FIFTH EDITION

NAIMA
North American Insulation Manufacturers Association

Fibrous Glass Duct Construction Standard

Low Velocity Systems 2” w.g. (500Pa) Maximum Static Pressure

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Preface

The North American Insulation Manufacturers Association (NAIMA) presents this Standard as a recommended method of fabricating and installing air transmission ducts in buildings using fibrous glass material as specified herein.

Rectangular ducts covered by this Standard are designed to operate at 2" w.g. (500 Pa) static pressure or less and 6,000 feet per minute (30.5 m/sec) internal air velocity or less. Other duct configurations have been qualified for higher pressures and/or velocities.

UL Standard 181A, Closure Systems for Use With Rigid Air Ducts, incorporates key provisions of UL Standard 181 as well as additional provisions developed by NAIMA and various closure material manufacturers. The resultant Standard provides the means for assuring the contractor and building owner that the selected closure system will, when properly applied, perform within varied environmental conditions.

NAIMA acknowledges the Sheet Metal and Air Conditioning Contractors' National Association's (SMACNA) Fibrous Glass Duct Construction Standards as a basis for the scope and content of this Standard.

This Standard was developed using reliable engineering principles and research plus consultation with and information obtained from manufacturers, contractors, testing laboratories, and others having specialized experience. It is subject to revision as further experience and investigation may show it is necessary or desirable to do so. Construction methods and products that comply with this Standard will not necessarily be acceptable if, when examined and tested, they are found to have other features that impair the result intended by these requirements.

Dimensional data on 2" (51mm) thick fibrous glass duct board, with an R-value of 8.7 (RSI of 1.53), not having been widely used until recently was not provided in previous editions of this Standard. This revised Fifth Edition includes thermal, acoustical, and dimensional data for 2" (51mm) duct board. For more complete dimensional details, refer to supplement, NAIMA's Pub. No. AH136. NAIMA assumes no responsibility and accepts no liability for the application of the principles or techniques contained in this Standard. **In particular, NAIMA makes no warranty of any kind, express or implied or regarding merchantability or fitness for any particular purpose, in connection with the information supplied herein.**

Authorities considering adoption of this Standard should review all Federal, state, local and contractual regulations applicable to specific installations.

This Standard is not intended to preclude alternate methods and materials of fabrication, closure, reinforcement and support when such methods and materials can be documented as providing equivalent performance.

NAIMA extends its thanks to the member companies of its Air Handling Committee who have contributed their time and talents in the development of this Standard.

NAIMA Air Handling Committee Member Companies:

CertainTeed
www.certainteed.com • 800-782-8777

Johns Manville
www.jm.com • 800-654-3103

Knauf Insulation
www.knaufinsulation.us • 800-825-4434

Owens Corning
www.owenscorning.com • 800-GET-PINK

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Section I Performance Criteria

General Requirements of Air Ducts

A duct system is a structural assembly whose primary function is to convey air between specific points. In fulfilling this function, the duct assembly must perform satisfactorily with respect to certain fundamental performance characteristics. Elements of the assembly are duct material, reinforcement members, seams and joint treatments. With regard to the duct assembly and its elements, theoretical and/or practical limits must be established for:

- Dimensional stability, deformation and deflection.
- Containment of the air being conveyed.
- Exposure to damage, weather, temperature extremes, flexure cycles or other in-service conditions.
- Support.

In establishing limitations for these factors, consideration must be given to the effects of the pressure differential across the duct wall, air flow friction losses, air velocities, infiltration or exfiltration, and the inherent strength characteristics of the duct components. Construction methods that will permit an economical attainment of the predicted and desired performance must be determined.

Analysis and Determination of Requirements for Fibrous Glass Ducts

Fibrous glass duct systems are fabricated from three types of product:

1. Boards of resin-bonded inorganic glass fibers 1" (25mm), 1½" (38mm), or 2" (51mm) thick with a factory-applied reinforced aluminum foil/kraft laminate exterior air barrier finish for fabricating rectangular and ten-sided ducts, plenums and distribution boxes. Regardless of thickness, the same reinforcement tables are applicable based on the flexural rigidity of the board, which includes consideration of the thickness.
2. Lengths of preformed rigid tubular fibrous glass duct of various diameters with a reinforced aluminum exterior finish.
3. Lengths of round flexible duct with a reinforced inner air barrier core, resilient fibrous glass insulation, and an outer vapor retarder jacket cut to required lengths for ducts or run-outs from fibrous glass trunk ducts or plenums to grilles and diffusers.

Section I: Performance Criteria

General requirements for air ducts are as follows, except where differing procedures are part of a manufacturer's UL Standard 181 listing and must be used in lieu of the procedures shown in this Standard.

1. DUCT BOARD

1.1. Strength and Deflection

Board stiffness is defined by flexural rigidity, which is the product of Young's Modulus of Elasticity (E), and the moment of inertia (I) per unit width. Boards are identified by ratings of 475-EI, 800-EI, and 1400-EI, respectively. Flexural rigidity rating is determined in accordance with NAIMA Test Number AH-100 and is an average of specimens taken from sheets of duct board.

Duct board deflection relative to a flat position of the board is limited to 1/100 of the span. This criterion is based on stress in the material not exceeding the proportional elastic limit of the material with suitable safety margins built in.

In both positive and negative pressure applications, the pressure differential causes additional board deflection. When it is necessary to limit this deflection, reinforcement shall be installed as defined in Section V, Reinforcement, of this Standard.

At atmospheric pressures, natural sag occurs in unsupported panels of duct board. Studies of natural sag and duct performance in larger duct sizes resulted in the determination that when the top panels of fibrous glass duct sections or fittings are 48" (1,219mm) wide or greater, sag support must be provided by installing tie rod and conduit assemblies as shown on page 5-4 (at shiplapped joints) or page 5-5 (at butt joints). Fastening the top panels to channel reinforcement as shown on page 5-10 is also an option.

1.2. Fatigue Tests

In normal service conditions, ducts incur pressure cycles. In investigating the potential effects of fatigue occurring in a duct system, sections of each duct board type (475-EI, 800-EI and 1400-EI) were cycled from atmospheric pressure to 150% of design pressure. Each test assembly consisted of not less than three 48" (1,219mm) (nominal) long sections of fibrous glass duct. The tests were conducted at 3 to 4 cycles per minute for 50,000 cycles, after which samples were removed from the center of the duct and the board's flexural rigidity (EI) was determined in accordance with NAIMA AH-100. For comparison of board strengths and deterioration, comparable samples of new duct board of each class were tested in accordance with the same NAIMA test method. In each case, there was no significant reduction in the flexural rigidity of the cycled boards.

2. REINFORCEMENT

2.1. Strength and Deflection

After criteria for fibrous glass boards were established, reinforcement designs were calculated, fabricated, tested, and modified as necessary to restrain the board within the deflection limitation of 1/100 of the span and to limit tensile stress in the steel reinforcement members to 22,000 psi (152 MPa).

2.2. Tests

Tests of reinforced ducts were made in systems incorporating both straight runs and fittings. Duct sizes ranging from 15" x 15" (381mm x 381mm) up to 96" x 42" (2,438mm x 1,067mm) were evaluated using dynamic and/or static testing. Maximum deflections generally occurred in the center of the board between reinforcements. Using boards of 475-EI, 800-EI, and 1400-EI and selected transverse reinforcements, deflection measurements were recorded for positive or negative pressures after 50,000 cycles from zero to 150% of rated pressure.

2.3. Positioning

Duct analysis and determination of reinforcement sizes and spacing were based on the condition that reinforcement must be placed at transverse joints for optimum joint strength, and at intermediate points as required in both positive and negative pressure applications. (See pages 5-6, 5-10, and 5-12.)

Moreover, on negative pressure systems with channel reinforcement, the general requirement to fasten reinforcement at distances not exceeding 16" (406mm) (approximately) is supplemented by a requirement to place 2" x 6" (51mm x 152mm) (nominal) 20 gauge retaining clips on the interior of the duct at circumferential joints. (See figures on pages 5-11 and 5-12.)

3. LONGITUDINAL SEAMS, TRANSVERSE JOINTS

Recommended methods of forming and aligning duct sides are given in detail in this Standard. In order to maintain alignment of the duct assembly, both longitudinal seams and transverse joints are sealed with a continuous closure system. Field observations and laboratory testing have indicated very low leakage rates.

Closures are an integral part of fibrous glass duct construction. Only those closures complying with UL Standard 181A, Part I (P) for pressure-sensitive aluminum foil tape, Part II (H) for heat-activated aluminum foil tape, or Part III (M) for glass fabric and mastic, have been tested for compliance with all structural and safety requirements. (See Section IV, Closure, of this Standard for detailed closure application information.)

4. DUCT SUPPORT

Hanger sizing and spacing for fibrous glass duct board systems are coordinated with other performance requirements of duct components. Hangers and supports must be placed for proper support of all duct board fittings and accessories so that taped joints are not placed under additional unanticipated stress. (See Section VI, Hanging and Supports, of this Standard.)

Fibrous glass duct systems covered in this Standard are not designed to support human traffic or external loads.

5. THERMAL PERFORMANCE

At 75°F (24°C) mean temperature, fibrous glass duct board provides the following thermal performance values:

	1" (25mm)	1½" (38mm)	2" (51mm)
R-value, hr ft² °F/Btu (m² °C/W)	4.3 (0.76)	6.5 (1.14)	8.7 (1.53)
K-value, Btu in/hr ft² °F (W/m °C)	0.23 (0.033)	0.23 (0.033)	0.23 (0.033)
C-value, Btu/hr ft² °F (W/m² °C)	0.23 (1.32)	0.16 (0.88)	0.12 (0.65)

Consult local codes for specific thermal requirements. Where codes do not address thermal value, NAIMA recommends using the current ASHRAE minimum duct insulation requirements. (See Appendix, pages A-7 and A-8.)

6. ACOUSTICAL PERFORMANCE

Fibrous glass duct board absorbs fan and air turbulence noise and reduces the popping noises caused by expansion and contraction. Typical acoustical performance of fibrous glass duct board, measured in accordance with ASTM C 423 (mounting A), is as follows:

	SOUND ABSORPTION COEFFICIENTS AT OCTAVE BAND CENTER FREQUENCIES, Hz						
	125	250	500	1,000	2,000	4,000	NRC
1.0" (25mm)	.03	.18	.61	.83	.89	.93	.65
1.5" (38mm)	.09	.33	.89	.96	.95	.94	.80
2.0" (51mm)	.17	.63	1.08	1.05	1.04	1.06	.95

A major benefit of the fibrous glass duct system is its contribution to a quiet indoor environment.

7. LEAKAGE

Ducts should be sufficiently airtight to ensure quiet, economical performance. Supply duct leakage reduces the delivered volumes of air at diffusers and registers, which must be compensated for by increasing the total quantity of supply air. Return duct leakage reduces system thermal efficiency and may draw unwanted air and contaminants into the system.

Air duct leakage testing was sponsored by ASHRAE, SMACNA and NAIMA. This test program, managed by ASHRAE, measured the leakage rates of typical duct constructions, including fibrous glass ducts, sealed and unsealed rectangular metal ducts, round metal ducts, and flexible ducts. In addition to various duct materials and geometries, the testing also evaluated many of the connection methods and joint treatments typically used with these systems. The results from this extensive testing program were analyzed in an attempt to generate reliable leakage design data for each system type.

It was found that the leakage for each construction and joint treatment was related to the operating static pressure and the outside surface area of the duct system.

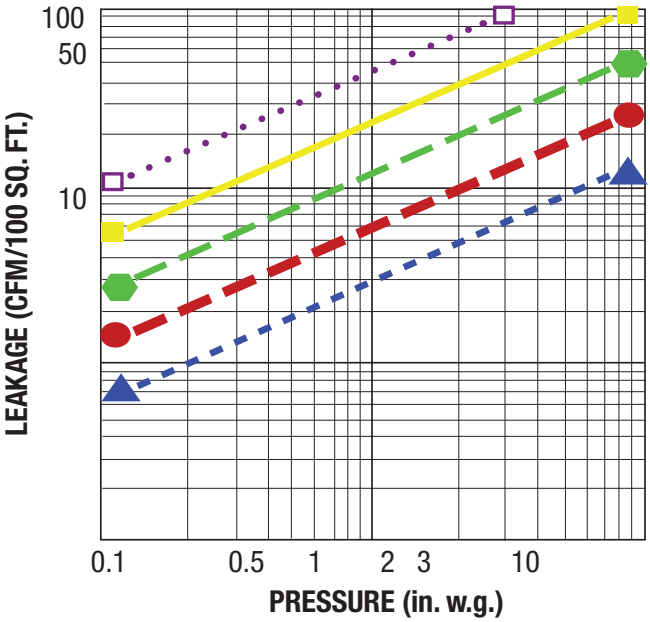
The form of this relationship was a power function:

$F = CL \times P^N$, where

F = leakage, cfm per 100 square feet of duct;
CL = leakage coefficient or leakage class, dimensionless;
P = duct static pressure, inches w.g.; and
N = dimensionless rational number.

With minor variations, the ASHRAE testing found N to be 0.65 for all duct materials and constructions. The leakage coefficient CL varied with material, construction, and joint treatment. The results from the fibrous glass duct testing were analyzed, and a classification was assigned based on the upper limits of the leakage measured for all of the duct board constructions. Reinforced fibrous glass duct board, tested up to 3" w.g. (750 Pa), was found to be a Class 6 system.

SMACNA has tabulated the leakage data to allow a designer to estimate the leakage per 100 square feet of duct outside surface area. The following chart summarizes this data. Again, fibrous glass duct systems are considered as Class CL = 6 for purposes of this chart.



LEGEND:

- $C_L = 48$ — Unsealed rectangular sheet metal duct
- $C_L = 24$, $C_L = 12$, $C_L = 6$ — Sheet metal ducts with differing levels of joint and seam sealing Reinforced rectangular fibrous glass duct board or rectangular sheet metal with all joints sealed
- $C_L = 3$ — Non-reinforced fibrous glass duct, round or rectangular, or spiral sheet metal duct

8. UL 181 CLASS 1 AIR DUCT RATING

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

1. They shall be constructed of Class 1 duct materials as tested in accordance with UL Standard 181, Factory-Made Air Ducts and Air Connectors.
2. Such ducts shall be installed in accordance with the conditions of their listing.
3. They may not be used in air duct systems that operate with an air temperature higher than 250˚F (121˚C) entering the ducts.
4. They shall not be used as vertical risers in air duct systems serving more than two stories.

Under UL Standard 181, Class 1 air duct materials have a flame spread rating of 25 and a smoke developed rating of 50. The following portions of UL Standard 181 are applicable to rigid fibrous glass ducts:

- Surface burning characteristics
- Flame penetration
- Burning
- Corrosion (metal parts not inherently corrosion resistant)
- Mold growth and humidity
- Temperature
- Puncture
- Static load
- Impact
- Erosion*
- Pressure*
- Collapse*
- Leakage

**Erosion, pressure, and collapse tests are run at 2½ times manufacturers' stated ratings. For the erosion test, the variable is velocity. For the pressure test, the variable is positive pressure. For the collapse test, the variable is negative pressure.*

9. REFERENCE DATA

For product design and performance reference data, refer to the manufacturers' data sheets.

Compilation of Fibrous Glass Duct Characteristics and Limitations

1. FLEXURAL RIGIDITY
The average flexural rigidity in the board is not less than the rating of 475, 800, or 1,400 pounds-inches squared per inch of width when tested in accordance with NAIMA Test Method AH-100.

2. STATIC PRESSURE
Up to 2" w.g. (500 Pa), positive or negative in the duct.

3. AIR VELOCITY
Rating of at least 2,400 feet per minute (12.0m/sec) in the duct.

4. ALLOWABLE DEFLECTION
1/100 of duct span maximum.

5. MAXIMUM ALLOWABLE STRESS IN STEEL MEMBERS USED FOR REINFORCEMENT OR SUPPORT
22,000 pounds per square inch (152 MPa).

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. WATER VAPOR SORPTION
Water vapor sorption of the duct board shall not exceed 5% by weight under conditions of 120°F (49°C) dry bulb at 95% relative humidity for 96 hours duration when tested in accordance with ASTM C 1104.

8. TEMPERATURE
- 40°F (4°C) (minimum) inside duct.
- 250°F (121°C) (maximum) inside duct.
- 150°F (66°C) (maximum) duct surface temperature.

9. CORROSIVENESS
Fibrous glass ducts are non-corrosive when in contact with steel, copper, or aluminum compared to a control specimen in contact with clean sterile cotton when tested in accordance with ASTM C 665.

10. CLOSURE
Closure materials (pressure-sensitive tapes, heat-activated tapes, glass fabric and mastic) shall conform to UL Standard 181A. When installed in accordance with manufacturers' instructions, closure systems will conform to UL Standard 181, Class 1 Air Duct requirements.

11. SAFETY STANDARDS
National Fire Protection Association Standards 90A/90B.

12. BACTERIA AND FUNGAL GROWTH RESISTANCE
Fibrous glass duct products meet fungal and bacterial growth requirements when subjected to microbial attack as described in UL Standard 181 and in ASTM C 1338 (no-growth procedure). Standard practices ASTM G 21 (fungus test) and G 22-95 (bacteria test) are also used to evaluate microbial growth.

13. REINFORCEMENT TESTING
Test programs have demonstrated that fibrous glass duct systems, including fittings and accessory items, are capable of maintaining their structural integrity through 50,000 cycles at 1½ times system design pressurization. This testing demonstrates the reliability of properly constructed systems but does not imply that systems should be operated at pressures above their reinforcement rating.

14. RESTRICTIONS
Fibrous glass duct systems should not be used in the following applications:
- Kitchen or fume exhaust ducts or to convey solids or corrosive gases.
- Installation in contact with concrete or buried below grade.
- Outdoors.
- As casings and/or housings of built-up equipment.
- Immediately adjacent to high temperature electric heating coils without radiation protection. Refer to NFPA Standard 90A and also to page 3-25 of this Standard for proper design.
- For vertical risers in air duct systems serving more than two stories.
- With coal or wood fueled equipment.
- In variable air volume systems on the high pressure side unless reinforced to withstand the full fan pressure.
- As penetrations in construction where fire dampers are required, except as shown on page 3-23 of this Standard with the fire damper installed in a sheet metal sleeve extending through the wall.

15. MOUNTING OF ACCESSORIES
When mounting equipment, dampers, damper operators, control motors, and other accessories, the duct system shall 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.

16. MOISTURE CONTROL

The following precautions should be taken to avoid soaking of the duct board with liquid water:

- When using either evaporative coolers or humidifiers, the immediate area around the device introducing water into the system should be protected by using a drip pan and protective corrosion-resistant sheet metal sleeve.
- Duct systems running through unconditioned space and used for cooling only must be tightly closed during the heating season to prevent accumulation of water vapor in the duct system.
- Fibrous glass duct materials that have become wet at the job-site before or during installation should not be installed. Duct systems in service that are found to be wet should be replaced. Consult the product manufacturer for further information.

17. COMPLIANCE WITH BUILDING CODES

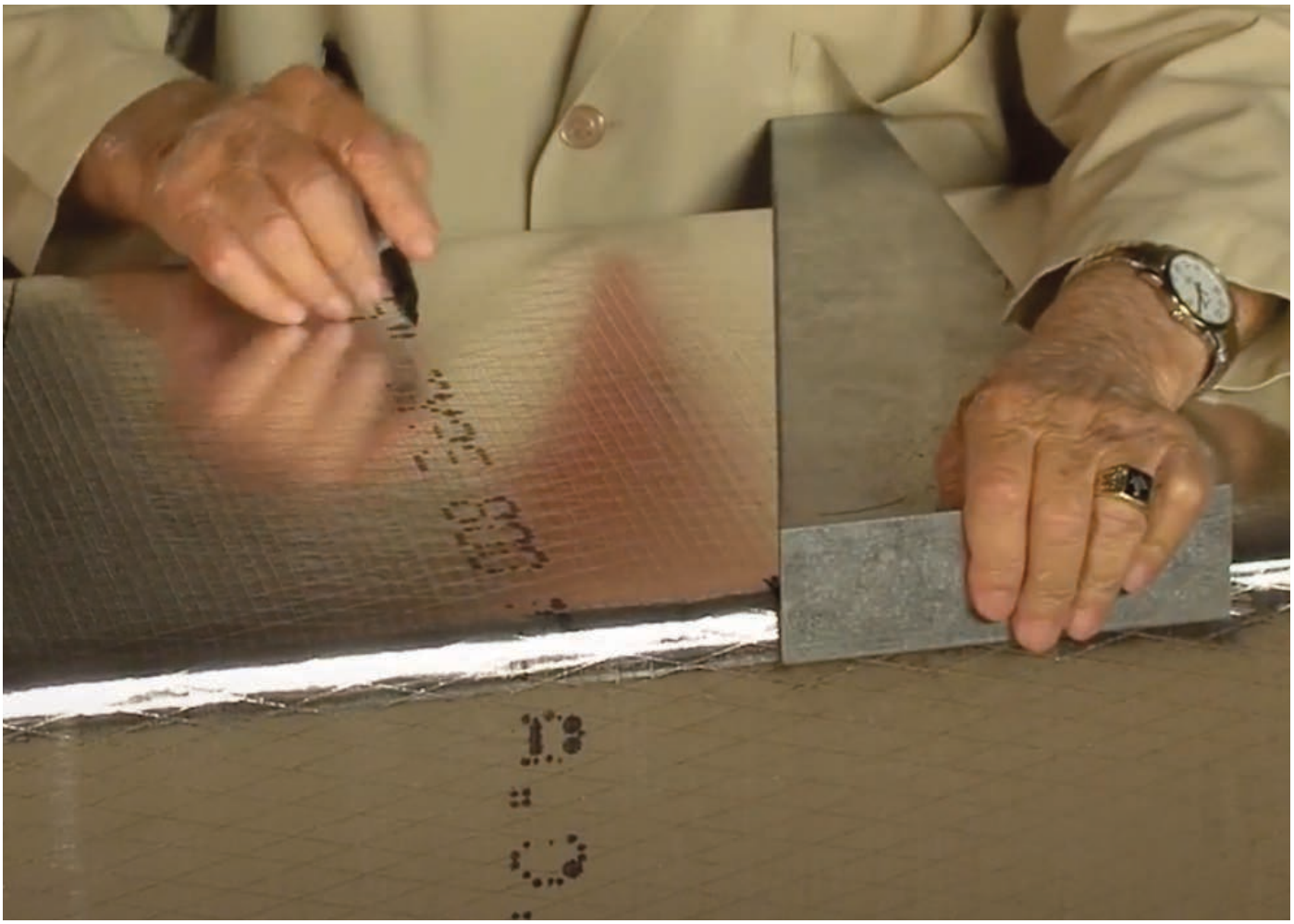
Fibrous glass insulated duct systems are acceptable for use in the following model codes and most other applicable codes:

ICC - International Code Council, Inc.

- International Mechanical Code
- International Building Code
- International Residential Code for One and Two Family Dwellings
- International Energy Conservation Code

Refer to area codes and municipal ordinances for additional local requirements for ducted HVAC systems.

(See Appendix of this Standard for the current code edition and how to contact code organizations.)



FIBROUS GLASS DUCT SYSTEM INSTALLATION CHECKLIST

A "YES/NA" response is required for all entries. A "NO" response to any entry should be brought to the attention of the HVAC contractor for reexamination.

Project Name and Number _____

HVAC Contractor _____

Mechanical Contractor _____

General Contractor _____

Engineer _____

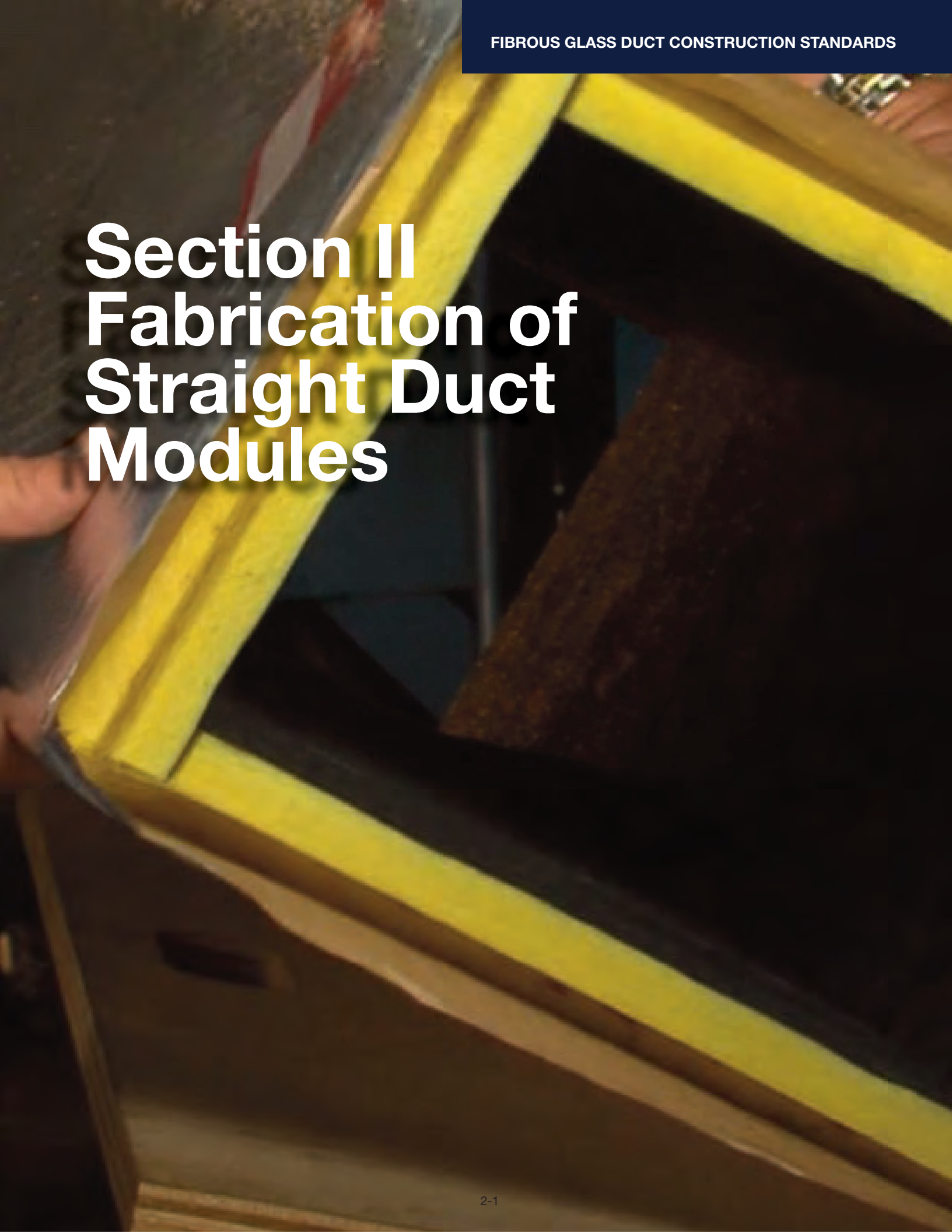
Checklist compiled by _____ Date _____

A. Reference Materials Needed

1. Current edition, NAIMA Fibrous Glass Duct Construction Standard (FGDCS) NAIMA Pub. No. AH116
2. Manufacturer's recommendations (where applicable)
3. Submittal drawings
4. Plans and specifications for job

B. General	YES/NA	NO
5. Is the fibrous glass duct system installed under conditions permitted in NAIMA's Standard, pages 1-5 and 1-6?	( )	( )
6. Is the system operating within the design limitations for which it was built?	( )	( )
7. Have all tears or punctures of facing material been repaired using proper techniques?	( )	( )
8. Are all sheet metal accessory items galvanized or plated?	( )	( )
C. Product		
9. Is the product used identified as duct board by facing imprint?	( )	( )
10. Is the UL label present? (While each board has one UL label, not every duct section will be labeled.)	( )	( )
11. Are there NO visual signs of facing delamination (ballooning, condensation if system operating)?	( )	( )
D. Fabrication and Installation (See Sections II and III)		
12. Are turning vanes installed in accordance with NAIMA's Standard? (Pressing your hand into the cheek of the "L" will reveal if specified turning vanes are being used.)	( )	( )
13. When metal parts are attached, are 2½" (64mm) square or 3" (76mm) diameter galvanized or plated steel washers installed on 16" (406mm) (max.) centers?	( )	( )
14. Is the system completely free from tears or punctures in the facing? (These are readily repaired following procedures given in Section VII of this Standard.)	( )	( )
15. 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?	( )	( )
16. Are all system joints tight, free from bulges, and with joint closures showing good workmanship?	( )	( )
17. Are all fittings fabricated in accordance with instructions in Section III, and do they demonstrate good workmanship?	( )	( )
18. Have offsets been installed so duct sections aren't forced to bend around obstructions?	( )	( )
19. Are all panels in any fitting at least 6" (152mm) (min.) long, including male or female joints?	( )	( )
E. Dampers (See NAIMA FGDCS, page 3-22)		
20. If a motorized damper is being used, is the sheet metal sleeve extended so the operator is mounted on the same sleeve with the damper?	( )	( )
21. On a manual damper, does the quadrant move a full 90 degrees?	( )	( )
F. Fire Dampers (See NAIMA FGDCS, page 3-23)		
22. Is the sheet metal sleeve present, and is duct properly attached to it with fasteners on 12" (305mm) (max.) centers? (Fibrous glass ducts must not penetrate assemblies required to have a fire damper.)	( )	( )
23. Is interior sleeve present and properly attached with screws and washers on 16" (406mm) (max.) centers?	( )	( )
G. Flanged Heaters (See NAIMA FGDCS, page 3-24)		
24. Are interior sleeves present and properly attached with screws and washers on 16" (406mm) (max.) centers?	( )	( )
25. Is the heater properly supported?	( )	( )
H. Slip-in Heaters (See NAIMA FGDCS, page 3-25)		
26. Is the interior sleeve present and properly attached with screws and washers?	( )	( )
Is the heater properly supported?	( )	( )

	YES/NA	NO
I. Access Doors (See FGDCS, pages 3-26 and 3-27)		
27. Is installation in accordance with NAIMA Standard?	( )	( )
J. Grilles, Diffusers, Registers (See NAIMA FGDCS, pages 3-28 and 3-29)		
28. 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 square inches may be attached to the duct wall with metal channel, and without other support.)	( )	( )
K. Unit Connection (See NAIMA FGDCS, page 3-30)		
29. Are connections to the unit or sheet metal ducts in accordance with NAIMA's Standard? (Securing duct to unit flange without mechanical fasteners is insufficient.)	( )	( )
L. Closure (See NAIMA FGDCS, Section IV)		
30. Are all longitudinal seams and circumferential joints properly taped or closed with glass fabric and mastic?	( )	( )
31. Is the closure system listed under UL Standard 181A, Parts I (P), II (H), or III (M)?	( )	( )
32. Are staples of the outward clinching type?	( )	( )
33. When staples are not used, are 8" (203mm) (min.) tape tabs of approved type used in place of staples? (Tab spacing requirements are 12" (305mm) on centers, minimum 1 per side.)	( )	( )
34. Are staples or tape tabs correctly spaced on circumferential joints?	( )	( )
35. Are all pressure-sensitive tape closures made with tape of proper width, rubbed down adequately, with staples or scrim in facing clearly visible?	( )	( )
36. Are heat-activated closures applied correctly, as shown by changing dot color?	( )	( )
37. Does tape show manufacturer name, UL Standard 181A nomenclature, and date code?	( )	( )
38. If glass fabric and mastic are used, is the mesh of the glass fabric completely filled with mastic?	( )	( )
M. Hanging and Supports (See NAIMA FGDCS, Section VI)		
39. Are hangers installed in accordance with the hanger schedule published in NAIMA's FGDCS, Section VI?	( )	( )
40. Are hanger designs in accordance with those shown in NAIMA's FGDCS?	( )	( )
41. Are accessories that add weight to the system separately supported so as not to stress the system?	( )	( )
42. Are vertical risers limited to systems serving two stories and supported on 12 foot (3.6 m) (max.) centers?	( )	( )
43. If formed sheet metal reinforcements are used as hangers, are attachments within 6" (152mm) (nom.) of duct sides?	( )	( )
44. Are all fittings supported by hangers in accordance with NAIMA's FGDCS, Section VI?	( )	( )
45. In humid climates, is system separated at least 1" (25mm) within crawl space or above ceiling insulation?	( )	( )
N. Reinforcement (See NAIMA FGDCS, Section V)		
46. Is the reinforcement system of a recommended type (formed metal channel, tie rod, or both)?	( )	( )
47. Is the tie rod wire galvanized, and 12 gauge?	( )	( )
48. Is the tie rod spacing correct according to duct span, board type, and static pressure?	( )	( )
49. Are tie rod washers 2½" (64mm) square or 3" (76mm) diameter of galvanized or plated steel and of proper thickness?	( )	( )
50. Do the tie rod washers have turned edges facing away from the duct board so they will not cut into it?	( )	( )
51. If the tie rods reinforce a butt joint, are they used on both sides of the joint?	( )	( )
52. Is the tie rod termination one of those documented in NAIMA's FGDCS or by manufacturer's recommendations?	( )	( )
53. Are sag support devices used on ducts of 48" (1,219mm) span or greater to support top panels?	( )	( )
54. Do the tie rods run straight through ducts and not at angles except as provided for in reinforcing certain fittings?	( )	( )
55. Are the heels of tees and elbows and end caps reinforced when necessary to meet NAIMA's FGDCS, Section V requirements?	( )	( )
56. When formed sheet metal channel reinforcement is used, are sheet metal gauges, dimensions, and spacing correct and is sheet metal galvanized?	( )	( )
57. On supply ducts, is the reinforcing member on the female side of the shiplap joint?	( )	( )
58. On return ducts, is the einforcing member on the male side of the shiplap joint?	( )	( )
59. On return ducts, are sheet metal channel reinforcements attached to ducts with screws and washers or with 2" x 6" (51mm x 152mm) clips when located at circumferential joint?	( )	( )
O. Flexible Duct Connections		
60. Are all runs of flexible duct installed in accordance with the NAIMA's FGDCS or the Air Duct Council's (ADC) Standards manual?	( )	( )
61. Are all flexible duct connections to the fibrous glass duct board made as shown in ADC's Standards manual?	( )	( )
62. Are all runs of flexible duct as straight as possible and free from unnecessary loops or bends?	( )	( )



Section II Fabrication of Straight Duct Modules

Principles of Modular Duct Construction

In designing, fabricating and installing fibrous glass duct systems, the principle of Modular Duct Construction (MDC) is used. (See Fig. 2-1.) This is based on use of the 48" (1,219mm) (nominal)* duct module for both straight duct runs and fittings of most types.

The remaining pages of this section show how these objectives are met using the MDC principle.

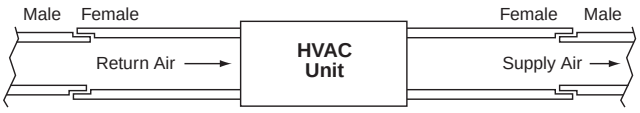
Use of the MDC principle enhances productivity, minimizes the number of circumferential joints, simplifies fabrication of fittings both in the shop and on the job, and improves the quality of workmanship.

*For actual installed length, subtract shiplap length from nominal length:

DUCT BOARD THICKNESS	SHIPLAP LENGTH	INSTALLED DUCT LENGTH
1" (25mm)	⅞" (22mm)	47⅛" (1,197mm)
1½" (38mm)	1⅜" (35mm)	46⅝" (1,184mm)
2" (51mm)	1⅞" (48mm)	46⅛" (1,172mm)

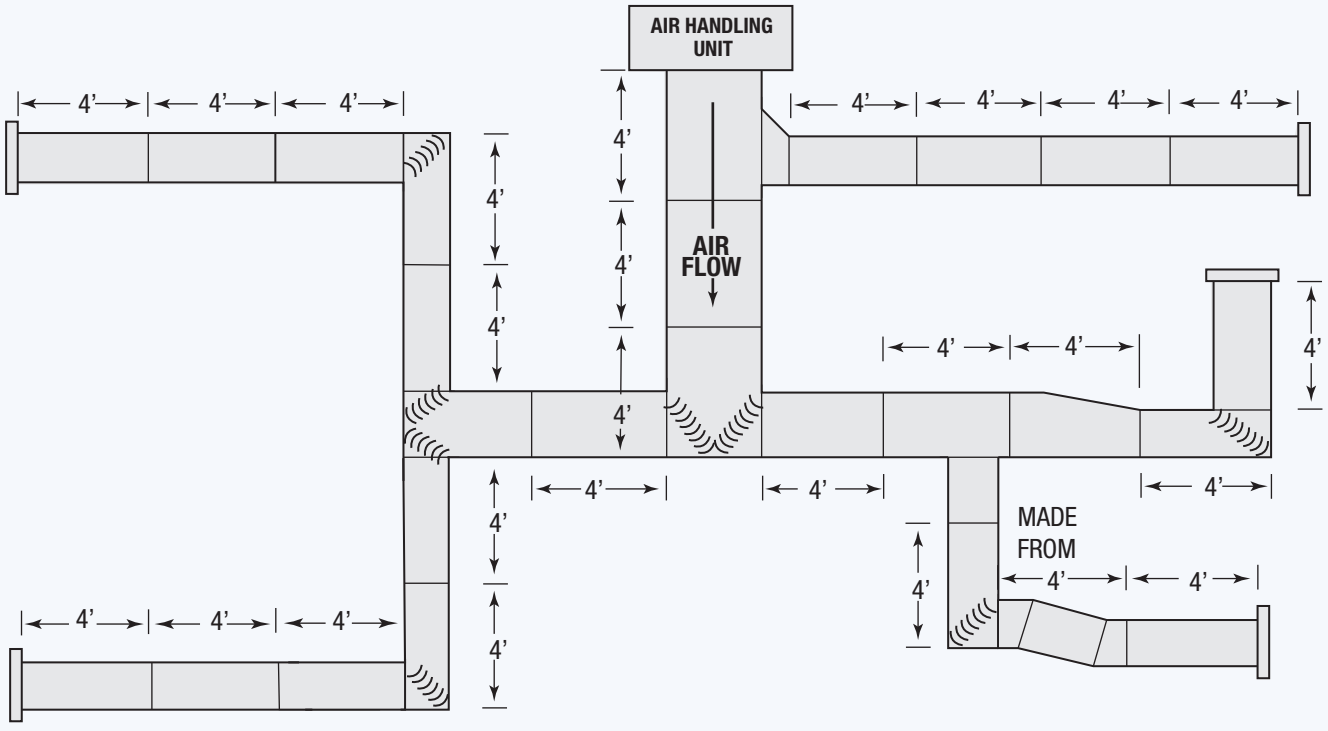
Application of the MDC principle involves the following design considerations:

- The modified shiplap groove is used in preference to the V-groove method. (See page 2-4.)
- Elbows and tees are designed to be throatless.
- Transitions are extended to maintain the module dimension.
- Sweep and radius fittings are not used.
- The female end of the duct (without staple flap) is installed away from the unit. The male shiplap end of the duct section is installed facing the fan or equipment.



- Branch taps should be made from shiplap panels wherever possible.
- The integrity of the module should be maintained as consistently as possible throughout the system during design, fabrication and installation. Shop drawings and blueprints should reflect this.

Fig. 2-1. Modular Duct Construction (MDC) Layout



Fabrication Logistics

When planning fibrous glass duct system fabrication logistics, the contractor has several choices concerning tools and workplace. Selection of the most suitable fabrication tools and the best place to do the work will depend on such considerations as:

- Type of system being installed: extended plenum, radial system with duct board distribution boxes, or simple flexible duct radial system.
- Type of project: whether large or small residential or commercial, single or multi-story.
- Availability of suitable clean, dry work space either at the duct fabricator's shop or on the job-site.
- Availability of trained, experienced workers.

Fabrication Tools

This Standard identifies and describes the use of both hand tools and machines designed for fabrication of fibrous glass duct board. (Fabrication of flexible duct is entirely done with hand tools.)

- Hand tool fabrication of fibrous glass duct board: Specially designed tools are used to cut grooves and stapling flaps in the fibrous glass duct board. See pages 2-5 through 2-7. (Straight duct modules are then fabricated by folding, stapling, and sealing grooved boards as described on page 2-20.)
- Powered groove-cutting machines are used to cut grooves and stapling flaps in fibrous glass duct board. (See pages 2-8 and 2-9.) (Straight duct modules are then fabricated as described on page 2-20.)
- Duct board fitting fabrication: Fittings such as elbows, tees, offsets and transitions are made using hand grooving tools either from straight duct modules or flat duct board. (See Section III, Fabrications of Fittings from Modules or Flat Board, of this Standard.)
- System assembly: Straight duct modules, fittings and rectangular run-outs of fibrous glass duct board are connected by stapling and sealing as shown on page 2-21.

Joints and seams are sealed with pressure-sensitive or heat-activated aluminum foil tape or with glass fabric and mastic as shown in Section IV, Closure, of this Standard.

How and Where to Fabricate

Depending on the nature of the job, the contractor has several options as to how and where to fabricate the fibrous glass duct system. Various choices are:

- Fabricate all the straight duct modules and fittings in the shop using powered grooving and closure machines. This would be a good option if the project requires many duct modules of the same size and/or many fittings of the same design. Since fibrous glass duct elements are light in weight and easy to handle, it may be practical to pre-assemble lengths of duct and transport these to the job-site.
- Fabricate all the work at the job-site, including machine grooving. This may be the best option for a large job if the site has ample space for the machine and a storage area that is clean, warm, and protected from the elements.
- Fabricate all the work at the job-site using hand grooving tools.
- Groove the duct board on machines in the shop, shipping the flat grooved board to the job-site where workers can assemble straight modules, fabricate fittings, connect elements, and install the system. A truck can haul much more of a fibrous glass duct system in one load when it's in flat board form than when it consists of fabricated modules and fittings.

In any of the above cases, all duct system materials must be transported and stored so they are protected from exposure to water, dirt, and physical damage. Job-site work areas must be clean, dry, and protected from the weather.

Pressure sensitive tape closures should not be attempted below manufacturer's temperature recommendation. Consult mastic manufacturers regarding protection of material during storage, transportation and installation. Also, read and follow instructions on all product labels. For complete closure details, refer to Section IV, Closure, of this Standard.

Layout Methods – Hand Fabrication

Fig. 2-2. Guide Edge Layout

Guide Edge Method

Grooves are cut using a special squaring tool as a guide edge. (See Fig. 2-2.) Inside dimensions of the duct determine how far the tool is moved after each cut. Various hand tool and squaring tool combinations are available; consult tool manufacturers' literature for instructions.

Stretch-Out

When laying out a straight duct module, an allowance is added to each inside duct dimension to compensate for the widths of corner breaks and closure flaps. The sum of these allowances is added to the inside duct dimensions (twice the height plus twice the width) to determine "stretch-out," which is the total board length necessary to fabricate a straight duct module with the desired inside dimensions.

Four Basic Ways to Make a Duct Module

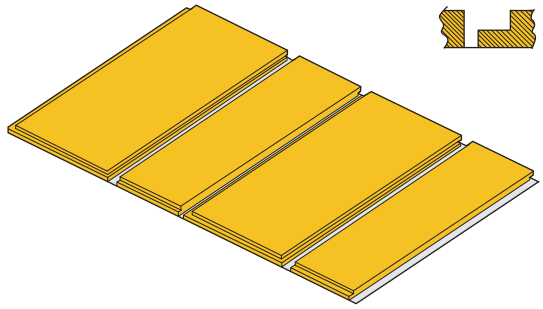
There are four basic methods to fabricate straight duct modules. (See Fig. 2-4.) Stretch-out calculations for each method are shown on pages 2-14 through 2-19. Selection of the best method depends on the duct size, total stretch-out, labor and material optimization, and availability of leftover duct board after large one-piece or two-piece duct modules have been fabricated.

Fabrication Methods

Fibrous glass duct board may be fabricated using either of two types of corner joints.

Modified Shiplap

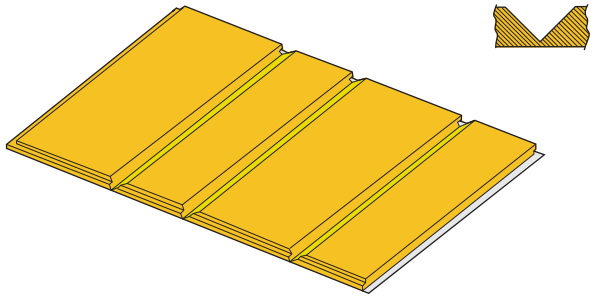
Fig. 2-3A. Modified Shiplap



The modified shiplap is considered the industry standard for machine grooving. Hand and machine tools are available for all three thicknesses of duct board.

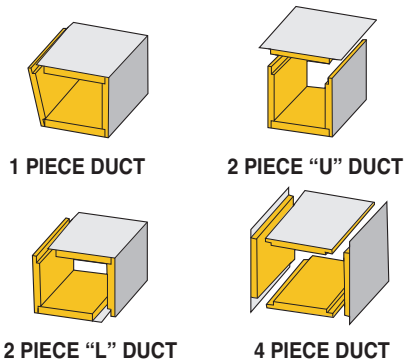
V-Groove

Fig. 2-3B. V-Groove



This is an alternative method for grooving duct board. Hand and machine tools are available for all three thicknesses of duct board. Fabrication of many of the fittings shown in this Standard is not possible using V-grooved duct modules.

Fig. 2-4. Four Ways to Make a Duct Section

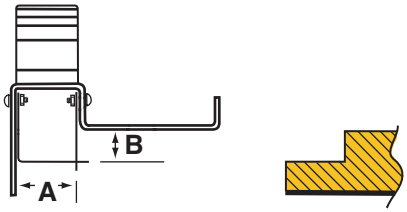


Hand Grooving Tools

Hand grooving tools normally required in fabricating straight sections of fibrous glass duct board are shown below. Correct hand tool blade settings are very important in assuring accurate fabrication, tight joints and connections, and an air-tight duct system that performs to specifications.

Blade settings should be checked prior to starting work. Imporper position of the blade may cause inaccurate cuts to be made. Dimensions shown below are nominal and may vary among different tool manufacturers.

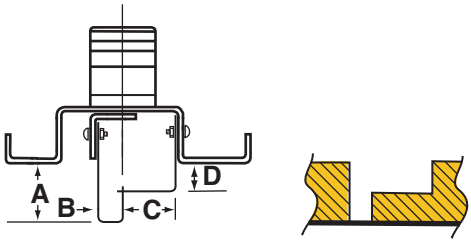
Fig. 2-5A. Female Shiplap Tool



BOARD THICKNESS	A	B
1" (25mm)	⅞" (22mm)	½" (13mm)
1½" (38mm)	1⅜" (35mm)	¾" (19mm)
2" (51mm)	1⅞" (48mm)	1" (25mm)

Cuts female slip joint. Also cuts seating edge of duct board at longitudinal closure corner.

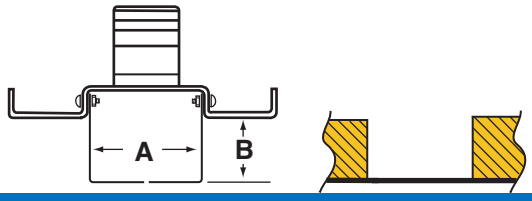
Fig. 2-5B. Modified Shiplap Tool



BOARD THICKNESS	A	B	C	D
1" (25mm)	15⁄16" (24mm)	⅜" (24mm)	⅞" (22mm)	½" (13mm)
1½" (38mm)	1⅜" (35mm)	9⁄16" (14mm)	1⅜" (35mm)	11⁄16" (17mm)
2" (51mm)	1⅞" (48mm)	⅞" (22mm)	1⅞" (48mm)	15⁄16" (24mm)

Removes insulation for shiplap corner folds. Reversing the tool allows both left hand and right hand shiplaps to be cut.

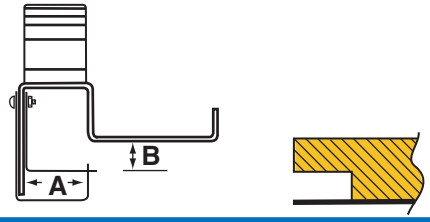
Fig. 2-5C. Staple Flap Tool



BOARD THICKNESS	A	B
1" (25mm)	1¾" (44mm)	1" (25mm)
1½" (38mm)	2⅝" (67mm)	1½" (38mm)
2" (51mm)	3½" (89mm)	2" (51mm)

Used with straight knife to make staple flap and end cut.

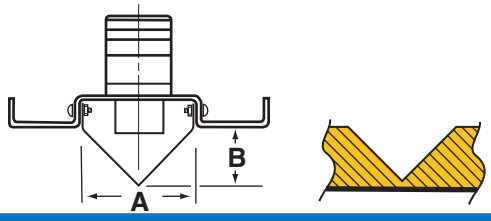
Fig. 2-5D. Male Shiplap Tool



BOARD THICKNESS	A	B
1" (25mm)	⅞" (22mm)	½" (13mm)
1½" (38mm)	1⅜" (35mm)	¾" (19mm)
2" (51mm)	1⅞" (48mm)	1" (25mm)

Cuts male slip joint which mates with female slip joint to connect two duct sections.

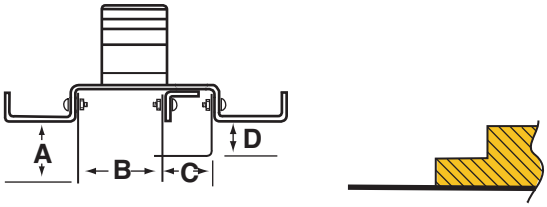
Fig. 2-5E. V-Groove Tool



BOARD THICKNESS	A	B
1" (25mm)	1¾" (44mm)	⅞" (22mm)
1½" (38mm)	2¾" (70mm)	1⅜" (35mm)
2" (51mm)	3¾" (95mm)	1⅞" (48mm)

Cuts 90° V-grooves for corner folds when modified shiplap grooving method is not used.

Fig. 2-5F. Shiplap and End Cut-Off Tool



BOARD THICKNESS	A	B	C	D
1" (25mm)	⅞" (22mm)	1⅜" (35mm)	⅞" (22mm)	½" (13mm)
1½" (38mm)	1⅜" (35mm)	1 11⁄16" (43mm)	1⅜" (35mm)	¾" (19mm)
2" (51mm)	1¾" (48mm)	2⅛" (54mm)	1¾" (44mm)	1" (25mm)

Cuts shiplap on end of board for longitudinal corner closure, plus staple flap. May also be used in some fitting fabrication techniques.

Hand Fabrication – Guide Edge Method

Shown on pages 2-6 and 2-7 is the typical method where grooving tools are used working from the right hand side of the guide edge. Some tool manufacturers also provide for using tools to work from the left hand side of the guide edge. Both the squaring tool and hand grooving tools must be changed to accomplish this. Consult the tool manufacturers' for detailed instructions on using their products.

Layout and Grooving

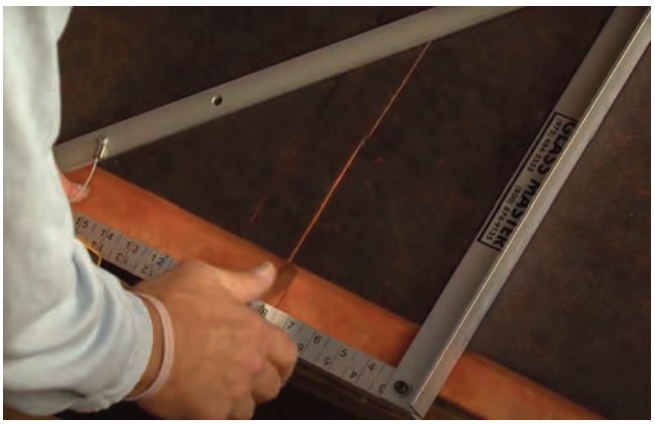
The one-piece duct fabrication method is shown. Two-piece "L", two-piece "U", and four-piece fabrication methods are also possible. (See pages 2-10 through 2-13 for add-on dimensions.)

1. For the right hand shiplap and staple flap, set up the squaring tool as shown above. The guide edge will be at the right and the factory female shiplap will be toward you.

2. Cut along the left edge of the duct board using the female shiplap tool to form the shiplap edge without the closure flap. Remove the scrap from groove.

3. Place the squaring tool on the duct board so rule edge is parallel with the factory female shiplap. Line up the inside duct width dimension on the rule with the right hand edge of the cut made in Step 2.

4. Place the corner grooving tool (modified shiplap or V-groove) along the guide edge of the squaring tool and cut the first corner groove. Remove the groove scrap.



5. Reposition the squaring tool to the right, lining up the desired inside duct height dimension on the rule with the right hand edge of the first corner cut.

6. Rotate the corner grooving tool end-for-end (or use the next sequentially numbered tool) and place along the guide edge of squaring tool to cut the second corner groove. Remove the groove scrap.

8. Reposition the squaring tool to the right to make the stapling flap.

7. Reposition the squaring tool to the right, to line up the desired inside duct width dimension as in Step 3. Cut the third corner groove using the tool as in Step 4.

9. Using a straight knife, cut through the insulation and facing along the right hand cut. Peel the insulation from the closure flap. The board is now ready for assembly and closure to form a straight duct module.

IMPORTANT NOTE:
These instructions are general in nature. Since several manufacturers produce tools and guide edge squares, the tool manufacturer's instructions should be followed. Also, total stretch-out dimensions may vary. Therefore, the user must determine the actual total stretch-out applying to the tools being used.

Machine Fabrication of Straight Duct Modules – Shiplap Method

Machine fabrication is fast, accurate, repeatable, and usually more productive than hand fabrication.

Grooving machines can make all of the corner fold cuts for a one-piece straight module of fibrous glass duct board, make the cuts to correct stretch-out dimensions, and finish the longitudinal seam edges with staple flap all in one pass. Two-piece “L”, two-piece “U”, and four-piece duct components can also be cut on grooving machines.

The modified shiplap method is recommended for machine fabrication of straight modules of fibrous glass duct board, although V-groove tools for all three duct board thicknesses are available for most grooving machines.

Machine grooving tools have numbered or lettered tabs corresponding to the location and width of the cutting portion. To set up the machine, the interior dimensions of the duct are measured between the tabs on the tools; the tabs represent the necessary add-on allowances.

Closure Machines

Closure machines provide tightly sealed longitudinal seams at high production rates. When using approved heat-activated tape on closure machines, it is not necessary to staple the longitudinal flap.

Tooling Set-Up

The typical tooling set-up for one-piece straight duct produces the closure flap at the left hand side of the duct board as it passes through the grooving machine. Tools are identified by letters. (See Fig. 2-6A.)

Optional Set-Ups

Optional set-ups can be found at Figs. 2-6B and 2-6C.

Fig. 2-6A. Tool Set-Up: One Piece Straight Duct

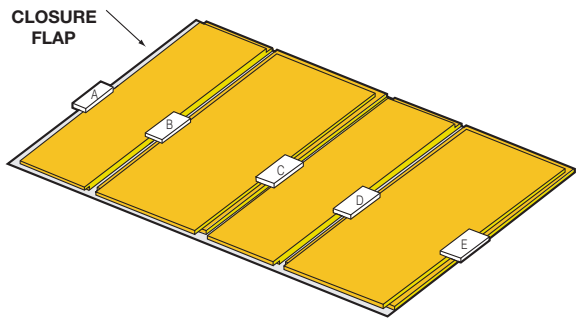


Fig. 2-6B. Optional Tool Set-Up

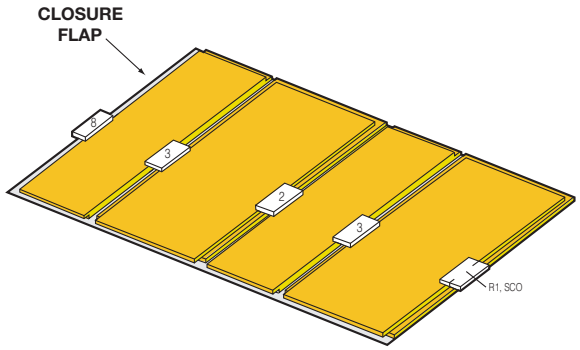
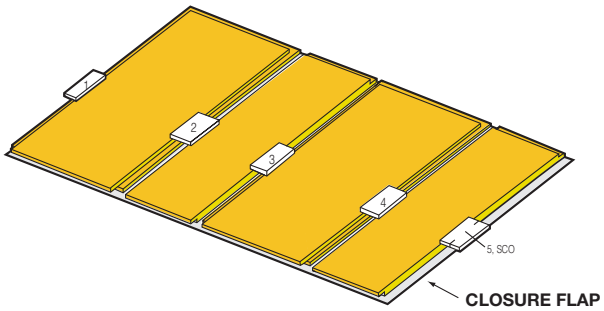


Fig. 2-6C. Optional Tool Set-Up



Typical Grooving Machine Tools

Fig. 2-7. Grooving Machine Tools

#1 (or F). Left hand female shiplap tool.

#R1+ SCO (or E). Right hand female shiplap tool.

#2 & #4 (or C). Left hand modified shiplap tool.

#3 (or B). Right hand modified shiplap tool.

#5 SCO (or G). Right hand square cut tool with closure flap.

#6. Left hand female shiplap tool with cutoff.

#7. Right hand female shiplap tool with cutoff.

#8 (or A). Left hand square cut tool with closure flap.

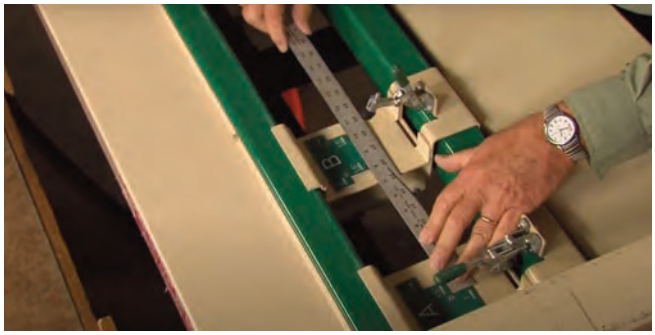
#9. Left hand male shiplap tool.

#0. Right hand male shiplap tool.

#SCO. Straight cutoff tool. May be used with #R1 to make the same cut as #7 tool.

Machine Fabrication

Fig. 2-8. Tool Set-Up



Install tools in the grooving machine according to the machine manufacturer's instructions, board layout, and cutting plan (see pages 2-10 through 2-13), using either the Standard or Preferred tooling set-up. (See page 2-10.)

Fig. 2-9. Feed Duct Board

Feed duct board into machine, female shiplap edge first, left hand edge firmly against the guide, parallel to the rollers. Turn on the machine and guide the board as friction rollers pick it up and pull it through the cutting tools.

Fig. 2-10. Remove Scrap

Remove the groove scrap. Confirm dimensions. The board is now ready for assembly and closure of a straight duct module or for fabrication of a fitting.

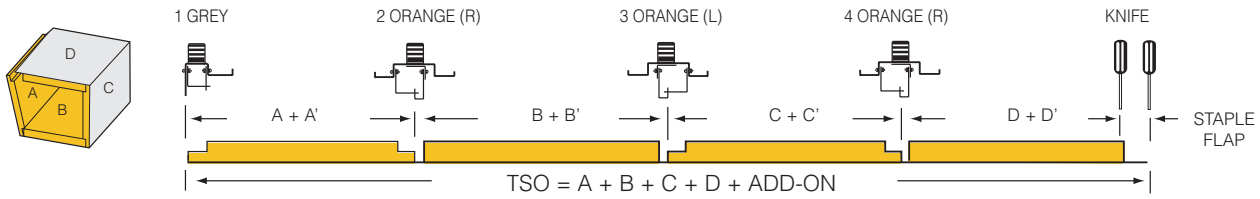
FABRICATION – ONE-PIECE DUCT

Fig. 2-11. Fabrication – One-Piece Duct

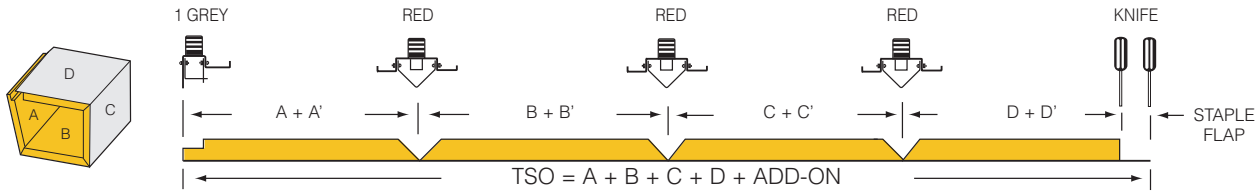
Layout and fabrication methods below are typical. Others are possible. When fabricating by machine, check the set-up dimensions carefully. Dimensions may vary from machine to machine.

