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Structural Journeyman

Volume 2. Metal/Fiberglass Components and Overhead/Rollup Doors

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IN THIS VOLUME you will study metal/fiberglass components and overhead/rollup door information that you will use in your future work on the job. Unit 1 addresses sheet metal duct systems. Unit 2 covers duct fabrication, installation, and repair. Unit 3 focuses on stacks, ventilators, and hoods. Unit 4 explains overhead and rollup doors.

Foldouts 1 and 2 are bound in a separate supplement to this volume. Refer to them as the text directs.

A glossary is included for your use.

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NOTE:

In this volume, the subject matter is divided into self-contained units. A unit menu begins each unit, identifying the lesson headings and numbers. After reading the unit menu page and unit introduction, study the section, answer the self-test questions, and compare your answers with those given at the end of the unit. Then complete the unit review exercises.

Unit 1. Sheet Metal Duct Systems

IN THIS unit, we discuss airflow through duct systems. You'll find that air, like water, passes easily through straight ducts, but at turns (elbows) the flow becomes turbulent, forms whirlpools, and moves against the main current. To minimize this turbulence and resistance to airflow, duct systems are designed with certain characteristics. For example, the size and shape of an elbow duct can greatly affect airflow. You will learn which characteristics permit the best airflow. Also, you will learn how splitters and turn vanes can improve airflow, how dampers can restrict airflow, and how deflectors can change airflow. Lastly, you will learn how to determine duct system dimensions and how to fabricate and install duct system components.

1–1. Airflow Principles and Controls

Working drawings and blueprints specify how duct systems are fabricated to provide maximum airflow. If duct systems are to work properly, you need to apply the principles of good airflow management as you fabricate, install, and repair them. An earlier volume discussed the symbols for ducts, dampers, registers, grilles, and louvers used on working drawings. Now is a good time to review these illustrations and refresh your memory.

Virtually every heating, ventilation, and air conditioning distribution system depends on the flow or movement of air to perform its function. How well you fabricate, install, or repair the air distribution system equipment, to a great extent, determines how successfully the total system operates. It's a fact that improper air distribution is frequently the cause of complaints such as "there's not enough heat" or "it's too hot" or "it's too cold." It may not be the whole system that's at fault; the air distribution system may be causing drafts, hot spots, cold spots, cold floors, or other complaints. Although engineers make original designs for air distribution systems, you play an important part in their success. Many times you'll be required to determine how and where air is to be admitted and what construction features provide the correct air velocity and distribution pattern. To provide basic guidance for your responsibilities, this section covers designing duct systems for maximum airflow.

201. Designing duct systems

The forced air systems for heating, ventilation, and air-conditioning equipment include many components; each plays a vital role in the total success of the system. Basically, a typical system is comprised of the following components:

1. Motor-driven blowers.
2. Coils.
3. Filters.
4. Associated components of the heating and cooling units.
5. The supply duct system.
6. The return duct system.

When engineers design a building's forced air system, they consider factors that provide the most efficient airflow distribution. For example, after determining the load requirements for heating and cooling, they consider *pressure loss, friction,* and *turbulence.*

You must also consider *pressure loss, friction*, and *turbulence* in your fabrication and installation of a ductwork to create an efficient and properly operating airflow distribution system. The first factor, *pressure loss,* describes the conditions affected by the quality of your work. Any loose or improper connections can cause air leaks. The next factor, *friction,* describes the resistance that air has over the inside surfaces of the duct system. A good rule to reduce friction is to keep duct run length as short as possible. The longer a duct is, the more friction that the moving air encounters, which means a loss in air pressure. The last factor, *turbulence,* results from changes in the direction or the cross-sectional area of the duct. Figure 1–1 shows examples of turbulence in duct systems. As you can see, the flow of air tends to whirl and move in different directions as it passes through different configurations. Note that a straight duct has less turbulence than an elbow or transition. To get the best airflow possible, follow these practical procedures for efficient airflow:

- Select the proper size of duct.
- Pipe the air as directly as possible to the required location.
- Avoid sharp turns.
- If you must change the size or shape of a duct, make the change as slight as possible.
- Avoid restriction of airflow in elbows and transitions.
- Make rectangular ducts as nearly square as possible.
- Reduce friction by using smooth duct material.

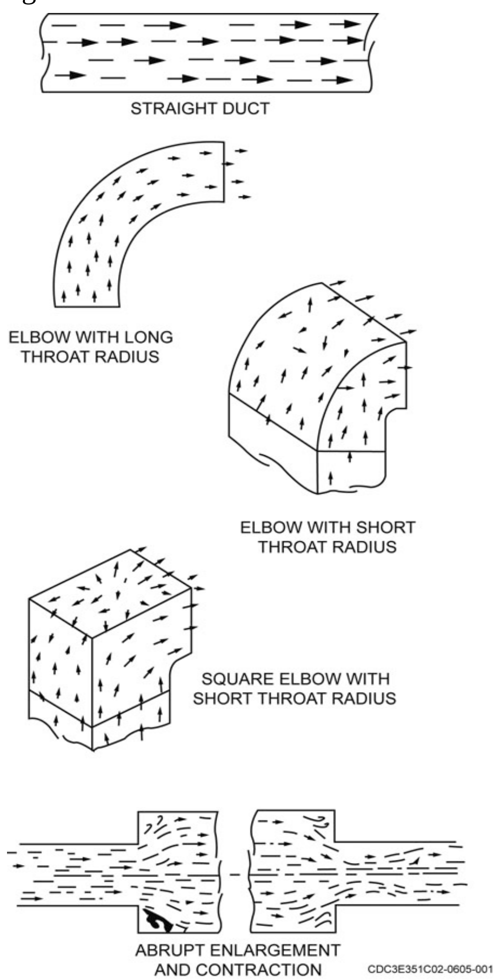

Figure 1–1. Air turbulence in duct components.

Maintaining duct pressure

Earlier we stated that heating, ventilation, and air-conditioning systems depend on the flow or movement of air to perform their design functions. We also found that resistance to airflow in a duct system has a direct effect on the duct pressure. For example, friction is created by air moving against the duct wall surface (even in a smooth, straight duct); this created friction affects the pressure. Constrictions, or changes in duct shape, have an even more dramatic effect on the pressure. This is true because these constrictions and changes require more pressure to speed up the air velocity so the volume of airflow through the duct is unchanged. Let's look at the requirements you need to maintain the pressure in straight, diverging, and converging ducts.

Straight ducts

Air forced through a straight duct loses less pressure than the air forced through elbows or transitions. As we said, pressure loss through a straight duct is caused primarily by friction between the air and the sides of the duct. The loss increases when the duct sides are rough, the duct is lengthened, or when elbows or transitions are used. Another factor that affects airflow is the shape of the duct. Certain duct shapes allow the air to flow with less turbulence and friction than others do. For example, a round duct is more efficient than a square duct and a square duct is more efficient than a rectangular duct.

When you're fabricating a straight duct, its size, shape, and length are usually specified in the working drawings. Your main concern is to make the joint connections and seams as smooth as possible. This helps to minimize friction and turbulence inside the duct.

Diverging and converging ducts

It's sometimes necessary to enlarge a straight duct to install a cooling or heating coil. You can see a typical heating coil installation in figure 1–2. Coils like this are often larger than the duct, making it necessary to install two transitions. In figure 1–2 you can see that angle "A" is in the diverging transition, and angle B is in the converging transition. In both transitions, it's important to make the angles as gradual as possible. In the diverging transition, angle "A" shouldn't exceed 20°. Install splitters, discussed later, to reduce pressure loss and to ensure an even distribution of the air through the coil. In the converging transition, angle "B" shouldn't exceed 60° and splitters are usually not required.

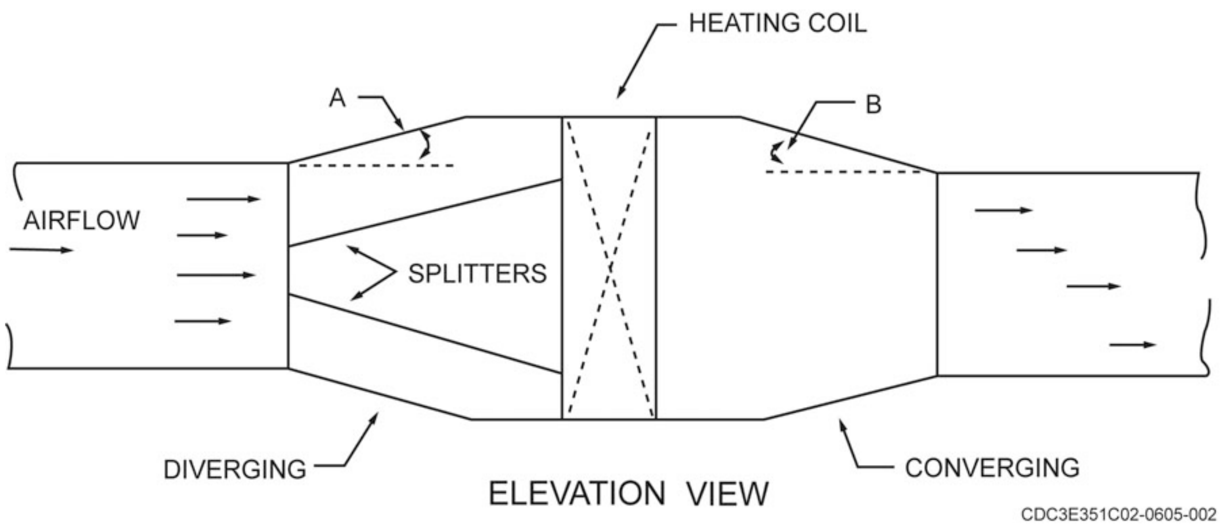

Figure 1–2. Diverging and converging duct.

Elbows

Elbows in duct systems cause air turbulence and pressure loss. You can minimize turbulence and pressure loss through the elbow with an efficiently designed, fabricated, and installed elbow. Be sure to avoid sharp turns by using elbows with large throat radii. In addition, build elbows with dimensions that allow maximum airflow.

Width

The elbows in square or rectangular ducts have a dimensioning characteristic you must understand if you want maximum airflow. This characteristic concerns the elbow width, which is somewhat different from the straight duct section width. Figure 1–3 shows two elbows in a rectangular duct. Notice that the elbow width in A is 12 inches, and the elbow width in B is 6 inches.

NOTE: The elbow width in a square or rectangular duct is always the dimension lying in the *same plane* as the radius of the elbow.

Radius ratio

Elbow A in figure 1–3 produces more turbulence and resulting pressure loss than elbow B. This is due to the ratio between the throat radius (R) and the elbow width (W). A ratio among 1 to 1 and 2 to 1 is best, with 2 to 1 being more desirable. The throat radius ratio is also called the inside radius ratio. We can determine it by dividing throat radius (R) by width (W). For example, the inside radius ratio for elbow A is 1 to 1. We determine this by substituting the width and throat radius dimensions (R/W = 12/12 = 1/1 = 1). In speaking of ratios, it's common practice to use the equivalent value, such as 1:1 = 1. Thus, a ratio of 2 to 1 is a ratio of 2, and a ratio of 1 to 2 is a ratio of 0.5, and so forth. Elbow B in figure 1–3 has an inside radius ratio of 2, or R/W = 12/6 = 2/1 = 2, which is more desirable than a ratio of 1. Both elbows in the illustration have satisfactory airflow, although elbow B has better airflow.

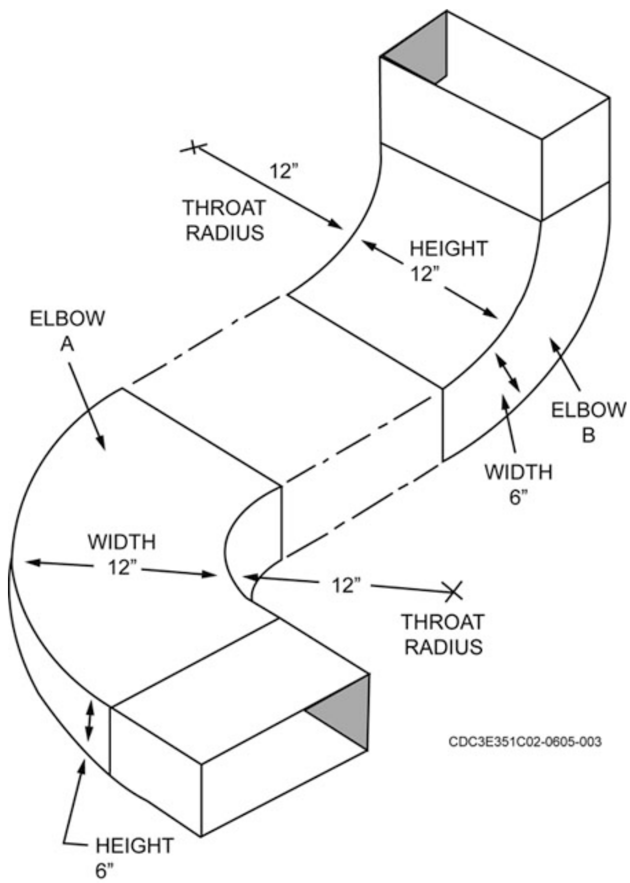

Figure 1–3. Rectangular duct elbows.

202. Identifying volume control devices

There are many types of devices used in duct systems to control airflow. These include splitters, turn vanes, dampers, diffusers, registers, and grilles.

Splitter and turn vanes

Turn vanes and splitters are installed inside of duct elbows to control air turbulence. We explain these two types.

Splitters

Splitters, like those shown in figure 1–4, improve the flow of air through elbows that have poor inside radius ratios. The splitters reduce the turbulence of airflow passing through square or rectangular elbows by dividing the flow of air into passages with better inside radius ratios. Splitters are also used when the outlet end of an elbow doesn't connect to another duct of the same size, or the air discharges into a large space or into the atmosphere. The elbow on the left in figure 1–4 (if used without a splitter) has an inside radius ratio of 0.33 or, R/W = 6/18 = 1/3 = 0.33. These dimensions produce excessive turbulence in the air passing through the elbow. Remember from an earlier lesson, we said the inside radius ratio should be between 1 and 2.

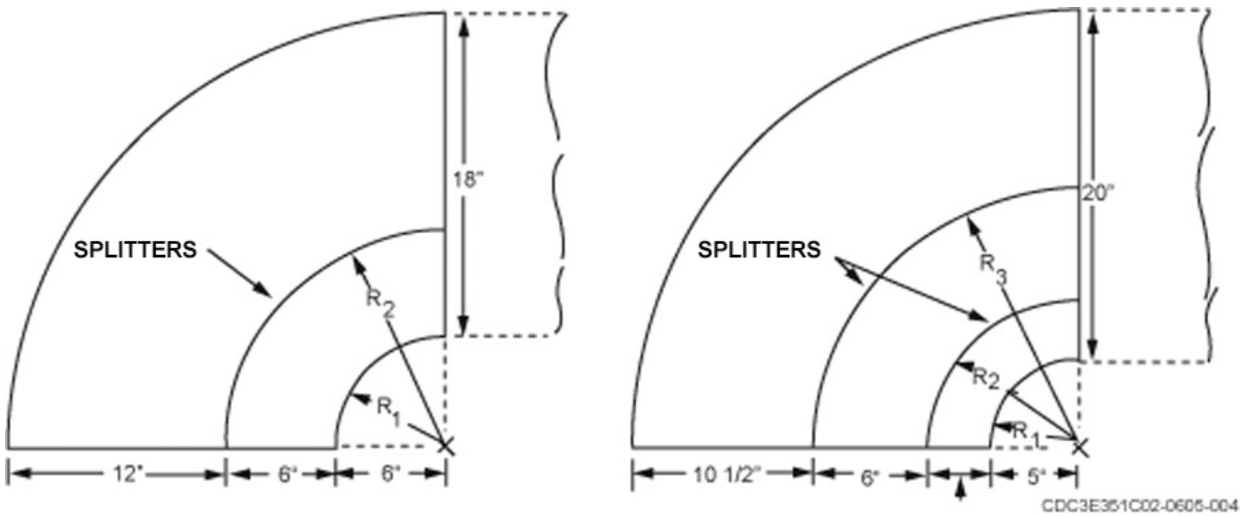

Figure 1–4. Splitters in rectangular duct elbows.

