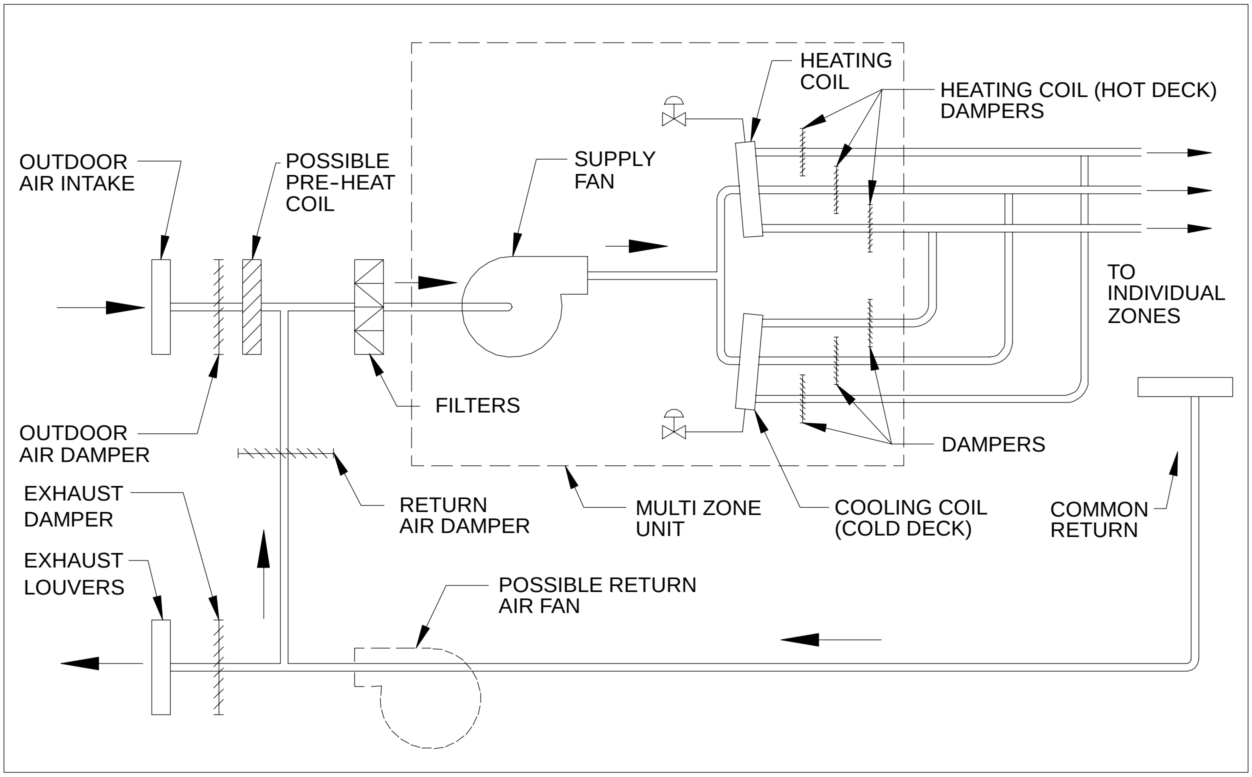


FIGURE A-4 MULTI-ZONE SYSTEM

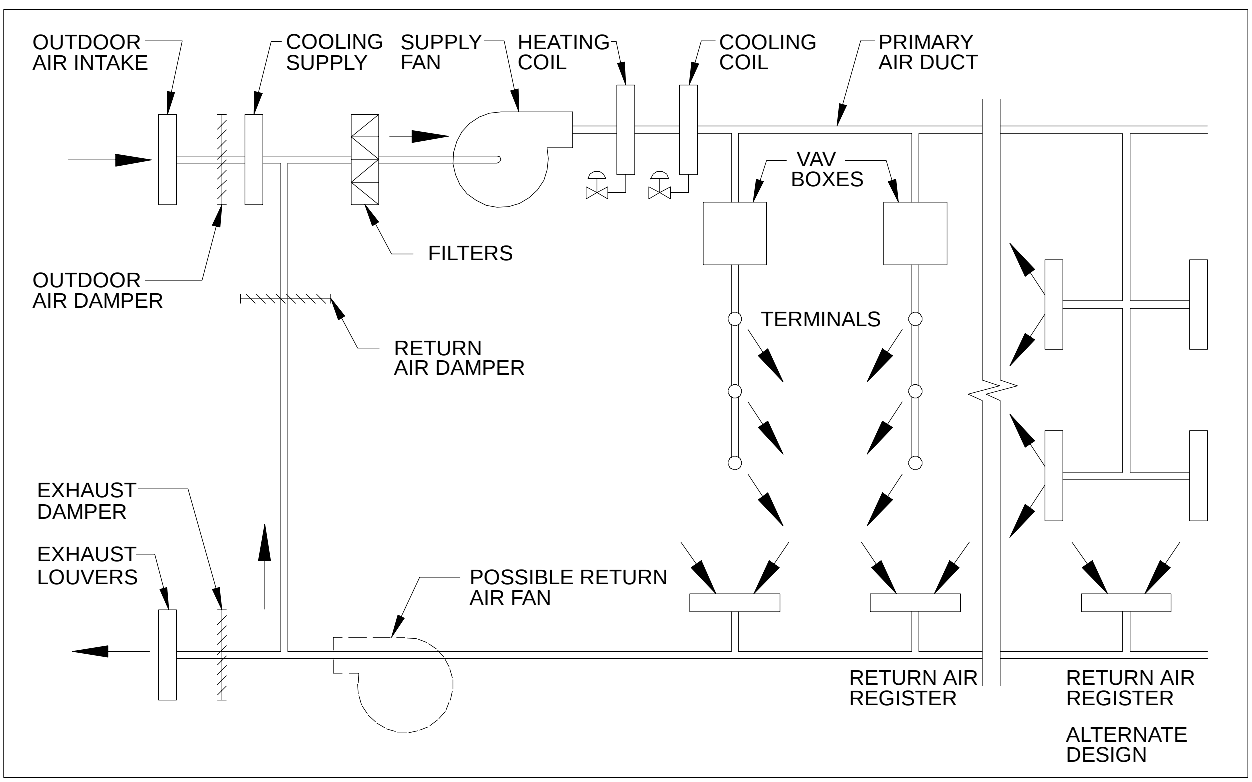


FIGURE A-5 VARIABLE VOLUME SYSTEM

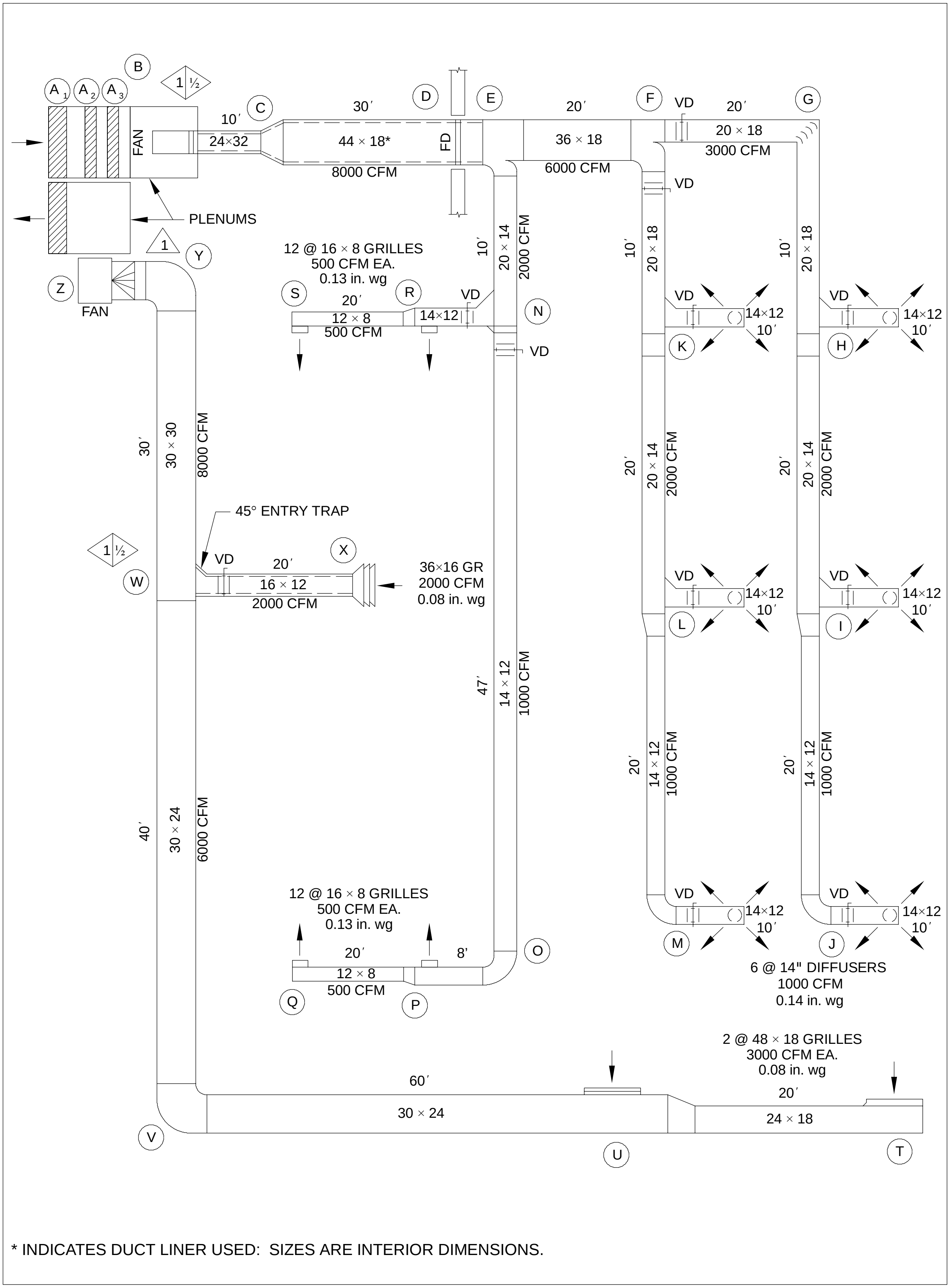


FIGURE A-6 DUCT SYSTEM EXAMPLE

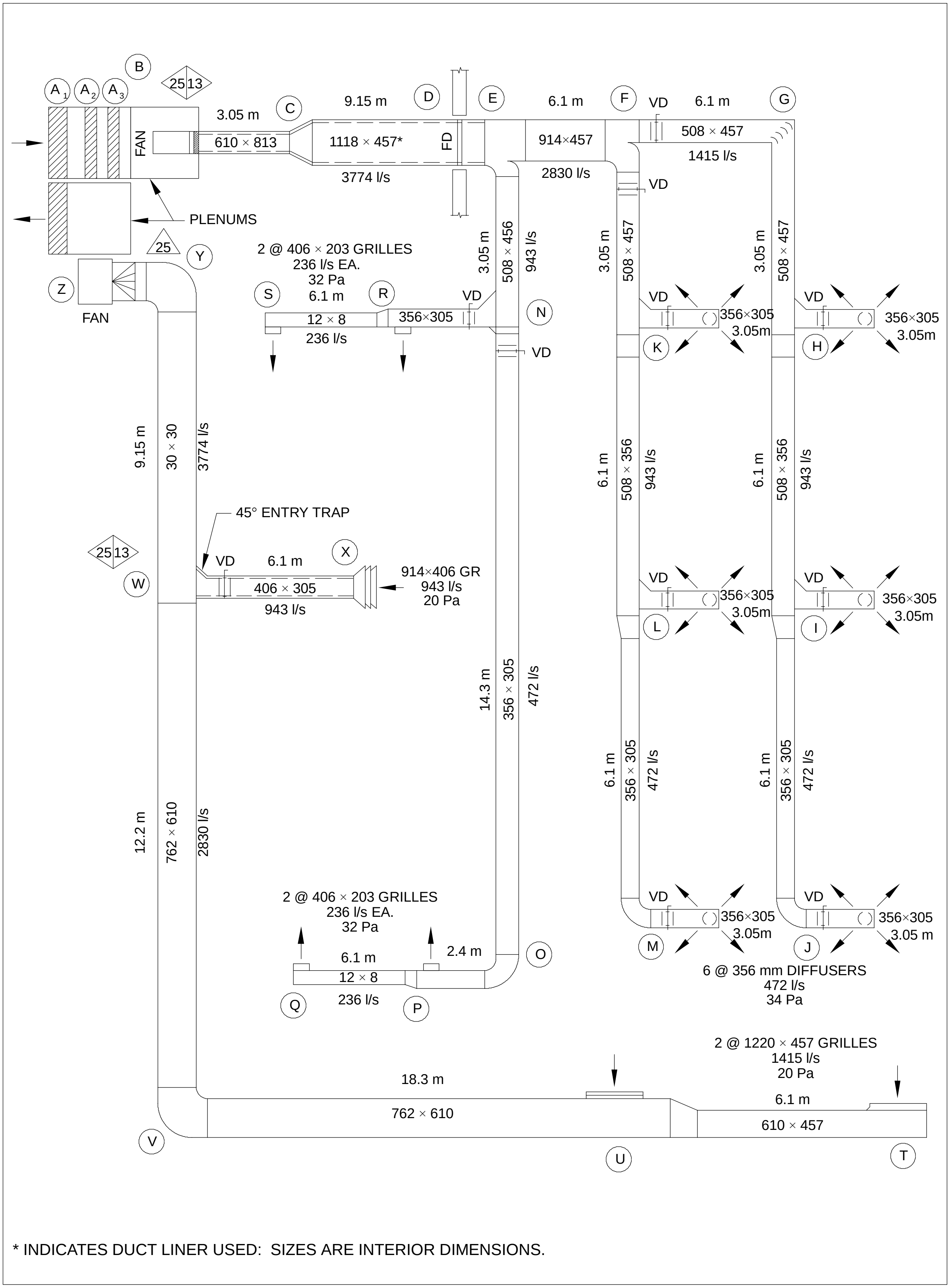


FIGURE A-6M DUCT SYSTEM EXAMPLE (METRIC)

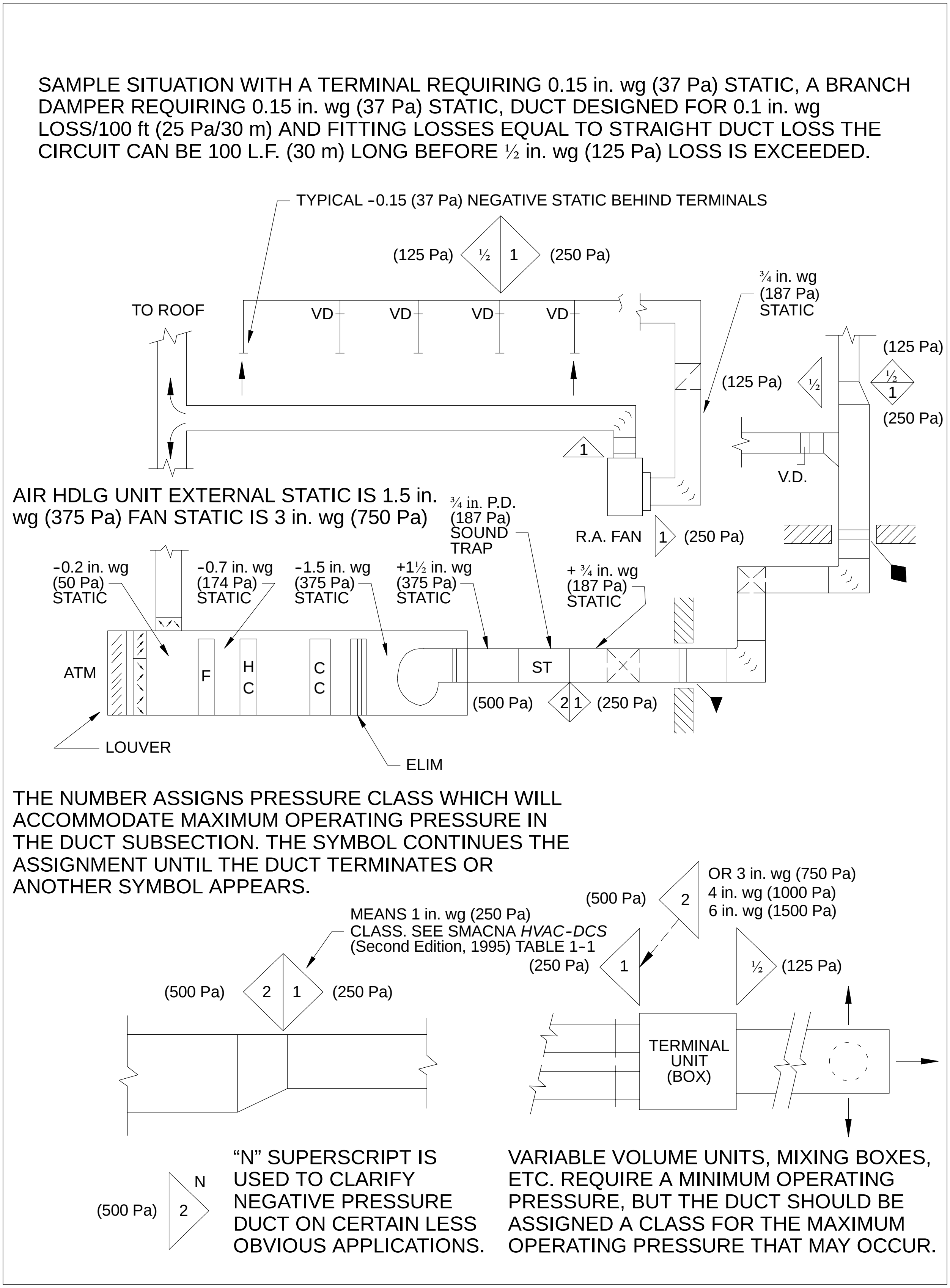


FIGURE A-7 DUCT PRESSURE CLASS DESIGNATION

APPENDIX B

DUCT CONSTRUCTION MATERIALS

Materials used for rigid ducts include: galvanized steel, black carbon steel, aluminum, stainless steel, copper, fiberglass reinforced plastic (FRP), polyvinyl chloride (PVC), polyvinyl steel (PVS), concrete, fibrous glass (duct board), and gypsum board. Codes, construction standards, and the design documents governing air handling systems define acceptable limits of use of each material. This Appendix contains a brief review of materials application.

B.1 GALVANIZED STEEL

APPLICATIONS—Widely used as a duct material for most air handling systems; not recommended for corrosive product handling or temperatures above 400°F (204°C).

ADVANTAGES—High strength, rigidity, durability, rust resistance, availability, non-porous, workability, and weldability.

REMARKS—Galvanized steel sheet is customarily available in commercial and lock forming quality. *See* additional characteristics in Table B-1.

B.2 CARBON STEEL (BLACK IRON)

APPLICATIONS—Breechings, flues, stacks, hoods, other high temperature duct systems, kitchen exhaust systems, ducts requiring paint, or special coating.

ADVANTAGES—High strength, rigidity, durability, availability, paintability, weldability, non-porous.

REMARKS—Hot-rolled sheet is manufactured by hot-rolling slabs in a continuous mill. Cold-rolled sheet is manufactured from hot-rolled, descaled coils by cold reducing to the desired thickness, generally followed by annealing. Hot-rolled carbon steel is generally softer, less precisely rolled, less expensive, and is used more frequently than cold-rolled steel. *See* the specifications in Table B-2.

B.3 STAINLESS STEEL

APPLICATIONS—Duct systems for kitchen exhaust, moisture laden air, fume exhaust.

ADVANTAGES—High resistance to corrosion from moisture and most chemicals, ability to take a high polish.

REMARKS—Available in many different alloy combinations. Types 304 and 316 are most commonly used. Stainless is usually available in the finishes listed in Table B-3.

B.4 ALUMINUM

APPLICATIONS—Duct systems for moisture laden air, louvers, special exhaust systems, ornamental duct systems.

ADVANTAGES—Light weight, resistance to moisture, corrosion (salt free), availability.

REMARKS—Various alloys are available in sheet form with the 3000-H14 temper series being the most commonly specified for duct systems. A “utility grade” sheet is also available. Sheets can also be obtained with embossed or anodized surfaces. The commonly used grade has about one half of the tensile strength and one third of the rigidity of steel. It also has high thermal expansion. *See* additional characteristics in Table B-4.

B.5 COPPER

APPLICATIONS—Duct systems for exposure to outside elements and moisture laden air, certain chemical exhaust, ornamental ductwork, hoods.

ADVANTAGES—Accepts solder readily, durable, resists corrosion, non-magnetic.

REMARKS—Its connection to other metals can result in galvanic corrosion. Its use is limited to pressure below 2 in. wg (500 Pa).

B.6 FIBERGLASS REINFORCED PLASTIC (FRP)

APPLICATIONS—Chemical fume exhaust, scrubbers, underground duct systems.

ADVANTAGES—Resistance to corrosion, strength.

REMARKS—Codes usually limit its application. Although NFPA Standard 91 covers FRP, provisions therein relate more to pipe than to duct.

B.7 POLYVINYL CHLORIDE (PVC)

APPLICATIONS—Exhaust systems for chemical fumes and hospitals, underground duct systems.

ADVANTAGES—Resistance to corrosion, weight, weldability, ease of modification.

REMARKS—Use is restricted by codes and its combustibility and toxicity ratings.

B.8 POLYVINYL STEEL (PVS)

APPLICATIONS—Underground duct systems, moisture laden air, and corrosive air systems.

ADVANTAGES—Resistance to corrosion, availability.

REMARKS—Polyvinyl steel is a polyvinyl chloride plastic coating heat-fused to galvanized steel. 2 mil (0.05 mm) and 4 mil (0.10 mm) coating thicknesses usually are standard, with steel gages (US standard) available from 26 ga (0.55 mm) through, and including, 14 ga (2.0 mm). This product is most popular in spiral seam pipe and is available in flat sheets and coil stock of lockforming quality. It is susceptible to coating damage and temperature limits.

REMARKS—Due to high smoke generation rating, sprinklers may also be required by codes.

B.9 CONCRETE

APPLICATIONS—Underground ducts, air shafts.

ADVANTAGES—Compression strength, corrosion resistance.

B.10 ASBESTOS CEMENT

APPLICATIONS (FORMER)—Underground duct systems, kitchen exhaust, chemical exhaust, high temperature duct systems, flues, and vents.

ADVANTAGES—Resistance to most chemicals, can be used up to 2000°F (1093°C).

REMARKS—Asbestos products are now subject to many government regulations.

B.11 RIGID FIBROUS GLASS

APPLICATIONS—Interior HVAC low pressure duct systems.

ADVANTAGES—Lightweight, thermal insulation and vapor barrier, acoustical qualities, ease of modification, inexpensive tooling for fabrication.

REMARKS—Construction standards and code related provisions must be strictly followed.

B.12 GYPSUM BOARD

APPLICATIONS—Ceiling plenums, corridor air passageways, airshafts.

ADVANTAGES—Cost, availability.

REMARKS—Must be sealed. There are no construction standards for ducts of this material. Its temperature, moisture susceptibility, and damage potential are factors that affect its use. Codes regulate its application.

Gage	Thickness in Inches			Weight				Thickness in Millimeters		
	Min.	Max.	Nom.	Min lb/ft^2	Nom. lb/ft^2	Max. lb/ft^2	Nom. kg/m^2	Min.	Max.	Nom.
33	0.0060	0.0120	0.0090	0.2409	0.376	0.486		0.1524	0.3048	0.2286
32	0.0104	0.0164	0.0134	0.4204	0.563	0.665		0.2642	0.4166	0.3404
31	0.0112	0.0172	0.0142	0.4531	0.594	0.698		0.2845	0.4369	0.3607
30	0.0127	0.0187	0.0157	0.5143	0.656	0.759	3.20	0.3188	0.4783	0.3988
29	0.0142	0.0200	0.0172	0.5755	0.719	0.820		0.3569	0.5169	0.4369
28	0.0157	0.0217	0.0187	0.6367	0.781	0.881	3.81	0.3950	0.5550	0.4750
27	0.0172	0.0232	0.0202	0.6979	0.844	0.943		0.4331	0.5931	0.5131
26	0.0187	0.0247	0.0217	0.7591	0.906	1.004	4.42	0.4712	0.6312	0.5512
25	0.0217	0.0287	0.0247	0.8407		1.167		0.5274	0.7274	0.6274
24	0.0236	0.0316	0.0276	0.9590	1.156	1.285	5.64	0.6010	0.8010	0.7010
23	0.0266	0.0346	0.0306	1.0814		1.408		0.6772	0.8772	0.7772
22	0.0296	0.0376	0.0336	1.2038	1.406	1.530	6.86	0.7534	0.9534	0.8534
21	0.0326	0.0406	0.0366	1.3263		1.653		0.8296	1.0296	0.9296
20	0.0356	0.0436	0.0396	1.4486	1.656	1.775	8.08	0.9060	1.106	1.006
19	0.0406	0.0506	0.0456	1.6526		2.061		1.028	1.288	1.158
18	0.0466	0.0566	0.0516	1.8974	2.156	2.305	10.52	1.181	1.441	1.311
17	0.0525	0.0625	0.0575	2.1381		2.546		1.331	1.591	1.461
16	0.0575	0.0695	0.0635	2.3420	2.656	2.832	12.96	1.463	1.763	1.613
15	0.0650	0.0770	0.0710	2.6481		3.138		1.653	1.953	1.803
14	0.0705	0.0865	0.0785	2.8725	3.281	3.525	16.01	1.784	2.204	1.994
12	0.0854	0.1014	0.0934	3.4804		4.133		2.162	2.5823	2.372
12	0.0994	0.1174	0.1084	4.0516	4.531	4.786	22.11	2.523	2.983	2.753
11	0.1143	0.1323	0.1233	4.6505		5.394		2.902	3.362	3.132
10	0.1292	0.1472	0.1382	5.2675	5.781	6.002	28.21	3.280	3.740	3.510
9	0.1442	0.1622	0.1532	5.8795		6.614		3.661	4.121	3.891
8	0.1591	0.1771	0.1681	6.4874	6.875	7.222		4.040	4.500	4.270

Table B-1 Galvanized Sheet Thickness Tolerances

NOTES:

a. Based on ASTM A924/A924M-94, Standard Specification for General Requirements for Sheet Steel, Metallic Coated by the Hot-Dip Process (formerly ASTM A525); and ASTM A653/A653M-94, Standard Specification for Sheet Steel, Zinc-Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvanized) by the Hot-Dip Process.

b. Tolerances are valid for 48 in. (1220 mm) and 60 in. (1524 mm) wide coil and cut length stock - other dimensions apply to other sheet widths and to strip.

c. The lock forming grade of steel will conform to ASTM A653 (formerly ASTM A527).

d. The steel producing industry recommends that steel be ordered by decimal thickness only. Thickness and zinc coating class can be stenciled on the sheet. The gage designation is retained for residual familiarity reference only.

e. Minimum weight in this table is based on the following computation:
Min. sheet thickness (t) minus 0.001 in. of G60 coating times 40.8 lb per sf per inch plus 0.0369 lb per sf of zinc.
G90 stock would be comparably calculated from:
minimum weight = (t - 0.00153 in.) 40.8 + 0.0564.
However, scale weight may run 2% (or more) greater than theoretical weight. Actual weight may be near 40.82 lb per sf per inch.

f. G60 coating, per ASTM A653 and ASTM A90, has 0.60 oz/sf (triple spot test) total for two sides. 0.59 oz/sf of zinc equals 0.001 in. 1 oz is 0.0017 in. and is 305.15 g/m^2. G90 coating is 0.90 oz/sf (triple spot test), or 0.00153 in. Magnetic gage measurement of zinc coating may have 15% error.

g. ASTM A2092, Practices for Preparation of Zinc-Coated Galvanized Steel Surfaces for Paint, includes mill phosphatizing.

h. ASTM A755 is the Specification for Sheet Steel, Metallic Coated by the Hot-Dip Process and Prepainted by the Coil-Coating Process for Exterior Building Products. Other information is available from the National Coil Coaters Association, Philadelphia, PA.

i. Much chemical and atmospheric corrosion information is available from ASM International in Metals Park, Ohio and from NACE International in Houston, TX.

j. A principle international standard is ISO 3575, Continuous Hot-Dip Process, Zinc-Coated Carbon Steel Sheet of Commercial, Lock Forming, and Drawing Qualities.

M.S. Gage	Weight lb/sf (kg/m^2)	Thickness					ANSI STANDARD B32.3 Preferred in Thickness Millimeters	
		Nominal in. (mm)	Hot-rolled		Cold-rolled			
			Min.	Max.	Min.	Max.	First	Second
28	0.625 (3.051)	0.0149 (0.378)			0.0129 (0.328)	0.0169 (0.429)	0.30	0.35
26	0.750 (3.661)	0.0179 (0.455)			0.0159 (0.404)	0.0199 (0.505)	0.40	0.45
24	1.000 (4.882)	0.0239 (0.607)			0.0209 (0.531)	0.0269 (0.683)	0.50	0.65
22	1.250 (6.102)	0.0299 (0.759)			0.0269 (0.683)	0.0329 (0.836)	0.75	0.85
20	1.500 (7.232)	0.0359 (0.912)			0.0329 (0.836)	0.0389 (0.988)	1.0	0.90
18	2.000 (9.764)	0.0478 (1.214)	0.0428 (1.087)	0.0528 (1.341)	0.0438 (1.113)	0.0518 (1.316)	1.2	1.0
16	2.500 (12.205)	0.0598 (1.519)	0.0538 (1.367)	0.0658 (1.671)	0.0548 (1.392)	0.0649 (1.649)	1.6	1.4
14	3.125 (15.256)	0.0747 (1.897)	0.0677 (1.720)	0.0817 (2.075)	0.0697 (1.770)	0.0797 (2.024)	2.0	1.9
12	4.375 (21.359)	0.1046 (2.657)	0.0966 (2.454)	0.1120 (2.860)	0.0986 (2.504)	0.1106 (2.809)	2.5	2.8
10	5.625 (27.461)	0.1345 (3.416)	0.1265 (3.213)	0.1425 (3.619)	0.1285 (3.264)	0.1405 (3.569)	3.5	3.4
8	6.875 (33.564)	0.1644 (4.176)	0.1564 (3.973)	0.1724 (4.379)			3.8	

Table B–2 Manufacturers Standard Gage-Thickness (Uncoated Steel)

NOTES:

a. *Manufacturers Standard Gage* is based on a theoretical steel density of 489.6 lb/cf, or 40.80 lb/sf per inch of thickness plus 2.5% normally experienced increase in delivery weight. Thus, the weight basis associated with thickness specifications is 41.82 lb/sf per inch.

b. *U.S. Standard Gage,* the legal gage since 1893, although based on the density of wrought iron 480 lb/cf, used 40.00 lb/sf/in. for both iron and steel. Thus, U.S. gage thicknesses are derived from weights 2% lighter than steel.

c. The table is based on 48 in. (1220 mm) width coil and sheet stock. 60 in. (1524 mm) stock has the same tolerance for gages listed except for 16 gage which has ± 0.007 in. in hot-rolled sheet.

d. *See* ASTM Standards A366 (cold-rolled order form), A568 (properties of hot-rolled and cold-rolled sheet of commercial quality), and A569 (hot-rolled order form).

e. Thickness and weight in customary units are based on data in the *AISI Carbon Sheet Steel Products Manual*. Metric conversions listed here are straight multiplications for comparison purposes. Individual manufacturers may quote other tolerances.

f. ANSI is the American National Standards Institute. Standards B32.3 actually covers a wider range of thickness than listed here.

Gage	Thickness in Inches				Weight				Thickness in Millimeters		
					lb/ft²		kg/m²				
	Min.	Max.	Toler-ance	Nom.	300	400	300	400	Nom.	Min.	Max.
31	0.0089	0.0129	0.002	0.0109	0.459	0.451	2.239	2.200	0.2769	0.2269	0.3269
30	0.0105	0.0145	0.002	0.0125	0.525	0.515	2.562	2.512	0.3175	0.2675	0.3675
29	0.0121	0.0161	0.002	0.0141	0.591	0.579	2.883	2.825	0.3581	0.3081	0.4081
28	0.0136	0.0176	0.002	0.0156	0.656	0.644	3.200	3.142	0.3962	0.3462	0.4462
27	0.0142	0.0202	0.003	0.0172	0.722	0.708	3.522	3.454	0.4369	0.3569	0.5169
26	0.0158	0.0218	0.003	0.0188	0.788	0.773	3.844	3.771	0.4775	0.3975	0.5575
25	0.0189	0.0249	0.003	0.0219	0.919	0.901	4.483	4.395	0.5562	0.4762	0.6362
24	0.0220	0.0280	0.003	0.0250	1.050	1.030	5.122	5.025	0.6350	0.5550	0.7150
23	0.0241	0.0321	0.004	0.0281	1.181	1.159	5.761	5.654	0.7137	0.6137	0.8137
22	0.0273	0.0353	0.004	0.0313	1.313	1.288	6.405	6.283	0.7950	0.6950	0.8950
21	0.0304	0.0384	0.004	0.0344	1.444	1.416	7.044	6.908	0.8738	0.7738	0.9738
20	0.0335	0.0415	0.004	0.0375	1.575	1.545	7.683	7.537	0.9525	0.8525	1.0525
19	0.0388	0.0488	0.005	0.0438	1.838	1.803	8.966	8.796	1.1125	0.9835	1.2425
18	0.0450	0.0550	0.005	0.0500	2.100	2.060	10.245	10.050	1.2700	1.1400	1.4000
17	0.0513	0.0613	0.005	0.0563	2.363	2.318	11.528	11.308	1.4300	1.3000	1.5600
16	0.0565	0.0685	0.006	0.0625	2.625	2.575	12.806	12.562	1.5875	1.4375	1.7375
15	0.0643	0.0763	0.006	0.0703	2.953	2.897	14.406	14.133	1.7856	1.6356	1.9356
14	0.0711	0.0851	0.007	0.0781	3.281	3.219	16.006	15.704	1.9837	1.8037	2.1637
13	0.0858	0.1018	0.008	0.0938	3.938	3.863	19.211	18.845	2.3825	2.1825	2.5825
12	0.1000	0.1184	0.009	0.1094	4.594	4.506	22.411	21.982	2.7788	2.5488	2.9788
11	0.1150	0.1350	0.010	0.1250	5.250	5.150	25.612	25.124	3.1750	2.9250	3.4250
10	0.1286	0.1526	0.012	0.1406	5.906	5.794	28.812	28.265	3.5712	3.2712	3.8712
9	0.1423	0.1703	0.014	0.1563	6.563	6.438	32.017	31.407	3.9700	3.6100	4.3300
8	0.1579	0.1859	0.014	0.1719	7.219	7.081	35.217	34.544	4.3663	4.0063	4.7263

Table B–3 Stainless Steel Sheet Thickness

NOTES:

a. ASTM A167 — “Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip” (Properties of the 300 series)

b. ASTM A480 — “Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip”

c. Finishes:
No. 1 Finish — Hot-rolled, annealed, and descaled.
No. 2 D Finish — Cold-rolled, dull finish.
No. 3 B Finish — Cold-rolled, bright finish.
Bright Annealed Finish — A bright cold-rolled finish retained by annealing in a controlled atmosphere furnace.
No. 3 Finish — Intermediate polished finish, one or both sides.
No. 4 Finish — General purpose polished finish, one or both sides.
No. 6 Finish — Dull satin finish, Tampico brushed, one or both sides.
No. 7 Finish — High luster finish.
No. 8 Finish — Mirror finish.

d. The 300 series weight is based on 41.99 lb per square foot per inch of thickness (or 504 lb/cf).

e. The 400 series weight is based on 41.20 lb per square foot per inch of thickness (or 494 lb/cf).

f. ASTM A666 covers the structural grade of stainless steel (not used for ducts). For design criteria, generally, consult the AISI *Stainless Steel Cold-Formed Structural Design Manual*. For general application and corrosion data consult the AISI *Design Guidelines for the Selection and Use of Stainless Steels* and the Specialty Steel Industry of the United States in Washington, D.C.

Thickness in Inches				Weight		Thickness in Millimeters		
Nom.	Tolerance 48 in. and (60 in.) Width	Min.	Max.	lb/ft^2	kg/m^2	Nom.	Min.	Max.
0.016	0.0015	0.0145	0.0175	0.228	1.114	0.4068	0.3683	0.4445
0.020	0.0020 (0.0030)	0.0180	0.0220	0.285	1.393	0.5080	0.4572	0.5588
0.024	0.0020 (0.0030)	0.0220	0.0260	0.342	1.671	0.6096	0.5588	0.6604
0.025	0.0020 (0.0030)	0.0230	0.0270	0.356	1.7398	0.6350	0.5842	0.6858
0.032	0.0025 (0.0035)	0.0295	0.0345	0.456	2.228	0.8128	0.7493	0.8763
0.040	0.0035 (0.0045)	0.0365	0.0435	0.570	2.786	1.0160	0.9271	1.1049
0.050	0.0035 (0.0050)	0.0465	0.0535	0.713	3.484	1.2700	1.1811	1.3589
0.063	0.0035 (0.0050)	0.0595	0.0665	0.898	4.389	1.6000	1.5113	1.6891
0.080	0.0045 (0.0060)	0.0755	0.0845	1.140	5.571	2.0320	1.9117	2.1463
0.090	0.0045 (0.0060)	0.0855	0.0945	1.283	6.270	2.2860	2.1717	2.4003
0.100	0.0055 (0.0070)	0.0945	0.1055	1.426	6.969	2.5400	2.4003	2.6797
0.125	0.0055 (0.0070)	0.1195	0.1305	1.782	8.709	3.1750	3.0353	3.3147

Table B-4 Aluminum Sheet Thickness (Alloy 3003-H14)

NOTES:

a. Weight is based on 14.256 lb per square foot per inch of thickness (or 171.1 lb/cf). Alloy 1100 is of slightly lower density.

b. Specification references: ASTM B209 Standard Specification of Aluminum Alloy Sheet and Plate which references ANSI *Standard H-35.2 Dimensional Tolerances for Aluminum Mill Products.*

c. Other useful references are published by the Aluminum Association: *Specification for Aluminum Structures; Engineering Data for Aluminum Structures; Aluminum Standards and Data.*

APPENDIX C

HVAC DUCT CONSTRUCTION STANDARDS

C.1 DUCT CONSTRUCTION AND INSTALLATION STANDARDS

This appendix contains excerpts from the SMACNA *HVAC Duct Construction Standards – Metal and Flexible* (Second Edition, 1995). The information contained herein is designed to provide a framework of knowledge and perspective for HVAC Duct Construction and Duct Inspection. Use of the complete source manual is strongly encouraged as not all required standards are addressed here.

S1.0 General Requirements

S1.1 These construction and installation specifications and illustrations include:

a. single-prescription method requirements,

b. optional alternatives, and

c. performance requirements for specific items that are different in detail from the generalized illustrations.

S1.2 These standards are not meant to exclude any products or methods that can be demonstrated to be equivalent in performance for the application. Substitutions based on sponsor demonstrated adequacy and approval of the regulating authority are recognized.

S1.3 These requirements presume that the designers have prepared contract drawings showing the size and location of ductwork, including permissible fitting configurations. Where area change, direction change, divided flow, or united flow fittings other than those illustrated here are shown on the contract drawings, are not of proprietary manufacture, and are defined with friction loss coefficients in either the SMACNA *HVAC Duct System Design* manual or the ASHRAE *Fundamentals Handbook* chapter on duct design, such fittings shall be fabricated with materials, assembly techniques, and sealing provisions given here.

S1.4 EACH DUCT SYSTEM SHALL BE CONSTRUCTED FOR THE SPECIFIC DUCT PRESSURE CLASSIFICATIONS SHOWN ON THE CONTRACT DRAWINGS. WHERE NO PRESSURE CLASSES ARE SPECIFIED BY THE DESIGNER, THE 1 in. wg (250 Pa) PRESSURE CLASS IS THE BASIS OF COMPLIANCE WITH THESE STANDARDS, REGARDLESS OF VELOCITY IN THE DUCT, EXCEPT WHEN THE DUCT IS VARIABLE VOLUME: ALL VARIABLE VOLUME DUCT UPSTREAM OF VAV BOXES HAS A 2 in. wg (500 Pa) BASIS OF COMPLIANCE WHEN THE DESIGNER DOES NOT GIVE A PRESSURE CLASS.

S1.5 No specification or illustration in this manual obliges a contractor to supply any volume control dampers, fire dampers, smoke dampers, or fittings that are not shown on contract drawings.

S1.6 Where dimensions, sizes, and arrangements of elements of duct assembly and support systems are not provided in these standards the contractor shall select configurations suitable for the service.

S1.7 The contractor shall follow the application recommendations of the manufacturer of all hardware and accessory items and select them to be consistent with the duct classification and services.

S1.8 Unless otherwise specified steel sheet and strip used for duct and connectors shall be G-60 coated galvanized steel of lockforming grade conforming to ASTM A653 and A924 standards. Minimum yield strength for steel sheet and reinforcements is 30,000 psi (207 kPa).

S1.9 Where sealing is required in Table C-1 or in other tables or illustrations in this manual, it means the following:

a. the use of adhesives, gaskets, tape systems, or combinations of these to close openings in the surface of the ductwork and field-erected plenums and casings through which air leakage would occur or the use of continuous welds.

b. the prudent selection and application of sealing methods by fabricators and installers, giving due consideration to the designated pressure class, pressure mode (positive or negative), chemical compatibility of the closure system, potential movement of mating parts, workmanship, amount and type of handling, cleanliness of surfaces, product shelf life, curing time, and manufacturer-identified exposure limitations.

SEAL CLASS	Sealing Requirements	Applicable Static Pressure Construction Class
A	Class A: All Transverse joints, longitudinal seams, and duct wall penetrations	4 in. wg and up (1000 Pa)
B	Class B: All Transverse joints and longitudinal seams only	3 in. wg (750 Pa)
C	Class C: Transverse joints only	2 in. wg (500 Pa)
In addition to the above, any variable air volume system duct of 1 in. wg (250 Pa) and ½ in. wg (125 Pa) construction class that is upstream of the VAV boxes shall meet Seal Class C.		

Table C–1 Standard Duct Sealing Requirements

c. that these provisions apply to duct connections to equipment and to apparatus but are not for equipment and apparatus.

d. that where distinctions are made between seams and joints, a seam is defined as joining of two longitudinally (in the direction of airflow) oriented edges of duct surface material occurring between two joints. Helical (spiral) lock seams are exempt from sealant requirements. All other duct wall connections are deemed to be joints. Joints include, but are not limited to, girth joints, branch and subbranch intersections, so-called duct collar tap-ins, fitting subsections, louver and air terminal connections to ducts, access door and access panel frames and jambs, and duct, plenum, and casing abutments to building structures.

e. unless otherwise specified by the designer, that sealing requirements do not contain provisions to:

1. resist chemical attack;
2. be dielectrically isolated;
3. be waterproof, weatherproof, or ultraviolet ray resistant;
4. withstand temperatures higher than 120°F (48°C) or lower than 40°F (4.4°C);
5. contain atomic radiation or serve in other safety-related construction;
6. be electrically grounded;
7. maintain leakage integrity at pressures in excess of their duct classification;
8. be underground below the water table;
9. be submerged in liquid;
10. withstand continuous vibration visible to the naked eye;
11. be totally leakfree within an encapsulating vapor barrier; and
12. create closure in portions of the building structure used as ducts, such as ceiling plenums, shafts, or pressurized compartments;

f. the requirements to seal apply to both positive and negative pressure modes of operation.

g. externally insulated ducts located outside of buildings shall be sealed before being insulated, as though they were inside. If air leak sites in ducts located outside of buildings are exposed to weather, they shall receive exterior duct sealant. An exterior duct sealant is defined as a sealant that is marketed specifically as forming a positive air-and watertight seal, bonding well to the metal involved, remaining flexible with metal movement, and having a service temperature range of –30°F (–34°C) to 175°F (79°C). If exposed to direct sunlight, it shall also be ultraviolet ray-and ozone-resistant or shall, after curing, be painted with a compatible coating that provides such resistance. The term sealant is not limited to adhesives or mastics but includes tapes and combinations of open-weave fabric or absorbent strips and mastics.

C.2 DUCT SEALING COMMENTARY

Ducts must be sufficiently airtight to ensure economical and quiet performance of the system. It must be recognized that airtightness in ducts cannot, and need not, be absolute (as it must be in a water piping system). Codes normally require that ducts be reasonably airtight. Concerns for energy conservation, humidity control, space temperature control, room air movement, ventilation, maintenance, etc., necessitate regulating leakage by prescriptive measures in construction standards. Leakage is largely a function of static pressure and the amount of leakage in a system is significantly related to system size. Adequate airtightness can normally be ensured by a) selecting a static pressure, construction class suitable for the operating condition, and b) sealing the ductwork properly.

The designer is responsible for determining the pressure class or classes required for duct construction and for evaluating the amount of sealing necessary to achieve system performance objectives. It is recommended that all duct constructed for the 1 in. wg (250 Pa) and ½ in. wg (125 Pa) pressure class meet Seal Class C. However, because designers sometimes deem leakage in unsealed ducts not to have adverse effects, the sealing of all ducts in the 1 in. wg (250 Pa) and ½ in. wg (125 Pa) pressure class is not required by this construction manual. Designers occasionally exempt the following from sealing requirements: small systems, residential occupancies, ducts located directly in the zones they serve, ducts that have short runs from volume control boxes to diffusers, certain return air ceiling plenum applications, etc. When Seal Class C is to apply to all 1 in. wg (250 Pa) and ½ in. wg (125 Pa) pressure class duct, the designer must require this in the project specification. The designer should review the SMACNA *HVAC Air Duct Leak*age *Test Manual* for estimated and practical leakage allowances.

Seven pressure classes exist [½ in. wg (125 Pa), 1 in. wg (250 Pa), 2 in. wg (500 Pa), 3 in. wg (750 Pa), 4 in. wg (1000 Pa), 6 in. wg (1500 Pa), and 10 in. wg (2500 Pa)]. If the designer does not designate pressure class for duct construction on the contract drawings, the basis of compliance with the SMACNA *HVAC Duct Construction Standards* is as follows: 2 in. wg (500 Pa) for all ducts between the supply fan and variable volume control boxes and 1 in. wg (250 Pa) for all other ducts of any application.

Some sealants can adversely affect the release function of breakaway connections to fire dampers; consult the damper manufacturer for installation restrictions.

C.2.1 Leakage Tests

There is no need to verify leakage control by field testing when adequate methods of assembly and sealing are used. Leakage tests are an added expense in system installation. It is not recommended that duct systems constructed to 3 in. wg (750 Pa) class or lower be tested because this is generally not cost effective. For duct systems constructed to 4 in. wg (1000 Pa) class and higher, the designer must determine if any justification for testing exists. If it does, the contract documents must clearly designate the portions of the system(s) to be tested and the appropriate test methods. ASHRAE energy conservation standards series 90 text on leakage control generally requires tests only for pressures in excess of 3 in. wg (750 Pa).

The SMACNA *HVAC Air Duct Leakage Test Manual* provides practical and detailed procedures for conducting leakage tests.

Apparent differences of about ten percent between fan delivery and sum of airflow measurements at terminals do not necessarily mean poor sealing and excess leakage. Potential accuracy of flow measurements should be evaluated.

Otherwise, open access doors, unmade connections, missing end caps, or other oversights contribute to such discrepancies. When air terminals are at great distances from fans [over 500 feet (152 m)], more effective sealing is probably required to avoid diminished system performance.

Schools, shopping centers, airports, and other buildings may use exposed ductwork. Selecting sealing systems for such ducts may involve more attention to the final appearance of the duct system than with ducts in concealed spaces.

Certain types of paint may form reliable seals, particularly for small cracks and holes. Further research and confirmation is needed in this area.

Longstanding industry acceptance of so-called low pressure duct systems without sealants may have left some contractors (and designers) with little or no experience with sealing. The contractor should carefully select construction details consistent with sealing requirements, the direction of the air pressure, and familiar sealing methods. The cost of restoring systems not receiving the required sealing or not being properly sealed can greatly exceed the modest cost of a proper application. Contractors using slip and drive connection systems must control connector length and notch depth on rectangular duct ends to facilitate sealing.

Failure to do so will compromise seal effectiveness. Round duct joints are normally easier to seal than other types. However, with proper attention to joint selection, workmanship, and sealant application, almost any joint can achieve low leakage. The mere presence of sealant at a connection, however, does not ensure low leakage. Applying sealant in a spiral lockseam can result in poor seam closure and less satisfactory control. No single sealant is the best for all applications. Selecting the most appropriate sealant depends primarily on the basic joint design and on application conditions such as joint position, clearances, direction of air pressure in service, etc.

The listing of certain duct products by recognized test laboratories may be based on the use of a particular joint sealing product. Such a component listing only reflects laboratory test performance and does not necessarily mean that the closure method can routinely be successful for the contractor or that it will withstand in-service operation of the system on a long-term basis.

C.2.2 Liquids

Many manufacturers produce liquid sealants specifically for ducts. They have the consistency of heavy syrup and can be applied either by brush or with a cartridge gun or powered pump. Liquid sealants normally contain 30 to 60 percent volatile solvents; therefore, they shrink considerably when drying. They are recommended for slip-type joints where the sealant fills a small space between the overlapping pieces of metal. Where metal clearances exceed 1⁄16 in. (1.6 mm), several applications may be necessary to fill the voids caused by shrinkage or runout of the sealant. These sealants are normally brushed on to round slip joints and pumped into rectangular slip joints.

C.2.3 Mastics

Heavy mastic sealants are more suitable as fillets, in grooves, or between flanges. Mastics must have excellent adhesion and elasticity. Although not marketed specifically for ductwork, high quality curtain wall sealants have been used for this application. Oil-base caulking and glazing compounds should not be used.

C.2.4 Gaskets

Durable materials such as soft elastomer butyl or extruded forms of sealants should be used in flanged joints. For ease of application, gaskets should have adhesive backing or otherwise be tacky enough to adhere to the metal during joint assembly. The choice of open cell or closed cell rubber gaskets depends on the amount and frequency of compression and on the elastic memory.