HAND FABRICATION – SHIPLAP METHOD

TSO = Total Stretch-Out

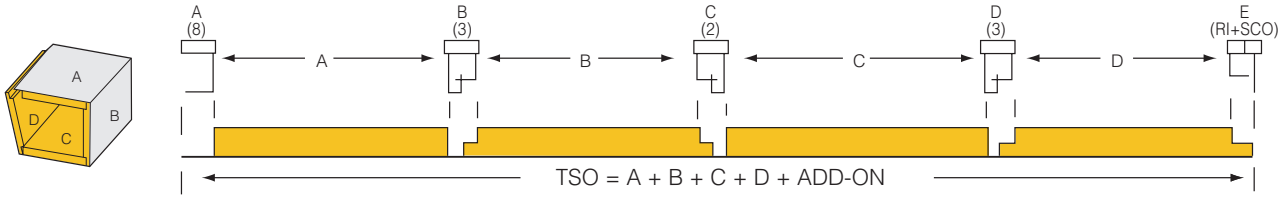


HAND FABRICATION – V-GROOVE METHOD

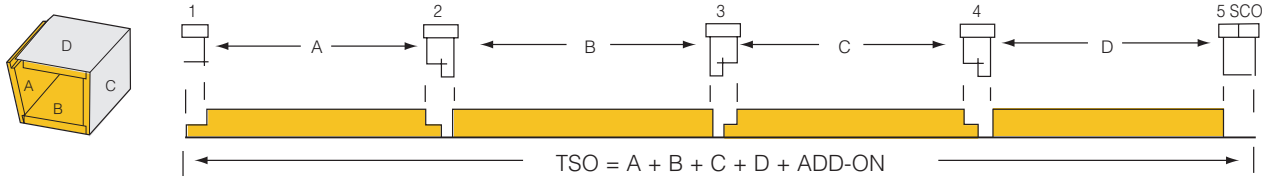


	DUCT BOARD THICKNESS	PANEL ADD-ON DIMENSIONS A'	B'	C'	D'	STAPLING FLAP	STRETCH-OUT ADD-ON
A, B, C, D ARE INSIDE DIMENSIONS	1" (25mm)	1¾" (44mm)	1¾" (44mm)	1¾" (44mm)	1⅜" (35mm)	1⅜" (35mm)	8" (203mm)
	1½" (38mm)	2¾" (70mm)	2¾" (70mm)	2¾" (70mm)	2⅛" (54mm)	2⅛" (54mm)	12½" (318mm)
	2" (51mm)	3¾" (95mm)	3¾" (95mm)	3¾" (95mm)	2⅞" (73mm)	2½" (64mm)	16⅝" (422mm)

MACHINE FABRICATION – OPTION 1



MACHINE FABRICATION – OPTION 2



Inside duct dimensions A, B, C, D are measured between tool tabs.

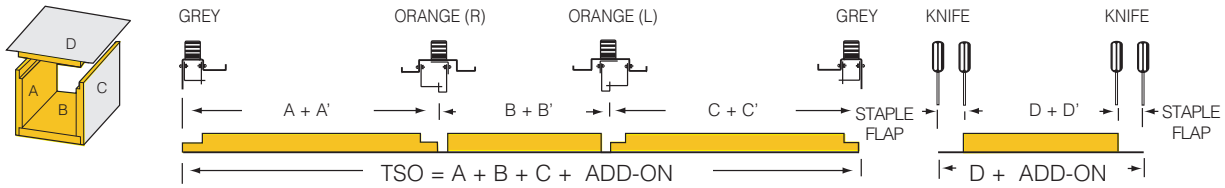
DUCT BOARD THICKNESS	STRETCH-OUT ADD-ON
1" (25mm)	8" (203mm)
1½" (38mm)	12" (305mm)
2" (51mm)	16" (406mm)

FABRICATION – TWO-PIECE U-STYLE DUCT

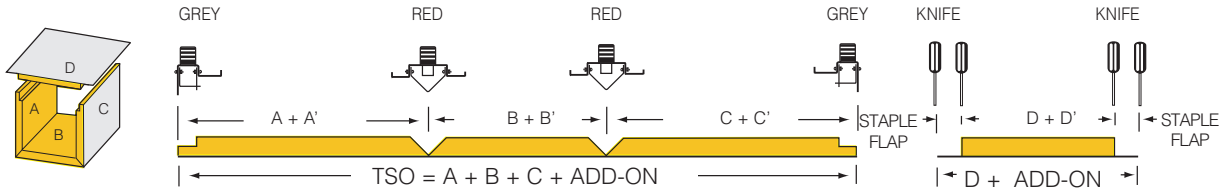
Fig. 2-12. Fabrication – Two-Piece U-Style Duct

Layout and fabrication methods below are typical. Others are possible. When fabricating by machine, check the set-up dimensions carefully. Dimensions may vary from machine to machine.

HAND FABRICATION – SHIPLAP METHOD **TSO = Total Stretch-Out**

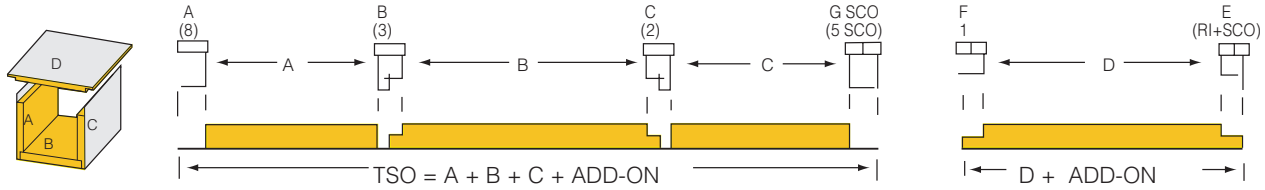


HAND FABRICATION – V-GROOVE METHOD

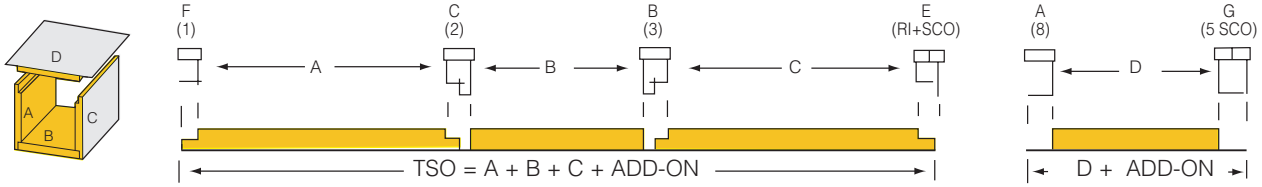


	DUCT BOARD THICKNESS	PANEL ADD-ON A', B', C'	U-SECTION TSO ADD-ON	D'	STAPLING FLAP	PANEL D TSO ADD-ON
A, B, C, D ARE INSIDE DIMENSIONS	1" (25mm)	1¾" (44mm)	5¼" (133mm)	1" (25mm)	1½" (38mm)	4" (102mm)
	1½" (38mm)	2¾" (70mm)	8¼" (210mm)	1½" (38mm)	2⅛" (54mm)	5¾" (146mm)
	2" (51mm)	3¾" (95mm)	11¼" (286mm)	2" (51mm)	2½" (64mm)	7" (178mm)

MACHINE FABRICATION – OPTION 1



MACHINE FABRICATION – OPTION 2



Inside duct dimensions A, B, C, D are measured between tool tabs.

DUCT BOARD THICKNESS	OPTION 1 U-SECTION ADD-ON	OPTION 1 FILLER PANEL ADD-ON	OPTION 2 U-SECTION ADD-ON	OPTION 2 U-SECTION ADD-ON
1" (25mm)	7¾" (197mm)	1½" (38mm)	4¾" (121mm)	4¼" (108mm)
1½" (38mm)	11" (279mm)	2½" (64mm)	7⅝" (194mm)	5¾" (146mm)
2" (51mm)	14¼" (362mm)	3½" (89mm)	10½" (267mm)	7¼" (184mm)

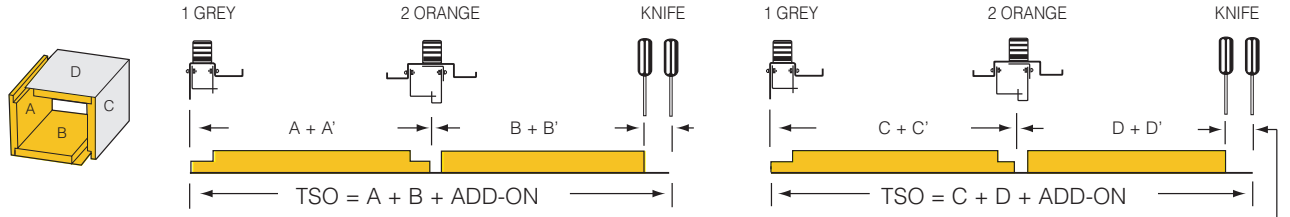
FABRICATION – TWO-PIECE L-STYLE DUCT

Fig. 2-13. Fabrication – Two-Piece L-Style Duct

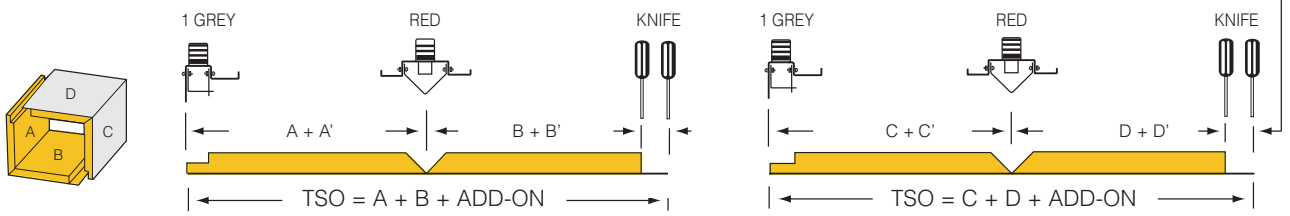
Layout and fabrication methods below are typical. Others are possible. When fabricating by machine, check the set-up dimensions carefully. Dimensions may vary from machine to machine.

HAND FABRICATION – SHIPLAP METHOD

TSO = Total Stretch-Out

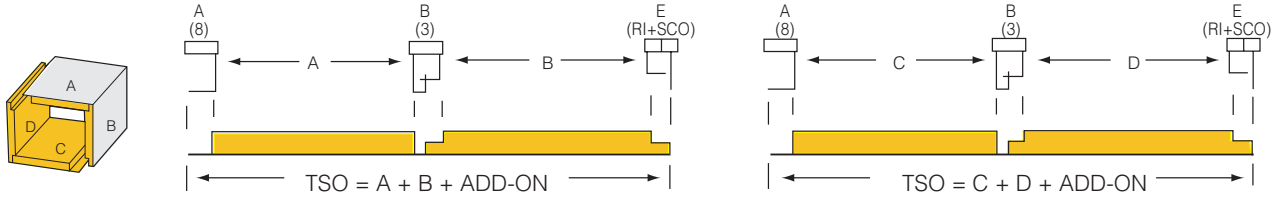


HAND FABRICATION – V-GROOVE METHOD

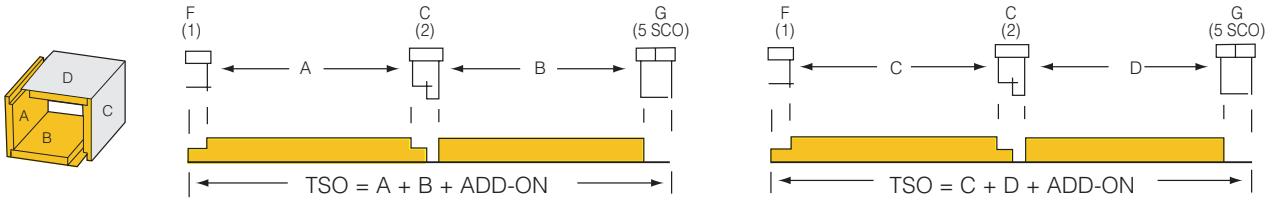


	DUCT BOARD THICKNESS	PANEL ADD-ON DIMENSIONS A'	B'	C'	D'	STAPLE FLAP	TSO ADD-ON
A, B, C, D ARE INSIDE DIMENSIONS	1" (25mm)	1¾" (44mm)	1⅜" (35mm)	1¾" (44mm)	1⅜" (35mm)	1½" (38mm)	4⅝" (117mm)
	1½" (38mm)	2¾" (70mm)	2⅛" (54mm)	2¾" (70mm)	2⅛" (54mm)	2⅛" (54mm)	7" (178mm)
	2" (51mm)	3¾" (95mm)	2⅞" (73mm)	3¾" (95mm)	2⅞" (73mm)	2½" (64mm)	9⅛" (232mm)

MACHINE FABRICATION – OPTION 1



MACHINE FABRICATION – OPTION 2



Inside duct dimensions A, B, C, D are measured between tool tabs.

DUCT BOARD THICKNESS	L-SECTION TSO ADD-ON
1" (25mm)	4½" (114mm)
1½" (38mm)	6¾" (171mm)
2" (51mm)	8⅞" (225mm)

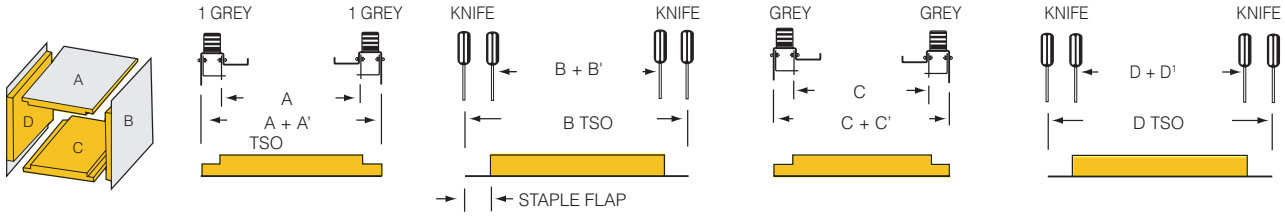
FABRICATION – FOUR-PIECE DUCT

Fig. 2-14. Fabrication – Four-Piece Duct

Layout and fabrication methods below are typical. Others are possible. When fabricating by machine, check the set-up dimensions carefully. Dimensions may vary from machine to machine.

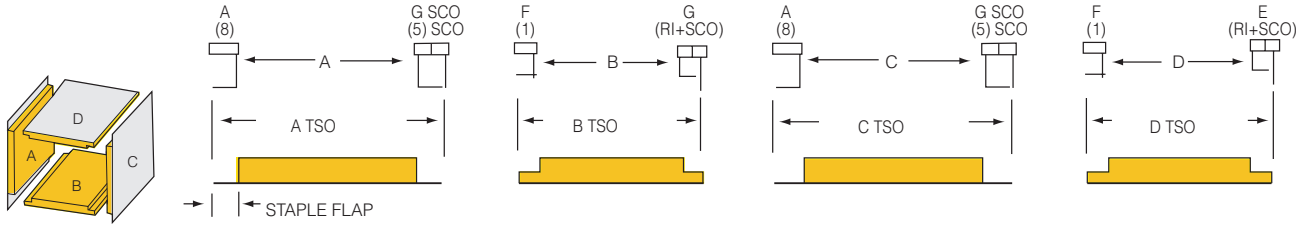
HAND FABRICATION – HAND TOOL METHOD

TSO = Total Stretch-Out

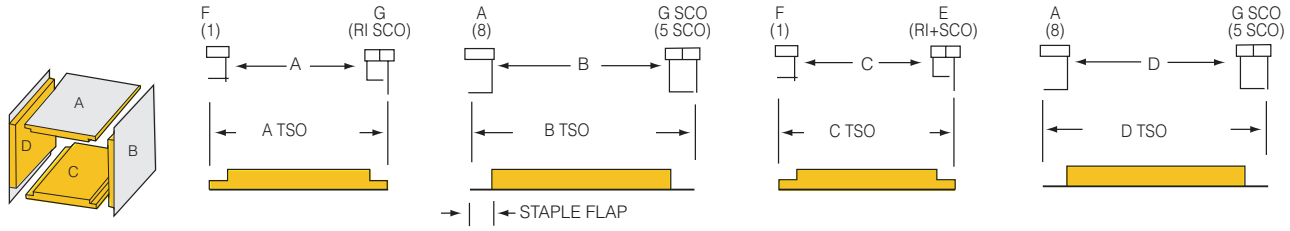


	DUCT BOARD THICKNESS	PANEL ADD-ON DIMENSIONS A' & C'	PANEL ADD-ON DIMENSIONS B' & D'	STAPLE FLAP	B & D TSO ADD-ON
A, B, C, D ARE INSIDE DIMENSIONS	1" (25mm)	1¾" (44mm)	1" (25mm)	1½" (38mm)	4" (102mm)
	1½" (38mm)	2¾" (70mm)	1½" (38mm)	2⅛" (54mm)	5¾" (146mm)
	2" (51mm)	3¾" (95mm)	2" (51mm)	2½" (64mm)	7" (178mm)

MACHINE FABRICATION – OPTION 1



MACHINE FABRICATION – OPTION 2



Inside duct dimensions A, B, C, D are measured between tool tabs.

	DUCT BOARD THICKNESS	OPTION 1 – TSO ADD-ON PANELS A & C	OPTION 1 – TSO ADD-ON PANELS B & D	OPTION 2 – TSO ADD-ON PANELS A & C	OPTION 2 – TSO ADD-ON PANELS A & C	STAPLE FLAP (REFERENCE)
A, B, C, D ARE INSIDE DIMENSIONS	1" (25mm)	4¼" (108mm)	1½" (38mm)	1½" (38mm)	4¼" (108mm)	1⅝" (41mm)
	1½" (38mm)	5¾" (146mm)	2½" (64mm)	2½" (64mm)	5¾" (146mm)	2⅛" (54mm)
	2" (51mm)	7¼" (184mm)	3½" (89mm)	3½" (89mm)	7¼" (184mm)	2⅝" (67mm)

STRETCH-OUT DIMENSIONS – 1" AND 25MM DUCT BOARD

Table 2-14A. One-Piece Stretch-out Dimensions in Inches, 1" Duct Board

DUCT WIDTH in.	DUCT HEIGHT, in.																							
	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50
6	32	36	40	44	48	52	56	60	64	68	72	76	80	84	88	92	96	100	104	108	112	116	120
8	36	40	44	48	52	56	60	64	68	72	76	80	84	88	92	96	100	104	108	112	116	120	
10	40	44	48	52	56	60	64	68	72	76	80	84	88	92	96	100	104	108	112	116	120		
12	44	48	52	56	60	64	68	72	76	80	84	88	92	96	100	104	108	112	116	120			
14	48	52	56	60	64	68	72	76	80	84	88	92	96	100	104	108	112	116	120				
16	52	56	60	64	68	72	76	80	84	88	92	96	100	104	108	112	116	120					
18	56	60	64	68	72	76	80	84	88	92	96	100	104	108	112	116	120						
20	60	64	68	72	76	80	84	88	92	96	100	104	108	112	116	120							
22	64	68	72	76	80	84	88	92	96	100	104	108	112	116	120								
24	68	72	76	80	84	88	92	96	100	104	108	112	116	120									
26	72	76	80	84	88	92	96	100	104	108	112	116	120										
28	76	80	84	88	92	96	100	104	108	112	116	120											
30	80	84	88	92	96	100	104	108	112	116	120												
32	84	88	92	96	100	104	108	112	116	120													
34	88	92	96	100	104	108	112	116	120														
36	92	96	100	104	108	112	116	120															
38	96	100	104	108	112	116	120																
40	100	104	108	112	116	120																	
42	104	108	112	116	120																		
44	108	112	116	120																			
46	112	116	120																				
48	116	120																					
50	120																						

NOTE: These tables assume the total stretch-out (add-on) dimension is 8". If the process used results in a different stretch-out dimension, these tables must be modified accordingly.

Table 2-14B. One-Piece Stretch-out Dimensions in Millimeters, 25mm Duct Board

DUCT WIDTH mm	DUCT HEIGHT, mm																							
	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050	1100	1150	1200	1250
150	803	903	1003	1103	1203	1303	1403	1503	1603	1703	1803	1903	2003	2103	2203	2303	2403	2503	2603	2703	2803	2903	3003
200	903	1003	1103	1203	1303	1403	1503	1603	1703	1803	1903	2003	2103	2203	2303	2403	2503	2603	2703	2803	2903	3003	
250	1003	1103	1203	1303	1403	1503	1603	1703	1803	1903	2003	2103	2203	2303	2403	2503	2603	2703	2803	2903	3003		
300	1103	1203	1303	1403	1503	1603	1703	1803	1903	2003	2103	2203	2303	2403	2503	2603	2703	2803	2903	3003			
350	1203	1303	1403	1503	1603	1703	1803	1903	2003	2103	2203	2303	2403	2503	2603	2703	2803	2903	3003				
400	1303	1403	1503	1603	1703	1803	1903	2003	2103	2203	2303	2403	2503	2603	2703	2803	2903	3003					
450	1403	1503	1603	1703	1803	1903	2003	2103	2203	2303	2403	2503	2603	2703	2803	2903	3003						
500	1503	1603	1703	1803	1903	2003	2103	2203	2303	2403	2503	2603	2703	2803	2903	3003							
550	1603	1703	1803	1903	2003	2103	2203	2303	2403	2503	2603	2703	2803	2903	3003								
600	1703	1803	1903	2003	2103	2203	2303	2403	2503	2603	2703	2803	2903	3003									
650	1803	1903	2003	2103	2203	2303	2403	2503	2603	2703	2803	2903	3003										
700	1903	2003	2103	2203	2303	2403	2503	2603	2703	2803	2903	3003											
750	2003	2103	2203	2303	2403	2503	2603	2703	2803	2903	3003												
800	2103	2203	2303	2403	2503	2603	2703	2803	2903	3003													
850	2203	2303	2403	2503	2603	2703	2803	2903	3003														
900	2303	2403	2503	2603	2703	2803	2903	3003															
950	2403	2503	2603	2703	2803	2903	3003																
1000	2503	2603	2703	2803	2903	3003																	
1050	2603	2703	2803	2903	3003																		
1100	2703	2803	2903	3003																			
1150	2803	2903	3003																				
1200	2903	3003																					
1250	3003																						

NOTE: These tables assume the total stretch-out (add-on) dimension is 203mm. If the process used results in a different stretch-out dimension, these tables must be modified accordingly.

BOARD UTILIZATION – 1” AND 25MM DUCT BOARD

Table 2-15A. Board Utilization, One-Piece Duct, 1" Duct Board, ft² per Lineal Foot of Duct

DUCT WIDTH in.	DUCT HEIGHT, in.																							
	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50
6	2.7	3.0	3.3	3.7	4.0	4.3	4.7	5.0	5.3	5.7	6.0	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0
8	3.0	3.3	3.7	4.0	4.3	4.7	5.0	5.3	5.7	6.0	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0	
10	3.3	3.7	4.0	4.3	4.7	5.0	5.3	5.7	6.0	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0		
12	3.7	4.0	4.3	4.7	5.0	5.3	5.7	6.0	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0			
14	4.0	4.3	4.7	5.0	5.3	5.7	6.0	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0				
16	4.3	4.7	5.0	5.3	5.7	6.0	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0					
18	4.7	5.0	5.3	5.7	6.0	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0						
20	5.0	5.3	5.7	6.0	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0							
22	5.3	5.7	6.0	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0								
24	5.7	6.0	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0									
26	6.0	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0										
28	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0											
30	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0												
32	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0													
34	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0														
36	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0															
38	8.0	8.3	8.7	9.0	9.3	9.7	10.0																
40	8.3	8.7	9.0	9.3	9.7	10.0																	
42	8.7	9.0	9.3	9.7	10.0																		
44	9.0	9.3	9.7	10.0																			
46	9.3	9.7	10.0																				
48	9.7	10.0																					
50	10.0																						

NOTE: This table is based on a total add-on allowance of 8". If the process and tools used result in a different add-on allowance, these tables must be modified accordingly.

Table 2-15B. Board Utilization, One-Piece Duct, 25mm Duct Board, m² per Lineal Meter of Duct

DUCT WIDTH mm	DUCT HEIGHT, mm																							
	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050	1100	1150	1200	1250
150	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40	2.50	2.60	2.70	2.80	2.90	3.00
200	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40	2.50	2.60	2.70	2.80	2.90	3.00	
250	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40	2.50	2.60	2.70	2.80	2.90	3.00		
300	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40	2.50	2.60	2.70	2.80	2.90	3.00			
350	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40	2.50	2.60	2.70	2.80	2.90	3.00				
400	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40	2.50	2.60	2.70	2.80	2.90	3.00					
450	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40	2.50	2.60	2.70	2.80	2.90	3.00						
500	1.50	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40	2.50	2.60	2.70	2.80	2.90	3.00							
550	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40	2.50	2.60	2.70	2.80	2.90	3.00								
600	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40	2.50	2.60	2.70	2.80	2.90	3.00									
650	1.80	1.90	2.00	2.10	2.20	2.30	2.40	2.50	2.60	2.70	2.80	2.90	3.00										
700	1.90	2.00	2.10	2.20	2.30	2.40	2.50	2.60	2.70	2.80	2.90	3.00											
750	2.00	2.10	2.20	2.30	2.40	2.50	2.60	2.70	2.80	2.90	3.00												
800	2.10	2.20	2.30	2.40	2.50	2.60	2.70	2.80	2.90	3.00													
850	2.20	2.30	2.40	2.50	2.60	2.70	2.80	2.90	3.00														
900	2.30	2.40	2.50	2.60	2.70	2.80	2.90	3.00															
950	2.40	2.50	2.60	2.70	2.80	2.90	3.00																
1000	2.50	2.60	2.70	2.80	2.90	3.00																	
1050	2.60	2.70	2.80	2.90	3.00																		
1100	2.70	2.80	2.90	3.00																			
1150	2.80	2.90	3.00																				
1200	2.90	3.00																					
1250	3.00																						

NOTE: This table is based on a total add-on allowance of 203mm. If the process and tools used result in a different add-on allowance, these tables must be modified accordingly.

STRETCH-OUT DIMENSIONS – 1½" AND 38MM DUCT BOARD

Table 2-16A. One-Piece Stretch-out Dimensions in Inches, 1½" Duct Board

DUCT WIDTH in.	DUCT HEIGHT, in.																					
	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
6	36	40	44	48	52	56	60	64	68	72	76	80	84	88	92	96	100	104	108	112	116	120
8	40	44	48	52	56	60	64	68	72	76	80	84	88	92	96	100	104	108	112	116	120	
10	44	48	52	56	60	64	68	72	76	80	84	88	92	96	100	104	108	112	116	120		
12	48	52	56	60	64	68	72	76	80	84	88	92	96	100	104	108	112	116	120			
14	52	56	60	64	68	72	76	80	84	88	92	96	100	104	108	112	116	120				
16	56	60	64	68	72	76	80	84	88	92	96	100	104	108	112	116	120					
18	60	64	68	72	76	80	84	88	92	96	100	104	108	112	116	120						
20	64	68	72	76	80	84	88	92	96	100	104	108	112	116	120							
22	68	72	76	80	84	88	92	96	100	104	108	112	116	120								
24	72	76	80	84	88	92	96	100	104	108	112	116	120									
26	76	80	84	88	92	96	100	104	108	112	116	120										
28	80	84	88	92	96	100	104	108	112	116	120											
30	84	88	92	96	100	104	108	112	116	120												
32	88	92	96	100	104	108	112	116	120													
34	92	96	100	104	108	112	116	120														
36	96	100	104	108	112	116	120															
38	100	104	108	112	116	120																
40	104	108	112	116	120																	
42	108	112	116	120																		
44	112	116	120																			
46	116	120																				
48	120																					

NOTE: These tables assume the total stretch-out (add-on) dimension is 12". If the process used results in a different stretch-out dimension, these tables must be modified accordingly.

Table 2-16B. One-Piece Stretch-out Dimensions in Millimeters, 38mm Duct Board

DUCT WIDTH mm	DUCT HEIGHT, mm																					
	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050	1100	1150	1200
150	905	1005	1105	1201	1305	1405	1505	1605	1705	1805	1905	2005	2105	2205	2305	2405	2505	2605	2705	2805	2905	3005
200	1005	1105	1205	1305	1405	1505	1605	1705	1805	1905	2005	2105	2205	2305	2405	2505	2605	2705	2805	2905	3005	
250	1105	1205	1305	1405	1505	1605	1705	1805	1905	2005	2105	2205	2305	2405	2505	2605	2705	2805	2905	3005		
300	1205	1305	1405	1505	1605	1705	1805	1905	2005	2105	2205	2305	2405	2505	2605	2705	2805	2905	3005			
350	1305	1405	1505	1605	1705	1805	1905	2005	2105	2205	2305	2405	2505	2605	2705	2805	2905	3005				
400	1405	1505	1605	1705	1805	1905	2005	2105	2205	2305	2405	2505	2605	2705	2805	2905	3005					
450	1505	1605	1705	1805	1905	2005	2105	2205	2305	2405	2505	2605	2705	2805	2905	3005						
500	1605	1705	1805	1905	2005	2105	2205	2305	2405	2505	2605	2705	2805	2905	3005							
550	1705	1805	1905	2005	2105	2205	2305	2405	2505	2605	2705	2805	2905	3005								
600	1805	1905	2005	2105	2205	2305	2405	2505	2605	2705	2805	2905	3005									
650	1905	2005	2105	2205	2305	2405	2505	2605	2705	2805	2905	3005										
700	2005	2105	2205	2305	2405	2505	2605	2705	2805	2905	3005											
750	2105	2205	2305	2405	2505	2605	2705	2805	2905	3005												
800	2205	2305	2405	2505	2605	2705	2805	2905	3005													
850	2305	2405	2505	2605	2705	2805	2905	3005														
900	2405	2505	2605	2705	2805	2905	3005															
950	2505	2605	2705	2805	2905	3005																
1000	2605	2705	2805	2905	3005																	
1050	2705	2805	2905	3005																		
1100	2805	2905	3005																			
1150	2905	3005																				
1200	3005																					

NOTE: These tables assume the total stretch-out (add-on) dimension is 305mm. If the process used results in a different stretch-out dimension, these tables must be modified accordingly.

BOARD UTILIZATION – 1½" AND 38MM DUCT BOARD

Table 2-17A. Board Utilization, One-Piece Duct, 1½" Duct Board, ft² per Lineal Foot of Duct

DUCT WIDTH in.	DUCT HEIGHT, in.																					
	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
6	3.0	3.3	3.7	4.0	4.3	4.7	5.0	5.3	5.7	6.0	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0
8	3.3	3.7	4.0	4.3	4.7	5.0	5.3	5.7	6.0	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0	
10	3.7	4.0	4.3	4.7	5.0	5.3	5.7	6.0	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0		
12	4.0	4.3	4.7	5.0	5.3	5.7	6.0	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0			
14	4.3	4.7	5.0	5.3	5.7	6.0	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0				
16	4.7	5.0	5.3	5.7	6.0	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0					
18	5.0	5.3	5.7	6.0	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0						
20	5.3	5.7	6.0	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0							
22	5.7	6.0	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0								
24	6.0	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0									
26	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0										
28	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0											
30	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0												
32	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0													
34	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0														
36	8.0	8.3	8.7	9.0	9.3	9.7	10.0															
38	8.3	8.7	9.0	9.3	9.7	10.0																
40	8.7	9.0	9.3	9.7	10.0																	
42	9.0	9.3	9.7	10.0																		
44	9.3	9.7	10.0																			
46	9.7	10.0																				
48	10.0																					

NOTE: This table is based on a total add-on allowance of 12". If the process and tools used result in a different add-on allowance, these tables must be modified accordingly.

Table 2-17B. Board Utilization, One-Piece Duct, 38mm Duct Board, m² per Lineal Meter of Duct

DUCT WIDTH mm	DUCT HEIGHT, mm																					
	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050	1100	1150	1200
150	0.91	1.01	1.11	1.21	1.31	1.41	1.51	1.61	1.71	1.81	1.91	2.01	2.11	2.21	2.31	2.41	2.51	2.61	2.71	2.81	2.91	3.01
200	1.01	1.11	1.21	1.31	1.41	1.51	1.61	1.71	1.81	1.91	2.01	2.11	2.21	2.31	2.41	2.51	2.61	2.71	2.81	2.91	3.01	
250	1.11	1.21	1.31	1.41	1.51	1.61	1.71	1.81	1.91	2.01	2.11	2.21	2.31	2.41	2.51	2.61	2.71	2.81	2.91	3.01		
300	1.21	1.31	1.41	1.51	1.61	1.71	1.81	1.91	2.01	2.11	2.21	2.31	2.41	2.51	2.61	2.71	2.81	2.91	3.01			
350	1.31	1.41	1.51	1.61	1.71	1.81	1.91	2.01	2.11	2.21	2.31	2.41	2.51	2.61	2.71	2.81	2.91	3.01				
400	1.41	1.51	1.61	1.71	1.81	1.91	2.01	2.11	2.21	2.31	2.41	2.51	2.61	2.71	2.81	2.91	3.01					
450	1.51	1.61	1.71	1.81	1.91	2.01	2.11	2.21	2.31	2.41	2.51	2.61	2.71	2.81	2.91	3.01						
500	1.61	1.71	1.81	1.91	2.01	2.11	2.21	2.31	2.41	2.51	2.61	2.71	2.81	2.91	3.01							
550	1.71	1.81	1.91	2.01	2.11	2.21	2.31	2.41	2.51	2.61	2.71	2.81	2.91	3.01								
600	1.81	1.91	2.01	2.11	2.21	2.31	2.41	2.51	2.61	2.71	2.81	2.91	3.01									
650	1.91	2.01	2.11	2.21	2.31	2.41	2.51	2.61	2.71	2.81	2.91	3.01										
700	2.01	2.11	2.21	2.31	2.41	2.51	2.61	2.71	2.81	2.91	3.01											
750	2.11	2.21	2.31	2.41	2.51	2.61	2.71	2.81	2.91	3.01												
800	2.21	2.31	2.41	2.51	2.61	2.71	2.81	2.91	3.01													
850	2.31	2.41	2.51	2.61	2.71	2.81	2.91	3.01														
900	2.41	2.51	2.61	2.71	2.81	2.91	3.01															
950	2.51	2.61	2.71	2.81	2.91	3.01																
1000	2.61	2.71	2.81	2.91	3.01																	
1050	2.71	2.81	2.91	3.01																		
1100	2.81	2.91	3.01																			
1150	2.91	3.01																				
1200	3.01																					

NOTE: This table is based on a total add-on allowance of 305mm. If the process and tools used result in a different add-on allowance, these tables must be modified accordingly.

ONE-PIECE STRETCH-OUT DIMENSIONS – 2” AND 51MM DUCT BOARD

Table 2-18A. One-piece Stretch-Out Dimensions in Inches, 2" Duct Board

DUCT WIDTH in.	DUCT HEIGHT, in.																				
	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46
6	40	44	48	52	56	60	64	68	72	76	80	84	88	92	96	100	104	108	112	116	120
8	44	48	52	56	60	64	68	72	76	80	84	88	92	96	100	104	108	112	116	120	
10	48	52	56	60	64	68	72	76	80	84	88	92	96	100	104	108	112	116	120		
12	52	56	60	64	68	72	76	80	84	88	92	96	100	104	108	112	116	120			
14	56	60	64	68	72	76	80	84	88	92	96	100	104	108	112	116	120				
16	60	64	68	72	76	80	84	88	92	96	100	104	108	112	116	120					
18	64	68	72	76	80	84	88	92	96	100	104	108	112	116	120						
20	68	72	76	80	84	88	92	96	100	104	108	112	116	120							
22	72	76	80	84	88	92	96	100	104	108	112	116	120								
24	76	80	84	88	92	96	100	104	108	112	116	120									
26	80	84	88	92	96	100	104	108	112	116	120										
28	84	88	92	96	100	104	108	112	116	120											
30	88	92	96	100	104	108	112	116	120												
32	92	96	100	104	108	112	116	120													
34	96	100	104	108	112	116	120														
36	100	104	108	112	116	120															
38	104	108	112	116	120																
40	108	112	116	120																	
42	112	116	120																		
44	116	120																			
46	120																				

NOTE: This table assumes the total stretch-out (add-on) dimension is 16". If the process used results in a different stretch-out (add-on) dimension, this table must be modified accordingly.

Table 2-18B. One-Piece Stretch-Out Dimensions in Millimeters, 51mm Duct Board

DUCT WIDTH mm	DUCT HEIGHT, mm																				
	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050	1100	1150
150	1006	1106	1206	1306	1406	1506	1606	1706	1806	1906	2006	2106	2206	2306	2406	2506	2606	2706	2806	2906	3006
200	1106	1206	1306	1406	1506	1606	1706	1806	1906	2006	2106	2206	2306	2406	2506	2606	2706	2806	2906	3006	
250	1206	1306	1406	1506	1606	1706	1806	1906	2006	2106	2206	2306	2406	2506	2606	2706	2806	2906	3006		
300	1306	1406	1506	1606	1706	1806	1906	2006	2106	2206	2306	2406	2506	2606	2706	2806	2906	3006			
350	1406	1506	1606	1706	1806	1906	2006	2106	2206	2306	2406	2506	2606	2706	2806	2906	3006				
400	1506	1606	1706	1806	1906	2006	2106	2206	2306	2406	2506	2606	2706	2806	2906	3006					
450	1606	1706	1806	1906	2006	2106	2206	2306	2406	2506	2606	2706	2806	2906	3006						
500	1706	1806	1906	2006	2106	2206	2306	2406	2506	2606	2706	2806	2906	3006							
550	1806	1906	2006	2106	2206	2306	2406	2506	2606	2706	2806	2906	3006								
600	1906	2006	2106	2206	2306	2406	2506	2606	2706	2806	2906	3006									
650	2006	2106	2206	2306	2406	2506	2606	2706	2806	2906	3006										
700	2106	2206	2306	2406	2506	2606	2706	2806	2906	3006											
750	2206	2306	2406	2506	2606	2706	2806	2906	3006												
800	2306	2406	2506	2606	2706	2806	2906	3006													
850	2406	2506	2606	2706	2806	2906	3006														
900	2506	2606	2706	2806	2906	3006															
950	2606	2706	2806	2906	3006																
1000	2706	2806	2906	3006																	
1050	2806	2906	3006																		
1100	2906	3006																			
1150	3006																				

NOTE: This table assumes the total stretch-out (add-on) dimension is 406mm. If the process used results in a different stretch-out (add-on) dimension, this table must be modified accordingly.

BOARD UTILIZATION – 2" AND 51MM DUCT BOARD

Table 2-19A: Board Utilization, One-Piece Duct, 2" Duct Board, ft² per Lineal Foot of Duct

DUCT WIDTH in.	DUCT HEIGHT, in.																				
	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46
6	3.3	3.7	4.0	4.3	4.7	5.0	5.3	5.7	6.0	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0
8	3.7	4.0	4.3	4.7	5.0	5.3	5.7	6.0	6.3	6.7	70	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0	
10	4.0	4.3	4.7	5.0	5.3	5.7	6.0	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0		
12	4.3	4.7	5.0	5.3	5.7	6.0	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0			
14	4.7	5.0	5.3	5.7	6.0	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0				
16	5.0	5.3	5.7	6.0	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0					
18	5.3	5.7	6.0	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0						
20	5.7	6.0	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0							
22	6.0	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0								
24	6.3	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0									
26	6.7	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0										
28	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0											
30	7.3	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0												
32	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0													
34	8.0	8.3	8.7	9.0	9.3	9.7	10.0														
36	8.3	8.7	9.0	9.3	9.7	10.0															
38	8.7	9.0	9.3	9.7	10.0																
40	9.0	9.3	9.7	10.0																	
42	9.3	9.7	10.0																		
44	9.7	10.0																			
46	10.0																				

NOTE: This table assumes the total stretch-out (add-on) dimension is 16". If the process used results in a different stretch-out (add-on) dimension, this table must be modified accordingly.

Table 2-19B: Board Utilization, One-Piece Duct, 51mm Duct Board, m² per Lineal Meter of Duct

DUCT WIDTH mm	DUCT HEIGHT, mm																				
	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050	1100	1150
150	1.01	1.11	1.21	1.31	1.41	1.51	1.61	1.71	1.81	1.91	2.01	2.11	2.21	2.31	2.41	2.51	2.61	2.71	2.81	2.91	3.01
200	1.11	1.21	1.31	1.41	1.51	1.61	1.71	1.81	1.91	2.01	2.11	2.21	2.31	2.41	2.51	2.61	2.71	2.81	2.91	3.01	
250	1.21	1.31	1.41	1.51	1.61	1.71	1.81	1.91	2.01	2.11	2.21	2.31	2.41	2.51	2.61	2.71	2.81	2.91	3.01		
300	1.31	1.41	1.51	1.61	1.71	1.81	1.91	2.01	2.11	2.21	2.31	2.41	2.51	2.61	2.71	2.81	2.91	3.01			
350	1.41	1.51	1.61	1.71	1.81	1.91	2.01	2.11	2.21	2.31	2.41	2.51	2.61	2.71	2.81	2.91	3.01				
400	1.51	1.61	1.71	1.81	1.91	2.01	2.11	2.21	2.31	2.41	2.51	2.61	2.71	2.81	2.91	3.01					
450	1.61	1.71	1.81	1.91	2.01	2.11	2.21	2.31	2.41	2.51	2.61	2.71	2.81	2.91	3.01						
500	1.71	1.81	1.91	2.01	2.11	2.21	2.31	2.41	2.51	2.61	2.71	2.81	2.91	3.01							
550	1.81	1.91	2.01	2.11	2.21	2.31	2.41	2.51	2.61	2.71	2.81	2.91	3.01								
600	1.91	2.01	2.11	2.21	2.31	2.41	2.51	2.61	2.71	2.81	2.91	3.01									
650	2.01	2.11	2.21	2.31	2.41	2.51	2.61	2.71	2.81	2.91	3.01										
700	2.11	2.21	2.31	2.41	2.51	2.61	2.71	2.81	2.91	3.01											
750	2.21	2.31	2.41	2.51	2.61	2.71	2.81	2.91	3.01												
800	2.31	2.41	2.51	2.61	2.71	2.81	2.91	3.01													
850	2.41	2.51	2.61	2.71	2.81	2.91	3.01														
900	2.51	2.61	2.71	2.81	2.91	3.01															
950	2.61	2.71	2.81	2.91	3.01																
1000	2.71	2.81	2.91	3.01																	
1050	2.81	2.91	3.01																		
1100	2.91	3.01																			
1150	3.01																				

NOTE: This table assumes the total stretch-out (add-on) dimension is 406mm. If the process used results in a different stretch-out (add-on) dimension, this table must be modified accordingly.

Fabrication of Duct Module

1. Cut shiplaps and corner grooves with hand tools or by machine as shown on pages 2-10 through 2-13. Remove the groove scrap. Lifting board as shown will make it easier to remove the shiplap groove scrap.

3. While holding the duct canted over at or about 30˚, staple the longitudinal flap with 1/2" (minimum) outward clinching staples approximately 2" (51mm) on centers. (See Section IV, Closure, for stapling details.)

2. Fold to form the duct section, making sure the ends are flush and seated properly in the shoulder of the shiplap edge.

4. Complete the longitudinal seam according to procedures shown in Section IV, Closure per the page corresponding to the approved closure method. (Pressure-sensitive tape is shown above.) 3" tape is recommended for 1½" and required for 2" board. The board must be clean and dry.

Joining Two Duct Modules

1. Slit the facing flaps back at corners, making sure you do not cut below the male shiplap shoulder or into the inside duct surfaces.

3. Staple the flaps on the four sides with ½" (minimum) outward clinching staples approximately 2" (51mm) on centers. Stapling details can be found in Section IV, Closure.

2. Push the two modules together. Make sure the male and female shiplaps are tightly fitted together.

4. Complete the longitudinal seam according to procedures shown in Section IV, Closure, per the page corresponding to the approved closure method chosen. (Pressure-sensitive tape is shown above.) 3" tape is recommended for 1 ½" and required for 2" board. The board must be clean and dry.

Section III Fabrication of Fittings From Modules or Flat Board

Notes to Section III

1. FASTENER SCHEDULE

- #10 plated sheet metal screws, board thickness + ¼" (6mm), with 2½" (64mm) square, or
- 3" (76mm) round galvanized steel washers, 0.028" (0.7mm) thick, volcano type, with turned edges facing away from duct board, 12" (305mm) (nominal) centers, EXCEPT as noted in Section V, Reinforcement.

2. TAPE TAB SCHEDULE

UL Standard 181A pressure-sensitive or heat activated tape, 8" (203mm) (nominal) length, on 12" (305mm) (nominal) centers, at least one per side. Refer to Section IV, Closure.

3. REINFORCEMENT

Some fittings may require reinforcement even though schedules for straight ducts of the same span show reinforcement is not required. Refer to Section V, Reinforcement.

4. SHIPLAP ORIENTATION

Male shiplap ends of duct modules and fittings should face TOWARD the equipment. Female shiplap ends should face AWAY from the equipment.

5. TURNING VANES

Metal turning vane and runner assemblies shall be fabricated in accordance with the HVAC Duct Construction Standard requirements. Runners, two minimum, shall be fastened to the duct wall at 12 in. (305 mm) (MAX.) intervals.

90° Elbow With Rail Mounted Metal Turning Vanes From Module

1. Cut on dashed lines A - B and A' - B' with a straight knife through the facing only along the duct corners. Cut on dashed line A - A' through the board and facing across the square edge tap-out panel. (See Figs. 3-2A and 3-2B.)

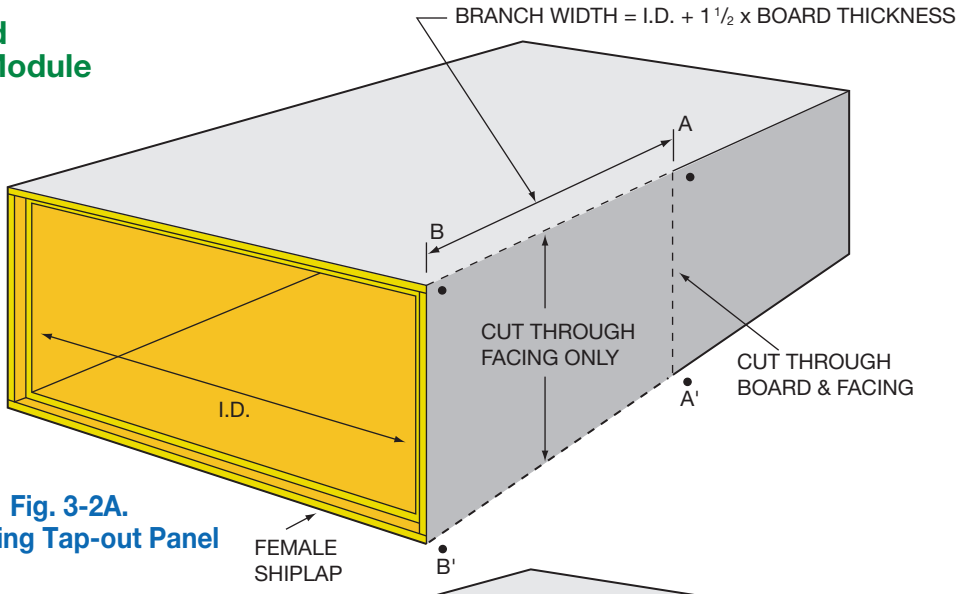


Fig. 3-2A. Creating Tap-out Panel

2. Install turning vanes per the Fastener Schedule with a minimum two per rail (See page 3-1). The metal turning vane and runner assemblies shall be fabricated in accordance with the HVAC Duct Construction Standard requirements. A minimum of two runners shall be fastened to the duct wall at 12" (305mm) (MAX.) intervals.

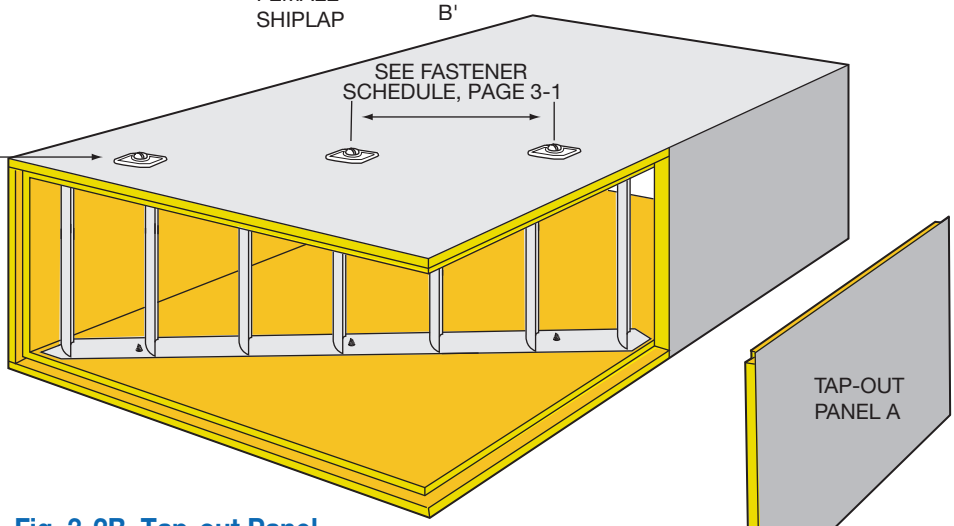


Fig. 3-2B. Tap-out Panel

3. Rotate the tap-out panel A and place in the end of the elbow so the female shiplap faces away from the equipment. (See Fig. 3-2C.)

4. Apply tape tabs per the Tape Tab Schedule. (See page 3-1)

5. Apply closure to all circumferential joints. (See Section IV, Closure.)

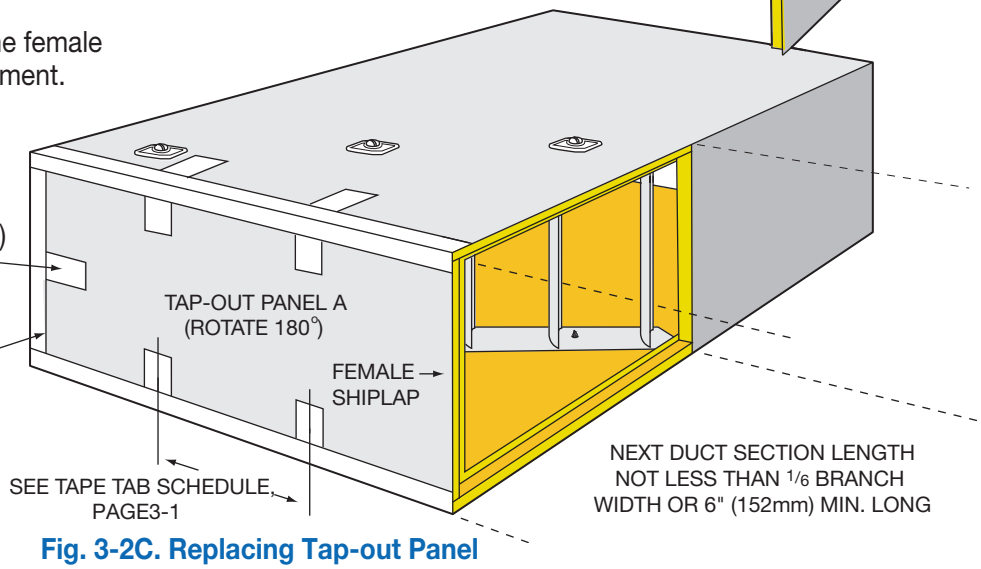


Fig. 3-2C. Replacing Tap-out Panel

90° Elbow With Turning Vanes From Flat Grooved Duct Board

Turning vanes may be fibrous glass or metal. Metal vanes must be rail mounted. Fibrous glass vanes may be installed as shown in Figs. 3-3B and 3-3C.

1. Cut tap-out panel A from the board with a straight knife. (See Fig. 3-3B.)

2. Draw diagonal lines A - B and A' - B' for turning vane placement. (See Fig. 3-3A.)

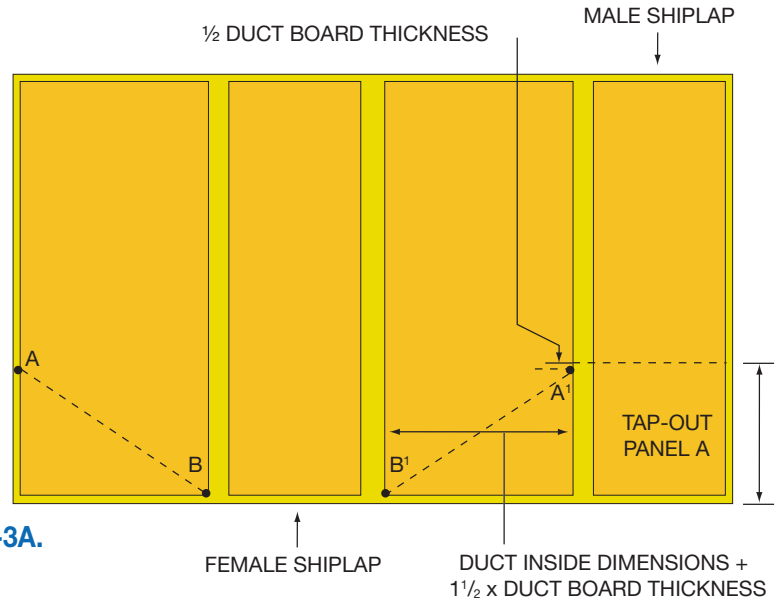


Fig. 3-3A.

3. Cut the vane sockets approximately 3" (76mm) spacing along diagonal lines, with the first vane being cut at edge of panel, using vane socket cutter. The socket depth shall not exceed $^{3}/_{4}$" (19mm) in depth. Remove loose insulation.

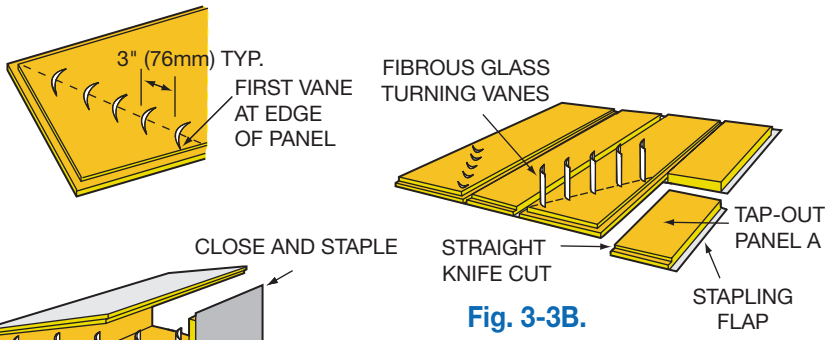


Fig. 3-3B.

4. Cut the turning vane stock to the inside duct height plus $1^{1}/_{2}$" (38mm) to $1^{3}/_{4}$" (44mm) and insert in the sockets in the bottom of panel. (See Fig.3-3C.) Orient the vanes to direct the air parallel to the axis of the next duct section. Install per the turning vane manufacturer's recommendations.

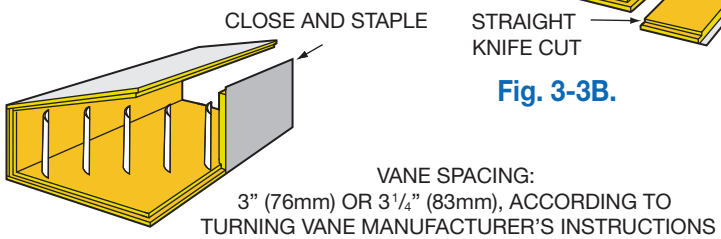


Fig. 3-3C.

5. Close the fitting and staple the longitudinal seam. (See Fig. 3-3C.)

6. Rotate tap-out panel A and place in the end of the duct section so the female shiplap faces away from the equipment. (See Fig. 3-3D.)

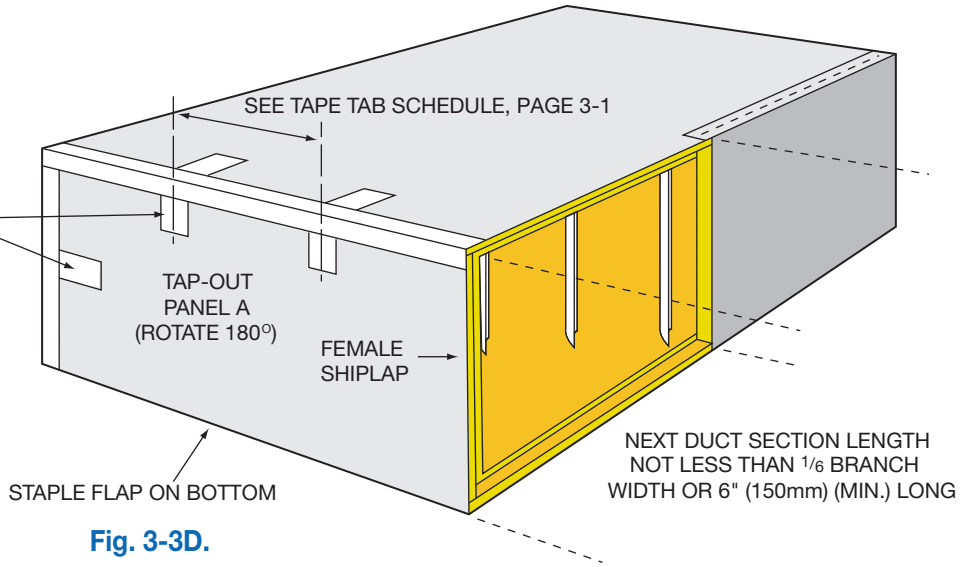


Fig. 3-3D.

7. Apply tape tabs per the Tape Tab Schedule. (See page 3-1.)

Three-Piece 90° Elbow From Duct Board Module

1. Make straight knife cuts along dashed lines A - B - C - D - A and A' - B' - C' - D' - A' (See Fig. 3-4A.) Maintain the cheek panel angle when making side panel cuts.

OPTIONAL – CHEEK PANELS ONLY: Make cuts with the shiplap tool along lines A - B and A' - B', C - D and C' - D'. Maintain the shiplap orientation of the original duct section.

2. Separate the three pieces. (See Fig. 3-4B.) Rotate the center piece 180°. (See Fig. 3-4C.) Push the three pieces together. (See Fig. 3-4D.)