To get a better inside radius ratio in ducts, you can install splitters. Notice in the illustration that you don't place the splitter in the center of the elbow; instead, you place it to divide the elbow into two unequal passages, one 6 inches and one 12 inches. The inside radius ratio for the 6-inch passage is 1, or R/W = 6/6 = 1. The inside radius for the 12-inch passage is also 1, or R/W = 12/12 = 1. By placing a splitter in the proper location, you reduce the turbulence and pressure loss through the elbow.

The elbow on the right in figure 1–4 (if used without splitters) has an inside radius ratio of 0.25, or R/W = 5/20 = 1/4 = .025. Again, this produces excessive turbulence and pressure loss. When you install two splitters, as shown in the illustration, each passage has an inside radius ratio that permits air to flow with a minimum of turbulence and pressure loss.

The calculations for the elbow on the right are as follows:

$$R/W = 5/3.5 = 1.4;\ R/W = 8\ 5/6 = 1.4;\ R/W = 14.5/10.5 = 1.4.$$

All of these calculations give a ratio between 1 and 2, so by placing splitters in the proper location, you can improve airflow through the elbow.

Figure 1–5 shows how you install splitters during the fabrication of square or rectangular elbows. You can see how difficult it would be to install the splitters after the elbow is assembled. Notice how the tabs on the splitters allow them to be fastened with rivets, screws, or spot welds. After you fasten the splitters to the bottom of the elbow, you place the top in place and assemble it with Pittsburgh lock seams. Then you fasten the splitters to the top. Remember, you must make the tab allowances ($^3/_4$ inch in this example) on the splitter patterns before you cut them out.

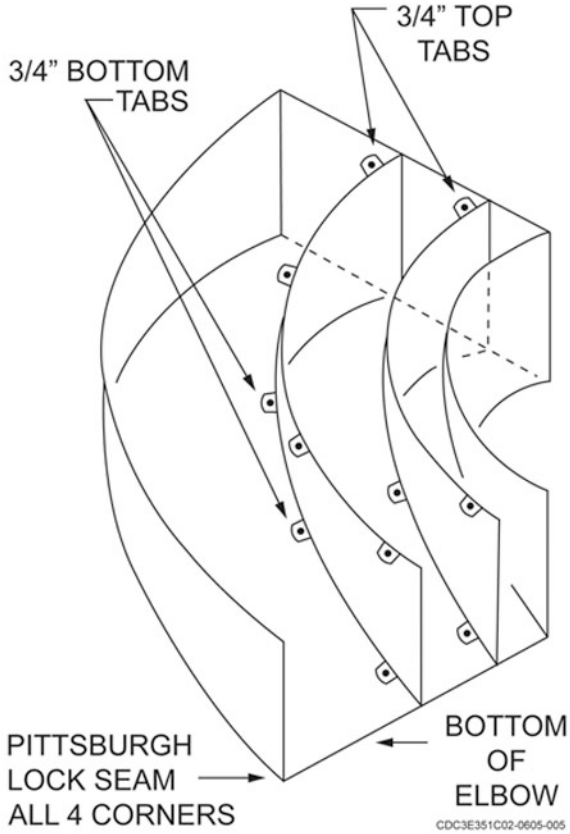

Figure 1–5. Installing splitters.

Turn vanes

The turn vanes illustrated in figure 1–6 are used to reduce turbulence and pressure loss and provide for uniform air distribution in square or rectangular elbows. Turn vanes are especially valuable in elbows that connect directly to supply registers and grilles.

In figure 1–6 you can see how the turn vanes form several small elbows that function very much like splitters. Although they resemble splitters, we determine the number of turn vanes and their spacing with a different formula. For best airflow, space the turn vanes so that they have an aspect ratio of 5 (5 to 1). The aspect ratio of an elbow is equal to the elbow height divided by its width (H/W = 5). Remember that the elbow width is in the same plane as its radius. For example, if the elbow in figure 1–6 is 15 inches high, you can substitute 15 for H, and solve for W (width or radius of the turn vanes) as we show below. You can see that the turn vane width or radius should be 3 inches to get maximum airflow. Therefore, install the turn vanes 3 inches apart to divide the elbow into several effective smaller elbows, each with the preferred aspect ratio of 5:

$$H/W = 5$$
$$15/W = 5$$
$$W = 15/5$$
$$W = 3$$

To determine how many turn vanes you need, measure the distance from the throat corner to the heel corner of the elbow and divide the distance by the 3-inch radius. For example, if in figure 1–6 the distance from throat to heel is 24 inches and each turn vane is to be 3 inches apart, divide 24 by 3. You need 8 turn vanes.

Notice in figure 1–6 how each turn vane is straight on both sides of the 90° radius bend. The length of each straight edge is equal to ½ the distance (radius) between the turn vanes. Since in this example the turn vanes must be 3 inches apart, each straight edge should extend 1½ inches past the radius bend.

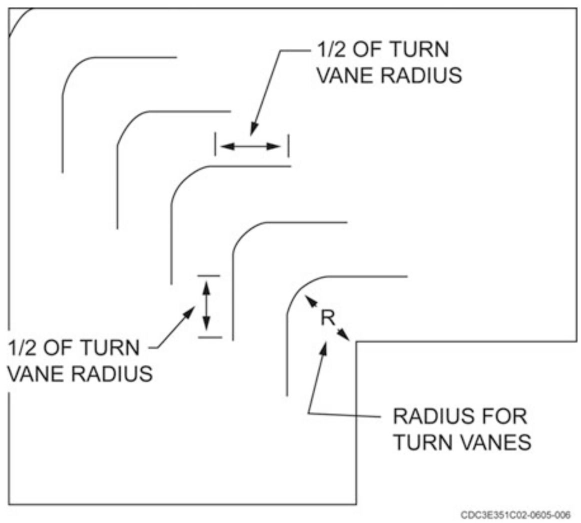

Figure 1–6. Turn vanes in a square elbow.

Turn vanes, like splitters, are installed with tabs and rivets, screws, or spot welds. Figure 1–6 doesn't show the tabs, but the end of each turn vane should have at least three tabs, one in the middle of the bend and one on each straight edge.

You also can install turn vanes with turn vane rails (fig. 1–7). These rails are commercially available and are manufactured in rolls, with slots to hold the ends of turn vanes. To use them, simply cut two pieces of rail to the proper length (the distance from the throat to the heel of the elbow), and cut the turn vanes to the proper length (duct height with no tabs). Next, assemble the rails and turn vanes by placing the turn vanes in the slots in the rails and twisting or bending the ends of the turn vanes to hold them in place. After attaching the turn vanes to the rails, install the whole assembly in the elbow with screws or rivets.

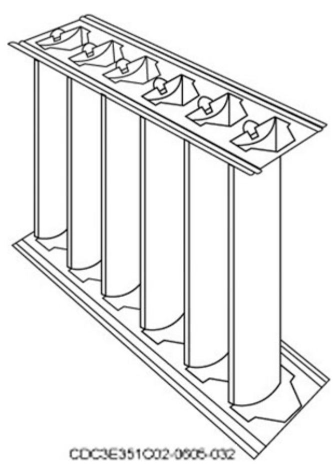

Figure 1–7. Turn vane rail assembly.

Characteristics of volume dampers

A damper is a movable blade that varies the air volume flowing through a duct system. Some dampers make only minor changes in volume, some completely shut off airflow, and others adjust the range of airflow from fully opened to fully closed. The dampers discussed in this unit include deflecting, butterfly, and louver dampers.

Deflecting damper

A deflecting damper (fig. 1–8), sometimes called a splitter damper, is a single blade hinged at one edge. You position it with a control handle on the outside of the duct after you've installed it in the duct system. In the illustration, you can see how you could increase or decrease airflow in the branch lines by changing the position of the deflecting damper. Deflecting dampers are usually set (adjusted for best operation) during the first operational check of the airflow system. After you achieve a balanced airflow, you lock the damper in position with a wingnut.

Deflecting damper blades are usually made from material that's 2 gauges thicker than the duct material. The damper blades are attached to shop-made shafts and handles or to factory-made directional control quadrants. If insulation is to be installed on the outside, the length of the damper blade is the same as the height of the duct, less a clearance of approximately ¼ inch. If insulation is to be installed inside the duct, the damper blade should be the duct height minus the insulation thickness. The blade width varies according to the amount of airflow to be deflected. Usually, the width of the deflecting dampers is approximately ¾ the width of the branch line 8 (fig. 1–8).

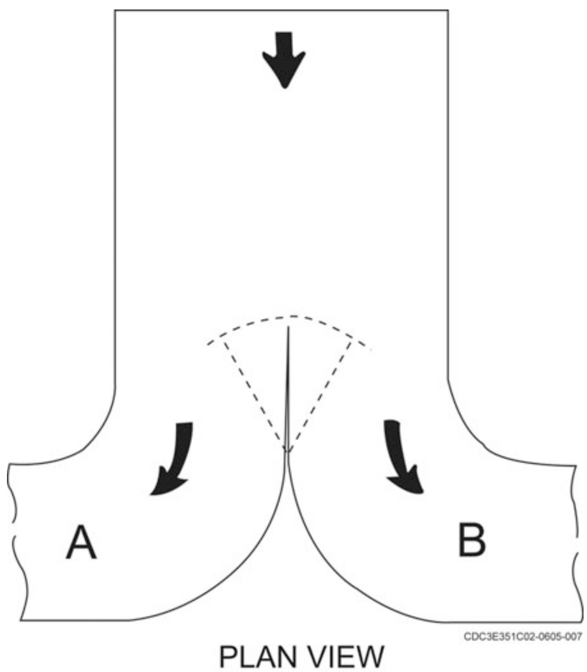

Figure 1–8. Deflecting damper in a duct system.

Butterfly damper

We commonly call a volume control damper like the one in figure 1–9 a butterfly damper. It has a blade made from sheet metal, it pivots in the middle, and it's usually placed in the middle of a straight duct.

With this damper, you can adjust the airflow from fully closed to fully opened by positioning the blade angle with the control quadrant handle. Notice in the illustration that the butterfly damper is placed near the branch takeoff. Don't put it near the branch duct outlet because if the damper is partly closed, it creates two high velocity air streams along the duct walls instead of a uniform flow. The angle of the damper blade also causes the air to flow from the duct at unusual angles, causing turbulence and poor airflow in the air distribution system.

The blade of a butterfly damper is usually made of sheet metal 2 gauges thicker than the duct. For a duct with insulation installed on the outside, the size of the blade is the same as the inside dimensions of the duct, except for a clearance of ¼ inch. If you want a tight fit, you can install a strip of felt around the edges of the blade. For a duct with insulation installed on the inside, you must cut the blade down to account for the insulation thickness.

In figure 1–9, you can see how a butterfly damper is installed in a branch line. Now look at figure 1–10 to see the components that make up a butterfly damper. Figure 1–9 shows the control quadrant as being riveted to the outside of the duct and a removable handle attached to the control quadrant to adjust the damper blade position. Notice that the round shaft bushing plate is riveted to the inside of the duct to strengthen the duct wall.

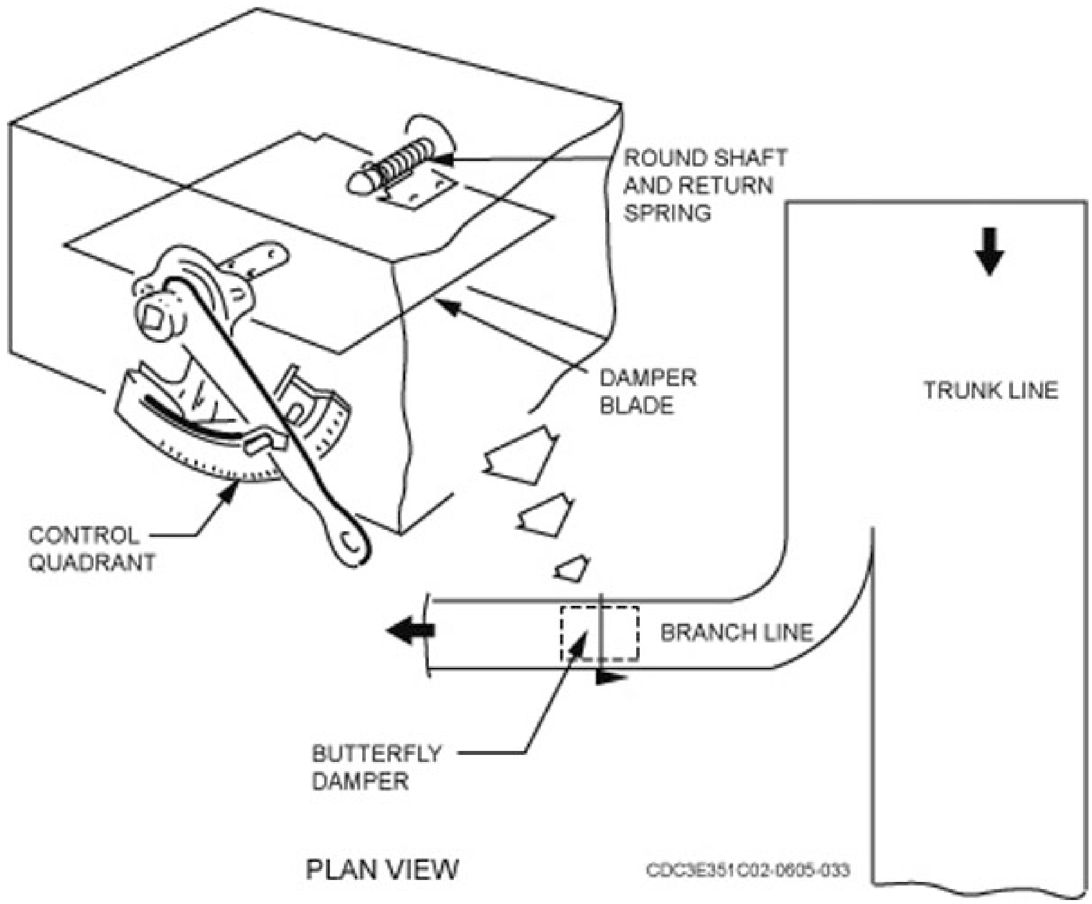

Figure 1–9. Butterfly damper in a branch line.