C.2.5 Tapes

Nothing in this standard is intended to unconditionally prohibit the use of pressure sensitive tapes. Several such closures are listed as components of systems complying with UL Standard 181 tests. *See* Appendix E herein. There are no industry recognized performance standards that set forth peel adhesion, shear adhesion, tensile strength, temperature limits, accelerated aging, etc., which are quality control characteristics specifically correlated with metal duct construction service. However, the SMACNA *Fibrous Glass Duct Construction Standards* manual illustrates the closure of a fibrous duct to metal duct with a tape system. The variety of advertised products is very broad. Some test results for tapes are published in the product directories of the Pressure Sensitive Tape Council located in Chicago, IL.

The shelf life of tapes may be difficult to identify. It may be only six months or one year. Although initial adhesion may appear satisfactory, the aging characteristics of these tapes in service is questionable. They tend to lose adhesion progressively at edges or from exposures to air pressure, flexure, the drying effects at the holes or cracks being sealed, etc. The tape's adhesive may be chemically incompatible with the substrate, as is apparently the case with certain nonmetal flexible ducts. Application over uncured sealant may have failures related to the release of volatile solvents. Sea air may have different effects on rubber, acrylic, silicone-based, or other adhesives.

Tapes of a gum-like consistency with one or two removable waxed liners have become popular for some applications. They are generally known as the peel and seal variety and have been used between flanges and on the exterior of ducts. Such tapes are typically of thicknesses several times that of tapes traditionally known as the pressure sensitive type. Some may have mesh reinforcement. Others may have metal or nonmetal backing on one surface.

C.2.6 Heat Applied Materials

Hot melt and thermally activated sealants are less widely known but are used for ductwork. The hot melt type is normally a shop application. Thermally activated types use heat to either shrink-fit closures or to expand compounds within joint systems.

C.2.7 Mastic and Embedded Fabric

There are several combinations of woven fabrics (fibrous glass mesh, gauze, canvas, etc.) and sealing compounds (including lagging adhesive) that appear better suited for creating and maintaining effective seals than sealant alone. Glass Fabric and Mastic (GFM) used for fibrous glass duct appears to adhere well to galvanized steel. *See* Figure E-5.

C.2.8 Surface Preparation

Surfaces to receive sealant should be clean, meaning free from oil, dust, dirt, rust, moisture, ice crystals, and other substances that inhibit or prevent bonding. Solvent cleaning is an additional expense. Surface primers are now available, but their additional cost may not result in measurable long-term benefits.

C.2.9 Sealant Strength

No sealant system is recognized as a substitute for mechanical attachments. Structural grade adhesive systems are being developed to replace spot welded and soldered connections of metals. They have lap shear strengths of 1000 to 5000 psi (6895 to 34,475 kPa) or more. SMACNA is not able to comprehensively define their characteristics at this time; however, authorities are encouraged to monitor their development progress and consider their use.

C.2.10 Shelf Life

The shelf life of all sealant products may be one year or less; often it is only six months. The installer is cautioned to verify that the shelf life has not been exceeded.

C.2.11 Safety Considerations

Sealant systems may be flammable in the wet, partially cured, or cured state.

USE LIQUIDS AND MASTICS IN WELL VENTILATED AREAS AND OBSERVE PRINTED PRECAUTIONS OF MANUFACTURERS.

The contractor should carefully consider the effects of loss of seal and fire potential when welding on or near sealed connections. NFPA Standard 90A requires adhesives to have a flame spread rating not over 25 and a smoke developed rating not over 50.

C.3 RECTANGULAR DUCT REINFORCEMENT

S1.10 Unless otherwise specified or allowed, rectangular ductwork shall be constructed in accordance with SMACNA *HVAC-DCS* (Second Edition, 1995) Tables 1-3 through 1-13 and with details associated with them. *See* Example Tables C-2, C-4, C-5, and C-6.

S1.11 The duct gage tables are based on G-60 coated galvanized steel of lockforming grade conforming to ASTM Standards A653 and A924. Uncoated steel, prepainted steel, steel with metal coating such as aluminum or aluminum-zinc compounds, and stainless steel may be used if a minimum corresponding base metal thickness and material strength is provided. Lockforming grades of such material must be used.

The use of alternative materials requires specification or approval by a designer. The surface conditions, hardness, ductility, corrosion resistance, and other characteristics of these materials must be judged acceptable by the designer for the planned service.

Specifications that refer to use of material that is two gages heavier mean two numbers separated in a series that uses both odd and even number progression; e.g., 18 is two gages heavier than 20 in Tables B-1 and B-2.

S1.12 Unless otherwise specified, reinforcement may be uncoated steel or galvanized steel.

S1.13 A reinforcement code classification (letter and EI index) higher than indicated must be substituted when the tables do not provide the specific construction details for a lower classification. A higher rated construction member may also be substituted for convenience.

S1.14 Joint spacing on unreinforced ducts is unlimited. On ducts that require reinforcement, joint spacing is unrestricted except that the joint itself must qualify for the minimum reinforcement code associated with the reinforcement spacing.

S1.15 Duct sides that are 19 in. (483 mm) and over and are 20 ga (1.00 mm) or less, with more than 10 ft^2 (0.93 m^2) of unbraced panel area, shall be crossbroken or beaded as indicated in Figure C-4 unless they are lined or externally insulated. Ducts that are of heavier gage, smaller dimensions, and smaller panel area and those that are lined or externally insulated are not required to have crossbreaking or beading.

S1.16 Fittings shall be reinforced like sections of straight duct. On size change fittings, the greater fitting dimension determines the duct gage. Where fitting curvature or internal member attachments provide equivalent rigidity, such features may be credited as reinforcement.

S1.17 Duct wall thickness, joints, seams, and reinforcements must be coordinated to provide proper assembly.

S1.18 Other construction that meets the functional criteria in SMACNA *HVAC-DCS* (Second Edition, 1995) Chapter 7 or is as serviceable as that produced by the construction tables may be provided.

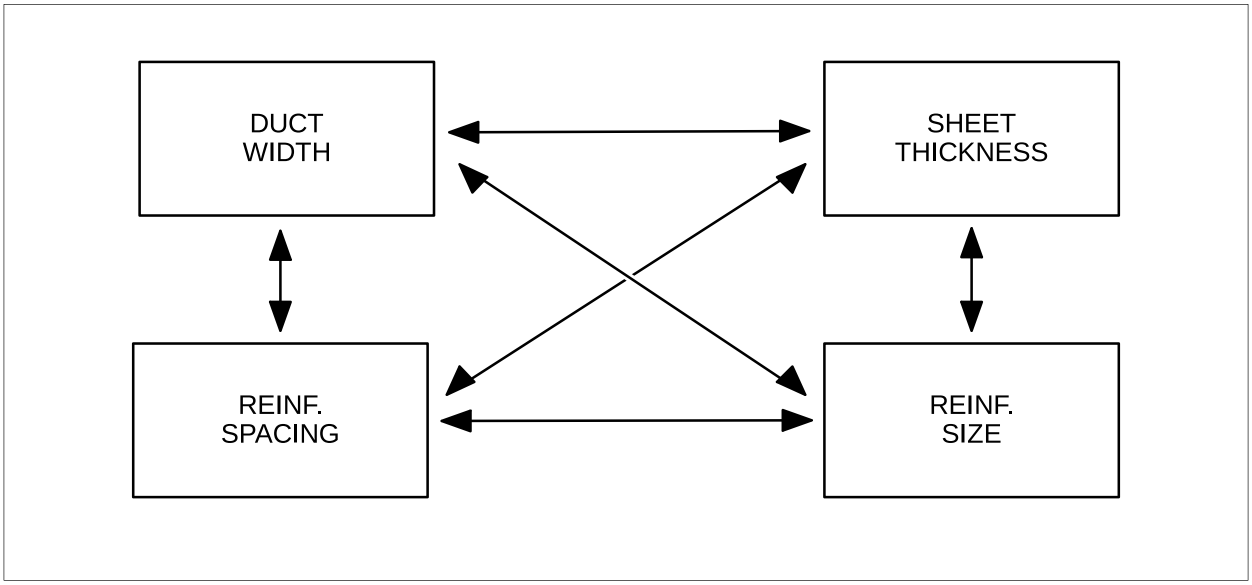


FIGURE C-1 DEPENDENT VARIABLES

RELATIONSHIPS:

a. For each pressure level and a constant duct size, the thicker the sheet the more distant the reinforcement spacing; the thinner the sheet the closer the reinforcement spacing.

b. For a given sheet thickness and constant duct size, reinforcement size, and reinforcement spacing, reduce with pressure reduction and increase with pressure increase.

c. The larger a duct at a given pressure, the larger the reinforcement and the closer the reinforcement spacing on a selected gage.

d. For each combination of sheet thickness, pressure, and duct width, a maximum reinforcement spacing occurs beyond which sheet deflection is not controlled by reinforcement size nor reinforcement position.

RECTANGULAR DUCTS:

MAXIMUM DEFLECTION

JOINT AND REINF.	**SHEET:**
¼ in. (6.4 mm) on 48 in. (1220 mm) w.	⅜ in. (9.5 mm) on 12 in. (305 mm) Dn.
W/200 on 49–120 in. (1245–3048 mm)	½ in. (12.7 mm) on 13–18 in. (330–457 mm)
	⅝ in. (15.9 mm) on 19–24 in. (483–610 mm)
	¾ in. (19.1 mm) on 25–84 in. (635–2134 mm)
	1 in. (25.4 mm) on 85–120 in. (2159–3048 mm)
TOLERANCE:	**TOLERANCE:**
+7.5%	+10%

MAXIMUM TEST PRESSURE

LAB:
CLASS RATING: +50%

FIELD:
CLASS RATING: +25%

C.4 INTRODUCTION TO THE RECTANGULAR DUCT CONSTRUCTION SCHEDULES

C.4.1 Rectangular Table Reading Guide (Figure C-2)

a. Determine pressure class assigned by the designer.

b. Go to the reinforcement schedule for the duct pressure class. SMACNA *HVAC-DCS* (Second Edition, 1995) Table 1-4 is used in this review.

c. The greater duct dimension determines the gage for all sides. Reinforcement may be different on sides with unequal dimension.

d. The duct side will either *qualify for flat type joint connections* because the duct wall gage is thick enough to control reflection without needing reinforcement *or will require an alphabet letter code reinforcement* that is suited for the width, the wall thickness and a maximum spacing interval.

1. The gage of duct not requiring reinforcement is in column 2. *See* Figure C-3.

2. Duct reinforcement options are in columns 3 to 10: Read horizontally right from the greater duct dimension in column 1 and vertically *under a reinforcement interval spacing* (in columns 3 to 10) *of your choice*.

   The number in the cell is minimum duct gage; the letter code is type of joint or intermediate reinforcement, whichever you choose. This applies for joint-to-joint, joint-to-intermediate, or intermediate-to-intermediate intervals. If, for example, you are using 5 ft (1.5 m) joint spacing and do not want to use between-joint reinforcements stay in the 5 ft (1.5 m) column (column 6) until it becomes “Not Designed”; then you go to column 9 to find the joint rating and the intermediate (between-joint) bracing and the potentially lighter gage duct wall permitted with 2½ ft (0.75 m) reinforcement spacing.

e. Having found the gage for the wide side, check column 2 to see if that gage is exempt from reinforcement on the short side. If it is not, find which column (of 3 to 10) this gage is in; there find *the maximum* spacing in the column heading and the prescribed joint (or reinforcement) size (letter code) listed in the gage.

   If the maximum short side reinforcement spacing thus found exceeds a joint spacing that you are committed to, go to the column with the joint spacing to find the joint size. Even though the duct gage listed at this width-spacing cell may be less, the joint rating cannot be less than at this cell.

f. Beading and crossbreaking are not substitutes for reinforcement. These are not required for any of the following conditions: liner or external insulation is used; width is less than 19 in.; duct pressure class is over 3 in. wg; duct gage is over 20 (1.0 mm); unbraced panel area is 10 ft^2 (0.93 m^2) or less. Otherwise, one or the other must be used.

g. Within the pressure limits given for specific forms, choices for reinforcement are:

1. use of flat drive (T-1) as Class A, B, or C per SMACNA *HVAC-DCS* (Second Edition, 1995) Table 1-25;

2. use of any flat connector backed up by a Table C-4 (intermediate type) member;

3. use of any appropriately rated joint or intermediate member from Tables 1-10 through 1-13 in SMACNA *HVAC-DCS* (Second Edition, 1995). *See* Example Tables C-4 through C-6;

4. downsizing certain joints, joint backup members or intermediates as tie rod options allow.

   In the table, an entry such as H-18G means that the H reinforcement size may be downsized to a G per SMACNA *HVAC-DCS* (Second Edition, 1995) section 1.10 if an internal tie rod is used. This does not apply for joints that require tie rods on both sides of the joint. In some schedules, only the tie rodded construction is given. Kt-18 is an example.

h. You may also use larger reinforcements than specified. In some cases, you must use a larger size than SMACNA *HVAC-DCS* (Second

READING GUIDE SUMMARY

Example: 54" × 18" duct, 5 ft. joint spacing. On 54" sides use F joints on 22 ga. On 18" sides flat slips or drives qualify per column 2.
Example: 54" × 30" duct, 22 gage. Use F at 5 ft. on 54". On 30" use D at 5 ft or E at 10 ft. If you put joints on the 30" side at 5 ft. spacing, they must be D rated.

Comment: If the table requires a letter code, all joints on that side must qualify for the minimum code letter related to the minimum gage and the spacing

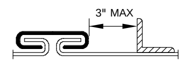
Use Drive Slip or Hemmed "S" Slip on duct gage in column 2

DRIVE SLIP

OR

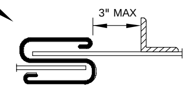
HEMMED "S" SLIP

Joint Option: Backup member qualifies Hemmed "S" Slip - Reinforced or Drive Slip - Reinforced for letter code when selected from Table 1-10



HEMMED "S" SLIP

OR



DRIVE SLIP - REINFORCED

Duct Gage	26 to 22	20	18	16
Minimum Flat Slip and Drive Gage	24	22	20	18

Spacing refers to letter code: use joint-to-joint, joint-to-intermediate or intermediate-to-intermediate. Columns 3 to 10 are alternatives

The drive slip is accepted as being A, B, or C rated up to 20" length.

TABLE 1-4
RETANGULAR DUCT REINFORCEMENT

1" W.G. STATIC POS.OR NEG.

DUCT DIMENSION	NO REINFORCEMENT REQUIRED	REINFORCEMENT CODE FOR DUCT GAGE NO. — REINFORCEMENT SPACING OPTIONS: 10'	8'	6'	5'	4'	3'	2 1/2'	2'
1	2	3	4	5	6	7	8	9	10
10"dn	26 ga.	NOT REQUIRED							
11, 12"	26 ga.								
13, 14"	24 ga.	B-26	B-26	B-26	B-26	B-26	A-26	A-26	A-26
15, 16"	22 ga.	B-24	B-26	B-26	B-26	B-26	B-26	B-26	A-26
17, 18"	22 ga.	B-24	B-26	B-26	B-26	B-26	B-26	B-26	B-26
19, 20"	20 ga.	C-24	C-26	C-26	C-26	C-26	B-26	B-26	B-26
21, 22"	18 ga.	C-24	C-24	C-26	C-26	C-26	B-26	B-26	B-26
23, 24"	18 ga.	C-24	C-24	C-26	C-26	C-26	C-26	B-26	B-26
25, 26"	18 ga.	D-22	D-24	C-26	C-26	C-26	C-26	C-26	B-26
27, 28"	16 ga.	D-22	D-24	D-26	C-26	C-26	C-26	C-26	C-26
29, 30"	16 ga.	E-22	D-24	D-26	D-26	C-26	C-26	C-26	C-26
31-36"	NOT DESIGNED	E-20	E-22	E-24	D-24	D-26	C-26	C-26	C-26
37-42"		F-18	F-20	E-22	E-24	E-26	D-26	D-26	C-26
43-48"		G-16	G-18	F-20	F-22	E-24	E-26	E-26	D-26
49-54"		H-16	H-18	G-20	F-22	F-24	E-24	E-24	E-24
55-60"			H-18	G-20	G-22	F-24	F-24	E-24	E-24
61-72"				H-18G	H-18G	H-22G	F-24	F-24	F-24
73-84"				I-16G	I-18G	I-20G	H-22G	H-22G	G-22
85-96"					I-16H	I-18H	I-20G	H-20G	H-22G
97-108"						I-18G	I-18G	I-18G	I-18G
109-120"							I-18H	I-18H	I-18G

See page 1-15. Circles in the Table denotes only column numbers. For column 2, *see* Fig. 1-7. For Columns 3 through 9, *see* Introduction to Schedules. The number in the box is minimum duct gage; the alphabet letter is the minimum reinforcement grade for joints and intermediates occurring at a maximum spacing interval in the column heading. A listing such as H18G means that the H may be downsized to G with a tie rod. At higher pressures and large widths, a reinforcement such as Jt means that only tie rodded members are given.

TABLE 1-11
(Option)
TRANSVERSE JOINT

MINIMUM RIGIDITY CLASS	EI*	T - ɑ STANDING S: H x T	WT LF
A	0.5	Use B	
B	1.0	1 x 26 ga.	0.6
C	1.9	1 x 22 ga.	0.8
D	2.7	1 x 1/8 x 20 ga.	0.9
E	6.5	1 1/8 x 18 ga.	1.0
F	12.8	Use G	
G	15.8	1 5/8 x 18 ga.	1.3
H	22		
I	69		
J	80		
K	103		
L	207		

OR

TABLE 1-10
(Option)
INTERMEDIATE

REINF. CLASS	EI*	ANGLE: H x T (MIN)	WT LF
A	0.5	Use C	
B	1.0	Use C	
C	1.9	C1 x 16 ga. C3/4 x 1/8	0.40 0.59
D	2.7	H3/4 x 1/8 C1 x 1/8	0.57 0.80
E	6.5	C1 1/4 x 12 ga. H 1 x 1/8	0.9 0.8
F	12.8	H 1 1/4 x 1/8	1.02
G	15.8	1 1/2 x 1/8	1.23
H	22 (+) 26.7 (-)	1 1/2 x 3/16 2 x 1/8	1.78 1.65
I	69	C2 x 3/16 2 1/2 x 1/8	2.44 2.1
J	80	H2 x 3/16 C2 x 1/4 2 1/2 x 1/8 (+)	3.2 2.1
K	103	2 1/2 x 3/16	3.1
L	207	H2 1/2 x 1/4	4.1

C angle is cold-rolled
H angle is hot-rolled

FIGURE C-2 READING GUIDE SUMMARY

Edition, 1995) Tables 1-3 to 1-10 (*See* Example Tables C-2 and C-4) call for because some prescribed sizes are observed as minimum.

i. In some cases, a flange is rolled (formed) on the end of a duct section and *the minimum gage in* the joint rating table will override a lighter gage of the duct wall that is indicated in the SMACNA *HVAC-DCS* (Second Edition, 1995) Tables 1-3 through 1-12 (*See* Example Tables C-2, C-4, C-5, and C-6). *Then the duct wall must be increased* above that needed for the reinforcement spacing and interval in order to meet the joint requirements.

j. Due to infrequent use, some of the joints in the first edition were omitted. The T numbers of those remaining were not changed for this edition. Authorities can be petitioned to allow use of the omitted joints based on the first edition requirements.

k. Reinforcement requirements are given in rigidity class (both in alphabet letter and EI coding) and also by prescribed sizes. The EI code is modulus of elasticity times the effective moment of inertia times 100,000 (ten to the 5^{th} power).

   The HVAC-DCS Text makes provision for use of equivalent substitutions. Use SMACNA *HVAC-DCS* (Second Edition, 1995) Chapter 7 to evaluate these.

l. Positive pressure reinforcements for service over 3 in. wg (750 Pa) generally require end ties outside of the duct unless internal tie rods are used. *See* Figure C-8. Negative pressure reinforcements attachments to the duct wall are generally at closer intervals than on positive pressure service.

m. For ducts over certain widths only tie rod construction is indicated in order to limit the size of reinforcements. The table entry Kt-16, for example, designates 16 gage duct with K class joints and intermediates having tie rods or straps at intervals not exceeding 60 in. (1524 mm). *See* Figure 1-12 in SMACNA *HVAC-DCS* (Second Edition, 1995).

   Very large ducts may require internal hangers as shown in Figure 4-6 in SMACNA *HVAC-DCS* (Second Edition, 1995) or may require other internal supports to provide shape retention. Such internal supports should be illustrated on the contract drawings.

n. Tie rods at mid panel are not currently classified as reinforcements by SMACNA due to insufficient testing and unpredictable service life.

o. Consult the Narrowscope tables and the Composite tables in the appendix for other study assistance.

The rectangular duct construction standards provide the following options for constructing ducts: a) those unreinforced and joined by flat type connections only, b) those joined by flat type joint connectors backed by a qualified reinforcement, c) those joined by an upright connector that meets reinforcement requirements alone or in conjunction with an incorporated reinforcement, and d) in sizes over 48 in. (1.2 m) width, those using tie rods that permit the use of smaller reinforcements. Not all options exist at all sizes and all static pressure classes. The options are provided to correlate performance with economy and the preference of fabricators and specifiers. SMACNA does not validate equivalency.

The tables can be investigated to suit a preference for each of several features:

a. Look for a preferred duct gage under each reinforcement spacing and find the associated code and maximum duct dimensions.

b. Look for a preferred joint or intermediate reinforcement size in SMACNA *HVAC-DCS* (Second Edition, 1995) Tables 1-10 to 1-14. *See* Example Tables C-4 to C-6.

c. Preference for a particular sheet or coil stock size will dictate reinforcement intervals (maximum and subdivisions).

Sometimes, if a project calls for small amounts of ductwork in many size ranges or pressure classes, it may be more economical to select heavier constructions than are required, so that fewer variations are needed.

The duct construction tables define relationships between static pressure, width, wall thickness, reinforcement spacing, and reinforcement strength so that ducts have adequate strength and acceptable deflection limits. The greater dimension of a duct determines the duct gage for all four sides. This applies to reinforced and unreinforced ducts.

The first step in determining construction requirements is to locate the table with the applicable static pressure.

C.4.2 Unreinforced Duct (Fig. C–3)

Duct sides having a gage listed in the second column of SMACNA *HVAC-DCS* (Second Edition, 1995) Tables 1-3 to 1-9 (*See* Example Table C-2) do not require reinforcement. These are summarized in Table C-3. Flat type joints may be used at any spacing. Flat slips and drives must not be less than two gages lower than the duct gage or below 24 gage (0.70 mm).

The T-1 drive slip connection provides sufficient rigidity to be treated as Class A, B or C reinforcement within the limits of SMACNA *HVAC-DCS* (Second Edition, 1995) Table 1-25. This gives the appearance of increasing the range of unreinforced duct sizes.

C.4.3 Reinforced Duct [Figs. 1–9, 1–10, 1–11 in SMACNA HVAC–DCS (Second Edition, 1995)]

In the Reinforcement Spacing columns of SMACNA *HVAC-DCS* (Second Edition, 1995) Tables 1-3 through 1-9 (*See* Example Table C-2), across from each duct width, each cell shows that duct width's minimum duct gage as a number and its minimum reinforcement grade as a letter. The arrow indicates that the right most value continues to the end of the row because the minimum duct gage and reinforcement grade remain the same for shorter spacings. Any cell within a row is an acceptable selection for that duct width. Reinforcement spacings of 10 ft (3.0 m) to 2 ft (0.61 m) are alternative choices. *See* Figure C-2 and Narrowscope Duct Construction Table 1-5 E5 on page A.14 in SMACNA *HVAC-DCS* (Second Edition, 1995) for discussion of variables.

First investigate the duct side with the greater dimension because this side dictates the duct gage. Then find the smaller duct dimension in the first column, and on the same horizontal line locate the duct gage of the wide side. If the duct gage is in the second column, no reinforcement is required on that side; otherwise, the minimum reinforcement code is the letter listed under the spacing used. The actual duct gage may occur in a column giving allowable spacing greater than will be used. In such a case the minimum reinforcement grade is that associated with the actual spacing.

C.4.4 Transverse Joint and Intermediate Reinforcement (Table C–4; Fig. C–8)

The reinforcement spacing in SMACNA *HVAC-DCS* (Second Edition, 1995) Tables 1-3 to 1-9 (*See* Example Table C-2) denotes distance between two joints or two intermediate reinforcements or from a joint to an intermediate member. Any joint or reinforcement member having a corresponding letter code in SMACNA *HVAC-DCS* (Second Edition, 1995) Tables 1-12 through 1-16 (*See* Example Table C-6) may be used to comply.

The letter code for reinforcement corresponds to a stiffness index number (EI). This is the modulus of elasticity multiplied by a moment of inertia that is based on the contributing elements of the connector, the reinforcement, the duct wall, or combinations of these. Unless other evidence of adequate strength and rigidity is presented, equivalent construction must meet the EI index associated with the code letter.

In some cases (for example, pocket locks and standing seams), the metal in the duct counts in the joint qualification. A minimum gage of duct that is heavier than the duct gage shown in SMACNA *HVAC-DCS* (Second Edition, 1995) Tables 1-3 through 1-9 (*See* Example Table C-2) may be indicated by the joint specifications in SMACNA *HVAC-DCS* (Second Edition, 1995) Tables 1-12 and 1-13. *See* Example Table C-6.

Flat slips or drives (or any flat joint shown) may be used at one of the spacing limits, provided that a backup member (of the intermediate type) is used with them; the joint is then rated by the backup member taken from Table C-4.

Tie rod duct construction described on pages 1-27 through 1-30 is also an alternative. For certain ducts of dimension greater than 48 in. (1.2 m), alternative sizes of reinforcement using tie rods is depicted in the tables. An entry such as H-18G indicates that on 18 gage (1.3 mm) duct, the reinforcement code for either joint or intermediate stiffener is H class, but G class may be substituted if an available tie rod alternative is selected.

For ducts over 120 in. (4.72 m) width, only tie rod construction is indicated in order to limit the size of reinforcements. The table entry Ht-18, for example, designates 18 gage duct with H class joints and intermediates having tie rods or straps at intervals not exceeding 60 in. (1524 mm). *See* SMACNA *HVAC-DCS* (Second Edition, 1995) Figure 1-12. Very large ducts may require internal hangers as shown in SMACNA *HVAC-*

DCS (Second Edition, 1995) Figure 4-8 or may require other internal supports to provide shape retention. Such internal supports should be illustrated on the contract drawings. Other construction that meets the functional criteria in SMACNA *HVAC-DCS* (Second Edition, 1995) Chapter 7 may be provided.

C.4.4.1 Sample Uses of SMACNA HVAC–DCS (Second Edition, 1995) Table 1–4 (at 1 in. wg (250 Pa))

Example 1, 18" × 12" (457 × 305 mm) duct:

If the duct is of 22 gage (0.85 mm), the second column shows that it may be unreinforced.

If the duct is of 24 gage (0.70 mm), the 12 in. (305 mm) side may be unreinforced, but grade B joints are required at 10 ft (3 m) maximum spacing on the 18 in. (457 mm) sides. However, SMACNA *HVAC-DCS* (Second Edition, 1995) Table 1-18 allows the T- 1 drive slip (alone) to be used on the 18 in. (457 mm) sides. Any joint used on the 18 in. side must meet grade B regardless of joint spacing.

If the duct is of 26 gage (0.55 mm), the 12 in. (305 mm) side may be unreinforced, but on the 18 in. (457 mm) sides, the maximum reinforcement spacing is 8 ft (2.4 m) and the minimum size is grade B. By SMACNA *HVAC-DCS* (Second Edition, 1995) Table 1-18, the T-1 drive slip is acceptable as grade A [up to 20 in. (508 mm) width and 8 ft (2.4 m) spacing]. Substitution of C or D for B would still not permit a reinforcement spacing greater than 8 ft (2.4 m) because the minimum gage associated with 10 ft (3 m) spacing is 24 gage (0.70 mm).

Example 2, 30" × 18" (762 × 457 mm) duct:

The choices for the 30 in. (762 mm) side are: 16 ga (1.61 mm) for unreinforced; E on 22 ga (0.85 mm) at 10 ft (3 m); D on 24 ga (0.70 mm) at 8 ft (2.4 m), or D on 26 ga (0.55 mm) at 6 ft (1.8 m) max. or C at 4 ft (1.2 m) max. For the 18 in. (457 mm) side, the choices are the same as outlined in Example 1 for 18 in. (457 mm) width.

Example 3, 54" × 30" (1372 × 762 mm) duct, with 5 ft (1.5 m) joint spacing preselected:

For 54 in. (1372 mm) width, F code is required if 22 ga (0.85 mm) is selected. 24 ga (0.70) duct may be used with 5 ft (1.5 m) joint spacing but an E rated intermediate (between E rated joints) would be added [effectively changing the reinforcement spacing to 2½ ft (0.76 m)].

For the 30 in. (762 mm) side: Grade D is required [for 5 ft (1.5 m) maximum spacing] on any duct gage less than 16 gage (1.61 mm).

If you did not have the 5 ft (l .5 m) joint limitation and it was economical to do so, 16 ga (1.61 mm) duct unreinforced on the 30 in. (762 mm) sides and G joints at 10 ft (3 m) spacing on 54 in. (1372 mm) sides is acceptable.

Example 4, 72" × 72" (100 × 188 mm), with 5 ft (1.5 m) joint spacing and no intermediate reinforcing use 18 ga (1.31 mm) duct with H rated joints or G rated joints with tie rods added (Gt) or use 24 ga (0.70 mm) with 2½ ft (0.75 m) spacing and F ratings.

This introduction does not review all aspects of construction. It is an overview. Certain other limitations will appear later in the text and tables. For example, certain joints have been assigned maximum pressure classes. However, other limits may be acceptable if they can be shown to result in equivalent construction.

Consult NFPA Standard 90B and other codes and specifications applicable for use of materials thinner than 26 gage (0.55 mm) in residential work.

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2 in. wg STATIC POS. OR NEG.	NO RE-INFORCE-MENT REQUIRED	REINFORCEMENT CODE FOR DUCT GAGE NO.							
DUCT DIMENSION		REINFORCEMENT SPACING OPTIONS (ft)							
		10	8	6	5	4	3	2½	2
①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩
10 in. dn.	26 ga	**NOT REQUIRED**							
11–12 in.	24 ga		B-26	B-26	B-26	B-26	B-26	B-26	B-26
13–14 in.	22 ga		B-24	B-26	B-26	B-26	B-26	B-26	B-26
15–16 in.	20 ga	C-22	C-24	C-24	C-26	C-26	C-26	B-26	B-26
17–18 in.	20 ga	C-22	C-24	C-24	C-26	C-26	C-26	C-26	B-26
19–20 in.	18 ga	C-20	C-22	C-24	C-26	C-26	C-26	C-26	C-26
21–22 in.	16 ga	D-20	D-22	D-24	D-26	C-26	C-26	C-26	C-26
23–24 in.	16 ga	E-20	E-22	D-24	D-26	D-26	C-26	C-26	C-26
25–26 in.		E-20	E-22	E-24	D-26	D-26	C-26	C-26	C-26
27–28 in.		F-18	E-20	E-22	E-24	D-26	D-26	C-26	C-26
29–30 in.		F-18	F-20	E-22	E-24	E-26	D-26	D-26	C-26
31–36 in.		G-16	G-18	F-20	F-22	E-24	E-26	D-26	D-26
37–42 in.			H-16	G-18	G-20	F-24	E-24	E-26	E-26
43–48 in.			I-16	H-18	H-20	G-22	F-24	F-24	E-24
49–54 in.				I-16G	H-18G	H-20G	G-24	F-24	F-24
55–60 in.				I-16G	I-18G	H-18G	G-22	G-24	F-24
61–72 in.	**NOT DESIGNED**				J-16H	I-18G	H-22G	H-22G	H-24
73–84 in.						I-18G	I-20G	I-22G	I-22G
85–96 in.						J-18H	I-18H	I-20H	I-22H
97–108 in.							K-18H	J-18H	I-18H
109–120 in.								K-18I	J-18I

Table C-2 Rectangular Duct Reinforcement

NOTE: See Page C.8. Circles in the Table only denote column numbers. For Column 2, *see* Fig. C-3. For Columns 3 through 9, *see* section C.4, Introduction to Schedules. The number in the box is minimum duct gage; the alphabet letter is the minimum reinforcement grade for joints and intermediates occurring at a maximum spacing interval in the column heading. A letter to the right of the gage gives a tie rodded reinforcement alternative. A “t” compels use of tie rod(s) for the reinforcement listing. For beading or crossbreaking, *see* Fig. C-4.

500 Pa STATIC POS. OR NEG.	NO RE-INFORCE-MENT REQUIRED	REINFORCEMENT CODE FOR DUCT THICKNESS (mm)							
DUCT DIMENSION		REINFORCEMENT SPACING OPTIONS (m)							
		3.0	2.4	1.8	1.5	1.2	0.90	0.75	0.60
(1) (mm)	(2) (mm)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
250 dn.	0.55	NOT REQUIRED							
251–300	0.70		B-0.55	B-0.55	B-0.55	B-0.55	B-0.55	B-0.55	B-0.55
301–350	0.85		B-0.70	B-0.55	B-0.55	B-0.55	B-0.55	B-0.55	B-0.55
351–400	1.00	C-0.85	C-0.70	C-0.70	C-0.55	C-0.70	C-0.70	B-0.55	B-0.70
401–450	1.00	C-0.85	C-0.70	C-0.70	C-0.55	C-0.55	C-0.55	C-0.55	B-0.70
451–500	1.31	C-1.00	C-0.85	C-070	C-0.55	C-0.55	C-0.55	C-0.55	C-0.55
501–550	1.61	D-1.00	D-0.85	D-0.70	D-0.55	C-0.55	C-0.55	C-0.55	C-0.55
551–600	1.61	E-1.00	E-0.85	D-0.70	D-0.55	D-0.55	C-0.55	C-0.55	C-0.55
601–650		E-1.00	E-0.85	E-0.70	D-0.55	D-0.55	C-0.55	C-0.55	C-0.55
651–700		F-1.31	E-1.00	E-0.85	E-0.70	D-0.55	D-0.55	C-0.55	C-0.55
701–750		F-1.31	F-1.00	E-0.85	E-0.70	E-0.55	D-0.55	D-0.55	C-0.55
751–900		G-1.61	G-1.31	F-1.00	F-0.85	E-0.70	E-0.55	D-0.66	D-0.55
901–1000			H-1.61	G-1.31	G-1.00	F-0.70	E-0.70	E-0.55	E-0.55
1001–1200			I-1.61	H-1.31	H-1.00	G-0.85	F-0.70	F-0.70	E-0.70
1201–1300				I-1.61G	H-1.31G	H-1.00G	G-0.70	F-0.70	F-0.70
1301–1500				I-1.61G	H-1.31G	H-1.31G	G-0.85	G-0.70	F-0.70
1501–1800	NOT DESIGNED				I-161H	I-1.31G	H-0.85G	H-0.85G	H-0.70
1801–2100						J-1.31G	I-1.00G	I-0.85G	I-0.85G
2101–2400						J-1.31I	I-1.31H	I-1.00H	I-0.85H
2401–2700							K-1.31H	J-1.31H	I-1.31H
2701–3000								K-1.31I	J-1.31J

Table C-2M Rectangular Duct Reinforcement

NOTE: See Page C.8. Circles in the Table only denote column numbers. For Column 2, *see* Fig. C-3. For Columns 3 through 9, *see* section C.4, Introduction to Schedules. The number in the box is minimum duct thickness; the alphabet letter is the minimum reinforcement grade for joints and intermediates occurring at a maximum spacing interval in the column heading. A letter to the right of the thickness gives a tie rodded reinforcement alternative. A "t" compels use of tie rod(s) for the reinforcement listing. For beading or crossbreaking, *see* Fig. C-4.

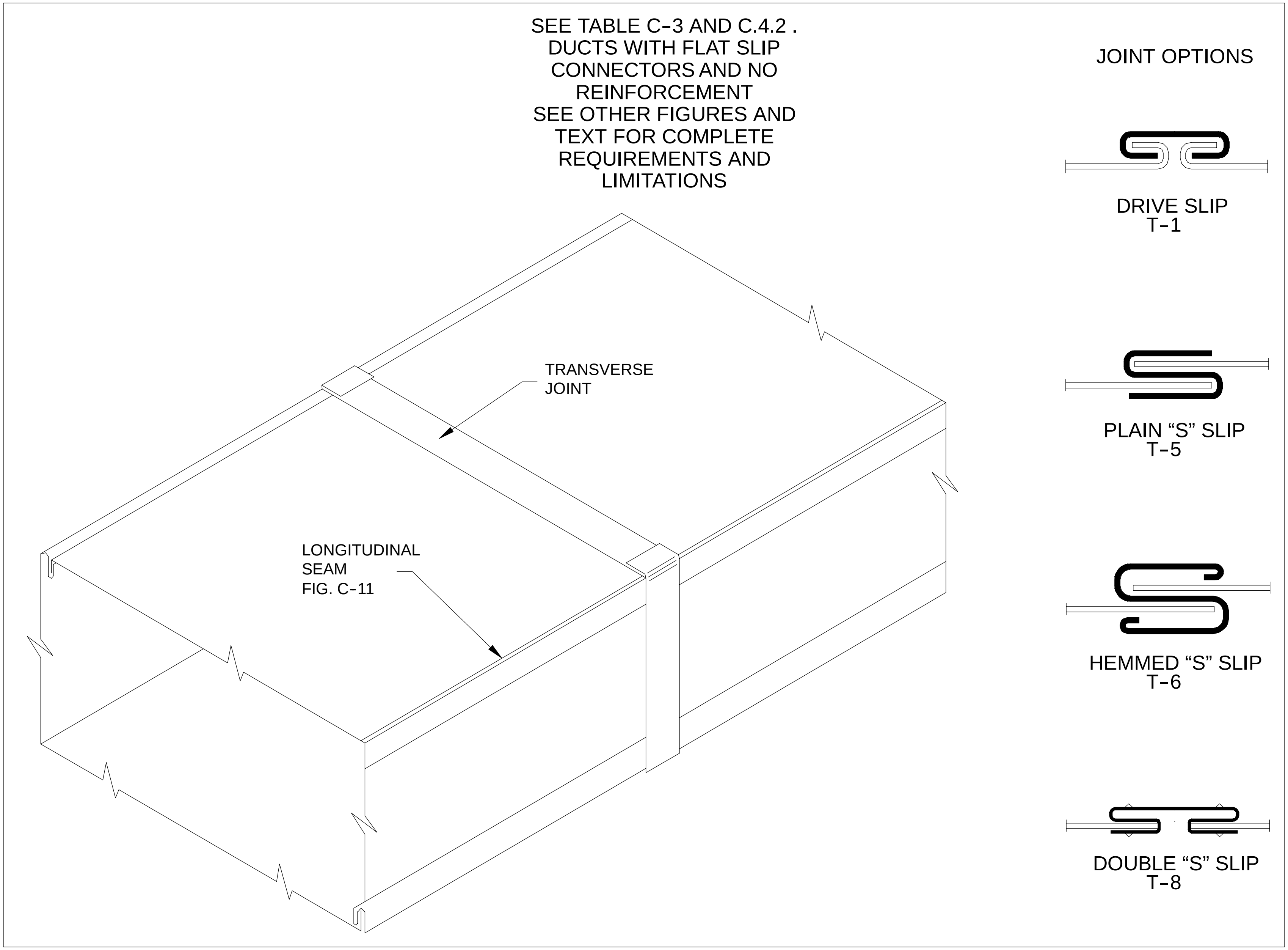

FIGURE C-3 UNREINFORCED DUCT

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DUCT DIMENSION (in.)	PRESSURE CLASS (in. wg) Positive or Negative						
	½	1	2	3	4	6	10
8	26	26	26	24	24	24	22
9–10	26	26	26	24	22	20	18
11–12	26	26	24	22	20	18	16
13–14	26	24	22	20	18	18	
15–16	26	22	20	18	18	16	
17–18	26	22	20	18	16		
19–20	24	20	18	16			
21–22	22	18	16	16			
23–24	22	18	16	16			
25–26	20	18				**REINFORCEMENT IS REQUIRED**	
27–28	18	16					
29–30	18	16					
31–36	16						

This table gives minimum duct wall thickness (gage) for use of flat type joint systems. Plain S and hemmed S connectors are limited to 2 in. wg maximum. Slips and drives must not be less than two gages lighter than the duct wall nor below 24 gage. Double S slips must be 24 gage for ducts 30 in. (762 mm) wide or less and 22 gage for greater width.

Duct Gage	26 to 22	20	18	16
Minimum Flat Slip and Drive Gage	24	22	20	18

See Figure C-3 for joint types.

Table C-3 Unreinforced Duct (Wall Thickness)

DUCT DIMENSION (mm)	PRESSURE CLASS (Pa) Positive or Negative						
	125	250	500	700	1000	1500	2500
200	0.55	0.55	0.55	0.70	0.70	0.70	0.85
201–250	0.55	0.55	0.55	0.70	0.85	1.00	1.31
251–300	0.55	0.55	0.70	0.85	1.00	1.31	1.61
301–350	0.55	0.70	0.85	1.00	1.31	1.31	
351–400	0.55	0.85	1.00	1.31	1.31	1.61	
401–450	0.55	0.85	1.00	1.31	1.61		
451–500	0.70	1.00	1.31	1.61			
501–550	0.85	1.31	1.61	1.61			
551–600	0.85	1.31	1.61	1.61			
601–650	1.00	1.31				REINFORCEMENT IS REQUIRED	
651–700	1.31	1.61					
701–750	1.31	1.61					
751–900	1.61						

This table gives minimum duct wall thickness (gages) for use of flat type joint systems. Plain S and hemmed S connectors are limited to 500 Pa maximum. Slips and drives must not be less than two gages lighter then the duct wall nor below 0.70 mm. Double S slips must be 0.70 mm for ducts 762 mm wide or less and 0.85 mm for greater width.

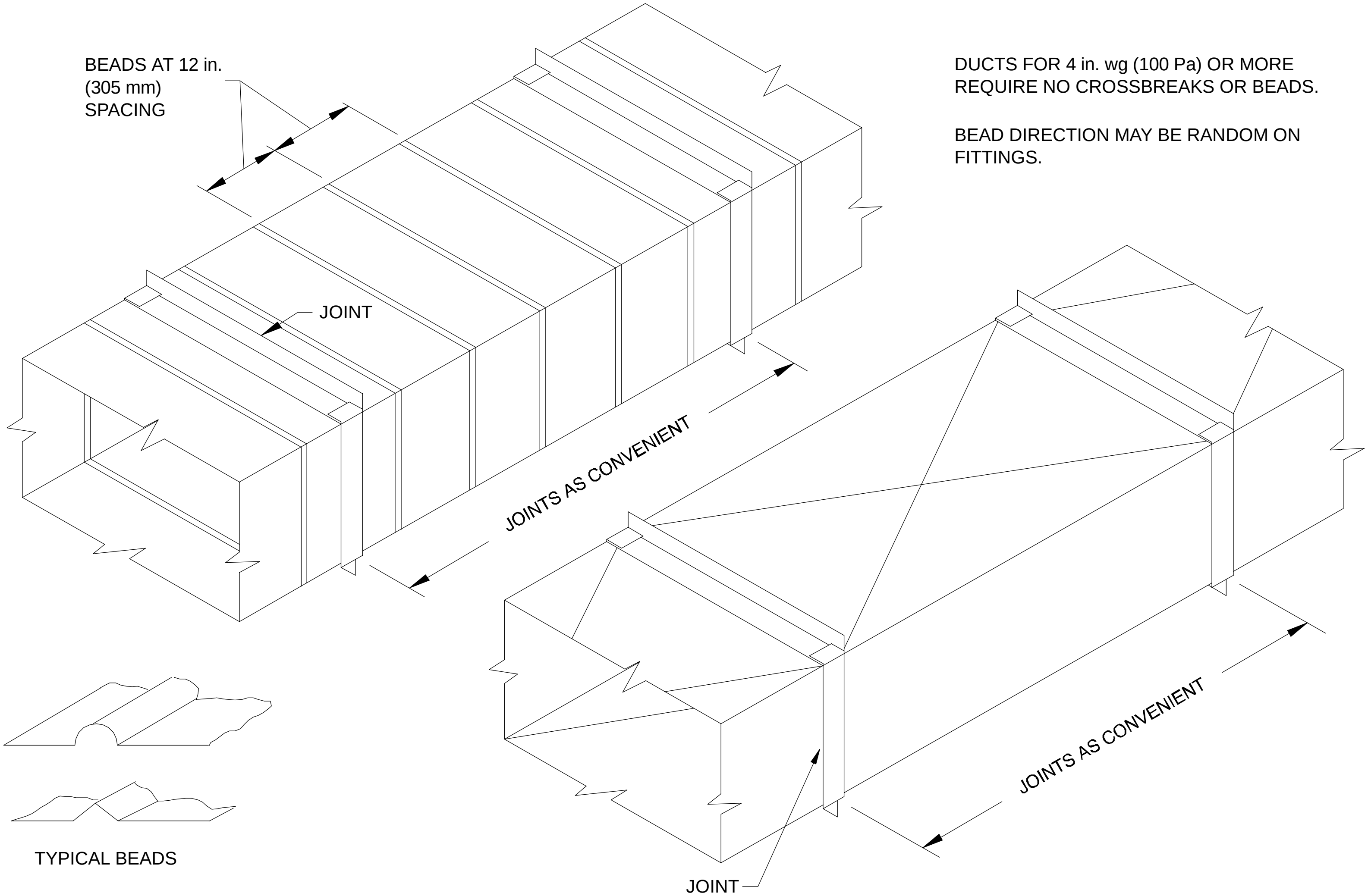
Duct Thickness (mm)	0.55 to 85	1.00	1.31	1.61
Minimum Flat Slip and Drive Gage (mm)	0.07	0.85	1.00	1.31

Table C-3M Unreinforced Duct (Wall Thickness)

DUCT SIZES 19 in. (483 mm) WIDE AND LARGER WHICH HAVE MORE THAN 10 SQUARE FEET (0.93 SQUARE METER) OF UNBRACED PANEL SHALL BE BEADED OR CROSS BROKEN UNLESS DUCTS WILL HAVE INSULATION COVERING OR ACOUSTICAL LINER. THIS REQUIREMENT IS APPLICABLE TO 20 GAGE (1.00 mm) OR LESS THICKNESS AND 3 in. wg (750 Pa) OR LESS. IT IS UNNECESSARY TO BREAK OR BEAD ALL SIDES UNLESS EACH DUCT DIMENSION REQUIRES IT.

DUCTS FOR 4 in. wg (100 Pa) OR MORE REQUIRE NO CROSSBREAKS OR BEADS.

BEAD DIRECTION MAY BE RANDOM ON FITTINGS.



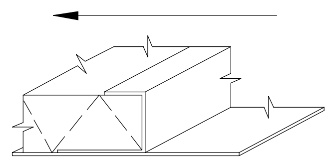
NOTICE: NEITHER BEADS NOR CROSSBREAKS AFFECT REINFORCEMENT SPACING SCHEDULE.

FIGURE C-4 CROSSBROKEN AND BEADED DUCT

NOTE:

SEE TYPICAL DUCT BRANCH ENTRY CONDITION IN FIG. C-15.

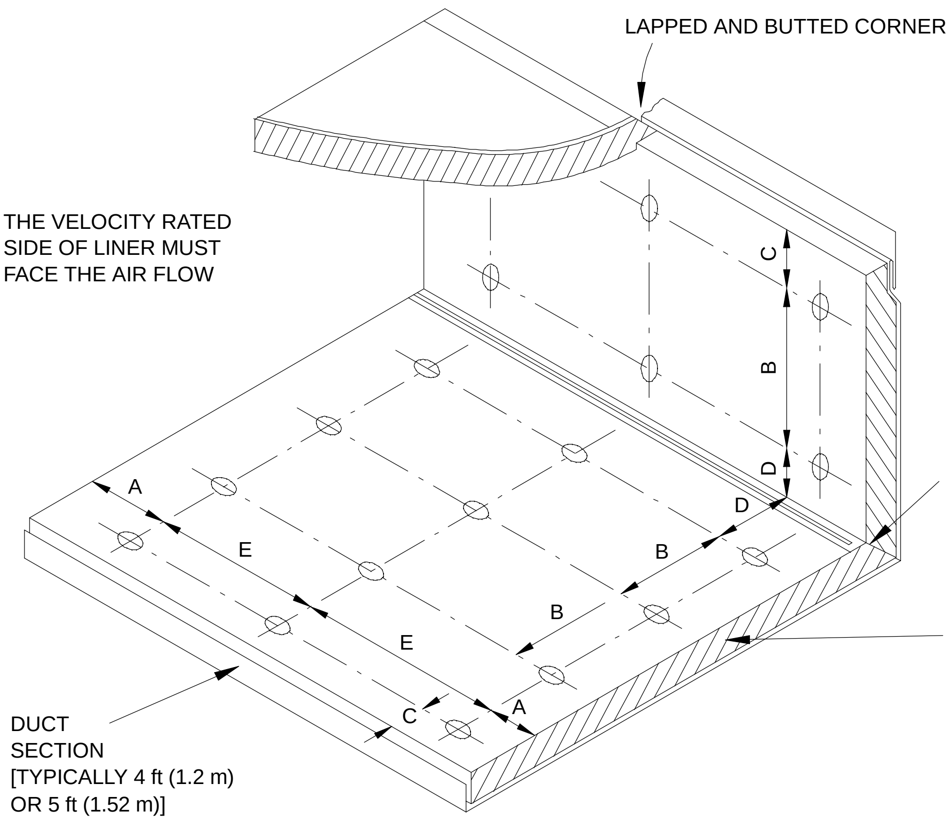
METAL NOSING MUST BE USED WHEREVER LINER IS PRECEDED BY UNLINED METAL; OTHERWISE WHEN VELOCITY EXCEEDS 4000 FPM (20.3 MPS) USE METAL NOSING ON EVERY LEADING EDGE. NOSING MAY BE FORMED ON DUCT OR BE CHANNEL OR ZEE ATTACHED BY SCREWS, RIVETS OR WELDS.