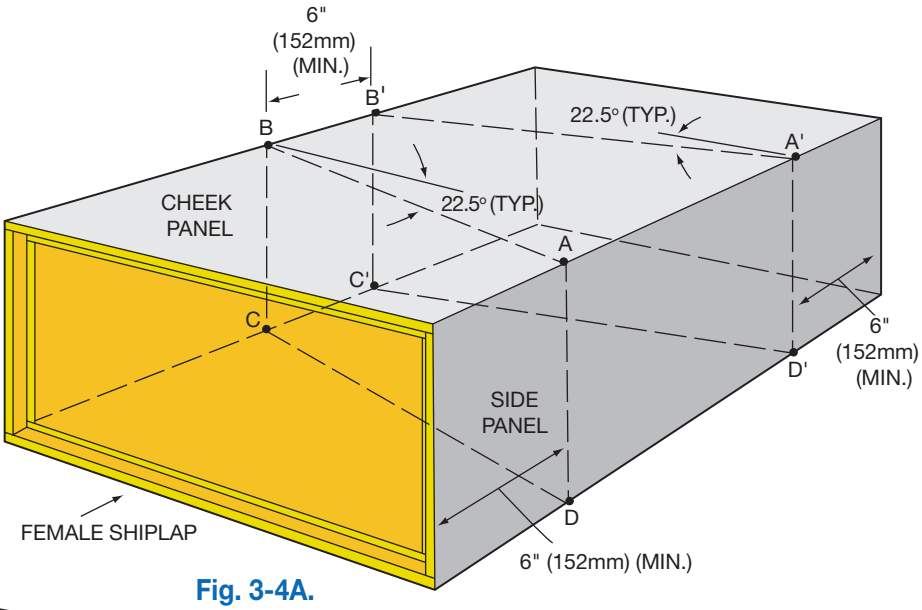


Fig. 3-4A.

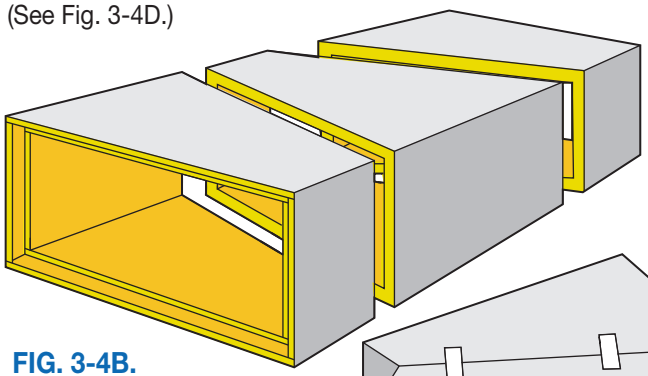


FIG. 3-4B.

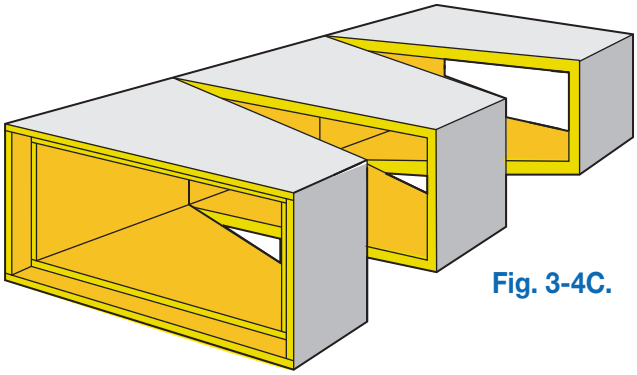


Fig. 3-4C.

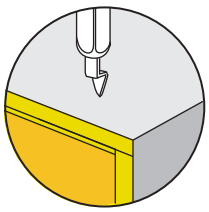


FIG. 3-4D.

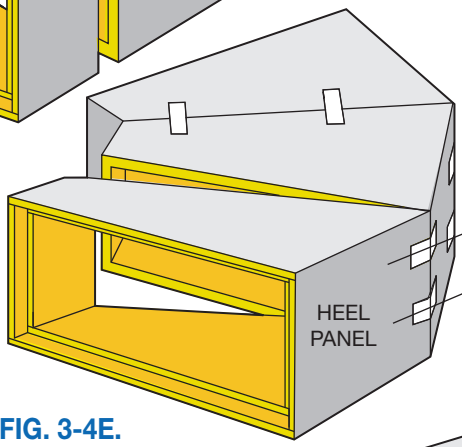


FIG. 3-4E.

3. Apply tape tabs per the Tape Tab Schedule (see page 3-1), starting with heel panels. (See Fig. 3-4E.)

4. Apply closure to all circumferential joints. (See Fig. 3-4F.) (See Section IV, Closure.)

NOTE: Turning vanes are not required.

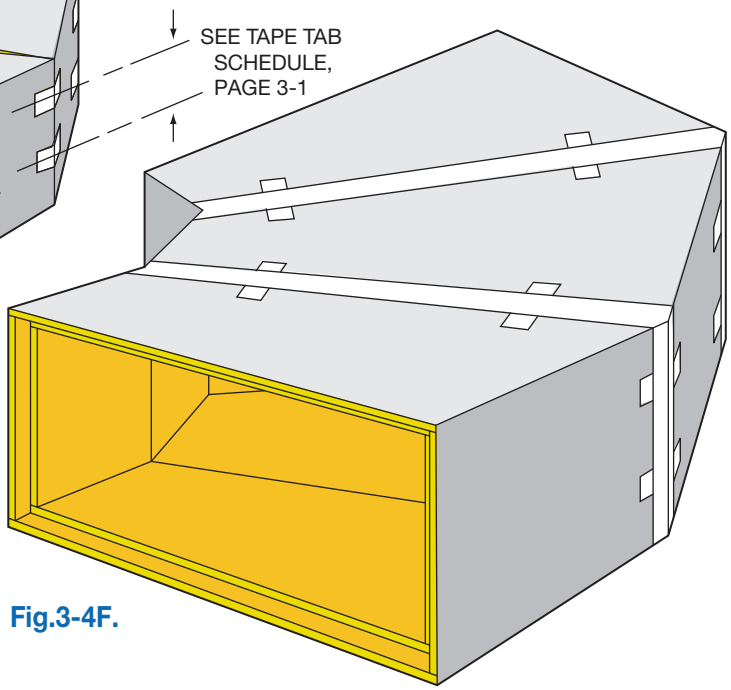


Fig.3-4F.

Elbows of Less Than 90° From Duct Board Module

1. Make a straight knife cut around the duct section, dashed line A - B - C - D - A, maintaining the cheek panel angle when making side panel cuts. (See Fig. 3-5B.)

OPTIONAL – CHEEK PANELS ONLY:
Score the facing with knife and cut along lines A - B and C - D with the shiplap tool. Maintain the shiplap orientation. (See Fig. 3-5C.)

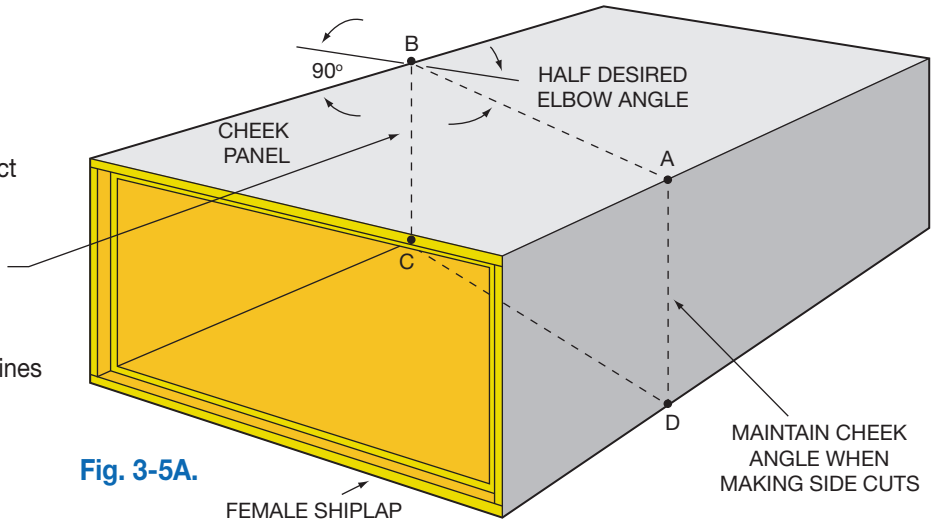


Fig. 3-5A.

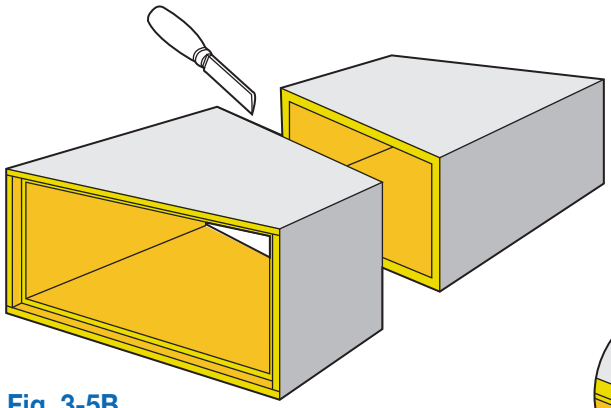


Fig. 3-5B.

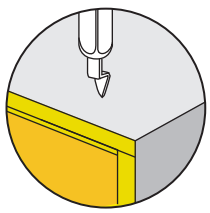


Fig.3-5C.

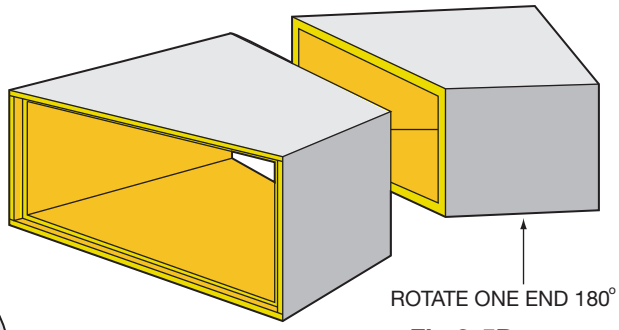


Fig.3-5D.

2. Separate the two pieces (See Fig. 3-5B.) Rotate the one piece 180° (See Fig. 3-5D.) Push the pieces together. (See Fig. 3-5E.)

3. Apply tape tabs per the Tape Tab Schedule (page 3-1), starting with the cheek panels.

4. Apply closure to the circumferential joint. (See Fig. 3-5E.) (See Section IV, Closure.)

NOTE: Turning vanes are not required.

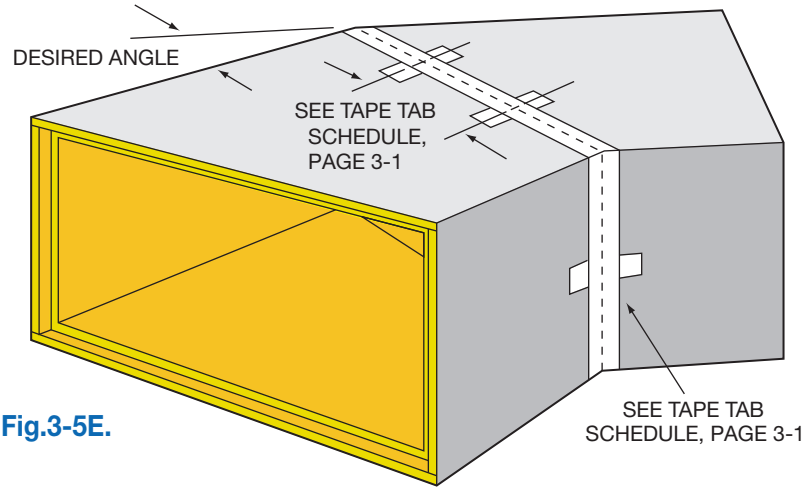


Fig.3-5E.

Tee From Duct Board Module With Rail Mounted Metal Turning Vanes

1. Cut with a straight knife on dashed lines A - B and A' - B', at all four corners, through facing only. (See Fig. 3-6A.)

2. Cut on dotted lines A - A', with a straight knife through the board and facing to create both square edge tap-out panels. (See Fig. 3-6A.) Discard tap-out panels. (See Fig. 3-6B.)

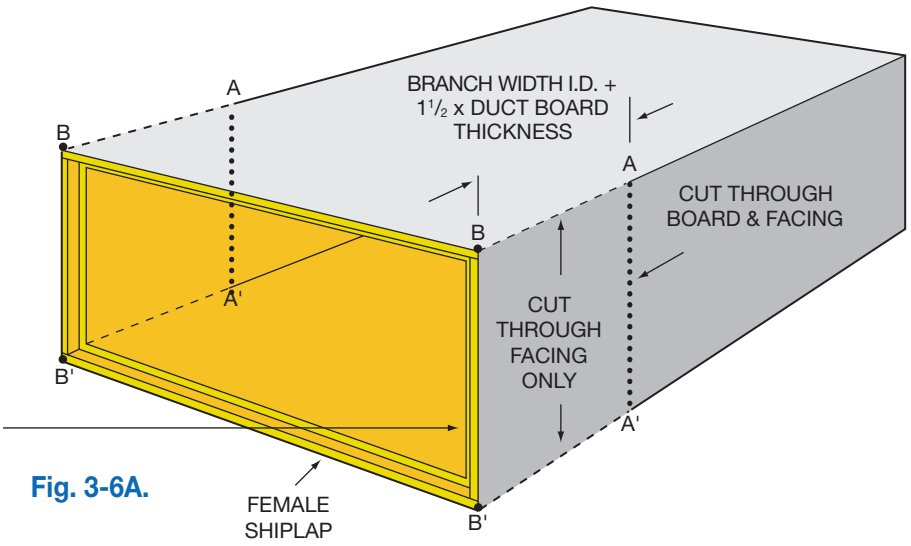


Fig. 3-6A.

3. Install turning vanes with a minimum of two per rail. (See Fig. 3-6B.) See Fastener Schedule (page 3-1).

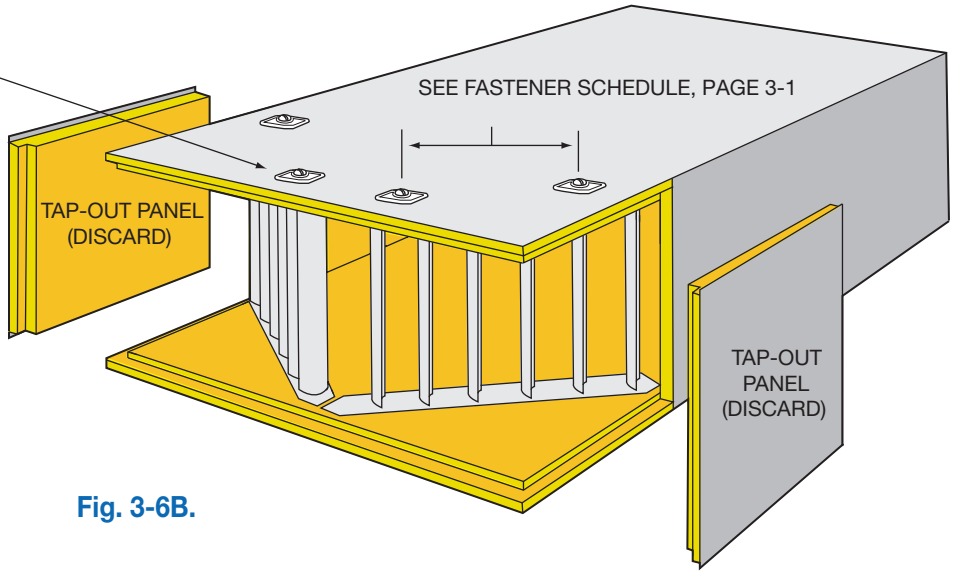


Fig. 3-6B.

4. Fabricate the end cap with the two female shiplaps to close the fitting. (See Fig. 3-6C.) Apply the tape tabs per Tape Tab Schedule (page 3-1).

5. Apply the closure to the circumferential joints. (See Fig. 3-6C.) (See Section IV, Closure.)

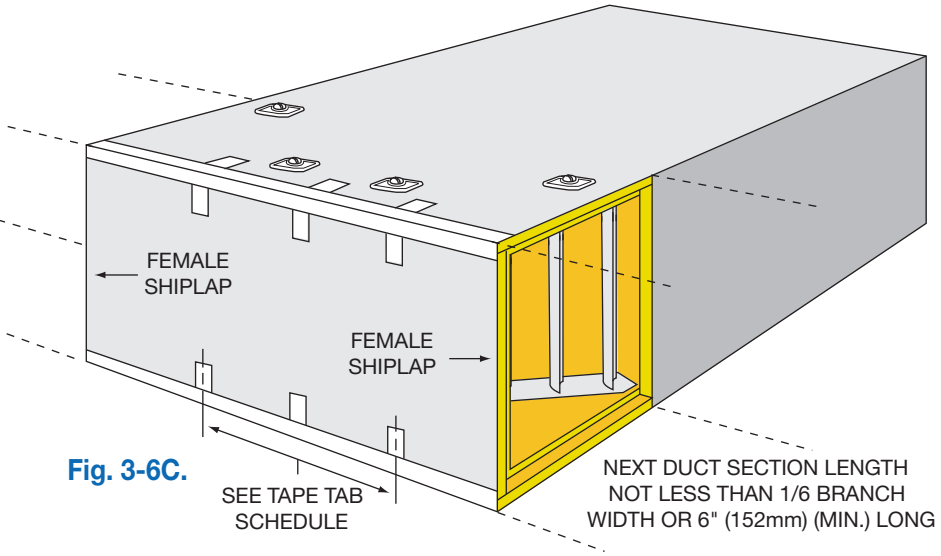


Fig. 3-6C.

Tee From Flat Duct Board With Fibrous Glass Turning Vanes

1. Draw turning vane center lines A - B for one branch, C - B for other. Draw lines D - E and D' - E' for the tee openings. (See Fig. 3-7A.)

2. Cut with straight knife along the tee opening lines C - D and C' - D'. Cut with a straight knife along the shiplap panel edges so the tee opening panels with staple flaps can be removed and discarded. (See Fig. 3-7B.)

3. Cut the vane sockets on 3" (76mm) spacing (approximately) along lines A - B and A' - B'. Orient the vanes to direct air parallel to axis of each branch. Remove loose insulation from the sockets.

4. Cut the turning vane stock to the inside duct height plus 1½ " (38mm) to 1¾ " (44mm). Insert in the sockets.

5. Close the fitting and the staple longitudinal seam. (See Fig. 3-7D.)

6. Fabricate the end cap with the two female shiplaps. Install it in the end of the fitting and apply tape tabs per Tape Tab Schedule (page 3-1). Close the fitting and the staple longitudinal seam. (See Fig. 3-7D.)

7. Apply closure to the longitudinal seam and circumferential joints. (See Section IV, Closure.)

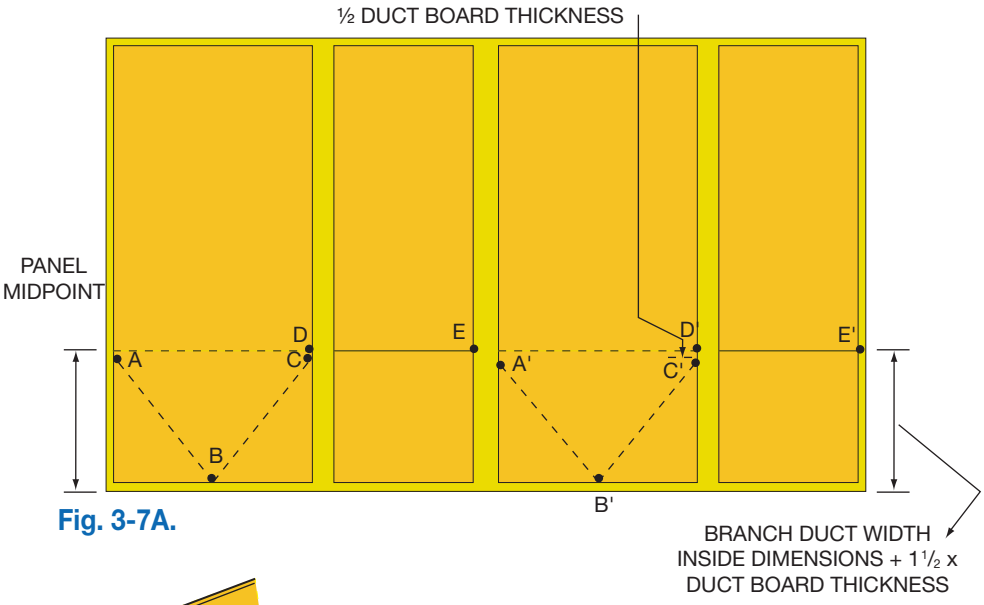


Fig. 3-7A.

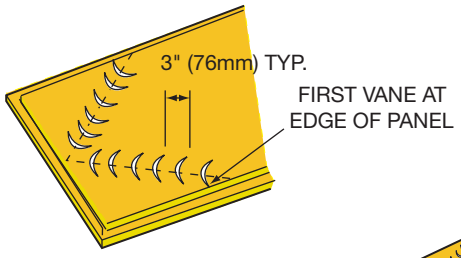
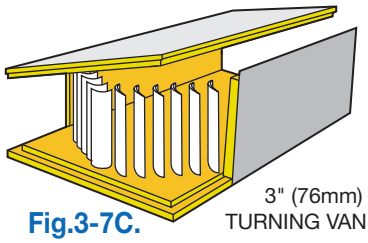


Fig. 3-7B.



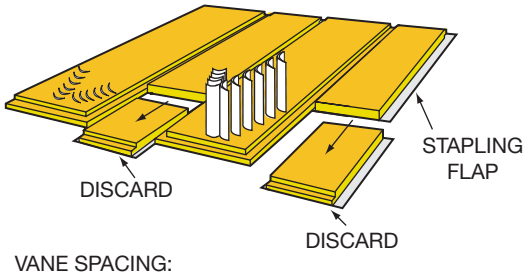


Fig.3-7C.

VANE SPACING:
3" (76mm) OR 3¼" (83mm), ACCORDING TO TURNING VANE MANUFACTURER'S INSTRUCTIONS

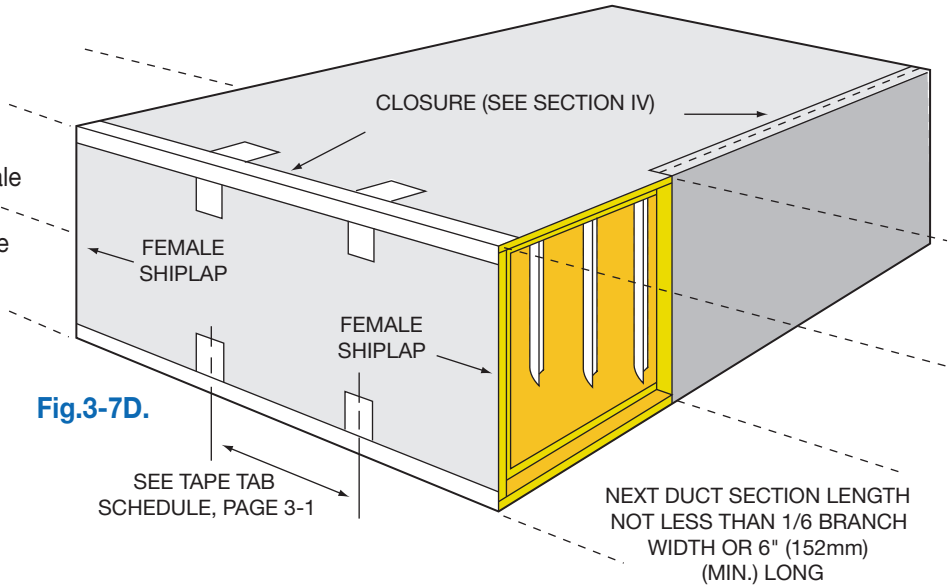


Fig.3-7D.

Section III: Fabrication of Fittings From Modules or Flat Board

One-Way 30° Offset From Duct Board Module

1. Make a straight knife cuts along dashed lines A - B - C - D - A and A' - B' - C' - D' - A'. Maintain a 15°cheek panel angle when making side panel cuts. (See Fig. 3-8B.)

OPTIONAL, CHEEK PANELS ONLY:
Score the facing with a knife and cut along lines A - B, A' - B', C - D, and C' - D' with a shiplap tool. Maintain the shiplap orientation. (See Figs. 3-8C and 3-8D.)

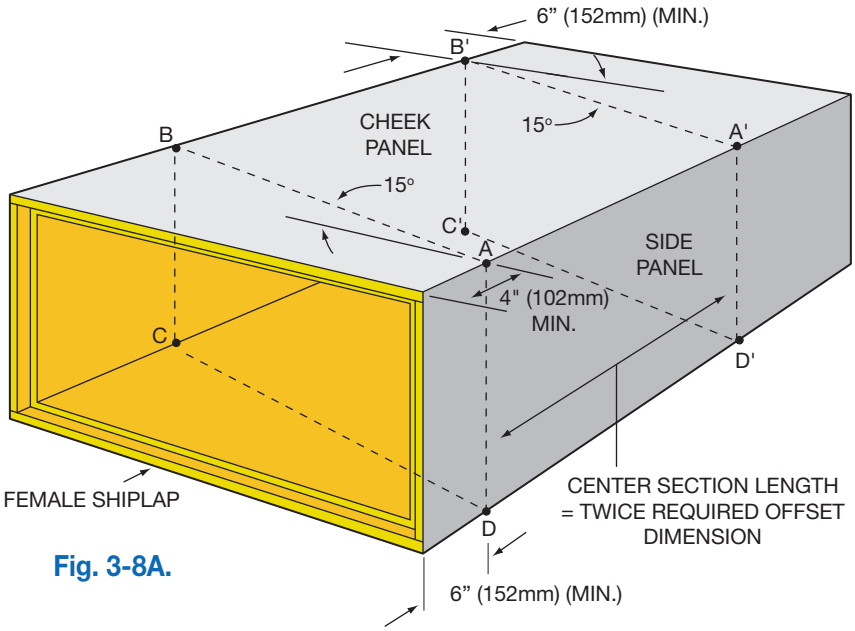


Fig. 3-8A.

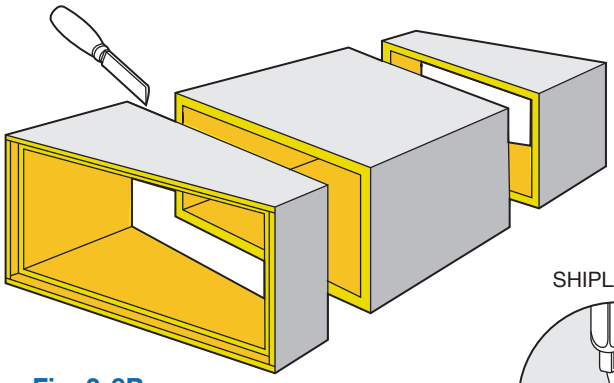


Fig. 3-8B.

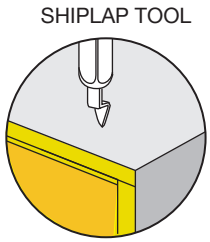


Fig. 3-8C.

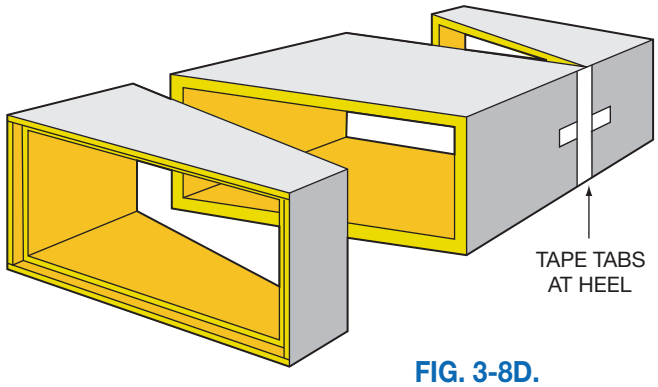


FIG. 3-8D.

2. Separate the three pieces. (See Fig. 3-8B.) Rotate the center piece 180°. (See Fig. 3-8D.) Push the three pieces together.

3. Apply the tape tabs per Tape Tab Schedule (page 3-1), starting with the cheek panels. (See Fig. 3-8E.)

4. Apply closure to the circumferential joints. (See Fig. 3-8E.) (See Section IV, Closure.)

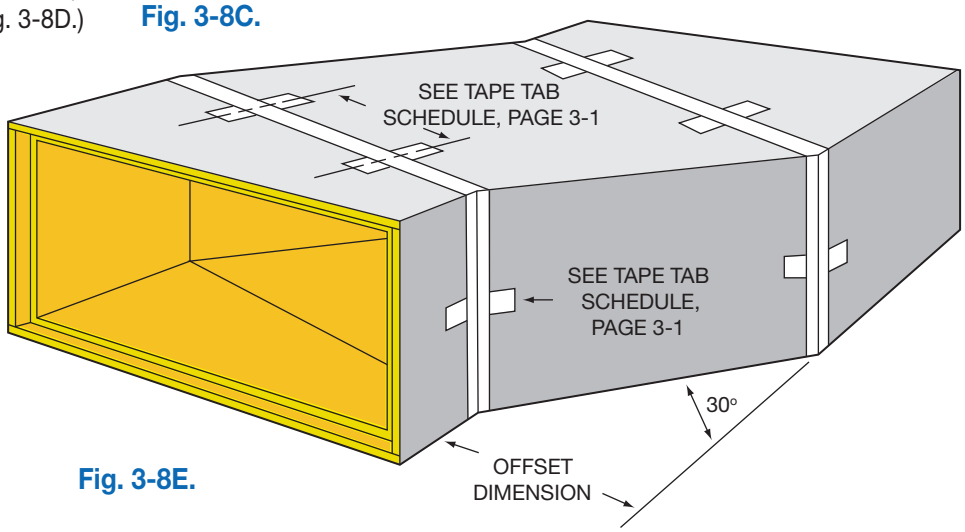


Fig. 3-8E.

One-Way Offset of Any Angle From Duct Board Module

Assume field conditions determine starting point A, offset length L, and offset dimension. (See Fig. 3-9A.)

1.Draw line O - O' parallel to the duct edge, creating the offset dimension from edge.

2. Locate point B by measuring the distance of L (offset length) from point A. Then strike the arc using B as the center and L as the radius. The intersection of the arc with line O - O' establishes point A'.

3. Draw line A - A', extending it across the cheek panel to point C. Mark point C. Line A - C establishes the offset angle.

4. Measure the L distance from point C to locate and mark point D. Draw line B - D, extending the layout lines around the duct section.

5. Make two straight knife cuts around the duct section on the dashed lines. Extend the layout lines square with the corner. Maintain the cheek panel angle when making side panel cuts. (See Figure 3-9B.)

OPTIONAL – CHEEK PANELS ONLY:
Score the facing with a knife and cut along lines A - C and B - D, E - F and G - H with the shiplap tool. (See Fig. 3-9D.) Maintain the shiplap orientation.

6. Separate the three pieces. (See Fig. 3-9B.) Rotate the center section 180°. (See Fig. 3-9C.) Push the three pieces together.

7. Apply the tape tabs per Tape Tab Schedule (page 3-1), starting with the heel panels. (See Fig. 3-9C.)

8. Apply closure to the circumferential joints. (See Fig. 3-9E.) (See Section IV, Closure.)

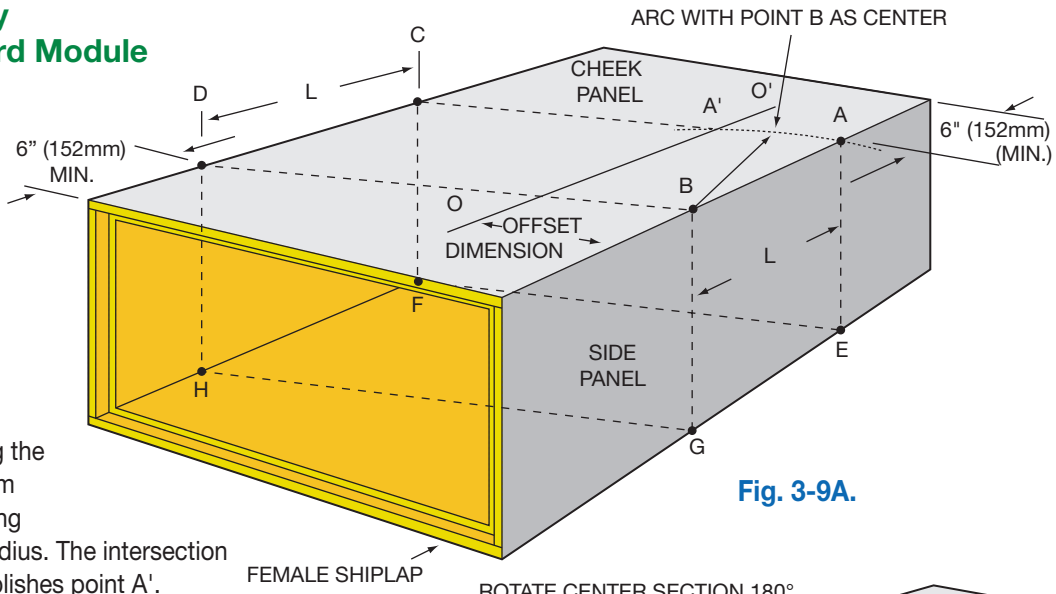


Fig. 3-9A.

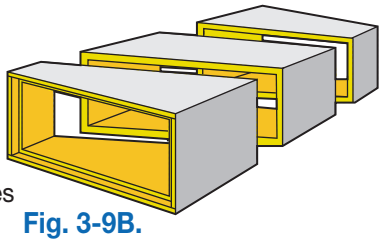


Fig. 3-9B.

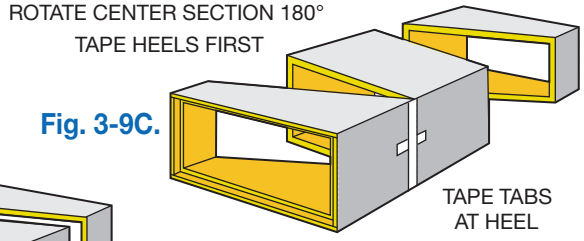


Fig. 3-9C.

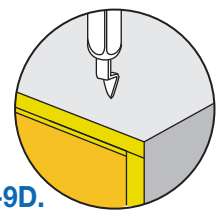


Fig. 3-9D.

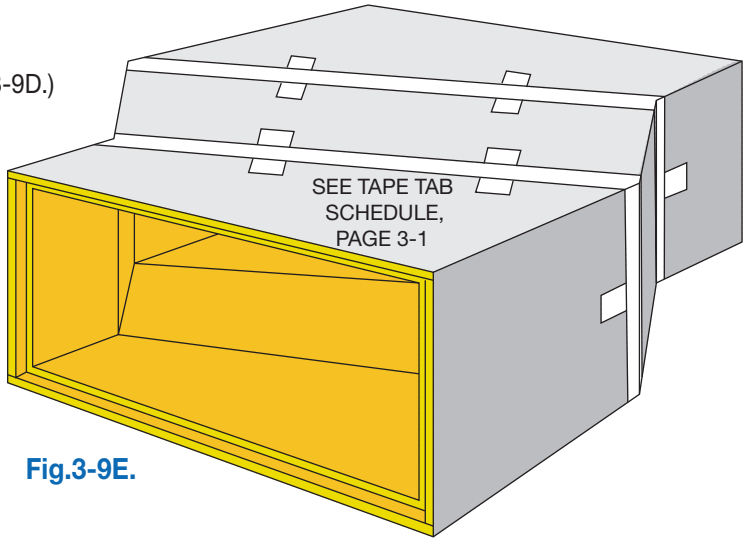


Fig.3-9E.

One-Way Transition From Duct Board Module, Reducing Square Edge Panel

Change dimension = the difference between the height of the male and female shiplap ends. If the shiplap and square edge panels are reversed, follow the instructions on page 3-11.

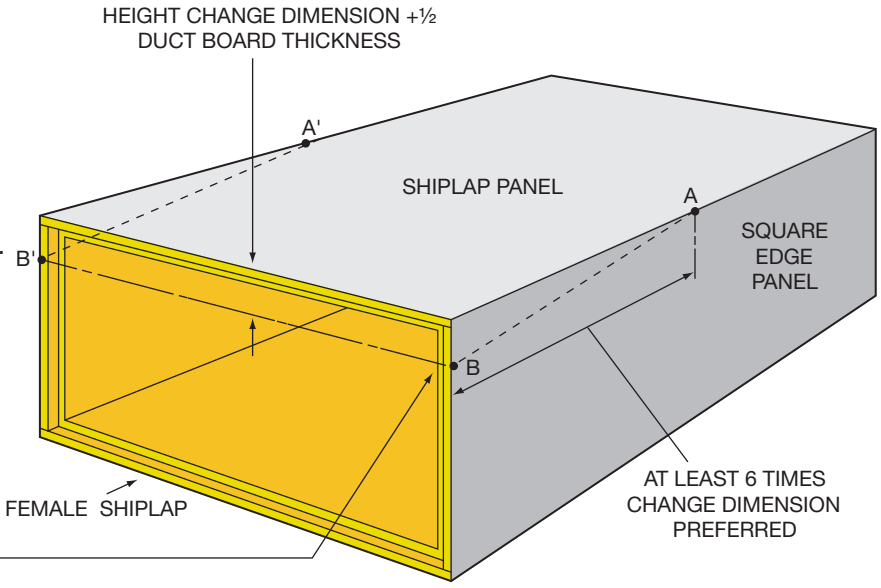


Fig. 3-10A.

1. Make a straight knife cut through the insulation and facing along the dashed lines A - B and A' - B'. (See Fig. 3-10A.)

2. Remove and discard the triangular scrap. Trim the facing on both sides leaving 2" (51mm) (APPROX.) staple flaps. (See Fig. 3-10B.)

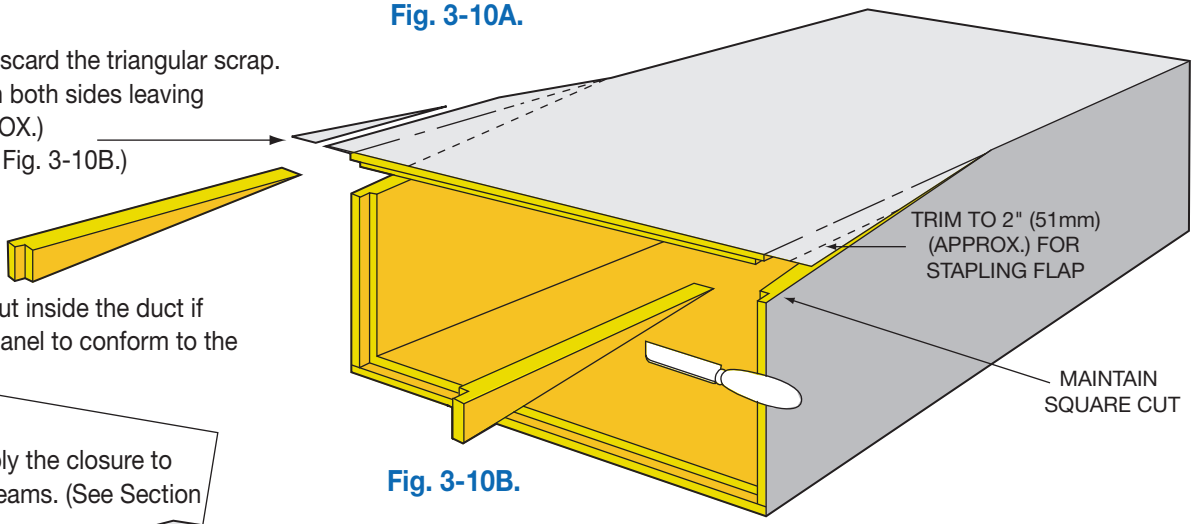


Fig. 3-10B.

3. Make a relief cut inside the duct if required for the panel to conform to the transition angle.

4. Staple and apply the closure to the longitudinal seams. (See Section IV, Closure.)

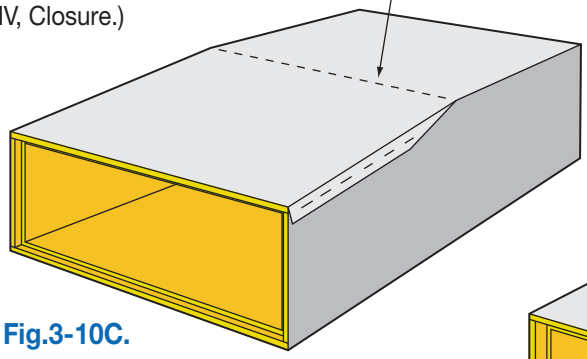


Fig.3-10C.

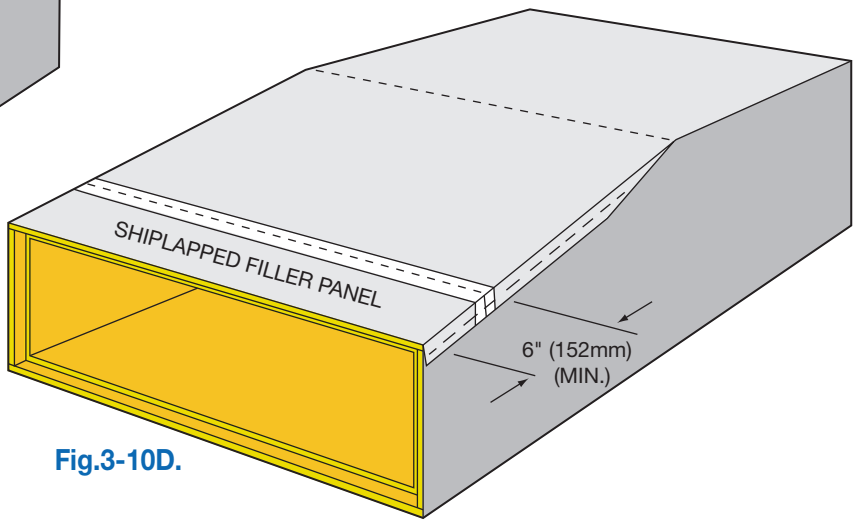


Fig.3-10D.

NOTE: If the sloping panel is short from the end by more than 3/8" (10mm), insert the shiplapped panel 6" (152mm) (minimum) long at the end of the sloping panel, OR halve the slope angle by using focal transition. (See page 3-14.)

One-Way Transition From Duct Board Module Reducing Shiplap Panel

Change dimension = the difference between the width of the male and female shiplap ends. If the shiplap and square edge panels are reversed, follow the instructions on page 3-10.

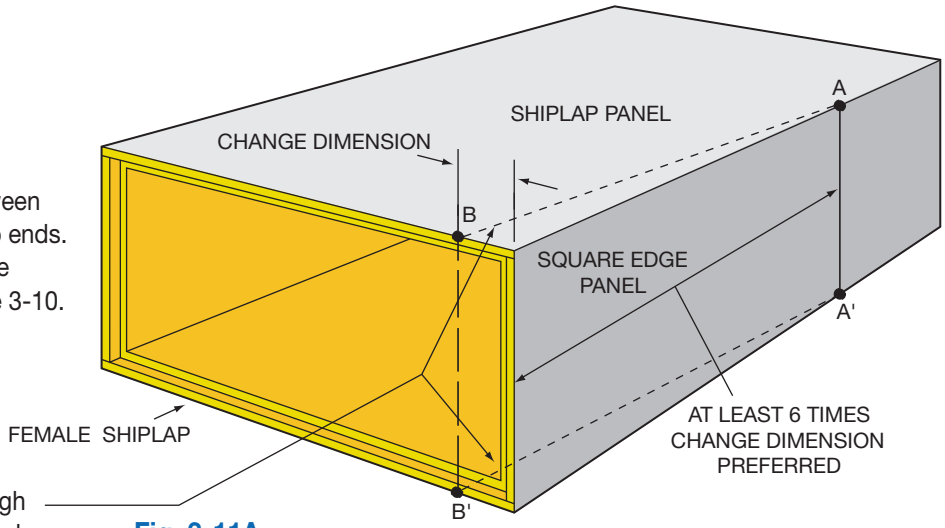


Fig. 3-11A.

1. Use the hand shiplap tool to cut through the insulation and facing along the dashed lines A - B and A' - B.' (See Fig. 3-11A.) Maintain the shiplap orientation of the original module. (See Fig. 3-11B.)

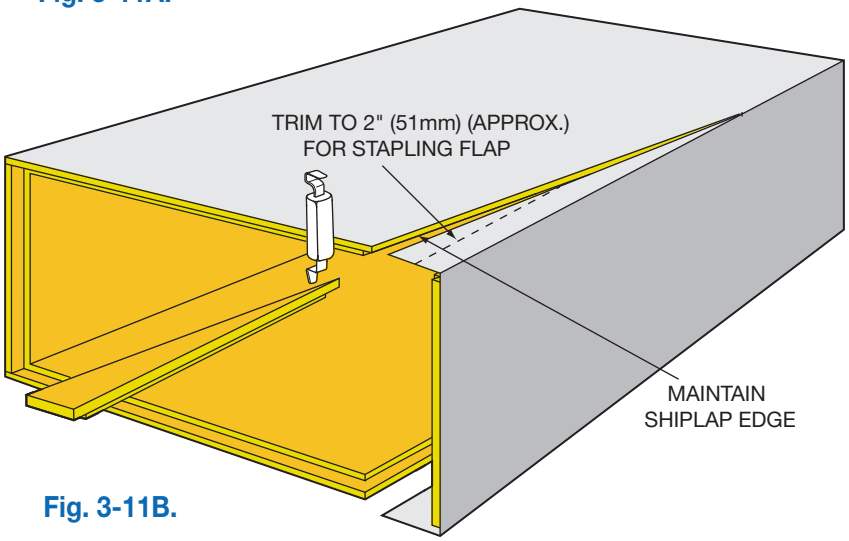


Fig. 3-11B.

2. Remove and discard the triangular scrap. Trim the facing both sides leaving 2" (51mm) (APPROX.) staple flaps. (See Fig. 3-11B.)

3. Make a relief cut inside the duct if required for the panel to conform to the transition angle.

4. Staple and apply closure to the longitudinal seams. (See Section IV, Closure.)

NOTE: If the sloping panel is short from the end by more than $^{3}/_{8}$" (10mm), insert the shiplapped panel 6" (151mm) (MIN.) long at the end of the sloping panel, OR halve the slope angle by using focal transition. (See page 3-14.)

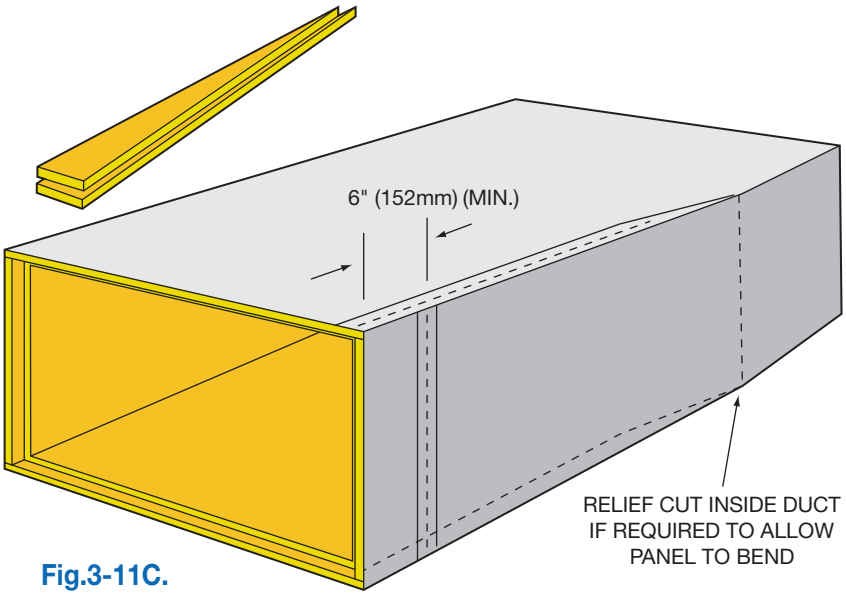


Fig.3-11C.

Two-Way Transition From Duct Board Module Reducing Shiplap and Square Edge Panels

Width change dimension = the difference between the width of the male and female shiplap ends.

Height change dimension = the difference between the height of the male and female ends.

1. Use a hand shiplap tool to cut through the insulation and facing along the dashed lines A - B and A' - B' on the shiplapped panels. (See Fig. 3-12A.) Maintain the shiplap orientation of the original module. (See Fig. 3-12B.)

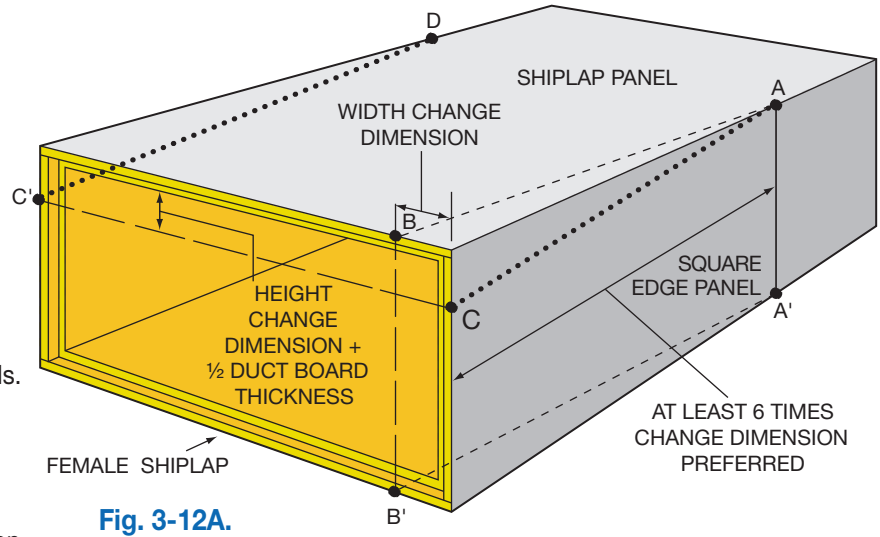


Fig. 3-12A.

2. Fold back the facing and make straight knife cuts through the insulation along the dotted lines A - C and D - C' on the square edge panels. (See Fig. 3-12B.)

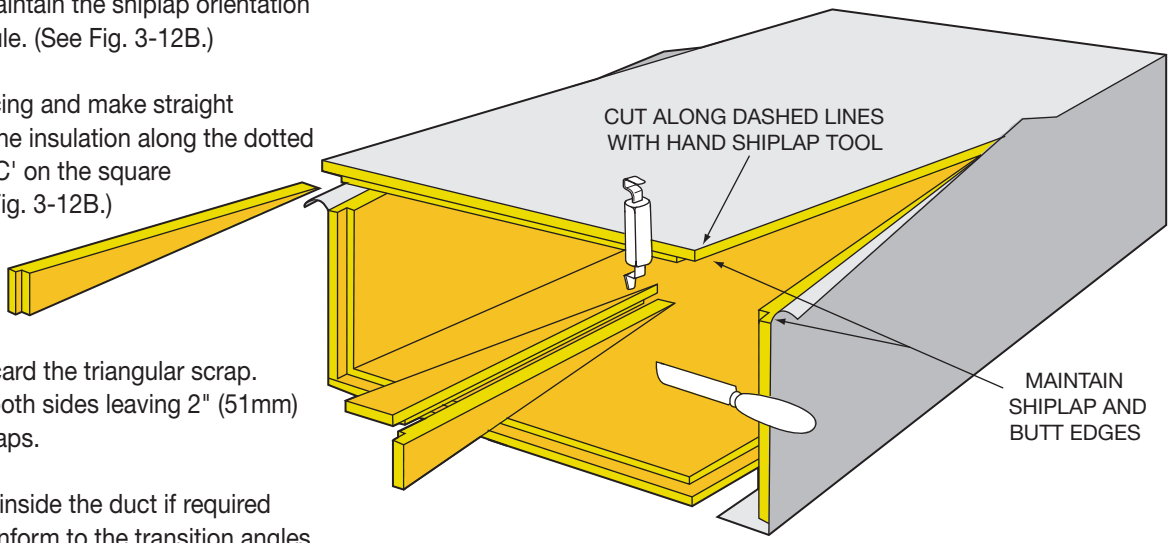


Fig. 3-12B.

3. Remove and discard the triangular scrap. Trim the facing on both sides leaving 2" (51mm) (APPROX.) staple flaps.

4. Make a relief cut inside the duct if required for the panels to conform to the transition angles.

5. Staple and apply the closure to the longitudinal seams. (See Section IV, Closure.)

NOTE: If the sloping panels are short from the end by more than $^{3}/_{8}$" (10mm), insert the shiplapped panels 6" (152mm) (MIN.) long at the ends of the sloping panels. (See Fig. 3-10D.) Trim the two long panels back to align with the foreshortened panel ends, OR halve the slope angle by using the focal transition. (See page 3-14.)

*This must be done correctly so the module length will not be shortened.

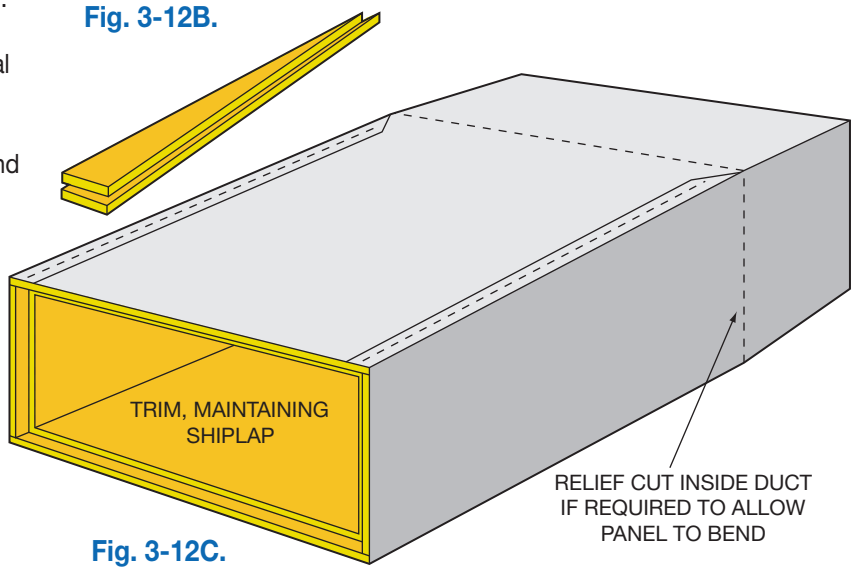


Fig. 3-12C.

One-Way Transition From Flat Grooved Duct Board Reducing Shiplap Panel

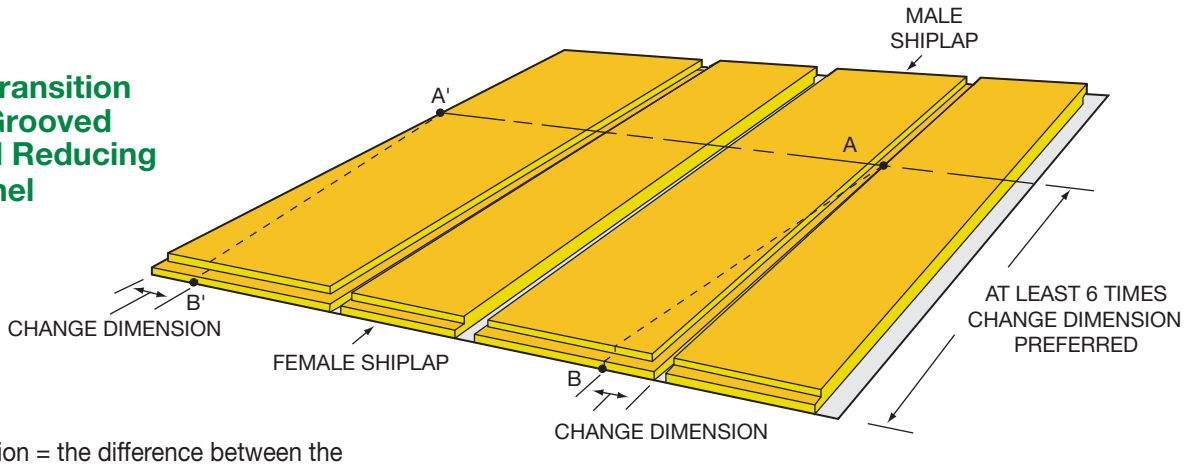


Fig. 3-13A.

Change dimension = the difference between the width of the male and female shiplap ends.

1. Draw diagonal lines A - B and A' - B' establishing the transition angle. (See Fig. 3-13A.)

2. Make a straight knife cut through the insulation and the facing along diagonal lines A - B and A' - B'. (See Fig. 3-13B.) Remove and discard the triangular scrap. Trim the facing to 2" (51mm) (APPROX.) for staple flaps.

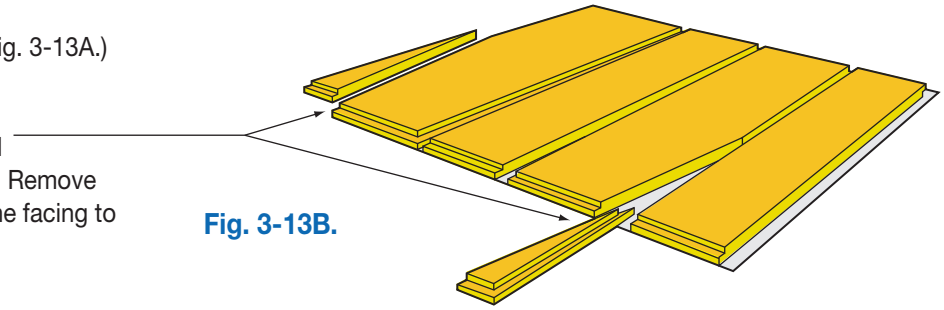


Fig. 3-13B.

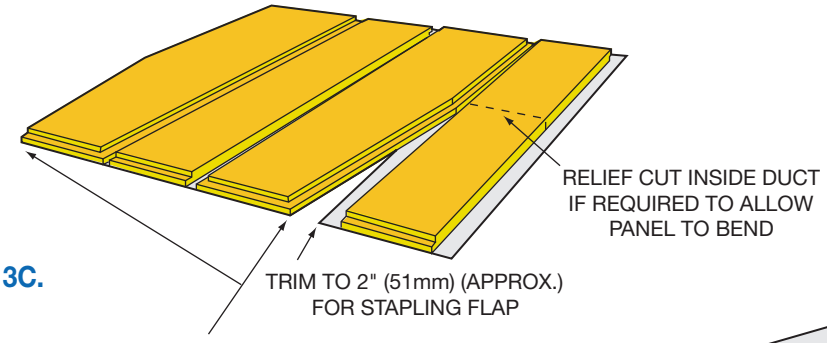


Fig. 3-13C.

3. Shiplap diagonal cuts with the gray (female) shiplap tool along diagonals. (See Fig. 3-13C.)

4. Make a relief cut (See Fig. 3-13C) inside the duct if required for the panel to conform to transition angle.

5. Staple and apply the closure to the longitudinal seams. (See Section IV, Closure.)

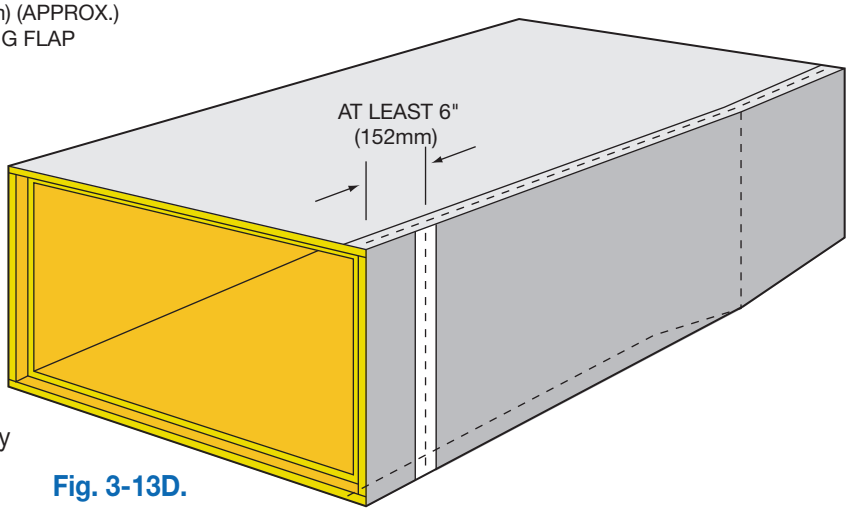


Fig. 3-13D.