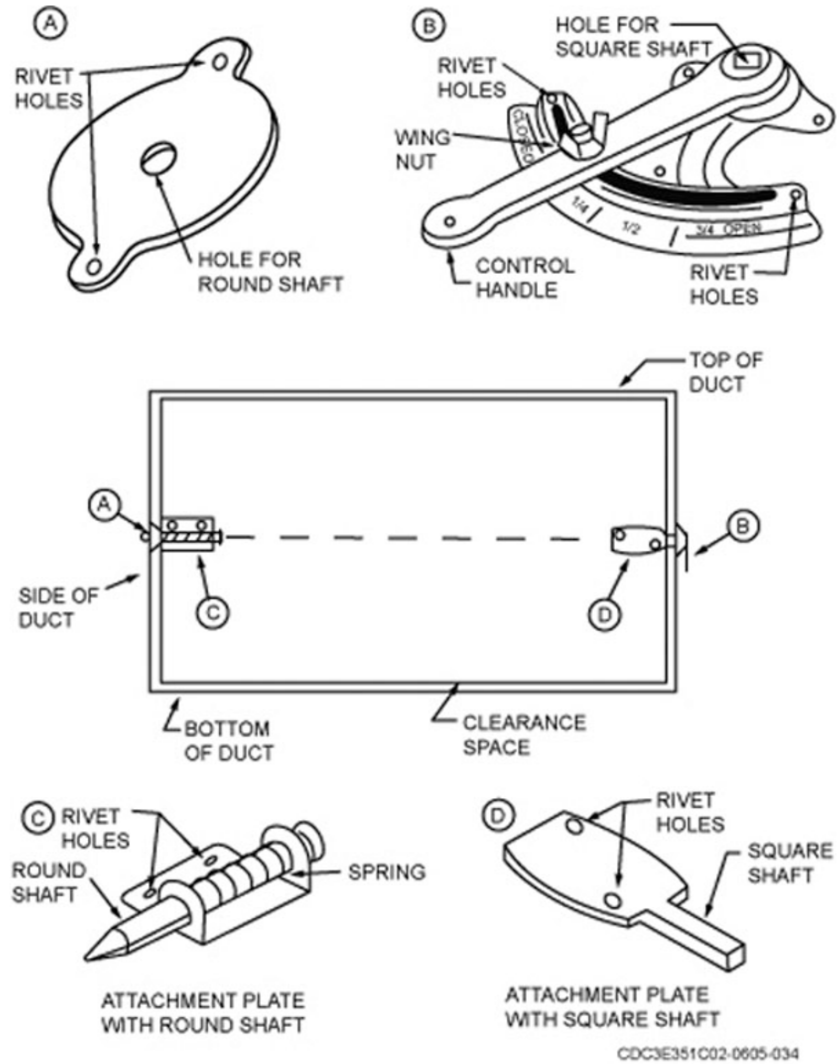

Figure 1–10. Butterfly damper components.

Before you can rivet the bushing plate and control quadrant to the duct, you must drill holes so the two shafts can extend through the duct. To install the assembled butterfly damper in a duct, position the blade inside the duct and insert the square shaft into the square hole of the quadrant. The round shaft is spring loaded and retracts to allow the round shaft to be inserted into the bushing plate. Next, install the control handle in the square shaft that extends through the control quadrant. Tighten the wingnut to lock the handle and damper blade at the desired angle.

Louver dampers

Many designs have been developed that use a series of adjustable louvers inside ducts or at duct outlets. On working drawings this type of volume damper may be labeled a multiblade damper or a louver damper.

Figure 1–11 shows a louver damper used to reduce or shut off airflow through a duct. Each of the four damper blades pivots on its centerline axis when the connecting linkage is moved. Although not shown, the linkage can be operated by various means, such as motors, springs, weights, and airflow. The louver damper can also be manually positioned with gears or quadrant handles. Notice in figure 1–11 how the edges of each blade have V grooves. When the blades are moved to the vertical position, the grooves fit together to seal the airflow. These grooves also stiffen the blades, reducing vibration as air flows between the blades.

Louver dampers usually are purchased as factory-made assemblies because it is more cost effective to buy them as complete assemblies than it is for you to fabricate them. The louver damper is easier to install if you put it in place before you install the duct. As figure 1–11 illustrates, you should install the louver damper to the inside of a straight duct section. Normally, you connect the louver blade linkage after you install the duct. Notice the access hole and cover plate. These are provided so that you can inspect and do maintenance work. Be sure the fasteners that you use to install the louvers don’t interfere with damper blade movement.

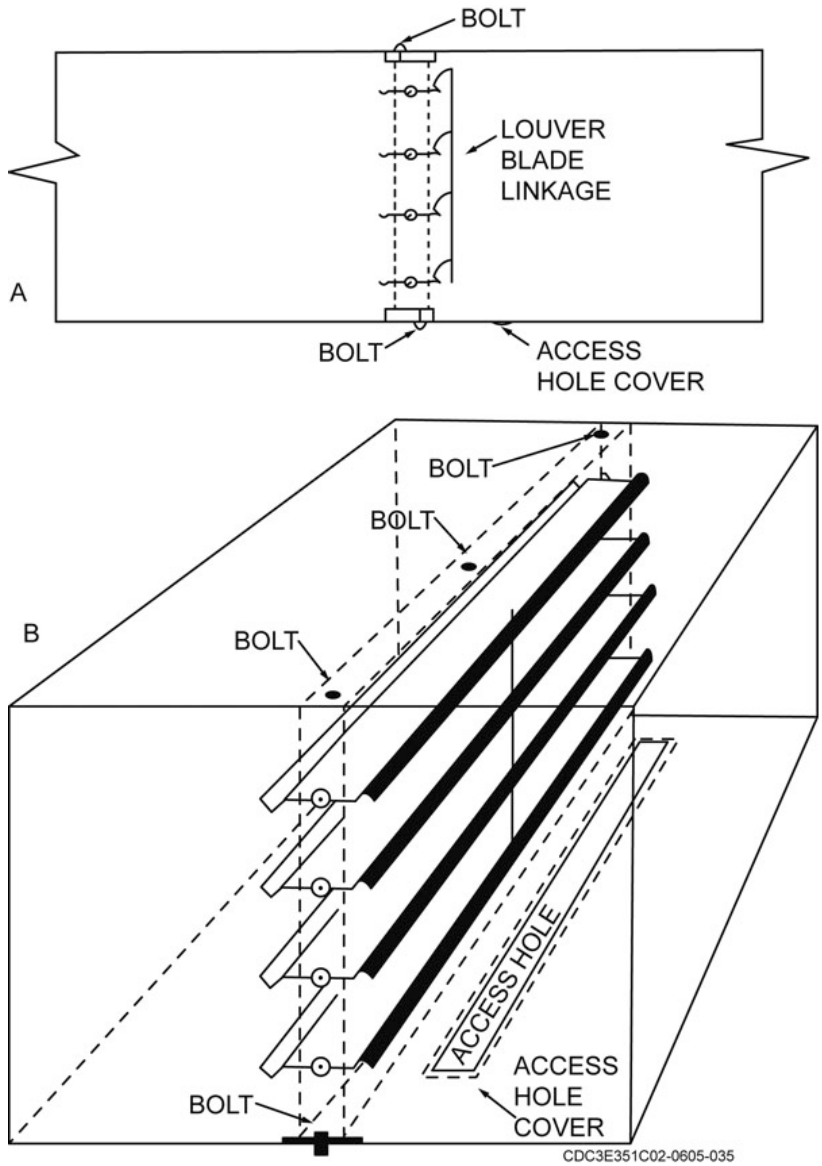

Figure 1–11. Louver damper.

Figure 1–12 shows another variation of a louver damper. The blades open automatically when the exhaust fan is operating. The exhaust system shown is a ceiling installation, but similar units are also installed in walls. When you’re installing or replacing this kind of damper, be sure that the blades open in the direction that you want the exhaust air to go. Also make sure that the blades close tightly when the fan is off. The tight seal prevents wind from blowing through the damper in the wrong direction.

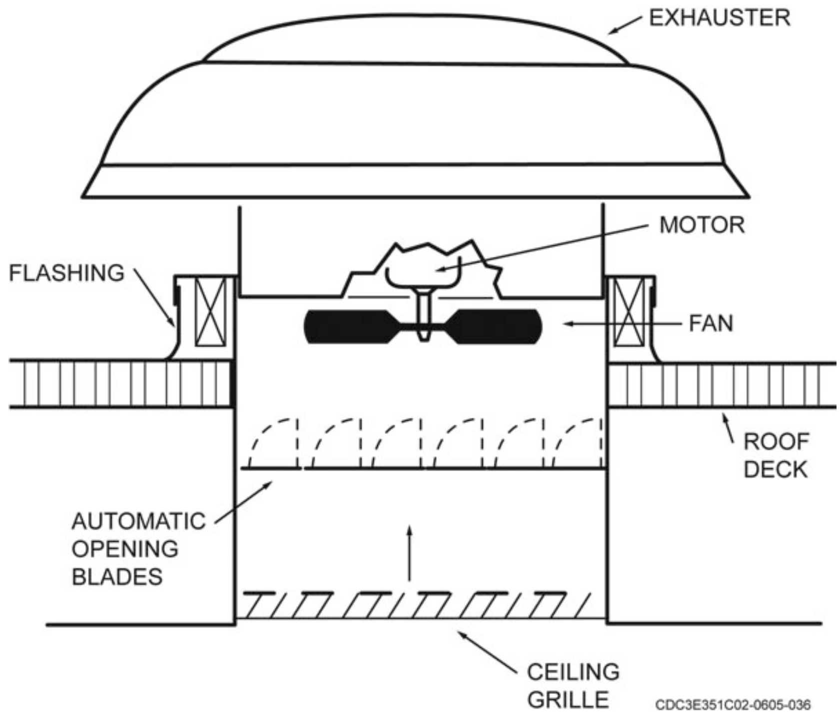

Figure 1–12. Louver damper used in an exhaust system.

Fire damper

A fire damper is an automatic louver damper installed at exhaust outlets or in ducts that pass through firewalls. This type of damper allows full airflow during normal operation. If a fire occurs, the heat generated melts a fusible link, which allows the spring-loaded damper blades to close. This shuts off the airflow, preventing drafts that could intensify the fire. Installing a fire damper is similar to installing other louver damper assemblies. Fire dampers with fusible links require an access door or panel in the duct so that technicians can inspect the fusible link periodically.

Characteristics of diffusers, registers, and grilles

Even though an airflow system is delivering the correct amount of conditioned air to a space, there are factors that can affect air distribution into the space. In fact, one of the most critical factors affecting room comfort is proper air velocity control as it is supplied through outlets to various rooms or areas. We can summarize the characteristics of the outlets as type, outlet air supply pattern, and most effective application. Although there are numerous styles and configurations of air distribution outlets available, they are recognized by three basic names:

1. Ceiling diffusers.
2. Registers.
3. Grilles.

Ceiling diffusers

Several types and styles of ceiling diffusers are used at duct system supply outlets. Figure 1–13 shows a round diffuser with an adjustable damper assembly. View C shows the diffuser as it appears when installed over the damper assembly (view B). View D is a cutaway view of the diffuser, showing how the turn vanes spread the airflow. Notice how the airflow is dispersed in all directions from the diffuser. View B shows the parts of the volume damper assembly, including the frame (ring), adjustable butterfly damper blades, and control knob. You can open and close the blades by turning the knob, which is attached to a threaded shaft. Some damper assemblies have a pull chain that you can use to open and close the blades.

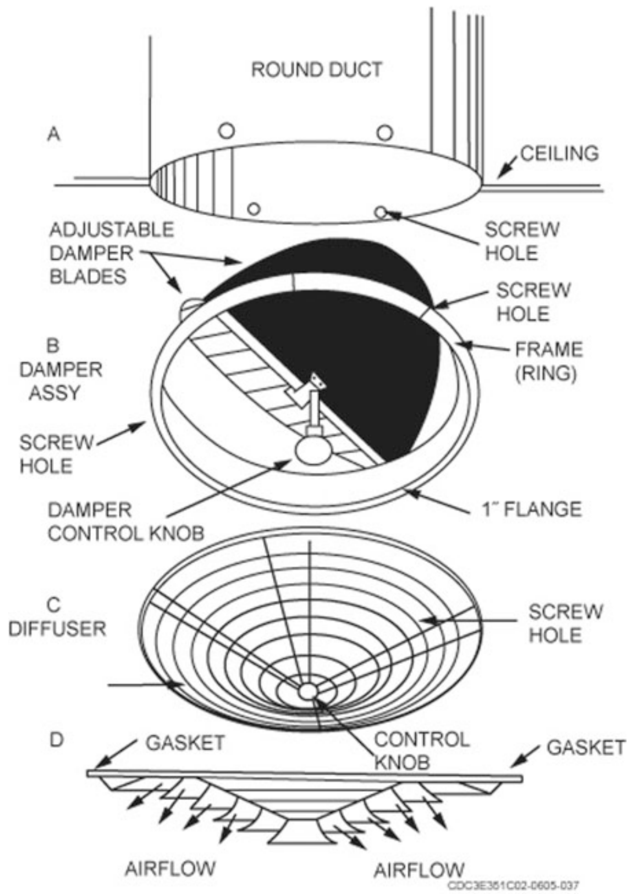

Figure 1–13. Ceiling diffuser and volume damper.

The frame of the damper assembly (view B) has a 1-inch flange that fits into the supply duct (view A). The flange is attached to the duct with four sheet metal screws. When the damper assembly is inserted and secured with screws, the damper frame fits snug against the ceiling.

The diffuser is attached to the damper with four sheet metal screws. Notice in view D that a gasket on the diffuser keeps air from leaking and smudging the ceiling (streaks of dust or dirt around diffusers). Ceiling diffusers and volume dampers are also available for square and rectangular supply duct outlets. The only difference between the round and square or rectangular damper assemblies and diffusers is the shape.

Another diffuser type is the drop-in diffuser. This diffuser is used with suspended ceilings and is installed by simply *dropping* or placing the diffuser into the T-bar ceiling grid. These diffusers are made to fit into the suspended ceiling T-bar grid with no cutting of the diffuser or ceiling grid.

Registers

Several types of registers are used to control the volume and direction of airflow at duct outlets in walls. The device shown in figure 1–14 is a multiple blade register with two sets of blades. The horizontal row of blades connects to linkage controlled by the hand-operated lever on the right side of the face frame. The horizontal blades can be adjusted from the full-flow to the full-closed position. The front edges of the blades lower through infinite stages as you close them.

The vertical blades we show in figure 1–14 aren't linked together and are individually adjusted to the desired angle. You can adjust the vertical blades with your fingers or with a small wrench that fits one blade at a time. For a register to give maximum control of airflow, the air coming through the duct must be distributed evenly over the entire area of the register. If the register is located near an elbow, turn vanes usually ensure an even distribution of air as it comes out of the elbow.

View B in figure 1–14 shows a side view of the diffuser. From this view you can see how the blade frame is attached with sheet metal screws to a flange at the end of the rectangular duct. The blade frame should have approximately ¼-inch clearance when it's installed in a duct.