DETAIL - A

METAL NOSING
CHANNEL OR ZEE

INTERIOR WIDTH OF 8 in. (200 mm) AND LESS DOES NOT REQUIRE PINS.



MAXIMUM SPACING FOR FASTENERS.
ACTUAL INTERVALS ARE APPROXIMATE.

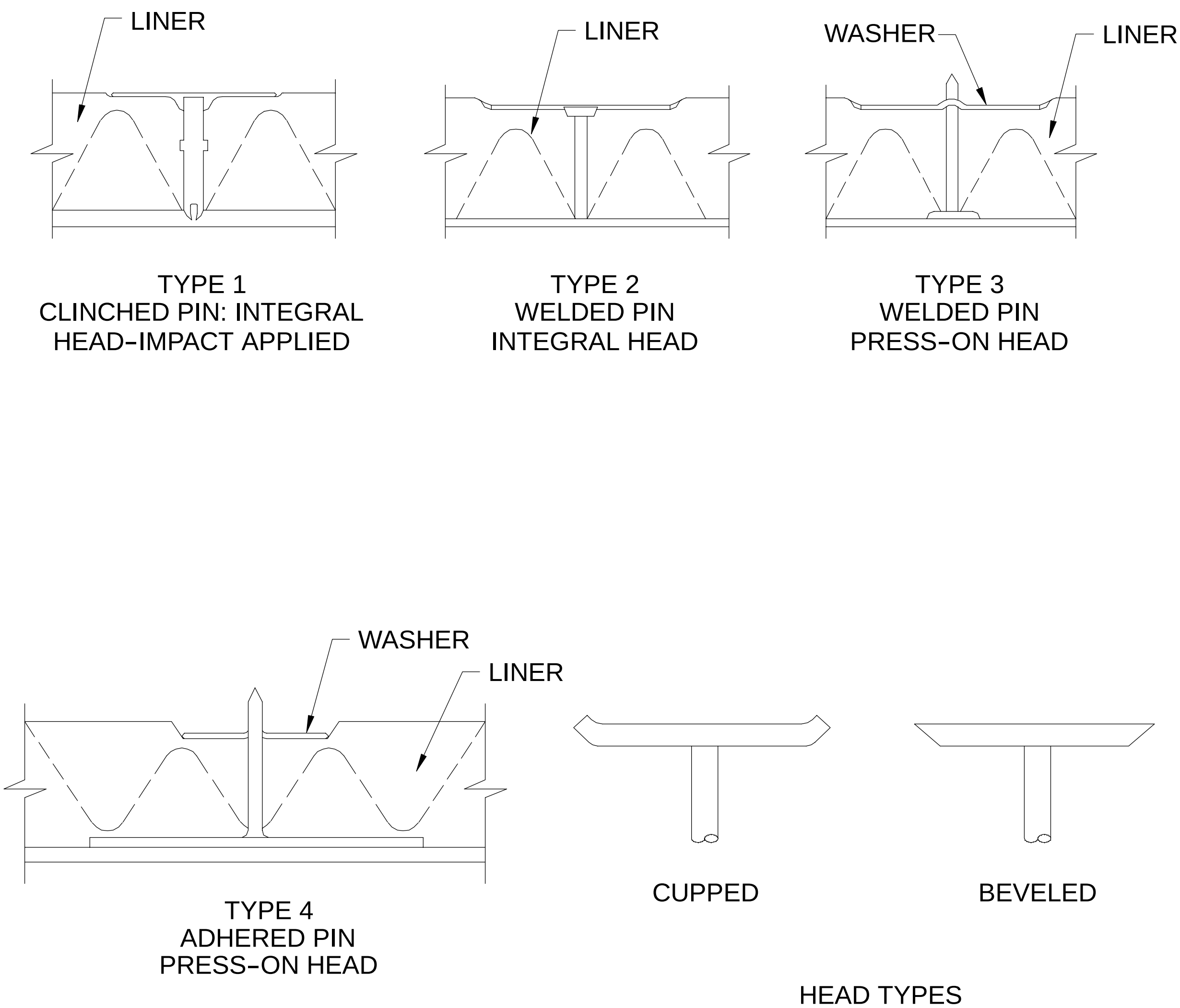
LINER ADHERED TO THE DUCT WITH 90% MIN. AREA COVERAGE OF ADHESIVE

"A" PIN ROW MAY BE OMITTED WHEN METAL NOSING IS USED. "E" THEN STARTS FROM THE NOSING.

Velocity *	Dimensions				
	A	B	C	D	E
0 - 2500 FPM (0 - 12.7 MPS)	3 in. (76.2 mm)	12 in. (305 mm)	4 in. (102 mm)	6 in. (152 mm)	18 in. (457 mm)
2501 - 6000 FPM (12.7 - 30.5 MPS)	3 in. (76.2 mm)	6 in. (152 mm)	4 in. (102 mm)	6 in. (152 mm)	16 in. (406 mm)

* UNLESS A LOWER LEVEL IS SET BY MANUFACTURER OR LISTING AGENCY

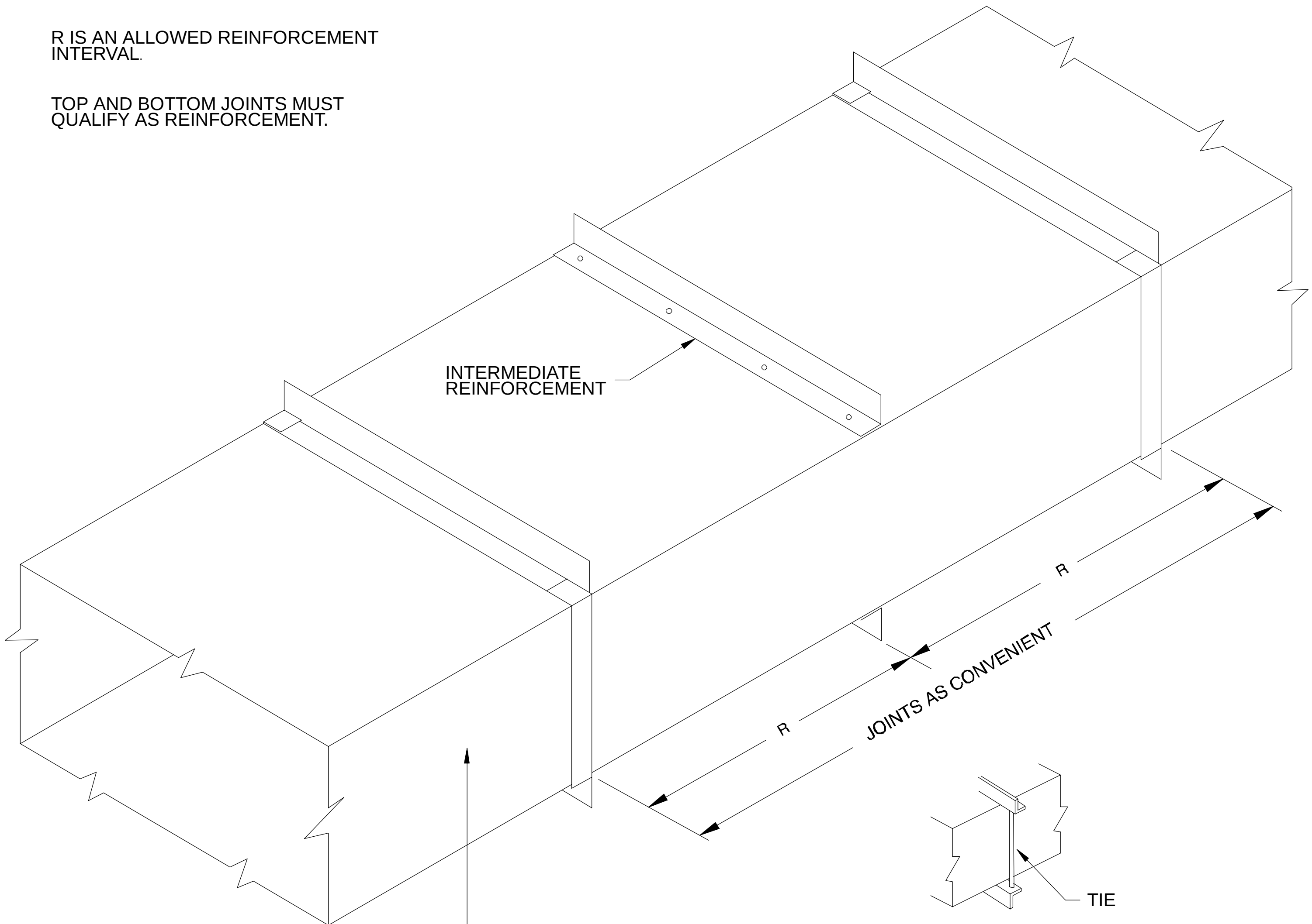
FIGURE C-5 FLEXIBLE DUCT LINER INSTALLATION



NOTE: INSTALLED PINS AND WASHERS SHALL NOT COMPRESS LINER MORE THAN THE CORRECT LENGTH SPECIFIED FOR THE LINER THICKNESS USED.

FIGURE C-6 LINER FASTENERS

FIGURE C-7 DUCT REINFORCED ON TWO SIDES



TIE ENDS OF REINFORCEMENTS AT 4 in. wg (1000 Pa) AND UP.

SEE CROSSBREAKING OR BEADING REQUIREMENTS ON FIG. C-4

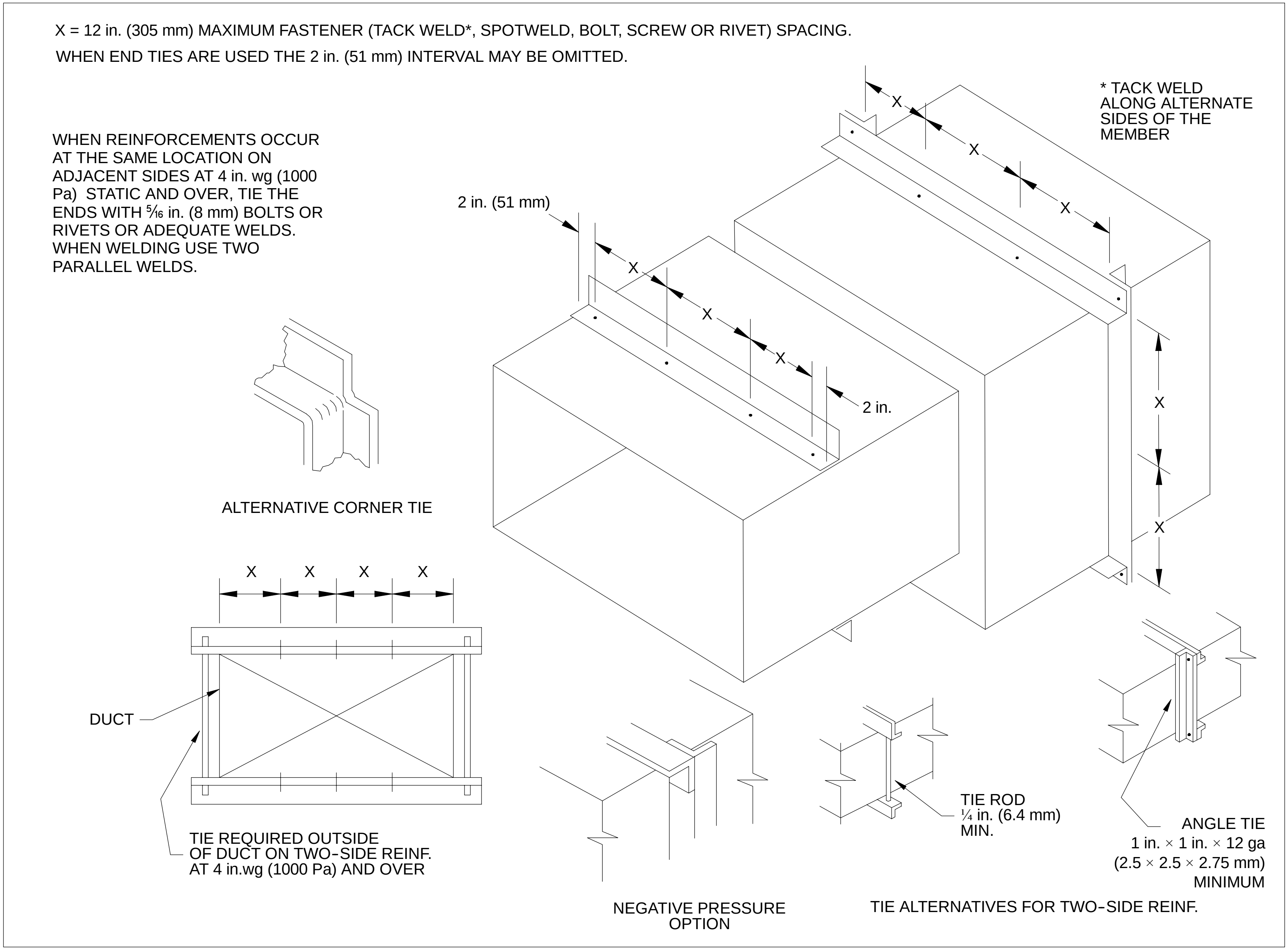


FIGURE C-8 REINFORCEMENT ATTACHMENT

C.5 TRANSVERSE JOINTS FOR RECTANGULAR DUCT

S1.19 Transverse joints shall be selected and used that are consistent with the static pressure class, applicable sealing requirements, materials involved, duct support intervals, and other provisions for proper assembly of ductwork outlined in the construction standards. The precise type, size, location, and material of fastenings used in joint assemblies are sometimes left open to prudent judgment for the specific service. Notching, bending, folding, and fit-up tolerances shall be appropriate for the composite assembly. When there is a choice of materials and methods, do not use such latitude as to create a deficiency in the integrity of the ductwork.

S1.20 *See* sections C.3 and C.4. Where the text and illustrations indicate certain sealing provisions independent of the provisions in C.3 and C.4, they apply regardless of exemptions from sealing shown in Table C-1.

S1.21 Where bar or angle stock is incorporated in a joint, it shall be secured. Where intermediate type reinforcements are used as supplements for joints, they shall be attached to the duct wall within 3 in. (76 mm) of the joint by weld, bolt, screw, or blind rivet fastening within 2 in. (51 mm) of duct corners and at intervals not exceeding 12 in. (305 mm).
EXCEPTION: Where the ends are tied to members on adjacent sides, the fastening to the duct within 2 in. (51 mm) may be omitted in consideration of the end restraint.

S1.22 Fasteners used on steel duct shall be steel. They may be zinc or cadmium coated. Standard or self-drilling sheet metal screws may be used as appropriate. Blind rivets using pull-through mandrels are not permitted if they leave holes for air leakage. Fastenings shall not project into duct interiors more than ½ in. (13 mm). Where only bolts or welds are specified, other types of fastening are not allowed.

S1.23 Unless otherwise specified, joints shall comply with all of the provisions in Sections C.3 and C.4 except the commentaries.

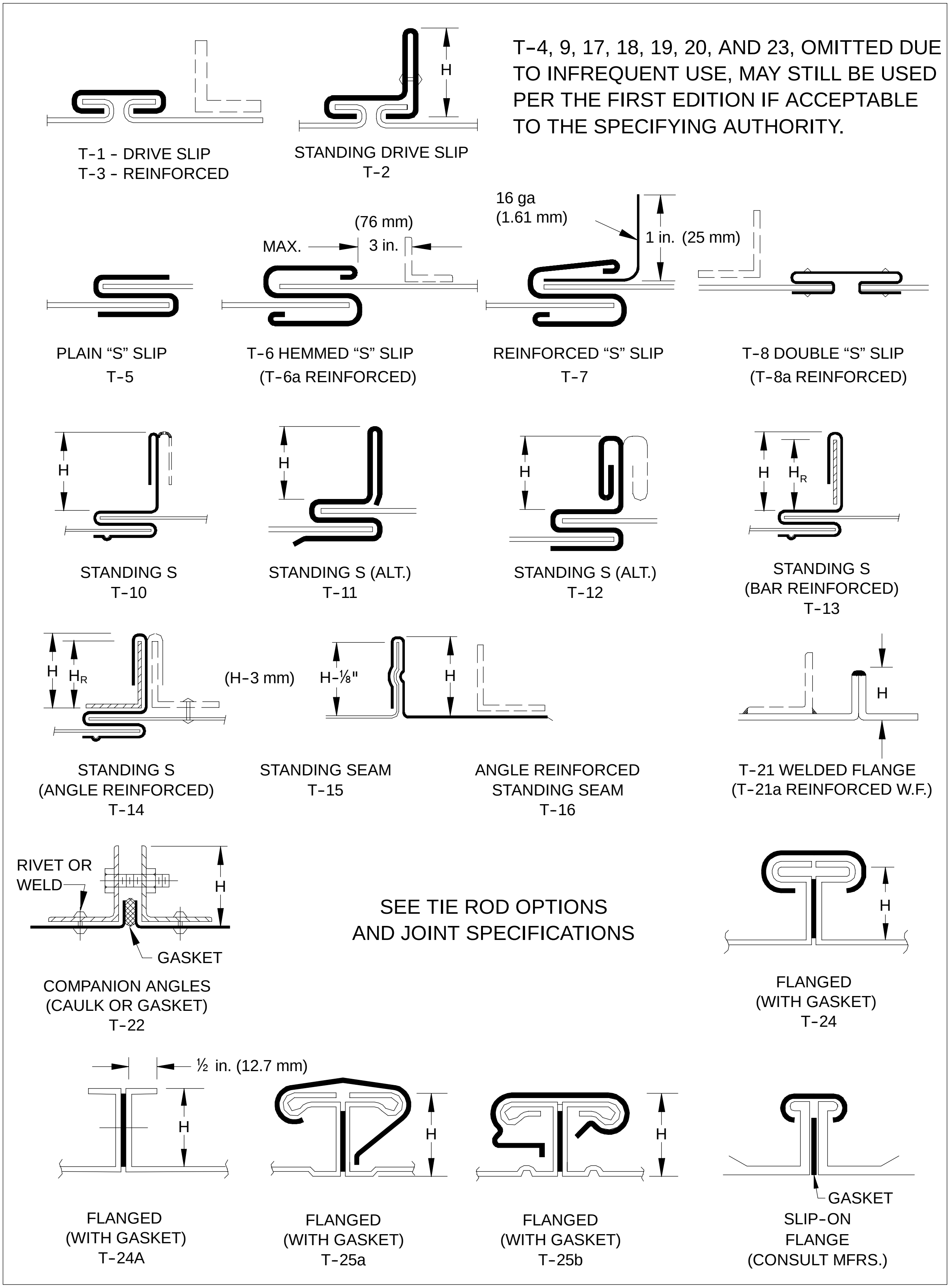


FIGURE C−9 TRANSVERSE (GIRTH) JOINTS

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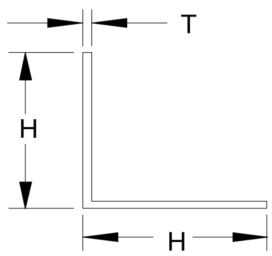
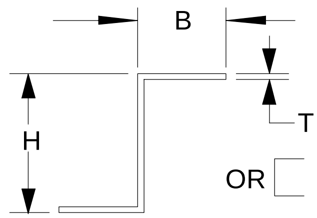
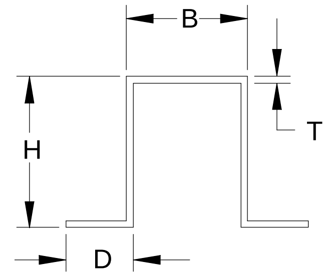
REINF- CLASS		 ANGLE		 CHANNEL OR ZEE		 HAT SECTION	
	EI*	**H × T (MIN)**	**LB/LF**	**H × B × T (MIN)**	**LB/LF**	**H × B × D × T (MIN)**	**LB/LF**
A	0.43	Use C		Use B		Use F	
B	1.0	Use C		¾ × ½ × 20 ga	0.24	Use F	
C	1.9	C1 × 16 ga C¾ × ⅛	0.40 0.57	¾ × ½ × 18 ga 1 × ¾ × 20 ga	0.31	Use F	
D	2.7	H¾ × ⅛ C1 × ⅛	0.57 0.80	1 × ¾ × 18 ga	0.45	Use F	
E	6.5	C1¼ × 12 ga H1 × ⅛	0.90	2 × 1⅛ × 20 ga	0.60	Use F	
F	12.8	H1¼ × ⅛	1.02	1½ × ¾ × 18 ga	0.54	1½ × ¾ × ⅝ × 18 ga 1½ × 1½ × ¾ × 20 ga	0.90 0.83
G	15.8	1½ × ⅛	1.23	1½ × ¾ × 16 ga	0.66	1½ × ¾ × ⅝ × 18 ga	0.80
H	22 (+) 26.4 (-)	1½ × 3⁄16 2 × ⅛	1.78 1.65	1½ × ¾ × ⅛	1.31	1½ × 1½ × ¾ × 18 ga 2 × 1 × ¾ × 20 ga	1.08 0.90
I	69	C2 × 3⁄16 2½ × ⅛	2.44 2.10	2 × 1⅛ × 12 ga 3 × 1⅛ × 16 ga	1.60 1.05	2 × 1 × ¾ × 16 ga	1.44
J	80	H2 × 3⁄16 C2 × ¼ 2½ × ⅛ (+)	2.44 3.20 2.10	2 × 1⅛ × ⅛	1.85	2 × 1 × ¾ × 12 ga 2½ × 2 × ¾ × 18 ga	2.45 1.53
K	103	2½ × 3⁄16	3.10	3 × 1⅛ × 12 ga	2.00	2½ × 2 × ¾ × 16 ga 3 × 1½ × ¾ × 16 ga	1.88 2.00
L	207	H2½ × ¼	4.10	3 × 1⅛ × ⅛	2.29	2½ × 2 × ¾ × ⅛ 3 × 1½ × ¾ × 12 ga	3.70 3.40

Table C-4 Intermediate Reinforcement

NOTE: *See* Page C.11. *Effective EI is number listed times 10^5 before adjustment for bending moment capacity. Plus (+) or minus (-) is a pressure mode restriction. Both modes are accepted when neither is given. C and H denote cold-formed and hot-rolled ratings; when neither is listed, either may be used. *See* tie rod options elsewhere.

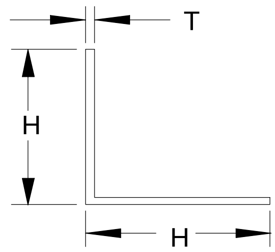
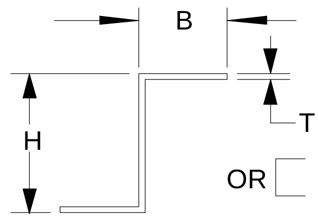
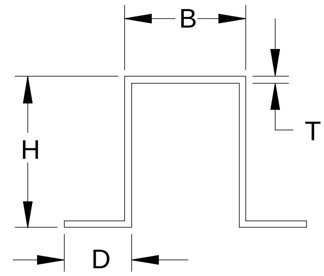
REINF-CLASS		ANGLE		CHANNEL OR ZEE		HAT SECTION	
							
	EI*	**H × T (MIN)**	**KG/LM**	**H × B × T (MIN)**	**KG/LM**	**H × B × D × T (MIN)**	**KG/LM**
A	0.12	Use C		Use B		Use F	
B	0.29	Use C		19.1 × 12.7 × 1.00	0.36	Use F	
C	0.55	25 × 1.61 C 19.1 × 3.2 C	0.60 0.85	19.1 × 12.7 × 1.31	0.46	Use F	
D	0.78	19.1 × 3.2 H 25 × 3.2 C	0.85 1.19	25 × 19.1 × 1.31	0.67	Use F	
E	1.9	31.8 × 2.75 C 25 × 3.2 C	1.34 1.19	51 × 28.6 × 1	0.89	Use F	
F	3.7	31.8 × 3.2 H	1.52	38.1 × 19.1 × 1.31	0.80	38.1 × 19.1 × 15.9 × 1.31 38.1 × 38.1 × 19.1 × 1.00	1.34 1.24
G	4.5	38.1 × 3.2	1.83	38.1 × 19.1 × 1.61	0.98	38.1 × 19.1 × 15.9 × 1.31	1.19
H	6.3 (+) 7.6 (-)	38.1 × 4.8 51 × 3.2	2.64 2.46	38.1 × 19.1 × 3.2	1.95	38.1 × 38.1 × 19.1 × 1.31 51 × 25 × 19.1 × 1.00	1.61 1.34
I	20	51 × 4.8 C 63.5 × 3.2	3.63 3.13	51 × 28.6 × 2.75 76.2 × 28.6 × 1.61	2.38 1.56	51 × 25 × 19.1 × 1.61	2.14
J	23	51 × 4.8 H 51 × 6.4 C 63.5 × 3.2 (+)	3.63 4.76 3.13	51 × 28.6 × 3.2	2.75	51 × 25 × 19.1 × 2.75 63.5 × 51 × 19.1 × 1.31	3.65 2.28
K	30	63.5 × 4.8	4.61	76.2 × 28.6 × 2.75	2.98	63.5 × 51 × 19.1 × 1.61 76.2 × 38.1 × 19.1 × 1.61	2.80 2.98
L	60	63.5 × 6.4 H	6.10	76.2 × 28.6 × 3.2	3.40	63.5 × 51 × 19.1 × 3.2 76.2 × 38.1 × 19.1 × 2.75	5.51 5.06

Table C-4M Intermediate Reinforcement

NOTE: See Page C.11. *Effective EI is number listed in kiloNewton-meters square (kNm^2) before adjustment for bending moment capacity. Plus (+) or minus (-) is a pressure mode restriction. Both modes are accepted when neither is given. C and H denote cold-formed and hot-rolled ratings; when neither is listed, either may be used. *See* tie rod options elsewhere.

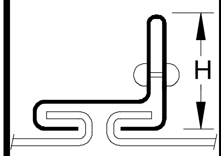
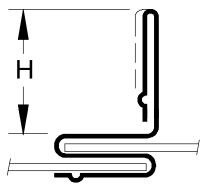
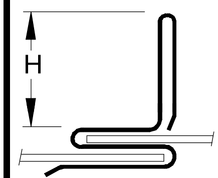
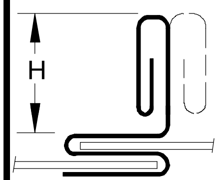
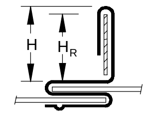
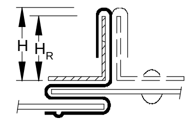
REINF-CLASS		T-2 STANDING DRIVE SLIP 		T-10 STANDING S 		T-11 STANDING S 		T-12 STANDING S 		 T-13  T-14 STANDING S	
	EI*	H × T	LB/LF	H × T	LB/LF	H × T	LB/LF	H × T	LB/LF	$H \times T \times H_R$	LB/LF
A	0.43	Use B		Use B		½ × 26 ga	0.5	Use B		Use D	
B	1.0	1⅛ × 26 ga	0.4	1 × 26 ga	0.6	½ × 22 ga 1 × 26 ga	0.6	1 × 26 ga	0.7	Use D	
C	1.9	1⅛ × 22 ga	0.6	1 × 22 ga	0.8	1 × 22 ga	0.8	1 × 24 ga	0.8	Use D	
D	2.7	1⅛ × 18 ga	0.8	1⅛ × 20 ga 1 × 22 ga (+)	0.9	1 × 20 ga 1 × 22 ga (+)	.09	1½ × 22 ga	1.0	1⅝ × 24 ga 1½ × ⅛ Bar	1.4
E	6.5	NOT GIVEN		1⅛ × 18 ga	1.0	1 × 18 ga (+)	1.0	1 × 18 ga 1½ × 20 ga	1.2	Use F	
F	12.8			Use G		NOT GIVEN		Use G		1⅝ × 22 ga. 1½ × ⅛ Bar	1.5
G	15.8			1⅝ × 18 ga	1.3			1½ × 18 ga	1.3	1⅝ × 20 ga 1½ × ⅛ Bar	1.7
H	22(+) 26.4 (-)			NOT GIVEN				NOT GIVEN		1⅝ × 18 ga 1½ × ⅛ Bar	2.0
I	69									2⅛ × 20 ga 2 × 2 × ⅛ Angle	2.9
J	80									2⅛ × 20 ga 2 × 2 × 3/16 Angle	3.7
K	103									NOT GIVEN	
L	207										

Table C-5 Transverse Joint Reinforcement

NOTE: See Page C.11. *Effective EI is number listed times 10^5 before adjustment for bending moment capacity. Plus (+) or minus (-) is a pressure mode restriction. Both modes are accepted when neither is given. Joints T-2 and T-10 through T-14 are restricted to 30 in. length at 4 in. wg, to 36 in. length at 3 in. wg and are not recommended for service above 4 in. wg.

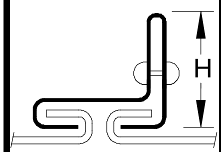
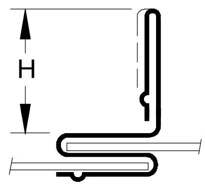
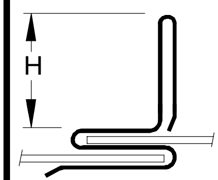
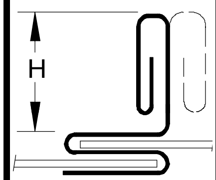
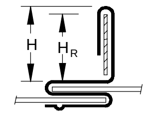
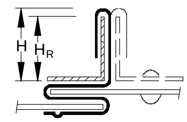
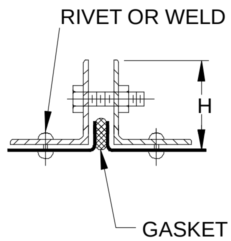
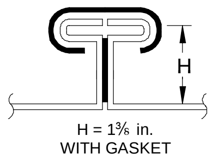
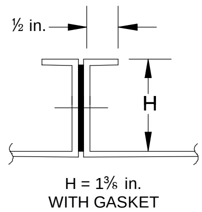
REINF-CLASS		 T-2 STANDING DRIVE SLIP		 T-10 STANDING S		 T-11 STANDING S		 T-12 STANDING S		 T-13  T-14 STANDING S	
	EI*	**H × T**	**KG LM**	**H × T**	**KG LM**	**H × T**	**KG LM**	**H × T**	**KG LM**	**$H \times T \times H_R$**	**KG LM**
A	0.13	Use B		Use B		12.7 × 0.55	0.74	Use D		Use D	
B	0.29	28.6 × 0.55	0.6	25 × 0.55	0.9	12.7 × 0.85 25 × 0.55	0.9	25 × 0.55	1.0	Use D	
C	0.55	28.6 × 0.85	0.9	25 × 0.85	1.2	25 × 0.70	1.2	25 × 0.70	1.2	Use D	
D	0.78	28.6 × 1.31	1.2	28.6 × 1.00 25 × 0.85 (+)	1.3	25 × 1.00	1.3	Use E		41.3 × 0.70(-) 38.1 × 3.2 Bar	2.1
E	1.9			28.6 × 1.31	1.5			25 × 1.31	1.8	Use F	
F	3.7			Use G				Use G		41.3 × 0.85 38.1 × 3.2 Bar	2.2
G	4.5			41.3 × 1.31	1.9			38.1 × 1.0	1.9	41.3 × 1.0 38.1 × 3.2 Bar	2.6
H	6.3(+) 7.6 (-)	NOT GIVEN				NOT GIVEN				41.3 × 1.31 38.1 × 3.2 Bar	3.0
I	21									54 × 1.0 51 × 51 × 3.2 Angle	4.3
J	24			NOT GIVEN				NOT GIVEN		54 × 1.0 51 × 51 × 4.76 Angle	5.5
K	31									NOT GIVEN	
L	62										

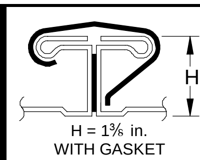
Table C–5M Transverse Joint Reinforcement

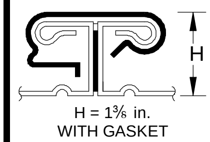
NOTE: See Page C.11. *Effective EI is number listed in kiloNewton-meters square (kNm^2) before adjustment for bending moment capacity. Plus (+) or minus (-) is a pressure mode restriction. Both modes are accepted when neither is given. Joints T-2 and T-10 through T-14 are restricted to 762 mm length at 1000 Pa, to 914 mm length at 750 Pa and are not recommended for service above 1000 Pa.

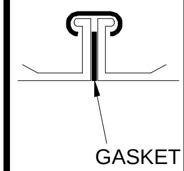








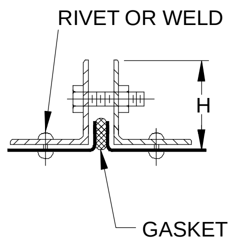
T-25a FLANGED


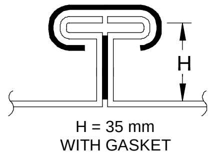


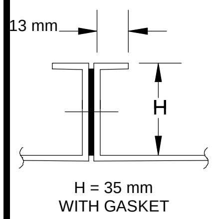
REINF-CLASS		T-22 COMPANION ANGLES		T-24 FLANGED		T-24a FLANGED		T-25b FLANGED		SLIP-ON FLANGED
	EI*	**H × T**	**LB/LF**	**T (NOM.)**	**LB/LF**	**H × T (NOM.)**	**LB/LF**	**T (NOM.)**	**LB/LF**	
A	0.43	Use E		Use D		Use D		Use D		Consult manufacturers for ratings established by performance documented to functional criteria in Chapter 7 of SMACNA *HVAC-DCS* (Second Edition, 1995). *See* text S1.18 on page C.6.
B	1.0	Use E		Use D		Use D		Use D		
C	1.9	Use E		Use D		Use D		Use D		
D	2.7	Use E		± 26 ga	0.5	1 × 22 ga	0.4	± 26 ga	0.5	
E	6.5	C 1 × ⅛ ±	1.7	± 24 ga	0.6	Use F		± 24 ga	0.6	
F	12.8	H 1 × ⅛ ±	1.7	± 22 ga	0.7	1½ × 20 ga	0.6	± 22 ga	0.7	
G	15.8	1¼ × ⅛ ±	2.1	± 22 ga (R) ± 20 ga	1.0	1½ × 18 ga	0.8	± 22 ga (R) ± 20 ga	1.0	
H	22 (+) 26.4 (-)	C1½ × ⅛ (+) H ½ × ⅛ (-)	2.6	+ 18 ga	1.1	SEE TIE ROD TEXT		+ 18 ga	1.1	
I	69	1½ × ¼	3.7	± 20 ga (R)	1.0			± 20 ga (R)	1.0	
J	80	1½ × ¼ (+) 2 × ⅛	4.7	± 18 ga (R)	1.1			± 18 ga (R)	1.1	
K	103	2 × 3⁄16	5	± 18 ga (R)	1.1			± 18 ga (R)	1.1	
L	207	H 2 × ¼	6.5	± 18 ga (R)	1.1			± 18 ga (R)	1.1	

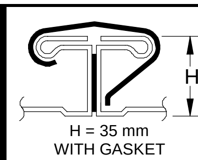
Table C-6 Transverse Joint Reinforcement

NOTES: See Page C.11. *Effective EI is number listed times 10^5 before adjustment for bending moment capacity. Plus (+) or minus (-) is a pressure mode restriction. Both modes are accepted when neither is given. For T-22, see tie rod downsize options in SMACNA *HVAC-DCS* (Second Edition, 1995) Tables 1-3 to 1-9; one rod for two angles. (R) means Tie Rodded. Accepted Pressure Mode for T-24a is (+) or (-) 2 in. wg maximum. See SMACNA *HVAC-DCS* (Second Edition, 1995) Figures 1-2, 1-3, 1-16, and tie rod text.

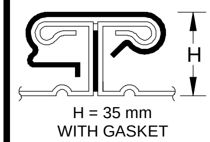


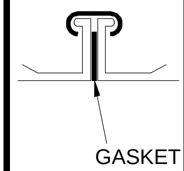






T-25a FLANGED

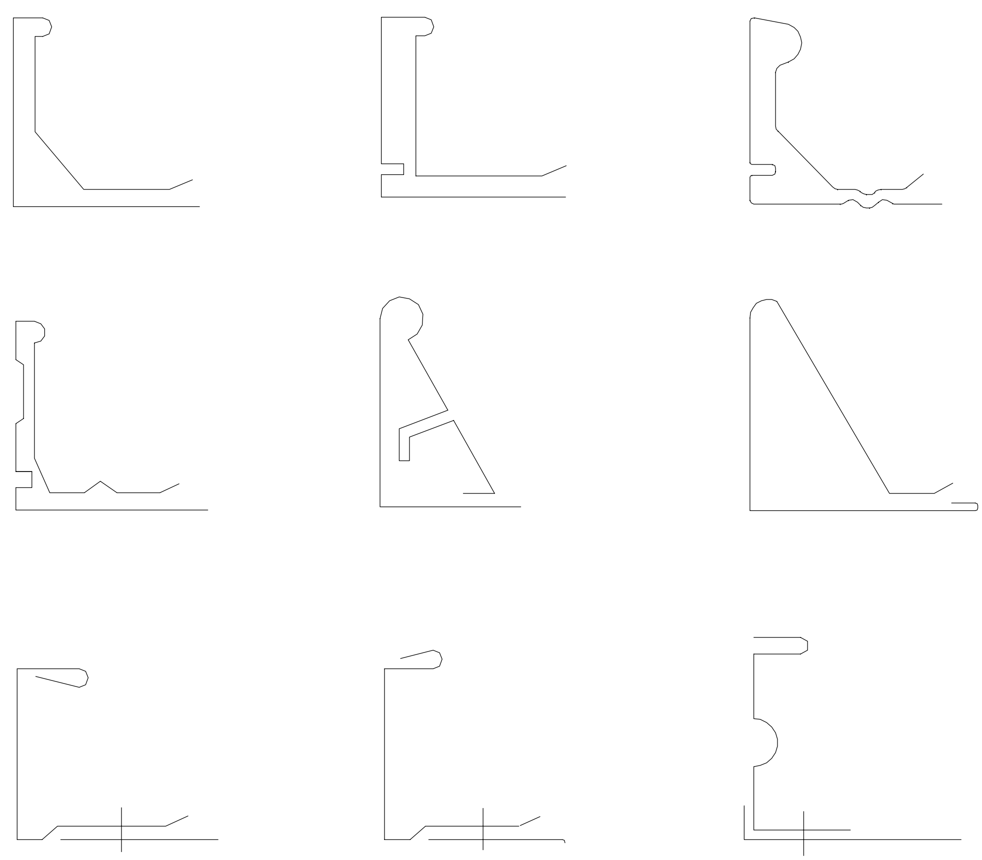




REINF-CLASS		T-22 COMPANION ANGLES		T-24 FLANGED		T-24a FLANGED		T-25b FLANGED		SLIP-ON FLANGED
	EI*	H × T	KG LM	T (NOM.)	KG LM	H × T (NOM.)	KG LM	T (NOM.)	KG LM	
A	0.12	Use E		Use D		Use D		Use D		Consult manufacturers for ratings established by performance documented to functional criteria in Chapter 7 of SMACNA *HVAC-DCS* (Second Edition, 1995). *See* text S1.18 on page C.6.
B	0.29	Use E		Use D		Use D		Use D		
C	0.55	Use E		Use D		Use D		Use D		
D	0.78	Use E		± 0.55		25 × 0.85	0.6	± 0.55		
E	1.90	25 × 3.2		± 0.70	0.9	Use F		± 0.70	0.9	
F	3.70	H 25 × 3.2		± 0.85	1.0	38.1 × 1.00	0.9	± 0.85	1.0	
G	4.50	31.8 × 3.2		± 0.85 (R) ± 1.00	1.5	38.1 × 1.31	1.2	± 0.85 (R) ± 1.00	1.5	
H	6.3 (+) 7.6 (-)	C (+) H± 38.1 × 3.2		+ 1.31	1.6			+ 1.31	1.6	
I	20	38.1 × 6.4		± 1.00 (R)	1.5			± 1.00. (R)	1.5	
J	23	38.1 × 6.4 (+) 51 × 3.2		± 1.31 (R)	1.6	SEE TIE ROD TEXT		± 1.31 (R)	1.6	
K	30	51 × 4.8		± 1.31 (R)	1.6			± 1.31 (R)	1.6	
L	60	51 × 6.4		± 1.31 (R)	1.6			± 1.31 (R)	1.6	

Table C-6M Transverse Joint Reinforcement

NOTES: See Page C.11. *Effective EI is number listed times 10^5 before adjustment for bending moment capacity. Plus (+) or minus (-) is a pressure mode restriction. Both modes are accepted when neither is given. For T-22, see tie rod downsize options in SMACNA *HVAC-DCS* (Second Edition, 1995) Tables 1-3 to 1-9; one rod for two angles. (R) means Tie Rodded. Accepted Pressure Mode for T-24a is (+) or (-) 500 Pa maximum. See SMACNA *HVAC-DCS* (Second Edition, 1995) Figures 1-2, 1-3, 1-16, and tie rod text.



THERE ARE SEVERAL PROPRIETARY DUCT CONNECTION SYSTEMS AVAILABLE AND IN USE. BECAUSE SUCH SYSTEMS ARE PROPRIETARY OR HAVE PROPRIETARY ELEMENTS SMACNA DOES NOT EVALUATE OR GRADE THEM. HOWEVER, SMACNA DOES ENCOURAGE THE DEVELOPMENT AND USE OF NEW TECHNOLOGY AND IT INVITES AUTHORITIES TO CONSIDER ALTERNATIVE CONSTRUCTIONS. AUTHORITIES MAY EVALUATE ALTERNATIVES USING ANAYLSES AND TESTS SUCH AS THOSE DESCRIBED IN CHAPTER 7 OF SMACNA *HVAC-DCS* (Second Edition, 1995) OR USING OTHER MEANS THEY DEEM APPROPRIATE.

THIS FIGURE ILLUSTRATES SOME OF THE ALTERNATIVE JOINT PROFILES AVAILABLE FOR RECTANGULAR DUCTS. GASKETS AND POSSIBLY SEALANTS AS WELL AS MECHANICAL FASTENINGS ARE REQUIRED FOR LEAKAGE CONTROL AND JOINT INTEGRITY. OTHER REINFORCEMENT ELEMENTS MAY BE NEEDED TO MEET PARTICULAR QUALIFICATIONS. CONSULT THE MANUFACTURERS OF ALTERNATIVE SYSTEMS FOR RATINGS, ASSEMBLY REQUIREMENTS AND RECOMMENDATIONS. ALTHOUGH THE ILLUSTRATIONS DEPICT CERTAIN FLANGE SYSTEMS NO PREFERENCE FOR CONSIDERATION OF THESE OVER OTHER ALTERNATIVES IS INTENDED. FURTHERMORE, NO INFRINGEMENT OF ANY RIGHTS IS INTENDED IN PRESENTING THESE ILLUSTRATIONS TO FURTHER ACQUAINT INDUSTRY WITH ALTERNATIVES AVAILABLE.

FIGURE C-10 SPECIAL JOINT PROFILES

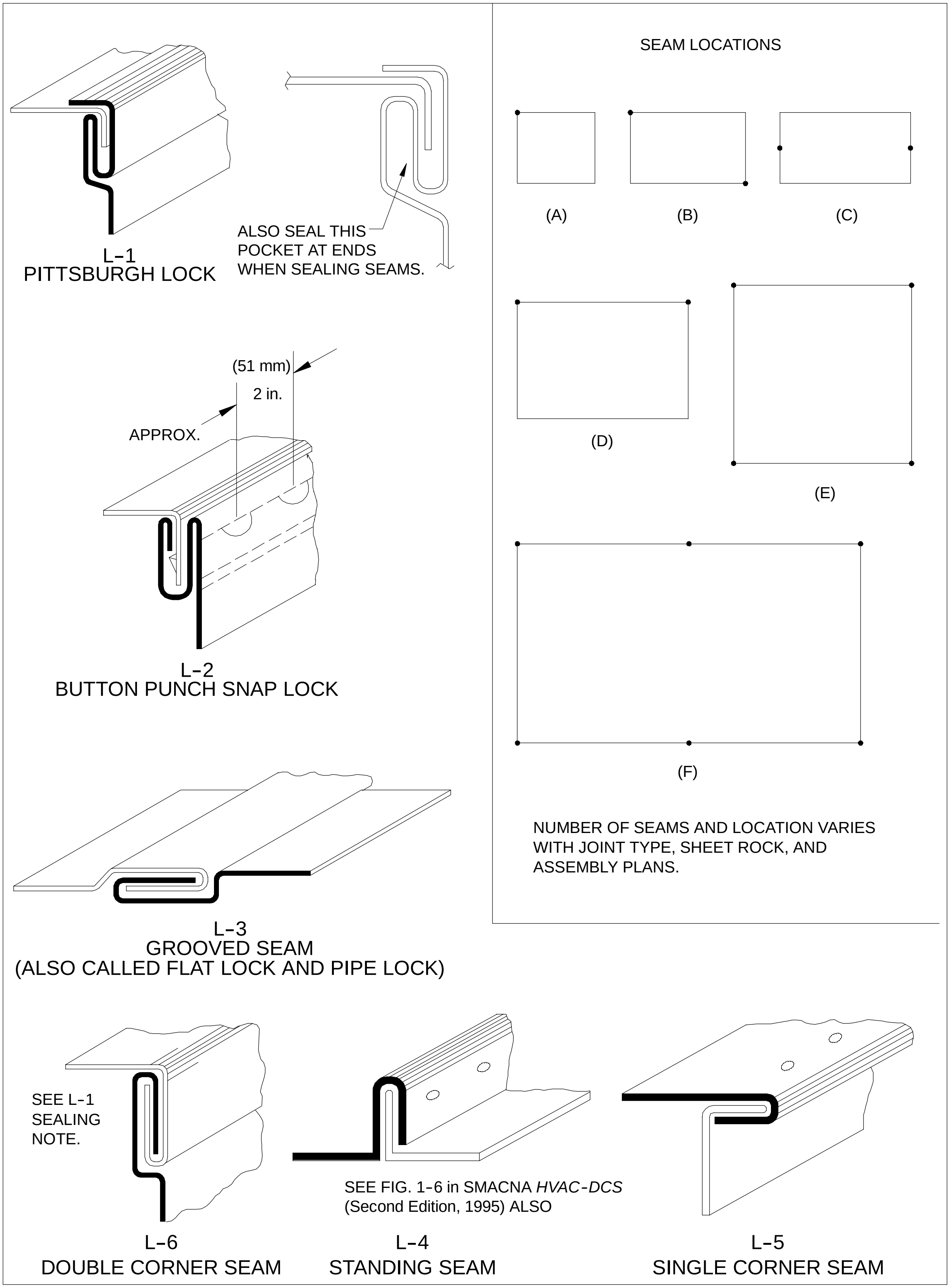
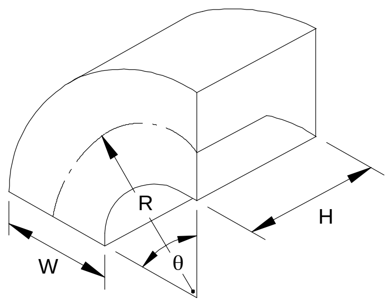
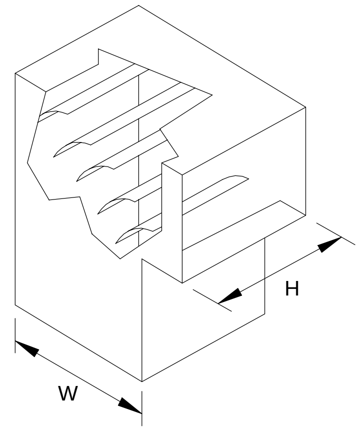


FIGURE C-11 LONGITUDINAL SEAMS - RECTANGULAR DUCT

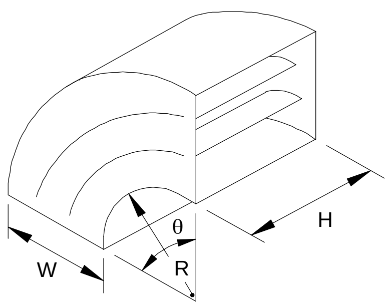


TYPE RE 1
RADIUS ELBOW

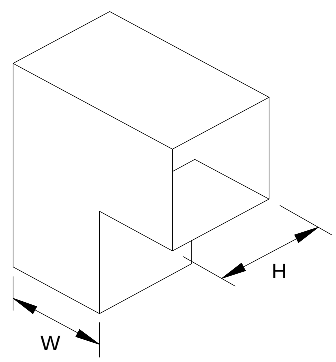
CENTERLINE R = $\frac{3W}{2}$ UNLESS OTHERWISE SPECIFIED θ IS NOT RESTRICTED TO 90°.
SQUARE THROAT, $\frac{R}{W}$ = 0.5, MAY BE USED, UP TO 1000 FPM (5 mps).