NOTE: If the sloping panel is short from the end by more than $^{3}/_{8}$" (10mm), insert the shiplapped panel 6" (152mm) (MIN.) long at the end of the sloping panel. (See Fig. 3-10D.) OR halve the slope angle by using the focal transition. (See page 3-14.)

Focal (Centerline) Transitions

Change dimension = the difference between the width of the male and female ends.

1. Divide the change dimension by 2. Draw diagonal lines A - B, A' - B', C - D, and C' - D' to take half the change dimension from each side of the module. (See Fig. 3-14A.)

2. Use the hand shiplap tool to cut through the insulation and the facing along the dashed lines. (See Fig 3-14B.) Maintain the shiplap orientation of the original module.

3. Discard the triangular scrap. Trim the facing on both sides leaving 2" (51mm) (APPROX.) staple flaps.

4. Make a relief cut (See Fig.3-14B) inside the duct if required for the panels to conform to the transition angles.

5. Staple and apply closure to longitudinal seams. (See Section IV, Closure.)

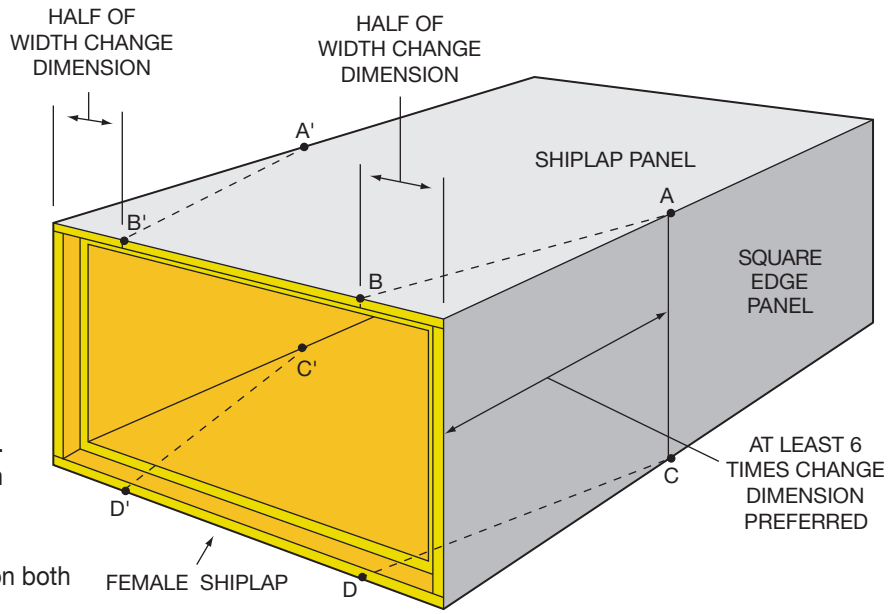


Fig. 3-14A.

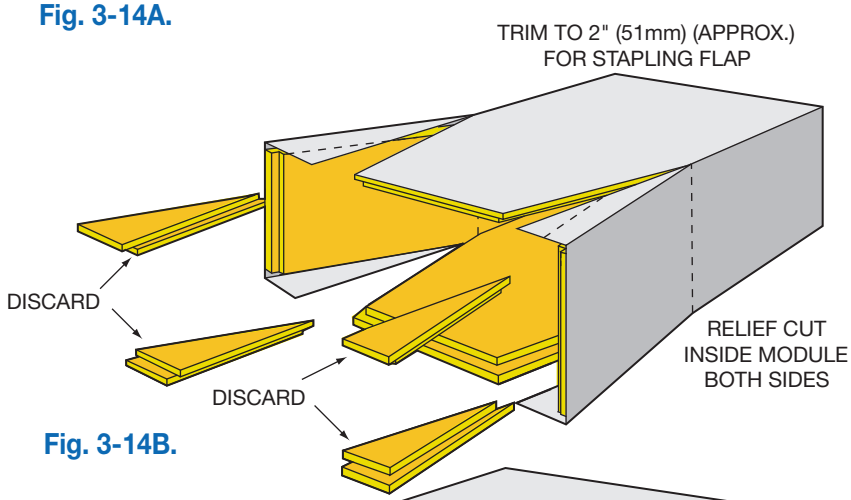


Fig. 3-14B.

NOTE:
If both the height and width must be changed at each corner, refer to page 3-12 and take half the height change from both the top and bottom of both square edge panels.

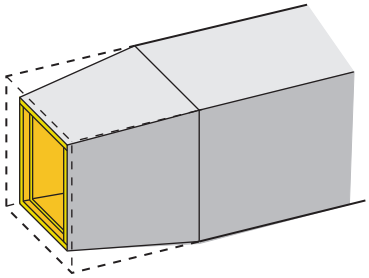


Fig.3-14C.

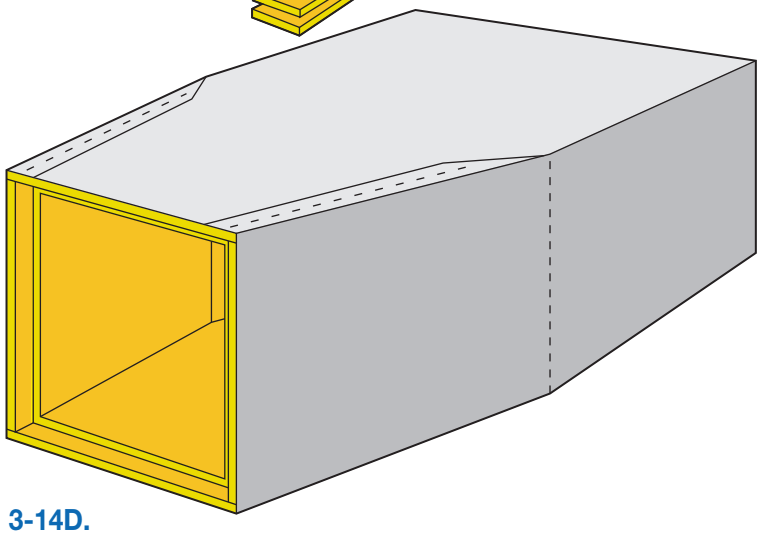


Fig. 3-14D.

Transition – Changing Height and Width From One Piece of Flat Duct Board

Size is determined by taking the larger of both the height and width dimensions.

EXAMPLE:
For transition from 24" x 12" (APPROX. 610mm x 305mm) to 18" x 18" (APPROX. 457mm x 457mm), groove duct board for 24" x 18" (APPROX. 610mm x 457mm).

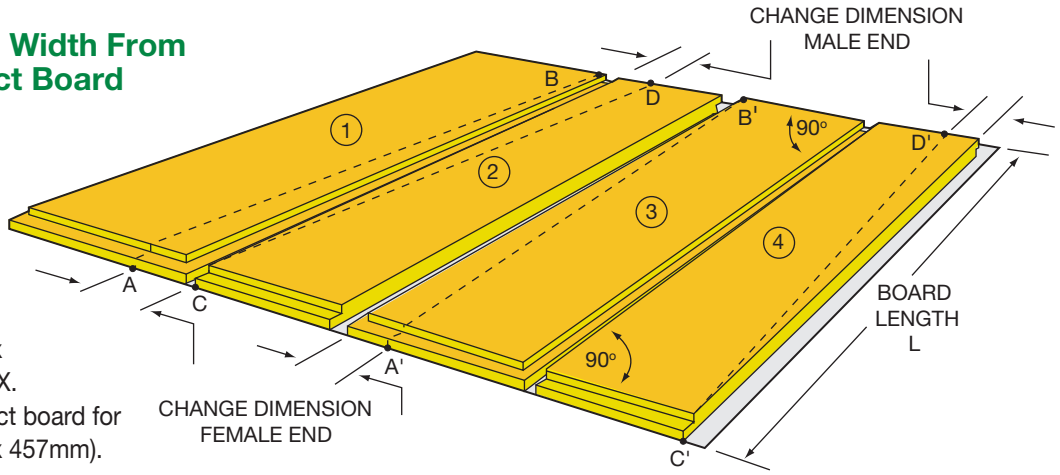


Fig. 3-15A.

1. Layout: Draw lines A - B and A' - B' on shiplap panels (1) and (3). Draw lines C - D and C' - D' on square edge panels (2) and (4). (See Fig. 3-15A.)

2. Make straight knife cuts along lines A - B and A' - B' through board and facing on panels (1) and (3). Replace the female shiplaps. Discard the triangular scrap. (See Fig. 3-15B.)

3. Make a straight knife cut through the insulation only along lines C - D and C' - D'. Remove and discard the triangular scrap. Trim the facing to provide 2" (51mm) staple flaps. (See Fig. 3-15B.)

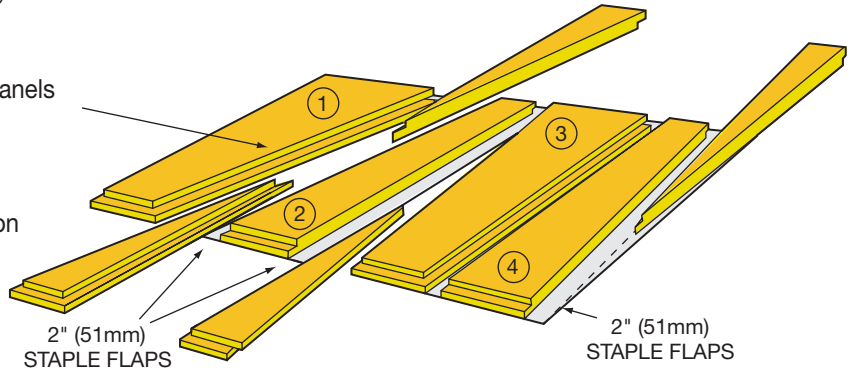


Fig. 3-15B.

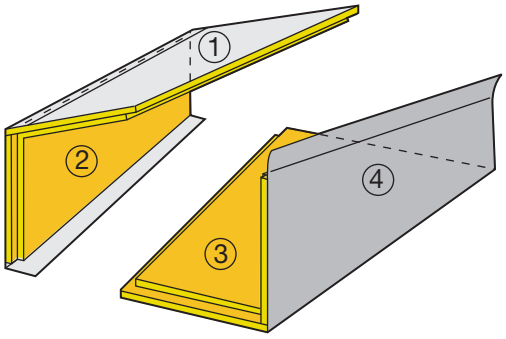


Fig. 3-15C.

4. Staple and tape panel (1) to panel (2). Staple and tape panel (2) to panel (3). (See Fig. 3-15C.) Fold into finished shape and staple panel (4) to panel (1). Apply closure to all staple flaps. (See Section IV, Closure.)

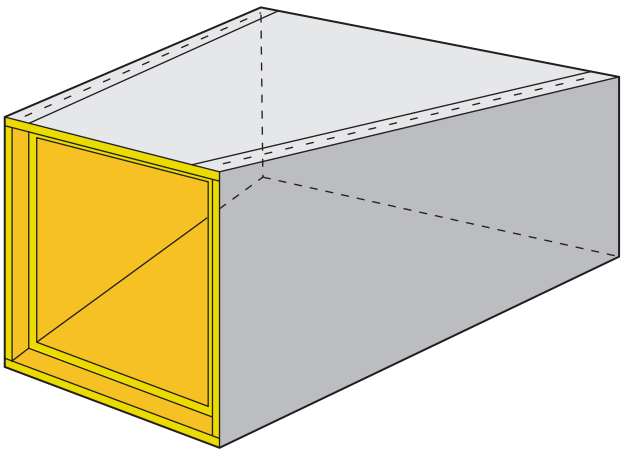


Fig. 3-15D.

Transition – Changing Height and Width From Four Pieces of Duct Board

1. Lay out the four pieces of duct board. (See Fig. 3-16A.)
Panels ① and ③ have square-cut edges with staple flaps on both sides.
Panels ② and ④ have shiplapped edges on both sides and no staple flaps.

EXAMPLE:
Inside measurements for a transition from 24" x 12" (APPROX. 610mm x 305mm) to 18" x 18" (APPROX. 457mm x 457mm) are shown in Fig. 3-16A. (Dimensions for 1" (25mm) fibrous glass duct board.)

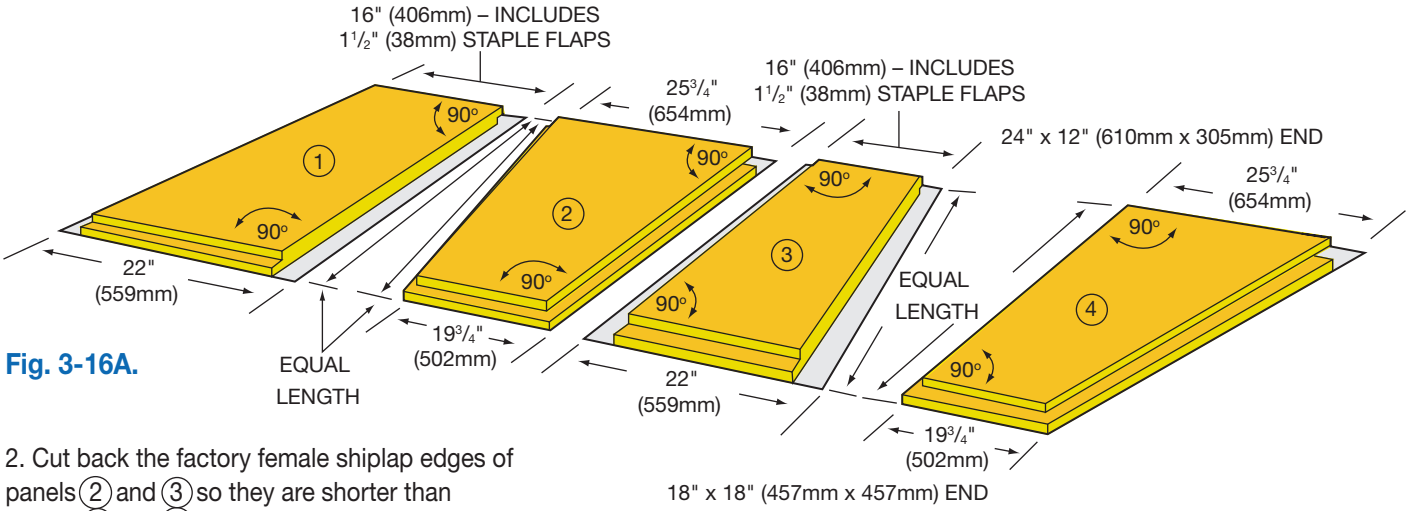


Fig. 3-16A.

2. Cut back the factory female shiplap edges of panels ② and ③ so they are shorter than panels ① and ④ as shown and so the diagonal cuts are the same length as the 90° cuts, to allow for foreshortening when assembled. (See Fig. 3-16A.)

3. Staple panel ① to panel ②.
Staple panel ③ to panel ④. (See Fig. 3-16B.)
Staple assembled panels ① - ② to assembled panels ③ - ④.

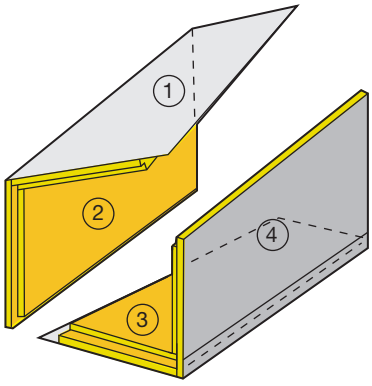


Fig. 3-16B.

4. Tape all the staple flaps. (See Section IV, Closure.)

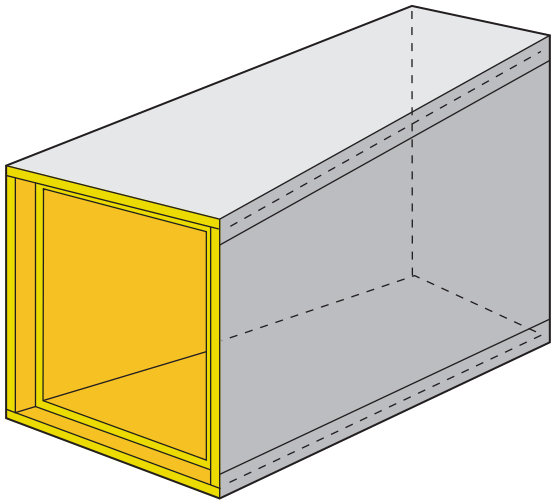


Fig. 3-16C.

Branch Take-off With Adjustable Splitter

NOTE:
A splitter damper creates turbulence in both the trunk and branch. A volume damper in the branch is a better design solution.

1. Cut the branch opening along the dashed lines A - B and A' - B', through the facing only; vertical cut, A - A', through the board and facing. (See Fig. 3-17A.)

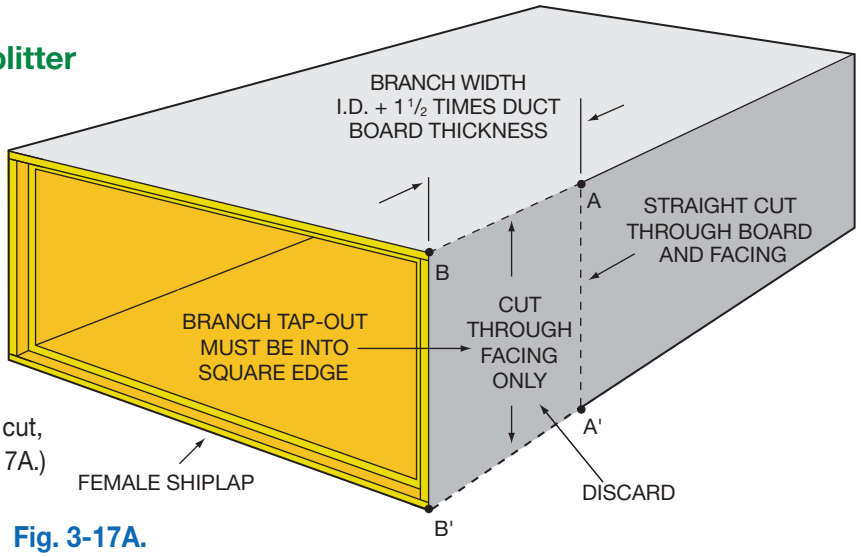


Fig. 3-17A.

2. Install the splitter per the Fastener Schedule (page 3-1) with a minimum of two per side.

3. Install the turning vanes, minimum of two fasteners per rail. Sheet metal turning vanes must be oriented to direct air parallel to the axis of the next duct section.

NOTE: Turning vanes are not a substitute for reinforcement.

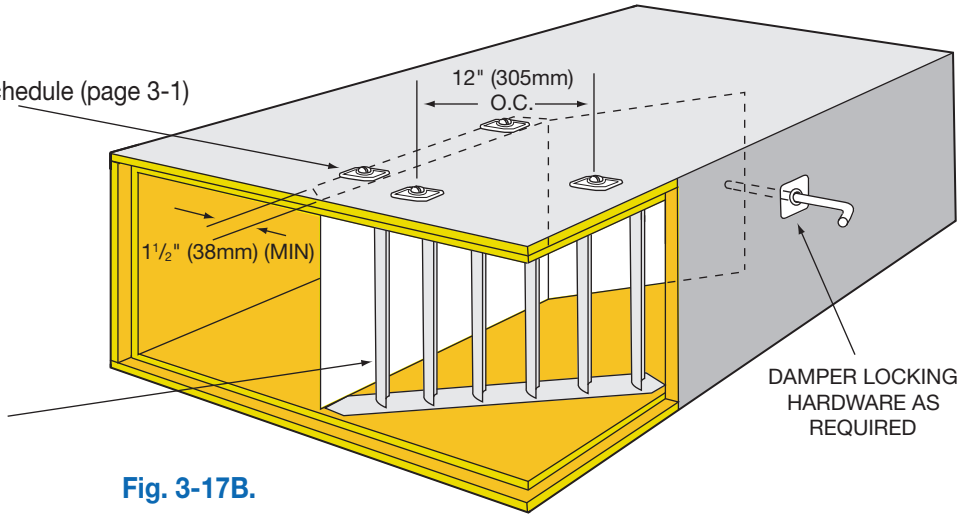


Fig. 3-17B.

4. Fabricate the end cap with the two female shiplaps. Install it in the end of the fitting (See Fig. 3-17C) and apply tape tabs per the Tape Tab Schedule (page 3-1).

5. Apply closure to the top and bottom of the end cap. (See Section IV, Closure.)

NOTE: Fibrous glass turning vanes are an acceptable substitute for metal turning vanes.

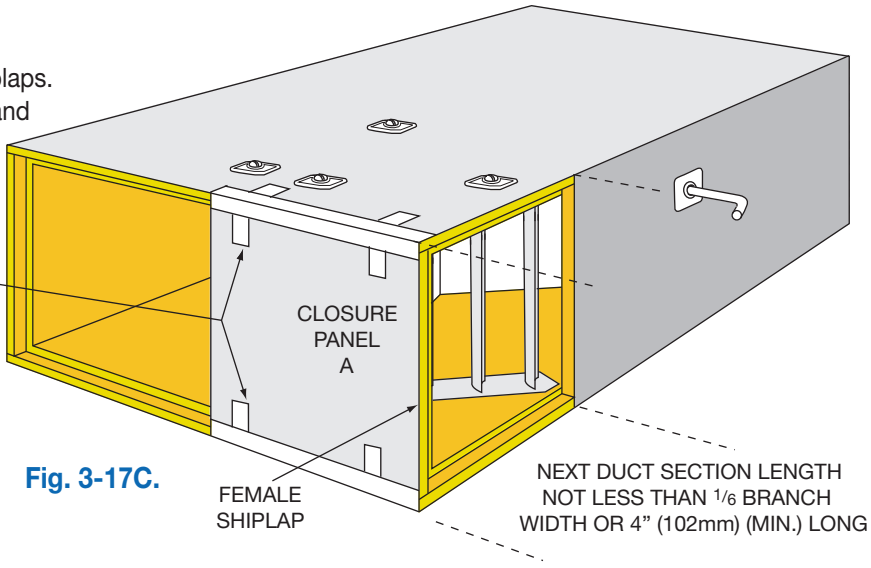


Fig. 3-17C.

Section III: Fabrication of Fittings From Modules or Flat Board

Square and Round Tap-outs

1. FULL HEIGHT TAP: This provides the greatest strength. The tap panel must be square-edged.

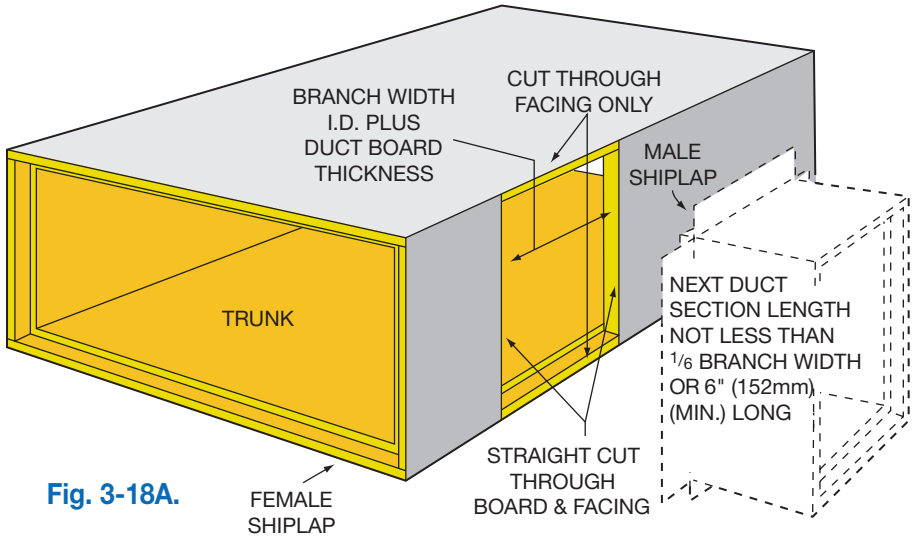


Fig. 3-18A.

2. LESS THAN FULL TAP: A tap of less than the full trunk height often requires that the trunk duct be reinforced. It is preferable to use a full trunk height tap and make the transition in the branch.

Assemble, staple and apply closure. (See Section IV, Closure.)

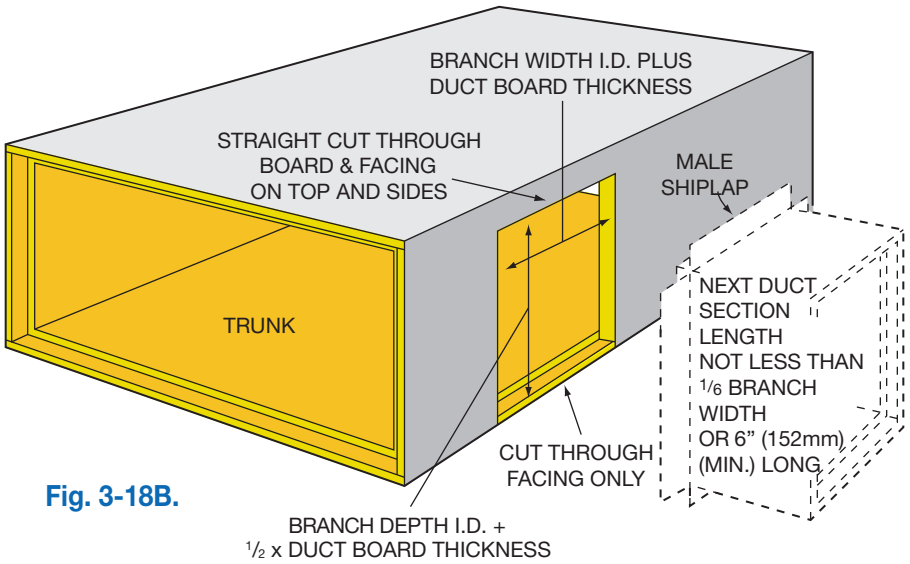


Fig. 3-18B.

3. ROUND TAPS: Cut a hole in the trunk with round hole cutter, not with a knife. Tap may be made in any panel.

NOTE: Either dove-tail or spin-in collars may be used to make round duct connections to the trunk duct. (See pages 4-6 and 4-7, or follow the installation instructions provided by fitting and/or round duct manufacturers.)

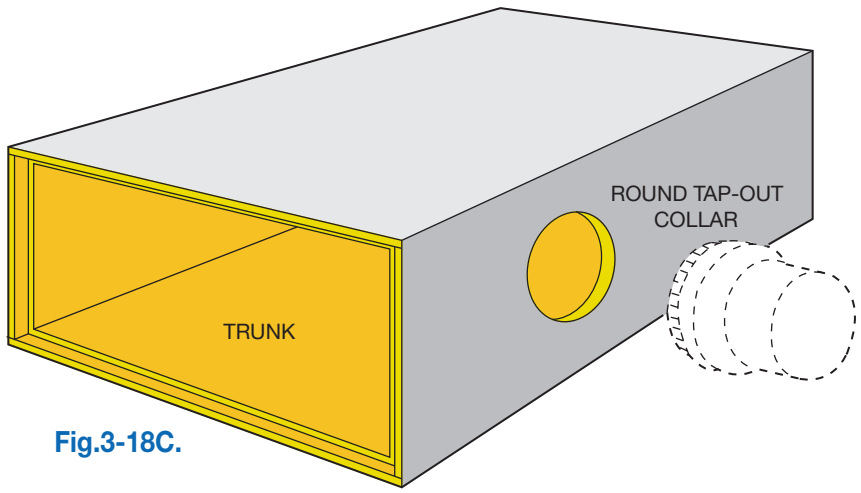


Fig.3-18C.

Wide-Mouth Tap

Dim. A = 6" (152mm) (MIN.) or, for taps over 30" (750mm) wide, 1/4 branch width.

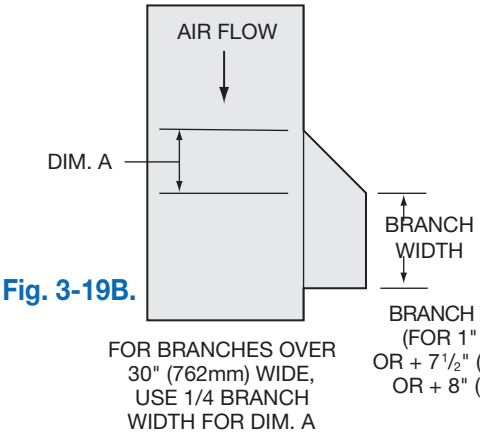


Fig. 3-19B.

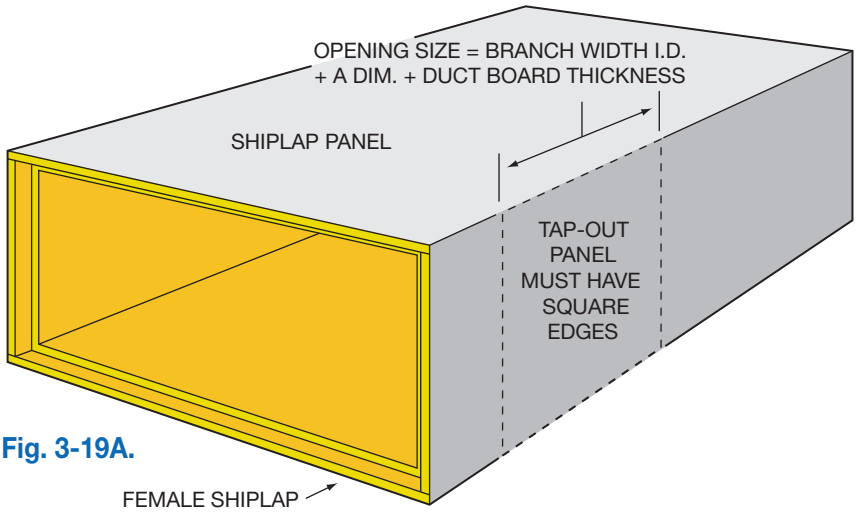
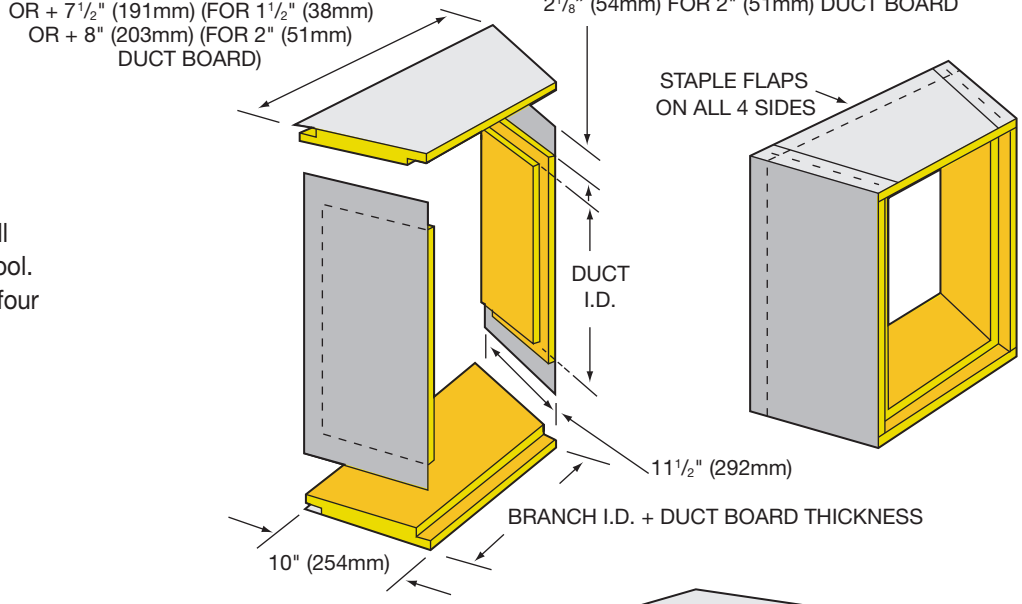


Fig. 3-19A.

1. Groove downstream ends of all four pieces with female shiplap tool. Groove the upstream ends of all four pieces with a male shiplap tool.



2. Assemble, staple, and apply closure. (See Section IV, Closure.)

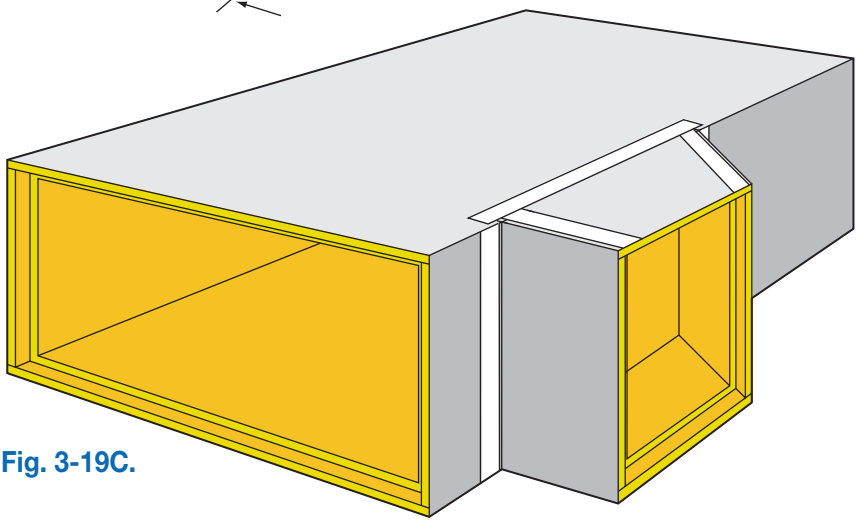


Fig. 3-19C.

Section III: Fabrication of Fittings From Modules or Flat Board

Positive Take-off

1. The method shown produces two wide mouth taps from one 48" (1,219mm) straight duct module. The original male shiplap must be cut off and replaced with a female shiplap.

2. OPTIONAL: Use a hand shiplap tool for the male/female joint on cheek panels (22.5° cuts only).

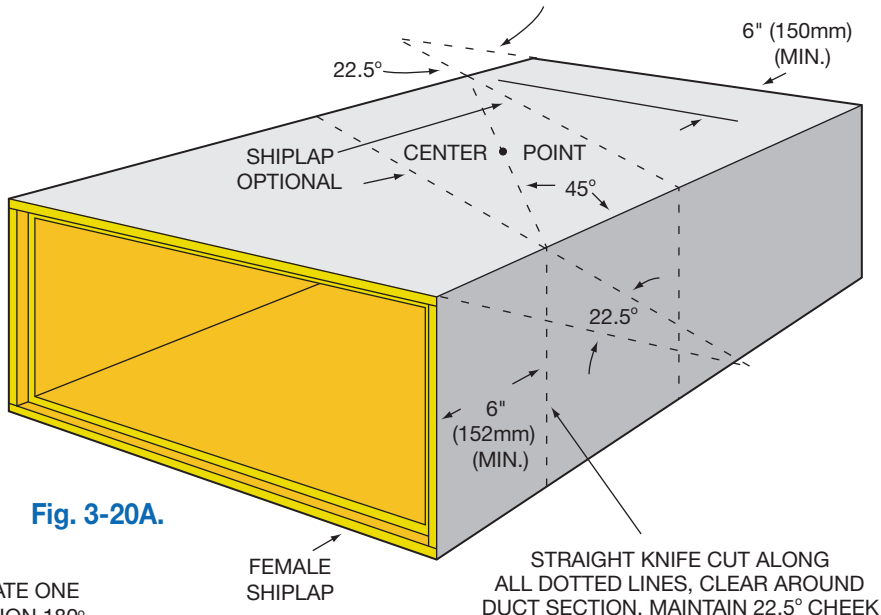


Fig. 3-20A.

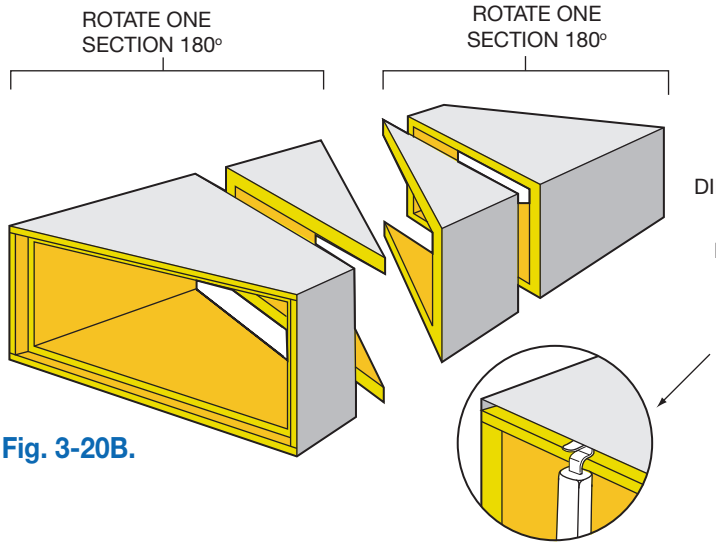


Fig. 3-20B.

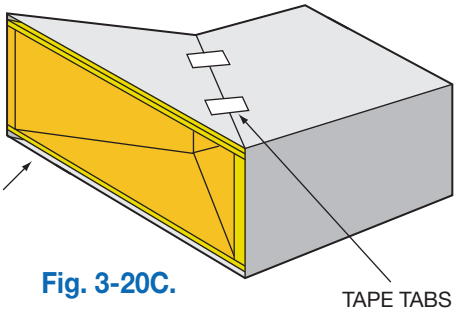


Fig. 3-20C.

3. Apply tape tabs per the Tape Tab Schedule (page 3-1).

4. Assemble, staple and apply closure. (See Section IV, Closure.)

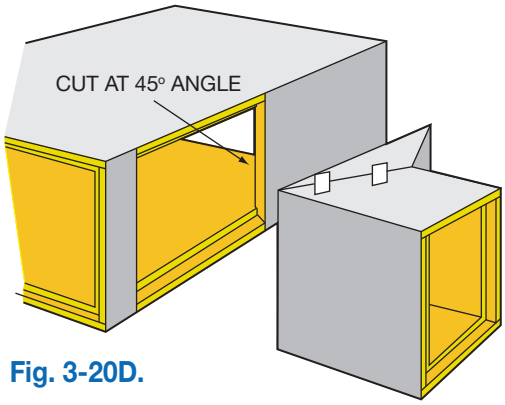


Fig. 3-20D.

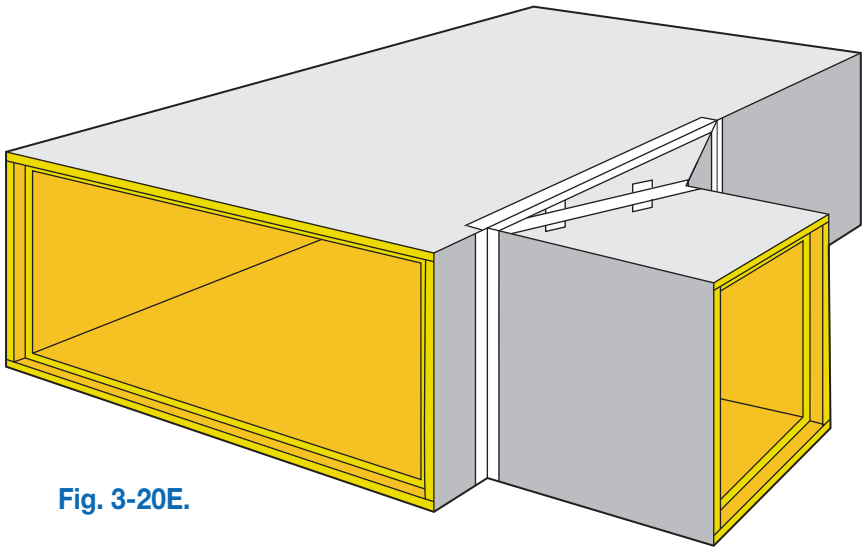
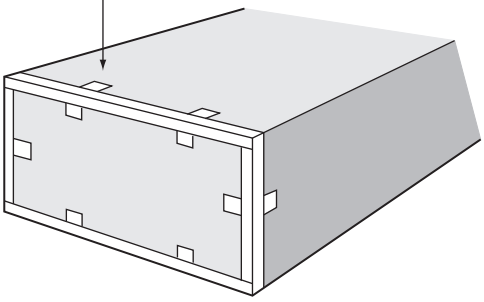


Fig. 3-20E.

End Caps



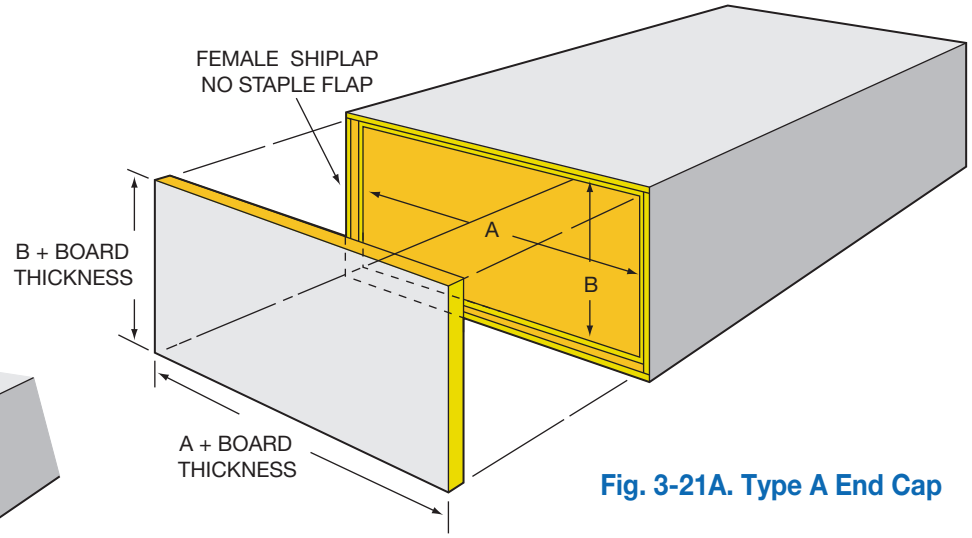
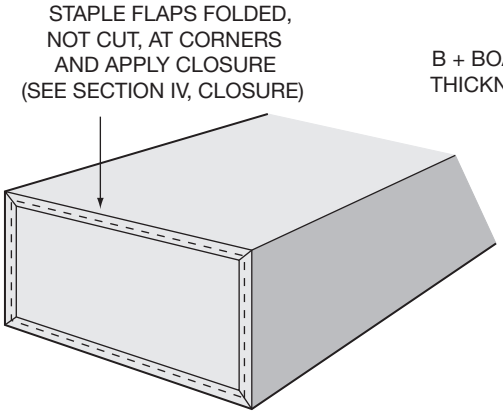


Fig. 3-21A. Type A End Cap



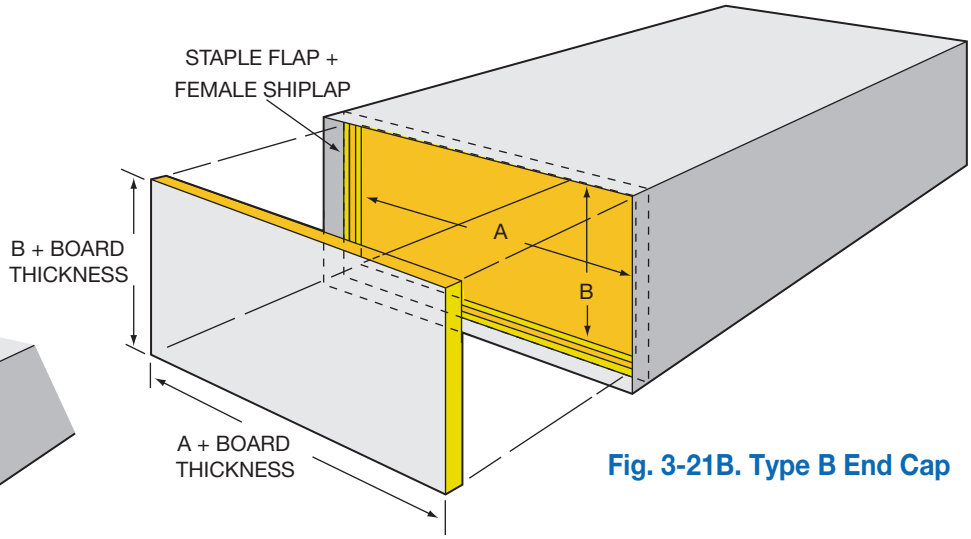
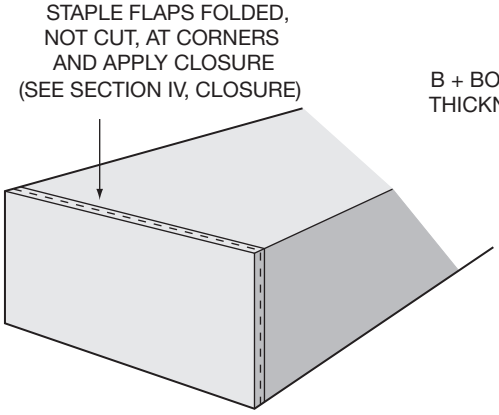


Fig. 3-21B. Type B End Cap



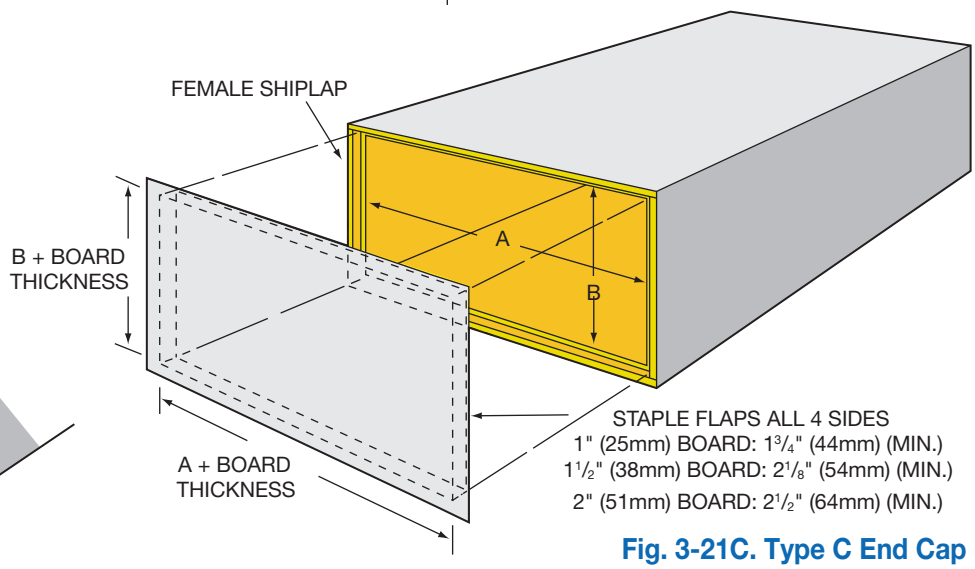


Fig. 3-21C. Type C End Cap

Volume Damper Installation

A traverse joint in the duct section may be shiplapped or butt joint.

1. Install the sheet metal sleeve so the damper shaft is located at the transverse joint. See the table below for the sheet metal gauge.

Table 3-22

DUCT SPAN IN. (mm)	SHEET METAL GAUGE
Less than 12” (305mm)	26
13” to 30” (330 to 762mm)	24
31” to 54” (787 to 1,372mm)	22

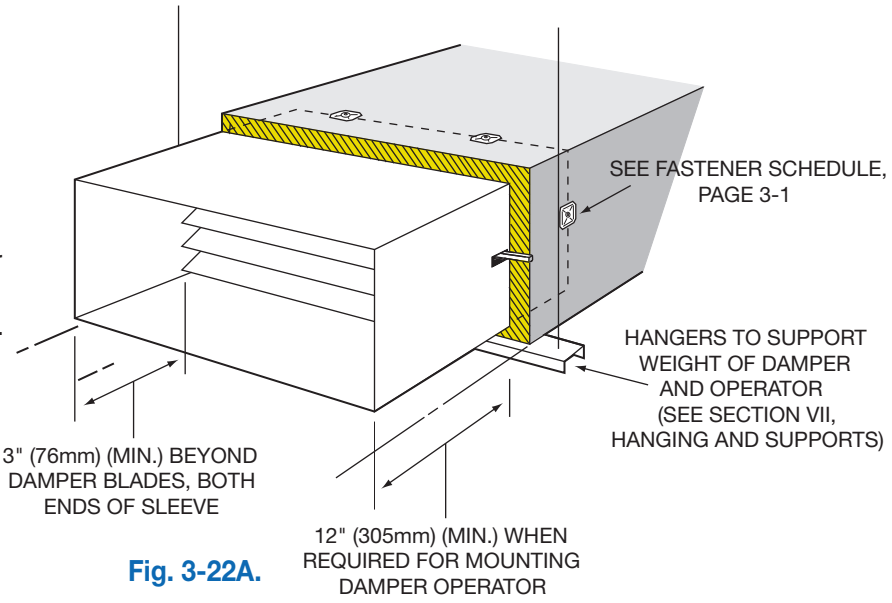


Fig. 3-22A.

2. Attach the operator mounting brackets per the Fastener Schedule, minimum 2" (51mm) each end of bracket, minimum two per side.

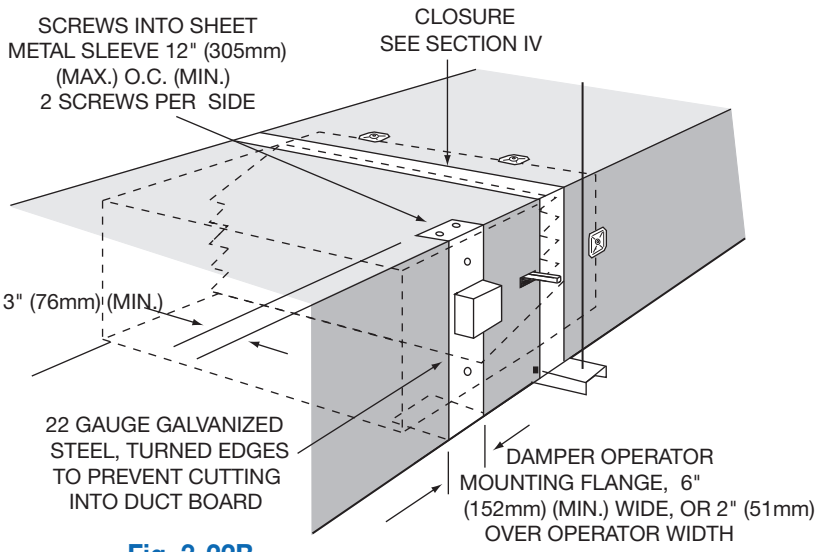


Fig. 3-22B.

SINGLE BLADE VOLUME DAMPER

3. When single blade dampers are installed with suitable mounting hardware in ducts exceeding dimensions shown in Fig. 3-22C, sheet metal sleeves and extra hangers are required.
A hem damper blade is installed as needed for stiffness.

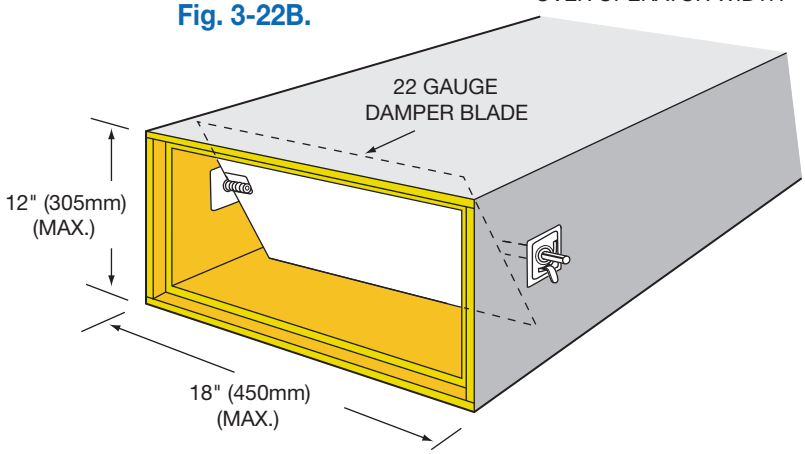


Fig. 3-22C.

Fire Damper Installation

1. Install the sheet metal sleeve through the rated fire wall. Check local codes and damper manufacturer's installation instructions for proper sheet metal gauge and attachment angle.

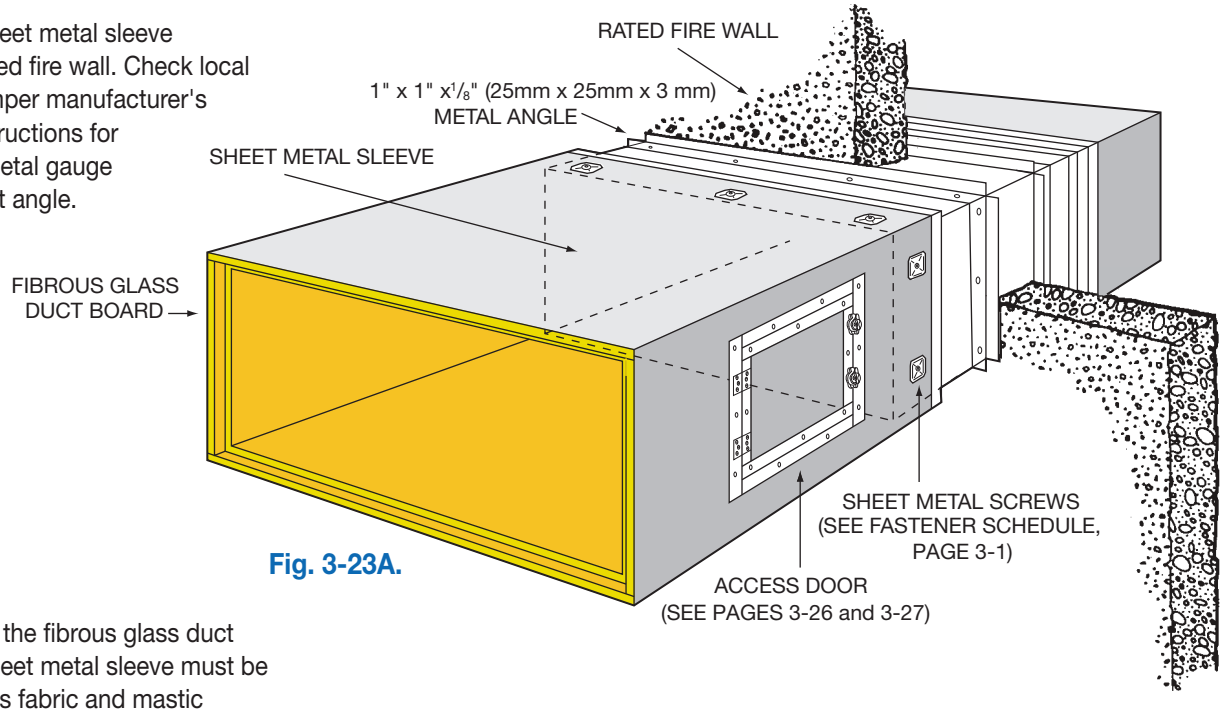


Fig. 3-23A.

NOTE: Sealing the fibrous glass duct board to the sheet metal sleeve must be made with glass fabric and mastic except where operating pressure is less than 1" w.g. (250 Pa) and sheet metal surfaces are carefully cleaned, in which case pressure-sensitive aluminum foil tape may be used. (See Section IV, Closure.)

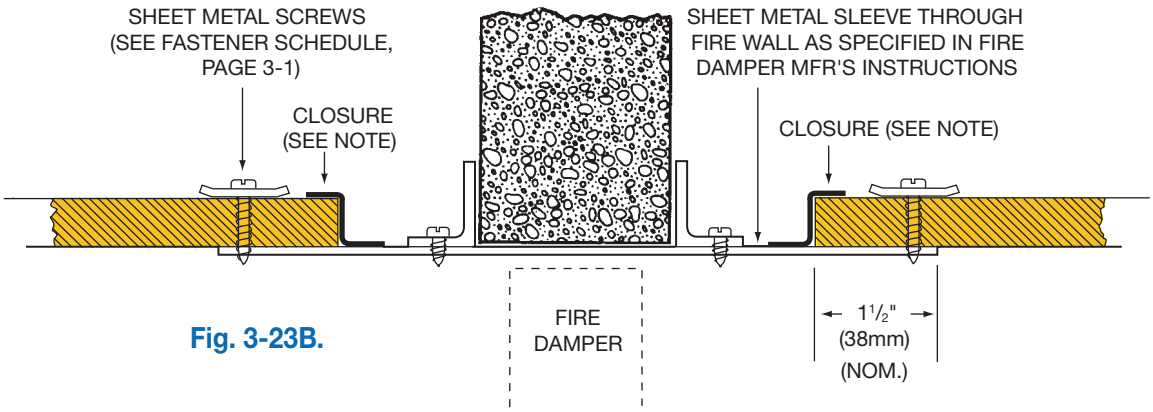


Fig. 3-23B.

Flanged Hot Water Heater Installation

1, Screw the flanged sheet metal sleeve, 6" (152mm) (MIN.) long, 26 gauge, to the heater flange, with suitable fasteners inserted into the ends of the duct.

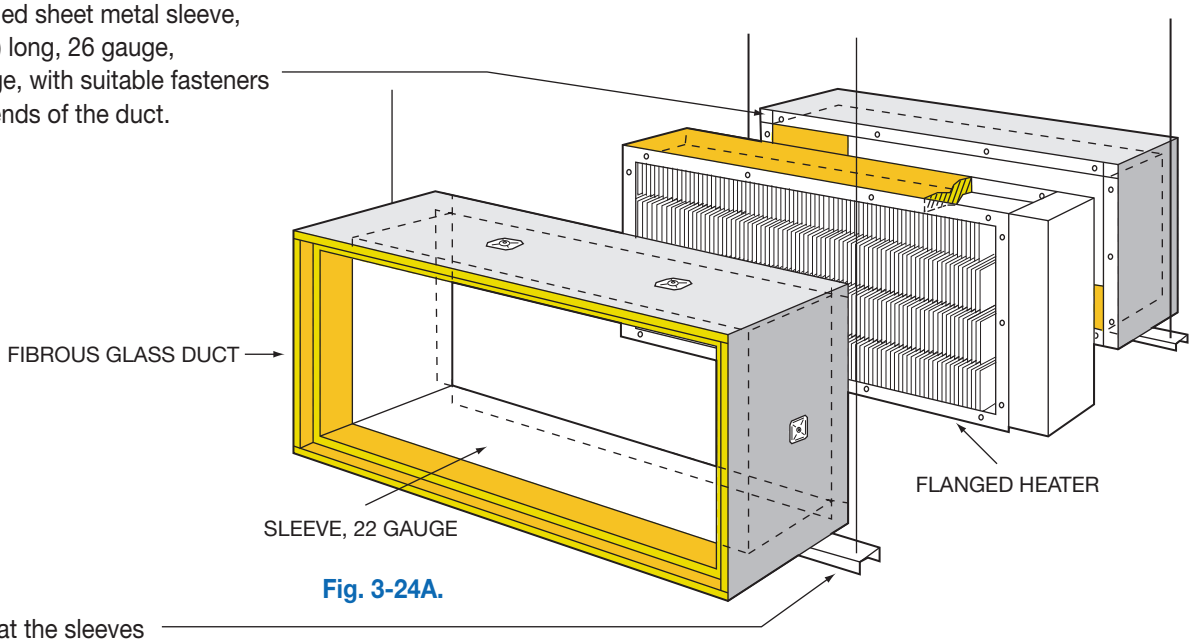


Fig. 3-24A.

2. Install hangers at the sleeves to support the heater weight. Hang the heater separately if the weight exceeds 50 pounds (23 kg.). (See Section VI, Hanging and Supports.)