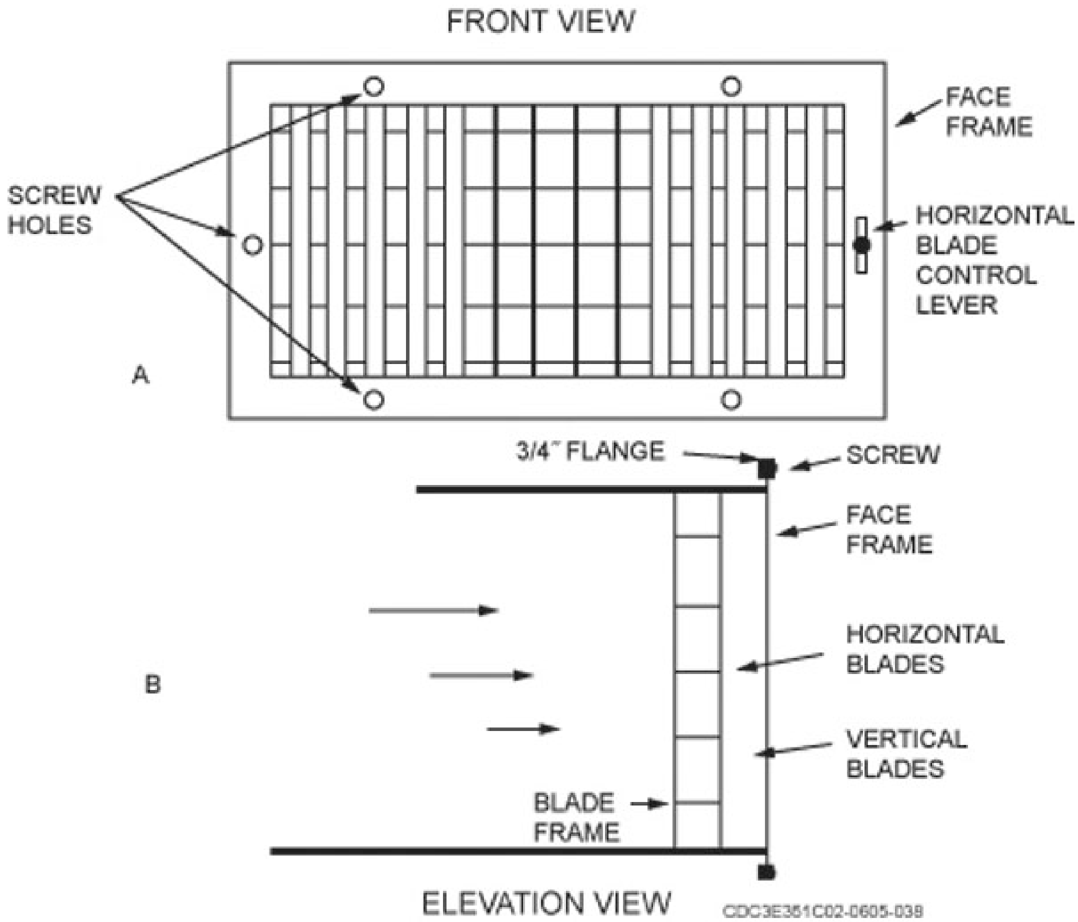

Figure 1–14. Multiple blade register.

Grilles

The purpose of grilles is to cover return air openings of ducts and to provide ventilation through doors or walls. Several types may be used if directional control of airflow isn't important. Grilles don't have adjustable blades or louvers. Figure 1–15 shows a grille installed in a door. The blades in this grille let air pass but limit sound and sight. Grilles usually are factory made, though some simple designs can be made in the shop. View B in figure 1–15 is the front of the grille. It shows the face frame and face bars. View C is a side view showing the shape of the blades, which are held in place by the blade frame. The blade frame is inserted into a cutout in the door and is held in place with screws.

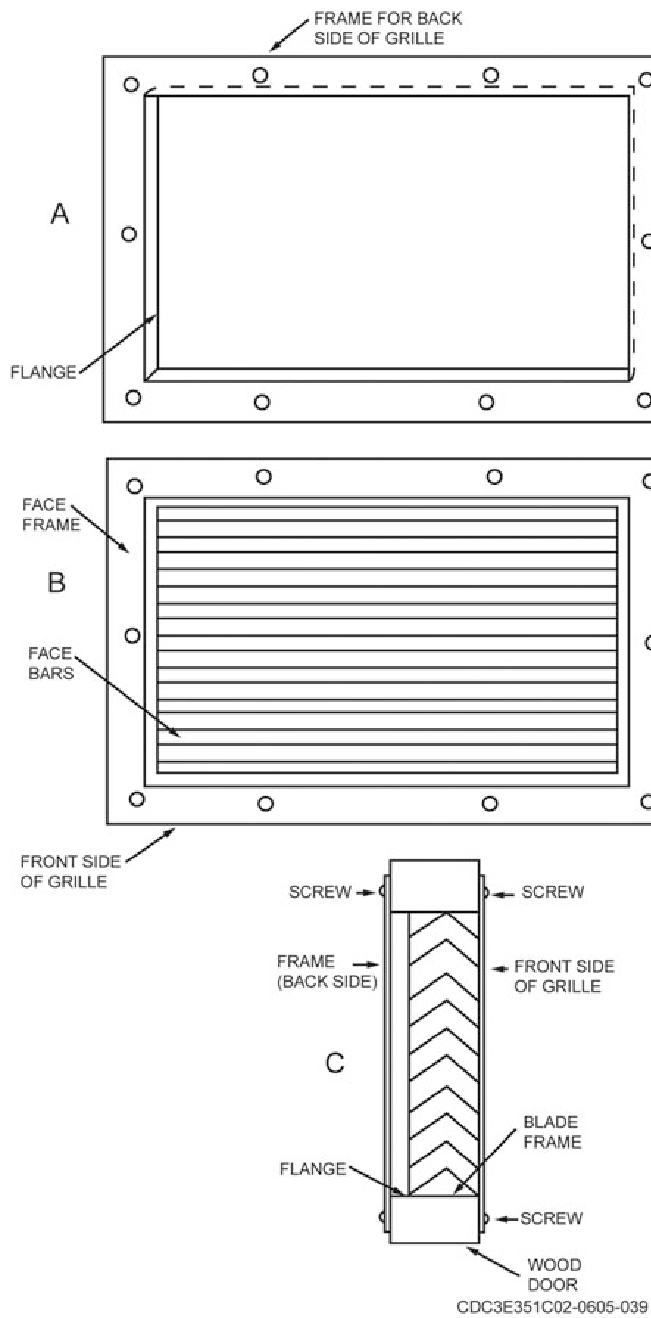

Figure 1–15. Door return grill.

Not all grilles use blades or louvers. Sometimes perforated metal grilles cover ventilators or return air openings in doors or walls. Perforated grilles have various ornamental patterns, such as squares, diamonds, and circular shapes. The perforated metal grille we show in figure 1–16 has a diamond pattern. Drop-in grilles, like drop-in diffusers, are available and their use can make duct installation quick and easy.

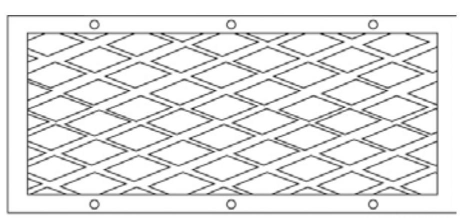

Figure 1–16. Perforated metal grille.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

201. Designing duct systems

1. What are the three factors to consider in designing and fabricating duct work?

2. Give the main causes of air turbulence in duct systems.

3. State the procedure that affects duct length.

4. State the air distribution procedure that describes the proper duct material.

5. As the fabricator, how can you work to reduce friction inside duct systems?

6. List the transitions used in duct systems.

7. The elbow width in a square or rectangular duct is always the dimension in what plane?

8. What is the ratio of a square elbow with an inside radius of 12 inches and a width of 8 inches?

202. Identifying volume control devices

1. What purpose do splitters serve when they’re installed inside of elbows?

2. An inside radius ratio between what two numbers gives a good flow of air?

3. How do you fasten splitters in rectangular duct elbows?

4. What formula do you use to compute the aspect ratio for turn vanes?

5. What commercially available product can you use to hold turn vanes?

6. Why do we use dampers in duct systems?

7. Generally, how much change do dampers make to airflow inside a duct?

8. What is the normal width of deflecting dampers?

9. Where are butterfly dampers normally located?

10. Where should a butterfly damper *not* be located?

11. What type of damper is installed in a duct that goes through a firewall?

12. What are diffusers used for?

13. What are registers used for?

14. How are grilles used?

1–2. Planning

In the previous section, we covered duct usage and the components that make up a duct system. Now, we go through the complete duct system fabrication and installation process. For our lessons, we discuss a duct system used to distribute air through a building. As you progress through this section, you discover how the preliminary planning and how materials and components are used to make up a duct system. We also cover a bill of material lists. Most new construction work has a bill of material list that includes the materials and components required. By contrast, repair work does not have a bill of materials list. Therefore, you have to make one. This section shows you how the materials and components look on working drawings. You can use this information to identify items listed on the bill of materials and where and how they're to be used. For example, when you pick up several sheets of metal at the material holding area, you must decide how you can best use each sheet.

203. Preliminary planning

The working drawings in foldouts (FO) 1 and 2 are general layout drawings. A big part of your job is to study and analyze these drawings to determine how to fabricate and install a system. As you can see, the drawings don't specify the seams, joints, or bracing requirements. We present these requirements as we go through the unit. Learning these requirements along with your job skills and knowledge helps you determine the best method to use in planning duct system repairs. We begin with the important step of breaking the system down into subsystems, sections, and components.

System breakdown

The first step is to break the system down into subsystems, sections, and components. Refer to FO 1 as we describe how the system is broken down into trunklines A, B, and C.

The supply duct system begins at the heater room in the middle of the working drawing. Notice how trunkline A (a 24" × 14" duct) connects the supply plenum to the heating and cooling unit to the two trunklines in the building. Trunkline B supplies the right wing and trunkline C supplies the left wing. You can find the length of these three trunklines by measuring with a rule and converting to feet according to the scale shown on the drawing.

Trunkline A measures 9 feet 2 inches between the plenum and the end of the duct. It isn't necessary to break down trunkline A into sections of different sizes because it's the same size throughout its entire length.

Trunkline B is 37 feet 6 inches long, with sections of different sizes. Therefore, we break it down by sizes. Beginning at the takeoff from trunkline A, trunkline B has these sections:

- 6" for takeoff fitting reducing 18" × 12" to 18" × 10".
- 3' of 18" × 10" rectangular duct.
- 12" for an 18" × 10" to 16" × 10" transition.
- 12'8" of 16" × 10" rectangular duct.
- 12" for a 16" × 10" to 14" × 8" transition.
- 9' of 14" × 8" rectangular duct.
- 12" for a 14" × 8" to 12" × 8" transition.
- 9'4" of 12" × 8" rectangular duct.

Trunkline C is 42 feet long; we break it down into four duct sizes and three transition sizes This breakdown is similar to the breakdown for trunkline B.

Continue breaking down the system in the branch line ducts. In FO 1, you can count 15 duct sections: 12 of these are 6 inches in diameter and 3 are 8 inches in diameter. Since the lengths differ, measure them to determine the breakdown into 6- and 8-inch sizes.

Starting with room 1, measure the 6-inch diameter branch lines from the side of the trunkline to the center of the outlet:

- Room 1, 7'8" (6'11" straight duct plus 9" for the elbow).
- Room 2, 7'7" (6'10" straight duct plus 9" for the elbow).
- Room 3, 7'6" (6'9" straight duct plus 9" for the elbow).
- Room 5, 7'6" (6'9" straight duct plus 9" for the elbow).
- Room 6, 7'7" (6'10" straight duct plus 9" for the elbow).
- Room 7, 7'8" (6'11" straight duct plus 9" for the elbow).
- Room 8, 7'8" (6'11" straight duct plus 9" for the elbow).
- Room 9, 7'7" (6'10" straight duct plus 9" for the elbow).

- Room 10, 7'6" (6'9" straight duct plus 9" for the elbow).
- Room 11, 7'6" (6'9" straight duct plus 9" for the elbow).
- Room 12, 7'7" (6'10" straight duct plus 9" for the elbow).
- Room 13, 7'8" (6'11" straight duct plus 9" for the elbow).

The 8-inch diameter branch lines are located in the latrine and two hallways and breakdown as follows:

- Latrine 6'6" (5'6" for straight duct plus 12" for the elbow).
- Hallway 7'6" (6'6" for straight duct plus 12" for the elbow).
- Hallway 7'6" (6'6" for straight duct plus 12" for the elbow).

Now return to the heater room and figure the dimensions of the supply plenum and the return air duct. To find these dimensions use FO 2 (½" = 1'0" scale). The supply plenum is 24 inches wide, 36 inches high, and 24 inches long.

The return air duct height (return air and outside air plenum) is shown on FO 2, and the length is measured from end to end. The width is measured on FO 1. The return air duct dimensions are 10 feet 6 inches of 36" × 18" rectangular duct.

In the preceding paragraphs, we've broken the heating and air-conditioning duct system down into 3 trunklines, 15 branch lines, the supply plenum, and the return air duct. We then broke these subsystems down into sections. Now we take the next step, which is to break down the various sections into appropriate lengths. For example, the 16" × 10" section of trunkline B contains several sections of 16" × 10" rectangular duct. You need to remember that duct section length depends primarily on the duct section width. Since each duct section width is shown on the working drawings, we use a duct construction chart to show the duct width, recommended metal gauge, joint connector types, each section length, and bracing needed. After finding the duct length from the chart, it's easy to determine how many duct pieces you need to make up a section.

At first glance it appears to be a matter of simple arithmetic to divide the section length by the length of each duct, but it's somewhat more complex. You must consider the best way to use your materials. You can get the most from your sheet metal materials by selecting the sheets that allow you to cut out the maximum amount of duct while minimizing waste. For example, the 6-inch round duct section in room 1 (FO 1) is 6 feet 11 inches long. The recommended procedure is to make the 6-inch branch line in two 36-inch ducts, with a 6-inch tap connection at one end and an 8-inch duct at the other. Next, we discuss why 36-inch wide sheets are best for this duct.

Seam type

Because seam allowances are included in the patterns, the seam type that you select is an important decision in preliminary planning. The size of each pattern determines the size of sheet to use. From the rectangular duct dimensions in FO 1, you can see that you can make each duct from a single metal sheet. By using only one sheet of metal, you only need to make one corner seam. Use the Pittsburgh lock seam on this job. As we discussed earlier in this course, the Pittsburgh lock seam is the best choice for a corner lock seam on rectangular duct. You can make the seam with a Pittsburgh lock-forming machine or a cornice brake.

Because grooved seams are best when a lock seam is needed on a round duct, choosing a seam for round duct is easy. Remember that you can make grooved seams with a Pittsburgh lock forming machine or with hand tools and a cornice brake.

The transition corners in FO 1 are also joined with Pittsburgh lock seams. The number of seams depends on how many pieces are used in each transition. Later in this unit, we discuss how to fabricate small items, such as transitions and short duct sections, from leftover pieces of metal instead of using a new sheet. Note, these leftover pieces are what remains after you cut components from full metal sheets. Most sheet metal shops keep a certain quantity of leftovers for repair work.

The branch lines in FO 1 include 6- and 8-inch elbows connecting the round, straight duct to the ceiling diffusers. Each elbow is made of five pieces, or gores. Each gore is rolled into a circular shape 6 or 8 inches in diameter, and the ends are fastened with a grooved seam.

Other duct system components in FO 1 requiring seams include the round takeoff fittings for the branch lines (dovetail seams), the covers for the ends of the trunklines (standing seams), and the top for the plenum chamber (standing seams).