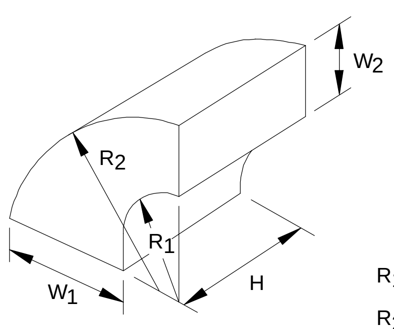
TYPE RE 2
SQUARE THROAT ELBOW
WITH VANES



TYPE RE 3
RADIUS ELBOW
WITH VANES



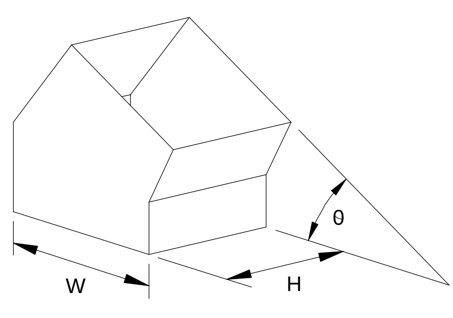
TYPE RE 4
SQUARE THROAT ELBOW
WITHOUT VANES
(1000 FPM (5 mps) MAXIMUM VELOCITY)



R_1 = $3/4W_1$

R_2 = $R_1 + W_2$

TYPE RE 5
DUAL RADIUS ELBOW

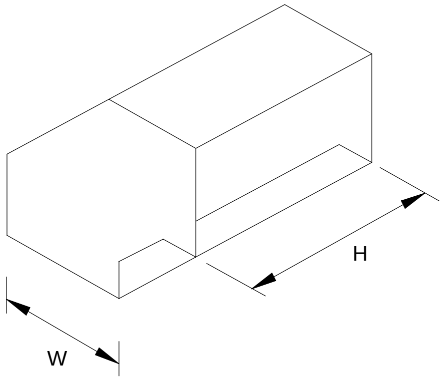


TYPE RE 6
MITERED ELBOW

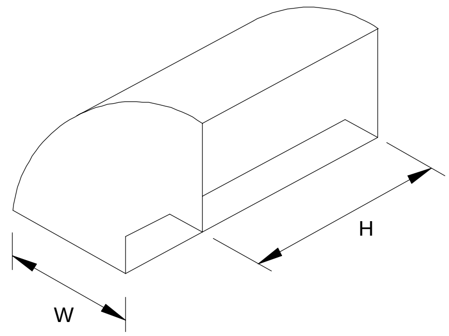
BEAD, CROSSBREAK AND REINFORCE FLAT SURFACES AS IN STRAIGHT DUCT

PAGE 1 OF 2

FIGURE C-12 RECTANGULAR ELBOWS

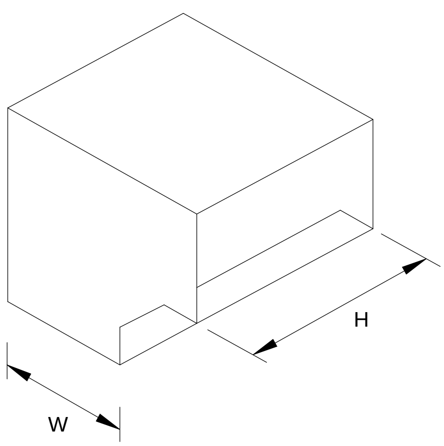


TYPE RE 7
45° THROAT
45° HEEL

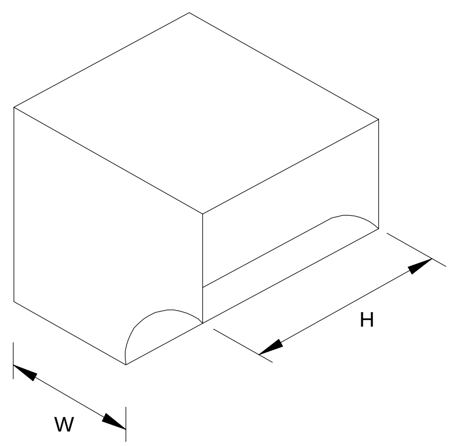


TYPE RE 8
45° THROAT
RADIUS HEEL

ALL 45° THROATS ARE 4 in. (100 mm) MINIMUM



TYPE RE 9
45° THROAT
90° HEEL

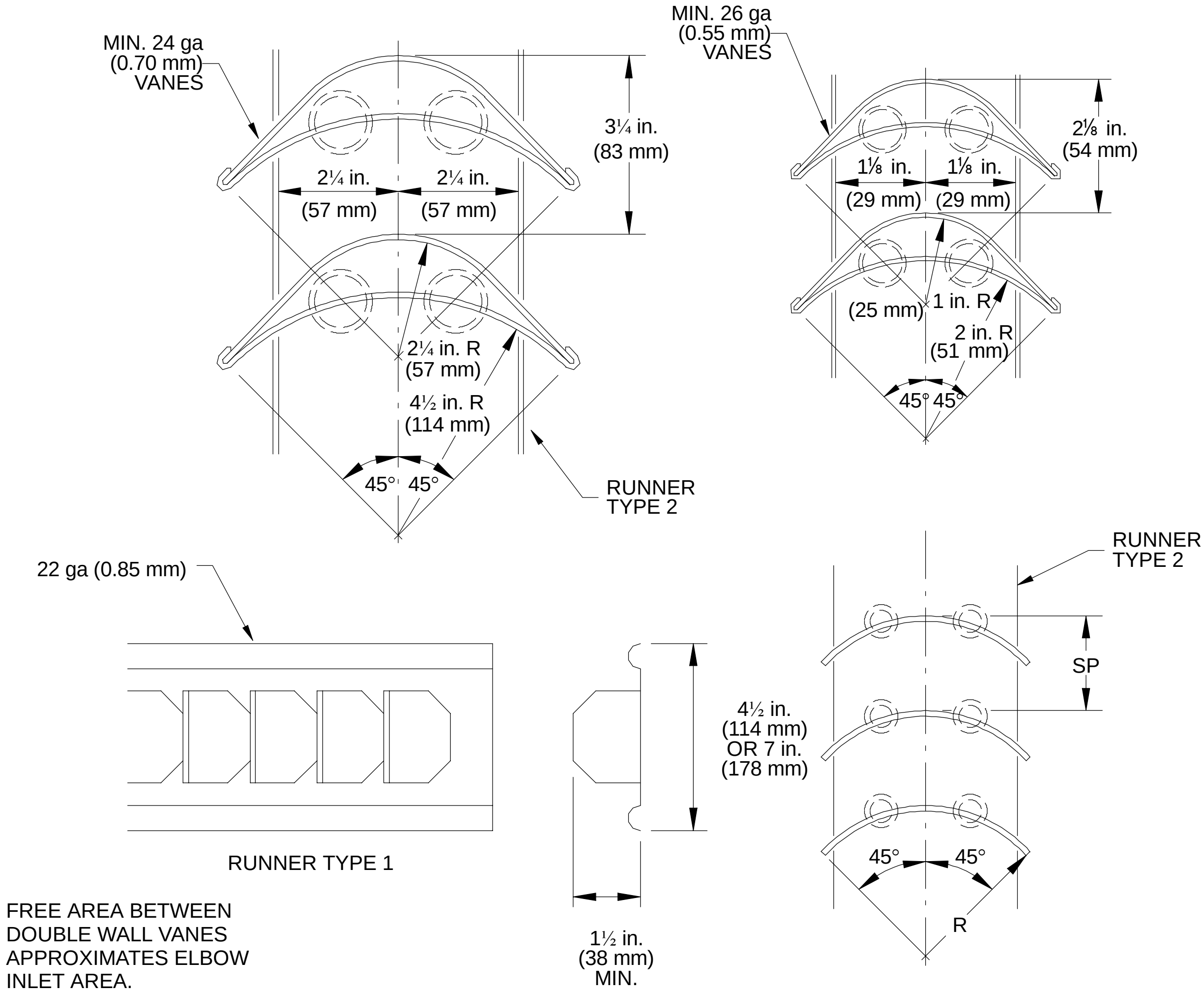


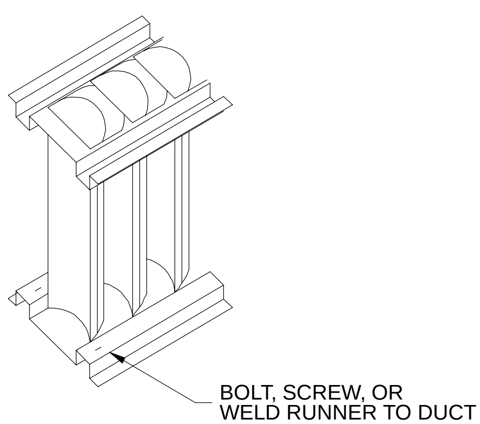
TYPE RE 10
RADIUS THROAT
90° HEEL

BEAD, CROSSBREAK AND REINFORCE FLAT SURFACES AS IN STRAIGHT DUCT

PAGE 2 OF 2

FIGURE C-12 RECTANGULAR ELBOWS (CONTINUED)

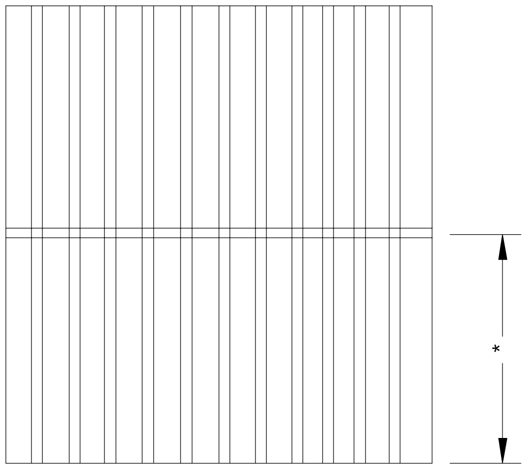




SINGLE VANE SCHEDULE			
	R	SP	GAGE
SMALL	2 in. (51 mm)	1½ in. (38 mm)	24 (0.70 mm)
LARGE	4½ in. (114 mm)	3¼ in. (83 mm)	22 (0.85 mm)

SEE NOTES ON FIG. C-14. OTHER RUNNERS MAY BE USED AS APPROPRIATE. OTHER VANE SIZES, SPACINGS OR CONFIGURATIONS ARE ACCEPTABLE ON DESIGNER APPROVAL.

FIGURE C-13 VANES AND VANE RUNNERS



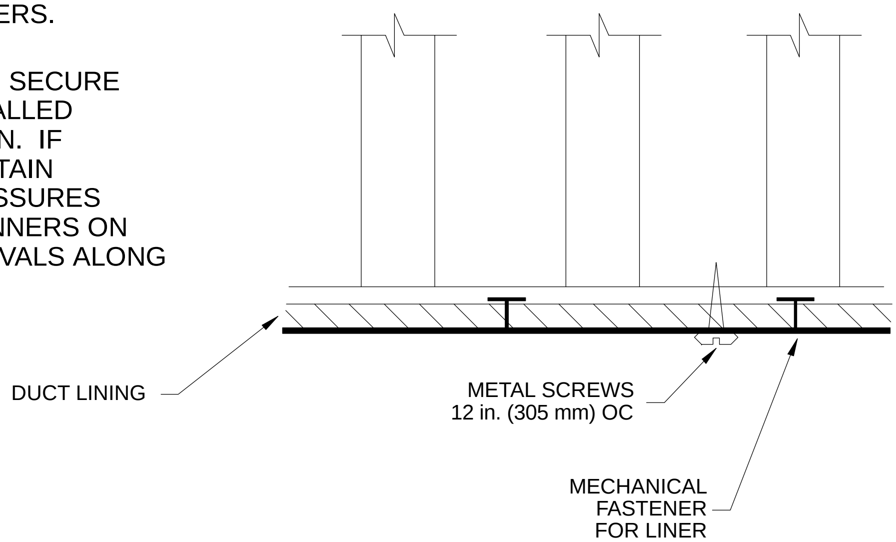
* MAXIMUM UNSUPPORTED VANE LENGTH

SMALL SINGLE VANE	36 in. (914 mm)
LARGE SINGLE VANE	36 in. (914 mm)
SMALL DOUBLE VANE	48 in. (1219 mm)
LARGE DOUBLE VANE	72 in. (1829 mm)

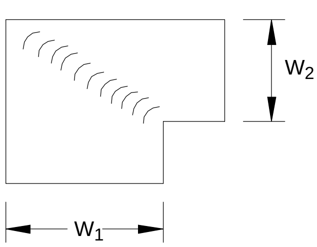
INSTALL VANES IN SECTIONS OR USE TIE RODS TO LIMIT THE UNBRACED VANE LENGTH.

VANES SHALL BE SECURELY FASTENED TO RUNNERS.

ALL VANES SHALL BE SECURE AND STABLE IN INSTALLED OPERATING POSITION. IF NECESSARY, AT CERTAIN VELOCITIES OR PRESSURES WELD VANES TO RUNNERS ON APPROPRIATE INTERVALS ALONG RUNNERS.



TO PREVENT LINER DAMAGE CARE MUST BE EXERCISED WHEN INSTALLING VANES IN LINED OR FIBROUS GLASS DUCT.



IF W_2 DOES NOT EQUAL W_1 SPECIAL PROVISIONS MUST BE MADE IN VANE SHAPE OR ANGLE OF ENTRY AND EXIT. APPLIES TO ALL TYPES OF VANES. CONSTRUCT VANE EDGES TO PROJECT TANGENTS PARALLEL TO DUCT SIDES. VANES AS USED WHEN $W_1 = W_2$ ARE NOT ACCEPTABLE ON SIZE CHANGE ELBOWS WITHOUT MODIFICATION.

SEE FIG. C-13 FOR VANE DETAILS.

FIGURE C-14 VANE SUPPORT IN ELBOWS

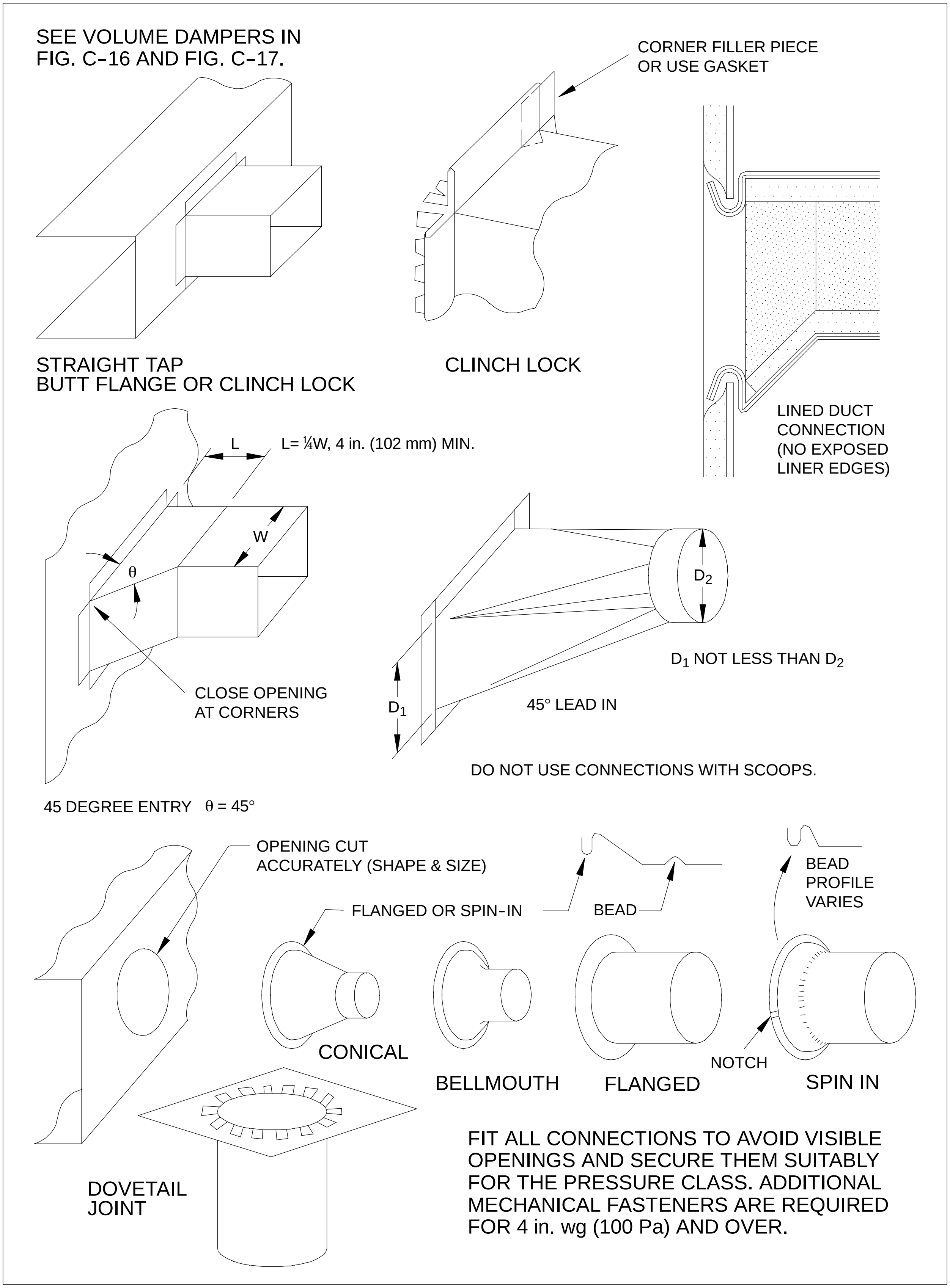


FIGURE C-15 BRANCH CONNECTIONS

C.6 VOLUME DAMPERS (NOTES FOR FIGURES C-16 AND C-17)

a. Unless otherwise permitted, dampers shall be provided with the general configuration, materials, and application limits indicated in SMACNA *HVAC-DCS* (Second Edition, 1995) Figures 2-14 and 2-15 and in related notes. *See* Example Figure C-20.

b. Damper hardware must be durable and installed properly.

c. Dampers must be stable under operating conditions. Round and rectangular damper blades must be stiffened by forming or other method if required for the duty.

d. All single blade dampers must have a locking device to hold the dampers in a fixed position without vibration.

e. Damper component penetration of ducts must be closed, in keeping with the sealing classification applicable for the pressure class. End bearings or other seals are required on 3 in. wg (750 Pa) static pressure class.

f. The installation of a damper in a lined duct must not damage the liner or cause liner erosion.

C.7 COMMENTARY

Designers must show all required air volume control devices on the contract drawings. Nothing in this document implies an obligation to provide volume control devices that are not on the contract drawings.

The ASHRAE *Systems Handbook* chapter on testing, adjusting, and balancing defines ducts as follows: a main duct serves the system's major or entire fluid flow; a submain serves two or more branch mains; a branch main serves two or more terminals; a branch serves a single terminal. Illustrating dampers on contract drawings relieves contractors from interpreting damper requirements.

The damper designs illustrated in SMACNA *HVAC-DCS* (Second Edition, 1995) Figures 2-12 and 2-13 (*See* Example Figure C-16) are for reduced volume control, not for positive shut off. Modified versions can be constructed for tight shut off.

OBD (opposed blade damper) devices installed with grilles and diffusers should not be relied on to take more than ¼ to ½ closure without noise.

Single-blade or opposed-blade dampers are preferred over splitters.

Orifice plates or perforated metal with required pressure-drop characteristics may be used in lieu of dampers to set up permanent loss in duct runs.

Multiblade damper styles are normally parallel blade for two position operation; opposed blade for modulating position.

Dampers with blade lengths over 48 in. (1220 mm) are normally sectioned horizontally.

Motor operators for dampers should develop sufficient torque to operate properly. The motor supplier should select operators carefully. In certain cases, a fire damper may be used for flow rate control. if it serves a dual function, its operation as a fire damper must not be impaired. The installation must not develop noise or vibration.

Volume control devices that are capable of throttling flow over wide pressure differentials without generating noise are normally special procurement items. Low-pressure drop dampers should not be used for wide-pressure differentials.

Consult duct design texts and manufacturer's data for loss coefficients.

The designer must carefully evaluate pressure change in ducts and provide pressure relief measures where necessary. System status changes, as in smoke control mode or energy conservation use, impose different requirements for normally open, normally closed, and modulating dampers.

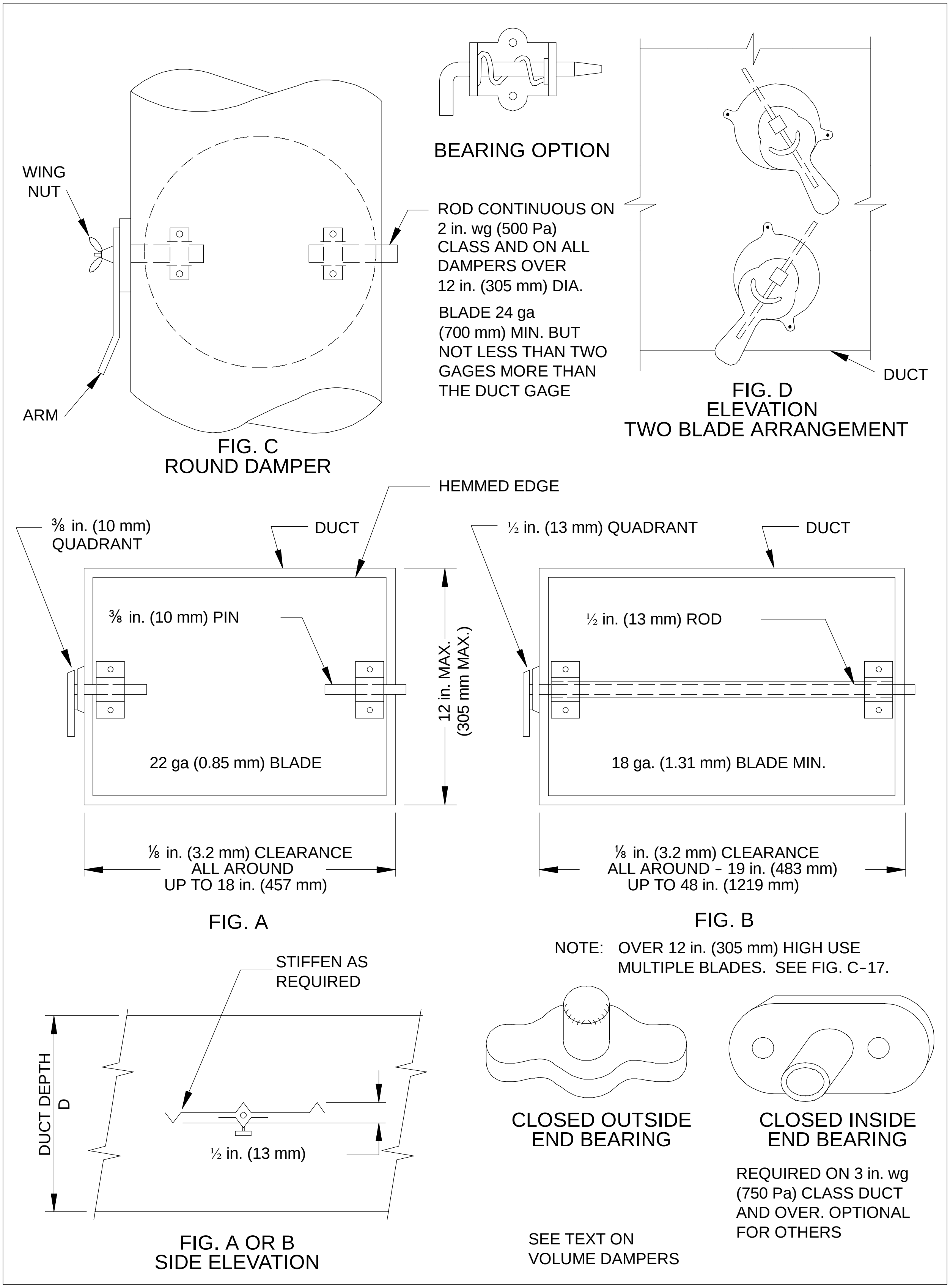


FIGURE C-16 VOLUME DAMPERS – SINGLE BLADE TYPE

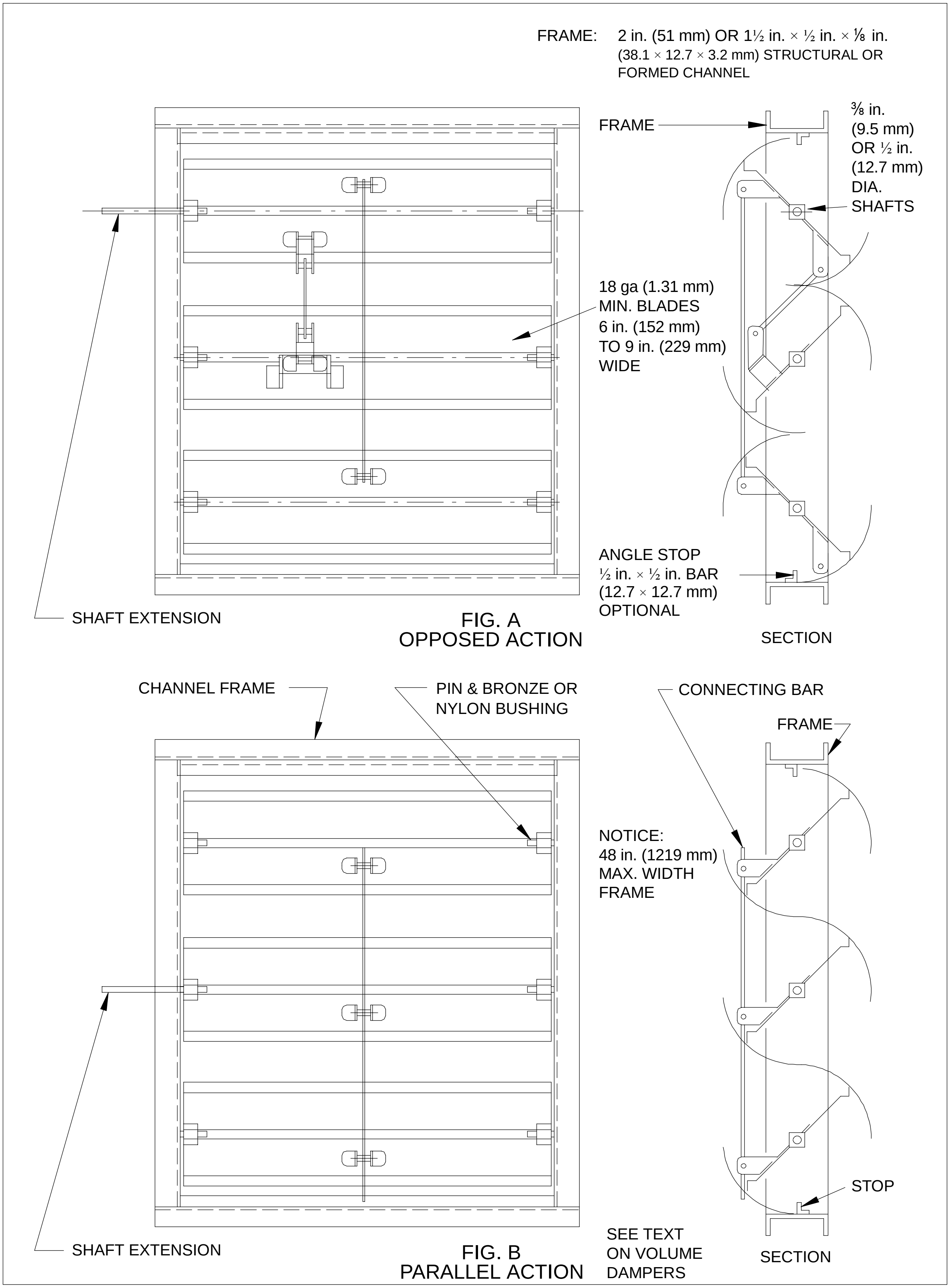


FIGURE C-17 MULTIBLADE VOLUME DAMPERS

OFFSETS 2 AND 3 TRANSITIONS MAY HAVE EQUAL OR UNEQUAL INLET AND OUTLET AREAS. TRANSITIONS MAY CONVERT DUCT PROFILES TO ANY COMBINATION FOR RECTANGULAR, ROUND, OR FLAT OVAL SHAPES.

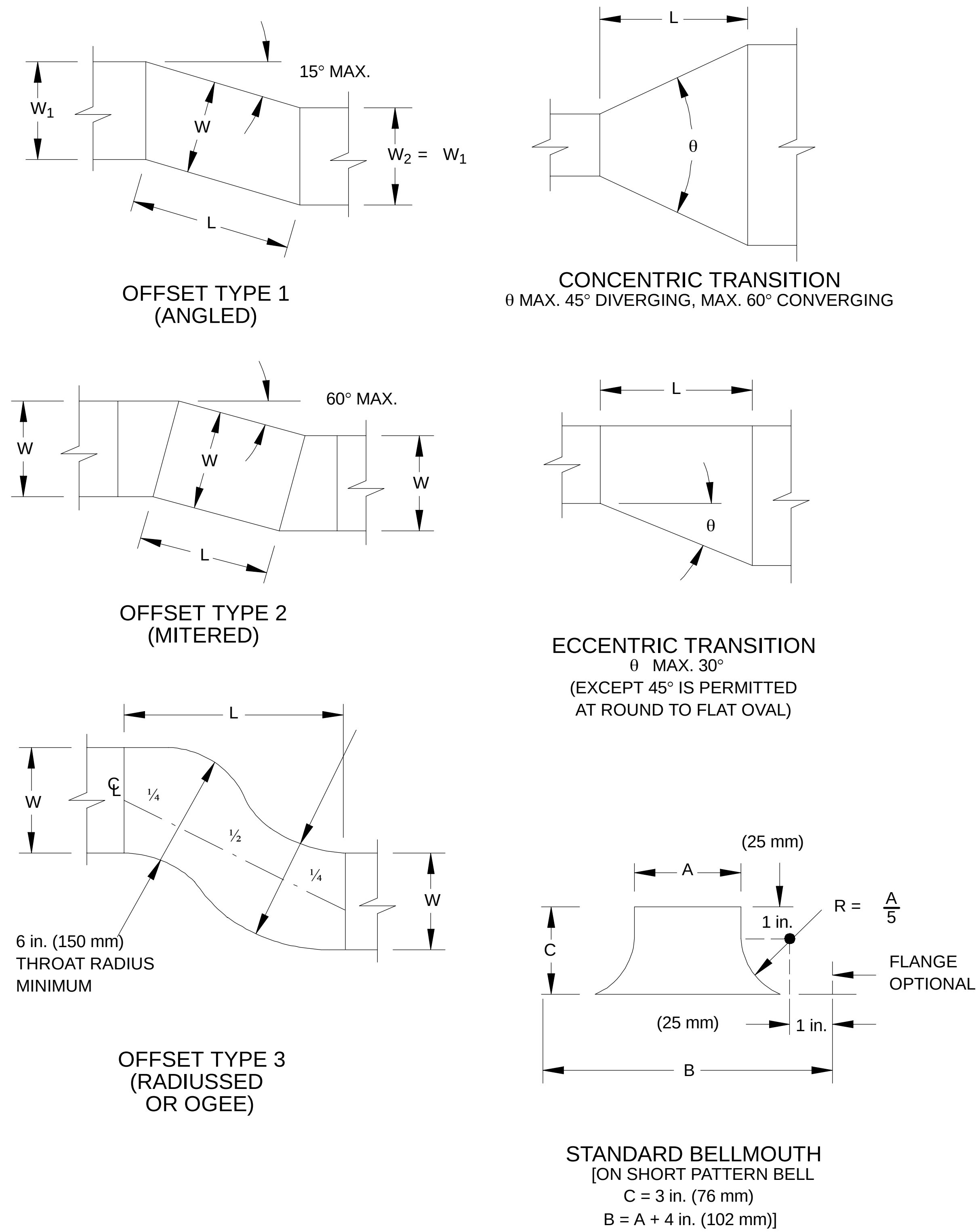
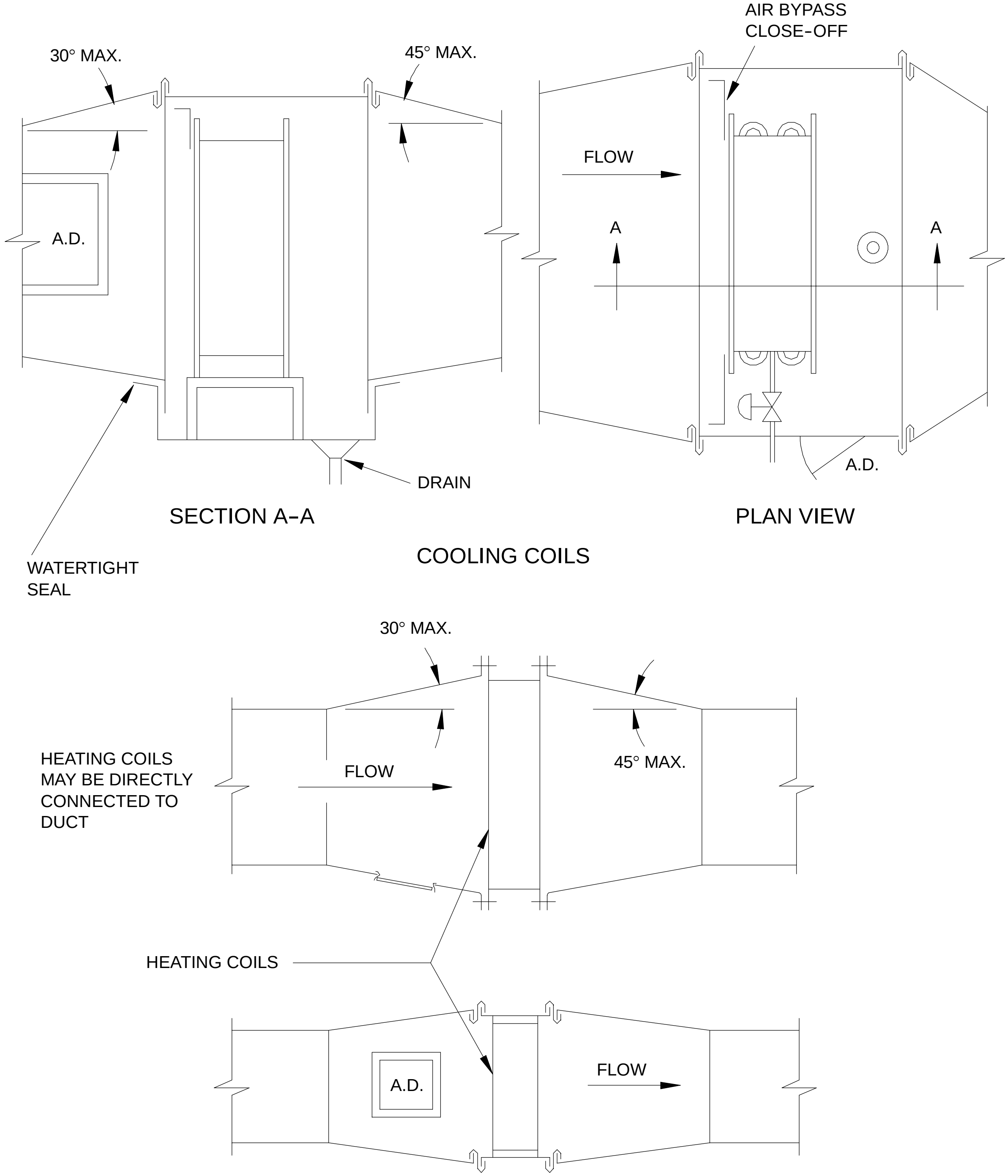


FIGURE C-18 OFFSETS AND TRANSITIONS

PREFERABLY, DIRECT EXPANSION COILS SHOULD HAVE THE CONTROL VALVE INSIDE THE DUCT, AS SHOWN. WITH WATER COILS, VALVE LOCATION IS OPTIONAL BUT RETURN BENDS AND HEADERS SHOULD BE INSIDE THE DUCT AS FOR DX COILS.



DESIGNERS SHOULD SPECIFY ACCEPTABLE COIL FRAME LEAKAGE OR PLACE THE COIL IN THE DUCT.

FIGURE C-19 REMOTE HEATING AND COOLING COIL INSTALLATIONS

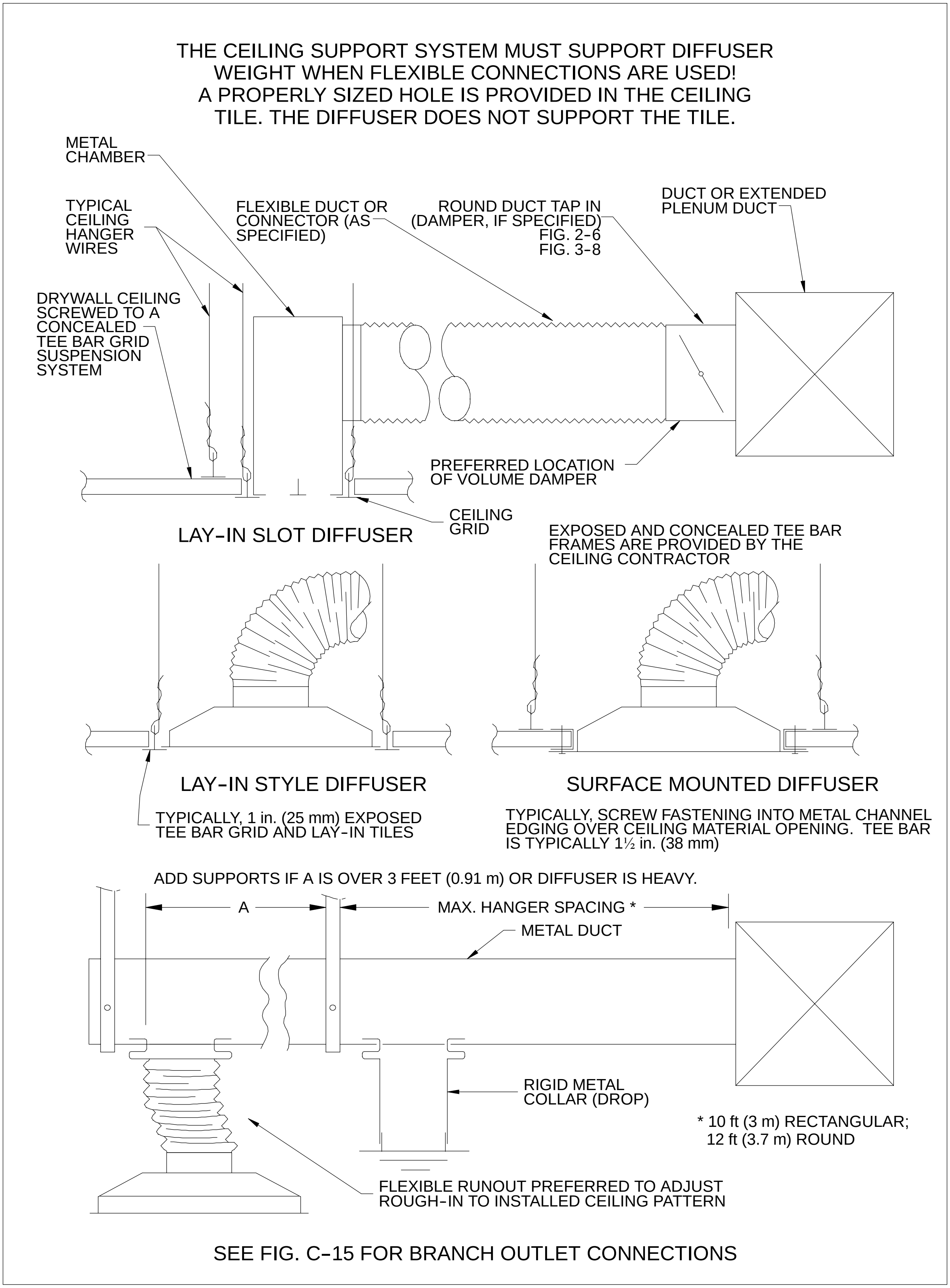


FIGURE C-20 CEILING DIFFUSER BRANCH DUCTS

C.8 SPECIFICATION FOR SUPPORTING FLEXIBLE DUCT

S1.24 Flexible duct shall be supported at the manufacturer's recommended intervals but at least every 5 ft (1.5m). Maximum permissible sag is a ½ in. per ft (41.7 mm/m) of spacing between supports. A connection to another duct or to equipment is considered a support point.

S1.25 Hanger or saddle material in contact with the flexible duct shall be wide enough so that it does not reduce the internal diameter of the duct when the supported section rests on the hanger or saddle material. In no case will the material contacting the flexible duct be less than 1 in. (25.4 mm) wide. Narrower hanger material may be used in conjunction with a sheet metal saddle that meets this specification. This saddle must cover one-half the circumference of the outside diameter of the flexible duct and fit neatly around the lower half of the duct's outer circumference.

S1.26 Factory-installed suspension systems that are integral to the flexible duct are acceptable for hanging when the manufacturer's recommended procedures are followed.

S1.27 Hangers shall be adequately attached to the building structure.

S1.28 To avoid tearing the vapor barrier, do not support the entire weight of the flexible duct on any one hanger during installation. Avoid contacting the flexible duct with sharp edges of the hanger material. Damage to the vapor barrier may be repaired with approved tape. If the internal core is penetrated, replace the flexible duct or treat the tear as a connection.

S1.29 Terminal devices connected by flexible duct shall be supported independently of the flexible duct.

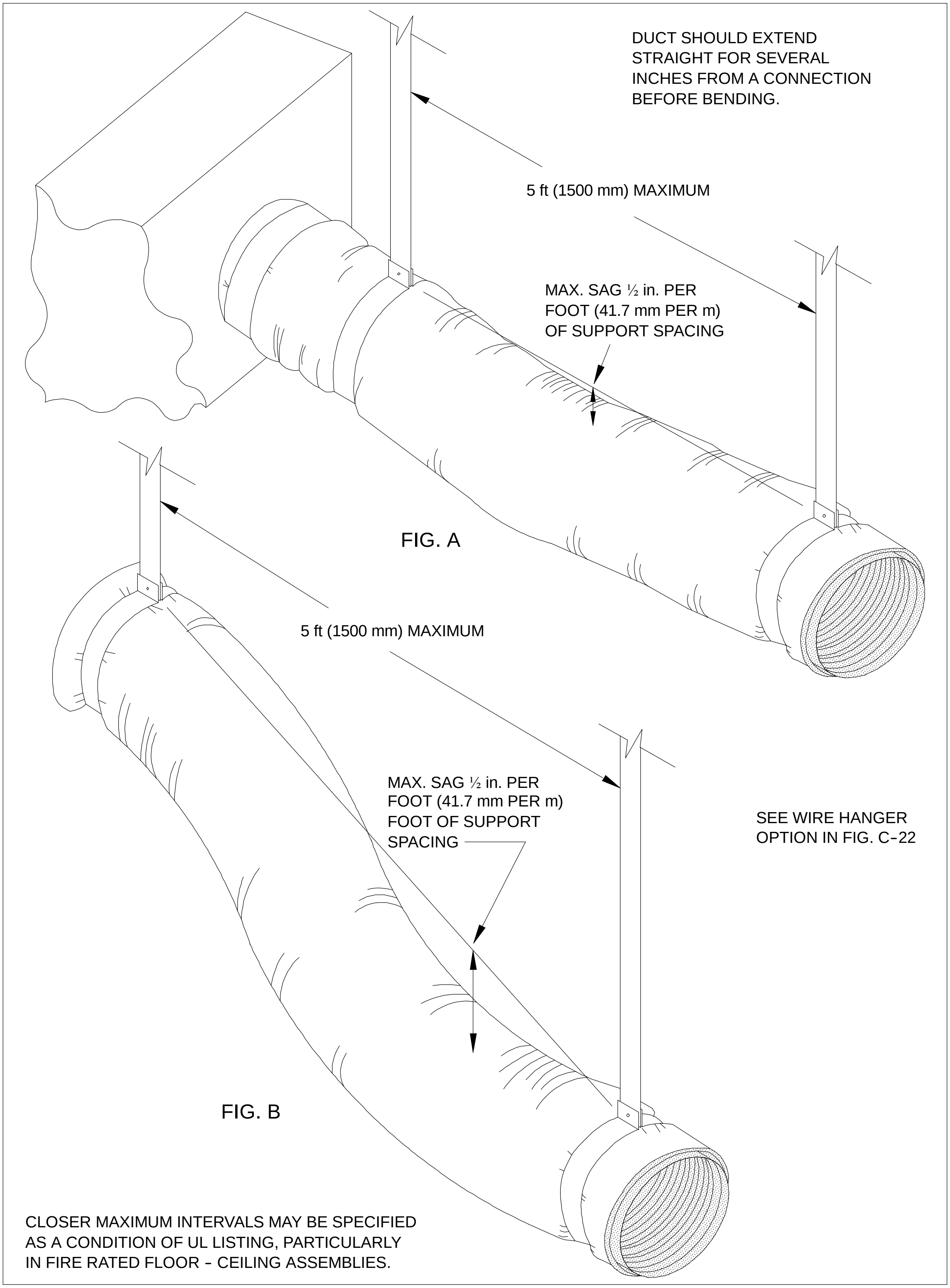


FIGURE C-21 FLEXIBLE DUCT SUPPORTS

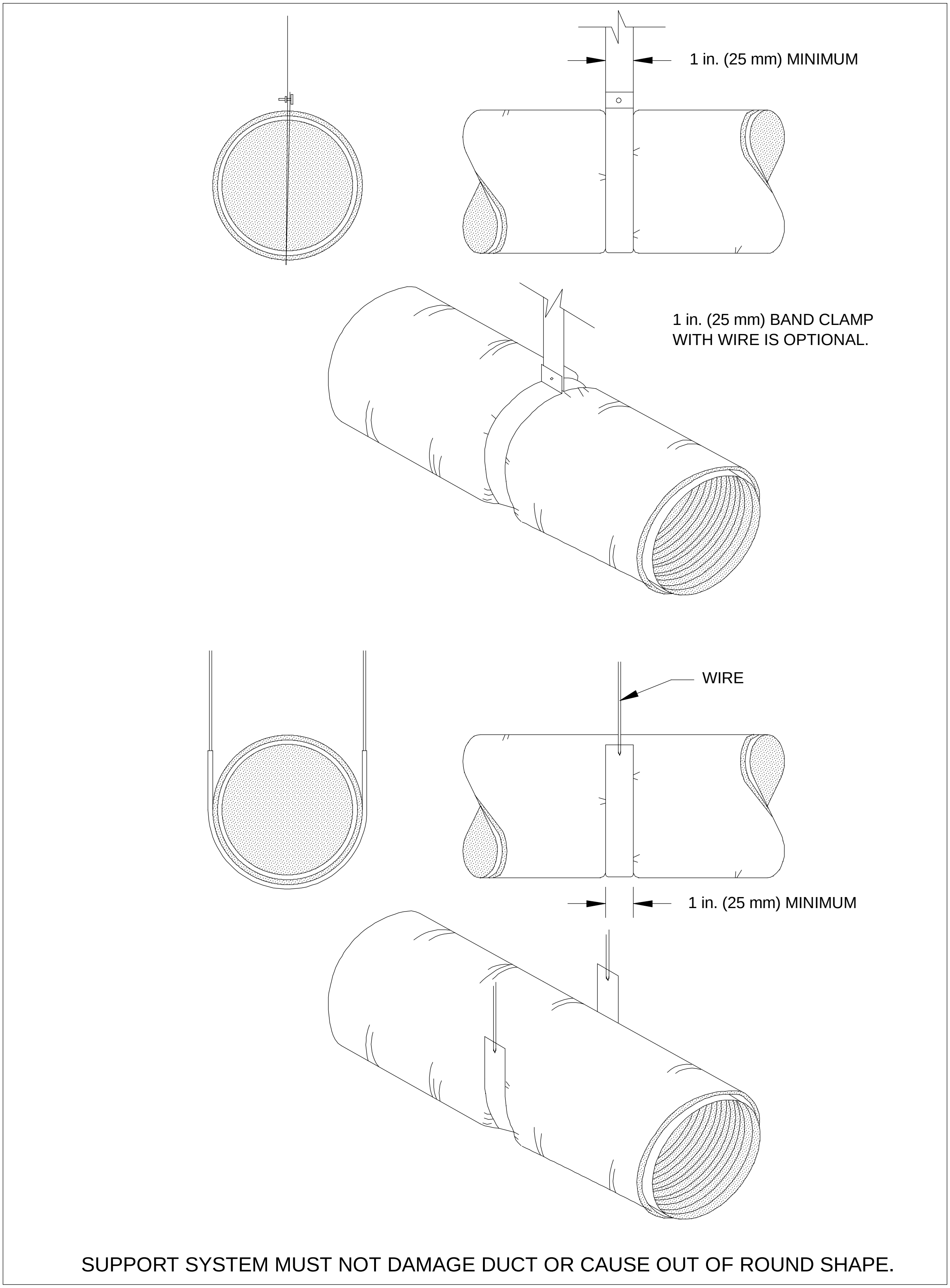


FIGURE C-22 FLEXIBLE DUCT SUPPORTS

C.9 ROUND DUCT CONSTRUCTION STANDARDS

Fitting classes available for designer use in project specifications or contractor selection as being fit for the project specifications that adopt these standards are as follows. Category listings are not intended to preclude different selections for fittings that function as area change, direction change, converging flow, diverging flow, or special purpose. Category listings also do not necessarily apply to their end connections to other fittings, straight duct sections, or equipment.

a. All continuously welded or brazed.

b. Tack or spot welded (and sealed or unsealed).

c. Seam locked (and sealed or unsealed).

d. Rivet, screw, or punched-die-stamp locked (and sealed or unsealed).

The preceding categories may have additional forming prescriptions such as rolled, stamped, gored, spun, pleated, semi-pleated, or other methods. For purposes of distinction, openings in sections of straight ducts to receive taps of any connection method are not deemed to be fittings; but connection thereto may be specified by a prescribed method.

S1.30 Round ducts shall be constructed in accordance with SMACNA *HVAC-DCS* (Second Edition, 1995) Tables 3-2 and 3-3 *(See* Example Table C-8). Table 3-2 is based on G-60 coated galvanized steel of ASTM Standards A653 and A924 grades. Uncoated, polyvinyl coated, aluminum alloy coated or aluminum-zinc alloy coated steel, or stainless steel may be used if a minimum corresponding base metal thickness and material strength is provided. Lockforming quality is required. The use of an alternative material requires specification or approval by a designer.

S1.31 Fittings shall have a wall thickness not less than that specified for longitudinal-seam straight duct in SMACNA *HVAC-DCS* (Second Edition, 1995) Tables 3-2 and 3-3 *(See* Example Table C-8). The diameter of fittings shall be appropriate for mating with sections of the straight duct, equipment, and air terminals to which they connect.

S1.32 Sleeves, collars, and fittings to connect a round duct to a rectangular duct or to flexible ducts shall conform to S1.31 unless a different practice is supported by test data or affidavits confirming suitability for the service. *See* Figures C-15 and C-20.

S1.33 Nothing in this specification is meant to imply that the designer cannot by project specification designate acceptable construction methods.

S1.34 The use of a saddle or direct connection of a branch into a larger duct is acceptable. Where they are used, the diameter of the branch shall not exceed two-thirds of the diameter of the main and protrusions into the interior of the main are not allowed. Direct connection of a branch into a main shall include mechanical attachment sufficient to maintain the integrity of the assembly. All saddle fittings shall be sealed at all pressures.

S1.35 Where other limitations are not stated, mitered elbows shall be based on the velocity of flow and shall be constructed to comply with Table C-7.