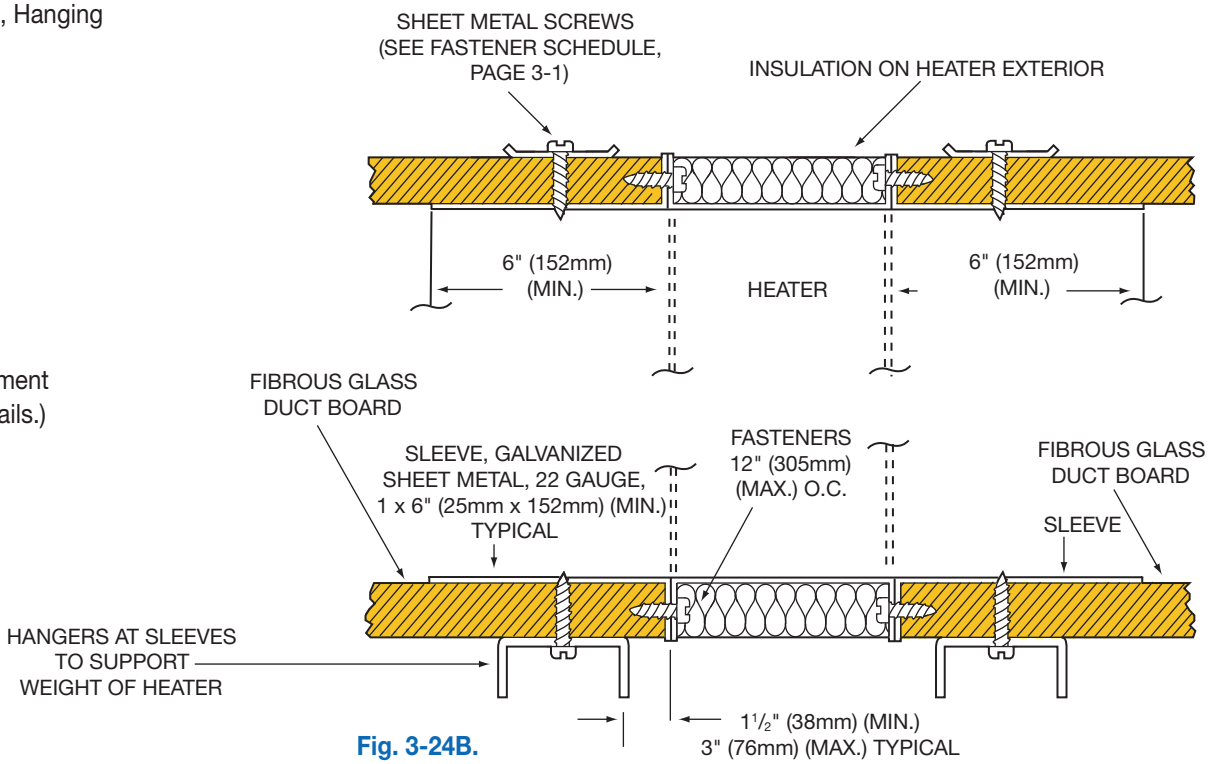


Fig. 3-24B.

(See page 3-30 for other equipment connection details.)

Slip-in Equipment Installation

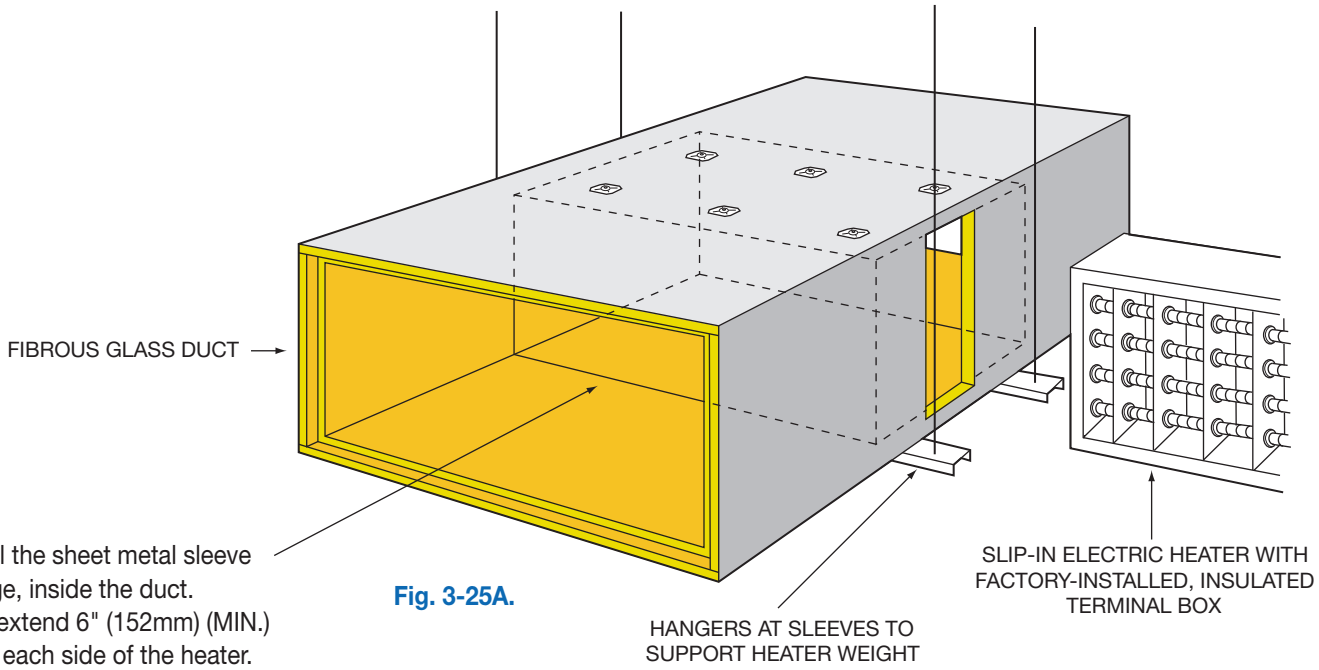


Fig. 3-25A.

1. Install the sheet metal sleeve 26 gauge, inside the duct. It must extend 6" (152mm) (MIN.) beyond each side of the heater.

2. Install hangers at the sleeves to support the heater weight. Hang the heater separately if the weight exceeds 50 pounds (23 kg.). (See Section VI, Hanging and Supports)

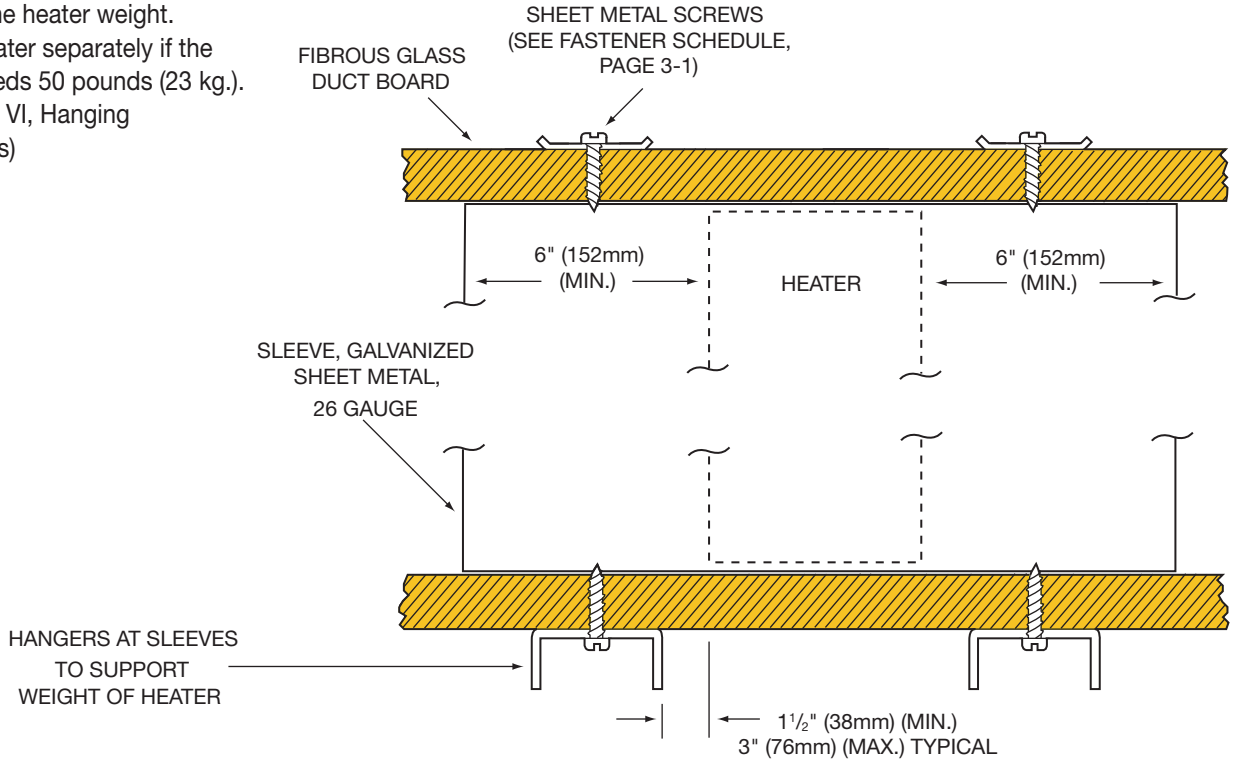


Fig. 3-25B.

Access Door, Flange on Opening in Duct

PRESSURE RANGE INCHES W.G. (Pa)	ACCESS DOOR SIZE INCHES(mm)
0 to 1 (0 to 250 Pa)	24 x 24 max. (610 x 610mm) max.
1 to 2 (250 to 500 Pa)	16 x 16 max. (406 x 406mm) max.

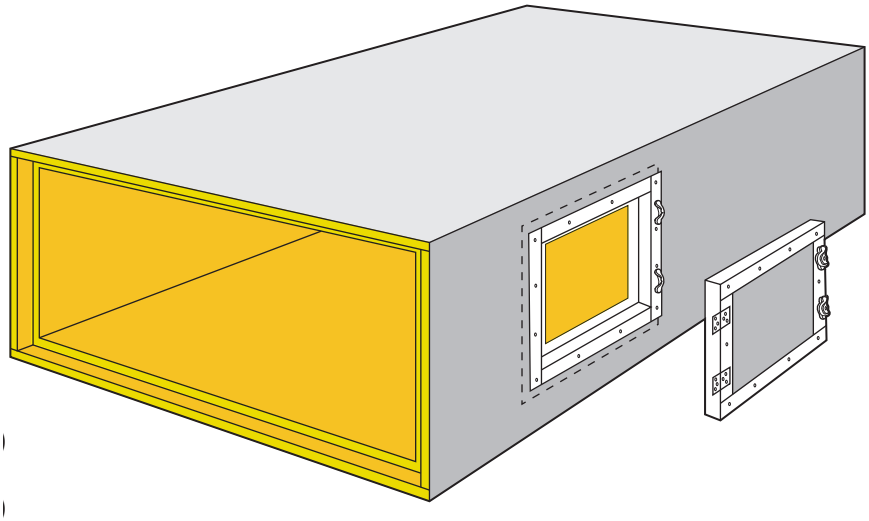


Fig. 3-26A.

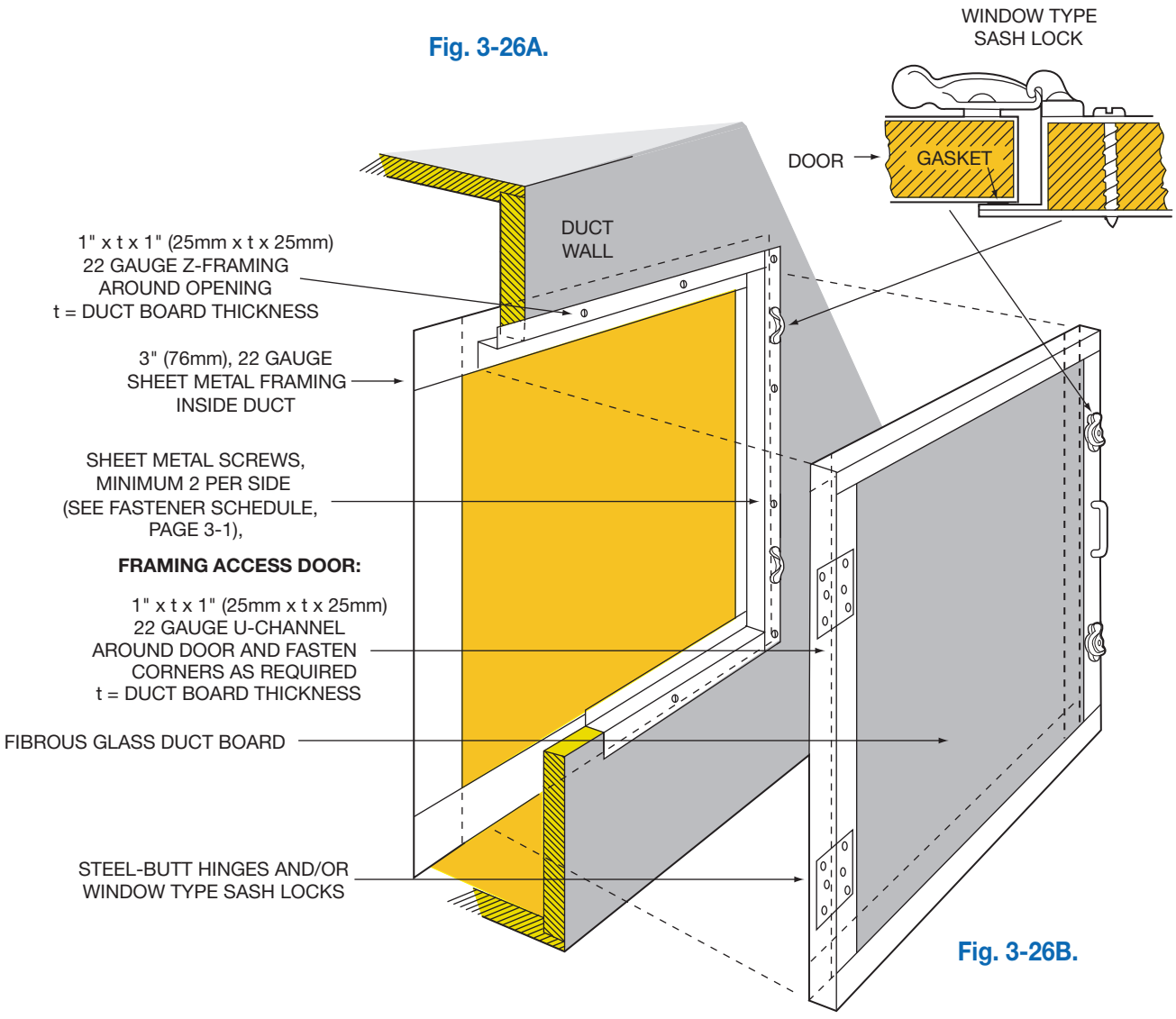


Fig. 3-26B.

Access Door, Flange on Door

PRESSURE RANGE INCHES W.G. (Pa)	ACCESS DOOR SIZE INCHES (mm)
0" to 1" (0 to 250 Pa)	24" x 24" max. (610 x 610mm) max.
1" to 2" (250 to 500 Pa)	16" x 16" max. (406 x 406mm) max.

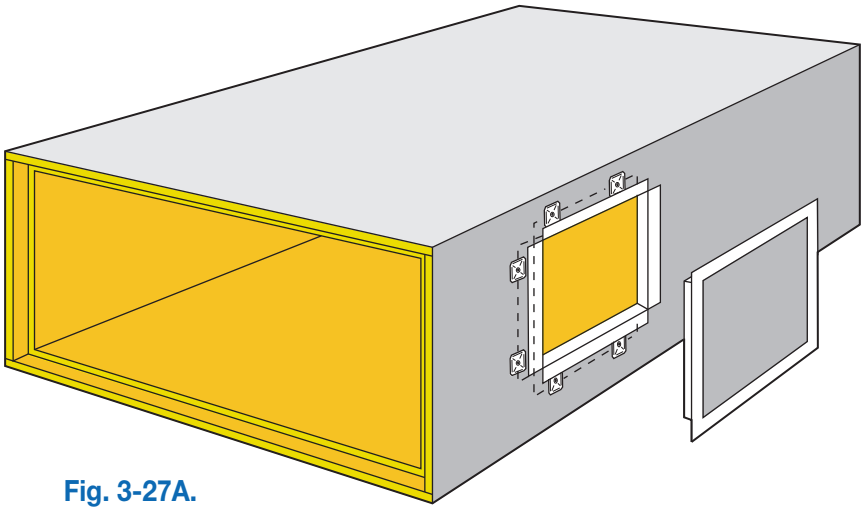


Fig. 3-27A.

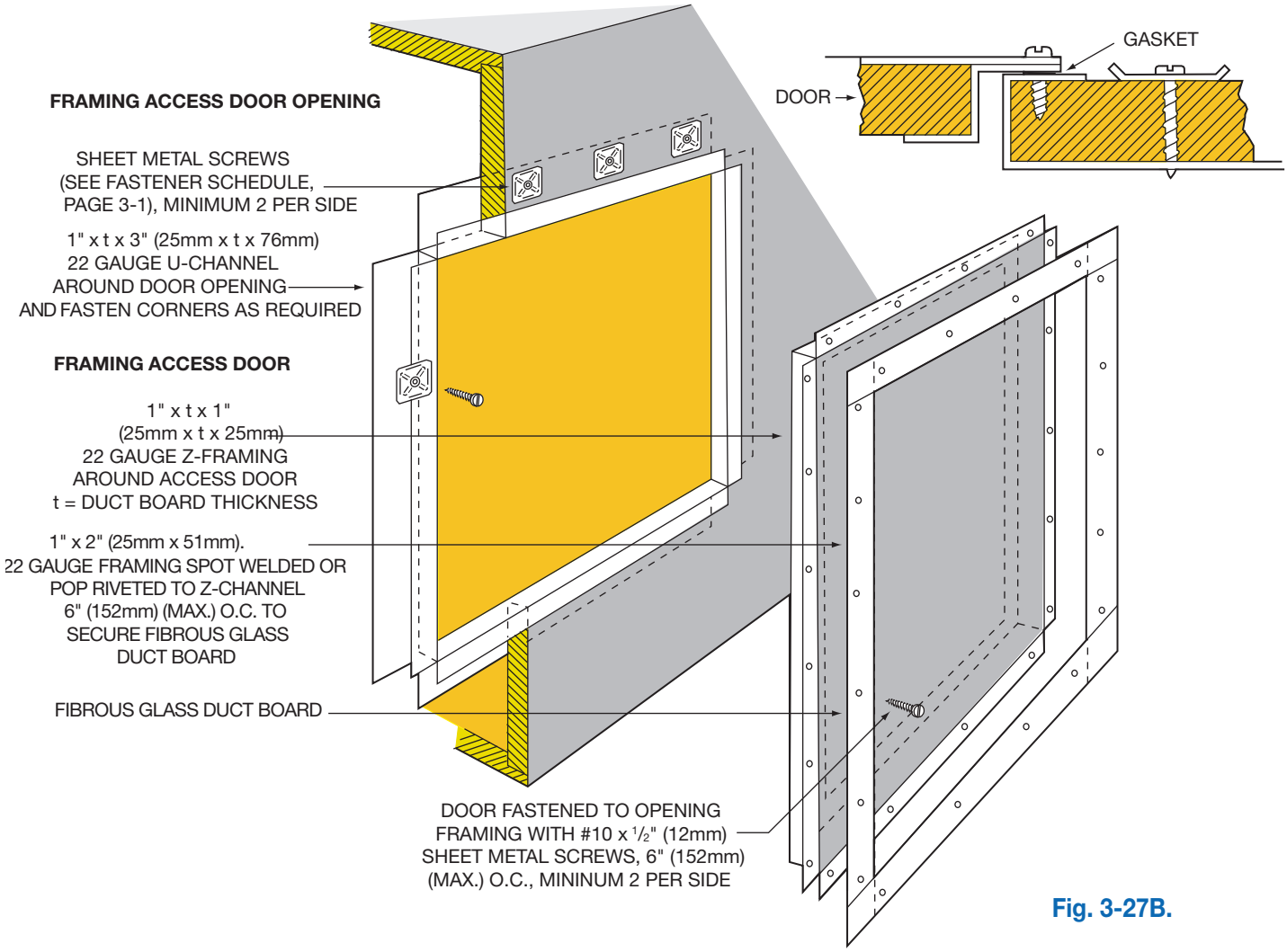


Fig. 3-27B.

Register and Grill Attachment

A sheet metal tap connection requires the use of bearing plate inside the duct. The sleeve and bearing plate sheet metal gauge are shown in the table below.

DUCT SPAN INCHES (mm)	SHEET METAL GAUGE
0 to 12" (0 to 305mm)	26
13 to 30" (330 to 750 mm)	24
31 to 54" (787 to 1372 mm)	22

NOTE: Sealing the fibrous glass duct board to the sheet metal sleeve must be made with glass fabric and mastic except where the operating pressure is less than 1" w.g. (250 Pa) and the sheet metal surfaces are carefully cleaned, in which case pressure-sensitive aluminum foil tape may be used. (See Section IV, Closure.)

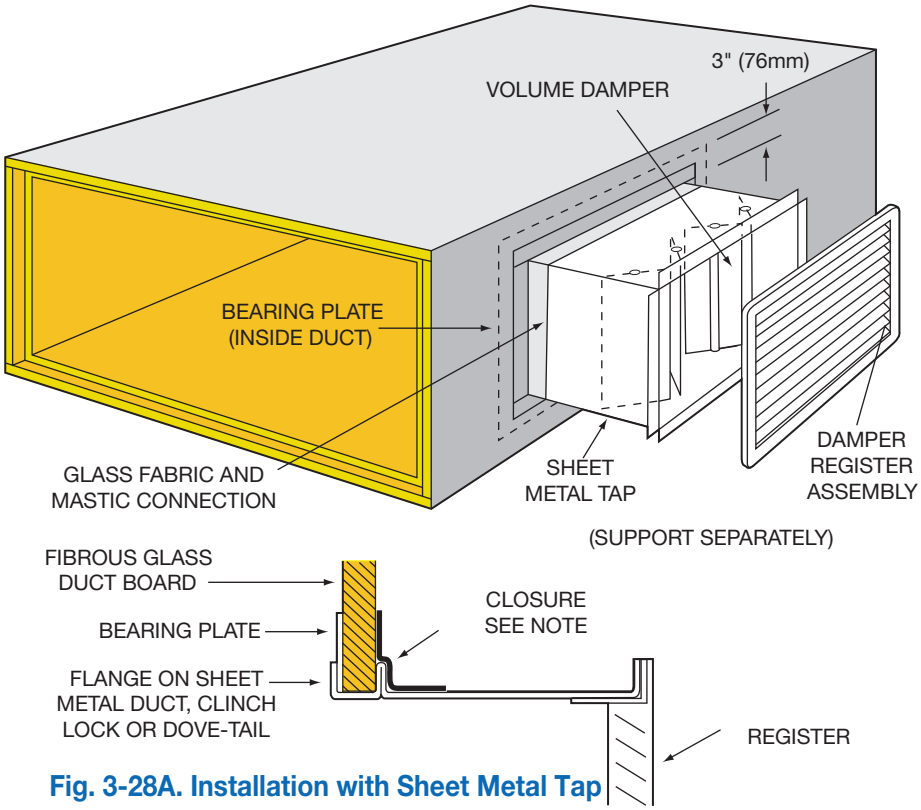


Fig. 3-28A. Installation with Sheet Metal Tap

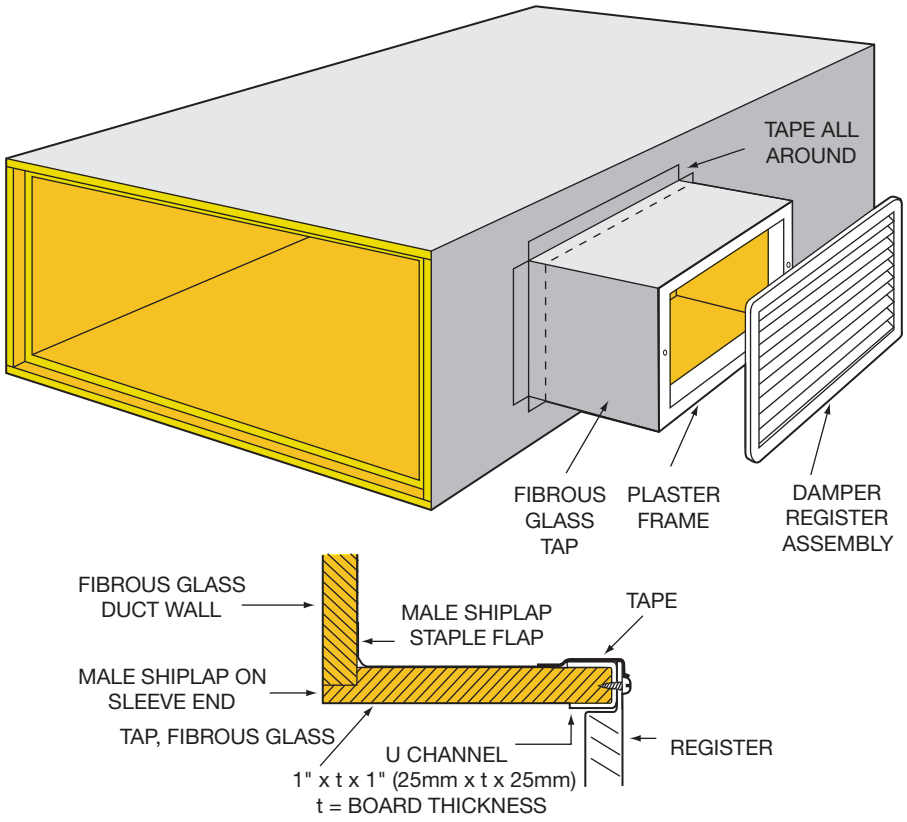
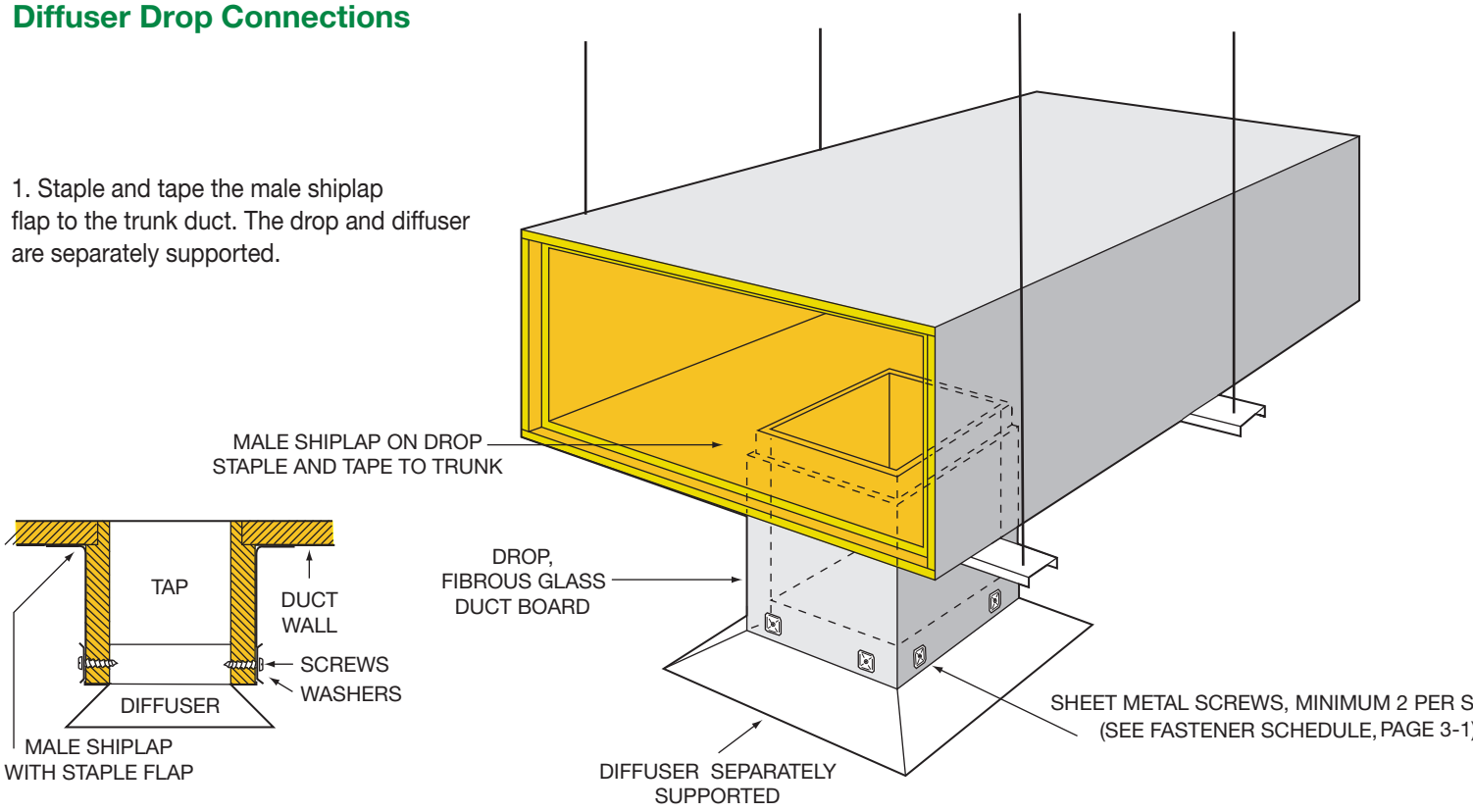


Fig. 3-28B. Installation with Fibrous Glass Tap

Diffuser Drop Connections

1. Staple and tape the male shiplap flap to the trunk duct. The drop and diffuser are separately supported.



2. If hangers must be moved to accommodate the diffuser drop, do not exceed the maximum spacing when reinstalling. (See Section VI, Hanging and Supports.)

Fig. 3-29. Installation with Stapling Flap

Connections to Sheet Metal

Sealing of the fibrous glass duct board to the sheet metal sleeve must be made with glass fabric and mastic except where the operating pressure is less than 1" w.g. (250 Pa) and the sheet metal surfaces are carefully cleaned, in which case pressure-sensitive aluminum foil tape may be used. (See Section IV, Closure.)

All mechanical connections (screws or screws and washers) of the fibrous glass duct to the equipment must be 12" (305mm) (MAX.) on centers.

Washers shall be 0.028" (0.7mm) (MIN.) thick, with turned edges to prevent their cutting into the duct board or the facing.

FASTENER SCHEDULE
#10 plated sheet metal screws, board thickness + 1/4" (6mm) with 2 1/2" (64mm) square or 3" (76mm) round plated steel washers 12" (305mm) (nominal) on centers.

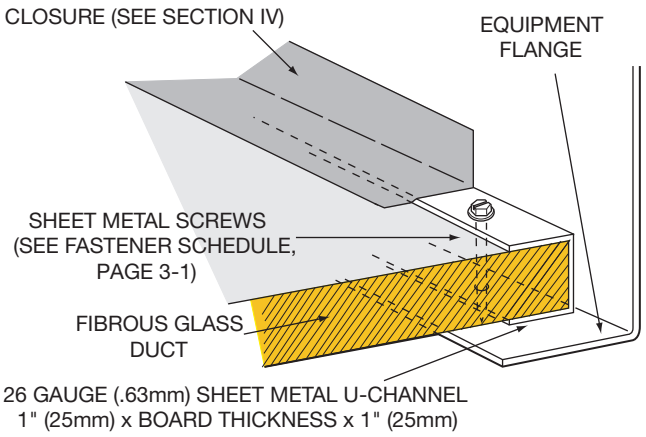


Fig. 3-30A.

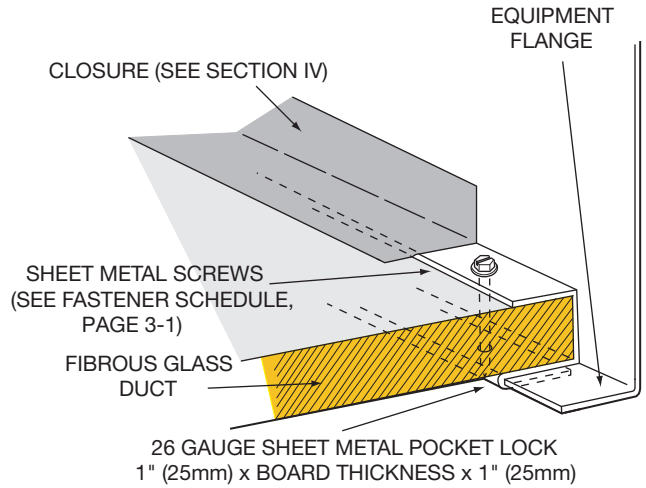


Fig. 3-30B.

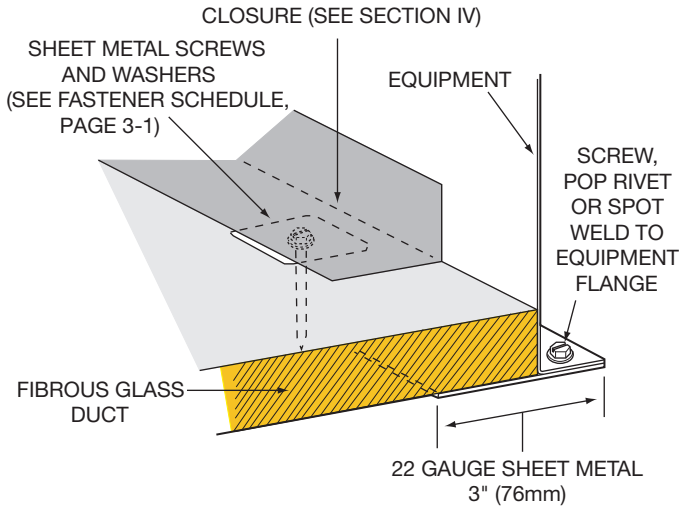


Fig. 3-30C.

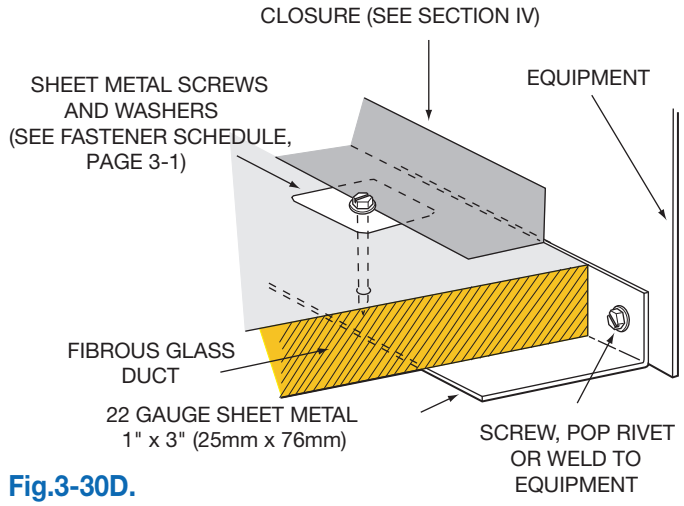


Fig.3-30D.

Fabrication with Ten-Sided Fibrous Glass Duct

A cross section of ten-sided fibrous glass duct appears relatively round and is an acceptable substitute for rigid round duct.

Sections of ten-sided duct up to 10 feet (3.05m) may be fabricated from standard fibrous glass duct board with a grooving machine equipped with the required tooling. A gauge is used to set the spacing between the groove cutting tools.

Circumferential joints may be shiplapped or butt-edged. Male and female ends should be fabricated while the material is in flat board form.

Internal metal sleeves must be used on all return air ducts and on supply ducts without shiplap joints.

Typical fittings, such as elbows, branch connections, tees, and offsets can be fabricated with ten-sided fibrous glass duct. (Examples are shown in Fig. 3-31.)

Closure of Ten-Sided Fibrous Glass Duct

Longitudinal joints are formed in the same manner as in rectangular ducts.

After stapling, use closure materials listed in Section IV, Closure.

When two half sections are to be joined, it is easiest to make the first joint while the duct board is in flat form. Sections must be tightly butted together before stapling.

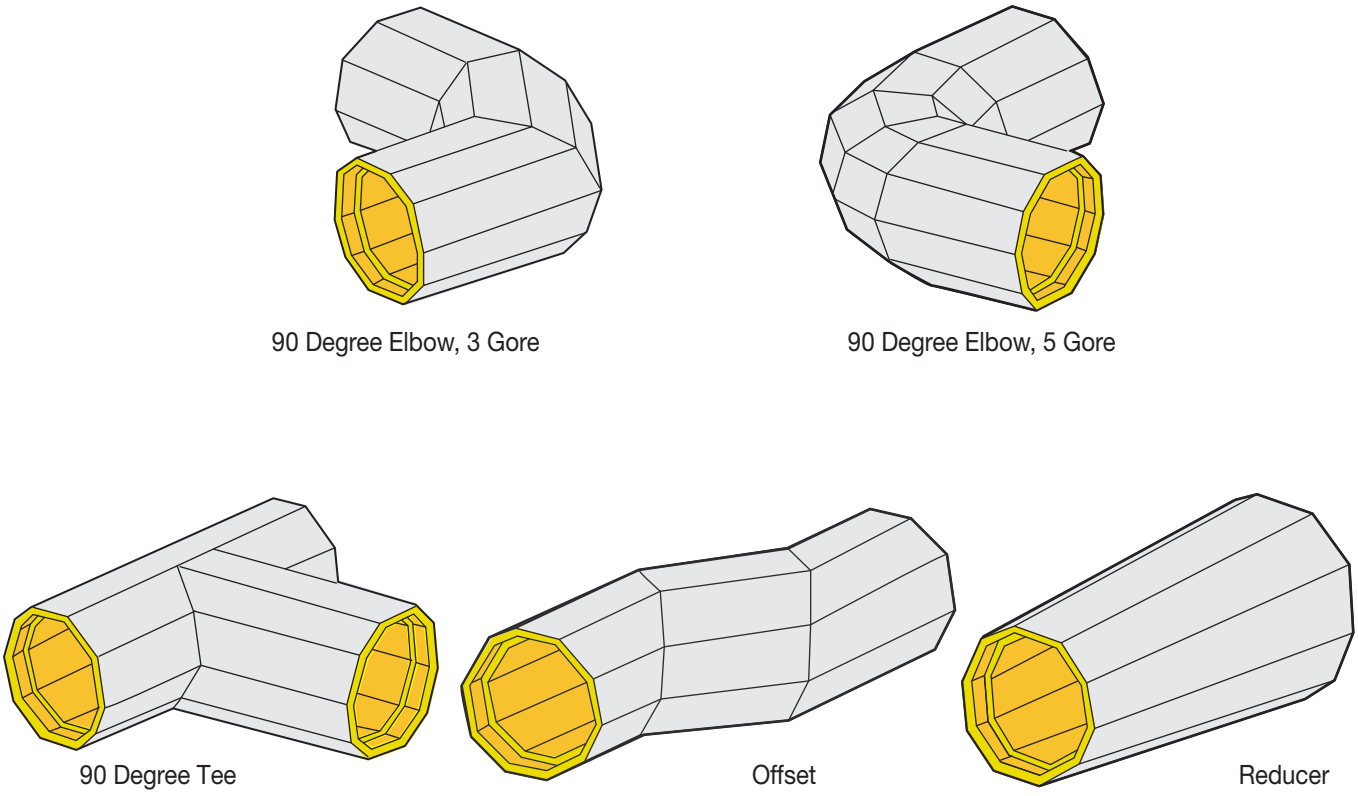


Fig. 3-31. Typical Ten-Sided Fibrous Glass Duct Fittings.

Board Utilization, Ten-Sided Duct

The table below shows options available in converting standard duct board sizes into ten-sided duct. The table is based on ideal tool settings. Because of the variation in blade settings, tool bar height, and size of sheet metal fittings that might be used with ten-sided duct, the fabricator should always check the material made on the specific machine for dimensional accuracy before producing large quantities of duct. The fabricator should also select the best combination of duct board length versus drop-off that fits the specific ten-sided duct application.

Example:

20 feet (6.1m) lengths of 5" (127mm) (nominal) inside diameter ten-sided duct can be made in two ways:

(1) With two sections 10 feet (3.05m) long;

(2) With five sections 4 feet (1.2m) long.

Both involve minimum drop-off. Use of 20 feet (6.1m) of ten-sided duct in 10 feet (3.05m) lengths has the advantage of requiring only one circumferential joint compared to four required for 4-section construction. In making 4 feet (1.2m) long, 7" (178mm) (nominal) inside diameter ten-sided duct, 10 feet (3.05m) duct board will yield four sections with essentially no drop-off.

8 feet (2.4m) duct board yields three sections with 2.3 square feet (.21m²) of scrap. Be certain to check your specific tool arrangement to verify these values.

Ten-Sided Duct Board Utilization – 1" (25mm) Duct Board

10 ft. (3.05m) Ducts From 4 ft. (1.2m) Duct Board

Nominal Inside Diam. in.	(mm)	No. of Sections	Material Left in.	(mm)	Drop-off ft²	(m²)
5	(127)	2	1	(25)	0.8	(0.24)
6	(152)	1½	7½	(191)	6.3	(1.92)
7	(178)	1½	2⅛	(73)	2.4	(0.73)
8	(203)	1	15⅛*	(384)	12.6	(3.84)
9	(229)	1	12	(305)	10.0	(3.05)
10	(254)	1	8⅛	(225)	7.4	(2.25)
11	(279)	1	5¾	(146)	4.8	(1.46)
12	(305)	1	2⅝	(67)	2.2	(0.67)
13	(330)	½	23¼*	(591)	19.4	(5.91)
14	(356)	½	21⅝*	(549)	18.0	(5.49)
15	(381)	½	20⅛*	(511)	16.8	(5.12)
16	(406)	½	18½*	(470)	15.4	(4.69)
17	(432)	½	17*	(432)	14.2	(4.33)
18	(457)	½	15⅜*	(391)	12.8	(3.90)
19	(483)	½	13⅞*	(352)	11.6	(3.54)
20	(508)	½	12¼*	(311)	10.2	(3.11)

4 ft. (1.2m) Ducts From 10 ft. (3.05m) Duct Board

Nominal Inside Diam. in.	(mm)	No. of Sections	Material Left in.	(mm)	Drop-off ft²	(m²)
5	(127)	5	2½	(63)	0.8	(0.24)
6	(152)	4	13½*	(243)	4.5	(1.37)
7	(178)	4	1	(25)	0.3	(0.09)
8	(203)	3½	4⅜	(111)	1.5	(0.46)
9	(229)	3	12	(305)	4.0	(1.22)
10	(254)	3	2⅝	(67)	0.9	(0.27)
11	(279)	2½	13⅞	(352)	4.6	(1.40)
12	(305)	2½	6	(152)	2.0	(0.61)
13	(330)	2	23*	(584)	7.7	(2.35)
14	(356)	2	16¾*	(425)	5.6	(1.71)
15	(381)	2	10½	(267)	3.5	(1.07)
16	(406)	2	4¼	(108)	1.4	(0.43)
17	(432)	1½	28*	(711)	23.3	(7.10)
18	(457)	1½	23¼*	(591)	19.4	(5.91)
19	(483)	1½	18⅝*	(473)	15.5	(4.72)
20	(508)	1½	13⅞*	(352)	11.6	(3.54)

4 ft. (1.2m) Ducts From 8 ft. (2.44m) Duct Board

Nominal Inside Diam. in.	(mm)	No. of Sections	Material Left in.	(mm)	Drop-off ft²	(m²)
5	(127)	4	2	(51)	0.7	(0.21)
6	(152)	3½	2¼	(57)	0.8	(1.24)
7	(178)	3	6¾	(171)	2.3	(0.70)
8	(203)	2½	13¼*	(337)	4.4	(1.34)
9	(229)	2½	5½	(140)	1.8	(0.55)
10	(254)	2	17¾*	(451)	5.9	(1.80)
11	(279)	2	11½	(292)	3.8	(1.16)
12	(305)	2	5¼	(133)	1.8	(0.55)
13	(330)	1½	22¾*	(578)	7.6	(2.32)
14	(356)	1½	18*	(457)	6.0	(1.83)
15	(381)	1½	13⅜*	(340)	4.5	(1.37)
16	(406)	1½	8⅝	(219)	2.9	(0.88)
17	(432)	1½	4	(102)	2.7	(0.82)
18	(457)	1	31⅛*	(810)	21.3	(6.49)
19	(483)	1	28¾*	(730)	19.2	(5.85)
20	(508)	1	25⅝*	(651)	17.1	(5.21)

Stretch-Out Ten-Sided Duct

Nominal Inside Diameter		1" (25mm) Duct Board				1½" (38mm) Duct Board			
		Full Section 10 Sides		Half Section 5 Sides		Full Section 10 Sides		Half Section 5 Sides	
in.	(mm)	in.	(mm)	in.	(mm)	in.	(mm)	in.	(mm)
5	(127)	23¾	(603)	12⅜	(314)	27¾	(705)	14⅜	(365)
6	(152)	26⅞	(683)	13 15/16	(354)	30⅞	(784)	15 15/16	(405)
7	(178)	30	(762)	15½	(394)	34	(864)	17½	(445)
8	(203)	33⅛	(841)	17 1/16	(433)	37⅛	(943)	19	(483)
9	(229)	36¼	(921)	18⅝	(473)	40¼	(1022)	20⅝	(524)
10	(254)	39 7/16	(1002)	20¼	(514)	43 7/16	(1103)	22¼	(565)
12	(305)	45¾	(1162)	23⅜	(594)	46 11/16	(1186)	25⅜	(645)
14	(356)	52	(1321)	26½	(673)	56	(1422)	28½	(724)
16	(406)	58¼	(1480)	29⅝	(752)	62¼	(1581)	31⅝	(803)
18	(457)	64 9/16	(1640)	32¾	(832)	68 9/16	(1741)	34¾	(883)
20	(508)	70 13/16	(1799)	35 15/16	(913)	74 13/16	(1900)	37 15/16	(964)
22	(559)	77⅛	(1959)	39 1/16	(992)	81⅛	(2061)	41 1/16	(1043)
24	(610)	83⅜	(2118)	42¼	(1073)	87⅜	(2219)	44¼	(1124)
26	(660)	89 1/16	(2278)	45⅜	(1153)	93 1/16	(2380)	47⅜	(1203)
28	(711)	96	(2438)	48½	(1232)	100	(2540)	50½	(1283)
30	(762)	102¼	(2597)	51⅝	(1311)	106¼	(2699)	53⅝	(1362)

NOTE:
A full section denotes 10 sides plus a stapling flap. A half section denotes five sides plus a stapling flap.
Joining two half sections requires two longitudinal joints.

Section IV Closure

Section IV: Closure

Introduction

Closure 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 Standard 181A are suitable for use with rigid fibrous glass duct systems. Listed closures include:

- Pressure-sensitive aluminum foil tapes listed under UL Standard 181A, Part I (P); or
- Heat activated aluminum foil/scrim tapes listed under UL Standard 181A, Part II (H); or
- Mastic and glass fabric tape closure systems listed under UL Standard 181A, Part III (M).

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

Closure systems may also be qualified under UL Standard 181 by individual duct board manufacturers.

1. JOINT AND SEAM PREPARATION

Longitudinal seams are prepared as described on page 2-20. Transverse joints between two duct sections are prepared as described on page 2-21 and as shown in Fig. 4-2A.

2. STAPLES

Staples shall be:

- Galvanized steel;
- Outward clinching;
- ½" (13mm) (minimum) length;
- Crown width 0.400" (10mm) (minimum);
- Flat wire, 0.040" x 0.020" (1.02mm x 0.51mm) (minimum).

3. TAPE TABS

When staple flaps are not present, tape tabs of either pressure-sensitive or heat-activated tapes are used at seams and joints. Tape tabs, made from 8" (203mm) (minimum) lengths of closure tape are equally spaced on either side of the joint on 12" (305mm) (maximum) centers with at least one tape tab per side. (See Fig. 4-2B.) Tape tabs may be placed either over or under the tape closure or under mastic and glass fabric closures.

Fig. 4-2A. Joint Closure With Shiplap and Staple Flap

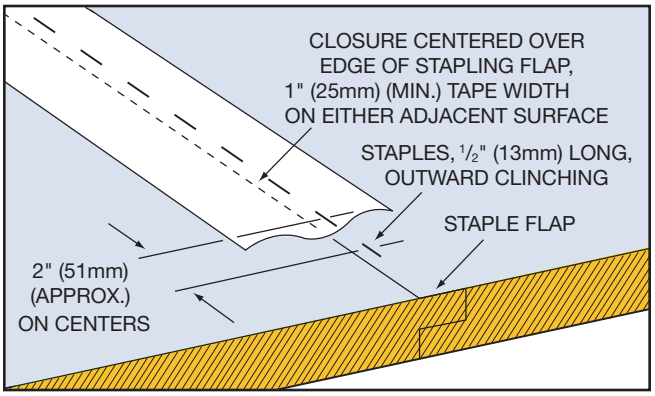
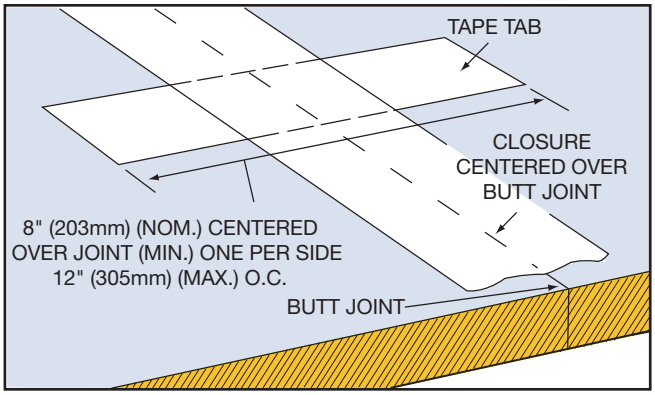


Fig. 4-2B. Joint Closure With Tape Tabs and No Staple Flap



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 is sufficient. However, for best results on contaminated surfaces, the cleaning recommendations of the tape manufacturer should be consulted.

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.

Application of Pressure Sensitive Aluminum Foil Tape Closures

1. APPLICATION ABOVE 50°F (10°C)

Use 2½" (64mm) (MIN.) wide tape for 1" (25mm) duct board. For 1½" (38mm) duct board, 3" (76mm) wide tape is recommended. For 2" (51mm) duct board, 3" (76mm) wide tape is required. Position the tape along the edge of the flap in a manner that will allow 1" (25mm) (MIN.) overlap on adjacent surfaces. While holding the tape taut, press in place taking care to avoid wrinkles and folds.
(See Fig. 4-3A.)

Rub tape firmly with a plastic sealing tool until the facing reinforcement shows through the tape. Avoid excessive pressure on the sealing tool that could cause the tape to be punctured at staple locations. (See Fig.4-3B.)

2. CONNECTIONS TO SHEET METAL

Pressure-sensitive tape may be used to seal fibrous glass ducts to sheet metal in systems operating at less than 1" w.g. (250 Pa) static pressure when the sheet metal surfaces are first carefully cleaned in accordance with the tape manufacturer's instructions.

3. APPLICATION BELOW 50°F (10°C)

If the temperature of either the duct board surface or the tape is less than 50°F (10°C) at the time of application, heat must be applied.

Using any suitable heating iron with the plate temperature set at approximately 400°F (204°C), pre-heat the area to be taped. Quickly position the tape on the pre-heated area and press in place. Pass the iron over the taped area two or three times using a rapid ironing motion.

Complete the bond by rubbing the tape firmly with the plastic sealing tool until the facing reinforcement shows through the tape clearly.

If the tape has been stored at temperatures below 50°F (10°C), it may be conditioned prior to use by placing it in a warm environment to improve the initial tack.

Fig. 4-3A.

Applying pressure-sensitive aluminum foil tape to the longitudinal seam. Hold one end in place firmly and press tape in place, taking care to avoid wrinkles and folds.

Fig. 4-3B.

Rub tape firmly with a plastic sealing tool until the facing reinforcement shows clearly through the tape. Avoid tearing or puncturing the tape at the staples.

Application of Heat-Activated Aluminum Foil Tape Closures

Position the 3" (76mm) wide tape along the edge of the flap in a manner that will allow a minimum overlap of 1" (25mm) on adjacent surfaces. Using a suitable heating iron with a plate temperature of between 550°F (288°C) and 600°F (316°C), pass the iron along the tape seam with sufficient pressure and dwell time to activate the adhesive. (See Fig. 4-4A.) A satisfactory bond has been achieved when the heat indicator dots on the tape have darkened. (See Fig. 4-4B.)

Use a second pass of the iron to complete the bond by applying pressure to the front edge of the iron in a smearing action. Exercise caution to prevent burn injuries from contact with the iron or with heated surfaces.

Allow all the joints and seams to cool below 150°F (66°C) surface temperature before any stress is applied. Avoid puncturing the tape at staple locations with excessive pressure from the iron.

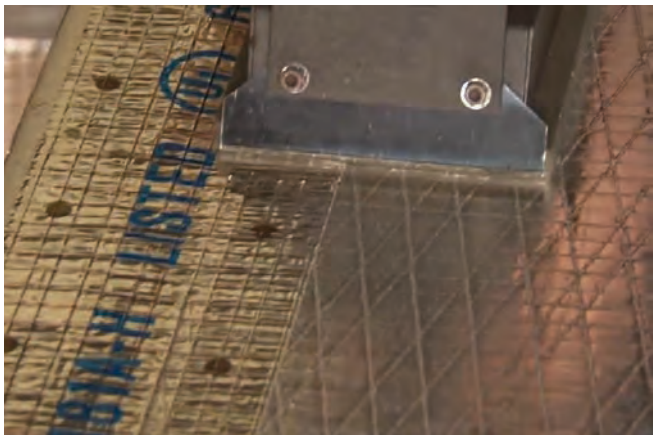
CLOSURE MACHINES

Automatic closure machines using approved heat-activated tape provide tightly sealed longitudinal seam closures at high production rates. Stapling of the longitudinal flap may be omitted.

Fig. 4-4A.

Apply heat with an iron. Do not use a blowtorch; both heat and pressure are required for an effective bond. Complete the bond with a second pass of the iron.

Fig. 4-4B.



A satisfactory bond has been achieved when the heat indicator dots on the tape become darkened.

Application of Mastic and Glass Fabric Tape Closure Systems

Apply a thin coat of mastic approximately 3½" (89mm) wide over the center of the seam or 1" (25mm) (MIN.) tape width on each adjacent surface. Embed the 3" (76mm) wide glass fabric in the mastic. (See Fig. 4-5A.)

Apply a second coat of mastic over the glass fabric, filling the scrim pattern. (See Fig. 4-5B.)

Follow the mastic manufacturer's label instructions on application rate, safety precautions, shelf life limitations, and minimum set-up time required before stress can be applied to the joint or seam.

Contact mastic manufacturers regarding protection of material during storage, transportation, and installation. Also read and follow instructions on the product label.

GLASS FABRIC AND MASTIC OVER SHEET METAL

When connecting fibrous glass duct systems to sheet metal, as in connections to flanges of central air equipment, fasteners such as sheet metal screws and washers must be used to carry the mechanical load. Glass fabric and mastic can then be applied to seal the connections at these points. Usually, two widths of glass fabric will be required.

(See page 3-30 for recommended fibrous glass-to-sheet metal connection details.)

NOTE: Either pressure-sensitive or heat-activated tape tabs may be used in conjunction with glass fabric and mastic closure systems.

Fig. 4-5A.

Apply a thin coat of mastic over the center of the joint seam. Embed the glass fabric in mastic.

Fig. 4-5B.

Apply a second coat of mastic over the glass fabric, filling the scrim pattern.

Flexible Duct Connections to Duct Board – Closure Strap Method

1. Cut a hole in the plenum, duct section, or distribution box with a hole cutter sized to accept a sheet metal collar. If using spin-in collar, also cut a 1" (25mm) slit radial to the hole. (See Fig. 4-6A.)

2. To reduce leakage, coat the collar flange with mastic listed under UL Standard 181A, Part III, to seal the collar to the duct board.

3 (a). If using a spin-in collar, be sure the lead edge of the inner flange is bent down at an angle. Install by screwing into the duct board until the flange is snugly sealed against the duct board facing and the entire inner ring is visible inside the duct. (See Fig. 4-6B.)

3 (b). If using a dove-tail collar, install by pushing it into the duct board until the flange is snugly sealed against the duct board facing. Bend all tabs 90° to lock the collar in place. (See Fig. 4-6C.)

4. Pull the inner air core of the flexible duct over the collar. Seal with UL181B tape and clamp per the flexible duct manufacturers' recommendations. (See Fig. 4-6D.)

5. Pull the flexible duct insulation over the inner air core so it is butted firmly against the duct wall. (See Fig. 4-6E.) Complete the installation of the flexible duct to collar in accordance with the manufacturer's instructions.

For additional information on connecting flexible duct to fibrous glass duct board, refer to the Air Duct Council's Flexible Duct Performance & Installation Standards and manufacturers' instructions.

Fig. 4-6A. Cutting Hole in Duct Board for Flexible Duct Connection

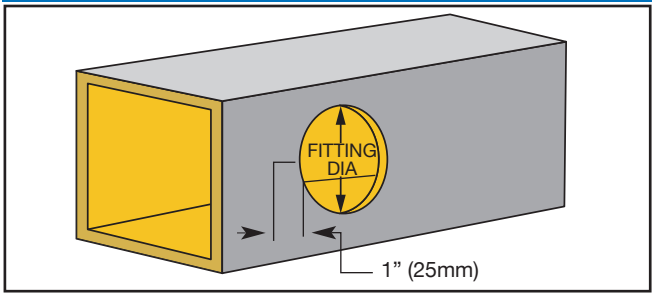


Fig. 4-6B. Installing Spin-In Collar

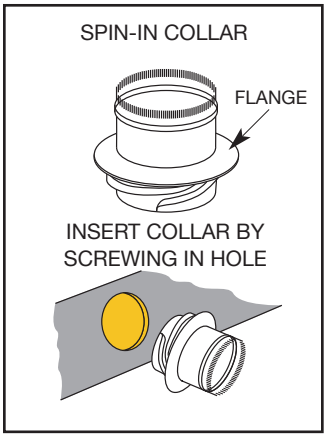


Fig. 4-6C. Installing Dove-Tail Collar

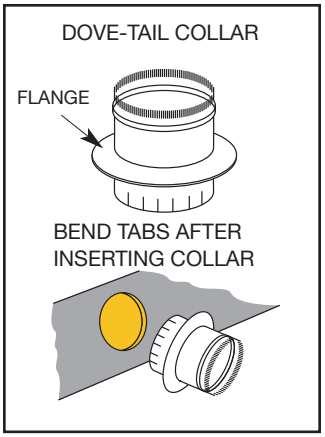


Fig. 4-6D. Installing Flexible Duct Over Collar

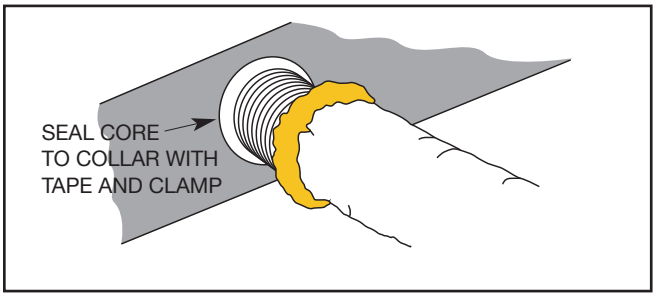
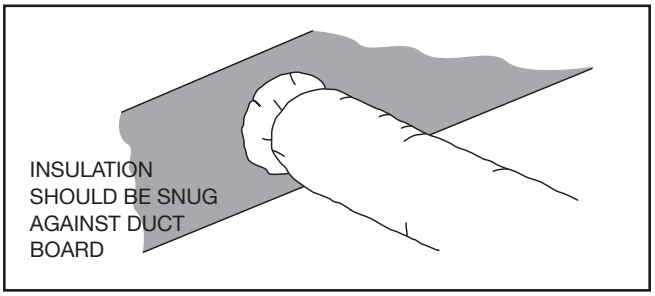


Fig. 4-6E. Install Flexible Duct to Collar According to Manufacturer's Instructions



Flexible Duct Connections to Duct Board - Insulated Collar Method

1. From a 1" (25mm) piece of duct board, cut a ring whose inside diameter is the same as that of the sheet metal collar and whose outside diameter gives a thickness that corresponds to the R-value of the flexible duct insulation as follows:

INSIDE DIAMETER PLUS	FLEXIBLE DUCT R-VALUE
2" (51mm)	4.2 (0.74 RSI)
3" (76mm)	6.0 (1.06 RSI)
4" (102mm)	8.0 (1.41 RSI)

2. Slide the ring onto the sheet metal collar with the foil facing of duct board away from the flange. Tape to the back of the flange with UL181A listed pressure-sensitive tape. (See Fig. 4-7A.)