Joint connections

Another part of your preliminary planning is to determine the joint connections to be used. Joint connections, like seams, require additions to the patterns when deciding what size sheets to use. You may recall that rectangular duct sections up to 24 inches wide can be made on 35-inch centers and should be connected with standing S and drive slips. The chart also shows you can make rectangular ducts 12 inches wide by 8 inches high on 7 foot 11-inch centers. FO 1 shows only one duct wider than 24 inches. This is the return air duct, which is 36 inches wide.

To figure the joint connections for round duct, you don’t need to refer to a chart. It’s common practice to use a slip-joint connection made with a crimping machine. The allowance for the slip joint is normally 1½ inches for the crimp. Add the crimp allowance when you plan the material for the round ducts. Use dovetail seams to connect the round ducts to the rectangular trunklines. The normal allowance for dovetail seams is ½ inch; add it during material planning.

Other joint connections for the duct system in FO 1 include the takeoff fitting tapped connections and the V grooves used to connect the elbow gores. When the gores are assembled, these V grooves form lock joints between the gores. The V grooves are made with an elbow-edging machine.

Bracing

Determining the bracing for the duct system shown in FO 1 isn’t difficult. Since most rectangular ducts in this system are less than 24 inches wide, the bracing recommended is the cross brake. Only the return air duct is wider than 24 inches but, it is installed on the floor and supported throughout its length so it does not require much bracing. If the return air duct is made on 35-inch centers, the standing S and drive slips and cross braking provides sufficient bracing. The round duct isn’t long enough to require bracing.

204. Selecting material

From the data gathered in the preliminary planning of the duct system, you can determine the best type of sheet metal to use, as well as its thickness, sheet size, and quantity.

Sheet metal duct material

Most metal ducts for heating, air conditioning, and ventilating are made from galvanized steel sheets because they are durable with good corrosion resistances and are economically priced. This is true for the duct system shown in FO 1 of this CDC. Other types of sheet metal that we could have selected include aluminum, stainless steel, and black iron. We chose the galvanized sheet steel because we didn’t need the weight savings that aluminum provides, and we did not want the added cost for best corrosion protection that stainless steel provides. We did want enough protection against moisture (condensation) to rule out the use of black iron, which has little corrosion protection. Another quality that galvanized-sheet metal has is a smooth surface, which reduces friction loss as air passes through the duct. Also, galvanized sheet metal is available in various sizes and gauges. The return air duct won’t be exposed to excessive condensation, but since it’s installed at floor level, it should also be made of galvanized steel.

Metal duct material thickness

We can determine the recommended sheet metal gauge needed to make rectangular ducts as shown in FO 1 from the duct construction chart located in volume 1 of this CDC. We can also determine the thickness of galvanized steel for round ducts from this chart.

NOTE: To make aluminum ducts, increase the thickness of each of the following by 2 gauges:

- For diameters up to 13 inches, use 26-gauge galvanized.
- For diameters over 13 inches to 33½ inches, use 24-gauge galvanized.
- For diameters over 33½ inches to 67½ inches, use 22-gauge galvanized.

Determining sheet metal size and quantity

Galvanized steel to fabricate sheet metal ducts is available in several sizes. The most frequently used sizes are 3 or 4 feet wide and 8 or 10 feet long. These are illustrated in figure 1–17. This may make you think duct sections are usually 8 or 10 feet long; however, this isn't always true because the popular length to fabricate rectangular ducts is 3 or 4 feet. The 3 or 4 feet lengths allow easier installation at the job site.

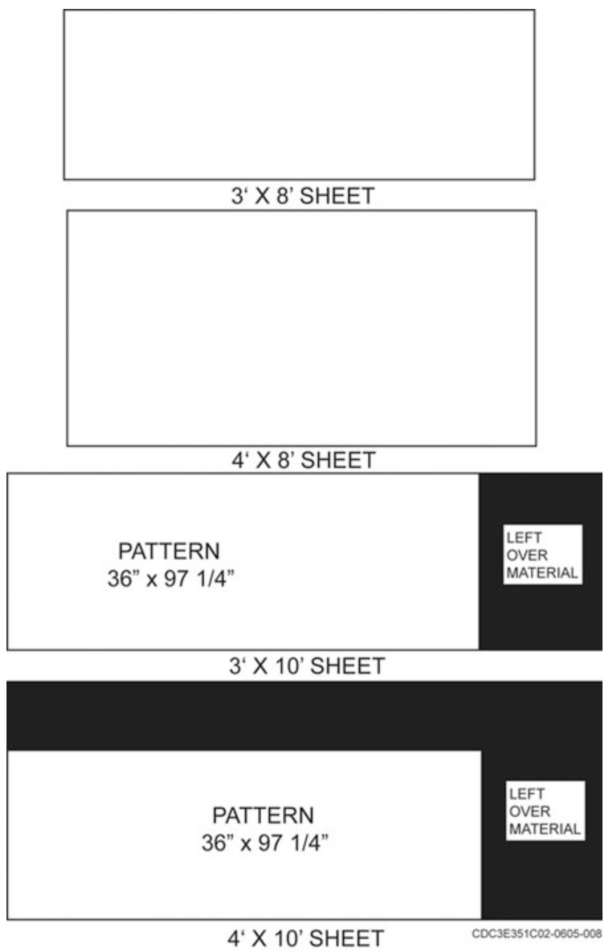

Figure 1–17. Selection of sheet sizes.

We can make these ducts in one piece with one corner seam or in two pieces with two corner seams. In the examples we discuss here, the duct sections are made in one piece. For example, a 24" × 14" joint, 47 inches long, requires a piece of metal 48" × 77¼" (including seam and joint allowances of 1" for the pocket and ¼" for the flange). In this case, you make the duct section from a sheet 4 feet wide and 8 or 10 feet long. How the leftover material can be used determines the length of sheet metal you should choose.

Another reason for making a duct in 3- or 4-foot lengths is to use less bracing. You can space the bracing on 35-inch centers or on 7-foot, 11-inch centers. We use these centers because the length given on working drawings is usually the distance from center to center of the connectors at each end of the duct. For example, a 36-inch duct section has a ½ inch allowance at each end for the S and drive slips; therefore, it measures 35 inches center to center.

In figure 1–17, a 36" × 97¼" pattern is to be made. Of the four available sheet sizes, the two 8 foot sheets are too short, and the choice is between the 3' × 10' and 4' × 10' sheets. The leftover pieces are indicated by the darkened areas. You can see the best choice is probably the 3' × 10' sheet. However, your choice depends on how the leftover material may be used.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

203. Preliminary planning

1. What's the first step in the preliminary planning of a duct system?

2. How can you determine the lengths of the duct trunklines from the working drawing?

3. How can you get the most from the materials when working on a duct job?

4. What's the best choice for a corner lock seam on a rectangular duct?

5. What type of seam do you use on a round duct if a lock seam is desired?

6. How much seam allowance for a crimp do slip joints require?

7. What type of bracing is required on ducts less than 24 inches wide?

204. Selecting material

1. What sheet metal duct material do we use to make most air-conditioning ducts?

2. What sheet metal duct material provides the greatest corrosion resistance?

3. What adjustment for material thickness do you make when you use aluminum instead of galvanized sheet metal to make a duct?

4. What gauge of galvanized sheet metal do you use for round ducts with diameters over 13 inches but less than 33½ inches?

5. What size sheet do you use for a 20" × 24" joint that’s 47 inches long?

6. Why do duct dimension charts list the sections as being on 35-inch or 7-foot, 11-inch centers?

7. How do you decide which size of sheet metal to use if two sizes can do the job?

1–3. Material Requirements

In the previous lessons, we discussed preliminary duct system planning. In the lessons that follow, we illustrate the detail required to get the most from your material when you’re planning a duct job.

205. Determining material requirements

In this lesson, we cover the material requirements for three different trunklines. Follow the steps carefully to see how the stages unfold. This can be a very tedious process if you don’t fully understand what is expected. If you have any questions, be sure to ask your supervisor for assistance.

Trunkline “A” and plenum

Figure 1–18 shows a breakdown of trunkline “A” in FO 1. This shows how you divide trunkline “A” into sections and takeoff fittings. To break down a trunkline like this, your *first* step is to make a scale drawing of the plan view, showing only the outline of the trunkline.

Since trunkline “A” is connected to the supply plenum of the heating and air conditioning unit, we include the plenum in the drawing. As we stated earlier, the plenum is 24 inches wide, 36 inches high, and 24 inches long. Trunkline “A” is 24 inches wide, 14 inches high, and 9 feet 2 inches long.

Since the height of the plenum is 36 inches, lay out its pattern on a 36-inch wide sheet. Since the stretchout (including 1¼ inch Pittsburgh seam allowance) is 97¼ inches, you must decide whether to make it from an 8- or a 10-foot sheet. (Look at fig. 1–17 and see the answer.) The top opening of the plenum is 24" × 24", and the plenum has a cover (top) of the same size, which is attached with 1-inch standing seams. When you add the standing seam allowance on all four edges of the cover, you see the pattern must be 28" × 28". On large jobs like this, don’t cut the 28" × 28" from another whole sheet. Instead, wait for a leftover piece from the next group of patterns, which in this example is from trunkline “A”.

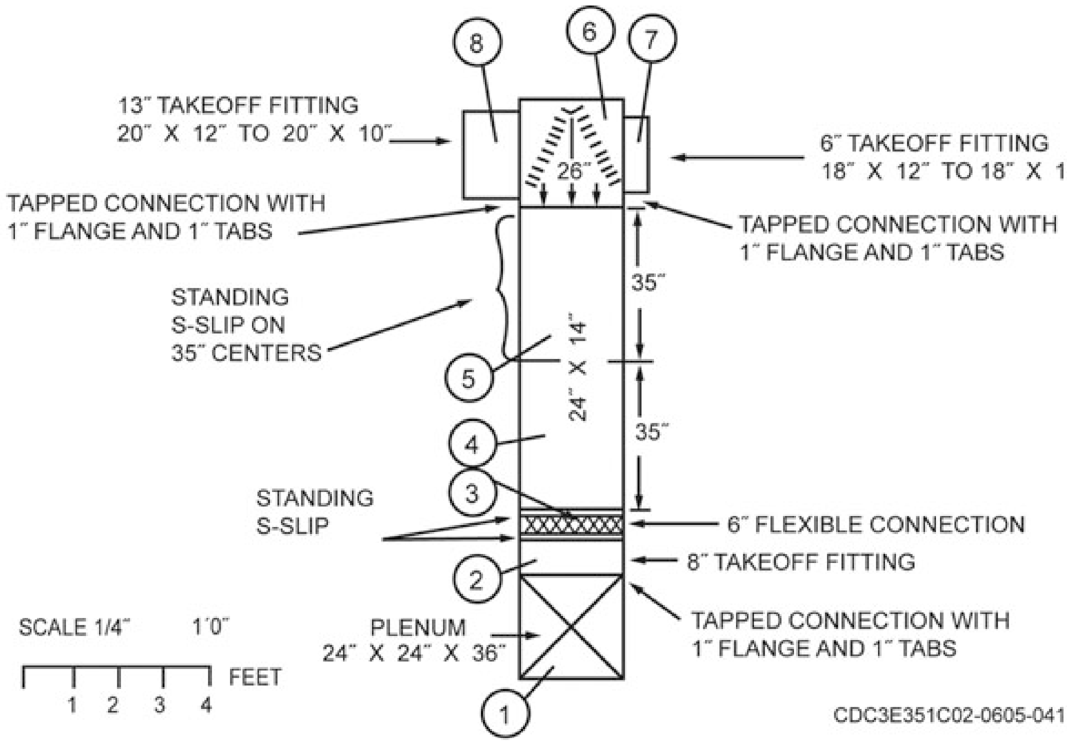

Figure 1–18. Breakdown of plenum and trunkline "A."

So far, we've determined the material required for two patterns. To do this job, you need one whole 3' × 10' sheet (with 36" × 22¾" left over) and another sheet from which you can make the 28" × 28" cover. This is the information needed to develop a bill of material list. Since you may need to make numerous components, we suggest that you create a bookkeeping system to identify the parts by size and quantity, to identify the sheet from which the pattern comes, and to indicate the size and number of sheets needed. Figure 1–19 is an example of such a record. To avoid waste, you'll also find it helpful to make a sketch of each metal sheet, showing how the patterns are to be arranged. Figure 1–20 shows how you can make the trunkline and plenum from four sheets. The sequence for determining the size and quantity of sheets required is a three step process:

1. Make a drawing, like figure 1–18, showing the dimensions of the ducts and joints.
2. Start a materials required list, like figure 1–19.
3. Make sketches of the sheets, as in figure 1–20.

The materials needed for the plenum and for the plenum cover are the first two entries on the bill of materials list (fig. 1–19). Although the illustration shows the chart filled out, we start from the beginning and see how it was developed. By doing this, you learn how to determine the sheet sizes and the number of sheets required for the job. You can use these same procedures for other jobs.

First, write "plenum" in the Item Identification column, followed by the dimensions and number of patterns needed. Since we already determined a 3' × 10' sheet will be used, enter this information in the Source of Material column. At this time, sketch sheet number 1 (fig. 1–20), showing the plenum as 36" × 97¼" with a single piece 22¾" × 36" left over. This piece isn't large enough to make the 28" × 28" plenum cover. (A leftover piece from joint 4 in sheet 2 will be suitable for the plenum cover.) The second entry in figure 1–19 is for the plenum cover, including its size and the quantity needed. You enter the source of material later.

MATERIALS REQUIRED				
ITEM IDENTIFICATION	MATERIAL NEEDED FOR PATTERNS (INCLUDING ALLOWANCES)		SOURCE OF MATERIAL	
	Dimensions	Quantity	Sheet Number	Size
PLENUM	36" X 97 1/4"	1	1	3' x 10'
Plenum Cover	28" X 28"	1	2	
TRUNK LINE A	————	—	—	———
Duct Section 4	36" X 77 1/4"	1	2	3' x 10'
Duct Section 5	36" X 77 1/4"	1	3	3' x 10'
Duct Section 6	26 1/2" X 77 1/4"	1	4	3' x 10'
End Cover (Duct Section 6)	18" X 28"	1	4	———
Duct Section 2	11 1/2" X 39 1/4"	2	3	———
Duct Section 7 (Top and bottom Pieces)	9 1/2" X 20"	2	4	———
Duct Section 7 (Side pieces)	9 1/2" X 12 1/2"	2	2 and 4	———
Duct Section 8 (Top and bottom pieces)	11 1/2" X 22"	2	1	———
Duct Section 8 (Side pieces)	11 1/2" X 12 1/2"	2	3 and 4	———
Duct Section 3 (Metal strips)	3 1/2" X 77 1/4"	2	4	———
Duct Section 3 (Cloth)	6" X 77"	1	From Roll	———
Standing S-Slips	5 1/2" X 23 3/4"	2	1	———
Standing S-Slips	5 1/2" X 23 3/4"	3	2	———
Standing S-Slips	5 1/2" X 23 3/4"	2	3	———
Standing S-Slips	5 1/2" X 23 3/4"	1	4	———
Drive Slips	2 1/4" X 16"	7	4	———
Drive Slips	2 1/4" X 16"	1	2	———

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Figure 1–19. Materials for plenum and trunkline “A”.