S1.36 The illustration of 90° elbows in SMACNA *HVAC-DCS* (Second Edition, 1995) Figure 3-3 does not preclude shapes of less than 90 degrees.

S1.37 Figure C-18 is applicable for in-line offsets.

S1.38 Volume damper construction is provided on pages C.41 and C.42.

S1.39 Ducts shall be suspended in accordance with SMACNA *HVAC-DCS* (Second Edition, 1995) Chapter 4. Additional supports shall be added if necessary to control deflection of ducts or to maintain their alignment at branch intersections. The support system shall not cause out-of-round shape.

S1.40 The requirements of Table C-1 for sealing are applicable.

C.10 COMMENTARY

Round duct has a high strength to weight ratio, uses the least material to convey air at a given friction loss,and is comparatively easy to seal. The wall thickness suitable for positive pressure application is generally less than that for negative pressure. For positive pressure (and low negative pressure), girth ring reinforcement is not necessary. However, rings may be used to maintain the round shape to facilitate handling, shipment, or connection.

The tables indicate that a 10 in. wg (2500 Pa) negative pressure is the maximum classification. Some of the constructions in the tables will qualify at higher negative levels. For spiral ducts, higher negative pressure service information (and bursting pressure in positive mode) is available from industry sources.

Designers should consult SMACNA's *Round Industrial Duct Construction* manual for:

a. construction of any system carrying particulate or corrosive fumes (*i.e.*, systems for other than clean air),

b. use of high negative pressure construction or (conservatively) for higher positive pressure than this document provides for,

c. extended hanger spacing,

d. engineering design of bolted flanged joints,

e. negative pressure construction alternatives, and

f. negative pressure service levels over 10 in. wg (2500 Pa) including spiral seam ducts.

This manual also does not indicate preference for any one type of longitudinal seam. The length of straight longitudinal seam duct will generally be determined by the size of the fabricator's rolling equipment. The length of spiral seam duct is limited by considerations such as in-line fitting frequency, potential for damage in shipment, maneuverability of the sections on the job, the number of support points needed to place the duct in its final location, and other factors.

The most popular transverse joints are the slip or lap types. The flanged joint is used in ducts over 60 in. (1524 mm) in diameter because of its advantage in retaining the circular shape.

Access to joints for makeup and orientation in vertical or horizontal positions will influence the choice of connection.

The SMACNA *HVAC Duct Systems Design* manual and the ASHRAE *Fundamentals Handbook* chapter on duct design contain far more configurations of round fittings than this manual. Friction loss data is provided in these design manuals. Where fittings of comparable or better performance are illustrated in duct design handbooks, designers are encouraged to consider allowing a substitution. Omissions from this document are not intended as prohibitions against using other constructions.

Double-wall rigid round duct is available from several industry sources. It is used for its acoustical value, and the perforated (typically metal) inner wall provides resistance to erosion of the duct liner.

Round spiral seam ducts with thinner than traditional wall thickness and with one or more corrugations (ribs) formed between the lock seams have been introduced in industry. Some of these forms have been tested for compliance with UL Standard 181 and have qualified for Class O listing. As the industry develops more experience with these in installation and service, and as more functional performance criteria are identified, it is anticipated that such forms will be added to SMACNA construction standards. Authorities and contractors are invited to evaluate them by information currently available.

PRECAUTION: Small differences occur in the diameter of ducts and fittings. Proper clearances are necessary. Verify suitability of fit, particularly when procurement is from outside sources.

Duct Velocity	R/D Ratio Centerline Radius to Duct Diameter	Number of Mitered Pieces		
		90 deg.	60 deg.	45 deg.
Up to 1000 fpm (5.08 m/s)	0.6	3	2	2
1001 to 1500 fpm (5.09 to 7.62 m/s)	1.0	4	3	2
Above 1500 fpm (7.62 m/s)	1.5	5	4	3

Table C–7 Mitered Elbows

MAX. DIA. (in.)	+2 in. wg		+4 in. wg		+10 in. wg	
	Spiral Seam	Long. Seam	Spiral Seam	Long. Seam	Spiral Seam	Long. Seam
6	28	28	28	28	28	28
8	28	28	28	28	28	26
10	28	26	28	26	28	26
12	28	26	28	26	26	24
14	28	26	26	24	26	24
16	26	24	26	24	24	22
18	26	24	24	24	24	22
19–26	26	24	24	22	24	22
27–36	24	22	22	20	22	20
37–50	22	20	20	20	20	20
51–60	20	18	18	18	18	18
61–84	18	16	18	16	18	16

Table C-8 Round Duct Gage Unreinforced Positive Pressure

REFERENCES FOR ROUND DUCT CONSTRUCTION

1. Pressure and Velocity Classification, SMACNA *HVAC-DCS* (Second Edition, 1995) page 1.6.

2. Sealing requirements, Table C-1.

3. Specifications for duct and fittings, section C.9.

4. Longitudinal seams, SMACNA *HVAC-DCS* (Second Edition, 1995) page 3.7.
   NOTE: Figure C-23 has other pressure limits.

5. Transverse joints, SMACNA *HVAC-DCS* (Second Edition, 1995) page 3.9.
   NOTE: Figure C-24 has other pressure limits.

6. Elbows, SMACNA *HVAC-DCS* (Second Edition, 1995) page 3.10.

7. Inline offsets and transitions, Figure C-18.

8. Tees and laterals, SMACNA *HVAC-DCS* (Second Edition, 1995) pages 3.11 and 3.12.

9. Rectangular main to round branch, Figure C-15.

10. Flexible connections, SMACNA *HVAC-DCS* (Second Edition, 1995) pages 3.15 to 3.18. *See* SMACNA *HVAC-DCS* (Second Edition, 1995) pages 3.16 and 3.18.

11. Dampers, Figure C-16.

12. Access doors, SMACNA *HVAC-DCS* (Second Edition, 1995) page 2.14.

13. Hangers, Table C-10.

14. Aluminium duct Schedule, SMACNA *HVAC-DCS* (Second Edition, 1995) page 3.7.

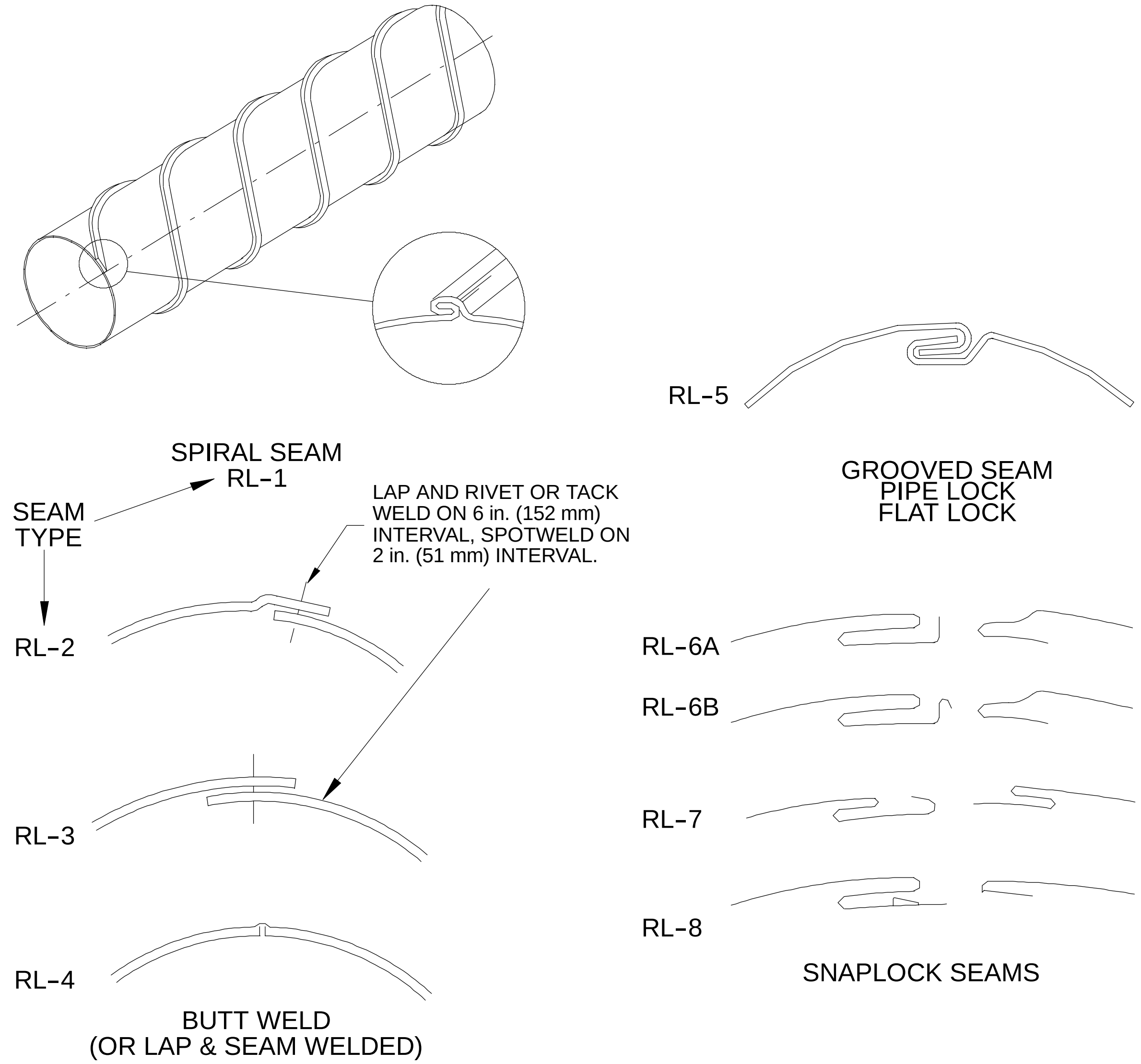
15. Polyvinyl coated steel or stainless steel: Use galvanized steel schedule, Table B-1.

MAX. DIA. (mm)	+500 Pa		+1000 Pa		+2500 Pa	
	Spiral Seam	Long. Seam	Spiral Seam	Long. Seam	Spiral Seam	Long. Seam
150	0.48	0.48	0.48	0.48	0.48	0.48
200	0.48	0.48	0.48	0.48	0.48	0.55
250	0.48	0.55	0.48	0.55	0.48	0.55
300	0.48	0.55	0.48	0.55	0.55	0.70
360	0.48	0.55	0.55	0.70	0.55	0.70
400	0.55	0.70	0.55	0.70	0.70	0.85
460	0.55	0.70	0.70	0.70	0.70	0.85
660	0.55	0.70	0.70	0.85	0.70	0.85
910	0.70	0.85	0.85	1.00	0.85	1.00
1270	0.85	1.00	1.00	1.00	1.00	1.00
1520	1.00	1.31	1.31	1.31	1.31	1.31
2130	1.31	1.61	1.31	1.61	1.31	1.61

NOMINAL THICKNESS IN MILLIMETERS.

See reference list on page C.52

Table C-8M Round Duct Gage Unreinforced Positive Pressure

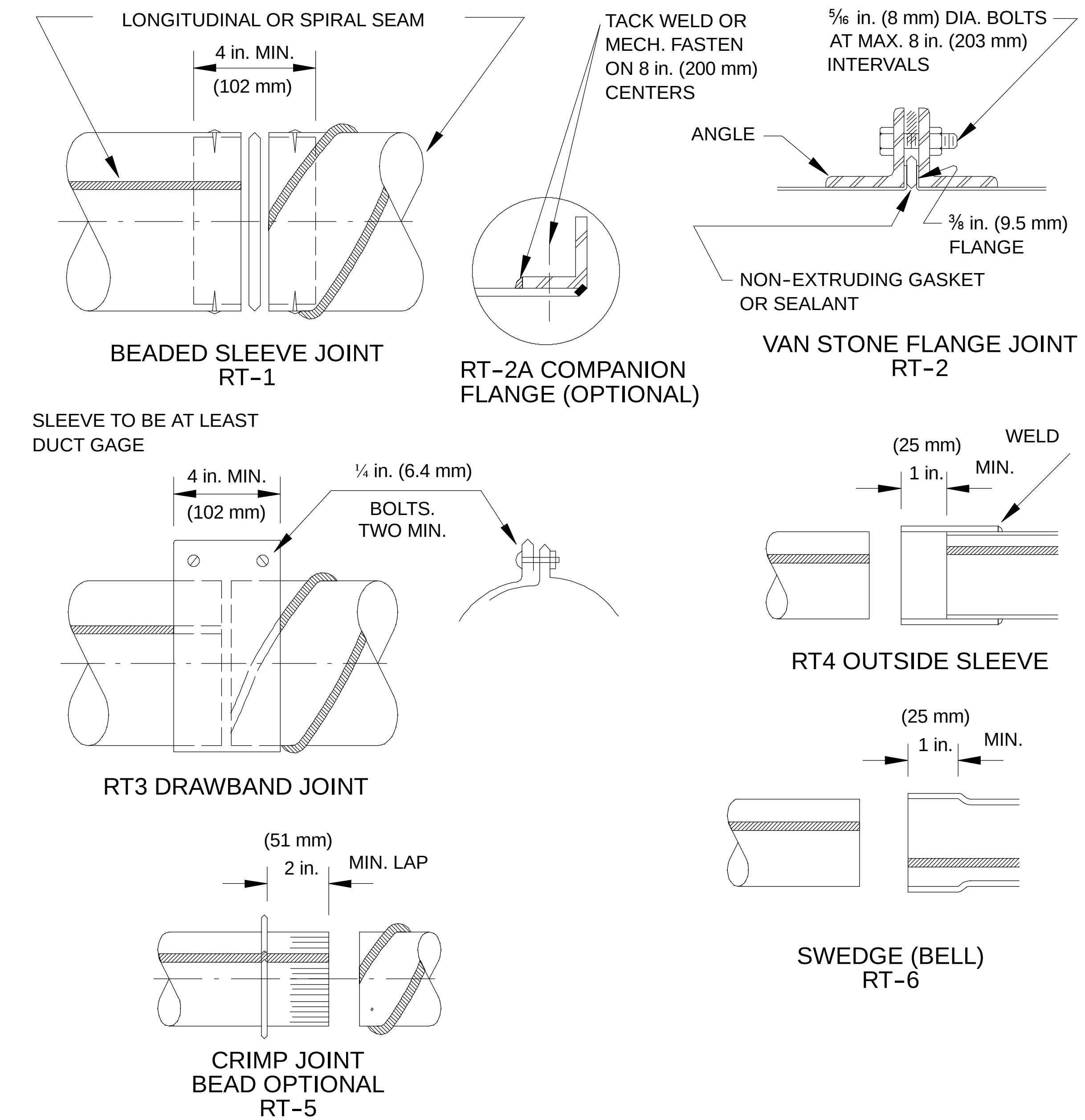


PRESSURE CLASS in. wg (Pa)		SEAM TYPE PERMITTED
POSITIVE		
To +10 in. wg	(2500)	RL–1,4,5 (2*,3*)
To +4 in. wg	(1000)	RL–1,2,3,4,5,
To +2 in. wg	(500)	ALL
NEGATIVE		
To –10 in. wg	(–2500)	RL–1,4 (2*,3*)
To –4 in. wg	(–1000)	RL–1,2,3,4 (5**)
To –1 in. wg	(–250)	ALL

*ACCEPTABLE IF SPOTWELDED ON 1 in. (25 mm) INTERVALS OR TACK WELDED ON 3 in. (75 mm) INTERVALS.

**RL–5 PRESSURE LIMIT IS –3 in. wg (–750Pa)

FIGURE C–23 SEAMS – ROUND DUCT AND FITTINGS



ON JOINTS RT-1, 4, 5 AND 6 SCREWS MUST BE USED AT UNIFORM INTERVALS 15 in. (381 mm) MAXIMUM ALONG THE CIRCUMFERENCE; THREE SCREWS MINIMUM ON 14 in. (35.6 mm) OR LESS DIAMETER.

MIN. FLANGE SIZES FOR RT-2 AND 2A

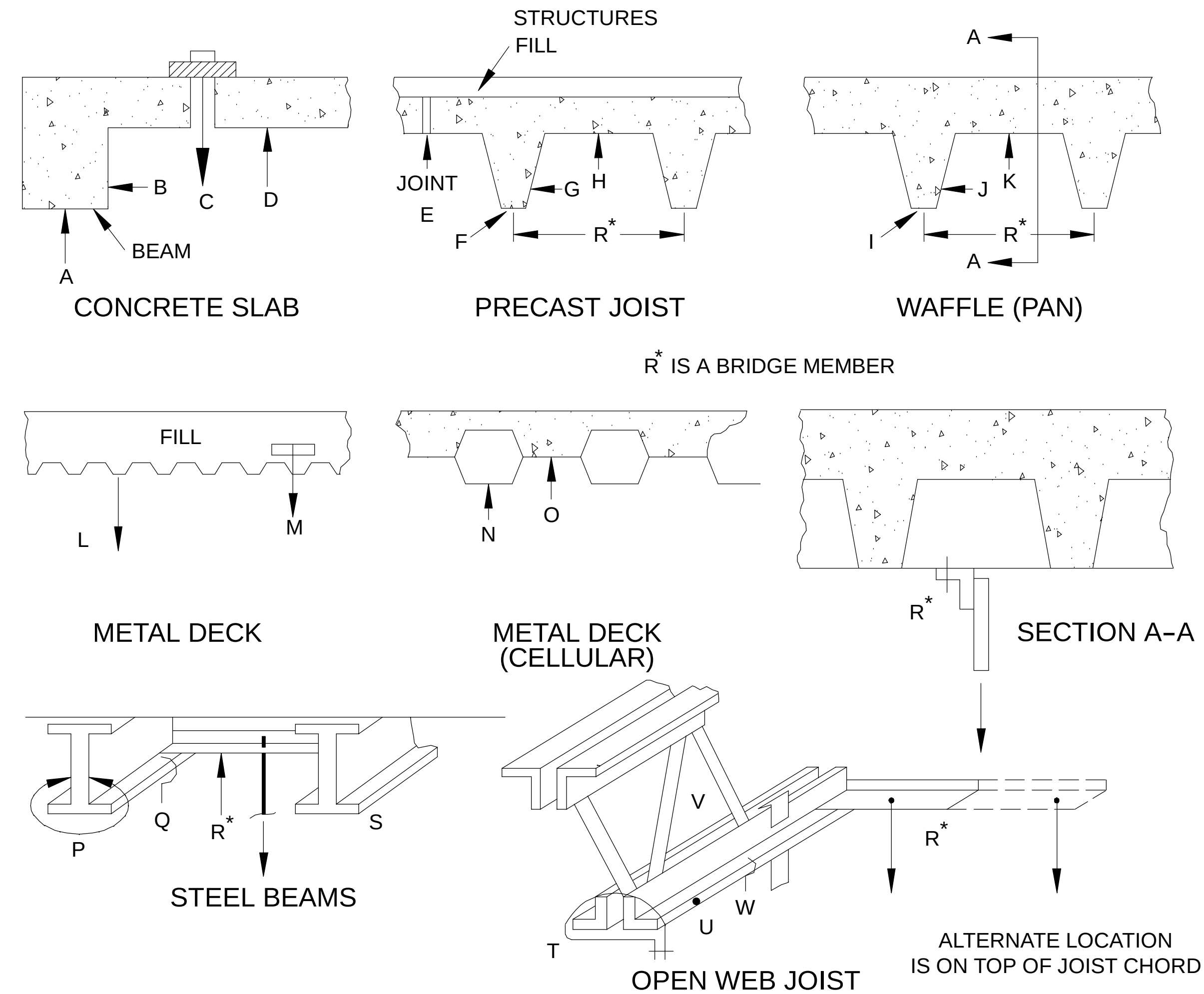
1 in. × 1 in. × 10 ga ON 14 in. MAX DIA.
(38.1 mm × 38.1 mm × 3.2 mm OR 35.6 mm MAX. DIA.)

1½ in. × 1½ in. × ⅛ in. DIA. OVER 14 in.
(38.1 mm × 38.1 mm × 3.2 mm OVER 35.6 mm)

LONGITUDINAL OR SPIRAL SEAM DUCT IS ACCEPTABLE FOR ALL JOINTS EXCEPT RT-4 AND 6 (FOR LONGITUDINAL ONLY)

FIGURE C-24 TRANSVERSE JOINTS - ROUND DUCT

ALPHABET LETTER ONLY INDICATES AN ALTERNATIVE LOCATION OR SITUATION THAT MAY BE PERMITTED OR RESTRICTED BY DESIGN DOCUMENTS. ILLUSTRATIONS OF CONCRETE AND STEEL DO NOT PRECLUDE ATTACHMENTS TO WOOD.



CONVENTIONAL HANGER METHODS AND DEVICES

CONCRETE INSERTS, SINGLE
CONCRETE INSERTS, SLOTTED
POWDER ACTUATED FASTENERS
"C" CLAMPS
WELDED STUDS
FRICTION CLAMPS
STRAP
ROD, THREADED, UNTHREADED
BRIDGE
BEAM CLAMP, HALF FLANGE
BEAM CLAMP, FULL FLANGE
EYE BOLT (OR ROD)
TOGGLE BOLTS

DRILLED HOLE AND BOLT
STANCHION
SELF TAPPING SCREWS PLUS STRAPS
DROP IN EXPANSION ANCHORS
KNEE BRACKET FROM WALL
LAG SCREW EXPANSION ANCHOR
NAILED PIN FASTENERS
RIVETS
SWAY BRACING
"FISH" PLATE OR WASHER AND ROD
HOOK OR LOOP
VIBRATION ISOLATOR
WIRE

SELECT HANGERS FOR TYPE OF STRUCTURE AND SUSPENSION.
DO NOT EXCEED ALLOWABLE OR SPECIFIED LOAD LIMITS.

ALLOWABLE LOAD ON UPPER ATTACHMENT IS ¼ OF FAILURE LOAD

FIGURE C–25 HANGER ATTACHMENTS TO STRUCTURES

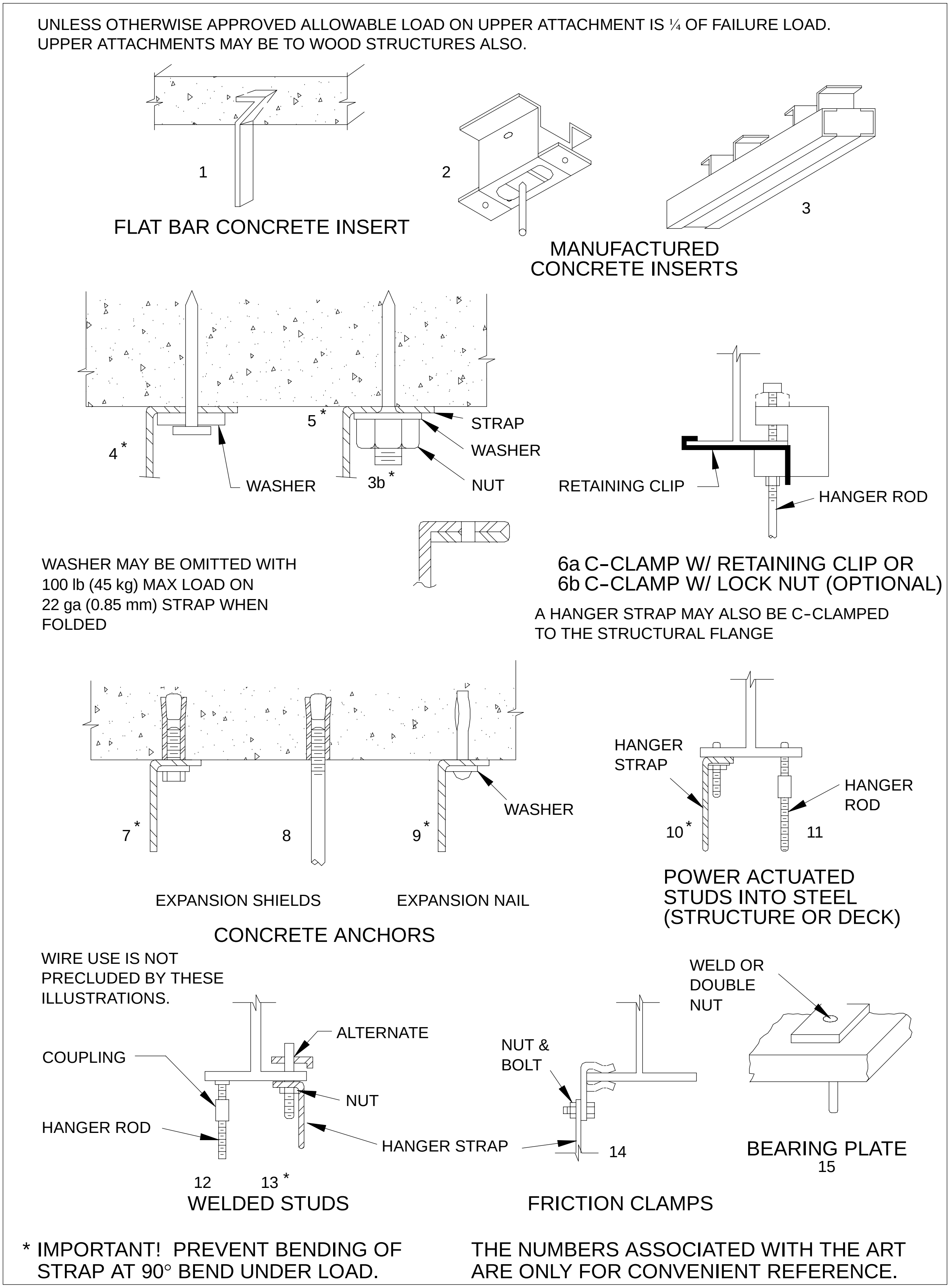


FIGURE C-26 UPPER ATTACHMENT DEVICES - TYPICAL

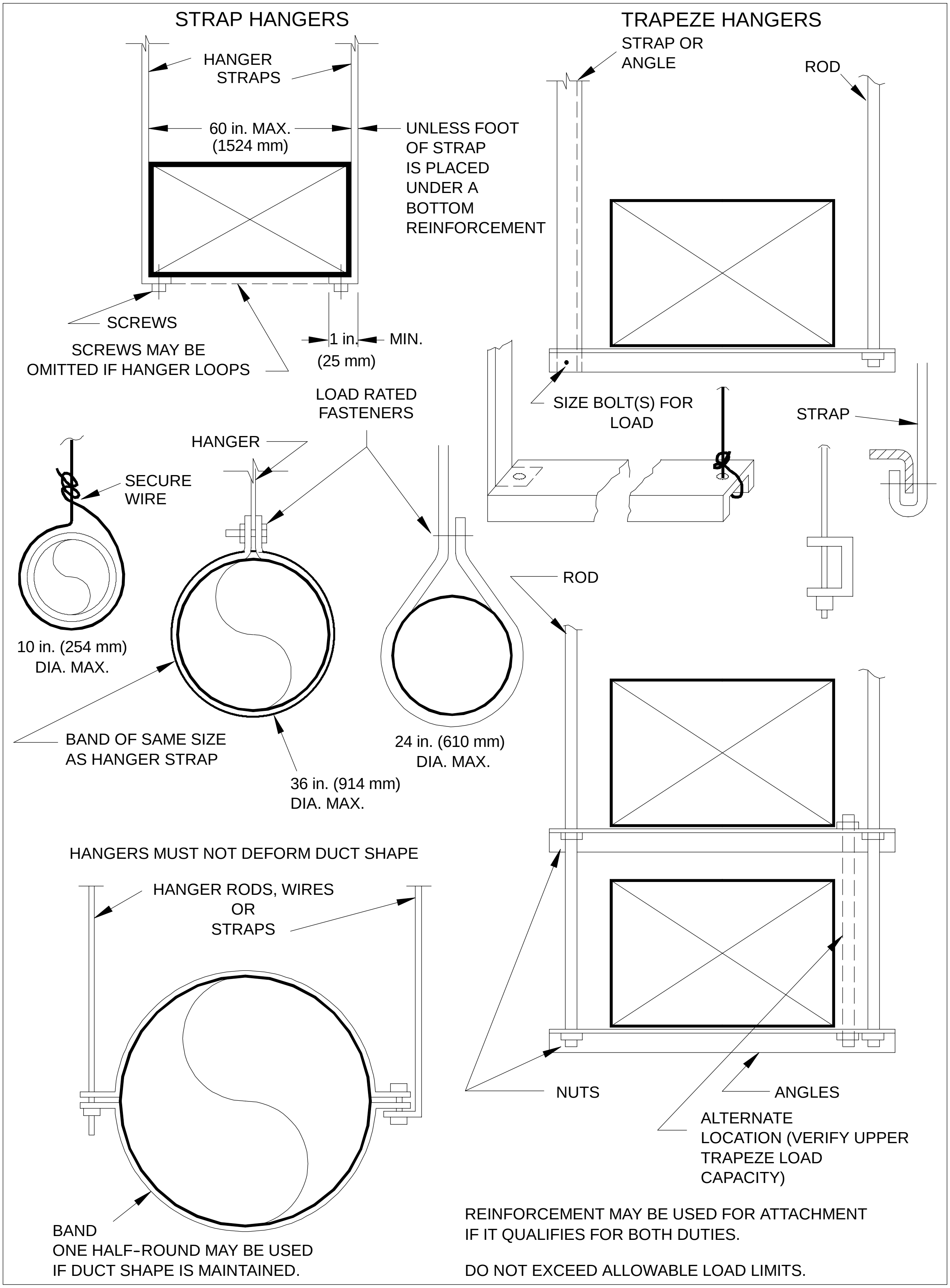


FIGURE C-27 LOWER HANGER ATTACHMENTS

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MAXIMUM HALF OF DUCT PERIMETER	Pair at 10 ft Spacing		Pair at 8 ft Spacing		Pair at 5 ft Spacing		Pair at 4 ft Spacing	
	STRAP	**WIRE/ ROD**	**STRAP**	**WIRE/ ROD**	**STRAP**	**WIRE/ ROD**	**STRAP**	**WIRE/ ROD**
P/2 = 30 in.	1 in. × 22 ga	10 ga (.135 in.)	1 in. × 22 ga	10 ga (.135 in.)	1 in. × 22 ga	12 ga (.106 in.)	1 in. × 22 ga	12 ga (.106 in.)
P/2 = 72 in.	1 in. × 18 ga	⅜ in.	1 in. × 20 ga	¼ in.	1 in. × 22 ga	¼ in.	1 in. × 22 ga	¼ in.
P/2 = 96 in.	1 in. × 16 ga	⅜ in.	1 in. × 18 ga	⅜ in.	1 in. × 20 ga	⅜ in.	1 in. × 22 ga	¼ in.
P/2 = 120 in.	1½ in. × 16 ga	½ in.	1 in. × 16 ga	⅜ in.	1 in. × 18 ga	⅜ in.	1 in. × 20 ga	¼ in.
P/2 = 168 in.	1½ in. × 16 ga	½ in.	1½ in. × 16 ga	½ in.	1 in. × 16 ga	⅜ in.	1 in. × 18 ga	⅜ in.
P/2 = 192 in.	Not Given	½ in.	1½ in. × 16 ga	½ in.	1 in. × 16 ga	⅜ in.	1 in. × 16 ga	⅜ in.
P/2 = 193 in. up	SPECIAL ANALYSIS REQUIRED							

WHEN STRAPS ARE LAP JOINED
USE THESE MINIMUM FASTENERS:

1 in. × 18, 20, 22 ga -two #10 or one ¼ in. bolt
1 in. × 16 ga -two ¼ in. dia.
1½ in. × 16 ga -two ⅜ in. dia.
Place fasteners in series, not side by side.

SINGLE HANGER MAXIMUM ALLOWABLE LOAD	
STRAP	WIRE OR ROD (Dia.)
1 in. × 22 ga - 260 lbs 1 in. × 20 ga - 320 lbs 1 in. × 18 ga - 420 lbs 1 in. × 16 ga - 700 lbs 1½ in. × 16 ga - 1100 lbs	0.106 in. - 80 lbs 0.135 in. - 120 lbs 0.162 in. - 160 lbs ¼ in. - 270 lbs ⅜ in. - 680 lbs ½ in. - 1250 lbs ⅝ in. - 2000 lbs ¾ in. - 3000 lbs

Table C-9 Rectangular Duct Hangers Minimum Size

NOTES:

1. Dimensions other than gage are in inches.
2. Tables allow for duct weight, 1 lb/sf insulation weight and normal reinforcement and trapeze weight, but no external loads!
3. For custom design of hangers, designers may consult SMACNA's *Rectangular Industrial Duct Standards,* the AISI *Cold Formed Steel Design Manual,* and the AISC *Steel Construction Manual.*
4. Straps are galvanized steel; other materials are uncoated steel.
5. Allowable loads for P/2 assume that ducts are 16 ga maximum, except that when maximum duct dimension (w) is over 60 in. then p/2 maximum is 1.25 w.
6. For upper attachments *see* Figure C-26.
7. For lower attachments *see* Figure C-27.
8. For trapeze sizes *see* SMACNA *HVAC-DCS* (Second Edition, 1995) Table 4-3 and Figure 4-5.
9. 12, 10, or 8 ga wire is steel of black annealed, bright basic, or galvanized type.

MAXIMUM HALF OF DUCT PERIMETER	Pair at 3 m Spacing		Pair at 2.4 m Spacing		Pair at 1.5 m Spacing		Pair at 1.2 m Spacing	
	STRAP	WIRE/ ROD	STRAP	WIRE/ ROD	STRAP	WIRE/ ROD	STRAP	WIRE/ ROD
P/2 = 760	25.4 × 0.85	3.4	25.4 × 0.85	3.4	25.4 × 0.85	2.7	25.4 × 0.85	2.7
P/2 = 1830	25.4 × 1.31	9.5	25.4 × 1.00	6.4	25.4 × 0.85	6.4	25.4 × 0.85	6.4
P/2 = 2440	25.4 × 1.61	9.5	25.4 × 1.31	9.5	25.4 × 1.00	9.5	25.4 × 0.85	6.4
P/2 = 3050	38.1 × 1.61	12.7	25.4 × 1.61	9.5	25.4 × 1.31	9.5	25.4 × 1.00	6.4
P/2 = 4270	38.1 × 1.61	12.7	38.1 × 1.61	12.7	25.4 × 1.61	9.5	25.4 × 1.31	9.5
P/2 = 4880	Not Given	12.7	38.1 × 1.61	12.7	25.4 × 1.61	9.5	25.4 × 1.61	9.5
P/2 = More	SPECIAL ANALYSIS REQUIRED							

WHEN STRAPS ARE LAP JOINED USE THESE MINIMUM FASTENERS:	SINGLE HANGER MAXIMUM ALLOWABLE LOAD	
	STRAP	WIRE OR ROD (Dia.)
25.4 × 1.31, 1.00, 0.85 mm - one 6.4 bolt 25.4 × 1.61 mm - two 6.4 bolts 38.1 × 1.61 mm - two 9.5 bolts Two bolts must be in series, not side by side	25.4 × 0.85 - 118 Kg 25.4 × 1.00 - 145 Kg 25.4 × 1.31 - 191 Kg 25.4 × 1.61 - 318 Kg 38.1 × 1.61 - 500 Kg	2.7 - 36 Kg 3.4 - 54 Kg 4.1 - 73 Kg 6.4 - 122 Kg 9.5 - 308 Kg 12.7 - 567 Kg 15.9 - 907 Kg 19.1 - 1360 Kg

Table C-9M Rectangular Duct Hangers Minimum Size

NOTES:

1. Dimensions other than hanger spacing are in millimeters.
2. Tables allow for duct weight, 4.89 kg/m^2 insulation weight and normal reinforcement and trapeze weight, but no external loads!
3. For custom design of hangers, designers may consult SMACNA's *Rectangular Industrial Duct Standards,* the AISI *Cold Formed Steel Design Manual* and the AISC *Steel Construction Manual.*
4. Straps are galvanized steel; other materials are uncoated steel.
5. Allowable loads for P/2 assume that ducts are 1.61 mm maximum, except that when maximum duct dimension (w) is over 1520 mm then p/2 maximum is 1.25 w.
6. For upper attachments *see* Figure C-26.
7. For lower attachments *see* Figure C-27.
8. For trapeze sizes *see* SMACNA *HVAC-DCS* (Second Edition, 1995) Table 4-3 and Figure 4-5.
9. 2.7, 3.4, and 4.1 mm wire is steel of black annealed, bright basic, or galvanized type.

Dia.	Maximum Spacing	Wire Dia.	Rod	Strap
10 in. dn 250 mm dn	12 ft 3.7 m	One 12 ga One 2.75 mm	¼ in. 6.4 mm	1 in. × 22 ga 25.4 × 0.85 mm
11-18 in.	12 ft	Two 12 ga or One 8 ga	¼ in.	1 in. × 22 ga
460 mm	3.7 m	One 4.27 mm	6.4 mm	25.4 × 0.85 mm
19-24 in. 610 mm	12 ft 3.7 m	Two 10 ga Two 3.51 mm	¼ in. 6.4 mm	1 in. × 22 ga 25.4 × 0.85 mm
25-36 in. 900 mm	12 ft 3.7 m	Two 8 ga Two 2.7 mm	⅜ in. 9.5 mm	1 in. × 20 ga 25.4 × 1.00 mm
37-50 in. 1270 mm	12 ft 3.7 m	**NOT SIZED**	Two ⅜ in. Two 9.5 mm	Two 1 in. × 20 ga (2) 25.4 × 1.00 mm
51-60 in. 1520 mm	12 ft 3.7 m	↓	Two ⅜ in. Two 9.5 mm	Two 1 in. × 18 ga (2) 25.4 × 1.31 mm
61-84 in. 2130 mm	12 ft 3.7 m	↓	Two ⅜ in. Two 9.5 mm	Two 1 in. × 16 ga (2) 25.4 × 1.61 mm

Table C–10 Minimum Hanger Sizes for Round Duct

NOTES:

1. Straps are galvanized steel; rods are uncoated or galvanized steel; wire is black annealed, bright basic, or galvanized steel. All are alternatives.

2. *See* Figure C-27 for lower supports.

3. *See* Figure C-26 and SMACNA *HVAC-DCS* (Second Edition, 1995) Figure 4-3 for upper attachments.

4. Table allows for conventional wall thickness, and joint systems plus one lb/sf (4.89 kg/m^2) insulation weight. If heavier ducts are to be installed, adjust hanger sizes to be within their load limits; *see* allowable loads with Tables C-9 and C-9M. Hanger spacing may be adjusted by special analysis.

5. Designers: For industrial grade supports, including saddles, single load trapeze loads, longer spans and flange joint loads, *see* SMACNA's *Round Industrial Duct Construction Standards.*

6. *See* Figures C-21 and C-22 for flexible duct supports.

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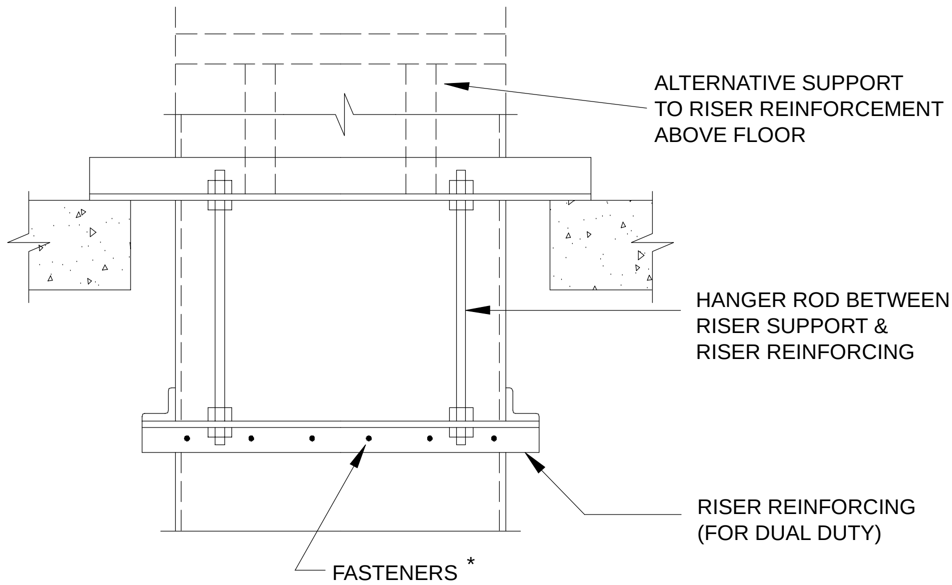
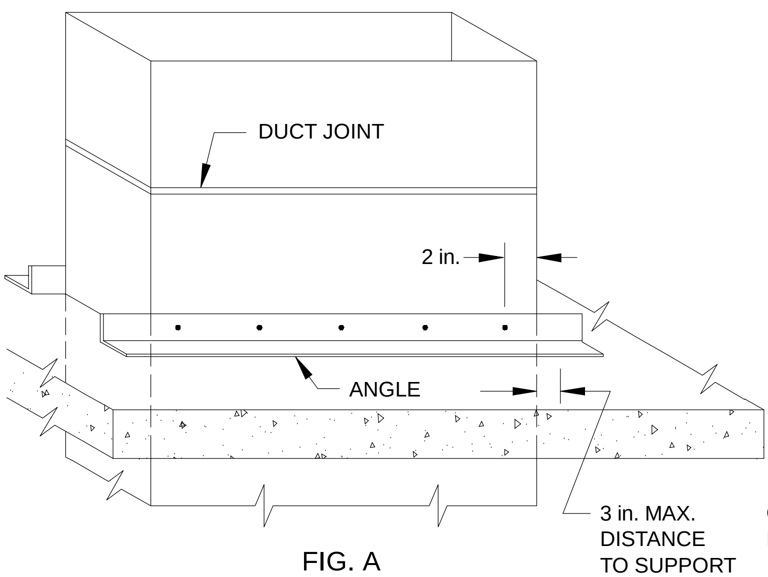


FIG. B

* MINIMUM NUMBER OF FASTENERS ON EACH OF TWO SUPPORT BARS

LARGEST DUCT DIM.	MINIMUM NUMBER OF FASTENERS
16 in. AND DOWN	2
17 in. – 24 in.	3
OVER 24 in.	LARGEST DUCT DIM. DIVIDED BY 8

LOCATE A FASTENER WITHIN 2 in. OF THE DUCT EDGES. LOCATE OTHERS AT EVENLY SPACED INTERVALS. SEE TABLE 4-4 ON PAGE 4.16 IN SMACNA *HVAC-DCS* (Second Edition, 1995).



SUGGESTED SIZING FOR SUPPORT OF 12 ft OF DUCT

DUCT SIZE	ANGLE
36 in. × 18 in.	1½ in. × 1½ in. × ⅛ in.
48 in. × 24 in.	1½ in. × 1½ in. × ⅛ in.
60 in. × 30 in.	1½ in. × 1½ in. × 3/16 in.
60 in. × 60 in.	1½ in. × 1½ in. × ¼ in. OR 2 in. × 2 in. × ⅛ in.

OVER 60 in. – INCREASE ANGLE SIZE AS REQUIRED FOR SPACE & DUCT SIZE

FIG. A

SUPPORT RISERS SO THAT THEY ARE IN TENSION

FIGURE C-28 RISER SUPPORTS – FROM FLOOR

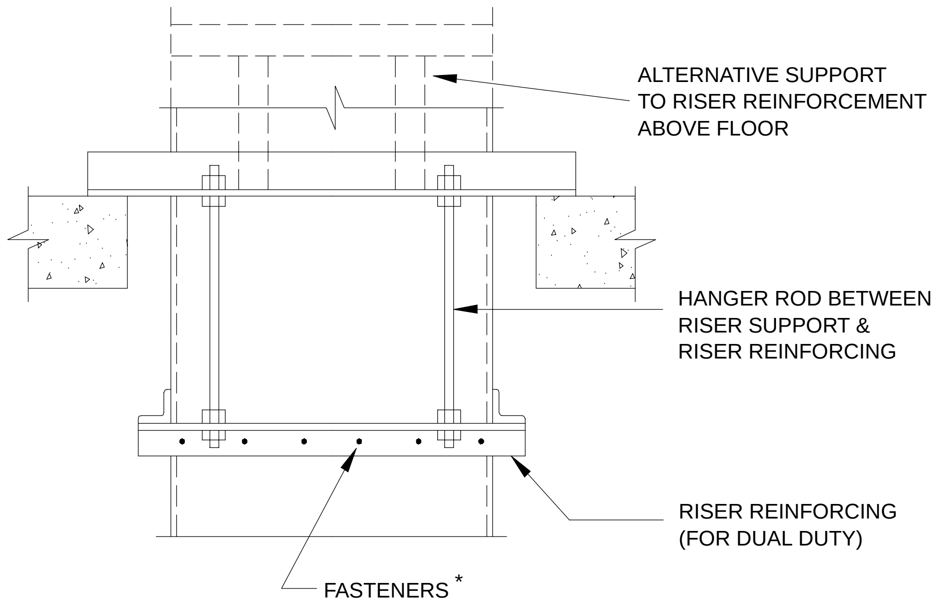


FIG. B

* MINIMUM NUMBER OF FASTENERS ON EACH OF TWO SUPPORT BARS

LARGEST DUCT DIM.	MINIMUM NUMBER OF FASTENERS
406 mm AND DOWN	2
432 mm – 610 mm	3
OVER 610 mm	LARGEST DUCT DIM. DIVIDED BY 8

LOCATE A FASTENER WITHIN 51 MM OF THE DUCT EDGES. LOCATE OTHERS AT EVENLY SPACED INTERVALS. SEE TABLE 4-4 ON PAGE 4-16 IN SMACNA *HVAC-DCS* (Second Edition, 1995).