3. Cut a hole in the duct board to accommodate the sheet metal collar. If using a spin-in collar (See page 4-6) cut a 1" (25mm) slit radial to hole. (See Fig. 4-6A.) To reduce leakage, coat the collar flange with mastic listed under UL Standard 181A, Part III to seal the collar to the duct board facing.

4. If installing a dove-tail collar, push it into hole in the duct board until the outer flange is snug against the facing. Bend dove-tails 90° outward to lock in place. (See Fig. 4-7B.)

5. If installing a spin-in collar, bend the leading edge of the inner flange down at an angle and slip through the slit in the duct board. Screw the collar into place with the outer flange snug against the foil facing and with the inner ring fully visible inside the duct.

6. Pull the inner air core of the flexible duct over the collar. Seal with UL181B tape and secure with closure strap between the bead on the collar and the duct board. (See Fig. 4-7B.)

7. Butt the flexible duct insulation firmly against the duct board ring. (See Fig. 4-7C.) Pull flexible duct vapor retarder jacket over the ring so it covers about one half the width of the ring.

8. Tape the jacket to the ring using UL181B tape. (See Fig. 4-7D.)

This procedure maintains the full thickness of the insulation across the flexible duct connection, minimizes through-metal conductance of the sheet metal fitting, and completes the vapor retarder across the connection to prevent moisture condensation.

Fig. 4-7A. Insulating Collar of Sheet Metal Fitting

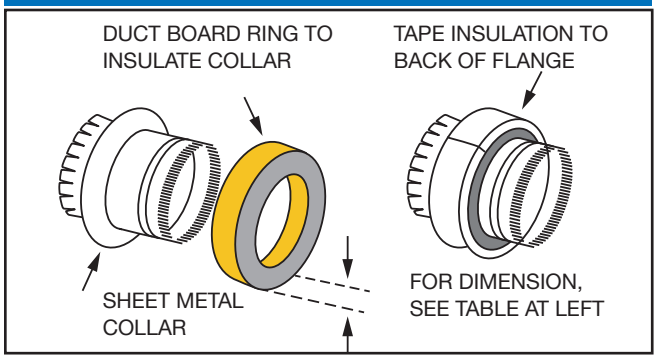


Fig. 4-7B. Securing Flexible Duct With Plastic Strap

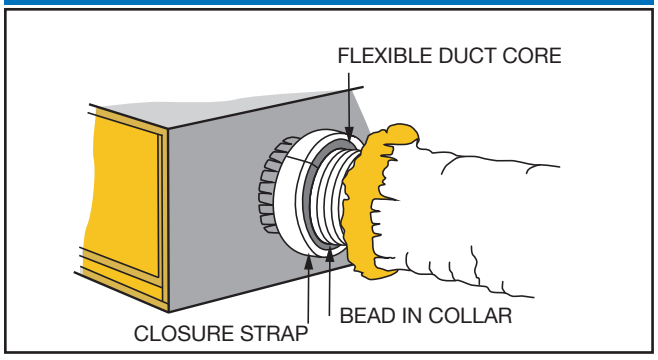


Fig. 4-7C. Positioning Flexible Duct Insulation and Vapor Retarder Jacket Against Insulated Collar

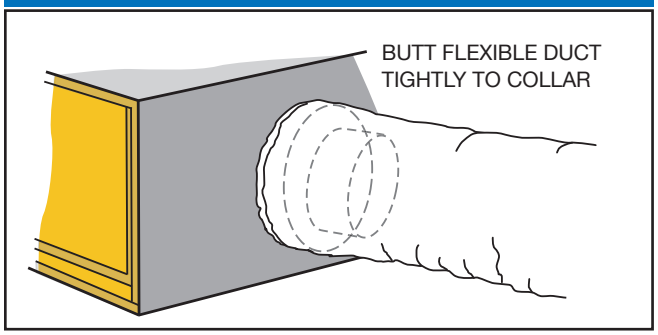
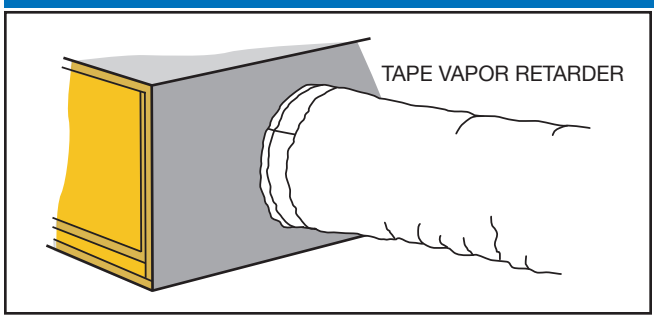
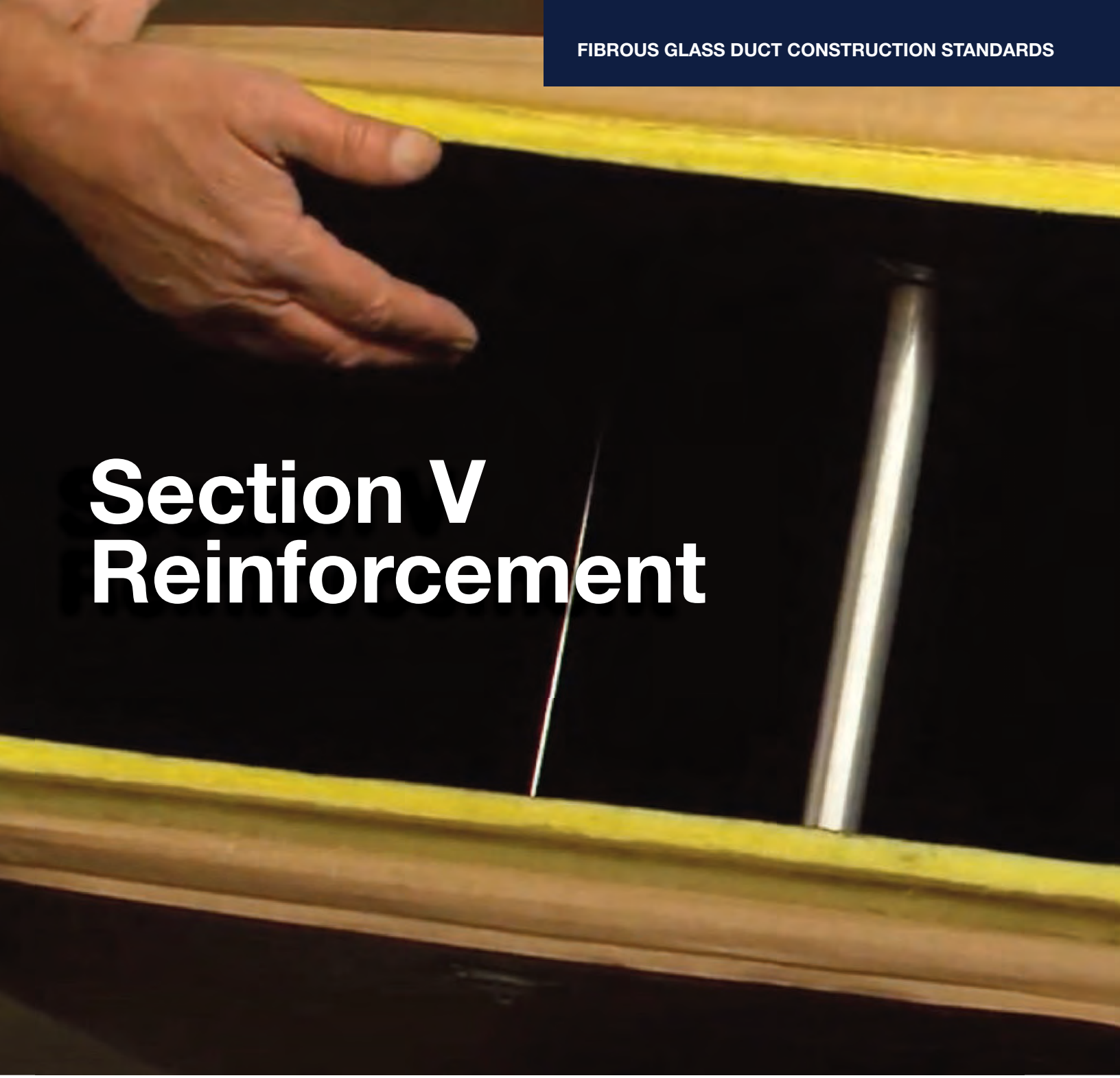


Fig. 4-7D. Taping Flexible Duct Jacket to Collar





Section V Reinforcement

Notes to Section V

1. FASTENER SCHEDULE:

- #10 plated sheet metal screws, board thickness + ¼" (6mm) (minimum) thread length.
- Volcano type washers, 2½" (64mm) square or 3" (76mm) round galvanized steel, 0.028 (0.71mm) thick.
- When installing washers, turned edges must face away from, board surface, spacing as indicated in the instructions that follow.

2. REINFORCEMENT OF FITTINGS:

Some fittings may require reinforcement even though straight ducts of the same span may not require reinforcement.

Section V: Reinforcement

Introduction

When internal static pressure loading may cause deflection greater than 1/100 of the span in fibrous glass duct systems, reinforcement is required. For deflection limits and criteria for evaluation of system integrity, refer to Section I, Performance Criteria.

Fibrous glass duct system straight sections and fittings may be reinforced by either or both of the following methods:

1. Tie rod reinforcement. (See pages 5-3 through 5-7.) Tie rods of 12 gauge steel terminating in square or round steel washers, restrain duct board deflection to within 1/100 of the span in positive pressure systems when duct dimensions require reinforcement. Washer size and tie rod location must be maintained to prevent facing rupture during system cycling.

2. Channel reinforcement. (See pages 5-8 through 5-13.) Sheet metal channels wrap entirely around the duct to restrain duct board deflection. Channel reinforcement may be used in positive pressure systems, but must be used in negative pressure systems, when duct dimensions require reinforcement.

Tie rod and channel reinforcement may be combined in reinforcing certain fittings. (See pages 5-13 thru 5-24.)

POSITIVE PRESSURE REINFORCEMENT

The following general rules apply:

1. While some duct dimensions may not require any reinforcement in straight sections, certain fittings of the same dimension may require reinforcement. This requirement is noted wherever applicable in the instructions that follow.

2. Reinforcement of fibrous glass duct fittings is an extension of certain basic principles of reinforcing straight duct sections by use of tie rods wherever possible and with channel reinforcement applied where tie rods cannot be used.

3. The reinforcement spacing required for straight duct sections of a given dimension will be required for duct fittings of that dimension.

4. If the duct section or fitting has shiplapped joints, reinforcements must be located starting within 4” (102mm) of the shiplap on the female side.

5. If the duct or fitting must be reinforced and has butt joints, refer to page 5-5 for details.

6. Use only tie rod termination methods described in this Standard for low pressure (0” to 2” w.g. [0 to 500 Pa]) duct systems, noting the limitations that preclude the use of certain tie rod termination methods with certain fittings. (See page 5-7.)

7. Use only formed sheet metal reinforcement materials and configurations as shown on the following pages. Channel reinforcement sheet metal shall be of a gauge as listed in Table 5-4, page 5-8.

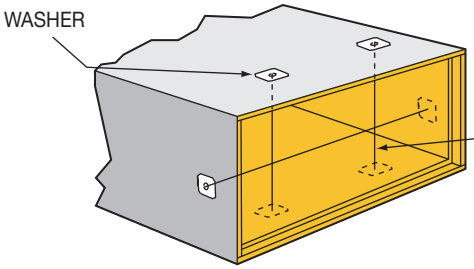
8. When a panel is to be cut into the system, additional reinforcement shall be used.

9. Reinforcement locations shall not interfere with the operation of the system controls or equipment.

10. If the branch connection is less than the full height, the distance from any side of the branch to the top or the bottom of the duct must be a minimum of 6” (152mm). In addition, the distance from the male or female shiplap must be a minimum of 6” (152mm) (minimum). This also applies to access doors.

Fig. 5-3. Tie Rod Reinforcement

WASHER, 2½" (64mm) SQUARE X 0.028" (0.7mm) GALVANIZED STEEL WITH TURNED EDGES AWAY FROM FACING, VOLCANO TYPE, HOLE IN CENTER. 3" (76mm) ROUND WASHER OPTIONAL



TIE ROD, 12 GAUGE STRAIGHT GALVANIZED STEEL WIRE (SEE PAGE 5-7 FOR APPROVED TERMINATIONS.)

TABLE 5-1. TIE ROD REINFORCEMENT SCHEDULE – POSITIVE PRESSURE ONLY

Maximum Positive Static Pressure	Inside Duct Dim., Inches	Type 475 Duct Board			Type 800 Duct Board			Type 1400 Duct Board		
		No. Rods Across Dimension	Maximum Longitud. Spacing	No. Rods Per 4 ft. Section	No.Rods Across Dimension	Maximum Longitud. Spacing	No. Rods Per 4 ft. Section	No. Rods Across Dimension	Maximum Longitud. Spacing	No. Rods Per 4 ft. Section
0" thru ½" w.g. (0 - 124 Pa)	0" -36"		*			*			*	
	37"-42"	2	24"	4	2	48"	2		*	
	43"-48"	2	24"	4	2	48"	2	2	48"	2
	49"-60"	3	24"	6	3	48"	3	3	48"	3
	61"-64"	3	24"	6	3	24"	6	3	48"	3
	65"-80"	4	24"	8	4	24"	8	4	48"	4
	81"-96"	5	24"	10	5	24"	10	5	48"	5
Over ½" thru 1" w.g. (125 - 249 Pa)	0"-24"		*			*			*	
	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	2	48"	2
	49"-64"	3	24"	6	3	24"	6	3	24"	6
	65"-80"	4	24"	8	4	24"	8	4	24"	8
	81"-96"	5	24"	10	5	24"	10	5	24"	10
Over 1" thru 2" w.g. (250 - 500 Pa)	0"-15"		*			*			*	
	16"-18"	1	24"	2		*			*	
	19"-24"	1	24"	2	1	48"	1		*	
	25"-32"	1	16"	3	1	24"	2	1	24"	2
	33"-48"	2	16"	6	2	24"	4	2	24"	4
	49"-60"	3	16"	9	3	24"	6	3	24"	6
	61"-64"	3	16"	9	3	16"	9	3	24"	6
	65"-80"	4	16"	12	4	16"	12	4	24"	8
	81"-96"	5	16"	15	5	16"	15	5	24"	10

*Straight ducts of these dimensions do not require reinforcement. However, fittings of these dimensions may require reinforcement.

NOTES:

1. Tie rods and washers must be no more than 16" (406mm) on centers across duct dimension.
2. Ducts of 48" (1,219mm) width and over require use of anti-sag devices. (See pages 5-4 and 5-5.)
3. For duct dimensions over 96" (2,438mm), maintain tie rod spacing on 16" (400mm) centers across the duct dimension following longitudinal spacing for the design pressure and sag support 48" on center.
4. If dimensions require, tie rods run in both horizontal and vertical directions.

To convert inches to millimeters in the above table, multiply by 25.4.

To convert feet to meters in the above table, multiply by .3048.

Placement of Tie Rod Reinforcement in Relation to Shiplapped Joints

Washers shall be installed so turned edges face away from the duct board facing. (See page 5-5 for reinforcement of butt joints in duct board.)

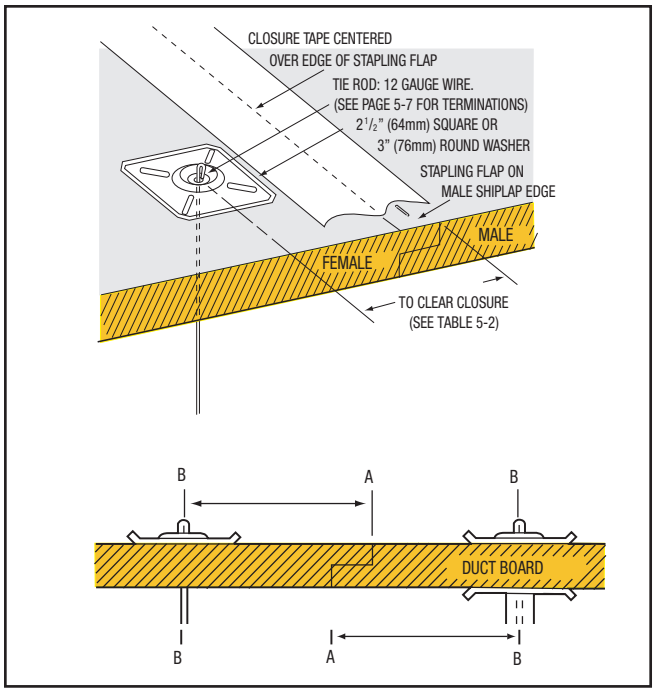
Tie Rod Distance from the shiplap edge:

- The closest a tie rod can be placed to the shiplap edge to allow clearance for tape closure.

TABLE 5-2. SHIPLAP WASHER SPACING

BOARD THICKNESS	DISTANCE FROM A TO B (NOMINAL)	
	SQUARE WASHER	ROUND WASHER
1" (25mm)	4" (102mm)	4¼" (106mm)
1½" (38mm)	5" (127mm)	5¼" (131mm)
2" (51mm)	5½" (140mm)	5¾" (143mm)

Fig. 5-4A. Tie Rod Reinforcement



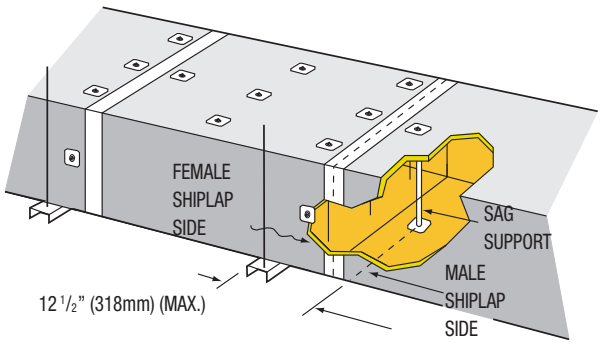
Sag Control — Tie Rod Reinforcement, Shiplapped Joints

Top panels of fibrous glass duct sections or fittings 48" (1,219mm) wide or greater may sag due to the weight of the duct board when the system is not pressurized. To control this condition, sag supports must be provided. Hanger or sag supports shall not sit on reinforcements.

Sag supports do not replace tie rod assemblies as called for in the reinforcement schedule but must be installed in addition to them. Hangers must be located within 12" (305mm) of sag supports. (See Section VI, Hanging and Supports.)

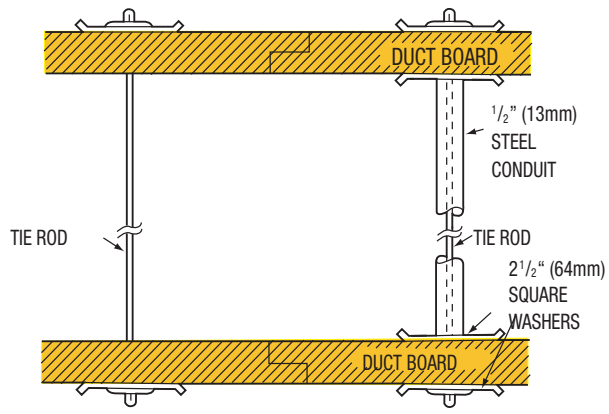
For easier mating of fittings and duct sections during installation, a ½" (13mm) diameter steel conduit, such as EMT, and washers may be added to an existing tie rod assembly at the female shiplap end. (See Table 5-2.)

Fig. 5-4B. Sag Control, Tie Rod Reinforcement



(SEE TABLE 5-2)

Fig. 5-4C. Sag Control Detail



Placement of Tie Rod Reinforcement in Relation to Butt Joints

Reinforcement techniques presented in this Standard assume fibrous glass duct system components have been fabricated with shiplap joints. When butt joints are to be reinforced, use the method shown on this page.

ALTERNATE: A single tie rod reinforcement placed as shown in Fig. 5-4B, page 5-4 may be used if the butt joint is glued with an adhesive system documented by the duct board manufacturer.

Correct procedures to be used in taping butt joints can be found in Section VI, Closures.

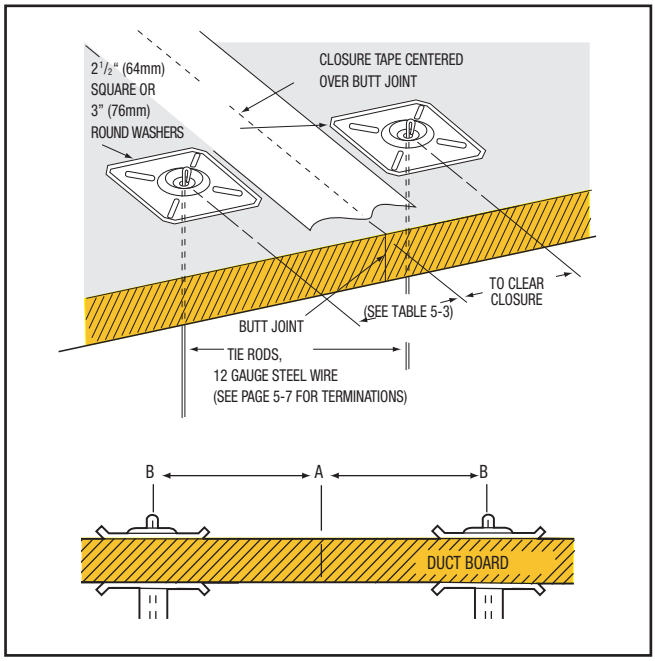
Tie Rod Distance from the shiplap edge:

- The closest a tie rod can be placed to the shiplap edge to allow clearance for tape closure.

TABLE 5-3. BUTT JOINT WASHER SPACING

BOARD THICKNESS	DISTANCE FROM A TO B (NOMINAL)	
	SQUARE WASHER	ROUND WASHER
1" (25mm)	3" (76mm)	3¼" (83mm)
1½" (38mm) and 2" (51mm)	3¼" (83mm)	3½" (89mm)

Fig. 5-5A. Butt Joint Reinforcement With Tie Rods and Washers



Sag Control — Tie Rod Reinforcement – Butt Joints

Top panels of fibrous glass sections or fittings 48" (1,219mm) wide or greater may sag due to the weight of the duct board when the system is not pressurized. To control this condition, sag supports must be provided on both sides of the butt joint using 2½" (64mm) square or 3" (76mm) round washers and a ½" (13mm) steel conduit added to the standard tie rods inside the duct. Hanger or sag supports shall not sit on reinforcements.

Fig. 5-5B. Sag Control, Butt Joint Reinforcement

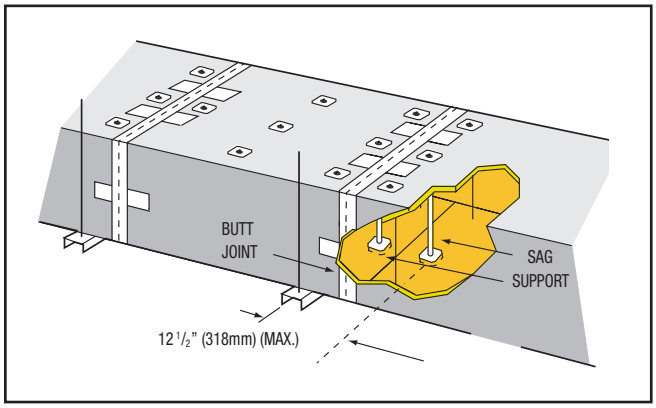
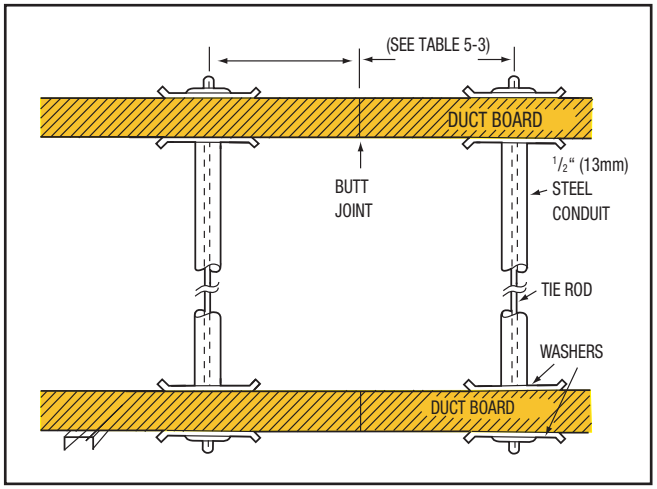


Fig. 5-5C. Sag Control Detail



Typical Tie Rod Reinforcement Examples – Positive Pressure Ducts

Placement of the tie rods and sag support in relation to the shiplapped joints can be found on page 5-4. Sag support is required in ducts 48” (1,219mm) and greater in width.

The required number of tie rods across the duct width shall be determined as required in the Table 5-1 schedule.

If the depth of the duct requires reinforcement, horizontal tie rods are used according to the Table 5-1 schedule.

Fig. 5-6A. Tie Rod Reinforcement, 48” (1,219mm) Centers, 48” (1,219mm) Duct Modules

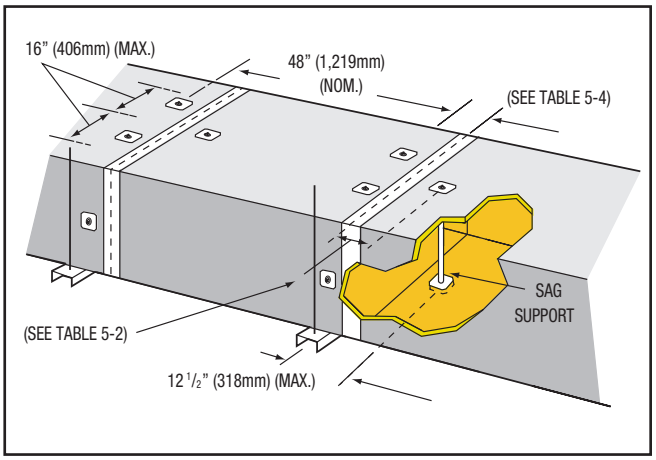


Fig. 5-6B. Tie Rod Reinforcement, 24” (610mm) Centers, 48” (1,219mm) Duct Modules

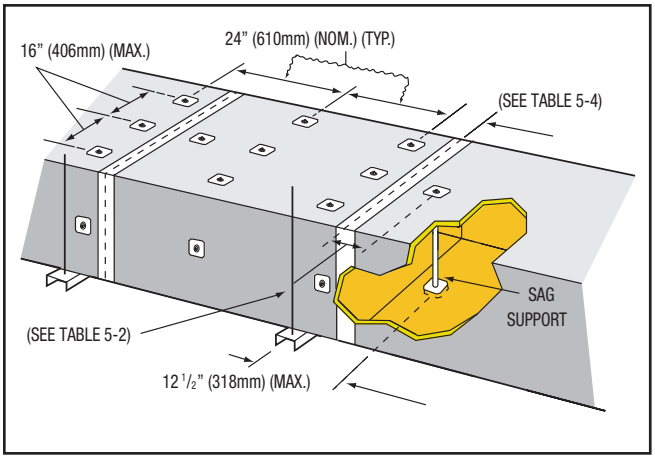
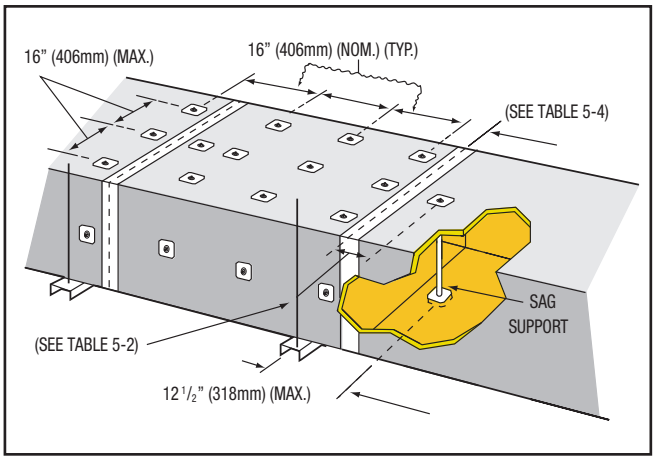


Fig. 5-6C. Tie Rod Reinforcement, 16” (406mm) Centers, 48” (1,219mm) Duct Modules



Tie Rod Termination Methods

1. FASLOOP METHOD – TOOLS REQUIRED

- Fasloop bending tool* or tool with equivalent performance.
- Wire cutters to make square cut (not chisel point).
- Tape measure.

*No other size or shape of loop has been tested by NAIMA, or submitted to NAIMA for testing to determine compliance with the 50,000 cycle test.

Materials Required per tie rod assembly:

- 12 gauge galvanized steel wire 1¾" (44mm) longer than outside duct dimension.
- Two washers, 2½" (64mm) square x 0.028" (0.7mm) (minimum) thick galvanized steel, volcano type with beveled edges, and 0.150" (4mm) hole in center. NOTE: 3" (76mm) round washers are acceptable. Other types of manufactured flat washers are not suitable for this application.

2. POP RIVET METHOD – TOOLS REQUIRED

- 14" (356mm) horseshoe nipper or carpenter's pincers modified so that pincers will close to a gap equal to 18 gauge sheet metal. IMPORTANT: Check the tool periodically to ensure that this gap dimension is maintained.
- Wire cutter.
- Tape measure.

Materials Required per tie rod assembly:

- 12 gauge galvanized steel wire, cut exactly to outside duct dimension
- Two washers, 2½" (64mm) square x 0.028" (0.7mm) (minimum) thick galvanized steel, with beveled edges and 7/32" (6mm) diameter center hole
- Two 3/16" (4.8mm) steel pop rivet sleeves, 3/8" (10mm) long

3. LOCKING CAP METHOD – TOOLS REQUIRED

(Not to be used on sloped panels of fittings)

- Wire cutters
- Tape measure

Materials Required per tie rod assembly:

- 12 gauge galvanized steel wire cut 7/16" (11mm) longer than outside duct dimension.
- Two washers, 2½" (64mm) square x 0.028" (0.7mm) (minimum) thick galvanized steel, with beveled edges and 0.150" (3.8mm) hole in center.
- Two locking caps 7/8" (22mm) diameter having spring steel or stainless steel locking inserts.

NOTES:

(a) An ordinary insulation locking washer does not have sufficient holding power.
(b) The wire must be free to move within the 2½" (64mm)
(c) Do NOT re-use locking caps.

Fig. 5-7A. Tie Rod Termination, Fasloop Style

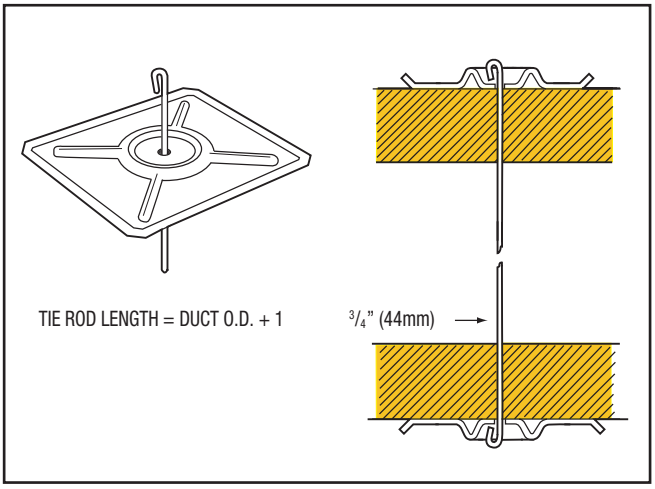


Fig. 5-7B. Tie Rod Termination, Pop Rivet and Sleeve

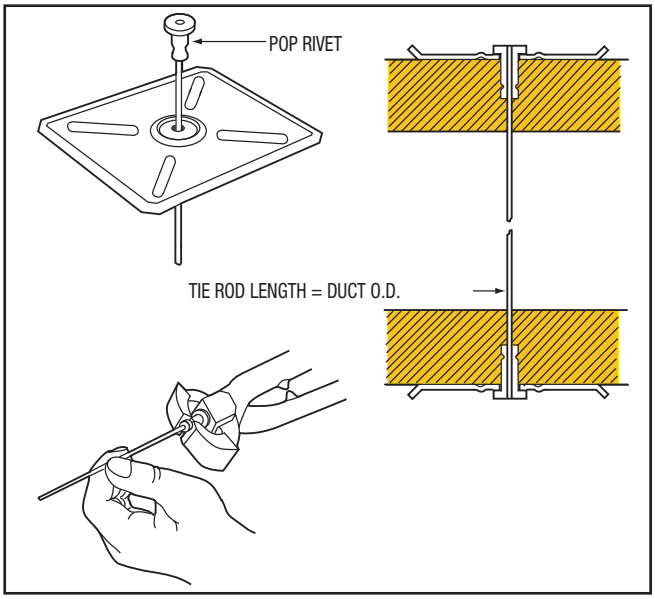
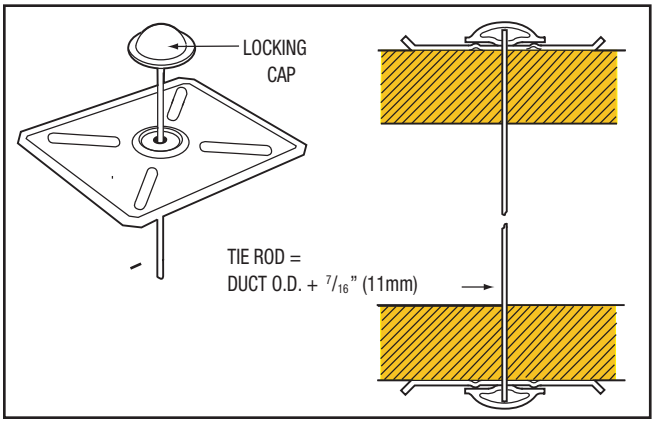


Fig. 5-7C. Tie Rod Termination With Locking Cap



Channel Reinforcement

Another reinforcement system for use in either positive or negative pressure duct systems specifies formed sheet metal channels normally wrapped around the perimeter of the duct. When channels must be attached to the duct, #10 plated screws and 2½" (64mm) square or 3" (76mm) round, and 0.028" (0.7mm) (minimum) thick galvanized steel washers are used. These must have turned edges to prevent cutting into the duct board. In positive pressure applications, wrap-around channels need not be attached to the duct board except when required for sag control.

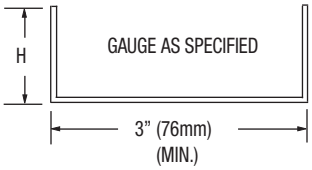
Table 5-4 gives reinforcement longitudinal spacing, sheet metal gauge, and channel height dimensions depending on the duct board type, maximum inside dimensions and static pressure. This is a minimum reinforcement schedule applicable to straight sections and generally applies to fitting reinforcement as shown in this Standard. However, a simplified reinforcement schedule may be established with lower variables provided minimum reinforcement sizes, gauges and spacings as shown below are met.

TABLE 5-4. CHANNEL REINFORCEMENT SCHEDULE – POSITIVE OR NEGATIVE PRESSURE

Maximun Static Pressure	Inside Duct Dim., Inches	Type 475 Duct Board			Type 800 Duct Board			Type 1400 Duct Board		
		Channel Gauge	Maximum Longitud. Spacing	H Dimension (see below)	Channel Gauge	Maximum Longitud. Spacing	H Dimension (see below)	Channel Gauge	Maximum Longitud. Spacing	H Dimension (see below)
0" thru -½" w.g. (0 - 124 Pa)	0"- 30"		*			*			*	
	31"-36"	22	24"	1"	22	48"	1"		*	
0" thru + ½" w.g. (0 - 124 Pa)	0"- 36"		*			*			*	
	37"-42"	22	24"	1"	22	48"	1"		*	
	43"-48"	22	24"	1"	22	48"	1"	22	48"	1"
	49"-60"	22	24"	1"	22	48"	1½"	22	48"	1"
	61"-72"	22	24"	1"	22	24"	1"	18	48"	1"
	73"-84"	22	24"	1"	22	24"	1"	18	48"	1¼"
	85"-96"	22	24"	1¼"	22	24"	1"	18	48"	1½"
Over ½" thru 1" w.g. (125 - 249 Pa) positive or negative	0"-24"		*			*			*	
	25"-30"	22	24"	1"	22	48"	1"		*	
	31"-36"	22	24"	1"	22	24"	1"		*	
	37"-42"	22	24"	1"	22	24"	1"	22	48"	1"
	43"-48"	22	24"	1"	22	24"	1"	22	48"	1¼"
	49"-60"	22	24"	1"	22	24"	1"	22	24"	1"
	61"-72"	18	24"	1"	18	24"	1"	18	24"	1"
	73"-84"	18	24"	1¼"	18	24"	1¼"	18	24"	1"
	85"-96"	18	24'	1¼"	18	24"	1¼"	18	24"	1¼"
Over 1" thru 2" w.g. (250 - 500 Pa) positive or negative	0"-15"		*			*			*	
	16"-18"	22	24"	1"		*			*	
	19"-24"	22	24"	1"	22	24"	1"		*	
	25"-36"	22	16"	1"	22	24"	1"	22	24"	1"
	37"-48"	22	16"	1"	22	24"	1¼"	22	24"	1"
	49"-60"	22	16"	1"	22	24"	1¼"	22	24"	1¼"
	61"-72"	18	16"	1"	18	16"	1"	18	24"	1¼"
	73"-84"	18	16"	1¼"	18	16"	1¼"	18	24"	1½"
	85"-96"	18	16"	1½"	18	16"	1½"	18	24"	1¾"

NOTE: Ducts 48" (1,219mm) width and greater require use of anti-sag devices. (See Detail A, page 5-10.)
To convert inches to millimeters in the above table, multiply by 25.4.
To convert feet to meters in the above table multiply by .3048.

*Straight ducts of these dimensions do not require reinforcement, although fittings of these dimensions may require reinforcement.



Channel Reinforcement for Positive Pressure Ducts

Each reinforcement may be fabricated from a continuous length of channel having three 90° bends and a fourth 90° corner that is securely fastened with bolts, screws, rivets, spotwelds or staples. Reinforcements may also be fabricated with two, three, or four securely fastened corners.

When the duct is 48" (1,219mm) wide or greater, channels are secured to the top for sag support with #10 plated sheet metal screws and square or round washers.

Where wrap-around channels without sag support are used, the channel should be slipped over the closure tape after the tape is applied. Center the channel over the female shiplap end for maximum support. (See Fig. 5-9A.) See Table 5-4 for appropriate channel gauge and profile.

TO DETERMINE LENGTH OF REINFORCING MEMBER:

If a single length is to be formed to wrap entirely around the duct, its length must be the outside duct perimeter plus twice the height of the channel. If the reinforcing member is to be two piece, each piece must be equal in length to the outside duct width plus the outside duct height plus twice the height of the channel.

A channel may be offset to clear closure. (See Fig. 5-9C.) If sag support is not required, the channel may be centered over the joint as shown in Fig. 5-9A.

Channel Distance from the shiplap edge:

- The closest a tie channel edge can be placed to the shiplap edge to allow clearance for tape closure.

TABLE 5-5. CHANNEL DISTANCE

Board Thickness	Distance From Shiplap to Channel Edge
1" (25mm)	2½" (64mm)
1½" (38mm)	3½" (89mm)
2" (51mm)	4" (102mm)

Note: 1½" and 2" (38mm and 51mm) distance is set to allow clearance for 3" (76mm) tape.

Fig. 5-9A. Channel Reinforcement, Positive Pressure Systems

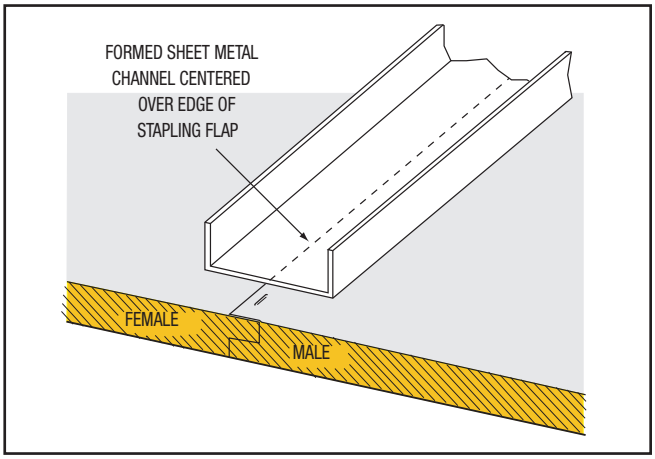


Fig.5-9B. Detail of Channel Reinforcement

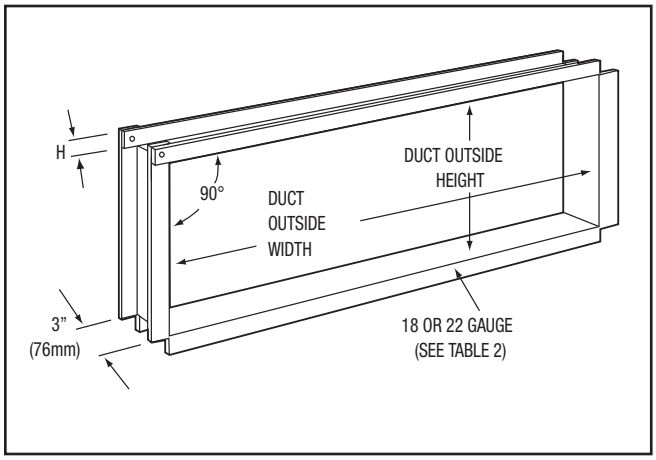
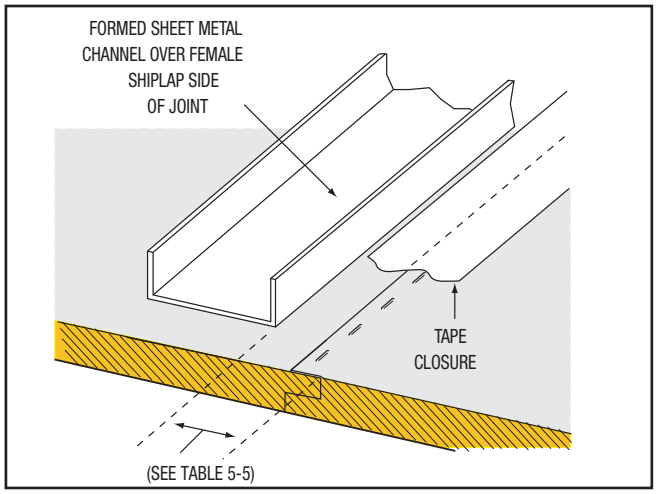


Fig. 5-9C. Channel Reinforcement Offset to Clear Closure



Typical Channel Reinforcement Examples – Positive Pressure Ducts

Placement of channel reinforcement in relation to shiplapped joints can be found on page 5-9. The number of channels along the duct shall be determined in table 5-4.

For sag support in ducts 48” (1,219mm) or greater in maximum dimension, each reinforcement must be fastened to top of the duct in mid-span. (See Detail Ⓐ).

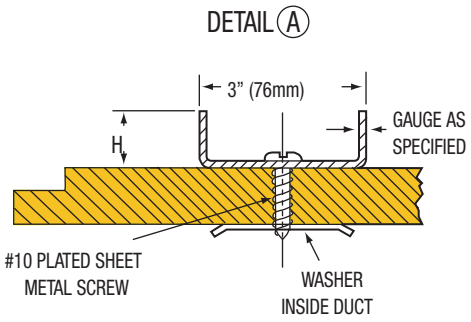


Fig. 5-10A. Channel Reinforcement, Approx. 48” (1,219mm) on Centers, 48” (1,219mm) Duct Modules

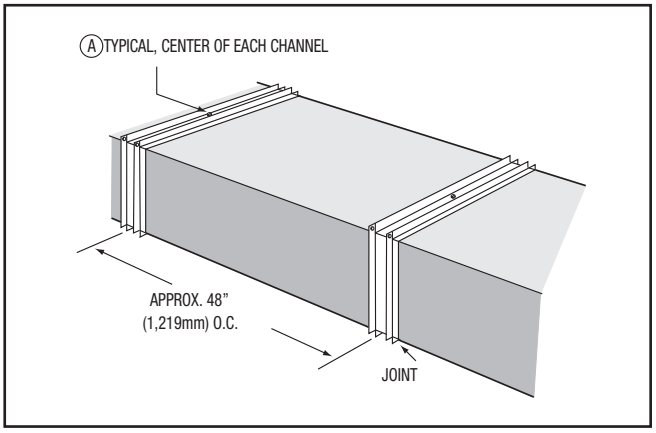


Fig. 5-10B. Channel Reinforcement, Approx. 24” (610mm) on Centers, 48” (1,219mm) Duct Modules

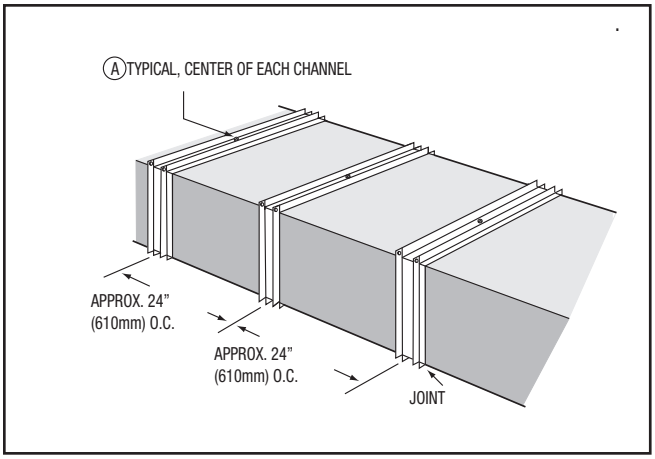
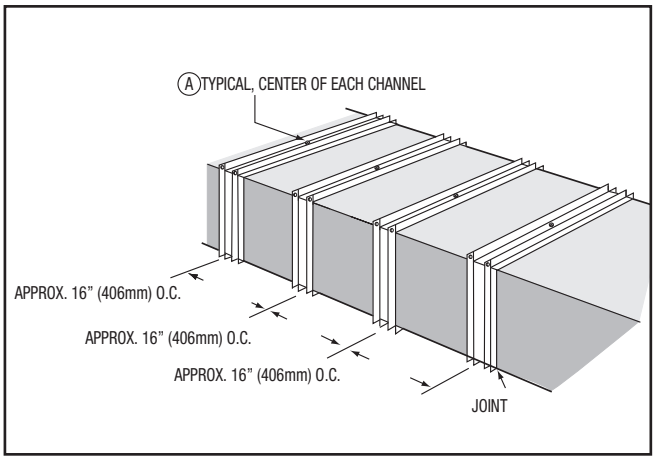


Fig. 5-10C. Channel Reinforcement, Approx. 16” (406mm) on Centers, 48” (1,219mm) Duct Modules



Negative Pressure Channel Reinforcement – Locating Reinforcing Channels

In negative pressure applications, reinforcement is applied over male shiplap. These arrangements are important and, if not followed as shown, may result in system failure. When additional channels are required, as with 24" (610mm) and 16" (406mm) (approximately) spacing, they are attached to the duct with #10 plated sheet metal screws and square or round washers. (See Detail Ⓐ, page 5-10.)

Channel Distance from the shiplap edge:

- The closest a tie channel edge can be placed to the shiplap edge to allow clearance for tape closure.

TABLE 5-6A. CHANNEL DISTANCE

Board Thickness	Distance From Shiplap to Channel Edge
1" (25mm)	1½" (38mm)
1½" (38mm)	2" (51mm)
2" (51mm)	2½" (64mm)

Note: 1½" and 2" (38mm and 51mm) distance is set to allow clearance for 3" (76mm) tape.

To make it easy to fasten channels to the duct board, thread and strip screws into channel first. Position the channel in the proper location on the duct section and push screws through the duct board. Then use a powered driver to thread screws into the washers or clips. Finally, fasten at the corners.

- Clips or washers in negative pressure systems (See Figure 5-6B): Clips are spaced not more than 16" (406mm) apart and not more than 16" (406mm) from the longitudinal edge of a duct side. (See Table 5-7 below.)

TABLE 5-6B. CLIP LENGTH

Board Thickness	Clip Length
1" (25mm)	6" (152mm)
1½" (38mm)	6½" (165mm)
2" (51mm)	7" (178mm)

CONSTRUCTION DETAILS

Each reinforcement may be fabricated from a continuous length of channel having three 90° bends and a fourth 90° corner that is securely fastened with bolts, screws, rivets, spotwelds or staples. Reinforcements may also be fabricated with two, three, or four securely fastened corners.

To determine length of reinforcing members, see page 5-9.

TABLE 5-7. NO. ATTACHMENTS PER REINFORCEMENT

Transverse Dimension	Minimum No. of Attachments
16"- 32" (406mm - 813mm)	1
33"- 48" (838mm - 1,210mm)	2
49"- 64" (1,245mm - 1626mm)	3
65"- 80" (1,651mm - 2,037mm)	4
81"- 96" (2,057mm - 2,438mm)	5

Fig. 5-11A. Channel Reinforcement, Negative Pressure Systems

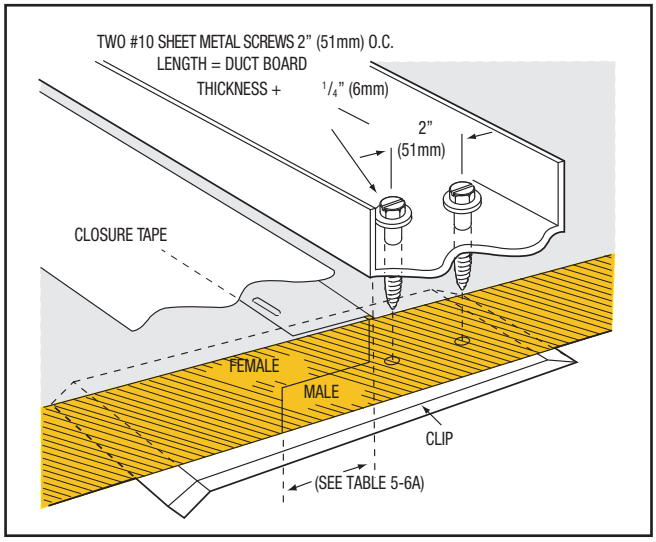


Fig. 5-11B. Clip Detail, Negative Pressure Reinforcement

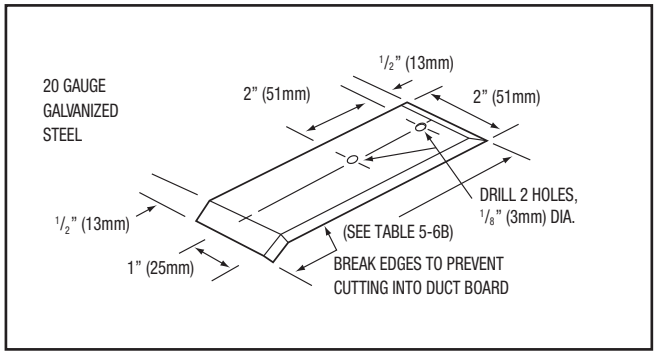
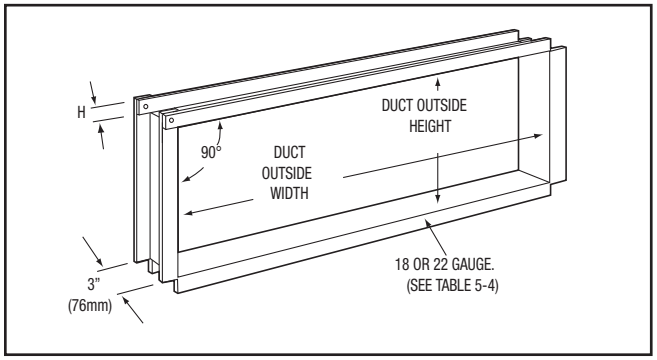


Fig. 5-11C. Channel Detail, Negative Pressure Reinforcement



Typical Channel Reinforcement Schedules – Negative Pressure Ducts

Placement of channel reinforcement in relation to shiplap joint in negative pressure duct systems can be found on page 5-11. The number of channels along the duct shall be determined as required in the schedule, Table 5-4.

Fig. 5-12A. Channel Reinforcement, 48” (1,219mm) (Approx.) Centers, 48” (1,219mm) Duct Modules

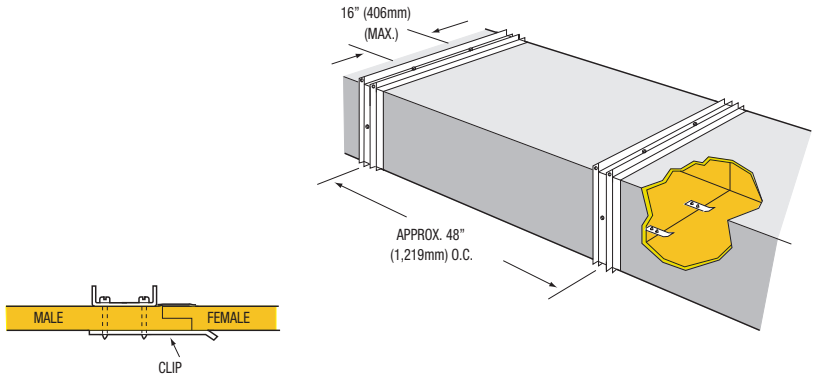


Fig. 5-12B. Channel Reinforcement, 24” (610mm) (Approx.) Centers, 48” (1,219mm) Duct Modules

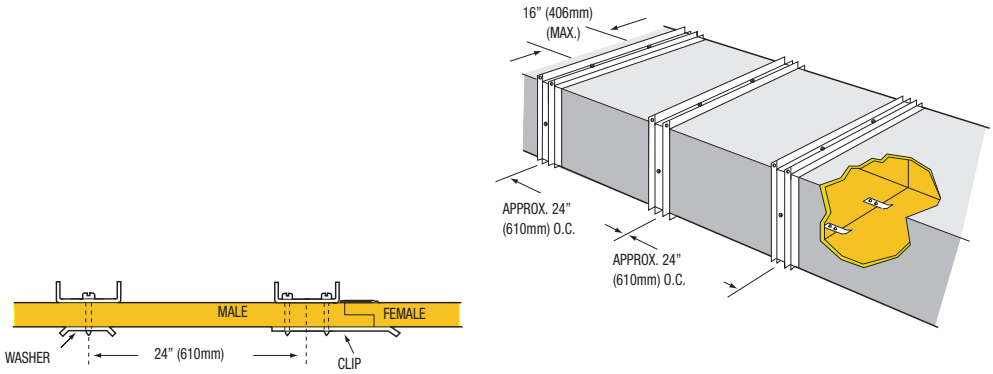
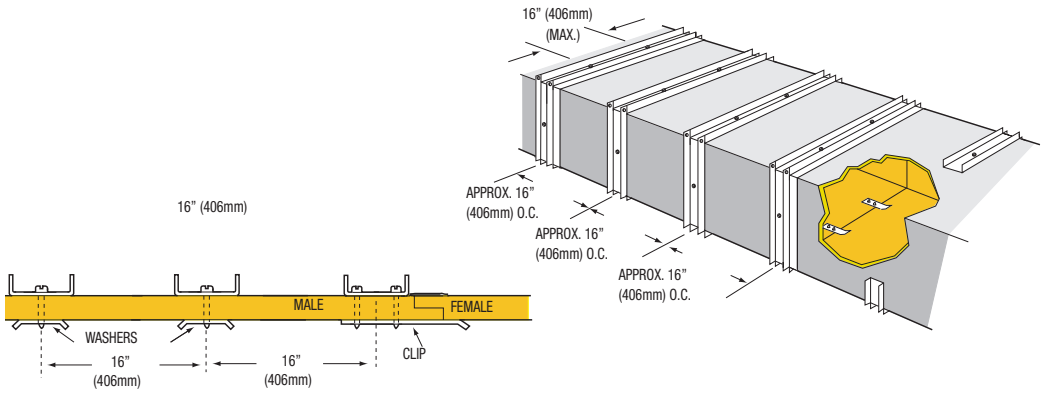


Fig. 5-12C. Channel Reinforcement, 16” (406mm) (Approx.) Centers, 48” (1,219mm) Duct Modules



Partial Wrap-Around Reinforcement

Where reinforcement is required but cannot be fastened to opposite sides of a duct section or fitting, it is necessary to install formed sheet metal channels that partially wrap around a fibrous glass duct system fitting at the required location. (See Table 5-4 for appropriate gauge and profile.) In such cases, #10 plated sheet metal screws ¼" (6mm) longer than the duct board thickness and square or round washers, 0.028" (0.7mm) (min.) thick are used to attach the ends of the channels to the duct board. (See Fig. 5-13 and Table 5-8.)

Fig. 5-13. Partial Wrap-Around Channel Reinforcement

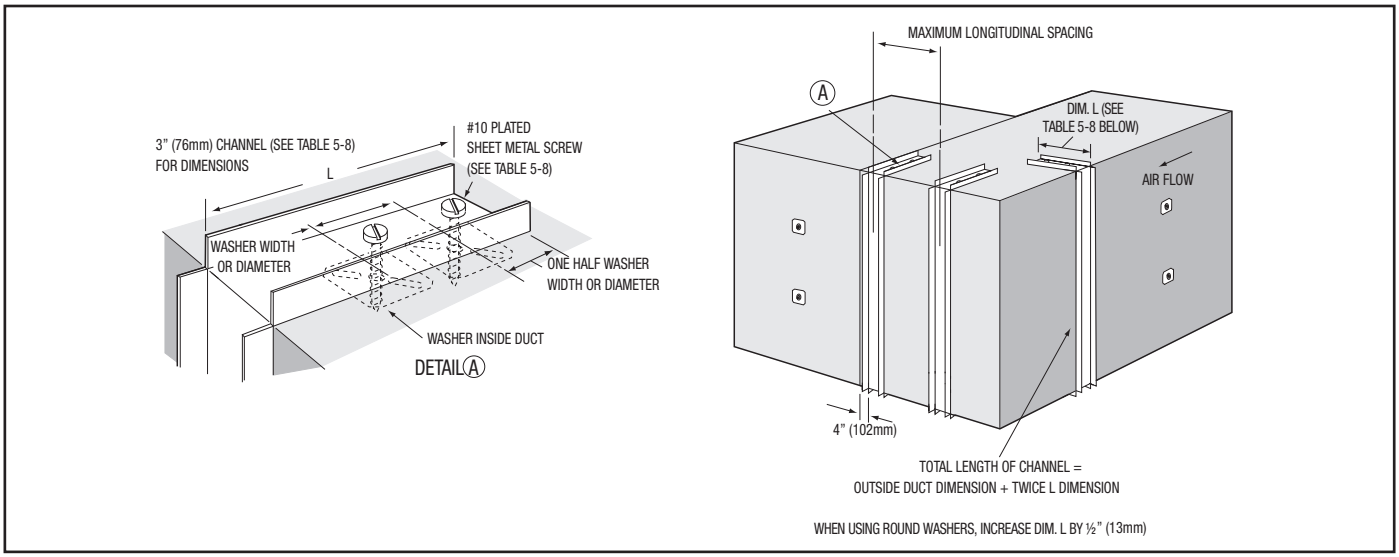


TABLE 5-8. PARTIAL WRAP-AROUND REINFORCEMENT SCHEDULE, POSITIVE PRESSURE

Maximum Positive Static Pressure	Type 475 Duct Board				Type 800 Duct Board				Type 1400 Duct Board			
	Maximum Inside Duct Dimension, Inches	Longitudinal Spacing	Dimension L	No. of Screws, Each End	Maximum Inside Duct Dimension, Inches	Longitudinal Spacing	Dimension L	No. of Screws, Each End	Maximum Inside Duct Dimension, Inches	Longitudinal Spacing	Dimension L	No. of Screws, Each End
0" thru ½" w.g. (0 - 124 Pa)	0"-36"	not required			0"-36"	not required			0"-42"	not required		
	37"-96"	24"	4"	1	37"-60"	48"	4"	1	43"-96"	48"	4"	1
					61"-96"	24"	4"	1				
Over ½" thru 1" w.g. (125 - 249 Pa)	0"-24"	not required			0"-24"	not required			0"-36"	not required		
	25"-48"	24"	4"	1	25"-30"	48"	4"	1	37"-48"	48"	4"	1
	49"-64"	24"	7"	2	31"-48"	24"	4"	1	49"-64"	24"	7"	2
	65"-80"	24"	10"	3	49"-64"	24"	7"	2	65"-80"	24"	10"	3
	81"-96"	24"	13"	4	65"-80"	24"	10"	3	81"-96"	24"	13"	4
					81"-96"	24"	13"	4				
Over 1" thru 2" w.g. (250 - 500 Pa)	0"-15"	not required			0"-18"	not required			0"-24"	not required		
	16"-24"	24"	4"	1	19"-24"	24"	4"	1	25"-32"	24"	7"	2
	25"-32"	16"	4"	1	25"-32"	24"	7"	2	33"-48"	24"	10"	3
	33"-48"	16"	7"	2	33"-48"	24"	10"	3	49"-60"	24"	13"	4
	49"-64"	16"	10"	3	49"-60"	24"	13"	4	61"-84"	24"	16"	5
	65"-80"	16"	13"	4	61"-64"	16"	10"	3	85"-96"	24"	19"	6
	81"-96"	16"	16"	5	65"-80"	16"	13"	4				
					81"-96"	16"	16"	5				

To convert inches to millimeters in the above table, multiply by 25.4. To convert feet to meters in the above table, multiply by .3048.