Trunkline “A” has the same dimensions (24" × 14") for its entire length. Therefore, its stretchout, including Pittsburgh lock seam allowance, is 77¼ inches. Its length, as we previously determined, is 9 feet 2 inches, which we can divide into duct sections as shown in figure 1–18. Beginning with duct sections 4 and 5, enter the pattern dimensions and requirements on lines of the materials chart (fig. 1–19). These patterns, including allowances, are each 36" × 77¼" and should be made from two 3' × 10' sheets with two 36" × 42¾" pieces leftover. (You can then use one of these leftover pieces to make the plenum cover.) You determine these dimensions by making sketches of sheets 2 and 3, as we show in figure 1–20. In figure 1–18, you can see joints 4 and 5 occupying only 70 inches of the total length (110 inches) of trunkline “A”. This leaves 40 inches for duct sections 2, 3, and 6.

We determine the size of duct section 6 by the size of its two takeoff fittings and the size of ducts 2 and 3. Remember that only 40 inches are available for duct sections 2, 3, and 6. In figure 1–18, you can see how you use these 40 inches to make ducts of appropriate sizes. Section 6 is shown to be on 26-inch centers and is connected to duct section 5 with S and drive slips. The pattern for duct section 6 measures 26½" × 77¼". This requires part of another whole sheet (sheet 4, fig. 1–20), with two leftover pieces. One of these pieces is large enough to make the 18" × 28" end cover for duct section 6. The duct section 6 entry is made in figure 1–19 and the sketch made on figure 1–20 for duct section 6 and its end cover. This end cover is to be installed with standing seams like the plenum cover.

Duct section 2 in figure 1–18 shows a 24" × 14" takeoff fitting. With seam and joint connection allowances added, it needs a pattern 11½" × 77¼". You can make this pattern from the leftover material from joint 5 (sheet 3) if you make it in two pieces 11½" × 39¼" (making the duct in two pieces requires two Pittsburgh lock seams). You now make the line entry for duct section 2 in figure 1–19 and make the sketches on sheet 3 of figure 1–20.

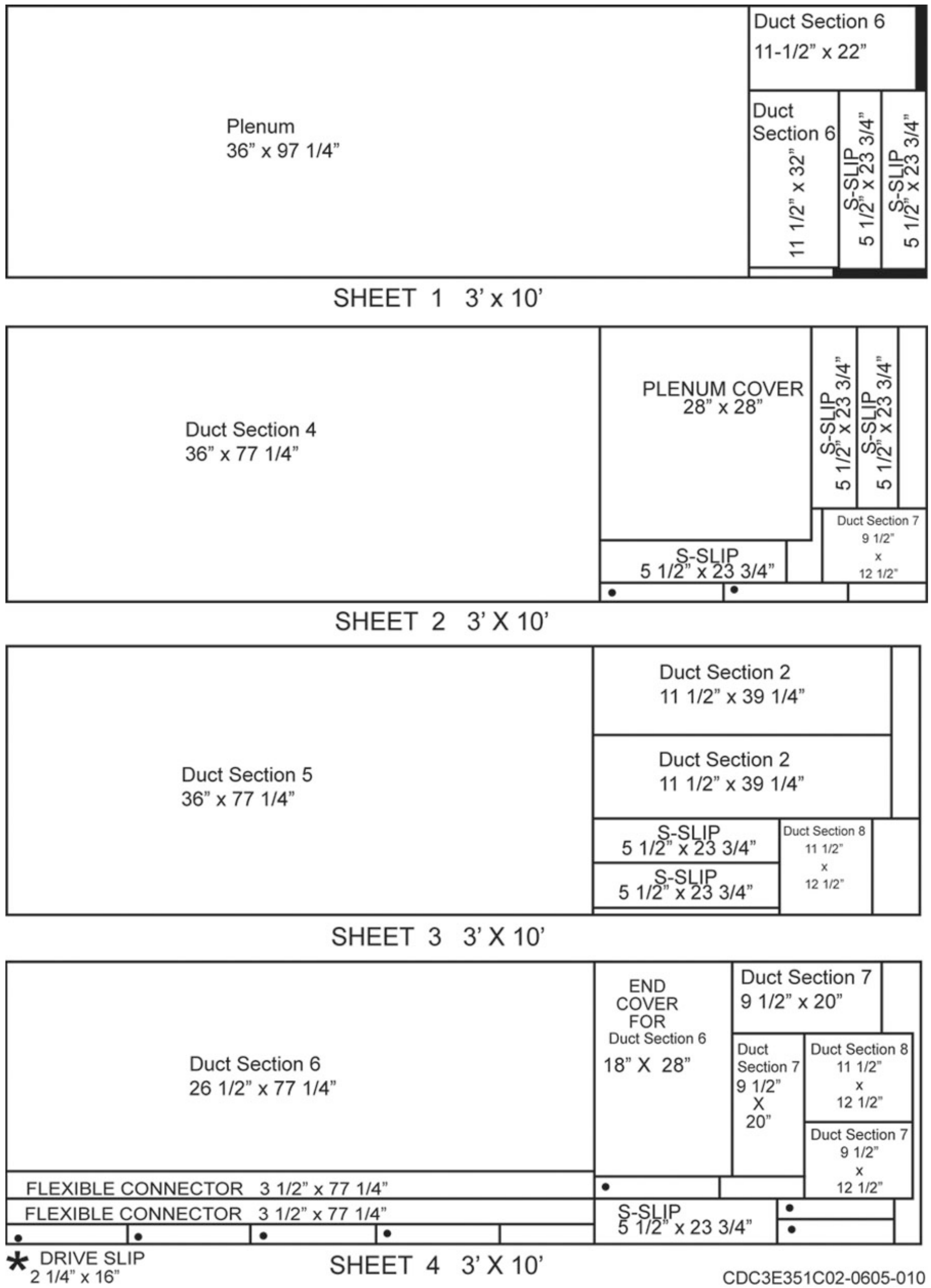

Figure 1–20. Determining size and quantity of sheet metal for plenum and trunkline "A".

Duct section 7 in figure 1–18 is a takeoff fitting 6 inches long, which reduces from 18" × 12" to 18" × 10". It has a tapped connection at one end and S and drive connections at the other. Since this transition tapers on two sides, make it in four pieces and assemble it with four Pittsburgh lock seams. The pattern for each piece is 9½ inches wide (6 inches in length plus 3 inches allowance for the tapped connection and ½-inch allowance for the S and drive connection). The two patterns for the top pieces are 9½" × 20" (allow 2 inches to make the pockets for the Pittsburgh lock seams). The two patterns for the sidepieces are 9½" × 12½" (allow ½ inch to make the ¼ inch flanges for the Pittsburgh lock seams). Enter these four pieces as line items in figure 1–19. Notice in the sketches that the piece left over from the duct section 6 end cover (sheet 4) is large enough to make two top pieces 9½" × 20". Also, notice that the two 9½" × 12½" sidepieces are made from sheets 2 and 4.

Duct section 8 in figure 1–18 is a takeoff fitting 8 inches long, which reduces from 20" × 12" to 20" × 10". It's the same shape as duct section 7 but has different dimensions. Duct section 8 requires four pieces and four Pittsburgh lock seams. You can make the two 11½" × 22" pieces for the top and bottom from the leftover piece from the plenum (sheet 1). You can make the two 11½" × 12½" sidepieces from leftover pieces in sheets 3 and 4.

Duct section 3 is a flexible connection made of a flexible cloth or other flexible material and metal. This section is installed to isolate the heating and cooling unit from the duct system. By isolating the heating and cooling unit, noise and vibration in the duct system is reduced. The flexible connections can be shop made or purchased as complete assemblies that are usually packaged as rolls. The connection is 6 inches long, 24 inches wide, and 14 inches high.

Figure 1–21 shows how the flexible material is connected to the metal strips. The metal strips then connect to the S and drive slips of duct sections 2 and 4. If you're making the connection in the shop, you need a piece of cloth 6 inches wide and 77 inches long (76-inch perimeter plus 1-inch allowance for the stitched lap seam), and two pieces of metal, 3½ inches wide and 77¼ inches long. The cloth or other flexible material is available in bulk lengths in various widths and thickness. You can make the 3½-inch wide metal strips from the 9½" × 77¼" piece left over from sheet 4. If you're using the prefabricated flexible connection material, simply cut a piece 77¼ inches long, notch and bend it, and connect the ends with a Pittsburgh or lap seam. Then record the entries in the materials required list (fig. 1–19).

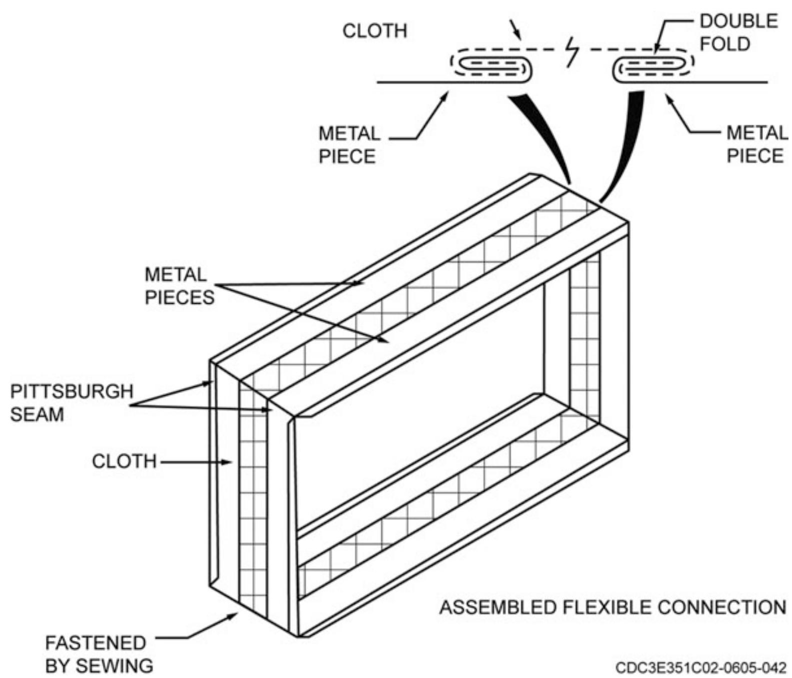

Figure 1–21. Flexible connection (joint 3) used in trunkline "A" and branch lines.

The *last* step in determining the size and quantity of material for trunkline "A" involves the standing S slips and drive slips needed to connect the joints. In figure 1–18, you can see where S slips and drive slips are needed in four places. This means you need eight standing S slips, with 5½" × 23¾" of metal each. The eight drive slips need 2¼" × 16" of metal each. According to the sketches in figure

1–20, you can make seven drive slips from sheet 4 and one from sheet 2. Record these entries in the materials required list (fig. 1–19).

Sometimes you can't make all of the pieces as a complete set, as in this example of trunkline "A". In these cases, it may be necessary to wait and get the additional material needed to complete trunkline "A" from the leftover pieces from trunkline "B".

Trunkline "B"

Earlier in this unit, we discussed the preliminary planning for a duct system. We covered breaking the system down into subsystems and deciding the type of seams, joint connections, bracing, material, and size and quantity of sheets to use. If you carefully study the text and illustrations, you find trunkline "B" is similar to trunkline "C". Look at trunkline "B" in FO 1. It has four different sizes of duct connected with transitions; it has seven round duct branch lines; and it's closed at the end with an end cover.

Now, let's determine the size and quantity of sheets needed to plan and fabricate trunkline "B". Again, our first step is to make a scale drawing of the plan view. Figure 1–22 shows the complete breakdown of trunkline "B" and its branch lines. (Remember to draw only the outside lines and add the joint connection lines and dimensions as you decide how long to make each duct section.) Although the trunkline is divided into two parts to fit on one page, make your drawings larger with the trunkline in a straight line.

To find the length of the duct sections for trunkline "B", draw the joint connection lines as shown in figure 1–22. Begin with duct section 1, which is 35 inches long, center to center. You may think this should be 41 inches, but 6 of the 41 inches are included in the takeoff fitting from trunkline "A". Duct section 1 has a perimeter of 56 inches that, with 1¼ inches added for the Pittsburgh lock seam allowance, makes a stretchout of 57¼ inches. The allowance for the S and drive connections at each end of the duct is ½ inch. Thus, the pattern, including allowances, for duct sections 1 and 2 is 36" × 57¼", which you can make from a 3' × 10' metal sheet. Record this information about joints 1 and 2 on the materials required list (fig. 1–23), and make sketches showing how you can make the pattern for duct section 1 from sheet 1. Figure 1–24 shows how you make these sketches to determine the size and quantity of sheets needed.

Continuing with the large sections of trunkline "B", notice that duct sections 4 and 5 have the same dimensions. Therefore, you can make a one line entry in the materials required list (fig. 1–23). You can also make a one line entry for duct sections 6 and 7 that are the same; duct sections 9, 10, and 11 that are the same; and duct sections 13 and 14 that are the same. In the sketches (fig. 1–24), notice the following duct section locations: 1 and 2 are on sheet 1; 4 and 5 are on sheet 2; 6, 7, and 9 are on sheet 3; 10 and 11 are on sheet 4; and 13 and 14 are on sheet 5.

The transitions in trunkline "B" are duct sections 3, 8, and 12, as shown in figure 1–22. Transitions 3 and 12 you can make in four pieces like the takeoff fitting 7 of trunkline "A". Transition 8 you also make in four pieces but it is somewhat different because both dimensions reduce. Later in this unit when you lay the patterns for these transitions out, you find the true length of the sloping sides. Looking at sheet 6 in figure 1–24, you can see sufficient leftover material to make duct sections 3, 8, and 12.

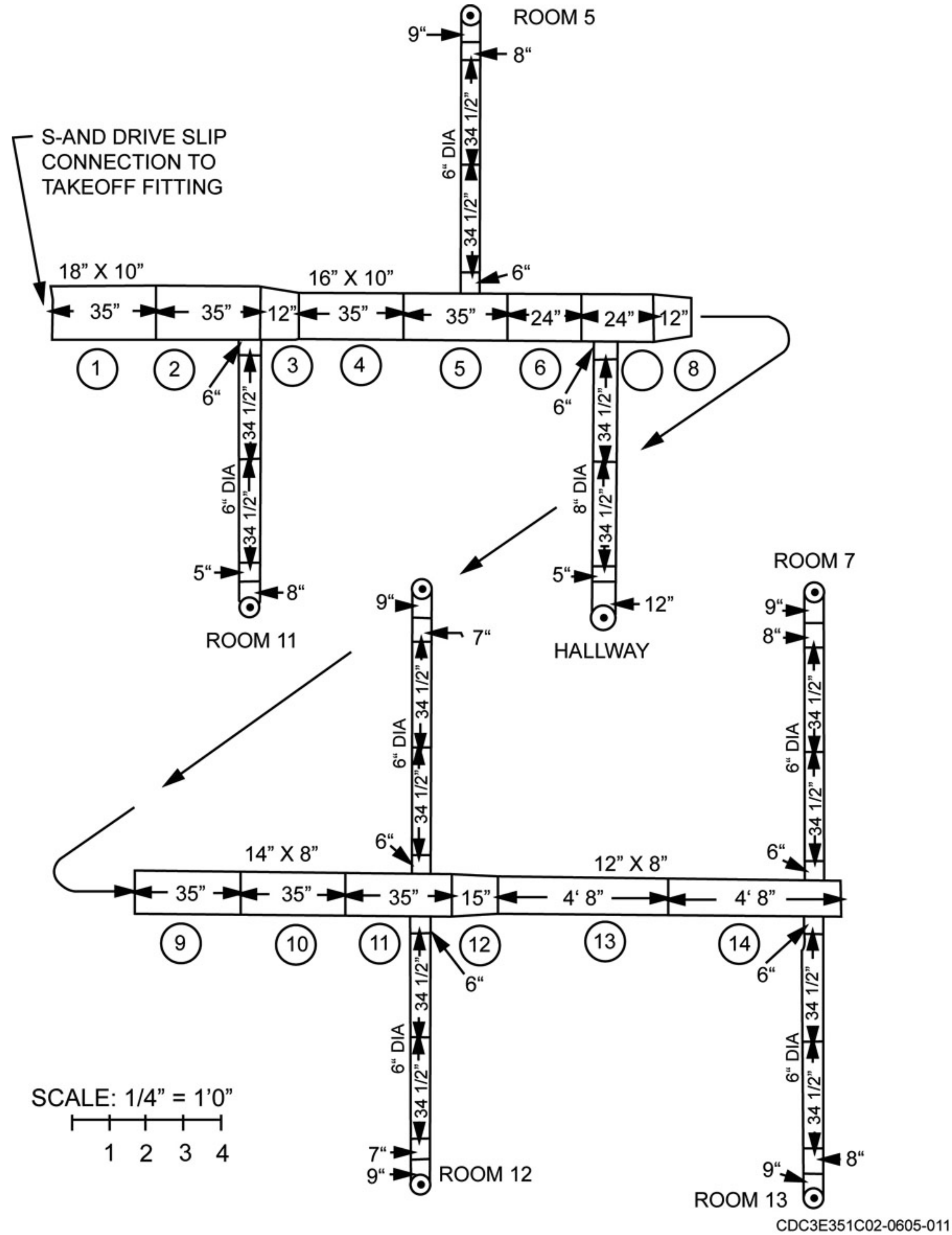

Figure 1–22. Breakdown of trunkline "B" and branch lines.