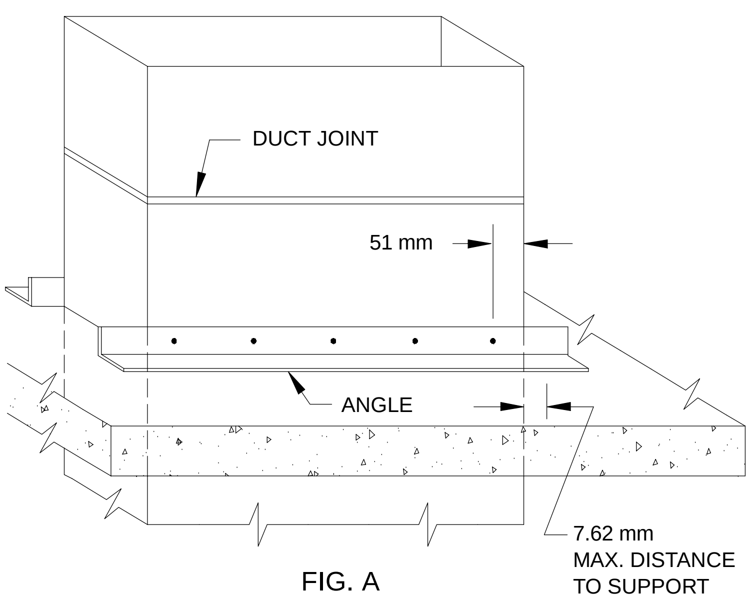


FIG. A

SUGGESTED SIZING FOR SUPPORT OF 3.7 m OF DUCT

DUCT SIZE	ANGLE
914 × 457 mm	38.1 × 38.1 × 3.2 mm
1219 × 610 mm	38.1 × 38.1 × 3.2 mm
1524 × 762 mm	38.1 × 38.1 × 4.8 mm
1524 × 1524 mm	38.1 × 38.1 × 6.4 mm or 51 × 51 × 3.2 mm

OVER 1524 mm – INCREASE ANGLE SIZE AS REQUIRED FOR SPACE & DUCT SIZE

FIGURE C-28M RISER SUPPORTS – FROM FLOOR

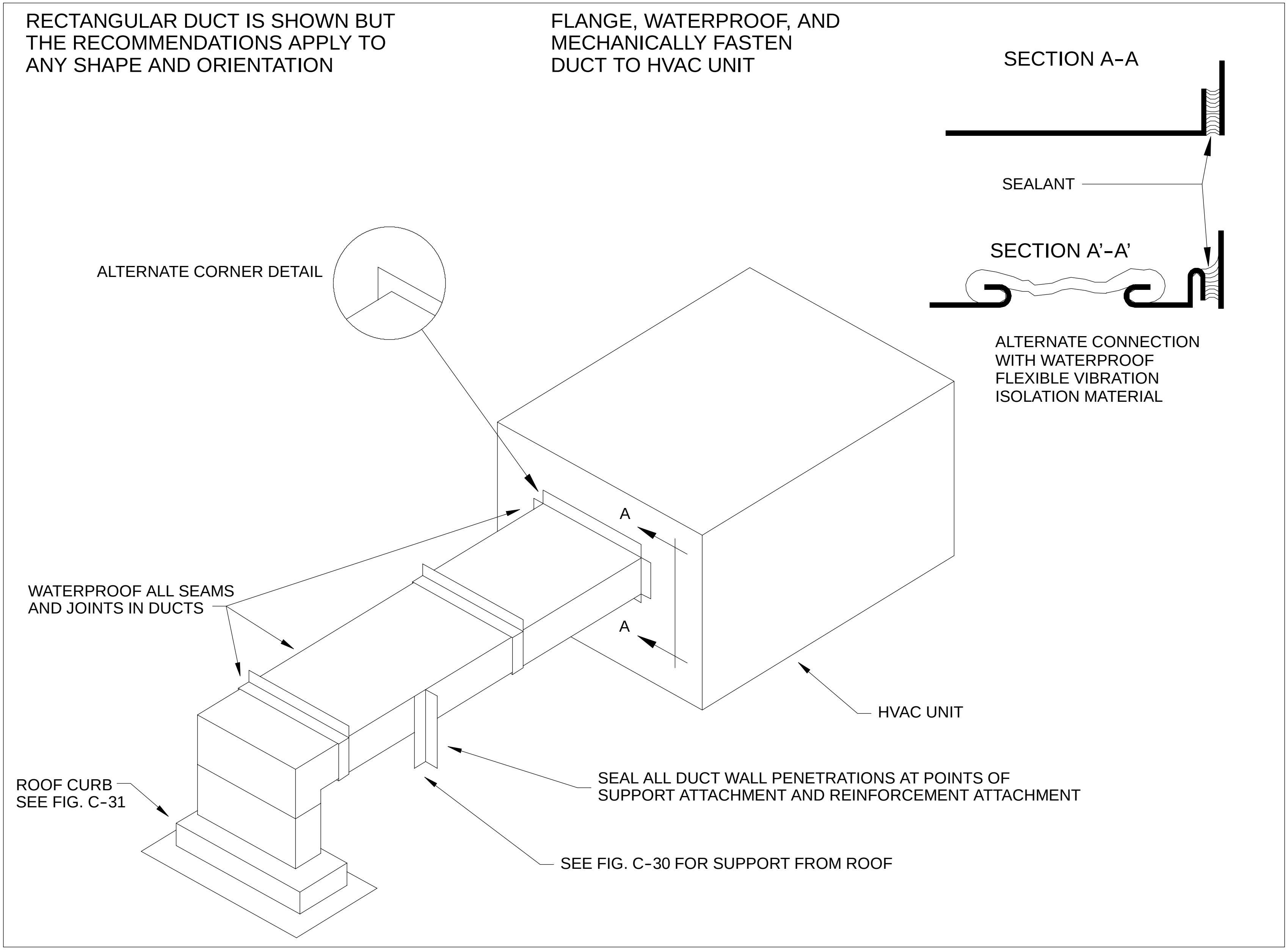
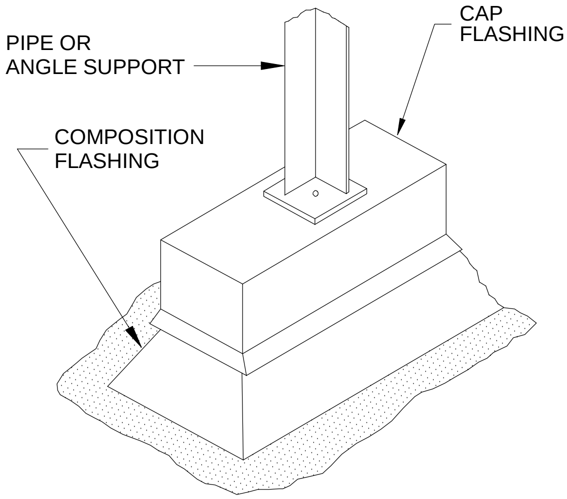
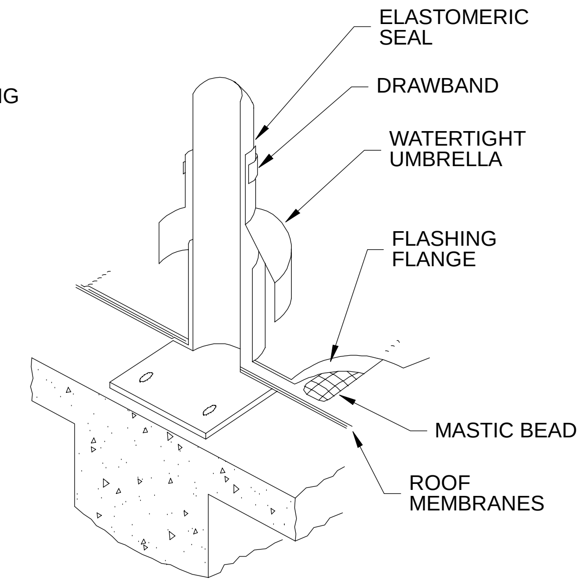


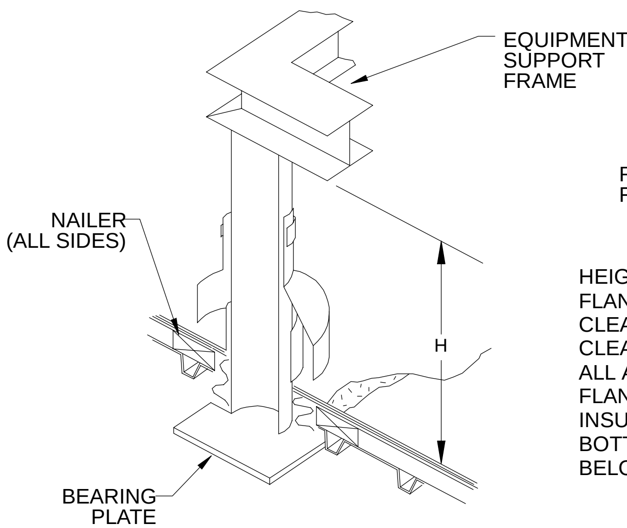
FIGURE C-29 ROOFTOP DUCT INSTALLATION



PIER OR CURB BASE



CONCRETE DECK



INSULATED STEEL DECK

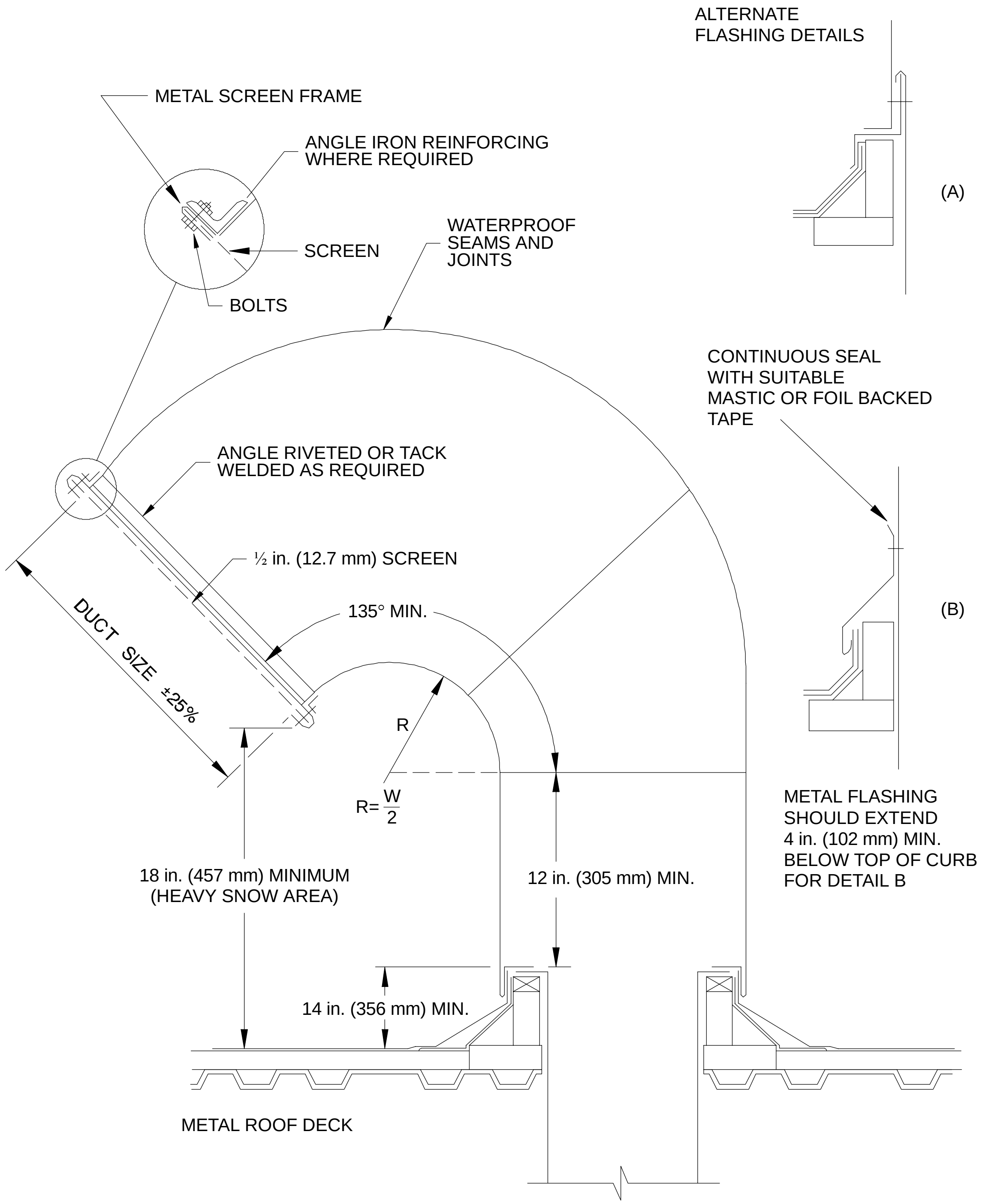
ROOF JACK
FLASHING REQUIREMENTS

HEIGHT: 8 in. (203 mm) MIN. ABOVE ROOF
FLANGE: 3 in. TO 4 in. (76 mm TO 102 mm) WIDTH
CLEARANCE TO PIPE: ¼ in. (6.4 mm) MIN.
CLEARANCE TO UMBRELLA: ¼ in. (6.4 mm) MIN.
ALL ARE SET IN MASTIC AND STRIPPED IN.
FLANGE IS FASTENED TO WOOD NAILER ON
INSULATED DECKS.
BOTTOM OF UMBRELLA TO BE 4 in. (102 mm)
BELOW TOP OF FLASHING.

WIDTH OF EQUIPMENT	HEIGHT H
UP TO 24 in. (610 mm)	14 in. (356 mm)
25 in. TO 36 in. (635 mm TO 914 mm)	18 in. (457 mm)
37 in. TO 48 in. (940 mm TO 1219 mm)	24 in. (610 mm)
49 in. TO 60 in. (1245 mm TO 1524 mm)	30 in. (762 mm)
61 in. (1549 mm) AND WIDER	48 in. (1219 mm)

H CLEARANCE FOR ROOF MAINTENANCE IS RECOMMENDED FOR EQUIPMENT AND DUCTS.

FIGURE C-30 EQUIPMENT AND DUCT SUPPORT FLASHING



SEE ADDITIONAL FLASHING ALTERNATIVES IN THE SMACNA ARCHITECTURAL SHEET METAL MANUAL. CURBS ARE PREFERABLE FOR ALL DUCT PENETRATIONS OF ROOFS.

FIGURE C-31 RECTANGULAR GOOSENECK

C.11 CASING AND PLENUM CONSTRUCTION STANDARDS

S1.41 Unless details are shown otherwise on contract drawings, provide casings and plenums of the designated pressure classification as required by this standard.

S1.42 Submit details selected from the illustrated alternatives for approval of the contracting authority. When equivalent construction is proposed as substitution, clearly identify the substitution. Use construction appropriate for the pressure classification.

S1.43 All casing on the suction side of the fan shall be of 2 in. wg (500 Pa) pressure classification. Casing on fan discharge shall be of the designated pressure class.

S1.44 All joints, seams, connections, and abutments to the building structure shall be sealed with suitable compounds or gaskets.

S1.45 Drains shall have water seals not less than 2 in. wg (500 Pa) greater than the maximum operating pressure in the chamber.

S1.46 Pipe penetrations shall be sealed to prevent air leakage and condensation movement through the seal.

S1.47 Casing material shall be of the same commercial grades as for ducts except that G90 coated galvanized steel shall be used in all chambers with moisture present.

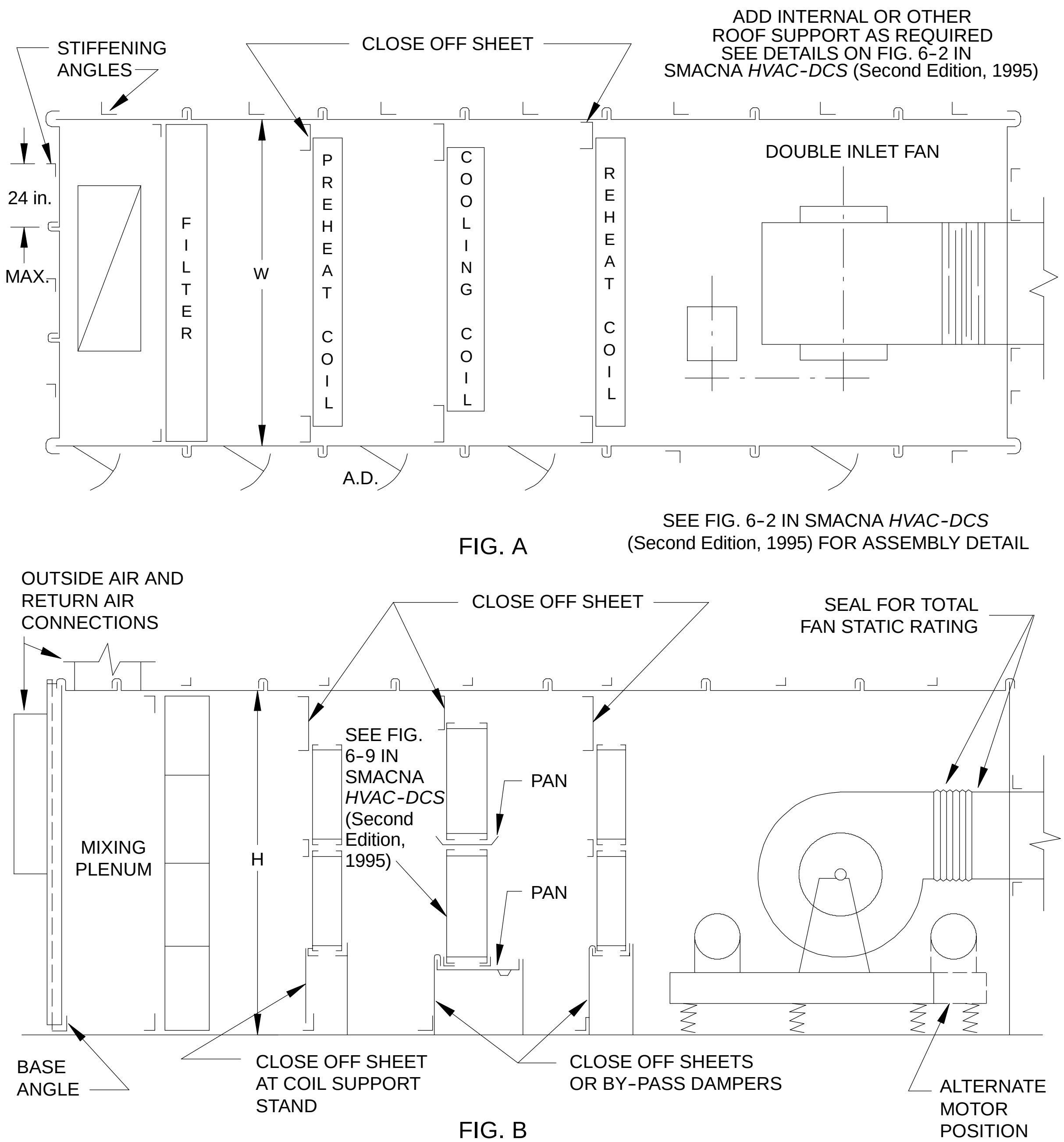
S1.48 Metal drain pans shall be of G90 coated galvanized steel.

S1.49 All welds on casing interiors shall be painted.

S1.50 Close-off or safing sheets and strips shall be of G90 galvanized steel of thickness not less than that of the duct widths and shall be securely attached. They shall not be used for structural support of equipment.

S1.51 Casings and plenums shall be constructed to withstand 133% of the rated pressure without structural failure. Wall and roof deflections at the rated pressure shall not exceed ⅛ in. per ft (0.97 mm/m) of width.

S1.52 Casing for negative pressures greater than 3 in. wg (750 Pa) may be constructed in accordance with the SMACNA *Rectangular Industrial Duct Construction Standards*.



CASING H OR W	GALV.	ALUM.	STEEL ANGLES	STANDING SEAM
TO 4 ft	20 ga	.064	1 in. × 1 in. × ⅛ in.	1 in.
4 ft TO 6 ft	18 ga	.080	1 in. × 1 in. × ⅛ in.	1 in.
6 ft TO 8 ft	18 ga	.080	1½ in. × 1½ in. × ⅛ in.	1½ in.
8 ft TO 10 ft	18 ga	.080	1½ in. × 1½ in. × 3⁄16 in.	1½ in.
OVER 10 ft	16 ga	.090	2 in.× 2 in. × 3⁄16 in.	1½ in.

MAXIMUM PRESSURE RATING 2 in. POSITIVE OR 2 in. NEGATIVE

FIGURE C-32 BUILT-UP STANDING SEAM CASING

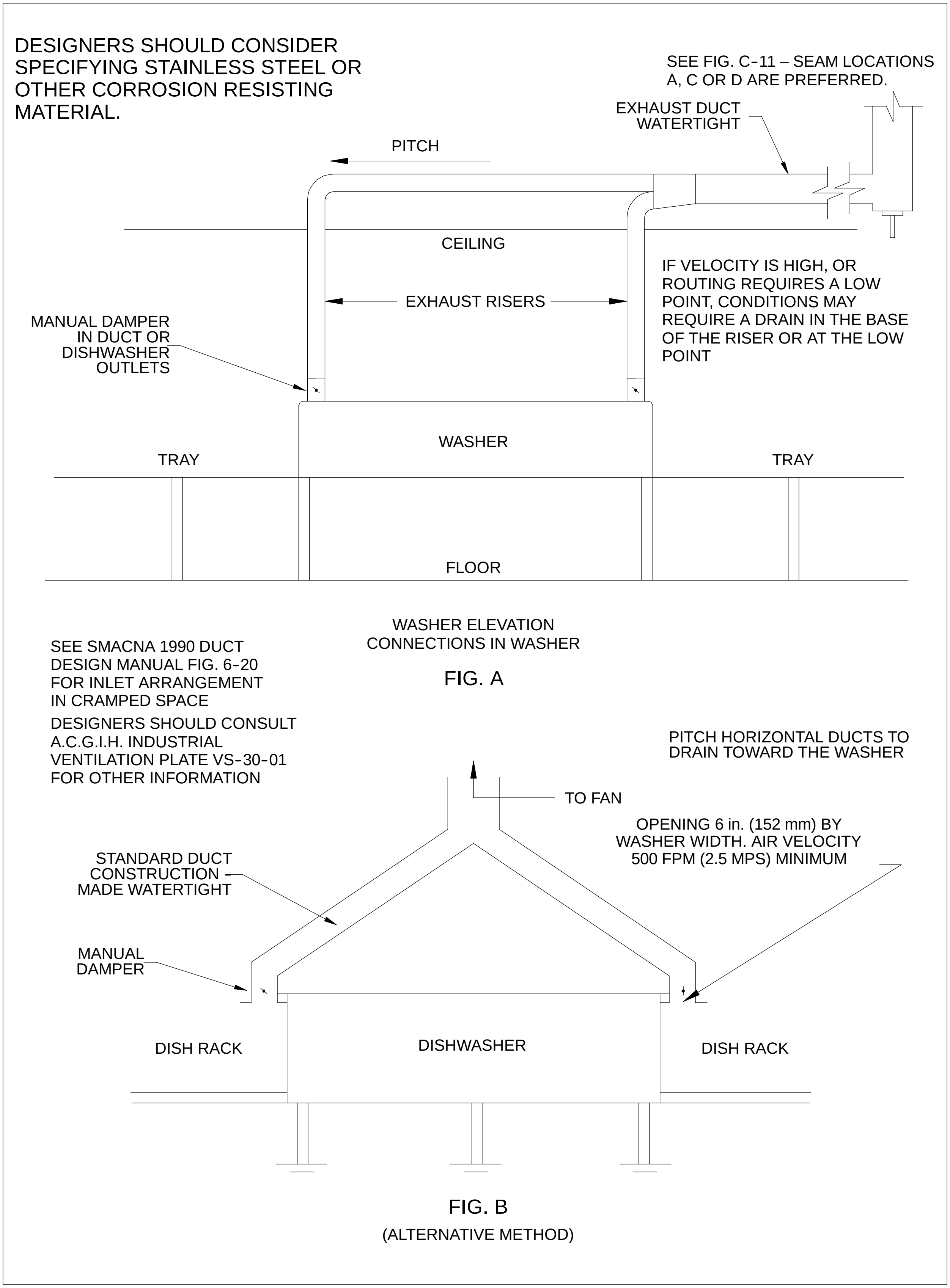


FIGURE C-33 DISHWASHER VAPOR EXHAUST

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APPENDIX D

FIRE, SMOKE, AND RADIATION DAMPER INSTALLATION GUIDE

This appendix contains excerpts from the SMACNA *Fire, Smoke, and Radiation Damper Installation Guide for HVAC Systems* (Fourth Edition, 1992). As stated previously, the information contained herein is designed to provide a framework of knowledge and perspective for Fire, Smoke, and Radiation Damper Installation and Duct Inspection. Use of the complete source manual is strongly encouraged as not all required standards are addressed here.

Item	Manufacturer Information to be Provided
1. Damper	a. function b. static or dynamic c. make (mfr.) d. model number
2. Fire Resistance Rating	a. time in hours
3. Approval	a. testing or listing agency
4. Sleeve	a. material b. thickness c. length (maximum) d. maximum distance of sleeve termination from wall (see UL 555)
5. Duct-to-Sleeve (or Frame) Connection	a. method(s) b. locations
6. Damper Attachment to Sleeve	a. method(s) b. locations
7. Retaining Angle	a. size b. material c. fastener locations
8. Maximum Rated Size of Damper	a. dimension
9. Assembly of Multiple Sections	a. methods b. fastener locations
10. Airflow	a. direction b. maximum velocity c. static pressure
11. Damper Orientation for Proper Closure	a. position
12. Illustrations	a. installation arrangement b. clearance category
13. Any Construction Detail Contingent on Approval for Listing by a Rating Authority	a. pertinent data (e.g. fusible link rating, opening framing provisions, etc.)

Table D-1 Recommended Fire Damper Installation Instructions

Typical Installation Details

(A) Retaining Angles:
Minimum 1½" (38 mm) × 1½" (38 mm) × 0.054" (1.37 mm) (16 ga)
Retaining angles must overlap structure opening 1" (25 mm) minimum and cover corners of openings as shown.

(B) Clearance: ⅛" Per Linear Foot (10.4 mm/m) Both Dimensions (see Note1 below)

(C) Steel Sleeve: See Table D-2

(D) Approved Fire Damper (curtain or blade type)

(E) Secure Retaining Angles To Sleeve *Only,* On 8" (203 mm) Centers With:
1. ½" (13 mm) long Welds *Or*
2. ¼" (6 mm) Bolts And Nuts, *Or*
3. No. 10 Steel Screws, *Or*
4. Minimum 3/16" Steel Rivets

(F) Secure Damper To Sleeve On 8" (203 mm) Centers With:
1. ½" (13 mm) long Welds *Or*
2. ¼" (6 mm) Bolts And Nuts, *Or*
3. No. 10 Steel Screws, *Or*
4. Minimum 3/16" (5 mm) Steel Rivets

(G) Connect Duct To Sleeve as Shown On Pages D.4 and D.5 and as outlined on Table D-2

(H) Install access door or panel as shown in Figure D-7

NOTES:

1. FIRE DAMPER SLEEVE CLEARANCE WITHIN WALL OPENING

Clearance requirements for damper sleeves within a wall opening are based on ⅛ inch per foot (10.4 mm/m) of width (or height) unless otherwise stated in the listing of the assembly. The sleeve may rest on the bottom of the opening, and need not be centered. (Fractional dimensions shall be taken as the next largest whole foot.)

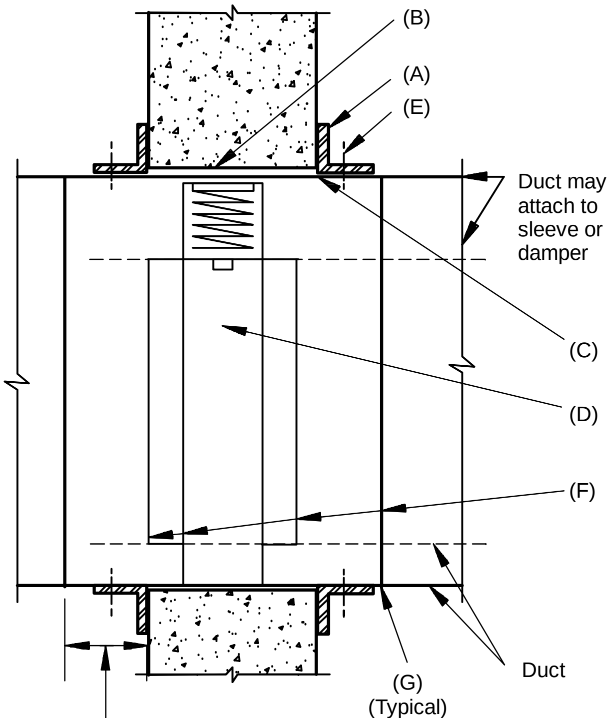
> ***EXAMPLE:*** A 30 × 24 in. (762 × 610 mm) fire damper sleeve is installed in a wall opening. The opening shall be 30⅜ in. (772 mm) wide [⅛ in. × 3 ft (3 × 915 mm)] by 24¼ in. (616 mm) high [⅛ in. × 2 ft (3 × 610 mm)]

The sleeve is retained in the wall opening by the use of steel retaining angles (A). These must overlap the edge of the framing by a minimum of one (1) inch (25 mm) over and beyond all material in the opening. This means that the minimum width of the retaining angle would be 1⅜ in. (35 mm) [good practice calls for an additional safety factor by making the angle in this case 1½ in. (38 mm) wide.]

The dimensions required for the opening shall be those remaining after the opening has been framed and fire resistive materials provided where required (see Figure D-3). The fire resistive material shall be equal to the requirements for fire resistive material used in the constructed wall so that a continuous rating exists at the wall penetration. *The contractor erecting the wall is responsible for providing the fire resistive material and correct size openings to achieve the required clearance.*

2. MANUFACTURERS' INSTALLATION DETAILS

The fire damper manufacturers' installation details and instructions as tested and approved by UL *must* be used in lieu of the above details where applicable.



Six inches (150 mm) on each side for dampers intended for use without an actuator or a factory installed access door in the sleeve.

Six inches (150 mm) on one side and sixteen inches (405 mm) on the opposite side for dampers intended for use with an actuator and/or a factory installed access door on the longer side.

Sixteen inches (405 mm) on each side for dampers intended for use with an actuator on one side and a factory installed access door on the other side.

Vertical position is shown: horizontal installation is similar. Follow installation instruction for fusible links.

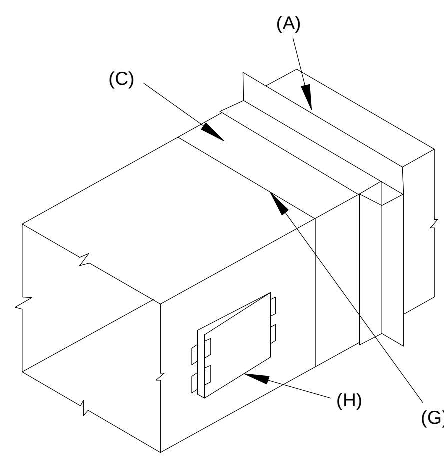


FIGURE D-1 BASIC FIRE DAMPER INSTALLATION DETAILS

Type of Connection	Duct	Duct Dimension	Sleeve Gauge
Rigid	Round – Rectangular	24 in. (610 mm) maximum diameter 24 in. (610 mm) maximum height and 36 in. (915 mm) maximum width	16^+ (1.613^+ mm)
Rigid	Round – Rectangular	over 24 in. (610 mm) diameter over 24 in. (610 mm) height and over 36 in. (915 mm) width	14^+ (1.994^+ mm)
Breakaway (See pages D.4 and D.5)	Round or Rectangular	12 in. (305 mm) and down 13 – 30 in. (330 – 760 mm) 31 – 54 in. (785 – 1370 mm) 55 – 84 in. (1400 – 2130 mm) 85 in. (2160 mm) and up	26 (0.5512 mm) 24 (0.7010 mm) 22 (0.8534 mm) 20 (1.006 mm) 18 (1.311 mm)

By UL Standard 555, all ducts are required to terminate at the fire damper sleeves or the damper frames. Sleeve thickness is contingent on the type of connection. All UL listed dampers also have maximum dimensions associated with the test rating. Contingent on sleeve thickness a rigid connection may be used in lieu of a breakaway connection. Sleeves may be omitted where dampers are designed to be in non-ducted air passages or where damper housing permits attachment of retaining angles to the housing. Attachment of retaining angles must not restrict operation of the fire damper. Certain UL approved designs do not require retaining angles.

Where the fire damper sleeve is exposed to the airstream, the metal sleeve will be of the same material as the duct system. A steel sleeve, of the type or finish specified by the system designer, will be used for fibrous glass ductwork and where the fire damper sleeve is not exposed to the airstream.

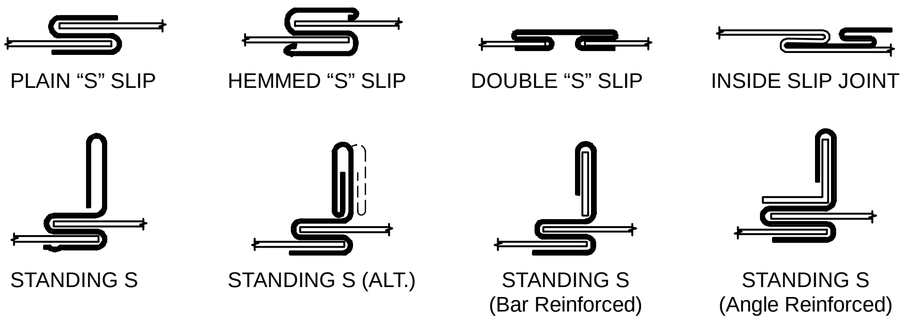
Table D-2 Recommended Minimum Sleeve Thickness for Fire Dampers*

NOTES:

+ Breakaway not required

* See Pages D.4 and D.5 for details and exceptions

1. DUCT-SLEEVE CONNECTIONS LISTED IN UL 555, FOURTH EDITION, “STANDARD FOR FIRE DAMPERS”.



2. ADDITIONAL DUCT-SLEEVE CONNECTIONS WHICH WERE TESTED BY SMACNA AND WITNESSED BY UL IN 1991. THE CONNECTIONS PERFORMED WITHIN THE REQUIREMENTS OF THE UL TEST CRITERIA. *SEE* NOTE.

(A) JOINTS USING CONNECTIONS SHOWN IN 1. ABOVE WITH A MAXIMUM OF TWO #10 SHEET METAL SCREWS ON EACH SIDE AND ON THE BOTTOM LOCATED IN THE CENTER OF THE SLIP POCKET AND PENETRATING BOTH SIDES OF THE SLIP POCKET. NOTE: UL TESTED DUCT SEALANT MAY BE USED.


FLAT DRIVE SLIP

(B) JOINTS USING CONNECTORS OF THE TYPE SHOWN IN 1. ABOVE ON THE TOP AND THE BOTTOM AND USING FLAT DRIVE SLIPS NOT EXCEEDING 20 in. (510 mm) DUCT HEIGHT ON THE SIDES (*SEE* SKETCH BELOW). NOTE: DUCT SEALANT MAY BE USED.

(C) JOINTS WHERE ROUND OR OVAL SPIRAL DUCTS ATTACH TO ROUND OR OVAL COLLARS WHICH ARE PART OF THE DAMPER SLEEVE AS SHOWN BELOW. #10 SHEET METAL SCREWS ARE SPACED EQUALLY AROUND THE CIRCUMFERENCE OF THE DUCT PER THE FOLLOWING:

- DUCT DIAMETERS 22 in. (560 mm) AND SMALLER—3 SCREWS.
- DUCT DIAMETERS OVER 22 in. (560 mm) TO AND INCLUDING 36 in. (915 mm)—5 SCREWS.

NOTES:
(1) FOR FLAT OVAL DUCTS, THE DIAMETER SHALL BE CONSIDERED THE LARGEST (MAJOR) DIMENSION OF THE DUCT.
(2) NON-HARDENING DUCT SEALANT MAY BE USED.

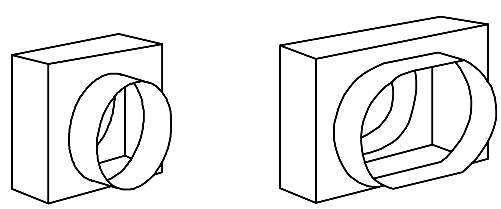
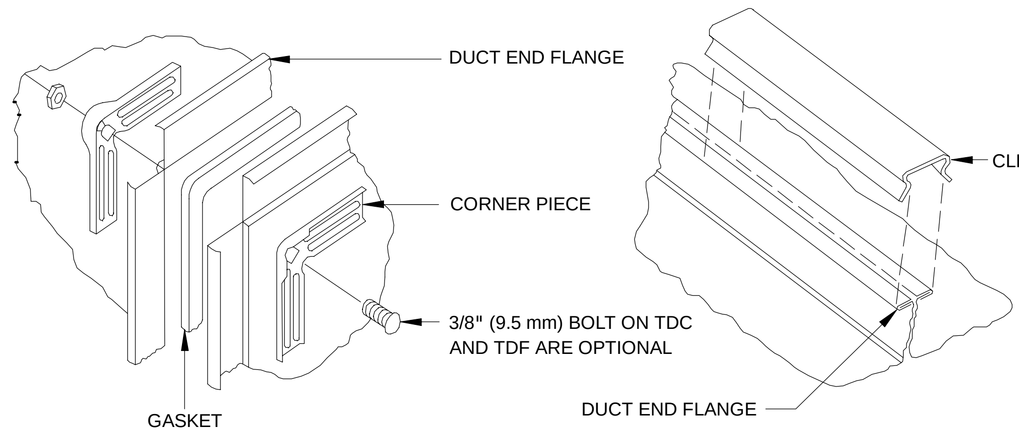
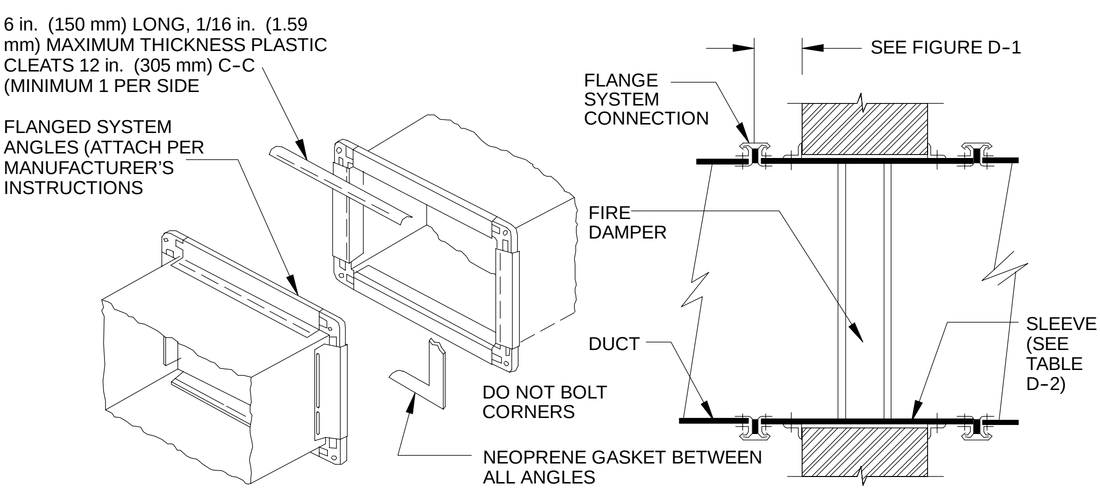

DAMPER/SLEEVE ASSEMBLIES WITH
COLLARS FOR ROUND AND FLAT OVAL DUCTS

FIGURE D-2 UL DUCT-SLEEVE CONNECTIONS (BREAKAWAY CONNECTIONS)

(D) TDC AND TDF ROLL-FORMED 4-BOLT FLANGED CONNECTIONS ASSEMBLED PER THE MANUFACTURER'S INSTRUCTIONS USING GASKETS, METAL CLEATS AND FOUR 3/8 in. (9.5mm) METAL NUTS AND BOLTS.



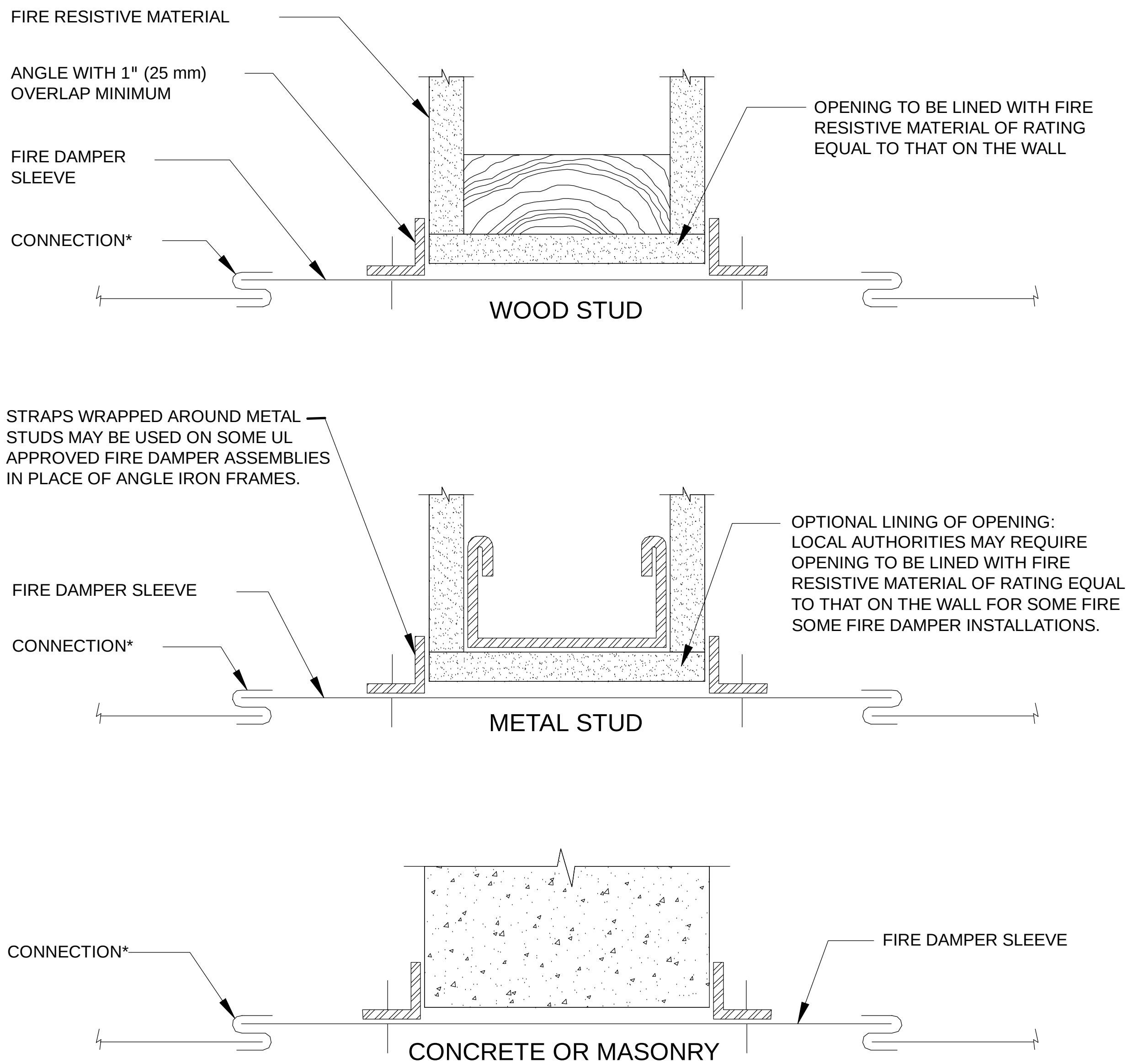
(E) MANUFACTURED SLIP ON 4-BOLT FLANGED CONNECTIONS ASSEMBLED PER THE MANUFACTURER'S INSTRUCTIONS USING GASKETS AND PLASTIC CLEATS AS SHOWN BELOW.



(UL TESTED CONNECTIONS)

NOTE: 1991 UL TESTS ARE DESCRIBED IN UL REFERENCE FILE NC 1380 DATED NOVEMBER 11, 1991.

FIGURE D-2 UL DUCT-SLEEVE CONNECTIONS (BREAKAWAY CONNECTIONS) (CONTINUED)



*S SLIP ILLUSTRATED; SEE FIGURE D–2
FOR RANGE OF APPROVED TYPES OF CONNECTIONS.

NOTE: THICKNESS AND TYPE OF FIRE RESISTIVE MATERIAL MAY VARY WITH THE JURISDICTION. SPECIFIC FRAMING REQUIREMENTS OF OPENINGS SHOULD BE PROVIDED IN THE ARCHITECTURAL AND STRUCTURAL DRAWINGS THAT ARE SUBMITTED FOR BUILDING PERMITS. ALSO SEE FIRE DAMPER MANUFACTURER'S FRAMING INSTRUCTIONS.

FIGURE D–3 FIRE DAMPER OPENING PROTECTION

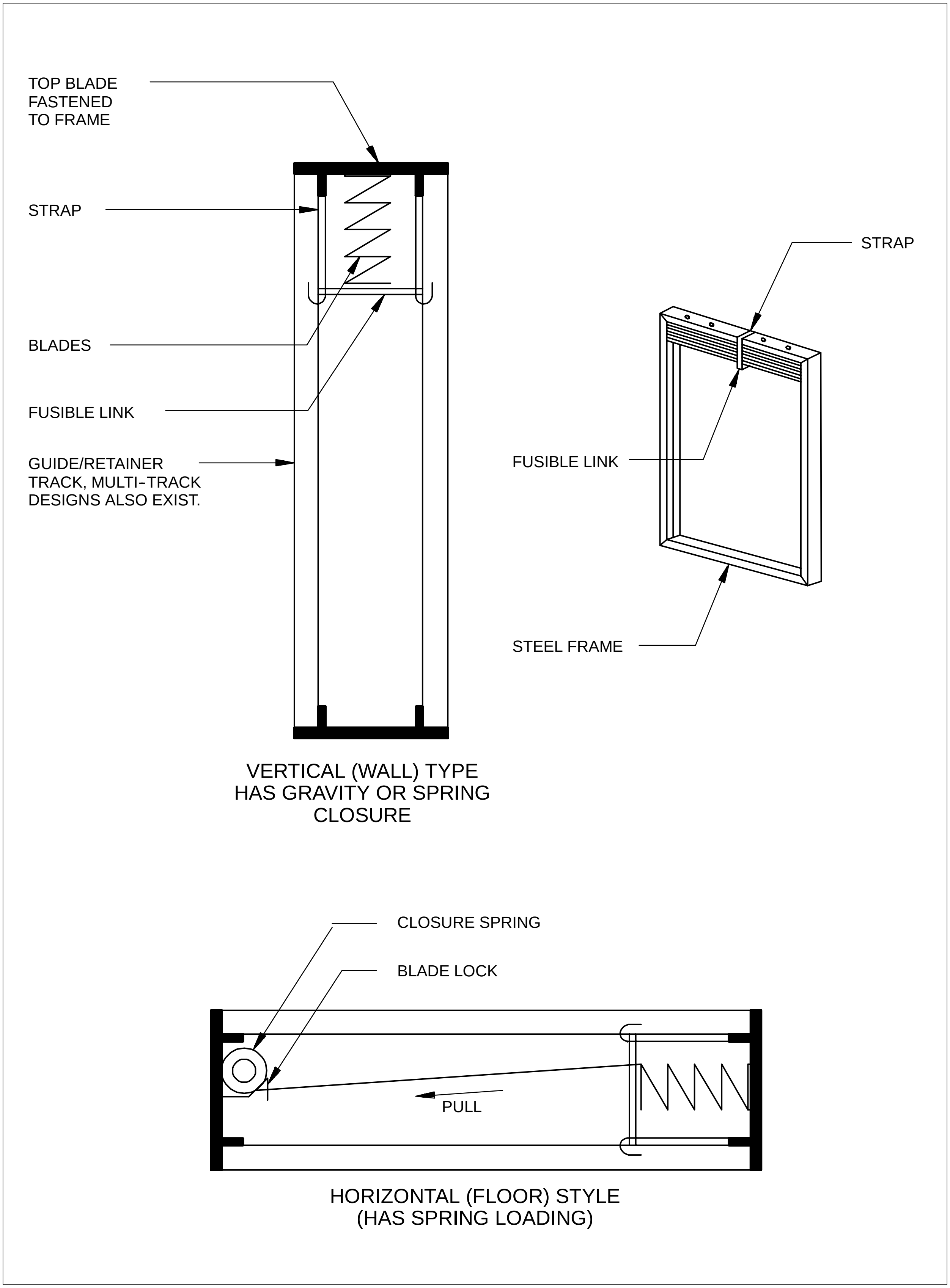
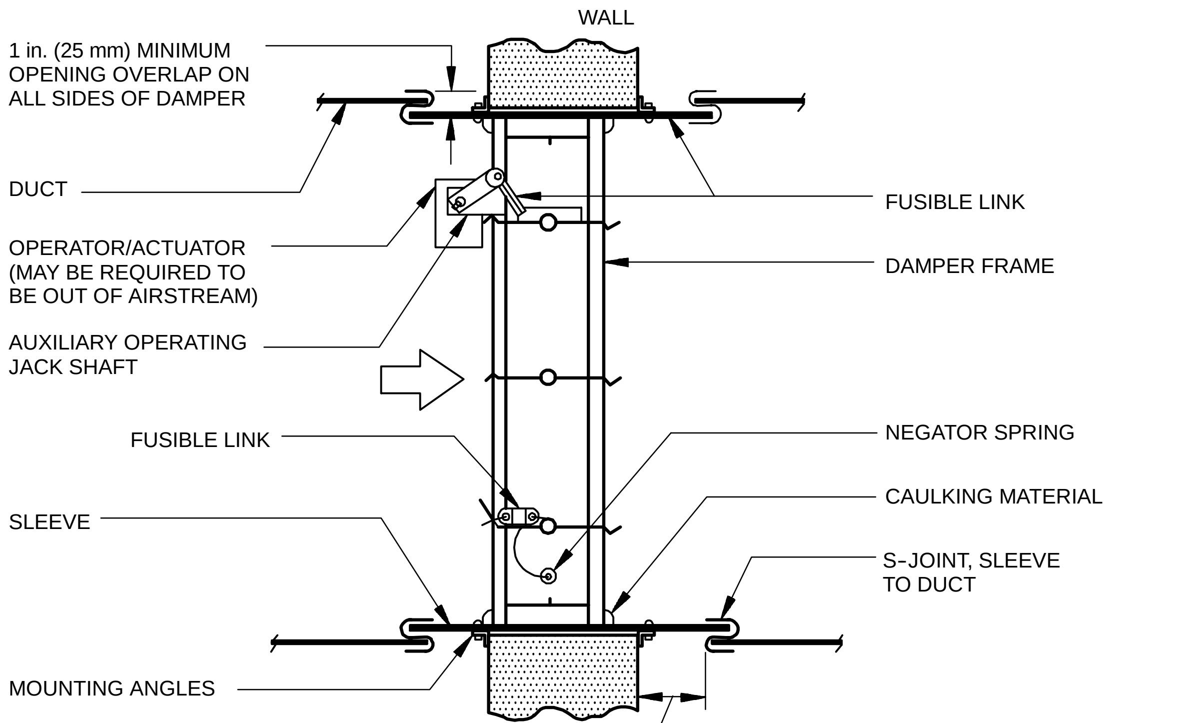


FIGURE D-4 CURTAIN FIRE DAMPERS



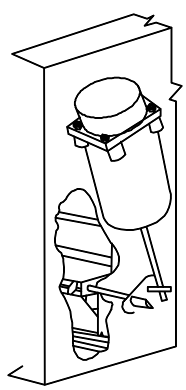
OPERATION:

A. FIRE DAMPER MODE:
HIGH TEMPERATURE MELTS FUSIBLE LINK, CLOSING FIRE DAMPER

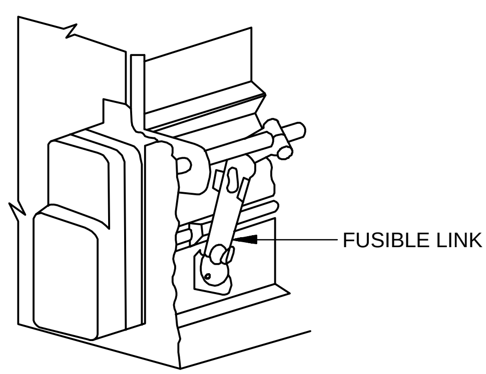
B. SMOKE DAMPER MODE:
SMOKE DETECTOR UPON SENSING HEAT/SMOKE ACTUATES DAMPER MOTOR TO CLOSE DAMPER.

A. SIX INCHES (150 mm) ON ONE SIDE AND SIXTEEN INCHES (405 mm) ON THE OPPOSITE SIDE WITH ACTUATOR.

B. SIXTEEN INCHES (405 mm) ON EACH SIDE FOR DAMPERS INTENDED FOR USE WITH AN ACTUATOR ON ONE SIDE AND A FACTORY INSTALLED ACCESS DOOR ON THE OTHER SIDE.