90° Elbows – Shiplap Construction Cheek Panels – Positive Pressure

NOTE: Some elbows may require reinforcement even though schedules for straight ducts of the same dimension may show reinforcement is not required.

If neither A nor B are greater than the maximum unreinforced duct dimension (MUDD) but diagonal X-Y is greater than the maximum unreinforced duct dimension per Table 5-1, install tie rod reinforcement at mid-span of the opening per (1), Fig. 5-14A. (See Table 5-2 for location from shiplap edge.)

NOTE: Turning vanes have been omitted for clarity.

If fiber glass turning vanes are used, the tie rod and washer assemblies should be placed in the center of the diagonal.

If either A or B is greater than the maximum unreinforced duct dimension (MUDD):

(2) Reinforce per Fig. 5-14B and Table 5-1.

(3) Reinforce upstream from the female shiplap joint per Table 5-2. More than one reinforcement may be needed depending on branch width B.

(4) Reinforce per Fig. 5-14B where lines of reinforcement intersect.

NOTE: Turning vanes do not replace reinforcement. For reinforcement of mitered elbows, refer to page 5-20 using reinforcement standards for offsets.

Fig. 5-14A. Tie Rod Reinforcement at Diagonal X-Y, Mid-Span of Opening. (See Table 5-2 for Location From Shiplap Edge. 90° Elbow.)

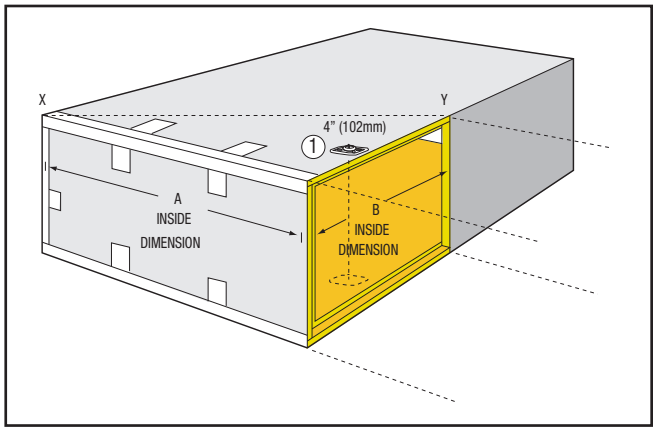
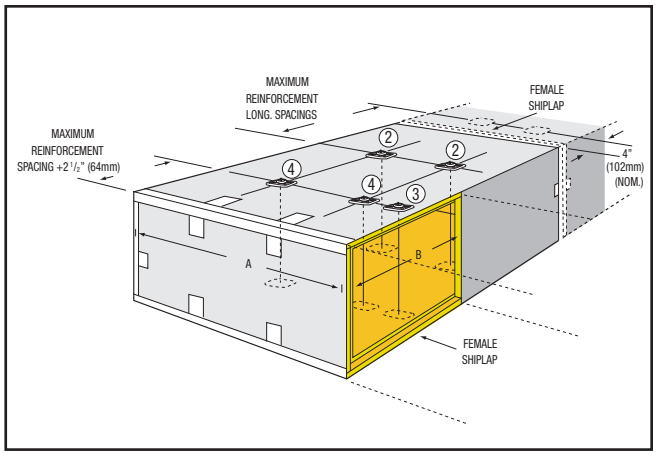


Fig. 5-14B. Tie Rod Reinforcement, Cheek Panels, Large 90° Elbows

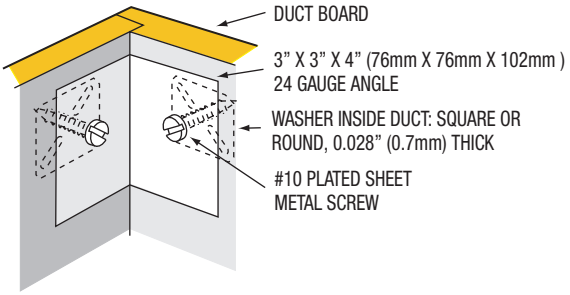


90° Elbows – Shiplap Construction Heel and Throat Panels – Positive Pressure

NOTE: Some elbows may require reinforcement even though schedules for straight ducts of the same dimension may show reinforcement is not required.

If duct dimension according to Table 5-8 does not require reinforcement but is 24" (610mm) or greater, install sheet metal angle per (1), Fig. 5-15A and detail (A) below. The angle may also be installed on the inside of the throat.

DETAIL (A) THROAT REINFORCEMENT

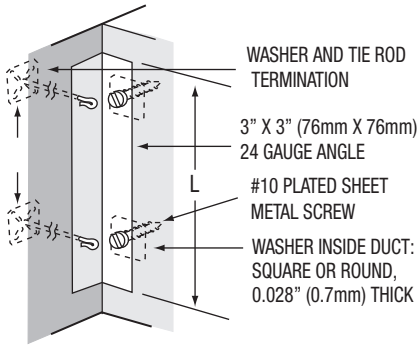


NOTE: Attachment of angles is best done after closure is completed. This requires sections to be short enough to allow the installer to reach inside to install the washers.

When duct dimension normally requires reinforcing, install a 24 gauge sheet metal angle per (2), Fig. 5-15B, and detail (B) below. Install tie rods through the angle on the upstream side, 16" (406mm) on centers, in accordance with Table 5-1, with angle length as indicated from table below.

No. tie rods	1	2	3	4	5
Angle length L, in. (mm)	4 (102)	20 (508)	36 (914)	52 (1,321)	68 (1,727)

DETAIL (B) THROAT REINFORCEMENT



Install 3" (76mm) channel reinforcement on the heel panels per (3), Fig. 5-15B, and per Table 5-8 and Fig. 5-13.

For reinforcement of mitered elbows, refer to page 5-13 using reinforcement standards for wrap-around reinforcements.

Fig. 5-15A. Sheet Metal Angle Reinforcement at Throat, 90° Elbow

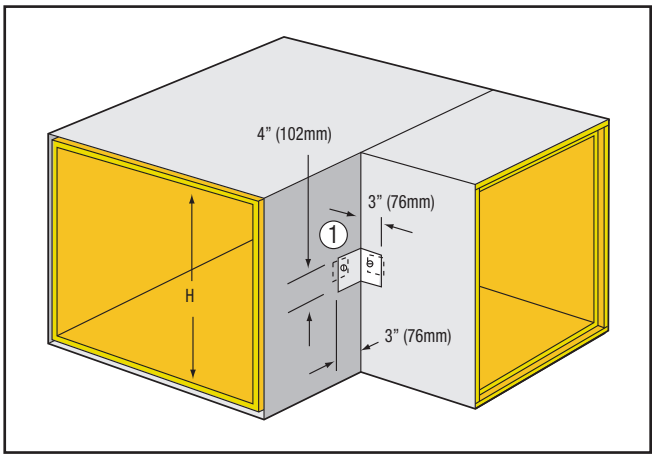
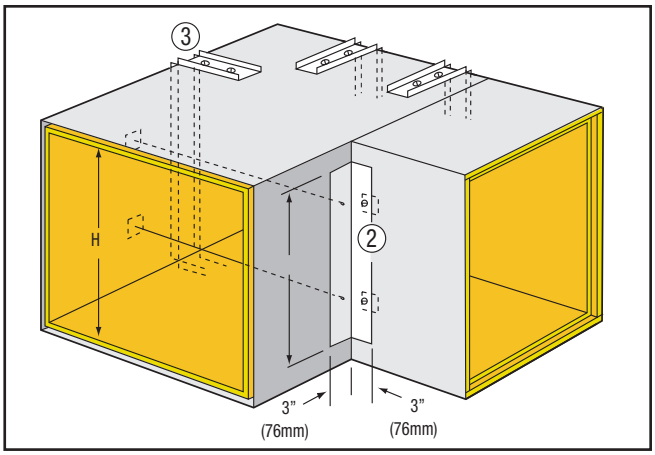


Fig. 5-15B. Sheet Metal Angle Reinforcement at Throat, Large 90° Elbow



Branch Connections – Connection Reinforcement – Positive Pressure (See Page 5-17 for Trunk Duct Reinforcement)

NOTE: Some branches may require reinforcement even though schedules for straight ducts of the same dimensions may show reinforcement is not required.

The branch height H should be equal to the height of the trunk section; this avoids the need to reinforce the top of the branch. A transition can then be used to reduce the branch to the desired size.

Angled branches and positive take-offs may also be reinforced generally following these standards.

If the branch height H is not greater than 16” (406mm) and the branch width W is greater than half the maximum unreinforced duct dimension (MUDD), reinforce the top of the branch per (1), Fig. 5-16A and Detail (A), page 5-15.

NOTE: Attachment of angles to trunk and branch ducts is done after closure is completed. This requires the use of a short branch to allow the installer to reach inside to install the washers.

If the branch height H is greater than 16” (406mm) and the branch width W is less than the maximum unreinforced duct dimension (MUDD), reinforce both sides of branch per (2), Fig. 5-16B, and Detail (B), page 5-15.

If the branch height H is greater than 16” (406mm) and the branch width W is greater than the maximum unreinforced duct dimension (MUDD), reinforce per (3), Fig. 5-16C, Detail (B), page 5-15, and Table 5-1.

For angle length, see table below.

No. Tie Rods	1	2	3	4	5
Angle Length, in. (mm)	4 (102)	20 (508)	36 (914)	52 (1,321)	68 (1,727)

Fig. 5-16A. Sheet Metal Angle Reinforcement, Top of Branch

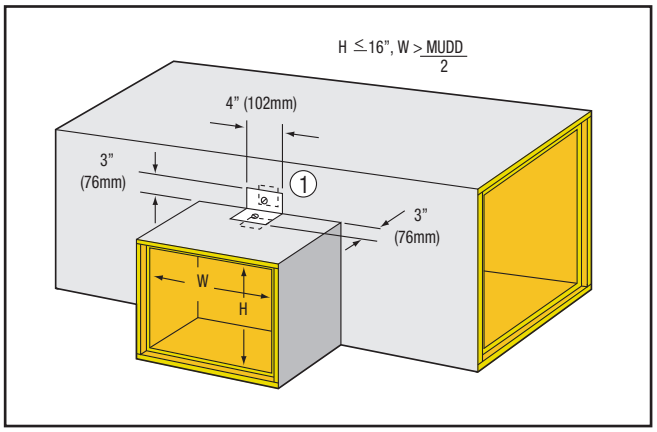


Fig. 5-16B. Sheet Metal Angle Reinforcement, Sides of Branch

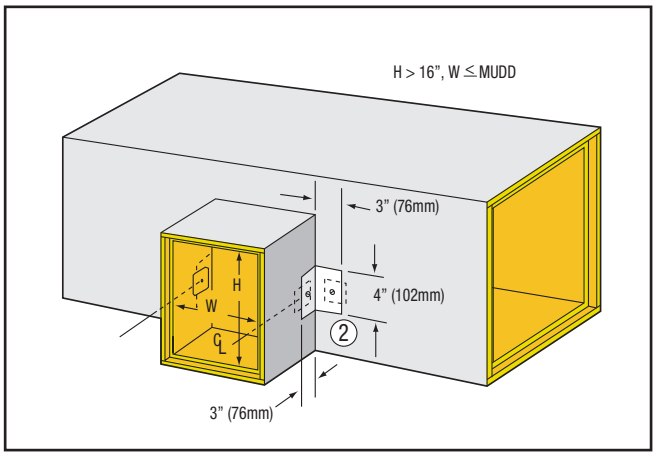
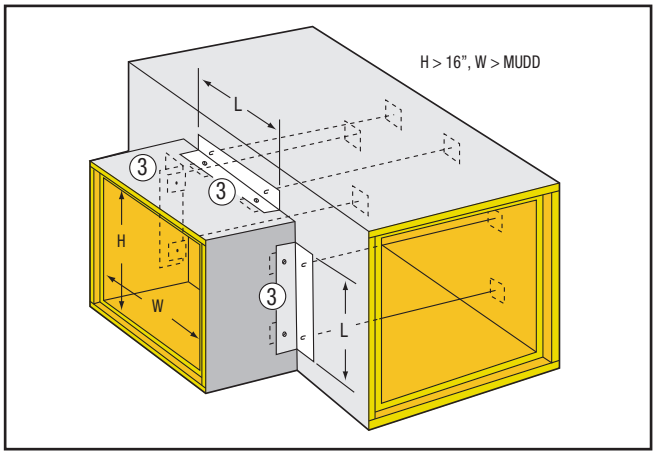


Fig. 5-16C. Sheet Metal Angle Reinforcement, Top and Sides of Branch

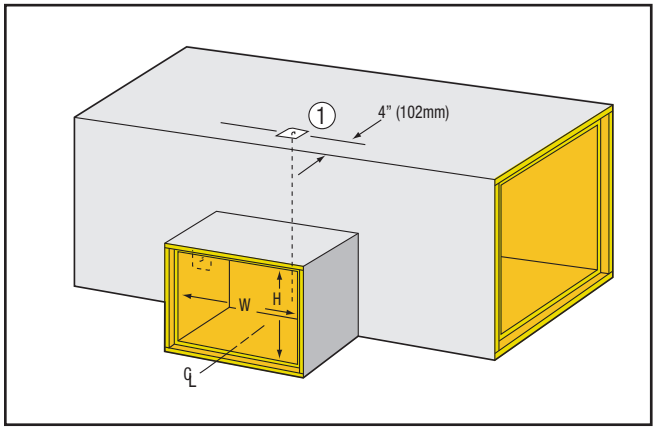


Branch Connections – Trunk Duct Reinforcement – Positive Pressure (See Page 5-16 for Branch Reinforcement)

NOTE: Some branches may require reinforcement even though schedules for straight ducts of the same dimensions may show reinforcement is not required.

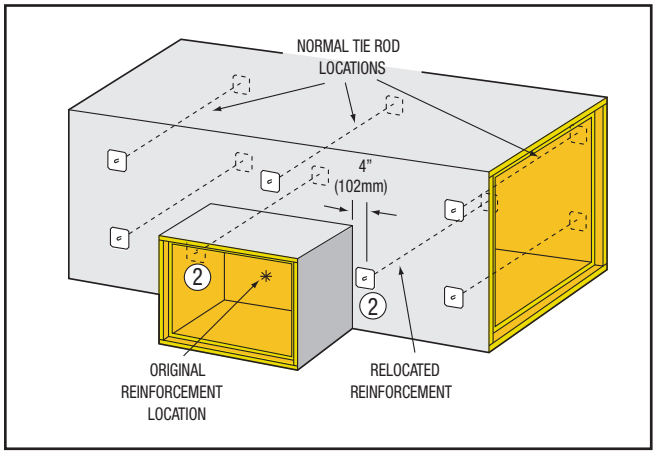
If the branch width W is greater than one half the maximum unreinforced duct dimension but not greater than the maximum unreinforced duct dimension (MUDD), reinforce per (1), 4" (102mm) off the female shiplap.

Fig. 5-17A. Trunk Duct Reinforcement 4" (102mm) Off Female Shiplap



If the branch is located so that it interferes with the normal tie rod locations per Table 5-1, install the tie rods 4" (102mm) from both sides of the branch opening per (2), Fig. 5-17B.

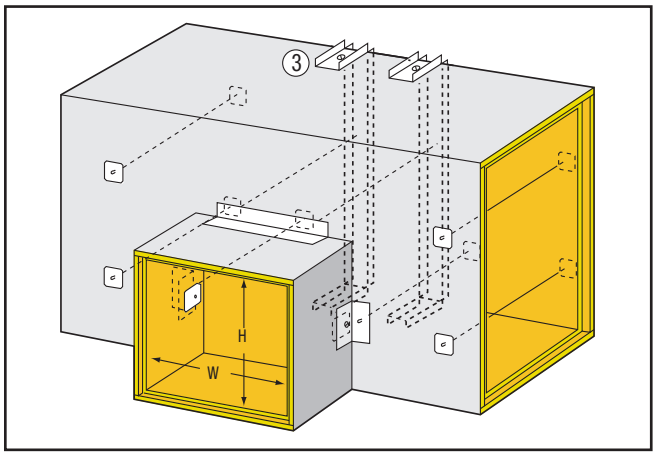
Fig. 5-16B. Sheet Metal Angle Reinforcement, Sides of Branch



If the branch width W is greater than the maximum longitudinal reinforcement spacing of the trunk duct, and/or the branch height H is greater than 16" (406mm), reinforce the tie rods per (3) and by using the wrap around channel, Fig. 5-17C and Table 5-8.

NOTE: Attachment of channels to the trunk ducts is done after closure is completed. This requires the use of a short branch to allow the installer to reach inside to install the square washers. Channels may also be wrapped around the rear corners of the trunk duct to make attachment easier.

Fig. 5-17C. Trunk Duct Reinforcement With 3" (76mm) Channels



Tees – Cheek Panels – Positive Pressure (See page 5-19 for Heel and Throat Panel Reinforcement)

NOTE: Some tees may require reinforcement even though schedules for straight ducts of the same dimension may show reinforcement is not required.

If A is less than the maximum unreinforced duct dimension (MUDD) but diagonals X-Y or Y-Z exceed the maximum allowable unreinforced duct dimension, install the tie rods per (1), Fig. 5-18A, from the female shiplap. (See Table 5-2.)

NOTE: Turning vanes have been omitted for clarity.

If A is greater than the maximum unreinforced duct dimension and B is greater than half the maximum unreinforced duct dimension (MUDD), install the tie rods in the trunk section per Table 5-2 from the female shiplap joints (see (2), Fig. 5-18B) and also along the branch and trunk center lines spaced per (3) Fig. 5-18B.

Where a splitter damper interferes with the tie rod reinforcement, wraparound channels must be used in their place.

NOTE: Turning vanes do not replace reinforcement.

Fig. 5-18A. Tee Reinforcement at Female Shiplap Joints

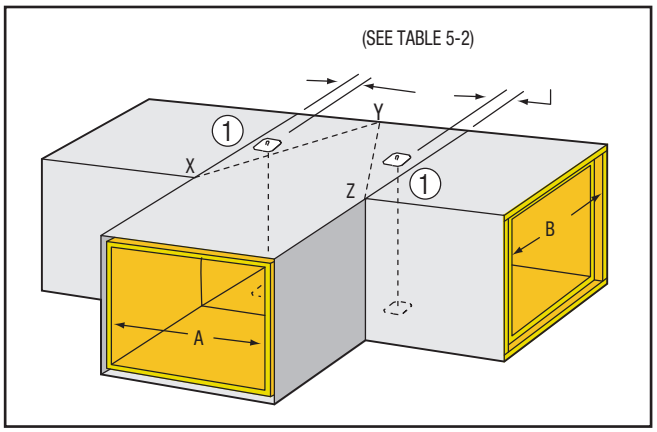
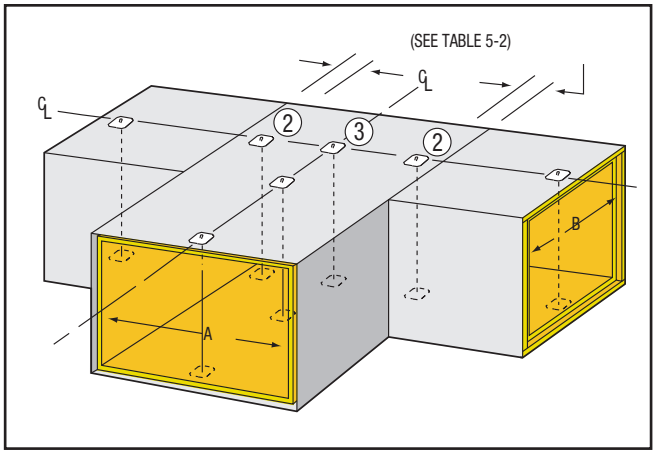


Fig. 5-18B. Tee Reinforcement, Normal Tie Rod Locations



Tees – Heel and Throat Panels – Positive Pressure (See Page 5-18 for Cheek Panel Reinforcement)

NOTE: Some tees may require reinforcement even though schedules for straight ducts of the same dimension may show reinforcement is not required.

If the channel height H is less than the maximum unreinforced duct dimension (MUDD), but 24" (610mm) or greater, reinforce per detail (1), Fig. 5-19A and detail (A), page 5-15. Reinforcement is not required at the heel.

NOTE: Attachment of angles to the trunk and branches is done after closure is completed. This requires the use of a short branch to allow the installer to reach inside to install the 2½" (64mm) washers.

If the channel height H is greater than the maximum unreinforced duct dimension (MUDD), install 3" x 3" (76mm x 76mm) 24 gauge angle, length from the table below, with tie rods spaced per Table 5-1. (See (2), Fig. 5-19B.)

No. Tie Rods	1	2	3	4	5
Angle Length, in. (mm)	4 (102)	20 (508)	36 (914)	52 (1,321)	68 (1,727)

Install 3" (76mm) channels on the heel at the female shiplaps and where required to maintain reinforcement spacing per Table 5-4. See (3), Fig. 5-19B, and detail (A), page 5-13.

Fig. 5-19A. Tee Reinforcement With 3" x 3" x 4" (76mm x 76mm x 102mm) Sheet Metal Angle at Throat

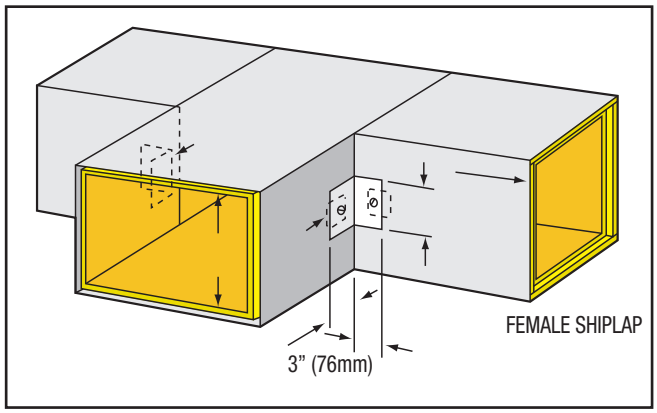
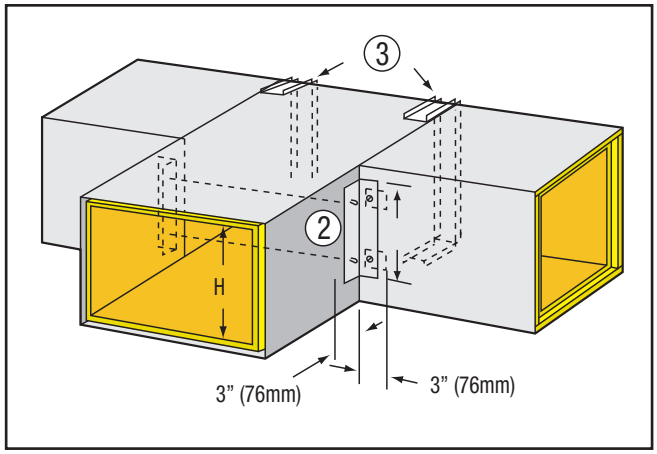


Fig. 5-19B. Tee Reinforcement With Throat Angles and Heel Channels

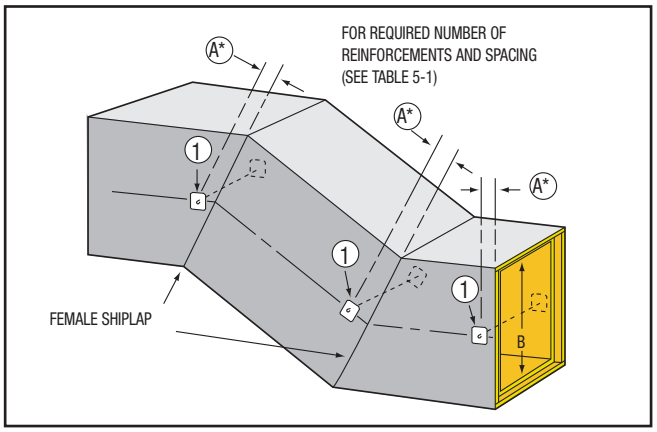


Offsets – Cheek Panels – Positive Pressure (See Page 5-21 for Heel and Throat Panel Reinforcement)

NOTE: Some offsets may require reinforcement even though schedules for straight ducts of the same dimensions may show reinforcement is not required.

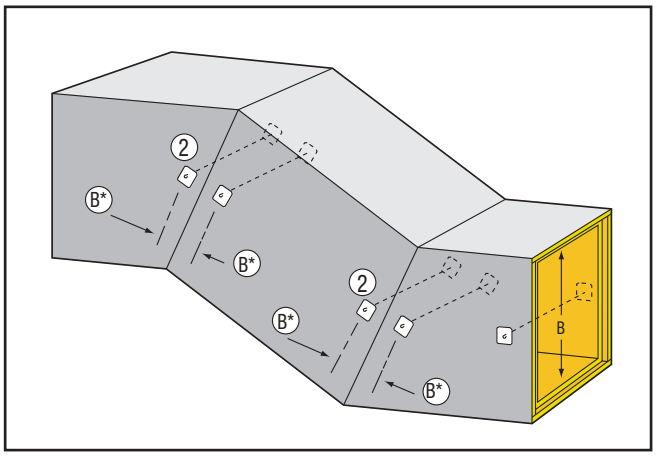
If B is greater than the maximum unreinforced duct dimension (MUDD) and the cheek panels have shiplap joints, reinforce per (1), Fig. 5-20A, 4" per Table 5-2. From female shiplap, spacing per Table 5-1.

Fig. 5-20A. Offset Reinforcement, Cheek Panels With Shiplap Joints



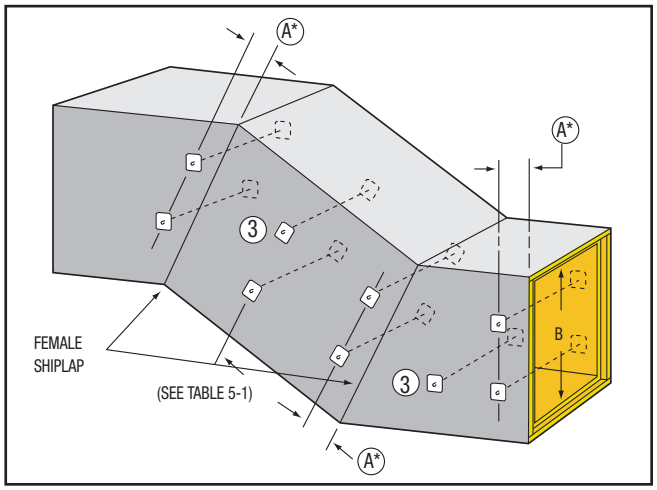
If B is greater than the maximum unreinforced duct dimension (MUDD) and the cheek panels have butt joints, install reinforcement at butt joints per (2), Fig. 5-20B. For details, (See Fig. 5-5B, page 5-5.)

Fig. 5-20B. Offset Reinforcement, Cheek Panels With Butt Joints



If B is greater than the maximum unreinforced duct dimension (MUDD) and cheek panels are shiplapped, install additional tie rods along lines parallel to the panel edges per (3), Fig. 5-20C, and Table 5-1. The tie rods must be at locations per Table 5-2.

Fig. 5-20C. Offset Reinforcement, Tie Rods Along Lines Parallel to Cheek Panel Edges



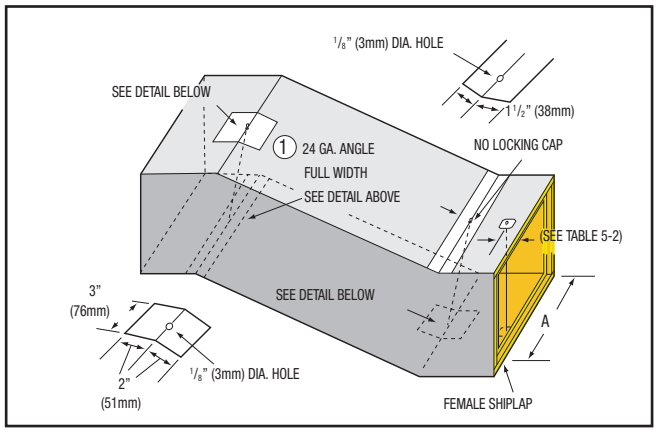
*(A) For spacing from shiplap, see Table 5-2.
*(B) For placement from butt edge, see Table 5-3.

Offsets – Heel and Throat Panels – Positive Pressure (See Page 5-20 for Cheek Panel Reinforcement)

NOTE: Some offsets may require reinforcement even though schedules for straight ducts of the same dimensions may show reinforcement is not required.

If A is greater than the maximum unreinforced duct dimension (MUDD), reinforce per (1), Fig. 5-21A.

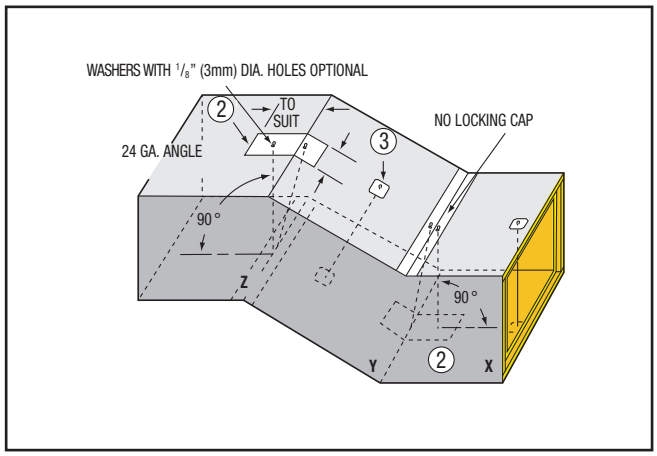
Fig. 5-21A. Offset Reinforcement With Sheet Metal Plates and Tie Rods



If dimension X-Y is greater than the maximum longitudinal reinforcement spacing, install additional tie rods per (2), Fig. 5-21B.

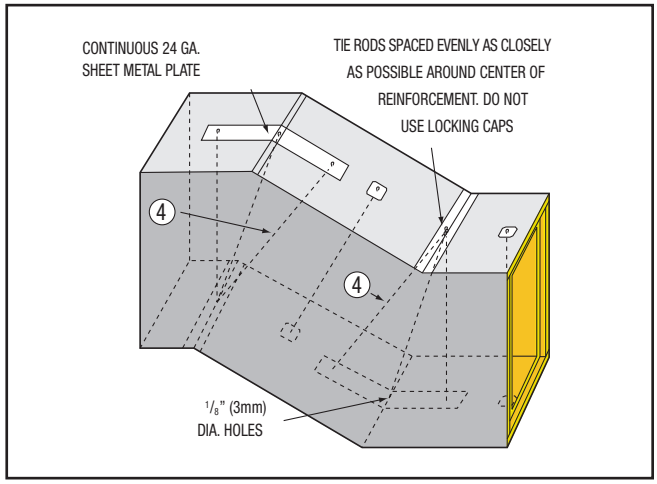
If dimension Y-Z is greater than the maximum longitudinal reinforcement spacing, install additional tie rods per (3), Fig. 5-21B, and Table 5-1 to maintain required spacing.

Fig. 5-21B. Offset Reinforcement With Tie Rods Through Throat



If the spacing between any two tie rods exceeds the maximum longitudinal reinforcement spacing, install intermediate tie rods through the throat per (4), Fig. 5-21C.

Fig. 5-21C. Offset Reinforcement, Intermediate Tie Rods and Extended Sheet Metal Plates

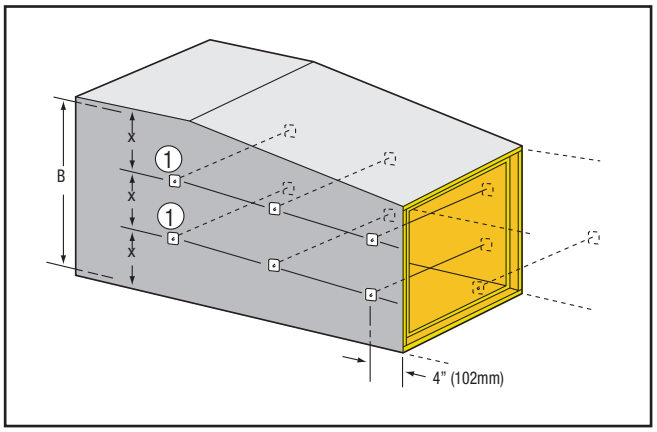


Transitions – Cheek Panels – Positive Pressure

NOTE: Some transitions may require reinforcement even though schedules for straight ducts of the same dimensions may show reinforcement is not required.

If B is greater than the maximum unreinforced duct dimension (MUDD), reinforce per (1), Fig. 5-22A, and Table 5-1. Determine the tie rod spacing from the larger duct dimension per Table 5-1. Maintain the spacing and the number of tie rods throughout the length of transition.

Fig. 5-22A. Transition Reinforcement, Cheek Panels



Transitions – Sloped Panels – Positive Pressure

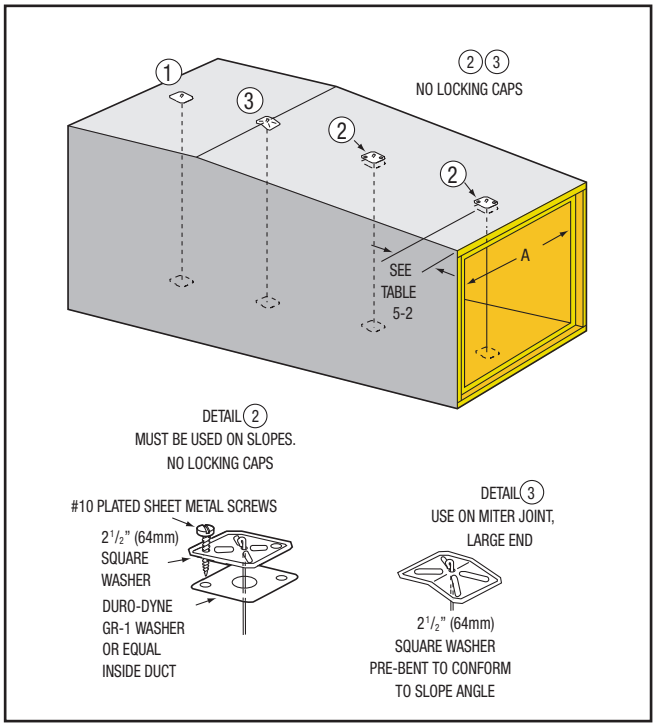
If A is greater than the maximum unreinforced duct dimension (MUDD), reinforce per (2), Fig. 5-22B, and Table 5-2, from the female shiplap. Continue with reinforcement per the Table 5-1 schedule, Fig. 5-22B, and Detail (2).

NOTE: Where the slope meets the large end and the facing is not cut, a 2½" (64mm) square washer pre-bent to conform to the slope angle may be used to secure tie rods. See Detail (3), Fig. 5-22B.

If the facing is cut, use a 3" x 4" (76mm x 102mm) 24 gauge sheet metal plate bent to conform to the transition angle.

Tie rod terminations on sloped panels must be made with fasloop terminations. They may not be made using the locking cap method.

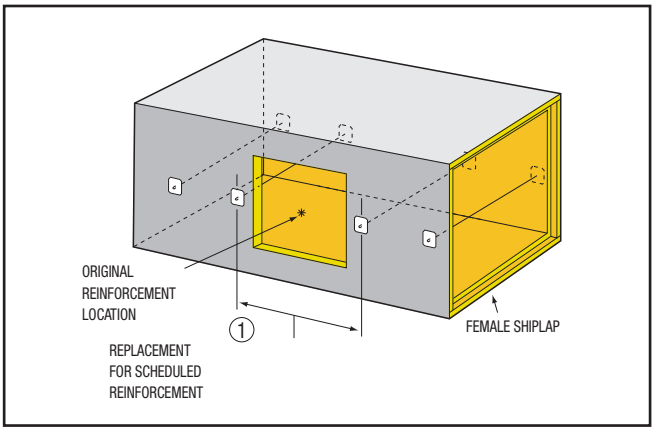
Fig. 5-22B. Transition Reinforcement, Sloping Section



Access Door Openings – Positive Pressure

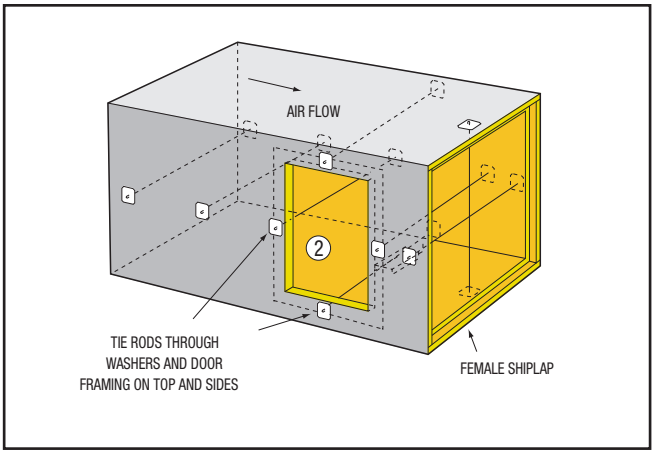
If the access door opening width is not greater than the maximum longitudinal reinforcement spacing from Table 5-1 but interferes with the reinforcement locations per Table 5-1, install the tie rods 4" (102mm) from both sides of the door opening per (1), Fig. 5-23A. Maximum reinforcement spacing must be in accordance with Table 5-1.

Fig. 5-23A. Access Door Location Interfering With Original Reinforcement Location



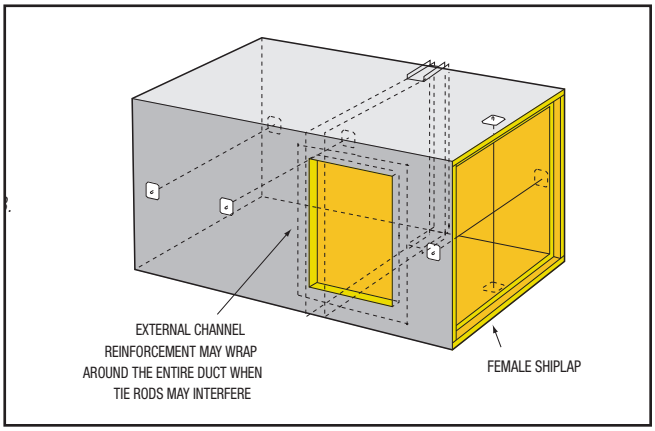
If the access door opening height is greater than 16" (406mm) and the width is greater than the maximum longitudinal reinforcement spacing as shown in Table 5-1, frame the inside per (2), Fig. 5-23B. (See Section III, pages 3-28 and 3-29.) Install the tie rods near the vertical sides of the door frame per the spacing in Table 5-1, with 2½" (64mm) square or 3" (76mm) round washers outside the duct. Install the tie rods near the horizontal sides of the frame per spacing in Table 5-1, measuring upstream from the vertical tie rod location.

Fig. 5-23B. Reinforcement of Access Door Framing



See Fig. 5-23C channel reinforcement in place of the tie rods between the access door and the fire damper where the tie rods would interfere with the damper access or operation.

Fig. 5-23C. Channel Reinforcement. See Page 5-13



End Caps – Shiplap Construction

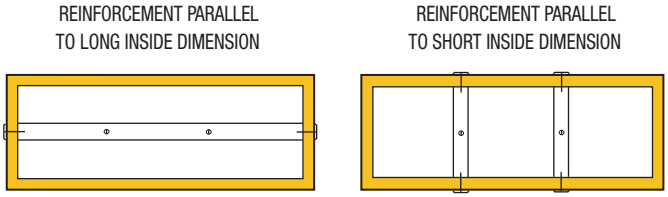
CHANNEL REINFORCEMENT — POSITIVE OR NEGATIVE PRESSURE

NOTE: End caps require reinforcement whenever the schedule for straight ducts of the same dimension shows reinforcement is required.

Channel reinforcement must be installed on the inside of the duct to enable the end cap to withstand the static and velocity pressures to which it will be subjected.

(See Table 5-4 for reinforcement channel height H and Table 5-8 for channel L.) (See Table 5-8 for longitudinal spacing and the number of attaching screws for the applicable duct span and the static pressure.)

NOTE: End cap reinforcement may be applied either parallel to the longest inside dimension or parallel to the shortest, depending on the sheet metal and fastener usage required.



Staple and tape the end cap in place. (See Section IV, Closure.)

Fig. 5-24A. End Cap Channel Reinforcement

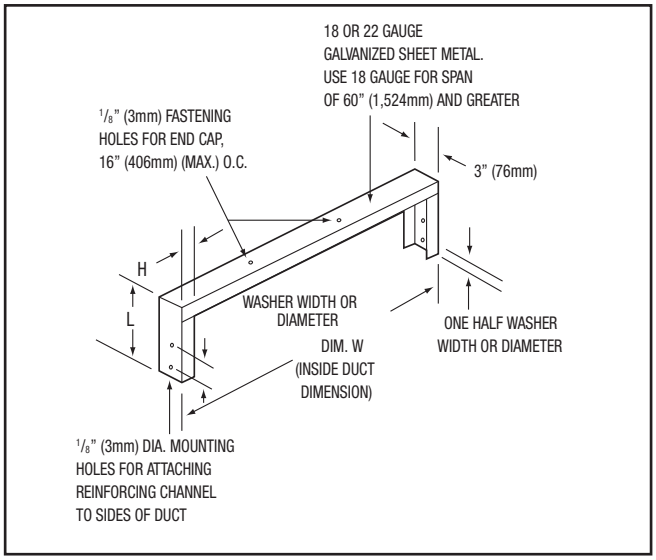
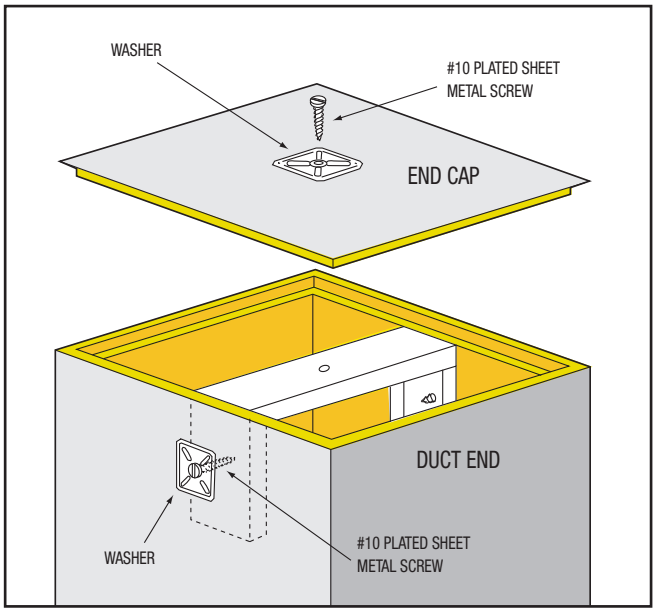


Fig. 5-24B. End Cap Channel Reinforcement Installed in Duct Section



Section VI
Hanging and Supports

Hanging and Supporting Fibrous Glass Duct Systems

Fibrous glass ducts are light in weight and, to a large degree, self-supporting. They can be supported with a minimum number of hangers if care is taken as to the placement of the supports. NAIMA has conducted a study to determine the proper placement of supports for horizontal and vertical straight duct modules as well as fittings. The support techniques recommended in this Standard were demonstrated to be able to sustain static loads equivalent to three times the duct module weight. During the testing, twice the duct weight was placed in the most critical position, at the mid-point between supports.

Other hanging systems may work equally well. However, it must be demonstrated that alternative methods can provide the same load-bearing capability without undue stress to either the hanger or the fibrous glass duct system. Use of alternative methods without careful consideration of the long term stability of the technique is discouraged.

The charts and examples illustrated in this section show that the hanger treatment and spacing required depends on duct dimensions. Channels suspended trapeze-style using 12 gauge (minimum) hanger wire are the preferred method of support. Channel gauge and profile vary with duct size. In no case should the supporting channel be less than 2" (51mm) wide for rectangular fibrous glass ducts.

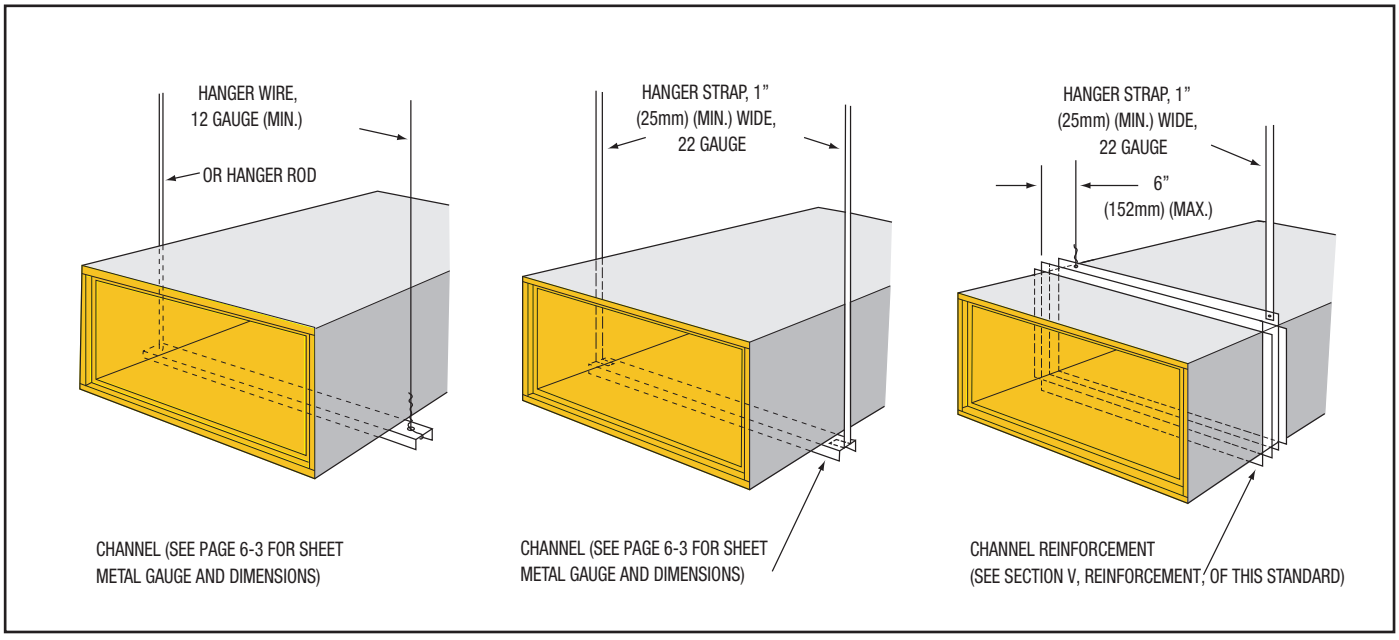
When channel reinforcement members occur within the maximum hanger spacing as shown on pages 6-3 and 6-4, sheet metal straps may be attached to the channel reinforcement as shown in Fig. 6-2. Unless local codes prohibit, 12 gauge (minimum) hanger wire may be used in place of hanger strap.

The illustrations below provide examples of proper support configurations for rectangular fibrous glass ducts.

Recommendations for hanging and support of ten sided and rigid round fibrous glass ducts may be found on page 6-8. Recommendations for hanging and support of flexible duct may be found on page 6-9.

Hanging fibrous glass duct systems in humid climates: In high humidity areas, duct systems must be suspended or elevated at least 1" (25mm) above the ceiling insulation.

Fig. 6-2. Approved Hanger Configurations for Rectangular Fibrous Glass Ducts



Standard 3” (76mm) Hangers for Rectangular Ducts

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

TABLE 6-1. CHANNEL SELECTION

IF TOTAL EXTENSION IS NO GREATER THAN:	MINIMUM CHANNEL GAUGE	MINIMUM CHANNEL PROFILE
6” (152mm)	24	3” x 1½” (76mm x 38mm)
18” (457mm)	22	3” x 2” (76mm x 51mm)
30” (762mm)	18	3” x 2” (76mm x 51mm)

USE OF 2” (51MM) WIDE HANGERS

22 gauge, 2” x 1½” (51mm x 38mm) hangers may be substituted for 3” (76mm) hangers for ducts not over 48” (1,219mm) wide and 24” (610mm) high. 2” (51mm) hangers must be spaced at 48” (1,219mm) (max.) intervals.

Fig. 6-3A. Hanger Spacing and Extension, 3” (76mm) Wide Channels

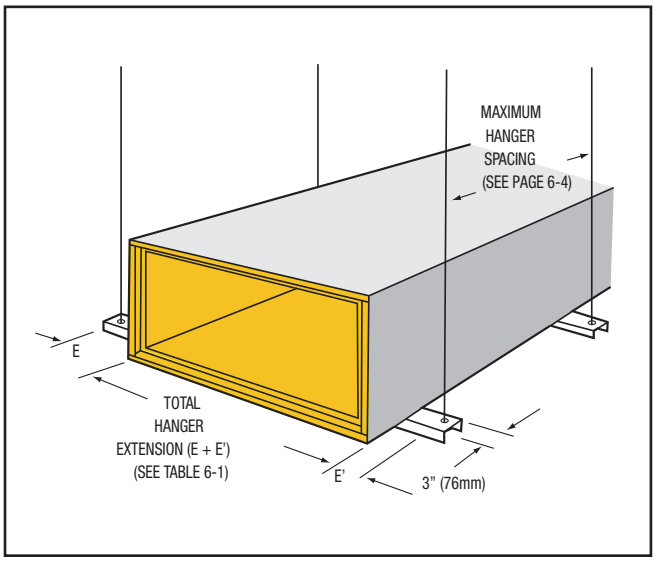


Fig. 6-3B. Use of 2” (51mm) Wide Hanger Channels for Ducts of Less Than 48” (1,219mm) Width x 24” (610mm) Height

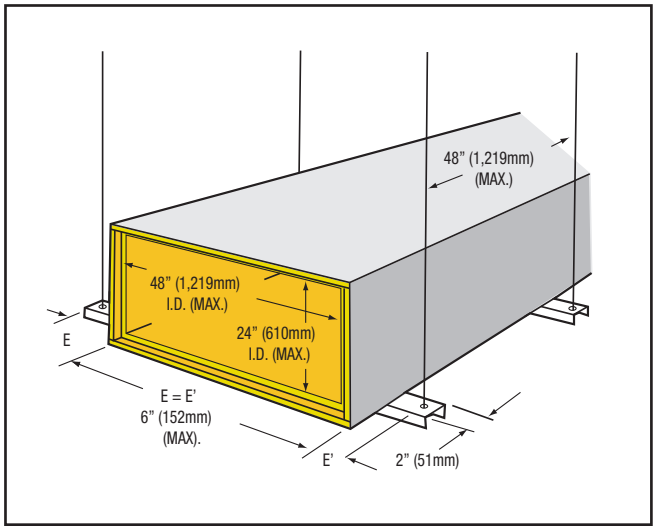


Fig. 6-4. Maximum Hanger Spacing Chart for Straight Duct, 3” (76mm) Wide Channel

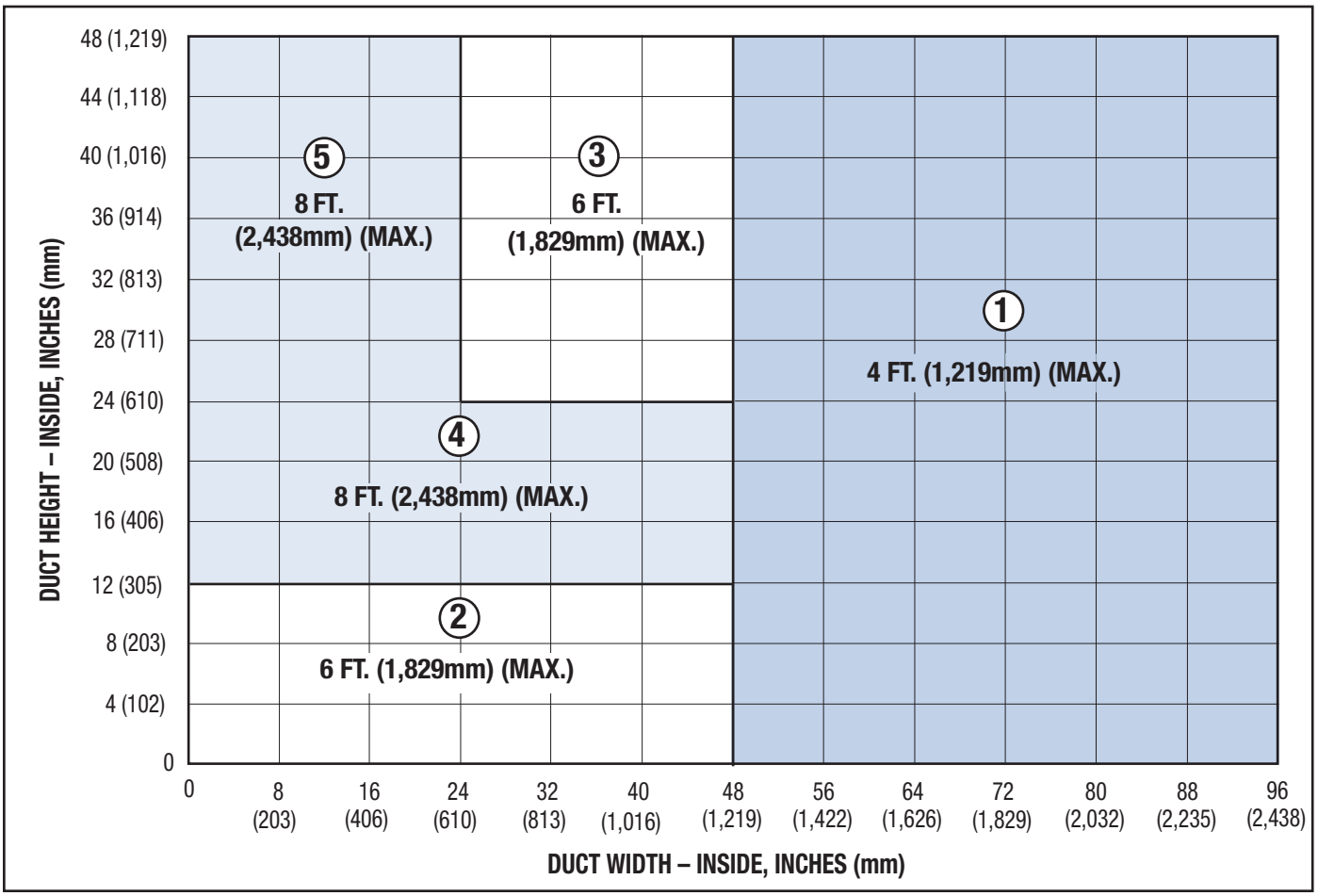


TABLE 6-2. MAXIMUM HANGER SPACING BY DUCT SIZE

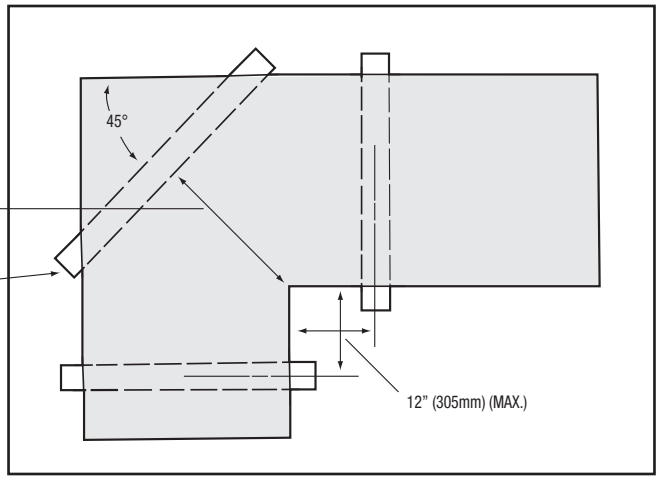
DUCT SIZE, INCHES (mm)				MAXIMUM HANGER SPACING
①	Width	48” (1,219mm)	or greater	4 ft. (1,219mm)
②	Width Height	< 48” (1,219mm) < 12” (305mm)		6 ft. (1,829mm)
③	Width Height	≥ 24” (610mm) ≥ 24” (610mm)	and < 48” (1,219mm)	6 ft. (1,829mm)
④	Width Height	< 48” (1,219mm) ≥ 12” (305mm)	and < 24” (610mm)	8 ft. (2,438mm)
⑤	Width Height	≤ 24” (610mm) ≥ 12” (305mm)		8 ft. (2,438mm)

Hanging Fibrous Glass Duct Fittings Up to 48” (1,219mm) in Width

Two thirds of the diagonal distance from throat to heel (approximately).

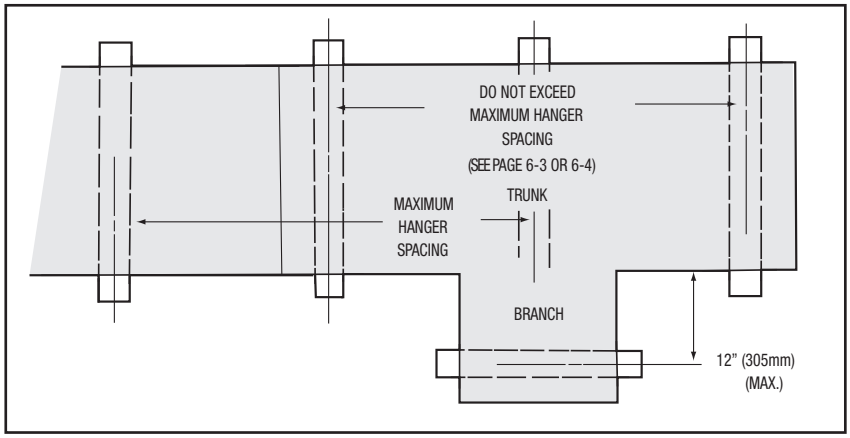
Required only when the duct is greater than 18” (457mm) in width.