Sketch the end cover for duct section 14, including the allowance for a 1-inch standing seam on the four sides, on sheet 6 of figure 1–24. Sketch the standing S slips and drive slips on sheet 7. You can save time when laying out and cutting patterns if you group small, similar shaped patterns together. In each of the seven sheets in figure 1–24, several pieces are left over. You can use these later, along with the leftover pieces from trunkline "A", for trunkline "C" and the branch lines.

MATERIALS REQUIRED				
ITEM IDENTIFICATION	MATERIAL NEEDED FOR PATTERNS (INCLUDING ALLOWANCES)		SOURCE OF MATERIAL	
	Dimensions	Quantitiy	Sheet Number	Size
TRUNK LINE B				
Duct Sections 1 and 2	36" X 57 1/4"	2	1	3' x 10'
Duct Sections 4 and 5	36" X 53 1/4"	2	1, 2	3' x 10'
Duct Sections 6 and 7	25" X 36"	2	3	3' x 8'
Duct Sections 9, 10, and 11	36" X 45 1/4"	3	3, 4	3' x 8'
Duct Sections 13 and 14	41 1/4" X 4' 9"	2	5	4' x 10'
Duct Section 3 (Transition top and bottom)	13" X 20"	2	6	3' x 8'
Duct Section 3 (Sides)	10 1/2" X 13"	2	6	———
Duct Section 8 (Transition top and bottom)	13" X 18"	2	6	———
Duct Section 8 (Sides)	10 1/2" X 13"	2	6	———
Duct Section 12 (Transition top and bottom)	16" X 16"	2	6	———
Duct Section 12 (Sides)	8 1/2" X 16"	2	6	———
End Cover (Duct Section 14)	16" X 16"	1	6	———
Standing S-Slips	5 1/2" X 17 3/4"	6	7	3' x 10'
Standing S-Slips	5 1/2" X 15 3/4"	10	7	———
Standing S-Slips	5 1/2" X 13 3/4"	8	7	———
Standing S-Slips	5 1/2" X 11 3/4"	4	7	———
Drive Slips	2 1/4" X 12"	16	7	———
Drive Slips	2 1/4" X 10"	12	7	———

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Figure 1–23. Materials required for trunkline “B”.

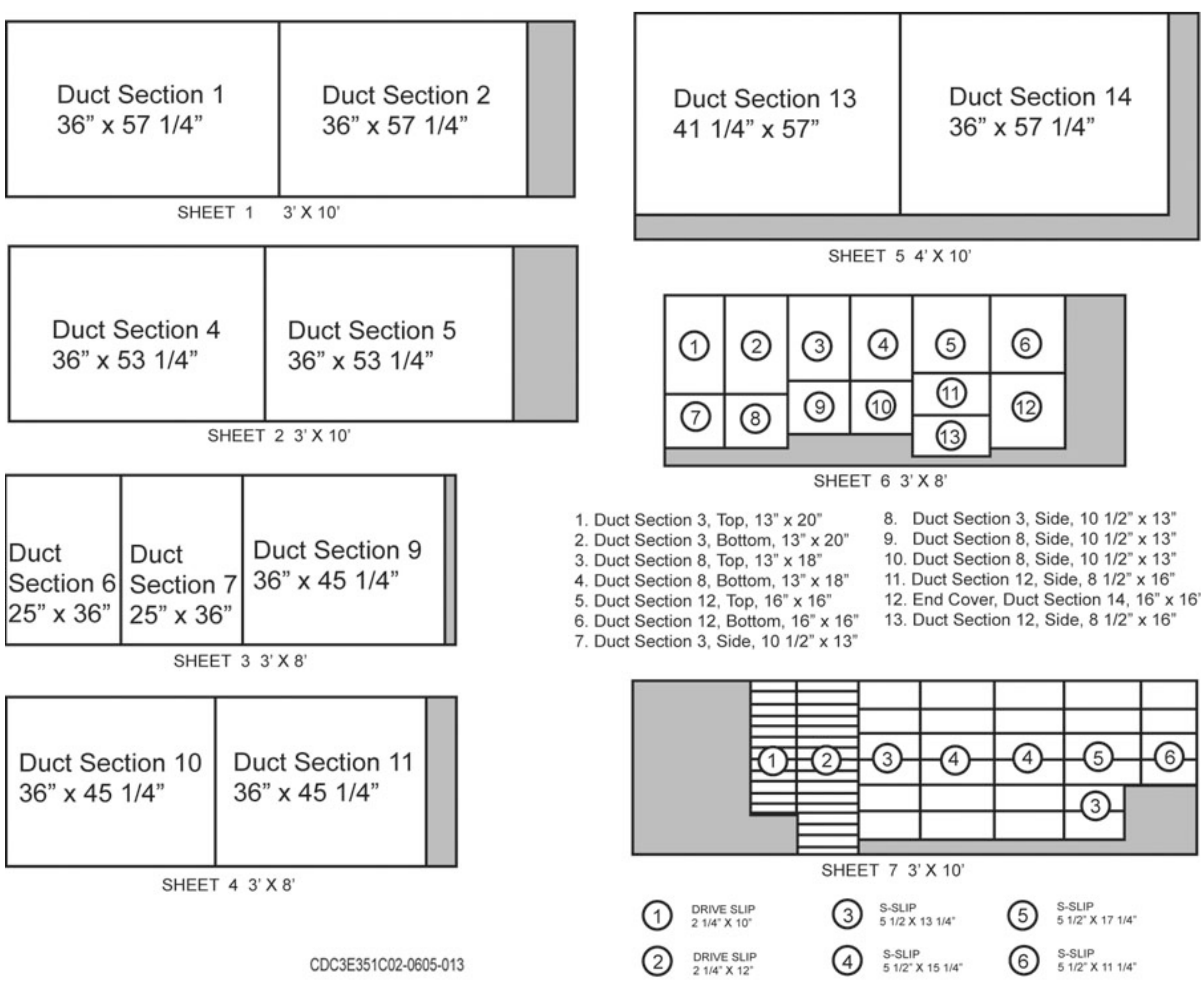

Figure 1–24. Determining size and quantity of sheet metal for trunkline “B” and branch lines.

Trunkline "C"

In FO 1, you can see how trunkline "C" is similar to trunkline "B". In the first duct system breakdown, you found trunkline "B" to be 36 feet 6 inches long, and trunkline "C" to be 42 feet long. Notice in FO 1 how some of the sections have the same dimensions. You can also see how you can use some of the leftover material from trunkline "B" in trunkline "C". Follow the same procedures for determining the size and quantity of sheets for trunkline "C". Make a scale drawing of trunkline "C", as shown in figure 1–25. Remember, this drawing begins with the outlines only and you add joint connection lines one at a time.

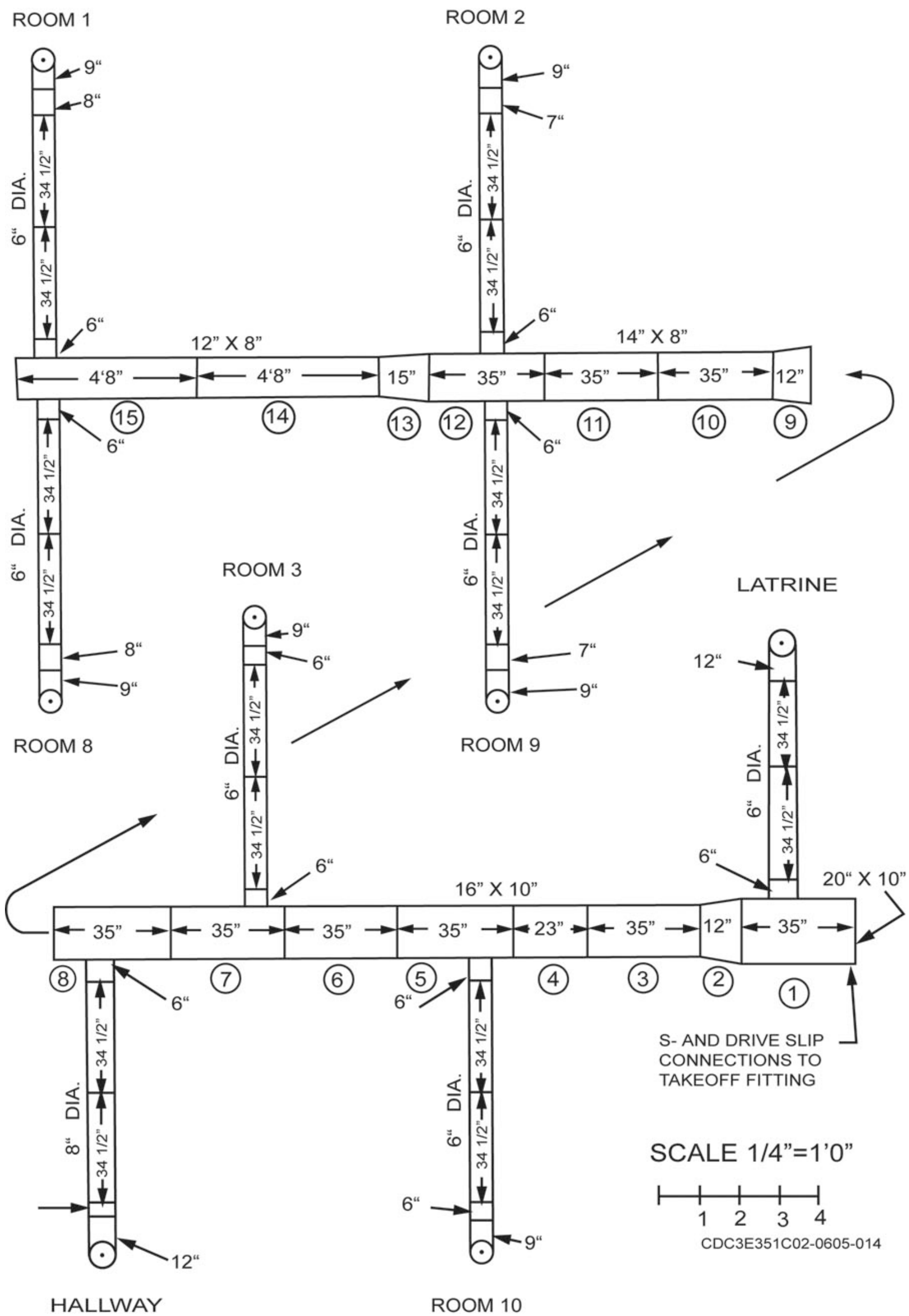

Figure 1–25. Breakdown of trunkline "C" and branch lines.

Branch lines

Earlier in this unit, when you broke down the duct system, you learned it had twelve 6-inch and three 8-inch round duct branch lines. At that time, you also found the length of each branch line. Now you're ready to determine the size (length and width) and quantity of sheets needed. Start by making scale drawings of the round duct branch lines like the ones drawn for the rectangular duct. Figure 1–26 illustrates a scale elevation view of a 6-inch round branch line.

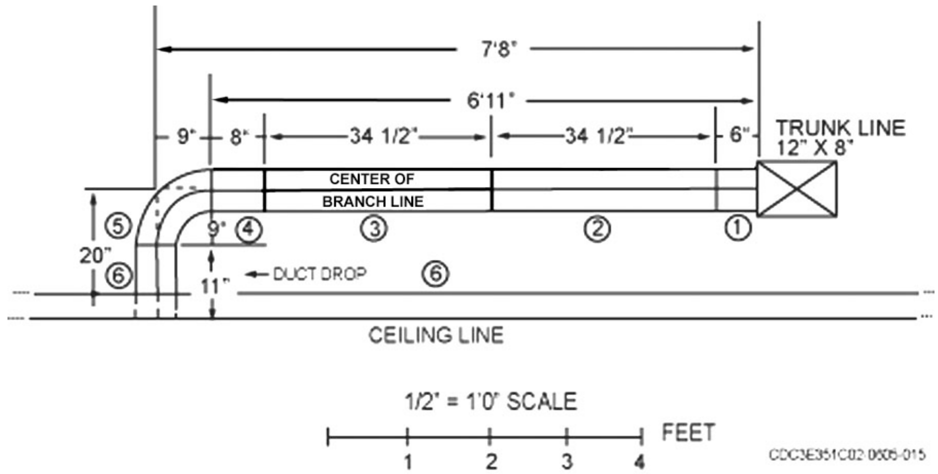

Figure 1–26. Elevation view of 6inch branch line used in rooms 1, 7, 8, and 13.

In these figures, notice how round duct sections on 34½-inch centers are used in most branches. Remember, the allowance for a slip joint is 1½ inches so you can see that 36-inch wide sheets are a good choice. For this example, we're using a Pittsburgh lock forming machine that makes $^{5}/_{16}$-inch grooved seams, which require a $^{15}/_{32}$" seam allowance. The formula to use for this grooved seam is

$\frac{3w}{2}$ as shown below:

$3 \times {}^{5}/_{16} = {}^{15}/_{16}$

$^{15}/_{16}$ divided by 2 = 7 $^{5}/_{16}$ or $^{15}/_{32}$

$^{15}/_{32}$" = allowance for each duct side

Next, you can figure the material needed for a 34½-inch joint in the 6-inch branches is 19 $^{15}/_{16}$" × 36".

34½" center to center	18 $^{15}/_{32}$ circumference of 6" duct (C = πd)
+1½" slip-joint allowance	+1" grooved seam allowance on both ends
36" length of duct section	19 $^{15}/_{32}$" stretch out

Enter the dimensions 19 $^{15}/_{32}$" × 36" in the bill of materials list for the branch lines (not illustrated) before determining the size and number of sheets needed. In this example, you find you can make six pieces 19 $^{15}/_{32}$" × 36" from a 3' × 10' sheet with $^{3}/_{4}$" × 36" left over.