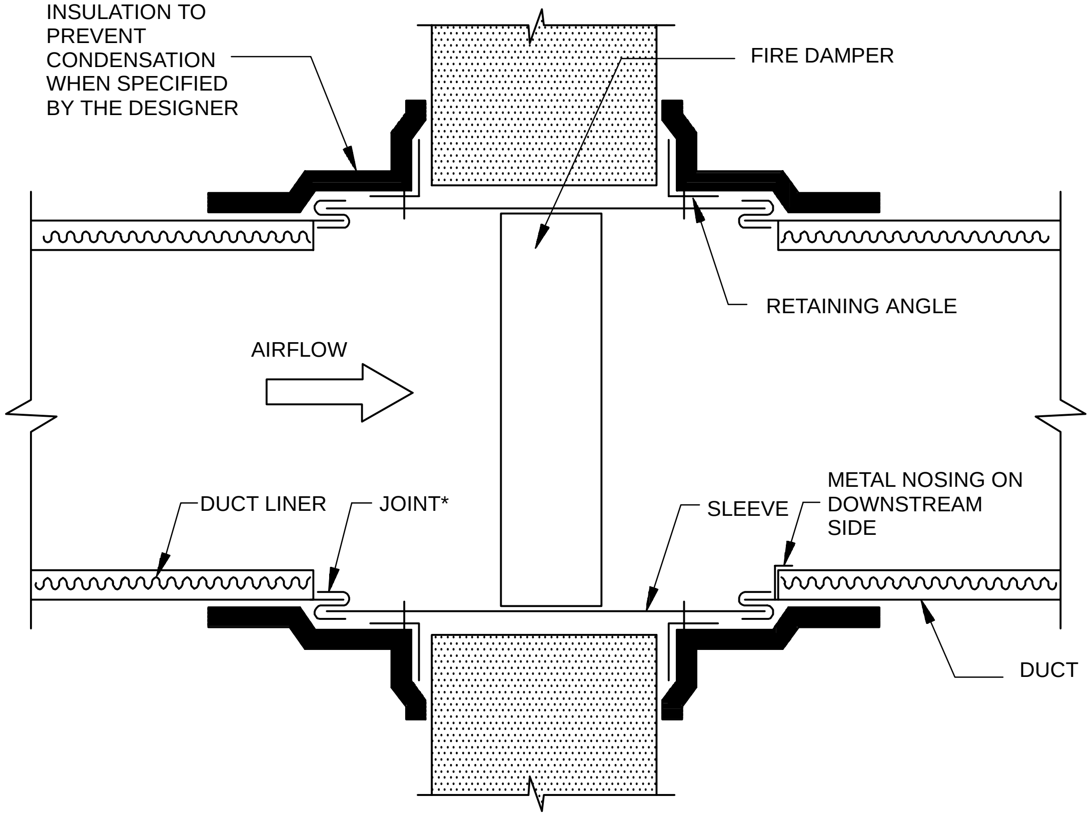
PNEUMATIC MOTOR OPERATION FOR BLADE DAMPER



ELECTRIC MOTOR FOR BLADE DAMPER

THESE ILLUSTRATIONS ARE NOT INTENDED TO EXCLUSIVELY ENDORSE OR INDICATE PREFERENCE FOR A COMBINATION FIRE AND SMOKE DAMPER. TWO SEPARATE DAMPERS THAT SATISFY REQUIREMENTS FOR THE RESPECTIVE FUNCTIONS MAY ALSO BE USED FOR FIRE AND SMOKE CONTROL.

FIGURE D-5 COMBINATION FIRE AND SMOKE DAMPERS



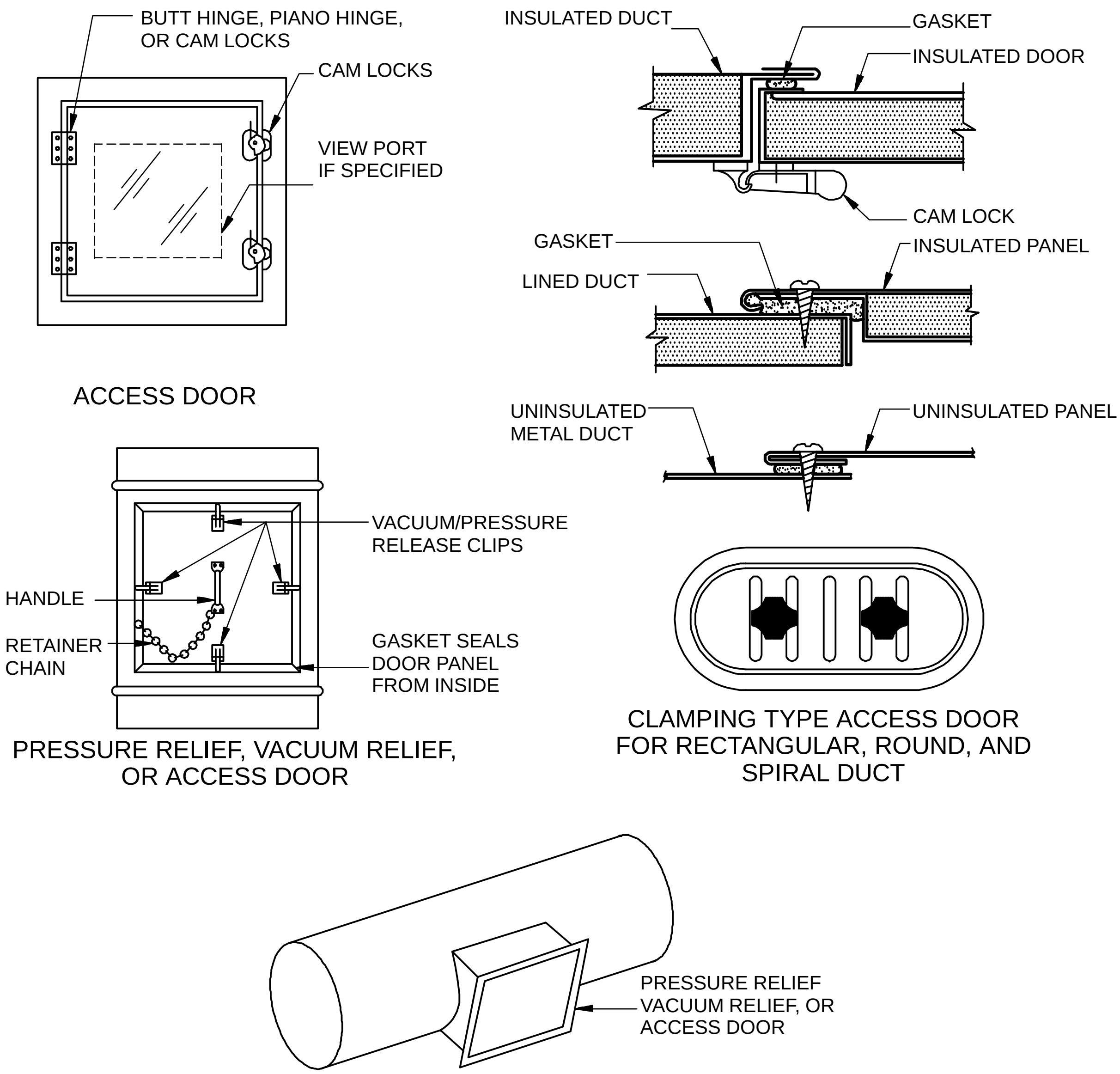
NOTES:

1. INTERRUPTION OF DUCT LINER AT THE FIRE DAMPER IS REQUIRED BY NFPA STANDARD 90A. WHERE 90A IS APPLICABLE INSTALLATION SHOULD BE MADE AS SHOWN AND SHOULD OTHERWISE CONFORM TO THE SMACNA HVAC DUCT CONSTRUCTION STANDARDS–METAL AND FLEXIBLE.

2. THE DESIGNER SHOULD SPECIFY EXTERNAL INSULATION AS SHOWN TO PREVENT CONDENSATION OCCURRING ON UNLINED METAL AT PENETRATIONS. WHERE THE PROVISIONS OF NFPA 90A ARE APPLICABLE, NEITHER INSULATION NOR LINER CAN EXTEND THROUGH THE WALLS OR FLOORS.

*S SLIP IS ILLUSTRATED; *SEE* FIGURE D–2 FOR RANGE OF APPROVED TYPES OF CONNECTIONS.

FIGURE D–6 DUCT LINER INTERRUPTION



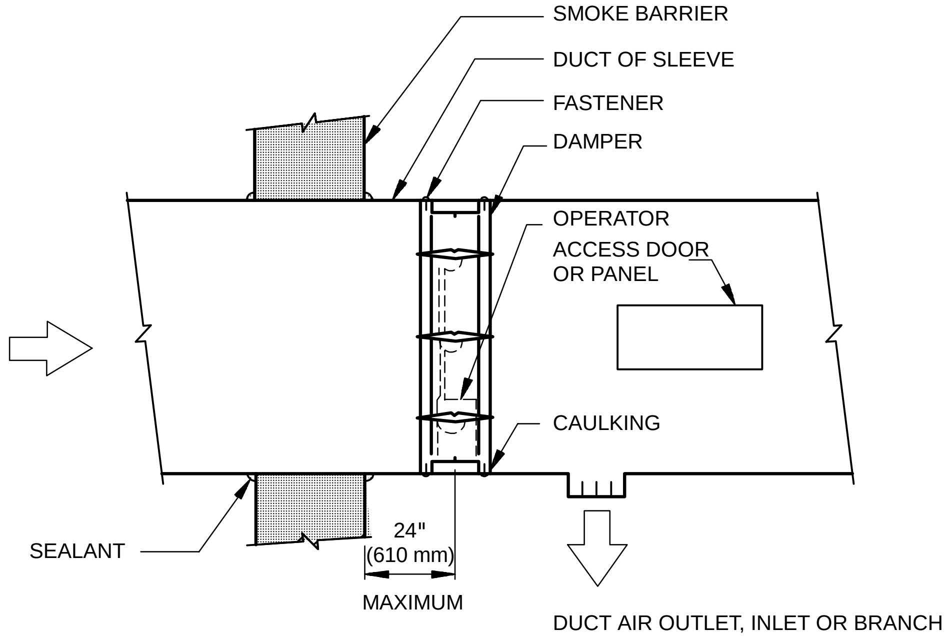
NOTES:

1. DOOR TYPE AND INSTALLATION SHALL BE FOR THE PRESSURE CLASSIFICATIONS AND CONSTRUCTION STANDARDS DESIGNATED BY THE SYSTEM DESIGNER TO PREVENT SYSTEM DAMAGE. THE PURPOSE OF A RELIEF DOOR IS TO REDUCE OR ELIMINATE POTENTIAL FOR DUCT COLLAPSE. THESE ILLUSTRATIONS ARE NOT INTENDED TO BE OBLIGATORY.

2. DAMPERS WITH LATCHES ARE GENERALLY ACCESSIBLE FROM ONE SIDE OF THE DAMPER ONLY. PLACE THE ACCESS DOOR ON THE LATCH RELEASE AND LINK SIDE OF THE FIRE DAMPER.

3. ACCESS DOORS AND PANELS ARE TO BE LARGE ENOUGH TO PERMIT MAINTENANCE AND RESETTING OF DEVICES. DUCT ACCESS DOORS SHALL BE A MAXIMUM OF 24 × 24 in. (610 × 610 mm) AND A MINIMUM OF 6 × 6 in. (150 × 150 mm) UNLESS THE DUCT SIZE DOES NOT ALLOW INSTALLATION OF THE DOOR, IN WHICH CASE, A REMOVABLE SECTION OF DUCT MUST BE USED FOR ACCESS.

FIGURE D-7 ACCESS DOORS AND PANELS



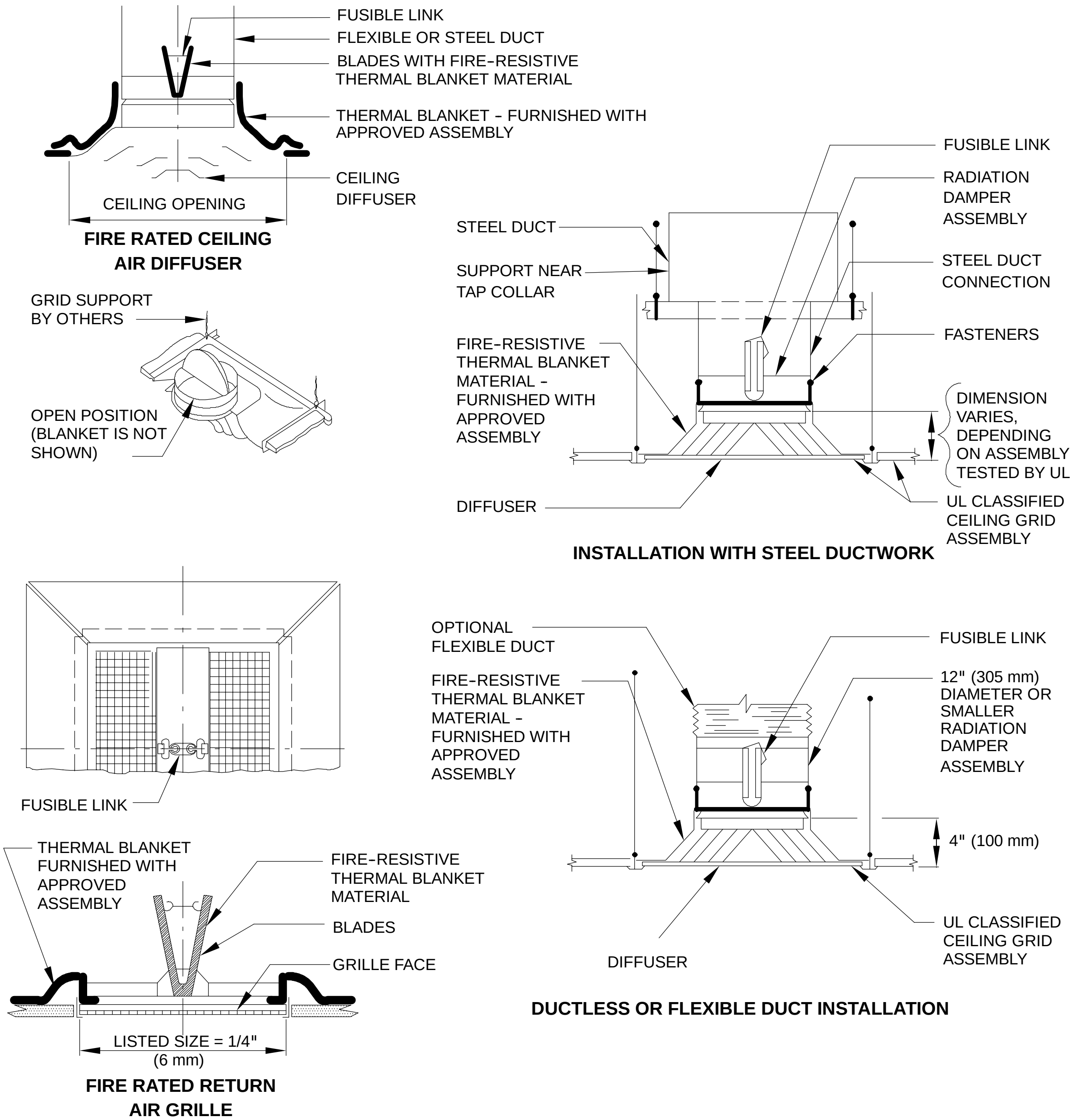
NOTES:

1. SMOKE DAMPERS MUST BE INSTALLED AT OR ADJACENT TO THE POINT WHERE THE DUCT PASSES THROUGH THE SMOKE BARRIER IN ACCORDANCE WITH NFPA 90A. THE MAXIMUM INSTALLATION DISTANCE IS 24 in. (610 mm) FROM THE SMOKE BARRIER, HOWEVER, THE PREFERRED LOCATION OF LEAKAGE RATED SMOKE DAMPERS IS IN THE SMOKE BARRIER. DUCT AIR OUTLETS, INLETS, OR BRANCHES SHALL NOT BE LOCATED BETWEEN THE SMOKE DAMPER AND THE SMOKE BARRIER. SMOKE DAMPERS MUST NOT BE INSTALLED IN FIBROUS GLASS-LINED DUCTS AND FIBROUS GLASS DUCTS IN A MANNER THAT WILL DAMAGE THE MATERIAL. USE A HAT SECTION STANDOFF, LINING INTERRUPTION, METAL SLEEVES OR SECTIONS ON EXTERNALLY INSULATED METAL DUCT. PROVIDE A DUCT HANGER AT A SMOKE DAMPER LOCATION WHEN THE DUCT STRENGTH IS INADEQUATE FOR THE DAMPER AND ITS OPERATOR. IF THE DAMPER OPERATOR IS LOCATED WITHIN THE DUCT, AN ACCESS DOOR MUST BE PROVIDED.

2. INSTALL PER MANUFACTURER'S INSTRUCTIONS.

3. SLEEVES/RETAINING ANGLES NOT REQUIRED.

FIGURE D-8 LEAKAGE RATED (SMOKE) DAMPER



NOTES:

1. SEE THE UL "FIRE RESISTANCE DIRECTORY" FOR USE WITH FIRE RATED CEILING/FLOOR OR CEILING/ROOF ASSEMBLIES.
2. OTHER STYLES, SIZES AND TYPES OF UL DESIGNATED CEILING DAMPERS EXIST. THESE ARE SHOWN AS SAMPLES ONLY. RATINGS ARE PER UL 555C, CEILING DAMPERS.
3. A MAXIMUM SIZE CEILING PENETRATION OF 576 SQUARE INCHES CAN BE PROTECTED USING THE THERMAL INSULATION BLANKET. THE THERMAL INSULATION BLANKET PROTECTS THE EXPOSED PORTION OF THE CEILING DIFFUSER AND THE CEILING DAMPER PROTECTS THE NECK OR INLET OF THE CEILING DIFFUSER.
4. SOME INSTALLATIONS REQUIRE A MINIMUM ½" LAP OF THE DIFFUSER FLANGE OVER THE CEILING TILE.
5. DAMPER ASSEMBLIES MAY REQUIRE SEPARATE SUPPORTS.

FIGURE D-9 FIRE RATED CEILING ASSEMBLIES

APPENDIX E

FIBROUS GLASS DUCT CONSTRUCTION STANDARDS

E.1 FIBROUS GLASS DUCT CHARACTERISTICS AND LIMITATIONS

This appendix contains excerpts from the SMACNA *Fibrous Glass Duct Construction Standards* (Sixth Edition, 1992). The information contained herein is designed to provide a framework of knowledge and perspective for Fibrous Glass Duct Construction and Duct Inspection. Use of the complete source manual is strongly encouraged as not all required standards are addressed here.

1. Flexural Rigidity (EI)
Average in the board, not less than rating of 475,800 or 1400 lb/sq. in. per inch of width when tested in accordance with NAIMA Test Method HS-100-74. Consult NAIMA or board manufacturers for 1400 EI board construction schedules; they are not in this edition due to infrequent use.

2. Maximum static pressure in duct
2 in. wg (500 Pa), positive or negative.

3. Maximum air velocity in duct
2400 ft per minute (13.92 m/s).

4. Maximum allowable deflection
Duct width/100 (for rectangular duct wall).

5. Maximum allowable stress in steel members used for reinforcement or support
22,000 pounds per square inch (152 MPa) with 30,000 psi (207 MPa) yield strength minimum.

6. Board fatigue
No significant deformation or deficiency of duct sections after 50,000 cycles at 3 to 4 cycles per minute from natural sag to 1½ times operating pressure.

7. Moisture adsorption
Moisture adsorption of the board will not exceed 5% by weight under conditions of 120°F (49°C) dry bulb at 95% R.H. for 96 hours duration, when tested in accordance with ASTM C1104.

8. Temperature
250°F (121°C) maximum inside the duct, continuous operation. 150°F (66°C) maximum duct surface temperature.

9. Corrosiveness
Non-corrosiveness on contact with galvanized steel, copper, or aluminum when compared to control specimen in contact with clean, sterile cotton when tested in accordance with ASTM C665.

10. Closure
Closure conforms to: Underwriters' Standard UL 181, (or UL 181A) installed in accordance with the manufacturer's Class 1 Air Duct listing.

11. Safety Standards
NFPA Standard 90A, 90B.

12. Reinforcement testing
Test programs have demonstrated that fibrous glass duct systems, including fittings such as offsets, tees, elbows, branches, transitions, and accessory items are capable of maintaining their structural integrity through 50,000 cycles at one and one half times system design pressurization. While this testing demonstrates the reliability of properly constructed systems, it does not imply that systems should be operated at pressures above their reinforcement rating.

13. Restrictions
Fibrous glass duct systems should not be used in the following applications:

a. Kitchen exhaust or fume exhaust ducts, or to convey solids or corrosive gases.

b. Installation in concrete or buried below grade.

c. Outdoors.

d. As casings or housings of built-up equipment.

e. Immediately adjacent to high temperature electric heating coils without radiation protection. Refer to NFPA Standard 90A.

f. In more than two stories of riser.

g. With equipment of any type which does not include automatic maximum temperature controls.

h. With coal or wood fueled equipment.

i. Where normal operating pressure or occasional over pressure would exceed product rating.

j. As penetrations in construction where fire dampers are required.

k. Where moisture would collect in the duct.

l. Where clean room condition is needed in the duct.

m. Where condensation would occur on the duct exterior, unless the duct exterior has a vapor barrier (impermeable).

14. Mounting of accessories

When mounting equipment, dampers, damper operators, control motors, etc., the duct system must be adequately reinforced and supported to accommodate the additional weight of the material and equipment without damage to the duct material. Particularly important is the mounting of both dampers and their operators on the same sleeve or mounting plate.

15. Class 1 Air Duct Rating

When ducts must conform to NFPA Standard 90A and/or model codes, fibrous glass ducts are required to conform to the following requirements:

a. They shall be constructed of Class 1 duct materials as tested in accordance with Underwriters' Laboratories Standard for Factory-Made Duct Materials and Air Duct Connectors, UL 181.

b. Such ducts shall be installed in accordance with conditions of their listing.

c. They may not be used in air duct systems which operate continuously with an air temperature higher than 250°F (121°C) entering the ducts.

d. They shall not be used as vertical risers of more than two stories.

e. They may be directly attached to listed heating and cooling equipment designed to operate at temperatures not exceeding 250 °F (121 °C).

f. Under UL Standard 181 Class 1 air duct materials have Flame Spread rating not exceeding 25 without evidence of continued progressive combustion and a Smoke Developed rating not exceeding 50. Furthermore, the following portions of UL 181 are applicable to rigid fibrous glass ducts in new material condition:

(1) Fire hazard classification
(2) Flame penetration
(3) Burning
(4) Temperature
(5) Puncture
(6) Static load
(7) Impact
(8) Erosion
(9) Pressure and collapse
(10) Leakage
(11) Corrosion, mold growth and humidity.

Pressure sensitive tapes that pass UL Standard 181A tests are imprinted with the producers name (or symbol), date of manufacture, product code and the wording "UL Listed 181A-P." Heat activated tapes, coded 181A-H, have similar imprinting.

16. Use in Medical Facilities

The United States Department of Health, Education and Welfare requirements for construction of hospitals and medical facilities (including outpatient surgical facilities) prohibit use of duct linings in ducts serving operating rooms, nurseries, isolation rooms, and critical care units. (Amended since 1992.)

17. Other Performance Characteristics

Consult design handbooks and board manufacturers for friction loss coefficients and thermal and acoustical performance. Duct leakage is not expected to exceed SMACNA Class 6. The applicable rates in CFM per 100 sq ft of duct surface area at various inches water gage static pressure levels are: 2.4 @ 0.25 in. wg; 3.8 @ 0.5 in. wg; 5.0 @ 0.75 in. wg; 6.0 @ 1.0 in. wg; 7.8 @ 1.5 in. wg and 9.4 @ 2.0 in. wg.

CFM per 100 sq ft	2.4	3.8	5.0	6.0	7.8	9.4
l/s per 10 sq. ft	1.2	1.9	2.5	3.0	3.9	4.7

in. wg	0.25	0.5	0.75	1.0	1.5	2.0
Pa	62	125	187	250	374	500

E.2 CLOSURES

E.2.1 General

Closures systems are a vital element in the proper assembly of fibrous glass duct systems, providing both the structural connection and sealing of seams and joints. Only those closure systems that comply with UL 181 or UL 181A are suitable for use with rigid fibrous glass duct systems. Listed closures include:

a. Pressure-sensitive aluminum foil tapes.

b. Heat activated aluminum foil/scrim tapes.

c. Mastic and glass fabric tape system (GFM).

Model codes and project specifications require that non-metallic duct construction, which includes fibrous glass ducts, conform to UL 181, Class 1 requirements. Under UL 181A listing procedures, an individual closure system may be qualified for use on all manufacturers' boards which meet the UL 181 requirement. UL 181A tapes are imprinted for identification.

E.2.2 Joint and Seam Preparation

Longitudinal seams are prepared as described in Figure E-3. Transverse joints between two duct sections are prepared by joining two duct sections, pulling the staple flap over the adjoining section and stapling as shown in the illustrations.

E.2.3 Seams and Joints without Staple Flaps

When staple flaps are not present, cross tabs are used to hold seams and joints in position prior to application of the closure system. Cross tabs, made from 8 in. (205 mm) minimum lengths of closure tape, are to be equally spaced on each side of the joint and on 12 in. (305 mm) (maximum) centers with at least one cross tab per duct side (Figure E-2). Cross tabs may be placed either under or over the closure tape.

E.2.4 Surface Preparation

In order to obtain satisfactory adhesion and bonding, the surface on which closures will be applied must be clean and dry. Dust, dirt, oil, grease, moisture and similar substances may result in adhesion and bonding failure when present. In many cases, wiping the application surface with an oil-free, lint-free rag, or paper towel would be sufficient. However, for the best results on contaminated surfaces, the cleaning recommendations of the tape manufacturer should be consulted.

E.2.5 Shelf Life

Tapes and mastics often have storage requirements and shelf life limitations. The installer should verify that these conditions have not been exceeded prior to use.

E.2.6 Notes

a. Manufacturers closure application instructions must be followed.

b. Heat activated tapes have color change dots to indicate satisfactory bond.

c. Glass fabric closure requires mastic application before and after fabric placement and has a prescribed set up time.

d. See mechanical reinforcement requirements at seams and joints in the reinforcement provisions.

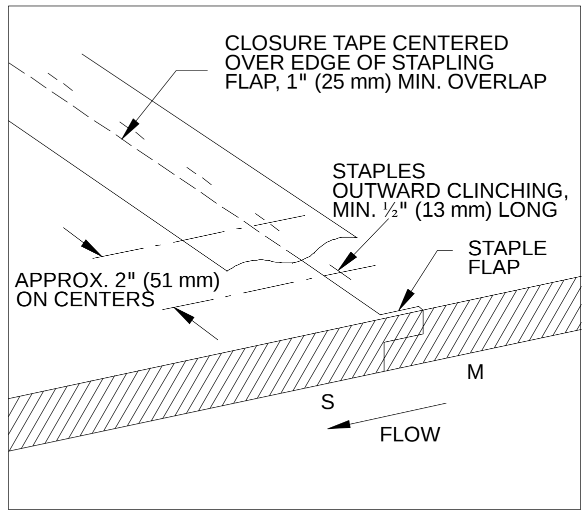


FIGURE E–1 TAPE CLOSURE JOINT, WITH STAPLE FLAP

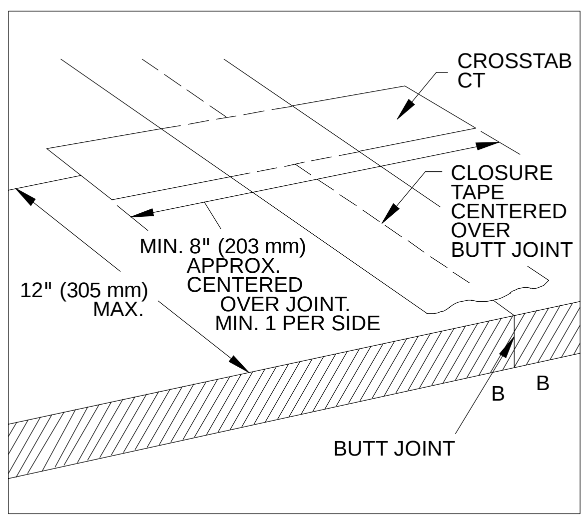
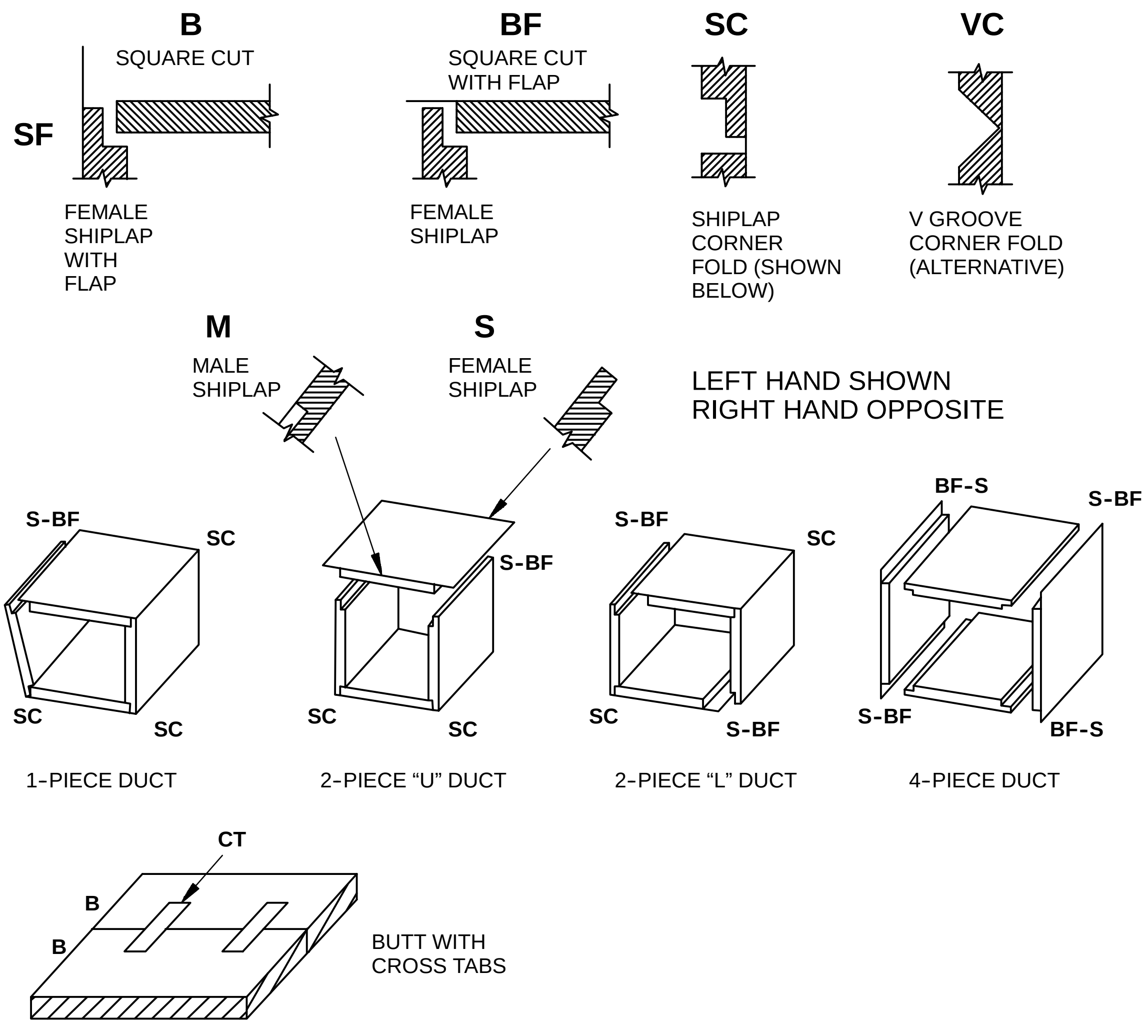


FIGURE E–2 TAPE CLOSURE JOINT, WITHOUT STAPLE FLAP

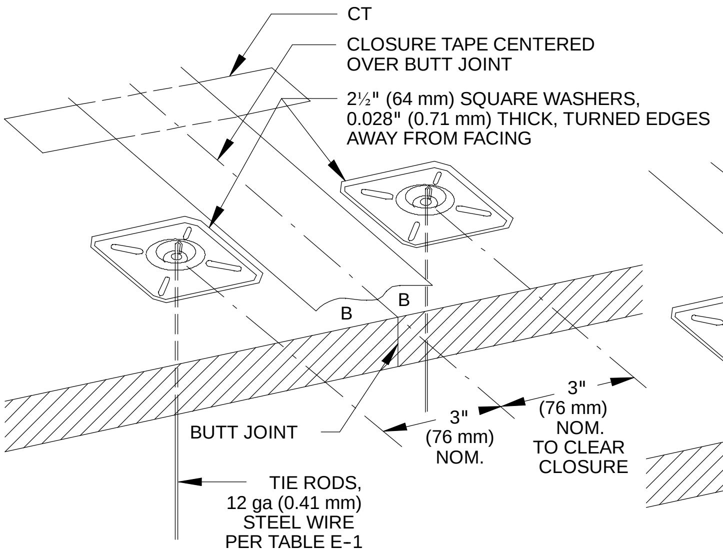


NOTES:

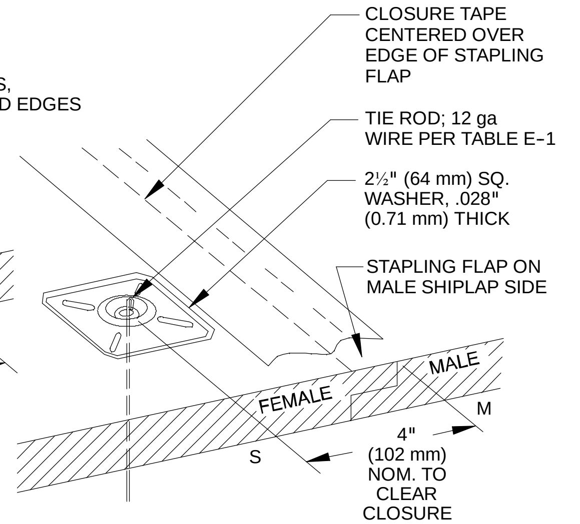
1. CORNER SEAMS ARE CLOSED WITH ½" (12.7 mm) MINIMUM OUTWARD CLINCHING STAPLES APPROXIMATELY 2" (50.8 mm) OC.
2. WITH MACHINE APPLIED HEAT-SEALABLE TAPE STAPLES MAY BE OMITTED.
3. TAPE IS CENTERED OVER THE EDGE OF THE FLAP SO THAT A MINIMUM OF 1" (25.4 mm) OVERLAP OCCURS ON ADJACENT SURFACES.
4. TAPE MUST BE ESSENTIALLY FREE OF WRINKLES, UNIFORMLY ADHERED, FREE OF STAPLE PUNCTURES AND PRESSED SUFFICIENTLY TO SHOW DUCT FACING REINFORCEMENT IMPRESSIONS IN THE TAPE.
5. ASSEMBLY OF CORNERS WITH TWO SQUARE CUT BUTT EDGES IS NOT PERMITTED.
6. CROSS TABS ARE 8" (203 mm) LONG TAPE STRIPS 12" (305 mm) OC MAXIMUM: NOT FEWER THAN ONE SHALL BE USED. THEY MAY GO ON BEFORE OR AFTER THE CLOSURE TAPE.

FIGURE E-3 CLOSURES (CONTINUED)

E.3 ADDITIONAL FIBROUS GLASS DUCT CONSTRUCTION DETAILS



BUTT JOINT REINFORCEMENT

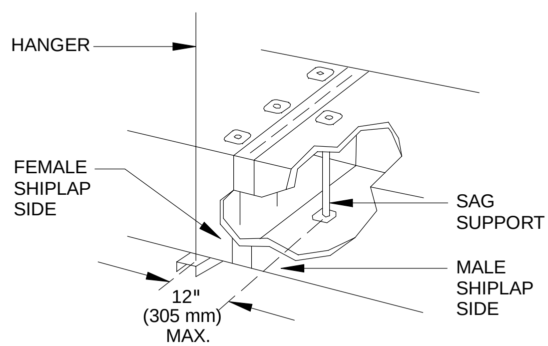


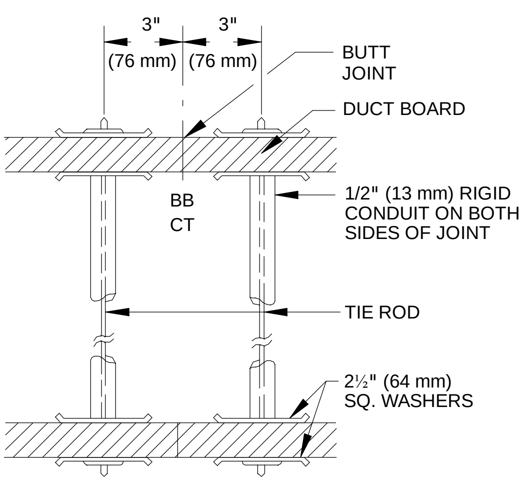
SHIPLAP JOINT REINFORCEMENT

SAG CONTROL – TIE ROD REINFORCEMENT

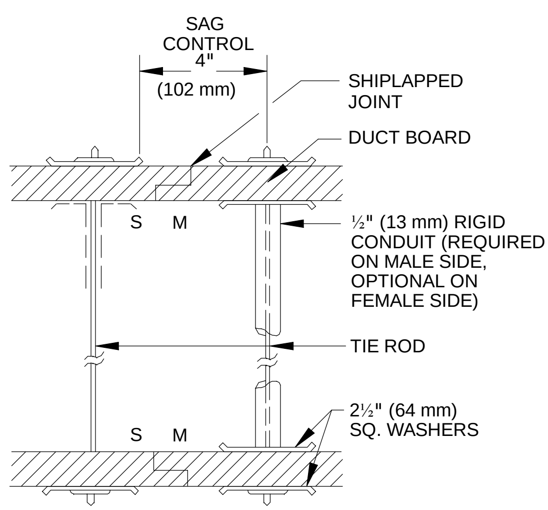
TWO PANELS OF FIBROUS GLASS DUCT SECTIONS OR FITTINGS 4 FEET (1.22 m) WIDE OR GREATER MUST HAVE SAG SUPPORTS PER ONE OF THE TWO SAG CONTROL FIGURES DRAWN BELOW.

SAG SUPPORTS DO NOT REPLACE TIE ROD ASSEMBLIES AS CALLED FOR IN THE REINFORCEMENT SCHEDULE, BUT MUST BE INSTALLED IN ADDITION TO THEM. SAG SUPPORTS MUST BE LOCATED WITH 12" (305 mm) OF HANGERS.





SAG CONTROL



SAG CONTROL

FIGURE E-4 TIE ROD REINFORCEMENT AT JOINT

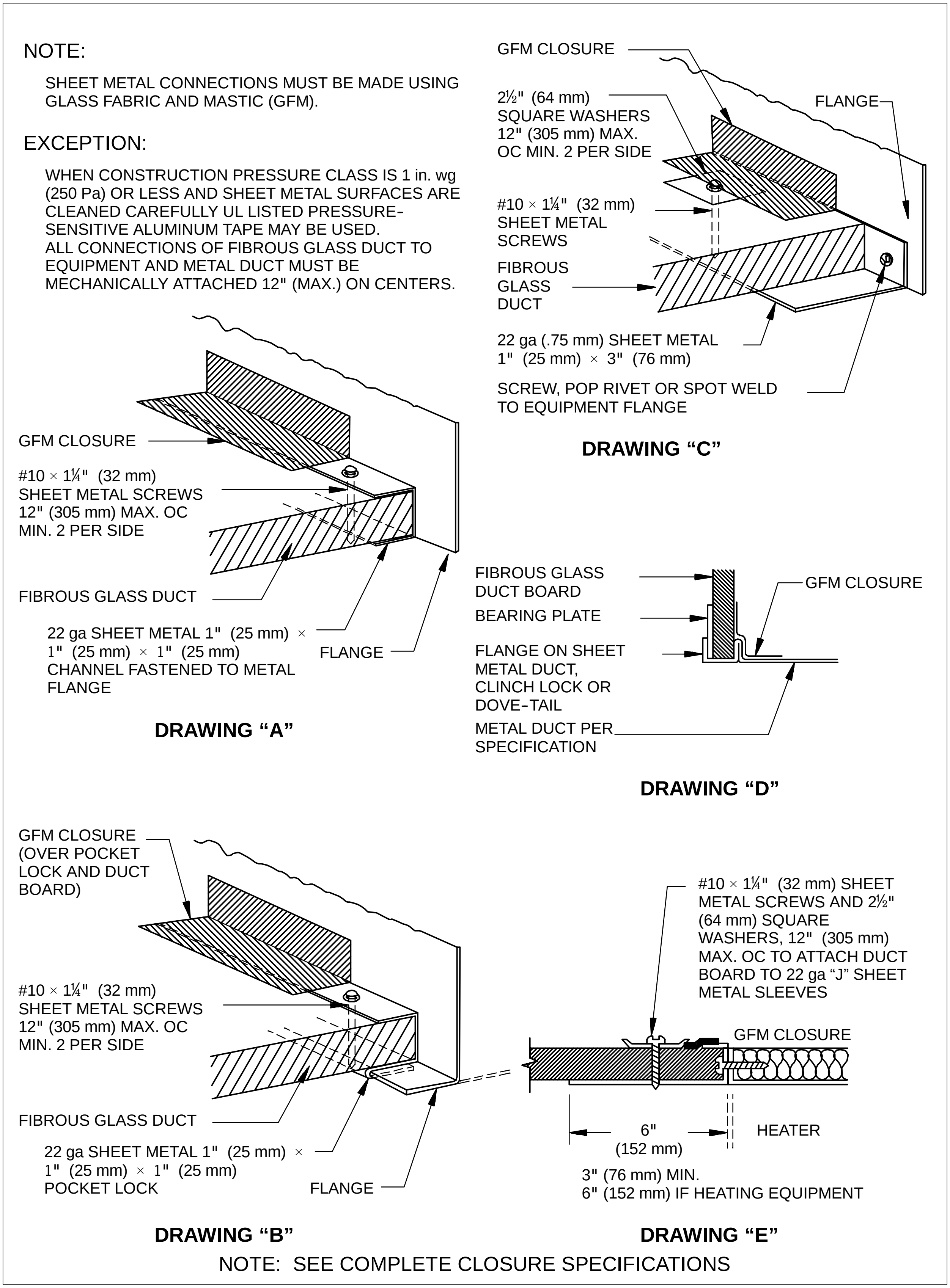


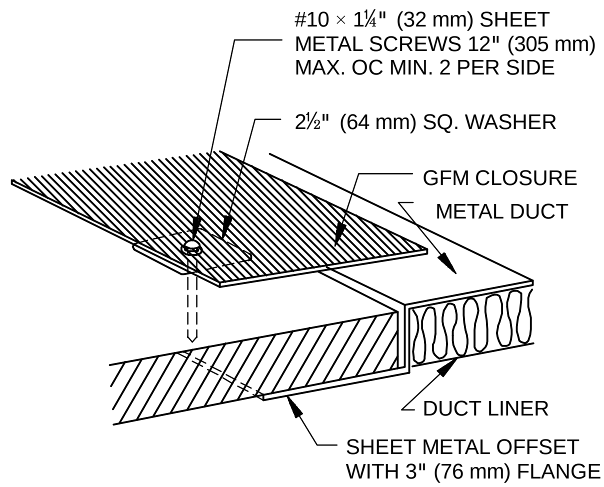
FIGURE E-5 SHEET METAL AND EQUIPMENT CONNECTION DETAILS

NOTE:

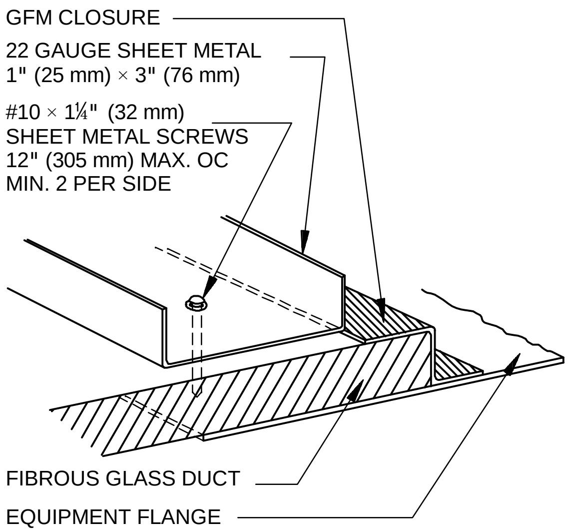
SHEET METAL CONNECTIONS MUST BE MADE USING GLASS FABRIC AND MASTIC (GFM).

EXCEPTION:

WHEN CONSTRUCTION PRESSURE CLASS IS 1 in. wg (250 Pa) OR LESS AND SHEET METAL SURFACES ARE CLEANED CAREFULLY UL LISTED PRESSURE-SENSITIVE ALUMINUM TAPE MAY BE USED.
ALL CONNECTIONS OF FIBROUS GLASS DUCT TO EQUIPMENT AND METAL DUCT MUST BE MECHANICALLY ATTACHED 12" (MAX.) ON CENTERS.

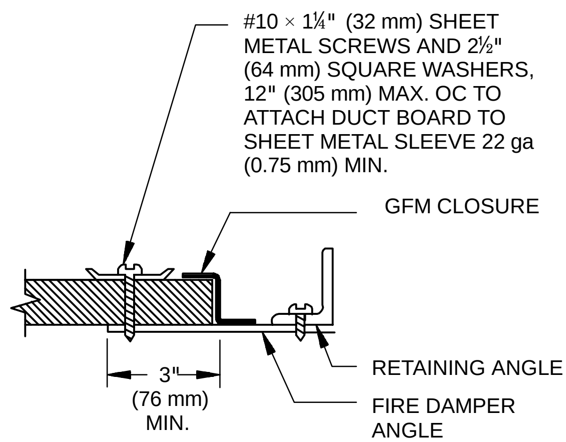


DRAWING "G"

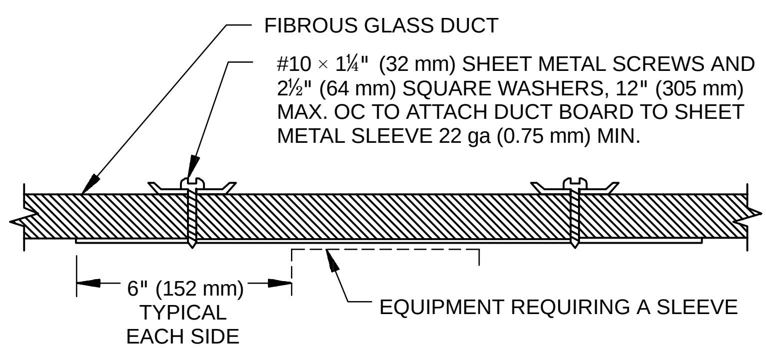


USE THIS CONNECTION WHEN:
DUCT SPAN IS GREATER THAN 60" (1524 mm), OR
STATIC PRESSURE IS GREATER THAN 1 in. wg (250 Pa).

DRAWING "F"



DRAWING "H"



DRAWING "I"

NOTE: SEE COMPLETE CLOSURE SPECIFICATIONS

FIGURE E-6 SHEET METAL AND EQUIPMENT CONNECTION DETAILS (CONTINUED)

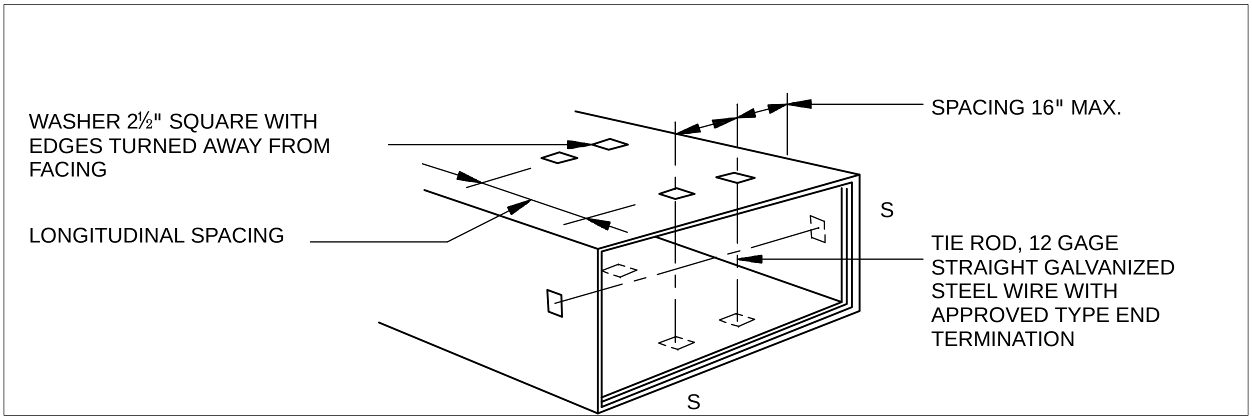


FIGURE E-7 TIE ROD REINFORCEMENT

Positive Static Pressure, in. wg	Maximum Inside Duct Dimension, in.	TYPE 475 BOARD			TYPE 800 BOARD		
		No. Rods Across Dimension	Maximum Longitudinal Spacing, in.	No. Rods per 4 ft Section	No. Rods Across Dimension	Maximum Longitudinal Spacing, in.	No. Rods per 4 ft Section
0 thru ½ in. wg	0 – 36	NOT REQUIRED			NOT REQUIRED		
	37 – 42	2	24	4	2	48	2
	43 – 48	2	24	4	2	48	2
	49 – 60	3	24	6	3	48	3
	61 – 64	3	24	6	3	24	6
	65 – 80	4	24	8	4	24	8
	81 – 96	5	24	10	5	24	10
Over ½ thru 1 in. wg	0 – 24	NOT REQUIRED			NOT REQUIRED		
	25 – 30	1	24	2	1	48	1
	31 – 32	1	24	2	1	24	2
	33 – 36	2	24	4	2	24	4
	37 – 48	2	24	4	2	24	4
	49 – 64	3	24	6	3	24	6
	65 – 80	4	24	8	4	24	8
	81 – 96	5	24	10	5	24	10
Over 1 thru 2 in. wg	0 – 15	NOT REQUIRED			NOT REQUIRED		
	16 – 18	1	24	2			
	19 – 24	1	24	2	1	48	1
	25 – 32	1	16	3	1	24	2
	33 – 48	2	16	6	2	24	4
	49 – 60	3	16	9	3	24	6
	61 – 64	3	16	9	3	16	9
	65 – 80	4	16	12	4	16	12
	81 – 96	5	16	15	5	16	15

Table E-1 Tie Rod System Reinforcement Schedule

NOTES:

a. Tie rods and washers must be no more than 16 in. on centers across duct dimension.
b. Ducts of 48 in. width and over require use of anti-sag devices.
c. If dimensions require, tie rods run in both horizontal and vertical directions.
d. Some fittings may require reinforcement even though the schedule for straight duct does not require it.