Fig. 6-5A. Elbow Support



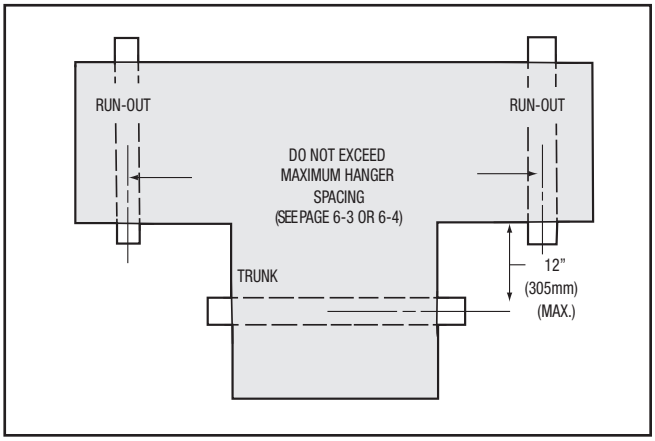
If the trunk duct hanger falls where a branch duct is located, add trunk hangers on either side of the branch duct. Do not exceed the maximum hanger spacing. (See page 6-3 or 6-4.)

Fig. 6-5B. Branch Support



If a tee run-out hanger falls where the trunk duct is located, add run-out hangers on either side of the trunk. Do not exceed the maximum hanger spacing. (See page 6-3 or 6-4.)

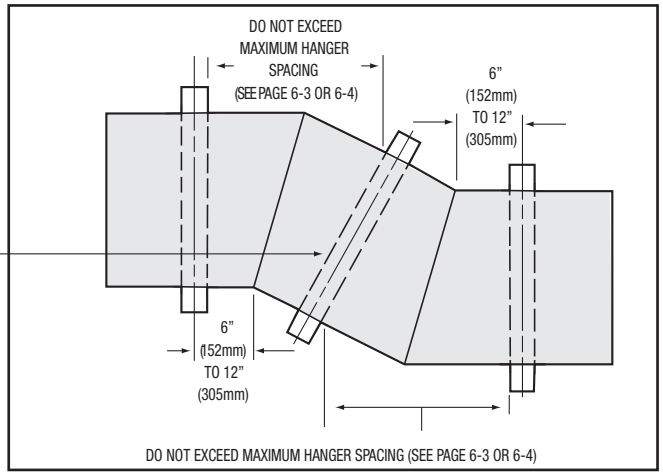
Fig. 6-5C. Tee Support



Hanging Fibrous Glass Duct Fittings Up to 48” (1,219mm) in Width

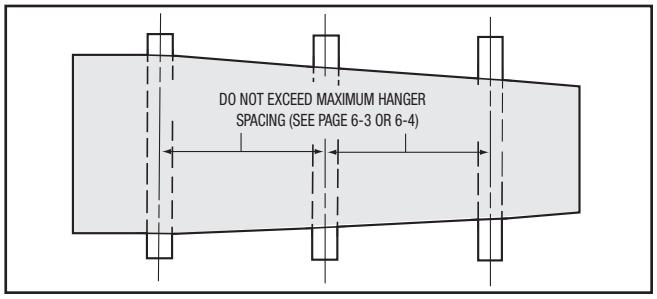
Required only when angled portion of offset is greater than 48” (1,219mm) long. Additional hangers may be required to comply with spacing. (See page 6-3 or 6-4.)

Fig. 6-6A. Offset Support, Flat Bottom Surface



Locate hangers as for straight duct. Use the closest spacing specified. (See page 6-3 or 6-4.)

Fig. 6-6B. Transition Support, Flat Bottom Surface



Required only when the inclined portion of the duct is greater than 48” (1,219mm). The hanger is attached to the duct per Fig. 6-6D. Additional hangers may be required to comply with the hanger spacing. (See page 6-3 or 6-4.)

Fig. 6-6C. Supporting Offsets and Transitions With Inclined Bottom Surfaces

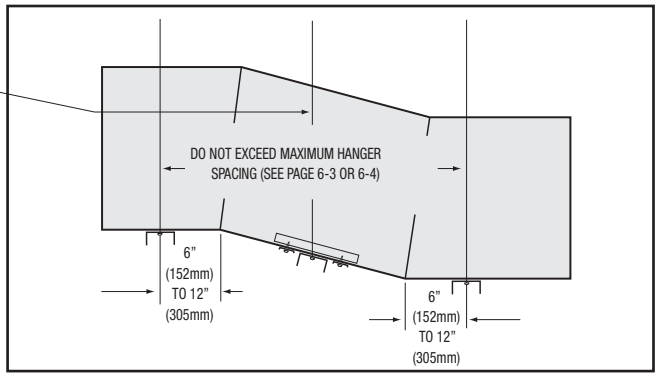
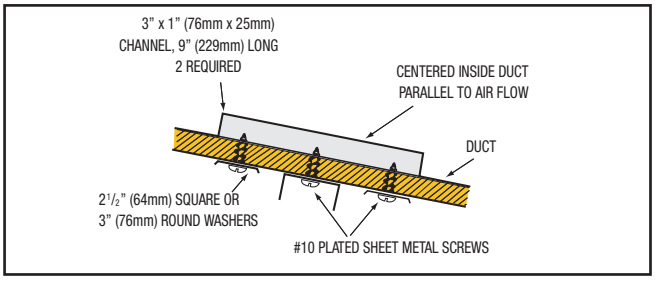


Fig. 6-6D. Detail, Support at Inclined Bottom Surface

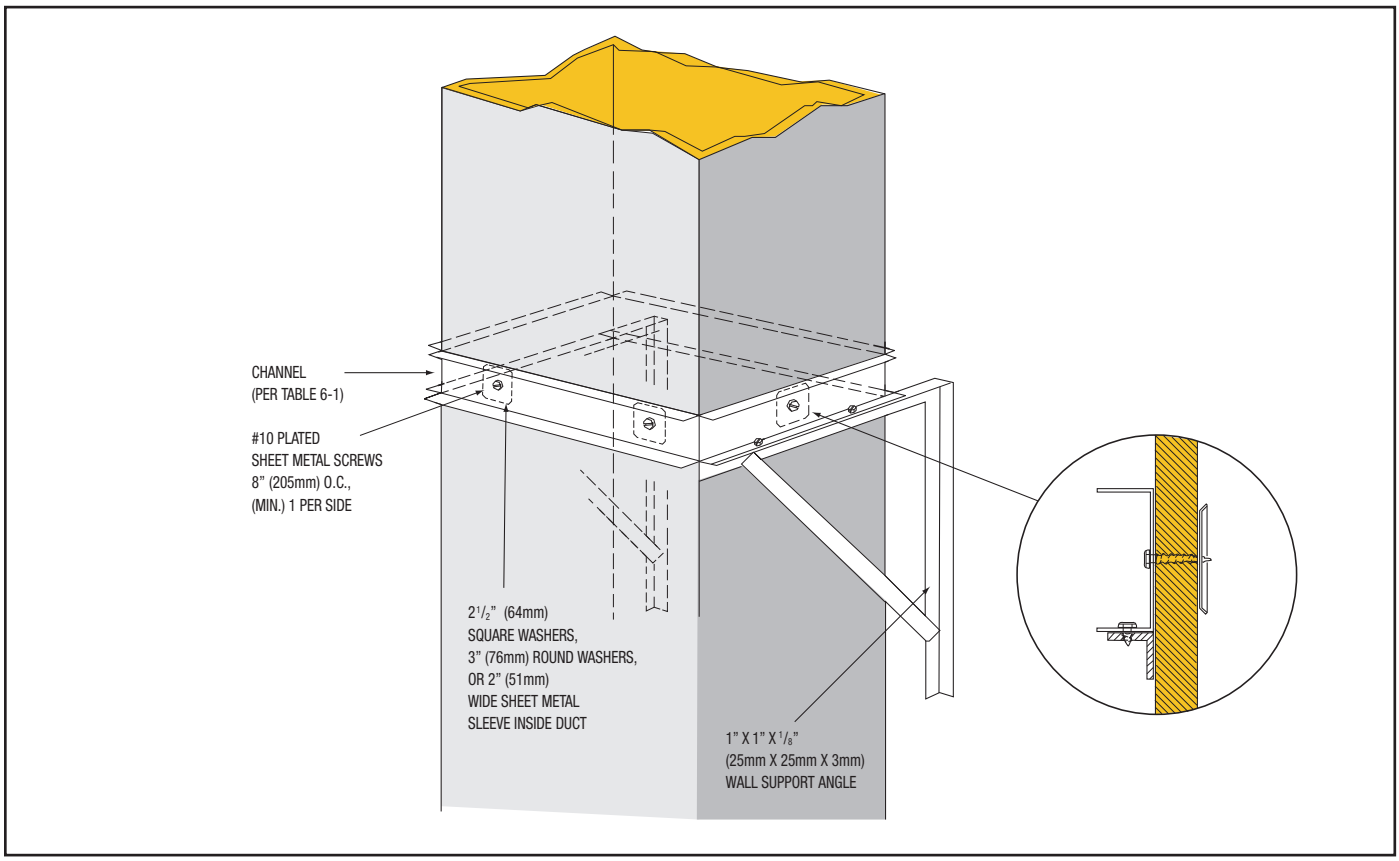


Vertical Riser Support

Risers in fibrous glass duct systems of 8 feet (2438mm) or greater require the use of a special support as shown in Fig. 6-7. This reinforcement and support are in addition to whatever reinforcement may be required by provisions of Section V, Reinforcement, of this Standard. Vertical riser supports shall be installed at maximum spacing intervals of 12 feet (3,658mm).

NOTE: Riser height is limited as stated in NFPA 90A "for vertical risers in air duct systems serving not more than two (2) stories."

Fig. 6-7. Vertical Riser Support



Hanging Ten-Sided and Preformed Round Duct

Ten-sided and preformed round fibrous glass ducts should be hung so that the hanger will not damage the duct facing. Straps or saddles in contact with the duct shall be 1½" (38mm) (minimum) wide. Avoid sharp edges and burrs. Hangers should be spaced on 8 feet (2.44m) centers (maximum). Where practical, hangers should be located at circumferential joints. Provide hanger support at all fittings.

Fig. 6-8A. Single Point Hanging of Ten-Sided and Preformed Round Fibrous Glass Duct

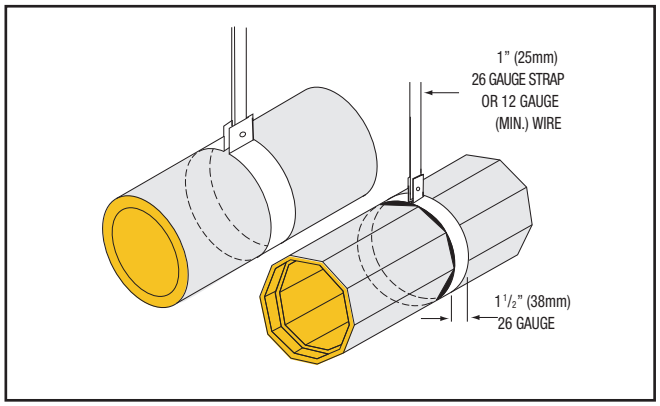


Fig. 6-8B. Hanging Ten-Sided and Preformed Round Fibrous Glass Duct With Saddles and Sheet Metal Straps

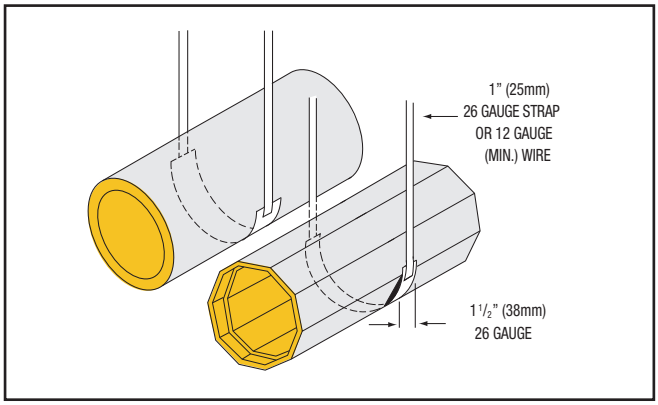
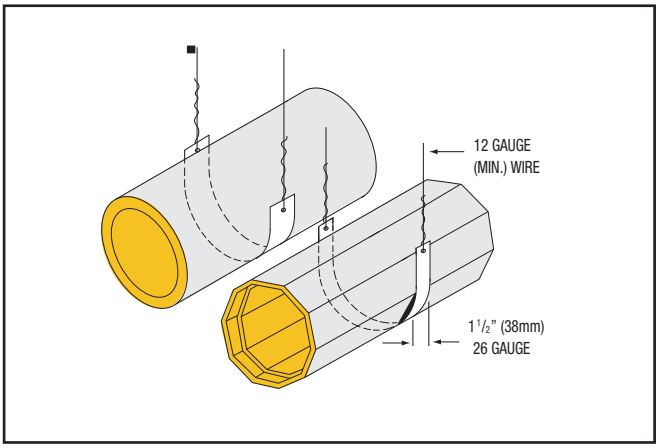


Fig. 6-8C. Hanging Ten-Sided and Preformed Round Fibrous Glass Duct With Saddles and Wire



Hanging and Supporting Flexible Duct

Flexible duct shall be supported at the manufacturers' recommended intervals but at no greater distance than 5 feet (1.52m) on centers. Maximum permissible sag is ½" per foot (42mm per meter) of spacing between supports. (See Fig. 6-9A.)

Connections to the rectangular fibrous glass duct shall be considered a support point. Long, horizontal duct runs with sharp bends shall have additional supports before and after the bend approximately one duct diameter from the centerline of the bend.

Hanger or saddle material in contact with the flexible duct shall be of sufficient width to prevent any restriction of the internal diameter of the duct when the weight of the supported section rests on the hanger or saddle material. In no case will the material contacting the flexible duct be less than 1½" (38mm) wide. (See Fig. 6-9B.)

Support the flexible duct between a connection to the rectangular ductwork and a bend by allowing the flexible duct to extend straight for a short distance before making the bend. This will avoid possible damage to the flexible duct by the edge of the sheet metal collar. (See Fig. 6-9C.)

Vertically installed flexible duct shall be stabilized by support straps located 6 feet (1.83m) on centers. (See Fig. 6-9D.)

NOTE: Fibrous glass ducts, including flexible duct, may not be used for vertical risers in air duct systems serving more than two stories.

NOTE: Information on this page has been taken from the Air Duct Council's *Flexible Duct Performance & Installation Standards.*

Fig. 6-9A. Support Flexible Duct Every 5 ft (1.52m) (Max.). Maximum Allowable Sag: ½" Per Foot (42mm Per Meter) of Support Spacing

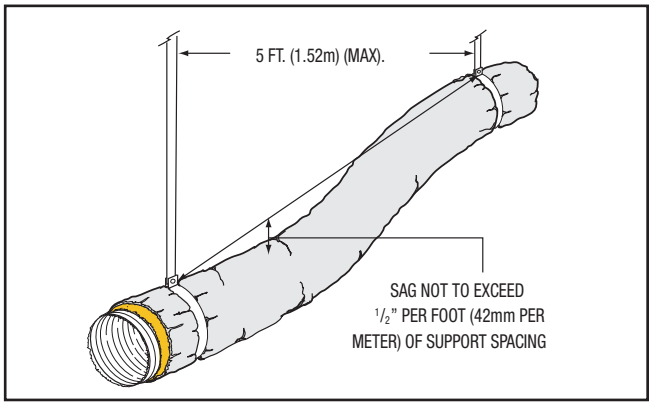


Fig. 6-9B. Hangers or Saddle Material Must Be at Least 1½" (38mm) Wide to Prevent Restriction of the Internal Diameter of the Flexible Duct.

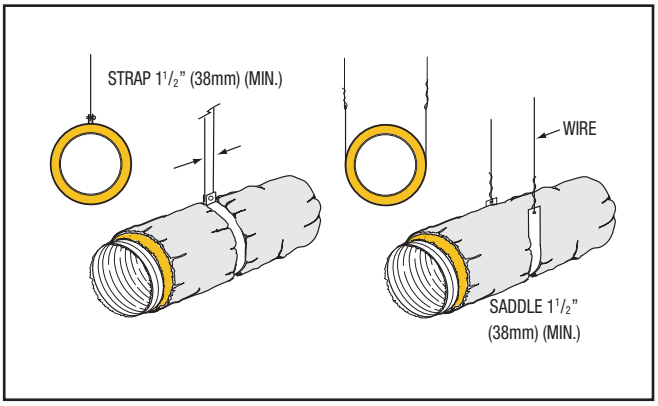


Fig. 6-9C. Support Flexible Duct Between Connection to Rectangular Duct and Bend

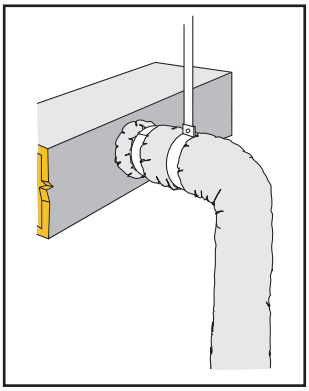
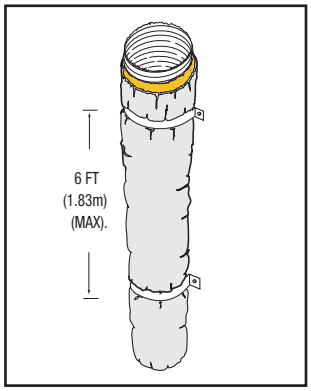


Fig. 6-9D. Vertical Ducts Shall Be Supported at 6 ft. (1.83m) (Max.) Intervals



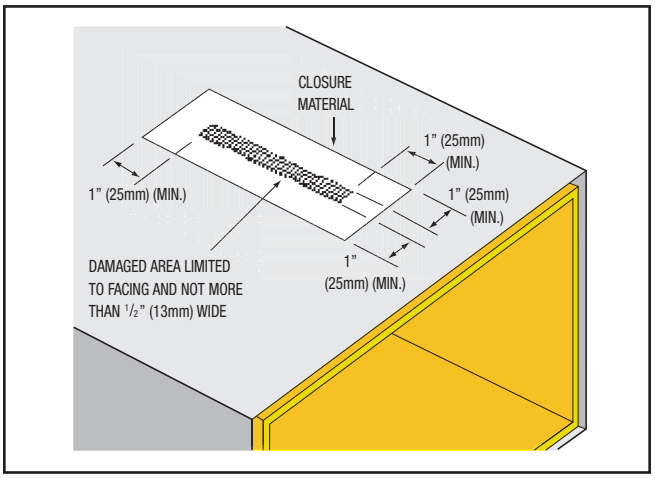
Section VII
Damage Repair

Repair of Small Facing or Closure Tears Without Loss or Damage to Insulation

If a facing tear is limited to just a straight slit, apply closure material in accordance with Section IV, Closure.

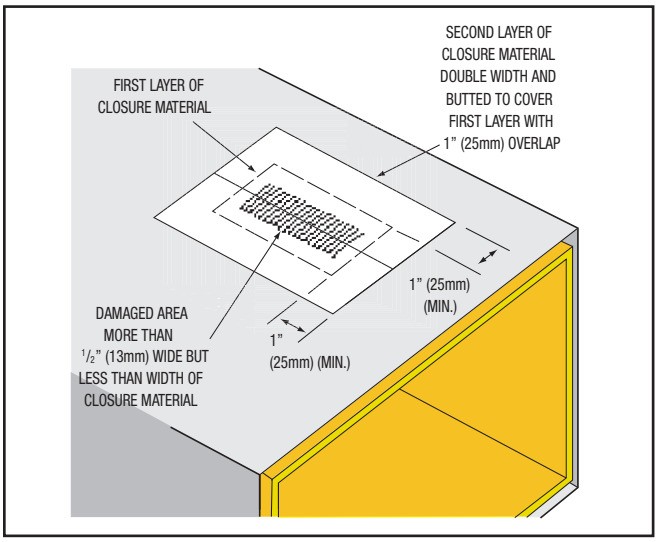
When facing damage is more than just a straight slit but is not greater than ½" (13mm) wide, repair as shown in Fig. 7-2A. Closure must extend beyond the tear at least 1" (25mm) on all sides of the tear.

Fig. 7-2A. Repair of Minor Facing Damage – Less Than ½" (13mm) Wide



When the facing damage is wider than ½" (13mm) but less than the width of the closure material, smooth the facing and repair as shown in Fig. 7-2B with double layer of material.

Fig. 7-2B. Repair of Minor Facing Damage – ½" (13mm) Wide or Greater



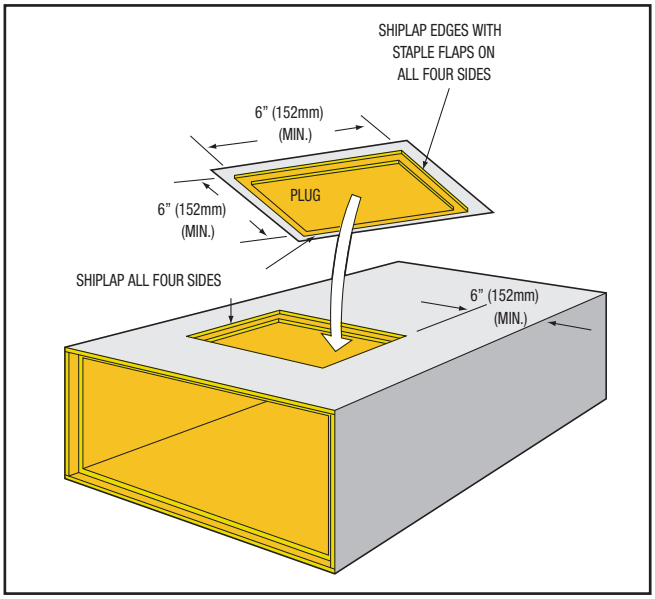
NOTES:

1. Use approved closure materials and methods only. Do not use heat-activated tape over either pressure-sensitive tape or glass fabric and mastic closure systems. (See Section IV, Closure.)
2. Restore any reinforcement members that may have been lost due to damage or removed to facilitate repair.

Repair of Major Damage to One Panel

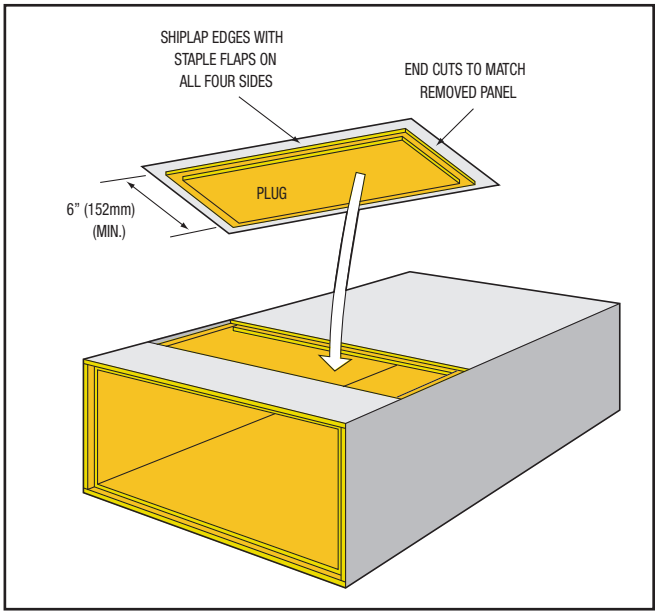
When the damage extends into the insulation and involves loss or severe displacement of material, repair per Fig. 7-3A. Staple and tape the plug on all four sides. (See Section IV, Closure.)

Fig. 7-3A. Repairing Major Damage to One Panel



If the damaged area extends to within 6" (152mm) of the edge, cut out and repair the entire width of the damaged panel per Fig. 7-3B. Staple and tape the plug on all four sides. (See Section IV, Closure.)

Fig. 7-3B. Repairing Major Damage Involving Entire Width of Panel



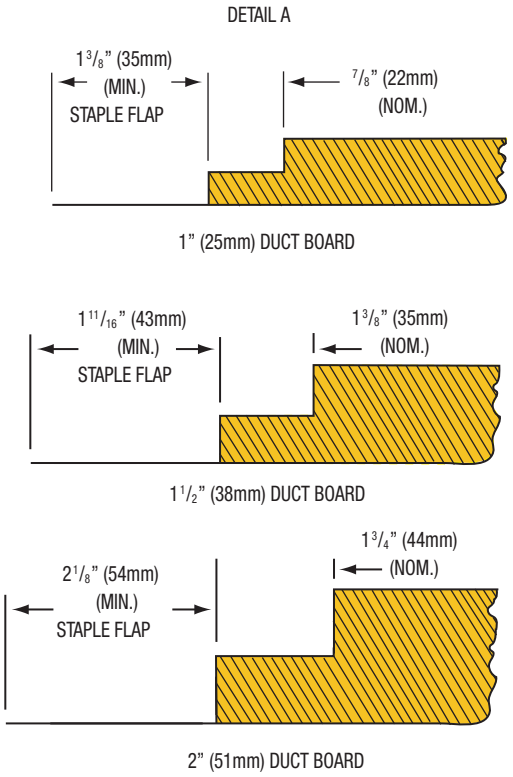
NOTES:

1. Use approved closure materials and methods only. Do not use heat-activated tape over either pressure-sensitive tape or glass fabric and mastic closure systems. (See Section IV, Closure.)
2. Restore any reinforcement members that may have been lost due to damage or removed to facilitate repair. (See Fig. 7-3B.)

Replacing Entire Shiplapped Panel

When the damage to a shiplapped panel is so extensive that the entire panel must be removed, such as impact damage that has cracked or creased the entire panel, repair per Fig. 7-4.

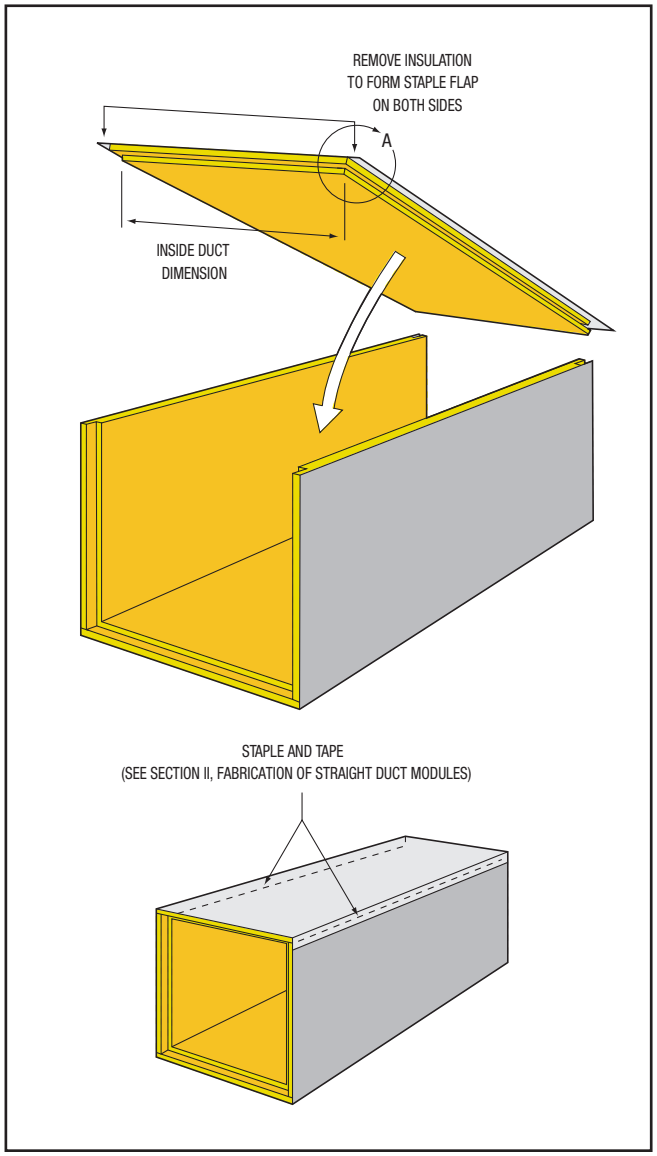
Fabricate a new panel per the U-style method (see Section II, Fabrication of Straight Duct Modules, page 2-11) and attach it to the undamaged sides of duct section using approved closure materials and methods. (See Section IV, Closure.)



NOTES:

1. Use approved closure materials and methods only. Do not use heat-activated tape over either pressure-sensitive tape or glass fabric and mastic closure systems. (See Section IV, Closure.)
2. Restore any reinforcement members that may have been lost due to damage or removed to facilitate the repair.

Fig. 7-4. Replacing Shiplapped Panel



Replacing Entire Square Edge Panel

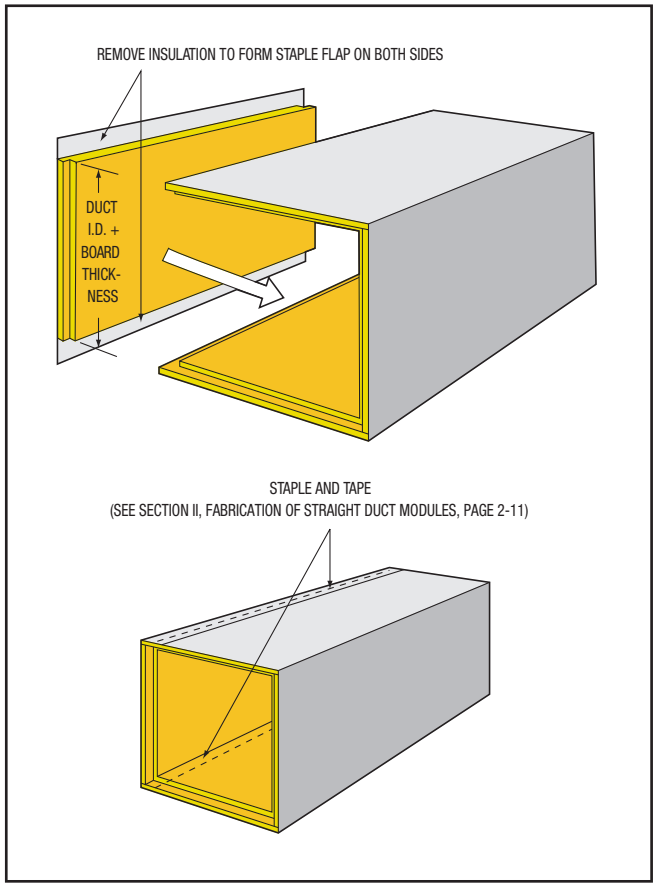
When the damage to a square edge panel is so extensive that the entire panel must be removed, such as impact damage that has cracked or creased the entire panel, repair per Fig. 7-5.

Fabricate a new panel per the U-style method (see Section II, Fabrication of Straight Duct Modules, page 2-11) and attach it to the undamaged sides of the duct section using approved closure materials and methods. (See Section IV, Closure.)

NOTES:

1. Use approved closure materials and methods only. Do not use heat-activated tape over either pressure-sensitive tape or glass fabric and mastic closure systems. (See Section IV, Closure.)
2. Restore any reinforcement members that may have been lost due to damage or removed to facilitate the repair.

Fig. 7-5. Replacing Square Edge Panel



Appendix

Appendix

References

The following may be used as references when working with information in this Standard. **NOTE:** Refer to latest editions.

ACCA – AIR CONDITIONING CONTRACTORS OF AMERICA ASSOCIATION, INC.

1520 Bellevue Boulevard #5220
Alexandria, VA 22307
(703) 575-4477 | www.acca.org

- Manual D, Residential Duct Systems
- Manual J, Residential Load Calculation

ADC – AIR DUCT COUNCIL

1300 Sumner Avenue
Cleveland, OH 44115
(216) 241-7333 | www.flexibleduct.org

- Flexible Duct Performance & Installation Standards

ASHRAE – AMERICAN SOCIETY OF HEATING, REFRIGERATING, AND AIR-CONDITIONING ENGINEERS, INC.

180 Technology Parkway NW
Peachtree Corners, GA 30092
(404) 636-8400 | www.ashrae.org

- ASHRAE Handbook – Heating, Ventilating, and Air-Conditioning Applications
- ASHRAE Handbook – Heating, Ventilating, and Air-Conditioning Systems and Equipment
- ASHRAE Handbook – Fundamentals
- ASHRAE Standard 62.1, Ventilation for Acceptable Indoor Air Quality
- ASHRAE/IES 90.1, Energy Efficient Design of New Buildings (Except Low Rise Residential Buildings)
- ASHRAE Standard 90.2, Energy Efficient Design of New Low Rise Residential Buildings
- A Practical Guide to Noise and Vibration Control for HVAC Systems: Mark E. Schaffer

ASTM – AMERICAN SOCIETY FOR TESTING AND MATERIALS

100 Barr Harbor Drive
West Conshohocken, PA 19428
(610) 832-9500 | www.astm.org

- Source for copies of ASTM test methods referenced throughout this Fibrous Glass Duct Construction Standards.

EPA – ENVIRONMENTAL PROTECTION AGENCY

1200 Pennsylvania Ave., N.W.
Washington, DC 20460
www.epa.gov

- Building Air Quality: A Guide for Building Owners and Facility Managers

NAIMA – NORTH AMERICAN INSULATION MANUFACTURERS ASSOCIATION

2013 Olde Regent Way, Suite 150, Box 120
Leland, NC 28451
(703) 684-0084 | www.naima.org

- Pub. # AH100, Fibrous Glass HVAC Duct Systems: Proven Performance
- Pub. # AH105, Requirements for listing UL181A Closure Systems
- Pub. # AH109, A Comparison of Duct Systems Energy Savings and Acoustical Performance
- Pub. # AH110, An Essential Component of Indoor Environmental Quality ... Fiber Glass HVAC Insulations
- Pub. # AH113, The Facts About Mold Growth
- Pub. # AH114, The Facts About Airborne Fibers
- Pub. # AH116, Fibrous Glass Duct Construction Standard
- Pub. # AH121, A Guide to Insulated Air Duct Systems
- Pub. # AH122, Cleaning Fibrous Glass Insulated Duct Systems
- Pub. # AH125, Facts About the Use of Biocides and Encapsulants with Fiber Glass Air Duct Insulations

NFPA – NATIONAL FIRE PROTECTION ASSOCIATION

1 Batterymarch Park
Quincy, MA 02269
(617) 770-3000 | www.nfpa.org

- NFPA 90A – Standard for the Installation of Air-Conditioning and Ventilating Systems
- NFPA 90B – Standard for the Installation of Warm Air Heating and Air-Conditioning Systems

SMACNA – SHEET METAL AND AIR CONDITIONING CONTRACTORS NATIONAL ASSOCIATION

4201 Lafayette Center Drive
Chantilly, VA 20151
(703) 803-2980 | www.smacna.org

- Fibrous Glass Duct Construction Standards
- HVAC Duct Construction Standards – Metal and Flexible
- HVAC Systems Duct Design
- Ducted Electric Heater Guide for Air Handling Systems
- Fire, Smoke & Radiation Damper Guide for HVAC Systems
- Indoor Air Quality: A Systems Approach

UL – UL SOLUTIONS (UNDERWRITERS LABORATORIES INC.)

333 Pfingsten Road
Northbrook, IL 60062
(847) 272-8800 | www.ul.com

- Standard for Factory-Made Air Ducts and Air Connectors, UL 181
- Standard for Closure Systems For Use with Rigid Air Ducts, UL 181A
- Standard for Closure Systems For Use with Flexible Air Ducts and Air Connectors, UL 181B

ICC INTERNATIONAL CODE COUNCIL

200 Massachusetts Avenue NW, Suite 250
Washington, DC 20001
(888) 422-7233 | www.iccsafe.org

- International Mechanical Code
- International Residential Code for One- and Two- Family Dwellings
- International Building Code
- International Energy Conservation Code

Guide Specification – Three Part Format | Section 15810

Fiber Glass Duct Work – Thermal/Acoustical Insulation Light Commercial and Residential Building Systems

PART 1.00 – GENERAL

1.01 Scope

A. The work covered by this specification consists of furnishing all labor, equipment, materials and accessories, and performing all operations required for fabrication and installation of air duct systems using fibrous glass duct board, in accordance with applicable project drawings and specifications subject to terms and conditions of the contract:

1. All air duct systems operating at internal static pressures not exceeding ± 2" w.g. (500 Pa), internal air velocities not exceeding 2,400 feet per minute (fpm) (12m/sec), and internal air temperatures not less than 40°F (4°C) or exceeding 250°F (121°C).

B. The finished duct system shall meet the requirements of NFPA 90A and 90B by complying with requirements of UL Standard 181 for Class 1 Air Ducts.

C. Dimensions shown on the plans are finished inside dimensions. Fabrication and installation shall conform to the manufacturer's recommendations and to the requirements of the latest edition of the North American Insulation Manufacturers Association's Fibrous Glass Duct Construction Standard.

D. Grooves and shiplaps shall be made using specific tools and/or machines designed for that purpose. Ends shall meet so that shiplaps fit without ridges or rough edges.

E. When flexible ducts are used as part of the system, installation shall be in accordance with the manufacturer's recommendations and to the requirements of the current edition of the Air Duct Council's Flexible Duct Performance & Installation Standards.

1.02 Delivery and Storage of Materials

A. Deliver of all materials and/or fabricated duct sections and fittings shall be made to the job site and stored in a safe, dry place.

B. All means necessary shall be made at the job site to protect materials from dust, dirt, moisture, and physical abuse before and during installation.

PART 2.00 – PRODUCTS

2.01 Insulated Duct System

A. All rectangular supply ducts, return ducts, and related fittings of 36" (914mm) span or less for 475-EI or 800-EI duct board, or of 42" (1,067mm) span or less for 1400-EI duct board, operating at plus or minus ½" w.g. (125 Pa) shall be fabricated from one of the following:

1. Type 475-EI or Type 800-EI fibrous glass duct board 1" (25mm) thick having an R-value of 4.3 (RSI, 0.76).
2. Type 800-EI fibrous glass duct board 1½" (38mm) thick having an R-value of 6.5 (RSI, 1.14).
3. Type 800-EI and 1400-EI fibrous glass duct board 2" (51mm) thick having an R-value of 8.7 (RSI, 1.53).
4. Insulated flexible duct of like R-value may be used for run-outs to registers and grilles.

B. The duct board shall have an air barrier/vapor retarder facing of aluminum foil-kraft laminate reinforced with scrim.

C. The duct board shall be imprinted with thw manufacturer's name, board type, and R-value in a repeat pattern. Additionally, each full duct board sheet shall have a UL Class 1 Air Duct label adhered to the facing of the board. Flexible ducts shall be identified in a similar manner.

2.02 Closure Materials

A. Closure materials shall be one of the following:

1. Pressure-sensitive aluminum foil tapes listed under UL 181A, Part I (P) identified by name, date of manufacture, product name/number, and UL 181A/P. The minimum width of pressure-sensitive tape for 1" (25mm) duct board is 2½" (64mm). Three inch (76mm) pressure-sensitive tape is recommended for 1½" (38mm) duct board and required for 2" (51mm) duct board.
2. Heat-activated tapes listed under UL Standard 181A, Part II (H) identified by name, date of manufacture, product name/number, and UL 181A/H may be used in all applications except for bonding to sheet metal. Tapes shall be at least 3" (76mm) wide.
3. Mastic as listed under UL Standard 181A, Part III (M) and applied in conjunction with 3" (76mm) wide glass fabric tape. This closure system may be used as an alternative to either pressure-sensitive or heat-activated tapes for all closure applications.

PART 3.00 – EXECUTION

3.01 Inspection

A. Verify that the duct system may be installed in accordance with project drawings, operating performance parameters, limitations, and standards published in NAIMA's Fibrous Glass Duct Construction Standard.

3.02 Fabrication, Straight Duct and Fittings

A. All straight duct sections shall be fabricated in accordance with NAIMA's Fibrous Glass Duct Construction Standard, Section II, Fabrication of Straight Duct Modules, using proper machinery and tools.

B. All fittings shall be fabricated in accordance with NAIMA Fibrous Glass Duct Construction Standards, Section III, Fabrication of Fittings From Modules or Flat Board, using proper machinery, tools and techniques.

C. All fibrous glass duct board distribution boxes shall be fabricated in accordance with NAIMA's Fibrous Glass Duct Construction Standard, Section II, Fabrication of Straight Duct Modules, and Section III, Fabrication of Fittings From Modules or Flat Board, using proper machinery, tools, and templates.

3.03 Closure

A. Mechanical fasteners of the types shown in NAIMA's Fibrous Glass Duct Construction Standard shall be used to connect the duct board to sheet metal before application of closure material.

B. Flaps on all field joints shall be stapled approximately 2" (51mm) on centers with ½" (13mm) (minimum) outward clinching galvanized steel staples near the edge of the flap. Staples shall be formed of 0.040" x 0.020" (1.02mm x 0.51mm) flat wire and shall have a crown width of 0.400" (10.2mm) (minimum). On fitting joints where stapling flaps cannot be included as part of the construction, tape tabs 8" (203mm) (nominal) in length shall be used. Tabs shall be centered over the joint with a minimum of one tab per duct side and/or 12" (305mm) (nominal) on centers.

C. On field joints, all taping surfaces shall be wiped clean before sealing. If the surface is contaminated with grease or oil, it shall be cleaned with a solvent recommended by the tape manufacturer.

D. Pressure-sensitive tape shall be firmly rubbed in place immediately after application using a squeegee-type tool. When the duct surface temperature is below 50°F (10°C), a heat sealing tool shall be used on pressure-sensitive tapes to assure bonding.

E. Heat-activated tape shall be sealed down with an iron (do not use a heat gun) using a smearing action. Heat sealing equipment must be capable of maintaining a sufficient temperature at the duct surface to assure an adequate bond. Colored dots on the tape surface shall become darkened, indicating that satisfactory bonding temperature has been reached. Staples may be omitted when closures are made by machine using heat-activated tape. Allow the joint to cool before stressing.

F. Mastic shall be brushed onto the joint and glass fabric imbedded in it. A second coat of mastic shall be brushed over the glass fabric until the fabric is filled. Mastics shall be applied in accordance with application instructions on the container.

3.04 Reinforcement

A. All straight ducts and fittings shall be reinforced to prevent ballooning, collapsing, or sagging using either the formed sheet metal system or the tie rod system in accordance with the provisions of Section V, Reinforcement, of NAIMA's Fibrous Glass Duct Construction Standard. Tie rod washers shall be 2½" (64mm) square or 3" (76mm) in diameter and shall be made of plated or galvanized steel of at least a 0.028" (0.7mm) thickness with turned edges to prevent cutting into the facing of the duct board. The hole size shall be approximately 0.150" (3.8mm) to allow the tie rod to move freely through the washer.

B. To prevent sagging of top panels of supply ducts over 48" (1,219mm) in width reinforced with formed sheet metal channels, #10 plated sheet metal screws shall be installed with 2½" (64mm) square or 3" (76mm) round plated or galvanized steel washers inside the duct on the longitudinal centerline of the duct. When tie rod reinforcement is used, sag support shall consist of ½" (13mm) rigid galvanized steel conduit and 2½" (64mm) square or 3" (76mm) round plated or galvanized steel washers inside the duct on the longitudinal centerline 3" (76mm) from the male shiplap edge. For all negative pressure systems, refer to NAIMA's Fibrous Glass Duct Construction Standard for proper spacing of reinforcement and proper attachment to the duct board.

3.05 Hanging and Support

A. The duct system shall be supported in accordance with the provisions of Section VI, Hanging and Supports, of NAIMA's Fibrous Glass Duct Construction Standard.

B. All hangers, supports, and attachments to the structure must be capable of withstanding three times the anticipated load.

3.06 Accessories

A. Doors, coils, dampers, registers, grilles, diffusers, turning vanes, volume extractors, and other accessory items shall be installed as detailed in NAIMA's Fibrous Glass Duct Construction Standard with adequate reinforcement and support to accommodate additional weight without damage to the duct board. Dampers over 2 square feet (0.19 m^2) shall be supported by sheet metal sleeves with all moving parts shielded with galvanized sheet metal at abrasion points. All 90° elbows shall contain turning vanes spaced at 3" (76mm) (maximum) intervals, mounted in accordance with the turning vane manufacturer's instructions. Turning vanes shall not be considered as reinforcing members. If volume extractors or splitter dampers are required on side take-off or split duct connections, they shall be fabricated using appropriate hardware. Slip-in electric heating coils shall be supported independently of the duct system and shall be installed in galvanized sheet metal sleeves extending 6" (152mm) (minimum) on both sides of the coils. Connection of accessory items shall be made to the duct system using 2½" (64mm) square or 3" (76mm) diameter galvanized or plated steel washers to spread the load to the duct board.

3.07 Inspection

A. Upon completion of installation of the duct system and before operation is to commence, visually inspect the system and verify that it has been correctly installed using the Inspection Checklist in NAIMA's Fibrous Glass Duct Construction Standard. Remove any scraps and loose pieces of material from inside the duct system.

B. Open all system dampers and turn on the fans to blow all remaining loose material out of the duct system.

C. Check the duct system to ensure that there are no air leaks through the joints or through the tears or punctures of the air barrier facing. If tears or punctures are found, repair these using procedures detailed in Section VII, Damage Repair, NAIMA's Fibrous Glass Duct Construction Standard.

3.08 Safety Precautions

A. The contractor shall conduct all job site operations in compliance with the applicable provisions of the Occupational Safety and Health Act, NAIMA's Product Stewardship Program, and all state and/or local safety and health codes and regulations that may apply to the work.

Guide Specification - Short Form

All supply and return ductwork operating within the range of positive or negative 2" w.g. (250 Pa) static pressure, 2,400 fpm (12m/sec) internal air velocity, and 40°F (4°C) to 250°F (121°C) internal air temperature, shall be constructed of fibrous glass duct board with a Class 1 UL Standard 181 rating of one of the following types:

- 1" (25mm) thick
  R-value at 75°F mean, hr ft^2 °F/Btu, 4.3 (RSI-value at 24°C mean, m^2 °C/W, 0.76).
- 1½" (38mm) thick
  R-value at 75°F mean, hr ft^2 °F/Btu, 6.5 (RSI-value at 24°C mean, m^2 °C/W, 1.14).
- 2" (51mm) thick
  R-value at 75°F mean, hr ft^2 F/Btu, 8.7 (RSI-value at 24°C mean, m^2 °C/W, 1.53).

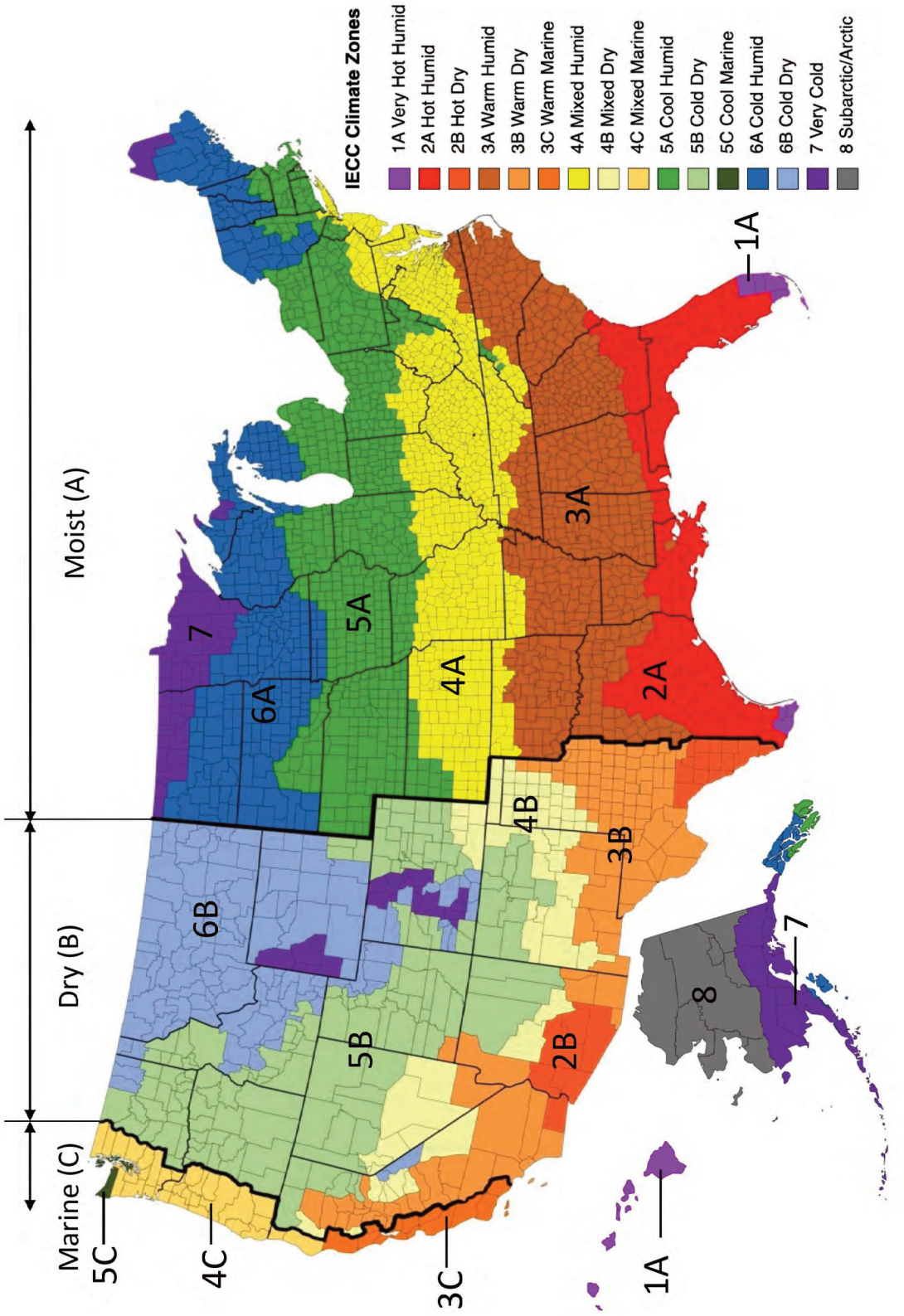
Fabrication and installation of fibrous glass duct shall conform to the requirements of the current edition of NAIMA's Fibrous Glass Duct Construction Standard and/or to the duct board manufacturer's recommendations.

The closure system shall be one listed by the duct board manufacturer or meeting the requirements of UL Standard 181A. Application shall comply with procedures specified in the manufacturer's instruction sheets. The minimum width pressure-sensitive tape for 1" (25mm) duct board is 2½"(64mm). Three inch (76mm) tape is recommended for 1½" (38mm) duct board and required for 2" (51mm) duct board.

Reinforcement, support, and accessory installation details shall comply with the current edition of NAIMA's Fibrous Glass Duct Construction Standard or as specified by the duct board manufacturer.

Details governing hanging of ducts and the installation of other accessory items shall be in compliance with the current edition of NAIMA's Fibrous Glass Duct Construction Standard or as specified by the duct board manufacturer.

Map of Doe's Climate Zones



Appendix

Thermal performance standards recommended in the American Society of Heating, Refrigerating and Air-Conditioning Engineers' National Voluntary Consensus Standard ASHRAE/IES 90.1, Energy Efficient Design of New Buildings Except Low Rise Residential Buildings are widely accepted by code jurisdictions across the country. For new commercial construction, ASHRAE/IES 90.1 provides minimum thermal resistance (R) requirements for ducts, plenums and enclosures. These requirements are based upon the geographical climate zone location of the project and the physical location of the duct in the building.

TABLE A-8. ASHRAE/ 90.1-2022 MINIMUM DUCT INSULATION R VALUE[a]

Climate Zone	Duct Location		
	Exterior [b]	Unconditioned Space and Buried Ducts	Indirectly Conditioned Space [c,d]
Supply and Return Ducts for Heating and Cooling			
0 to 4	R-8	R-6	R-1.9
5 to 8	R-12	R-6	R-1.9
Supply and Return Ducts for Heating Only			
0 to 1	None	None	None
2 to 4	R-6	R-6	R-1.9
5 to 8	R-12	R-6	R-1.9
Supply and Return Ducts for Cooling Only			
0 to 6	R-8	R-6	R-1.9
7 to 8	R-1.9	R-1.9	R-1.9

(a) Insulation R-values, measured in h•ft²•°F/Btu, are for the insulation as installed and do not include film resistance. The required minimum thicknesses do not consider water vapor transmission and possible surface condensation. Where portions of the building envelope are used as a plenum enclosure, building envelope insulation shall be required by the most restrictive condition of Section 6.4.4.1 or Section 5, depending on whether the plenum is located in the roof, wall, or floor. Insulation resistance is measured on a horizontal plane in accordance with ASTM C518 at a mean temperature of 75°F at the installed thickness.

(b) Includes attics above insulated ceilings, parking garages, and crawl spaces.

(c) Includes return air plenums with or without exposed roofs above.

(d) Return ducts in this duct location do not require insulation.

Residential Duct Insulation Requirements

ASHRAE Standard 90.2-2024 *Energy-Efficient Design Of Low-Rise Residential Buildings*

The ASHRAE 90.2 Standard requires that all portions of the air distribution system installed in or on buildings for heating and cooling shall be insulated to an R-8 minimum. Insulation is not required when the ducts are within the conditioned space.

International Energy Conservation Code (IECC) 2021

The 2024 IECC requires that all return and supply ducts shall be insulated to an R-8 minimum. Ducts smaller than 3 inches (76mm) in diameter shall be insulated to an R-6 minimum. Ducts or portions thereof located completely inside the building thermal envelope do not require insulation.

Appendix

Facts on Fibrous Glass Duct Insulation

Fiber glass has been commercially manufactured for more than 75 years. Today, fiber glass is an important component of the nation's economy, providing energy-conserving products that help reduce pollution and preserve the environment.

One of the world's most useful materials, fiber glass can absorb sound, help control heat flow, diminish impurities from liquids and gases, reinforce other materials and, with a vapor retarder, help control condensation. Fiber glass duct insulation will not support the growth of mold or bacteria when tested in accordance with specifications of the American Society for Testing and Materials (ASTM C 1338) or UL Standard 181. In addition, fiber glass duct insulation materials installed internal to the duct system are tested per ASTM G 21.

1. COMMITMENT TO PRODUCT STEWARDSHIP

In May 1999, the North American Insulation Manufacturers Association (NAIMA) implemented a comprehensive voluntary work practice partnership with the U.S. Occupational Safety and Health Administration (OSHA). This Health and Safety Partnership Program (HSPP) will train workers to keep airborne exposures below 1 fiber-per-cubic-centimeter (1 f/cc). After completion of the HSPP, NAIMA converted the program into NAIMA's Product Stewardship Program with essentially the identical recommendations.

NAIMA produced a pamphlet entitled "*Working Smart with Fiber Glass, Rock Wool and Slag Wool Products*" that describes the recommended work practices. Included in the pamphlet are recommendations for minimizing dust generation, maintaining adequate ventilation, wearing appropriate clothing and personal protective equipment, and removing fibers from skin and eyes. It also details specific work practices for blowing insulation in attics, installing cavity fill, batt, blanket, and roll insulation, fabricating pipe and board, installing ceiling tiles and spray-applied fireproofing, handling bulk unbonded products; and removing previously installed products. These recommendations were endorsed by OSHA as part of the HSPP and are now incorporated into the NAIMA Product Stewardship Program. The pamphlet, along with a video describing the work practice recommendations, is available free online at www.insulationinstitute.org.

NAIMA and its member companies are committed to ensuring that fiber glass products can be safely manufactured, installed and used. NAIMA's member companies have funded tens of millions of dollars of research at leading independent laboratories and universities in the United States and abroad. The weight of the scientific research shows no association between exposure to glass fibers and respiratory disease or cancer in humans.

In October 2001, an international expert review by the International Agency for Research on Cancer (IARC) reevaluated the 1988 IARC assessment of glass fibers and removed glass wools from its list of possible carcinogens by downgrading the classification of these fibers from Group 2B (possible carcinogen) to Group 3 (not classifiable as to carcinogenicity in humans). All fiber glass wools that are commonly used for thermal and acoustical insulation are included in this classification. IARC noted specifically:

> *"Epidemiologic studies published during the 15 years since the previous IARC Monographs review of these fibres in 1988 provide no evidence of increased risks of lung cancer or mesothelioma (cancer of the lining of the body cavities) from occupational exposures during manufacture of these materials, and inadequate evidence overall of any cancer risk."*

U.S., California, and international authorities have all agreed that biosoluble and inhalable glass fibers should not be labeled as a possible cancer hazard. The U.S. National Toxicology Program (NTP) and the California Office of Environmental Health Hazard Assessment's (OEHHA) actions mean that a cancer warning label for biosoluble fiber glass is no longer required under Federal or California law. NAIMA and its member companies are committed to the safe manufacture, installation, and use of fiber glass insulation products.

The NTP in June 2011 removed from its Report on Carcinogens (RoC) all biosoluble glass wool used in home and building insulation and for non-insulation products.

Also in 2011, California's OEHHA published a modification to its Proposition 65 listing to include only "Glass wool fibers (inhalable and biopersistent)."

Fiber glass is now the most thoroughly evaluated insulation material in the market. The data from these evaluations demonstrate that:

(1) No causal association has been found between either cancer or non-malignant pulmonary disease and human exposure to glass fibers.

(2) Inhalation exposures of animals to massive amounts of biosoluble glass wool fibers, hundreds and even thousands of times greater than human exposures, have not shown a relationship between glass wool fibers and disease.

(3) Glass wool fibers are biosoluble and, therefore, dissolve more rapidly in body fluids than other fibers that have been associated with human disease.

(4) Workplace levels of respirable glass fibers in most settings are less than 1 f/cc, and airborne levels in insulated buildings are not significantly different than levels outside or in uninsulated buildings.

NAIMA's member companies continue to support ongoing scientific investigations into the health and safety aspects of glass wool fibers as part of their comprehensive Product Stewardship Program.* NAIMA is dedicated to providing up-to-date information on the results of these studies as they become available.

2. SAFETY OF IN-PLACE DUCT PRODUCTS

When properly designed and installed, fiber glass products for air handling systems improve the indoor environment by controlling heat loss or gain while reducing condensation and providing acoustical insulation.

The results of several more recent scientific studies demonstrate that fiber glass insulated HVAC systems have no adverse effects on indoor environmental quality.

- International Programme on Chemical Safety (IPCS) – The Environmental Health Criteria 77 on man-made mineral fibers has stated: *"it has generally been concluded that the contribution of fibrous glass lined air transmission systems to the fibre content of indoor air is insignificant."*

- Duke University – A 1997 study showed that mold is no more likely to grow on fiber glass than on any other surface in the duct system. Mold grows in the presence of water. By helping to reduce condensation, fiber glass insulated ducts actually help minimize microbial growth.

- University of Nevada Las Vegas – A 1996 study confirmed the results of numerous earlier studies showing that fiber content in the indoor air from fiber glass lined systems is insignificant and does not adversely affect the health of building occupants.

3. CONCLUSION

NAIMA and its members believe fiber glass is safe to manufacture, install and use when recommended work practices are followed. Complete details on work practices and exposure guidelines are contained in NAIMA's Product Stewardship Program and can be obtained in written or video form by contacting NAIMA at the following address:

2013 Olde Regent Way, Suite 150, Box 120
Leland, NC 28451
Phone: (703) 684-0084
Or visit us at www.insulationinstitute.org.

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ABOUT NAIMA

NAIMA is the association for North American manufacturers of fiber glass, rock wool, and slag wool insulation products. Its role is to promote energy efficiency and environmental preservation through the use of fiber glass, rock wool, and slag wool insulation, and to encourage the safe production and use of these materials.

NAIMA, continuing its members' commitment to safety, has established a renewed Product Stewardship Program, which embodies the components of the earlier OSHA-NAIMA Health and Safety Partnership Program (HSPP). The HSPP was a comprehensive eight-year partnership with OSHA, which NAIMA completed in May 2007, and now NAIMA incorporates these safe work practices into NAIMA's Product Stewardship Program.

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