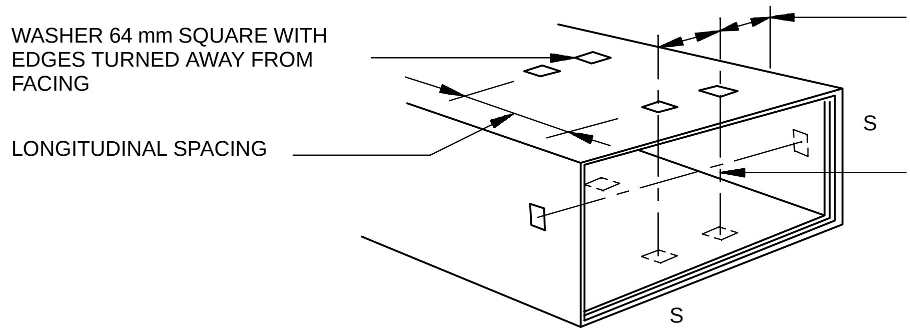


FIGURE E-7M TIE ROD REINFORCEMENT

Positive Static Pressure, in. wg	Maximum Inside Duct Dimension, m	TYPE 475 BOARD			TYPE 800 BOARD		
		No. Rods Across Dimension	Maximum Longitudinal Spacing, m	No. Rods per 1.2 m Section	No. Rods Across Dimension	Maximum Longitudinal Spacing, m	No. Rods per 1.2 m Section
0 thru 12.7 mm	0 – 0.91	NOT REQUIRED			NOT REQUIRED		
	0.94 – 1.06	2	0.600	4	2	1.200	2
	1.09 – 1.22	2	0.600	4	2	1.200	2
	1.24 – 1.52	3	0.600	6	3	1.200	3
	1.55 – 1.63	3	0.600	6	3	0.600	6
	1.65 – 2.03	4	0.600	8	4	0.600	8
	2.06 – 2.44	5	0.600	10	5	0.600	10
Over 12.7 thru 25 mm	0 – 0.61	NOT REQUIRED			NOT REQUIRED		
	0.64 – 0.76	1	0.600	2	1	1.200	1
	0.79 – 0.81	1	0.600	2	1	0.600	2
	0.84 – 0.91	2	0.600	4	2	0.600	4
	0.94 – 1.22	2	0.600	4	2	0.600	4
	1.24 – 1.63	3	0.600	6	3	0.600	6
	1.65 – 2.03	4	0.600	8	4	0.600	8
	2.06 – 2.44	5	0.600	10	5	0.600	10
Over 25 thru 50 mm	0 – 0.38	NOT REQUIRED			NOT REQUIRED		
	0.41 – 0.46	1	0.600	2			
	0.48 – 0.61	1	0.600	2	1	1.200	1
	0.64 – 0.81	1	0.400	3	1	0.600	2
	0.84 – 1.22	2	0.400	6	2	0.600	4
	1.24 – 1.52	3	0.400	9	3	0.600	6
	1.55 – 1.62	3	0.400	9	3	0.410	9
	1.65 – 2.03	4	0.400	12	4	0.410	12
	2.06 – 2.44	5	0.4000.400	15	5	0.410	15

Table E-1M Tie Rod System Reinforcement Schedule

NOTES:

a. Tie rods and washers must be no more than 0.41 m on centers across duct dimension.
b. Ducts of 1.2 m width and over require use of anti-sag devices.
c. If dimensions require, tie rods run in both horizontal and vertical directions.
d. Some fittings may require reinforcement even though the schedule for straight duct does not require it.

FASLOOP METHOD* (PROPRIETARY)

MATERIALS REQUIRED PER TIE ROD ASSEMBLY:

- 12 GAGE (2.753 mm) GALVANIZED STEEL WIRE 1¾" (44 mm) LONGER THAN OUTSIDE DUCT DIMENSION.
- TWO WASHERS, 2½" (64 mm) SQUARE × 0.028" (0.71 mm) THICK GALVANIZED STEEL, VOLCANO TYPE WITH BEVELED EDGES AND 0.150" (4 mm) HOLE IN CENTER.
  NOTE: OTHER TYPES OF MANUFACTURED FLAT WASHERS ARE NOT SUITABLE FOR THIS APPLICATION.

* A NAIMA REPORT STATES THAT NO OTHER SIZE OR SHAPE OF LOOP HAS BEEN TESTED TO DETERMINE COMPLIANCE WITH THE 50,000 CYCLE TEST.

POP RIVET SLEEVE METHOD

MATERIALS REQUIRED PER TIE ROD ASSEMBLY:

- 12 GAGE (2.753 mm) GALVANIZED STEEL WIRE, CUT EXACTLY TO OUTSIDE DUCT DIMENSION.
- TWO WASHERS, 2½" (64 mm) SQUARE × 0.020" (0.5 mm) (MIN.) THICK GALVANIZED STEEL WITH BEVELED EDGES AND 7/32" (6 mm) DIAMETER CENTER HOLE.
- TWO 3/16" (5 mm) STEEL POP RIVET SLEEVES, 3/8" (10 mm) LONG.

LOCKING CAP METHOD

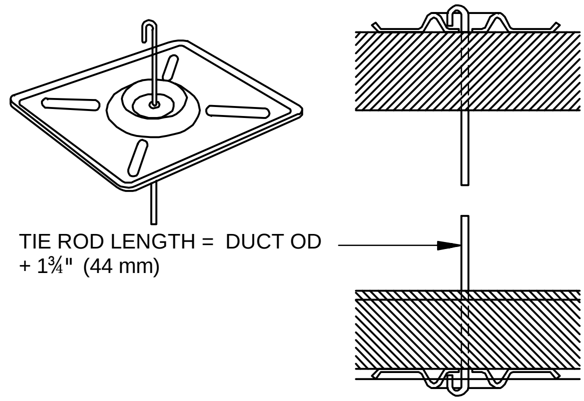
(NOT TO BE USED ON SLOPED PANELS OF FITTINGS)
MATERIALS REQUIRED PER TIE ROD ASSEMBLY:

- 12 GAGE (2.753 mm) GALVANIZED STEEL WIRE, CUT 7/16" (11 mm) LONGER THAN OUTSIDE DUCT DIMENSION.
- TWO WASHERS, 2½" (64 mm) SQUARE × 0.020" (0.5 mm) (MIN.) THICK GALVANIZED STEEL WITH BEVELED EDGES AND 0.150" (4 mm) DIAMETER HOLE IN CENTER .
- TWO LOCKING CAPS, 7/8" (22 mm) DIAMETER, HAVING SPRING STEEL OR STAINLESS STEEL LOCKING INSERTS.

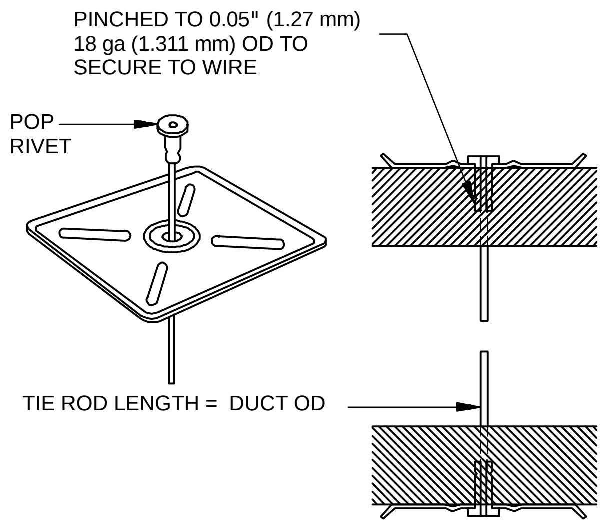
NOTES:

1. AN ORDINARY INSULATION LOCKING WASHER DOES NOT HAVE SUFFICIENT HOLDER POWER.
2. WIRE MUST BE FREE TO MOVE WITHIN THE 2½" (64 mm) SQUARE WASHER.
3. DO **NOT** RE-USE LOCKING CAPS.

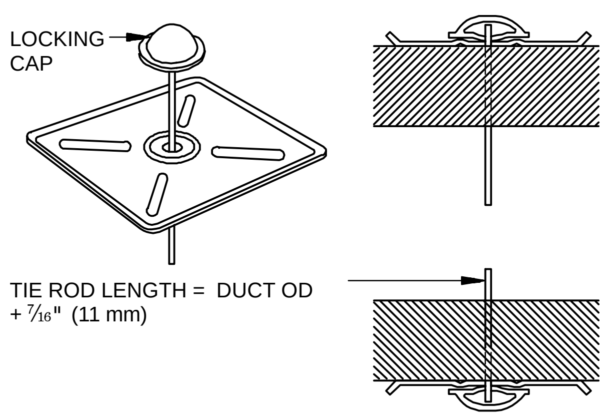
REUSE OF CAP IS PROHIBITED.



FASLOOP TERMINATION



POP RIVET SLEEVE TERMINATION



LOCKING CAP TERMINATION

FIGURE E-8 TIE ROD TERMINATION METHODS

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Static Pressure, in. wg		Maximum Inside Duct Dimension, in.	TYPE 475 BOARD			TYPE 800 BOARD		
			Maximum Longitudinal Spacing, in.	Channel Gage	H dimension, in. (see below)	Maximum Longitudinal Spacing, in.	Channel Gage	H dimension, in. (see below)
0 thru ½ in. wg	neg.	0 – 30	NOT REQUIRED			NOT REQUIRED		
		31 – 36	24	22	1	48	22	1
	pos.	0 – 36	NOT REQUIRED			NOT REQUIRED		
0 thru ½ in. wg positive or negative		37 – 42	24	22	1	48	22	1
		43 – 48	24	22	1	48	22	1
		49 – 60	24	22	1	48	22	1½
		61 – 72	24	22	1	24	22	1
		73 – 84	24	22	1	24	22	1
		85 – 96	24	22	1¼	24	22	1
Over ½ thru 1 in. wg positive or negative		0 – 24	NOT REQUIRED			NOT REQUIRED		
		25 – 30	24	22	1	48	22	1
		31 – 36	24	22	1	24	22	1
		37 – 42	24	22	1	24	22	1
		43 – 48	24	22	1	24	22	1
		49 – 60	24	22	1	24	22	1
		61 – 72	24	18	1	24	18	1
		73 – 84	24	18	1¼	24	18	1¼
		85 – 96	24	18	1¼	24	18	1¼
Over 1 thru 2 in. wg positive or negative		0 – 15	NOT REQUIRED			NOT REQUIRED		
		16 – 18	24	22	1			
		19 – 24	24	22	1	24	22	1
		25 – 36	16	22	1	24	22	1
		37 – 48	16	22	1	24	22	1¼
		49 – 60	16	22	1	24	22	1¼
		61 – 72	16	18	1	16	18	1
		73 – 84	16	18	1¼	16	18	1¼
		85 – 96	16	18	1½	16	18	1½

Table E-2 Channel System Reinforcement Schedule

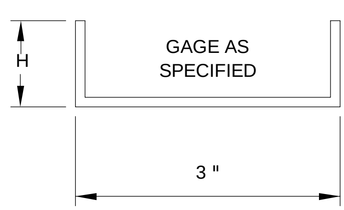
NOTES:

a. Ducts of 48 in. maximum width and over require use of anti-sag devices. *See* Figure E-9.

b. Some fittings may require reinforcement even though the schedule for straight duct does not require it.

c. Reinforcement for positive pressure need not be attached to the duct board except when required for sag control. See attachment details for both positive and negative pressure application.

d. On negative pressure ducts, attach channels to each duct side on 16 in. centers one fastener minimum. *See* Figure E-10.

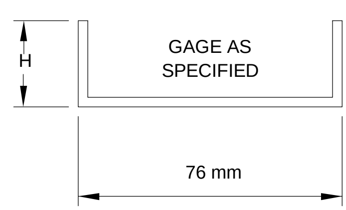


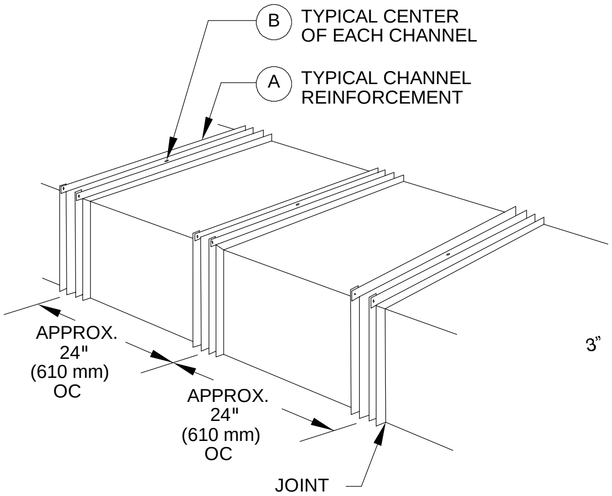
Static Pressure, Pa		Maximum Inside Duct Dimension, m	TYPE 475 BOARD Maximum Longitudinal Spacing, m	TYPE 475 BOARD Channel Gage mm	TYPE 475 BOARD H dimension, mm (see below)	TYPE 800 BOARD Maximum Longitudinal Spacing, m	TYPE 800 BOARD Channel Gage mm	TYPE 800 BOARD H dimension, mm (see below)
0 thru 125 Pa	neg.	0 – 0.76	NOT REQUIRED			NOT REQUIRED		
		0.79 – 0.91	0.600	0.753	25	1.200	0.753	25
	pos.	0 – 0.91	NOT REQUIRED			NOT REQUIRED		
0 thru 125 Pa positive or negative		0.94 – 1.07	0.600	0.753	25	1.200	0.753	25
		1.09 – 1.22	0.600	0.753	25	1.200	0.753	25
		1.24 – 1.52	0.600	0.753	25	1.200	0.753	38
		1.55 – 1.83	0.600	0.753	25	0.600	0.753	25
		1.85 – 2.13	0.600	0.753	25	0.600	0.753	25
		2.16 – 2.44	0.600	0.753	32	0.600	0.753	25
Over 125 thru 250 Pa positive or negative		0 – 0.61	NOT REQUIRED			NOT REQUIRED		
		0.64 – 0.76	0.600	0.753	25	1.200	0.753	25
		0.79 – 0.91	0.600	0.753	25	0.600	0.753	25
		0.94 – 1.07	0.600	0.753	25	0.600	0.753	25
		1.09 – 1.22	0.600	0.753	25	0.600	0.753	25
		1.24 – 1.52	0.600	0.753	25	0.600	0.753	25
		1.55 – 1.83	0.600	1.81	25	0.600	1.81	25
		1.85 – 2.13	0.600	1.81	32	0.600	1.81	32
		2.16 – 2.44	0.600	1.81	32	0.600	1.81	32
Over 250 thru 500 Pa positive or negative		0 – 0.38	NOT REQUIRED			NOT REQUIRED		
		0.41 – 0.46	0.600	0.753	25			
		0.48 – 0.61	0.600	0.753	25	0.600	0.753	25
		0.64 – 0.91	0.400	0.753	25	0.600	0.753	25
		0.94 – 1.20	0.400	0.753	25	0.600	0.753	32
		1.24 – 1.52	0.400	0.753	25	0.600	0.753	32
		1.55 – 1.83	0.400	1.81	25	0.400	1.81	25
		1.85 – 2.13	0.400	1.81	32	0.400	1.81	32
		2.16 – 2.44	0.400	1.81	38	0.400	1.81	38

Table E–2M Channel System Reinforcement Schedule

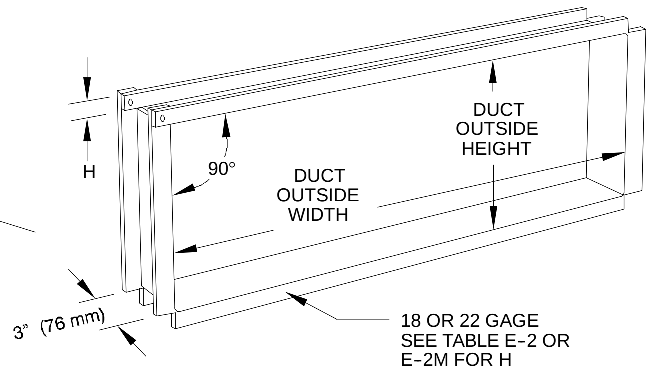
NOTES:

a. Ducts of 1.20 m maximum width and over require use of anti-sag devices. *See* Figure E-9.
b. Some fittings may require reinforcement even though the schedule for straight duct does not require it.
c. Reinforcement for positive pressure need not be attached to the duct board except when required for sag control. See attachment details for both positive and negative pressure application.
d. On negative pressure ducts, attach channels to each side on 0.41 m centers one fastener minimum. *See* Figure E-10.

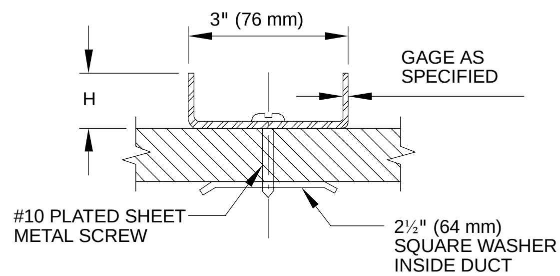




CHANNEL REINFORCEMENT SPACING



CHANNEL REINFORCEMENT DETAIL (A)

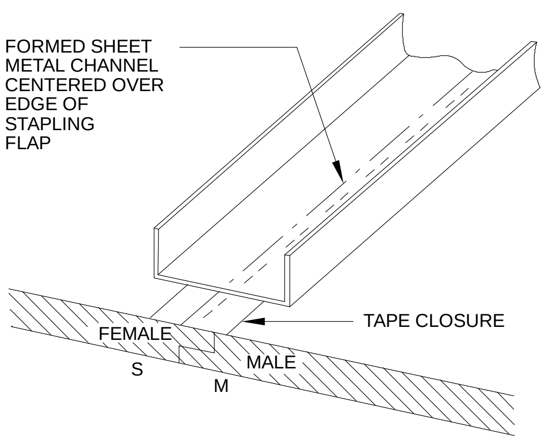


SAG SUPPORT DETAIL (B)

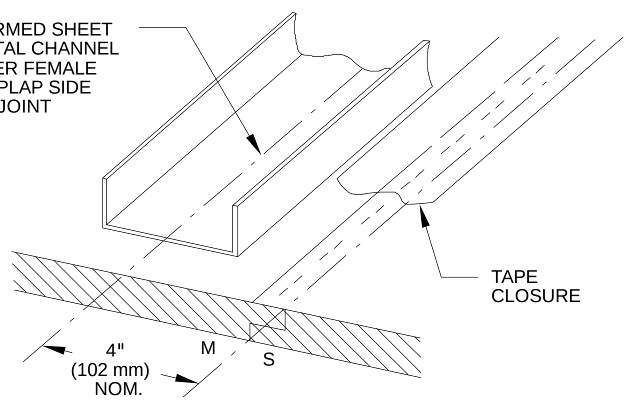
THE NUMBER OF CHANNELS ALONG THE DUCT SHALL BE AS SHOWN IN TABLE E–2 OR E–2M.

FOR SAG SUPPORT IN DUCTS 48" (1220 mm) OR GREATER IN MAXIMUM DIMENSION, EACH REINFORCEMENT MUST BE FASTENED TO TOP OF DUCT IN MIDSPAN. SEE DETAIL (B).

TYPICAL CHANNEL REINFORCEMENT ON 24" (610 mm) CENTERS, 48" (1220 mm) DUCT SECTIONS AND 48" (1220 mm) OR MORE WIDTH SEE TABLE E–2 (TABLE E–2M)



CHANNEL REINFORCEMENT AT JOINTS ON DUCTS WITH WIDTH LESS THAN 48" (1220 mm)



CHANNEL REINFORCEMENT OFFSET TO CLEAR CLOSURE ON DUCTS 48" (1220 mm) AND OVER

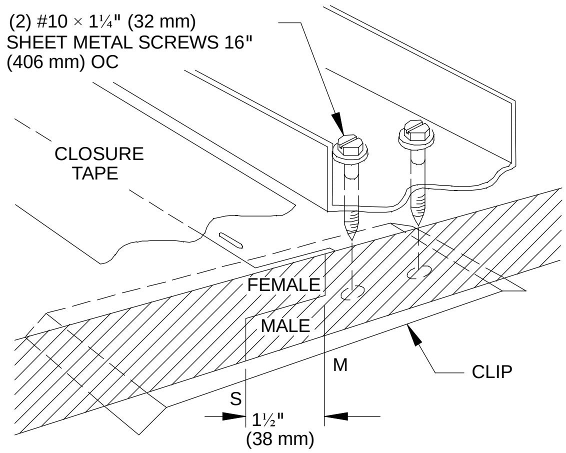
FIGURE E–9 CHANNEL REINFORCEMENT, POSITIVE PRESSURE SYSTEMS

CONSTRUCTION DETAILS

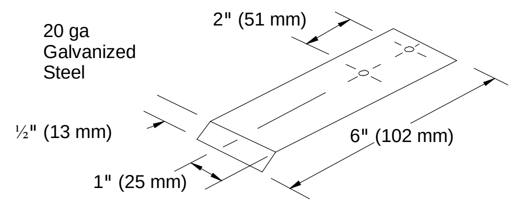
EACH REINFORCEMENT MAY BE FABRICATED FROM A CONTINUOUS LENGTH OF CHANNEL HAVING THREE 90 DEGREE BENDS AND A FOURTH 90 DEGREE CORNER WHICH IS SECURELY FASTENED WITH BOLTS, SCREWS, RIVETS, SPOTWELDS, OR STAPLES. REINFORCEMENTS MAY ALSO BE FABRICATED WITH TWO, THREE, OR FOUR SECURELY FASTENED CORNERS.

LOCATING REINFORCING CHANNELS

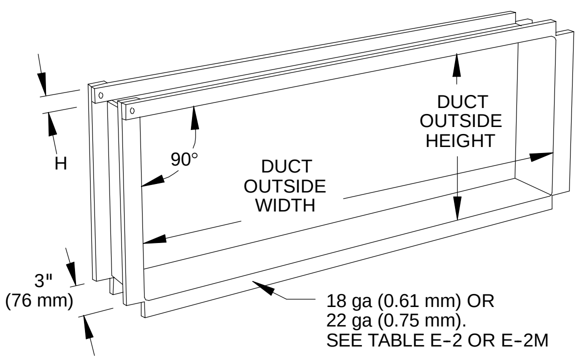
IN NEGATIVE PRESSURE APPLICATIONS, REINFORCEMENT IS APPLIED OVER MALE SHIPLAP AND IS ATTACHED WITH SCREWS AND CLIPS AT INTERVALS NOT EXCEEDING 16" (405 mm). WHEN ADDITIONAL CHANNELS ARE REQUIRED (BETWEEN JOINTS), THEY ARE ATTACHED TO THE DUCT WITH #10 PLATED SHEET METAL SCREWS AND 2½" (64 mm) SQUARE WASHERS AS IN DRAWING “A” BELOW. FOR POSITIVE PRESSURE APPLICATIONS.



CHANNEL REINFORCEMENT AT JOINTS FOR NEGATIVE PRESSURE SYSTEMS



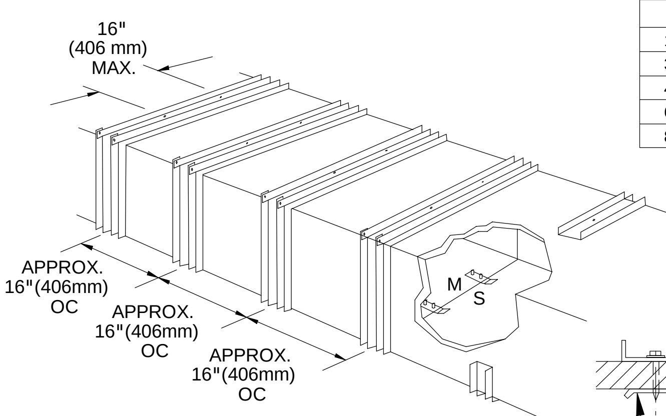
CLIP FOR NEGATIVE PRESSURE REINFORCEMENT SYSTEMS



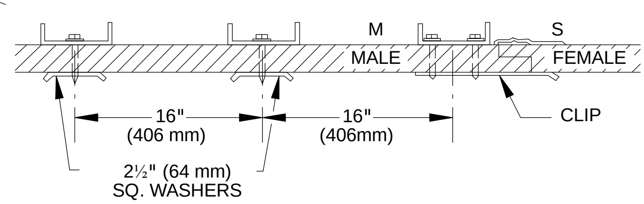
CHANNEL REINFORCEMENT

IN	½	1	1½	2	2½	3	6	16	48	18GA	20GA	22GA
MM	13	25	38	50	64	75	152	41 M	1.22M	1.181	0.905	0.7534

FASTENER REQUIREMENTS NEGATIVE PRESSURE		
TRANSVERSE DIMENSION		MINIMUM NUMBER OF CLIPS OR WASHERS PER REINFORCING MEMBER
INCHES	METERS	
16" - 32"	0.41 - 0.81	1
33" - 48"	0.84 - 1.22	2
49" - 64"	1.24 - 1.63	3
65" - 80"	1.65 - 2.03	4
81" - 96"	2.06 - 2.44	5



TYPICAL CHANNEL REINFORCEMENT ON 16" (406 mm) CENTERS, 48" (1220 mm) DUCT SECTIONS



DRAWING “A”

FIGURE E-10 CHANNEL REINFORCEMENT, NEGATIVE PRESSURE SYSTEMS

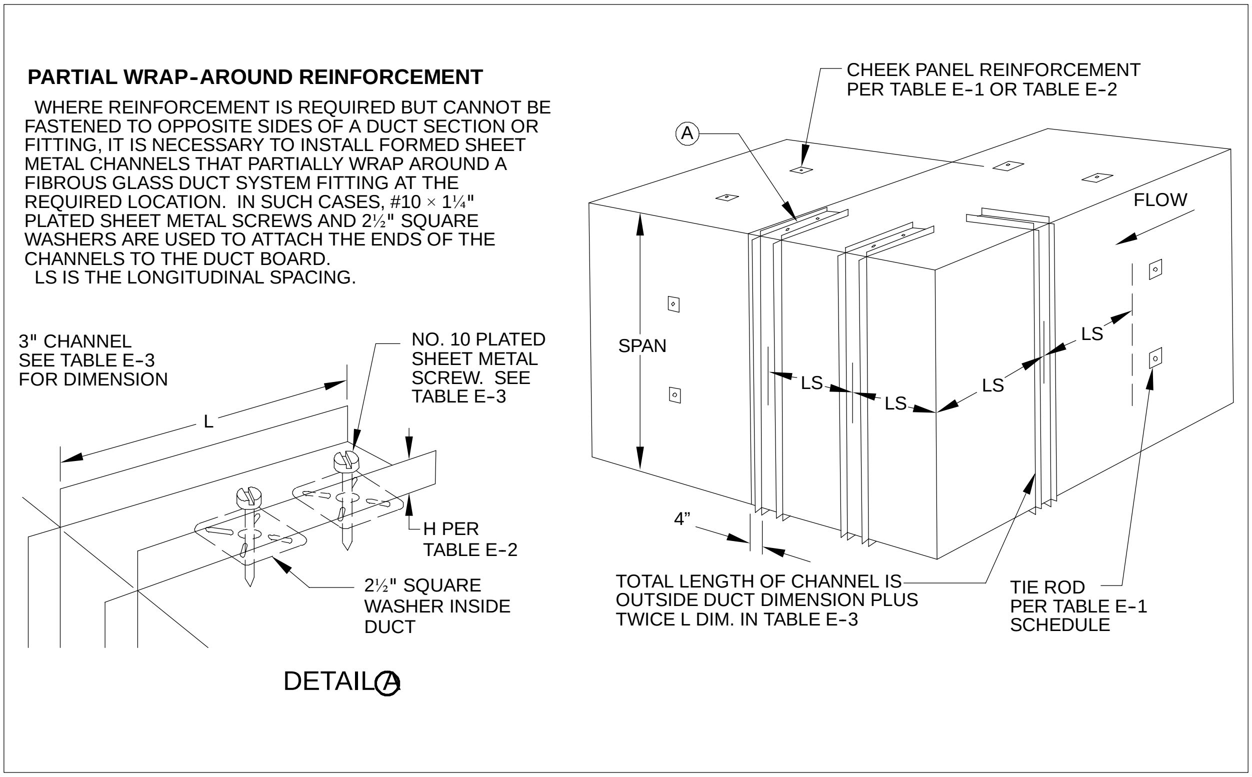


FIGURE E-11 PARTIAL WRAP-AROUND REINFORCEMENT

Positive Static Pressure, in. wg	TYPE 475 BOARD				TYPE 800 BOARD			
	Max Inside Duct Dim., in.	Longitudinal Spacing, in.	Dim L, in.	No. of Screws, Each End	Max Inside Duct Dim., in.	Longitudinal Spacing, in.	Dim L, in.	No. of Screws, Each End
0 thru ½ in. wg	0 – 36	NOT REQUIRED			0 – 36	NOT REQUIRED		
	37 – 96	24	4	1	37 – 60	48	4	1
					61 – 96	24	4	1
Over ½ thru 1 in. wg	0 – 24	NOT REQUIRED			0 – 24	NOT REQUIRED		
	25 – 48	24	4	1	25 – 30	48	4	1
	49 – 64	24	7	2	31 – 48	24	4	1
	65 – 80	24	10	3	49 – 64	24	7	2
	81 – 96	24	13	4	65 – 80	24	10	3
					81 – 96	24	13	4
Over 1 thru 2 in. wg	0 – 15	NOT REQUIRED			0 – 18	NOT REQUIRED		
	16 – 24	24	4	1	19 – 24	24	4	1
	25 – 32	16	4	1	25 – 32	24	7	2
	33 – 48	16	7	2	33 – 48	24	10	3
	49 – 64	16	10	3	49 – 60	24	13	4
	65 – 80	16	13	4	61 – 64	16	10	3
	81 – 96	16	16	5	65 – 80	16	14	3
					81 – 96	16	16	5

Table E-3 Partial Wrap-around Reinforcement Schedule

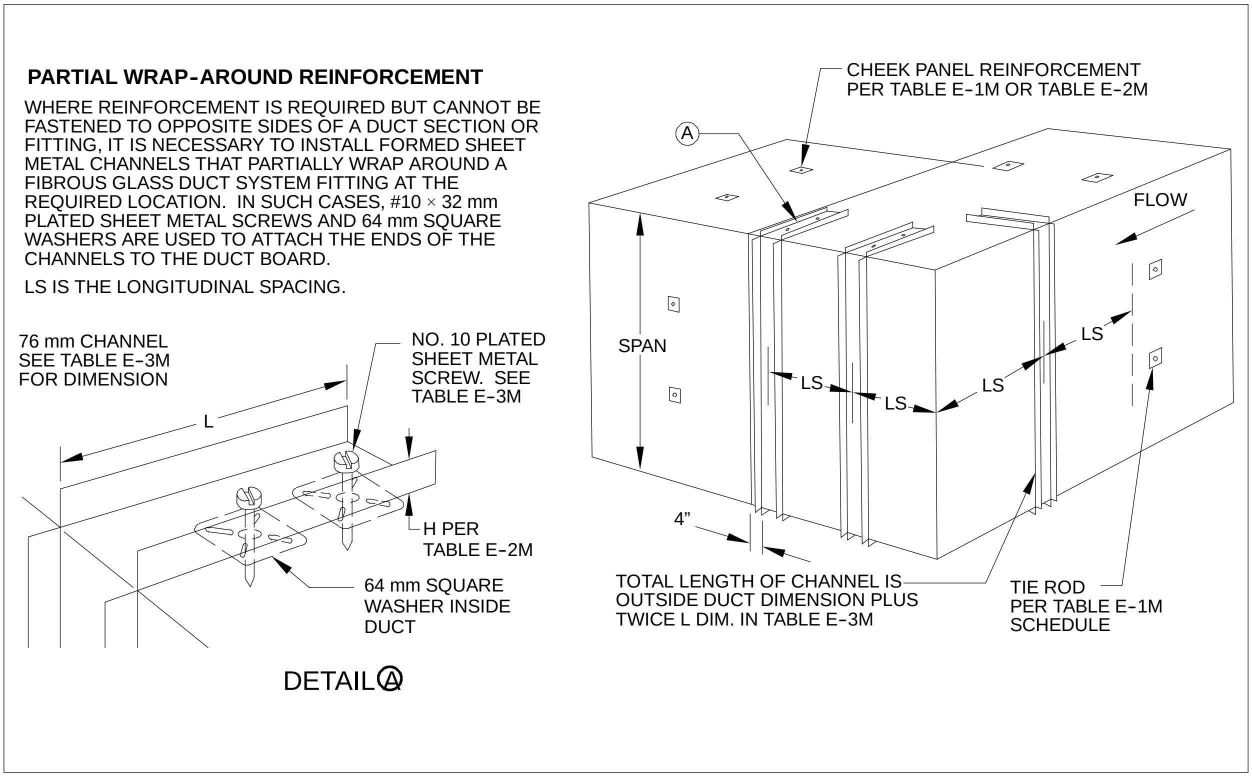


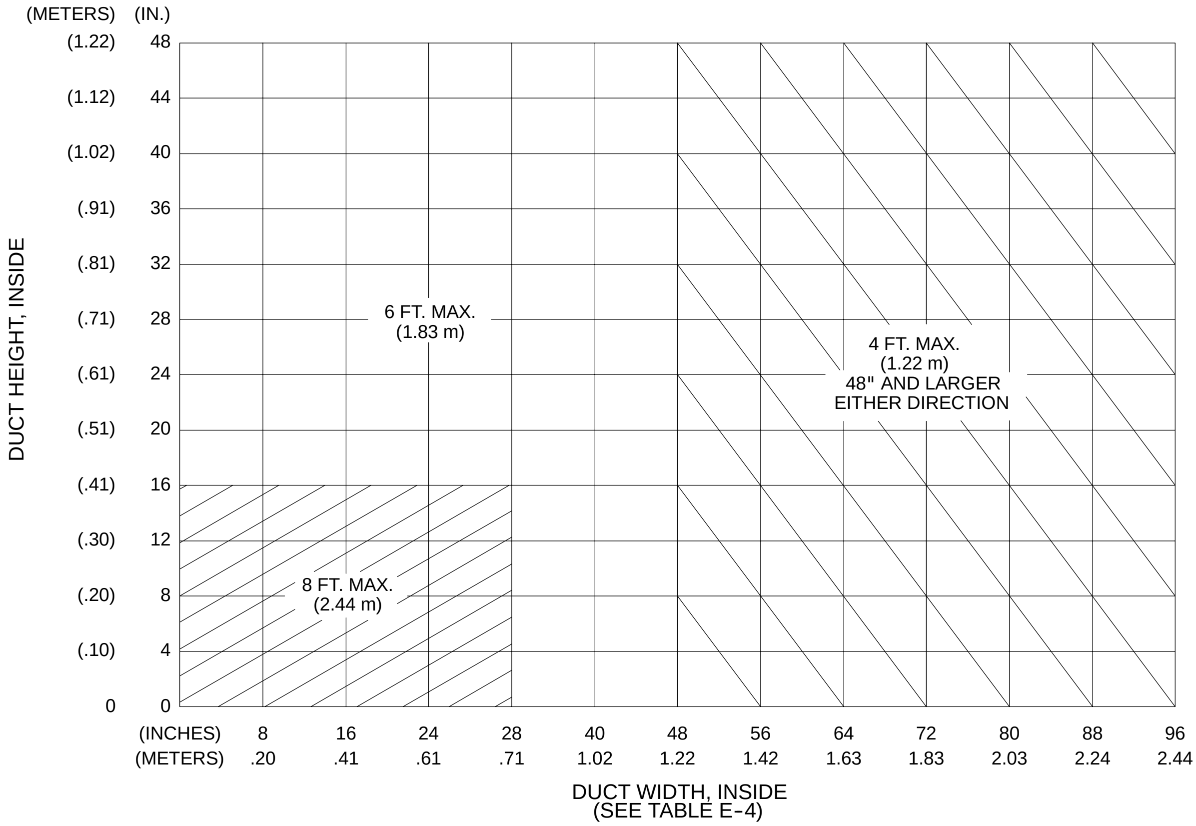
FIGURE E-11M PARTIAL WRAP-AROUND REINFORCEMENT

Positive Static Pressure, Pa	TYPE 475 BOARD				TYPE 800 BOARD			
	Max Inside Duct Dim., m	Longitudinal Spacing, m	Dim L, mm	No. of Screws, Each End	Max Inside Duct Dim., m	Longitudinal Spacing, m	Dim L, mm	No. of Screws, Each End
0 thru 125 Pa	0 – 0.91	NOT REQUIRED			0 – 0.91	NOT REQUIRED		
	0.94 – 2.44	0.61	102	1	0.94 – 1.52	1.22	102	1
					1.55 – 2.44	0.61	102	1
Over 125 thru 250 Pa	0 – 0.61	NOT REQUIRED			0 – 0.61	NOT REQUIRED		
	0.64 – 1.22	0.61	102	1	0.64 – 0.76	1.22	102	1
	1.24 – 1.63	0.61	178	2	0.79 – 1.22	0.61	102	1
	1.65 – 2.03	0.61	250	3	1.24 – 1.63	0.61	178	2
	2.06 – 2.44	0.61	330	4	1.65 – 2.03	0.61	250	3
					2.06 – 2.44	0.61	330	4
Over 250 thru 500 Pa	0 – 0.38	NOT REQUIRED			0 – 0.46	NOT REQUIRED		
	0.41 – 0.61	0.61	102	1	0.48 – 0.61	0.61	102	1
	0.64 – 0.81	0.41	102	1	0.64 – 0.81	0.61	178	2
	0.84 – 1.22	0.41	178	2	0.84 – 1.22	0.61	250	3
	1.24 – 1.63	0.41	250	3	1.24 – 1.52	0.61	330	4
	1.65 – 2.03	0.41	330	4	1.55 – 1.63	0.41	250	3
	2.06 – 2.44	0.41	410	5	1.65 – 2.03	0.41	360	3
					2.06 – 2.44	0.41	410	5

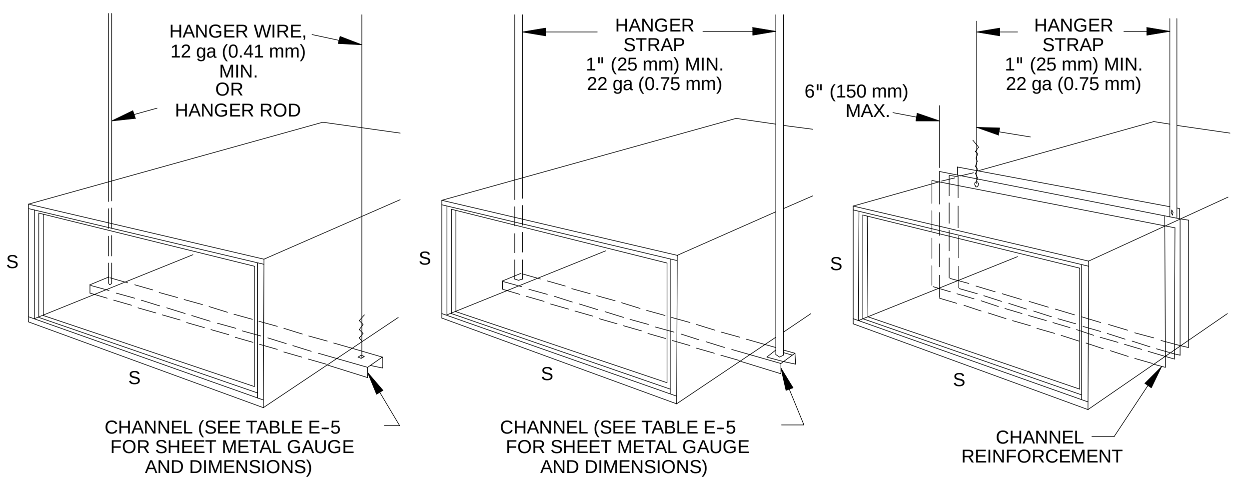
Table E-3M Partial Wrap-around Reinforcement Schedule

HANGERS AND SUPPORTS

ALLOWABLE HANGER SPACING, STRAIGHT DUCT, 3" WIDE CHANNEL



in.	1	6	12 ga	4 ft	6 ft	8 ft
mm	25	152	2.7	1.22 m	1.83 m	2.44 m



Drawing "A" **Drawing "B"** **Drawing "C"**

FIGURE E-12 ALLOWABLE HANGER SPACING, STRAIGHT DUCT – 3 INCH WIDE CHANNELS

STANDARD 3 IN. WIDE HANGERS

Hanger extension is defined as the sum of the distances between the hanging wires and the duct walls (both sides).

DUCT SIZE	MAX HANGER SPACING
48 in. (1220 mm) wide or greater	4 ft (1220 mm)
Less than 48 in. (1220 mm) wide and less than 48 in. (1220 mm) deep	6 ft (1828 mm)
Width between 28 in. (711 mm) and 48 in. (1220 mm) and greater than 16 in. (405 mm) deep	6 ft (1828 mm)
Less than 28 in. (711 mm) wide and depth 16 in. (405 mm) or less	8 ft (2440 mm)

Table E-4 Maximum Hanger Spacing by Duct Size, I.D.

IF TOTAL EXTENSION IS NOT GREATER THAN	MINIMUM CHANNEL GAGE	MINIMUM CHANNEL PROFILE
6 in. (150 mm)	24	3 × 1½ in. (76 × 37 mm)
18 in. (460 mm)	22	3 × 2 in. (76 × 50 mm)
30 in. (760 mm)	18	3 × 2 in. (76 × 50 mm)

Table E-5 Channel Selection

USE OF 2 IN. WIDE HANGERS

22 ga, 2 in. × 1½ in. (50 × 37 mm) hangers may be substituted for 3 in. hangers for ducts with widths not over 48 in. (1220 mm) and depths not over 24 in. (610 mm) provided that not more than one joint occurs between hangers and the maximum hanger spacing is 4 ft (1220 mm).

EXCEPTION: When duct perimeter is 80 in. (2030 mm) or less and does not require reinforcement, two joints are permitted between hangers.

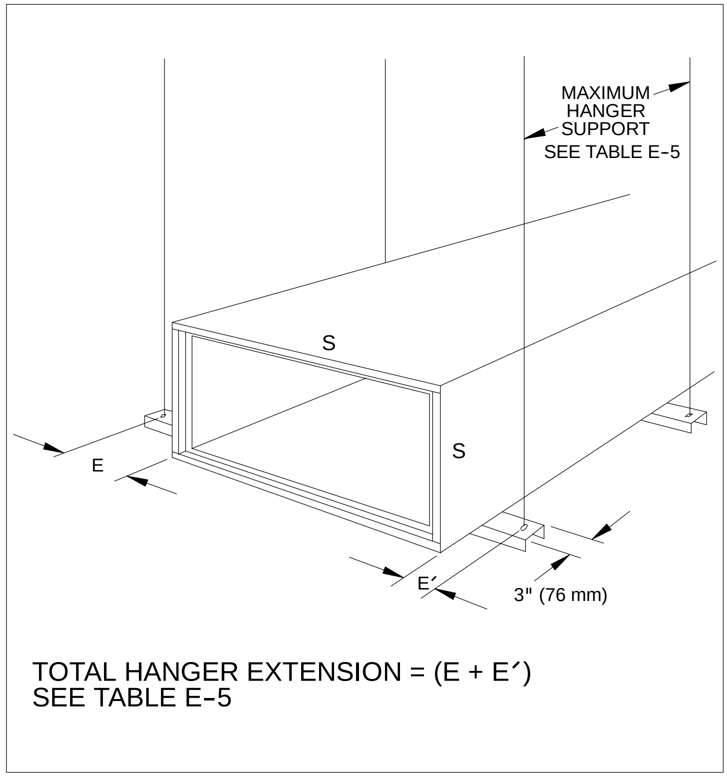


FIGURE E-13 HANGER SPACING AND EXTENSION – 3 INCH WIDE CHANNELS

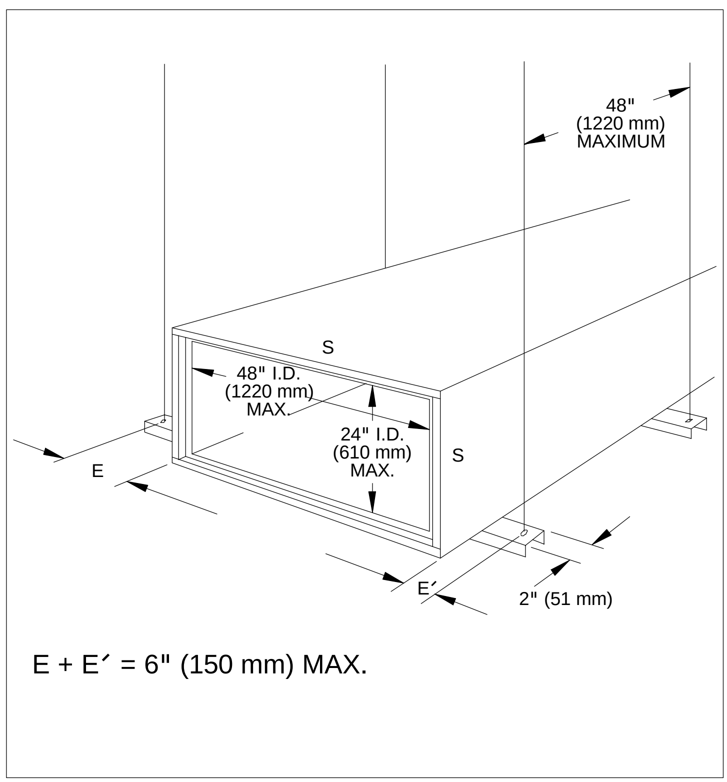


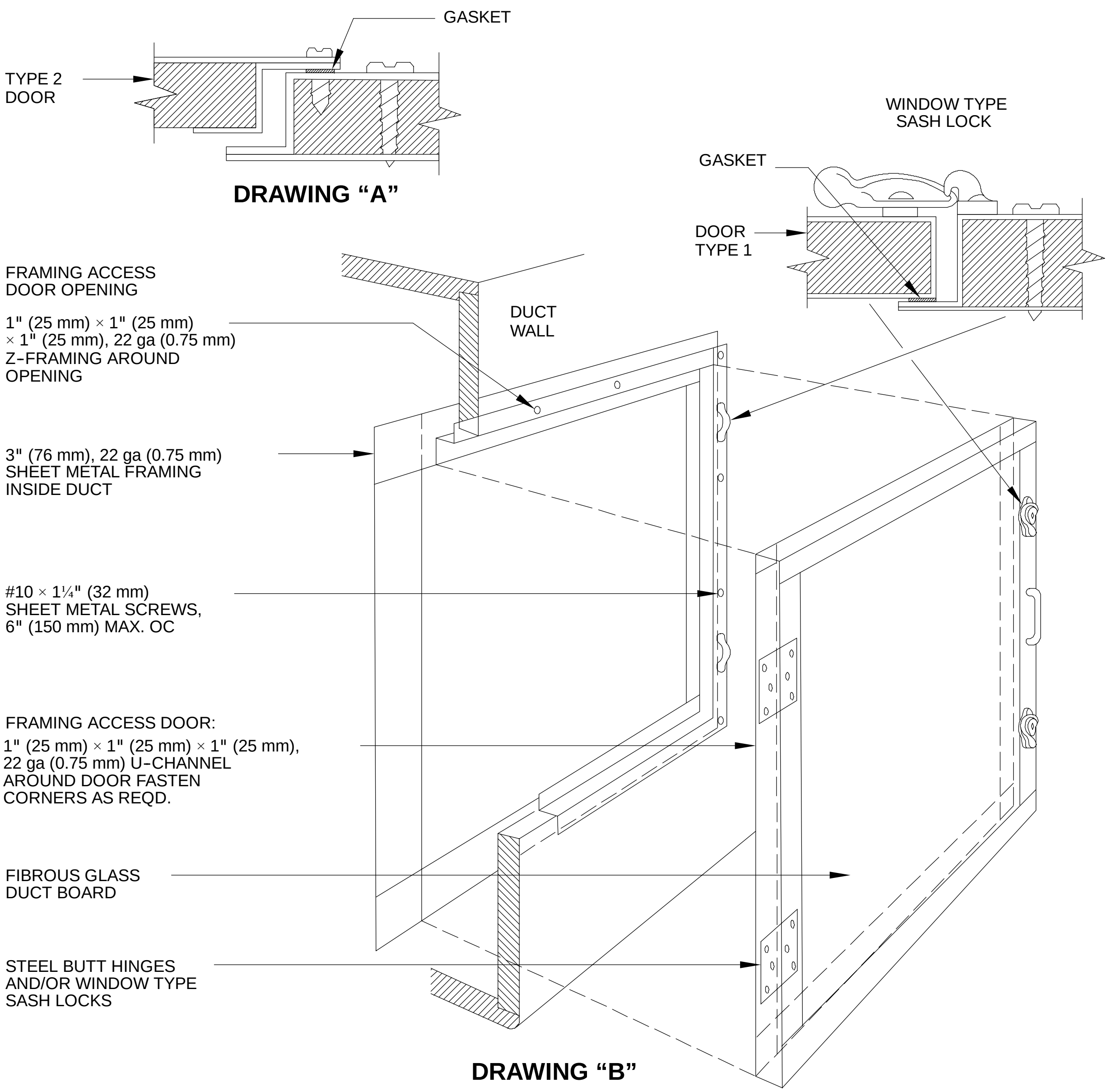
FIGURE E-14 USE OF 2 INCH WIDE HANGER CHANNELS

ACCESS DOOR, FLANGE ON OPENING

NOTE: SEE FIGURE 3-29.

PRESSURE RANGE	ACCESS DOOR SIZE
0 in. wg TO 1 in. (250 Pa)	24" (610 mm) × 24" (610 mm) MAX.
1 in. wg (250 Pa) TO 2 in. wg (500 Pa)	16" (406 mm) × 16" (406 mm) MAX.

REINFORCEMENT IS PROVIDED AS NECESSARY TO MAINTAIN DUCT PRESSURE CLASSIFICATION.



NOTE: SEE COMPLETE CLOSURE SPECIFICATIONS.

FIGURE E-15 ACCESS DOOR, FLANGE ON OPENING

SHEET METAL AND AIR CONDITIONING CONTRACTORS'
NATIONAL ASSOCIATION, INC.