Find the pattern dimensions for the 8-inch round ducts in the same way. Notice in figures 1–22 and 1–25 that all of the 8-inch diameter ducts aren't on 34½ inch centers.

While determining the materials for the branch lines, there are several things to which you must pay close attention. Notice in figures 1–22 and 1–25 that the takeoff fittings are all 6 inches long. These takeoffs are simply 6-inch sections of round duct fastened to the trunklines with dovetail seams. You'll remember from an earlier volume how dovetail seams are made and that the normal allowance is ½ inch. Also note in figures 1–22, 1–25, and 1–26 that the center to center lengths of the 6-inch elbows are 9 inches and the 8-inch elbows are 12 inches. This leaves one short duct in each branch line to compensate for the differences in branch line length. You've already seen that the branch line lengths vary in different rooms. This variation is caused by the transitions in the trunklines.

It's more cost effective to buy round elbows, but, if you make the elbows in the shop, you find the best way to arrange the patterns for the gores of each elbow are side by side. The branch lines shown in figures 1–22, 1–25, and 1–26 include twelve 6-inch elbows and three 8-inch elbows. By laying out a gore pattern for each size elbow, you can determine how many metal sheets are needed to make the 15 elbows.

The next system parts to be determined are the ducts connecting the branch line elbows to the ceiling diffusers. Since these ducts drop the flow of air from the previous centerline, we commonly call them drops. Figure 1–26 shows a typical drop used in the 6-inch branch lines. The length of the drops in the 6-inch ducts is different from those in the 8-inch ducts, due to the difference in the length of 6-inch and 8-inch elbows. The actual drop in this example is 20 inches, which is the distance from the duct system centerline of each room's ceiling. (This distance you determine from FO 2 by measuring the distance from the trunkline "A" centerline to the ceiling. This distance continues to be 20 inches throughout the system.) In figure 1–26, you can see how the 6-inch elbow takes up 9 inches of the 20-inch drop, leaving only 11 inches for the drop. This is the center to center length of the drop, which you must increase by 1½ inches for the crimped slip-joint allowance, making an actual duct length of 12½ inches. In the rooms having 8-inch elbows, the elbow extends 12 inches below the centerline, which shortens the length of the drop.

Return air duct

FO 2 shows an elevation view of the return air duct (return air and outside air plenum) for the heating and air-conditioning system we're discussing. Earlier in the unit, we broke down the return air duct and found the dimensions to be 18 inches high, 36 inches wide, and 9 feet 6 inches long. In figure 1–27, we break the duct further down into sections. Duct section 4 is located where it contains a multi-blade damper. Determining the size and number of sheets for this duct is similar to determining the material for the other rectangular ducts with one exception: its dimensions are large enough to take nearly a whole 3' × 10' sheet for each section. The stretchout including the Pittsburgh seam allowance is 109¼ inches.

The ends of duct sections 1 and 4, shown in figure 1–27, are plain and don't have flanges. This is because the duct opens through the walls and will be boxed in (framed). The hall register and the outside wall louver, when installed, will be fastened to the wood framing. The ducts are connected with S and drive slips.

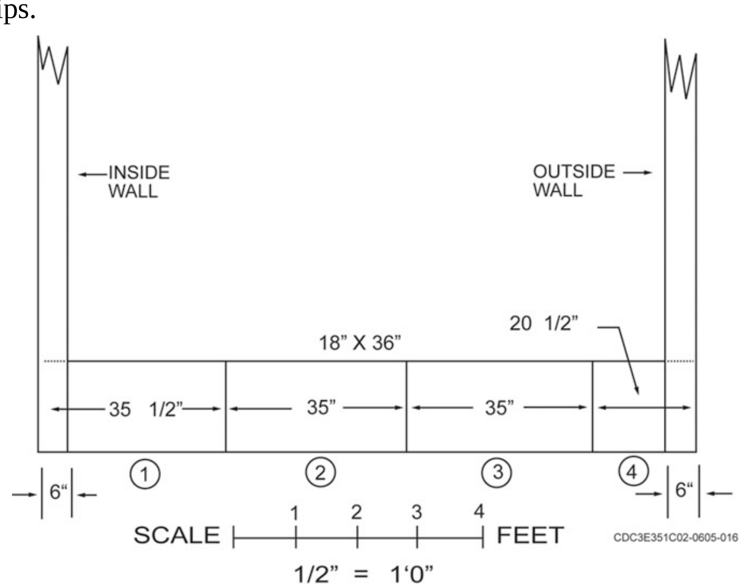

Figure 1–27. Breakdown of return and outside air plenum.

206. Selecting control devices and insulation

Airflow devices are used to control airflow inside of a duct system. Insulation is used for maintaining the air temperature in the duct. In this lesson, we explain what these airflow devices are and where they are used. We also discuss different insulation types and where they are installed.

Registers, grilles, and diffusers

The registers, grilles, and diffusers for a duct system are easy to select because you can find most of the information in the working drawings or blueprints. In the system described here, you use both FOs to select the registers, grilles, and diffusers. To build your bill of materials list, you add each item to the materials required lists (figs. 1–19 and 1–23), and make an appropriate statement in the Source of Material column. For example, if any of the items are to be made in the shop, the source column entry is *the estimated material amount needed*. If the items are to be purchased as factory-made units, the source column entry is *Factory made*.

The only register used in this system is the 18" × 36" return air register. This register, like most return air registers, is installed at floor level.

Two types of grilles are used, wall and door. Some of the grilles are 10" × 6", some are 12" × 6", and one is 12" × 8".

All of the diffusers are round ceiling diffusers with adjustable volume dampers. Two sizes are used: 6- and 8-inch diameter. These diffusers are installed at the duct system *supply outlets*. After the system is installed, you must adjust the damper in each diffuser for the designated cubic feet per minute (cfm).

Louvers and dampers

You also can select the louvers and dampers from the information contained in FOs 1 and 2. The system uses two louvers. One of them is 18" × 36" and is located on the outside air intake of the return air and outside air plenum. The other is 18" × 24" and is located on the outside wall above the return air and outside air louver. It allows filtered combustion air for the furnace to enter the furnace room. Note the description given on FOs 1 and 2 concerning both of these louvers.

The system uses 16 volume dampers. In FO 2, you see a multiblade volume damper located in joint 4 of the return air and outside air plenum (return air duct). This damper must be installed in joint 4 when the joint is fabricated. The damper blades are adjusted by a hand quadrant or automatically by a motor. This multiblade damper mixes inside and outside air for the heating and air conditioning system. In FO 1, you see 15 other volume dampers located in the ceiling diffusers.

Insulation

One type of insulation is soft flexible fiberglass insulation blankets with aluminum foil bonded to one side. These blankets can be wrapped around the exterior of heating and air conditioning ducts for thermal insulation. The insulation also slows the cooling of heated air, or warming of cooled air, as the air passes through the duct system. Insulation around air conditioning ducts also prevents condensation and the resulting water drips. Foil backed insulation is available in rolls up to 100 feet long in varying thickness and widths. The foil on the insulation extends about 2 inches past the edges of the glass fiber forming tabs. These tabs are lapped, stapled, and taped during installation to secure the insulation.

Another type of insulation used is called the duct liner. This insulation is also fiberglass, but instead of being installed on the outside of the duct, it’s installed on the inside. If duct liner is being used, make each section of duct in two pieces. By making the duct in halves, you can easily install the insulation before the sections are assembled. Duct liner is held inside the duct by adhesive or metal pins with clips.

You don't usually decide the type of insulation to use; instead, the type and thickness of insulation is specified on the working drawing or blueprint. Note 2 on FO 1 specifies 1-inch foil backed glass fiber insulation. Your job is to determine the amount of insulation to be used, including length and width. For example, on FO 1 the perimeter of trunkline A is 76 inches; the insulation is wrapped around the duct and the seam is stapled and taped. If you use insulation 48 inches wide for trunkline "A", each full-sized piece should be 48 inches wide and 82 inches long. You can determine the number of pieces needed by the length of the duct. Trunkline "A" is 9 feet 2 inches long; so, two pieces, 48" × 82", and one piece, 14" × 82", cover trunkline "A". The joints between these sheets are pushed together with the foil tabs overlapping to form a lap joint. The insulation for the end cover is 24" × 14" with 4 inches allowed on all four sides for a lap joint.

You can insulate such ducts as the 12" × 8" section of trunkline "B" in FO 1 with one piece of foil backed insulation 48 inches wide and 9 feet 4 inches long. There will be no joints and only one seam 9 feet 4 inches long. It's easier, quicker, and cheaper to use single pieces of insulation when possible.

While figuring the amount of insulation for a duct, select the type of fasteners to use and determine the number needed. Although you've sealed the seams and joints between insulation sheets by folding the edges, other fasteners are needed to hold the insulation in place. Staple and then tape all seams and joints between insulation sheets to seal the insulation. You can also glue the insulation to the duct with adhesive or hold it in place with soft zinc coated 20-gauge wire.

We've now explained the selection of materials for a typical heating and air-conditioning system. This should give you the information needed to make a bill of materials list for the entire duct system. Also illustrated were ways to sketch the metal sheets to get the most components from each metal sheet.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

205. Determining material requirements

1. What's the first step in breaking down a trunkline to find the materials needed?

2. Why do you need a bookkeeping system when planning a duct system?

3. What purpose does sketching patterns on the sheet serve?

4. Why do you install the flexible connection in the duct system?

5. How do you enter joints with the same dimensions on the materials required list?

6. How many pieces do you use to make each transition in trunkline "B"?

7. How can you save time when you're laying out and cutting small, similar-shaped patterns?

8. During duct planning, scale drawings are made. How detailed do you make these drawings when you first draw them?

9. Why does a 36-inch round duct only come out on 34½-inch center when installed?

10. How do you attach round takeoff fittings to the trunkline?

11. Why do branch line lengths vary in different rooms?

12. What component directs air from the branch line elbows to ceiling level?

13. Why are flanges *not* put on the return air duct where the hall register and outside wall louver are to be installed?

206. Selecting control devices and insulation

1. What airflow control device is used for the air supply outlets in a duct system?

2. What is the function of the multi-blade damper in the return air duct?

3. What material do you use to wrap the exterior of heating and air conditioning ducts for thermal insulation?

4. How is a duct liner held in place on the inside of duct systems?

Answers to Self-Test Questions

201

1. Pressure loss, friction, and turbulence.
2. Changes in the direction or size of the duct and air friction with the duct sides.
3. Pipe the air as directly as possible to the required location.
4. Reduce friction by using smooth duct materials.

5. Make the seams and joints as smooth as possible.
6. Diverging and converging duct.
7. The same plane as the radius of the elbow.
8. R/W = 12/8 = 3/2 = 1½ = 1.5; thus, we call it a ratio of 1.5.

202

1. They reduce the turbulence of airflow passing through elbows.
2. 1 and 2.
3. Rivets, screws, or spot welds hold the splitter tabs to the inside of the elbow.
4. H/W = 5.
5. Turn vane rail.
6. To vary the volume of air flowing through the system.
7. Some dampers make only minor changes in volume, some completely shut off airflow, and others adjust the range of airflow from maximum to zero.
8. ¾ the width of the branch line.
9. At the middle of a straight duct.
10. Near the outlet of a branch duct.
11. A fire damper, a type of louver damper.
12. To disperse air in all directions from the ceiling.
13. To control volume and direction of airflow from a duct outlet in a wall.
14. To cover return air openings and permit ventilation through doors and walls.

203

1. Breaking the system down into subsystems, sections, and joints.
2. By measuring with a rule and converting according to the scale shown on the drawing.
3. By selecting the sheets that allow you to cut out the maximum amount of duct while minimizing waste.
4. The Pittsburgh lock seam.
5. Grooved seam.
6. 1½ inches.
7. Cross brake.

204

1. Galvanized sheet metal.
2. Stainless steel.
3. Material thickness is increased by 2 gauges.
4. 24 gauge.
5. 4 feet wide and 8 or 10 feet long.
6. These centers are used because the length given on working drawings is usually the distance from center to center of the connectors at each end of the duct.
7. Consider how the leftover material can be used.

205

1. Make a scale drawing of the plan view.
2. To identify the parts by size and quantity, to identify the sheet from which the pattern comes, and to indicate the size and number of sheets needed.
3. It allows you to arrange the patterns in the best way to avoid waste.
4. It isolates the duct from the air-conditioning unit, which reduces noise and vibration in the duct system.
5. With one line entries.
6. Four.

7. By grouping these patterns together.
8. You begin with only the outlines and then add the joint connection lines later.
9. Because 1½ inches is used for the slip joint.
10. With dovetail seams.
11. Because of transitions in the trunklines.
12. Drops.
13. They don’t have flanges because they’ll be boxed (framed) in.

206

1. Diffusers.
2. To mix inside and outside air for the air conditioning system.
3. Blankets of aluminum foil backed fiberglass insulation.
4. With adhesive and metal pins with clips.

Do the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

1. (201) What type of system do motor-driven blowers, coils, and filters *typically* comprise?
   a. Fiberglass duct.
   b. Metal duct.
   c. Return air.
   d. Forced air.

2. (201) Which duct component maintains the best pressure when air is forced through?
   a. Round elbow.
   b. Rectangular elbow.
   c. Straight duct section.
   d. Square to round transition.

3. (201) Which technique allows you to achieve an air distribution system with smooth airflow?
   a. Make sharp turns.
   b. Use duct material with rough surfaces.
   c. Make transitions as restrictive as possible.
   d. Make rectangular ducts as nearly square as possible.

4. (201) Why is it important to make angles as gradual as possible for transitions that contain a heating coil?
   a. To ensure even air distribution.
   b. To reduce air pressure.
   c. To increase turbulence.
   d. To eliminate friction.

5. (201) When you figure radius ration for square or rectangular elbows, the width should be the dimension
   a. lying in the same plane as the radius of the elbow.
   b. lying in the same plane as the width of the duct.
   c. that equals the height of the elbow.
   d. that equals the height of the duct.

6. (202) To reduce turbulence in square or rectangular elbows connected directly to supply registers, you would install
   a. louvers.
   b. diffusers.
   c. turn vanes.
   d. butterfly dampers.

7. (202) What aspect ratio is the *best* for turn vanes in a duct elbow?
   a. 1.
   b. 3.
   c. 5.
   d. 7.

8. (202) Dampers are used in duct systems to
   a. reduce turbulence in elbows.
   b. vary the volume of airflow.
   c. reduce turbulence in straight duct.
   d. direct the flow of air at a supply outlet.

9. (202) When are deflecting dampers *usually* adjusted for best airflow?
   a. At the end of each month.
   b. At the beginning of each month.
   c. During the first operational check.
   d. During conversion from heat to cool.

10. (202) Where do you *usually* install a butterfly damper?
    a. At the end of a plenum.
    b. At the edge of a trunk line.
    c. In the middle of a straight duct.
    d. In conjunction with a Y-branch.

11. (202) After you adjust a butterfly damper, you lock the handle and damper blade in place with a
    a. wingnut.
    b. lever latch.
    c. nut and bolt.
    d. self-tapping screw.

12. (202) The springs that close a fire damper during a fire are activated by
    a. fire fighters.
    b. a fusible link.
    c. the thermostat.
    d. an electronic switch.

13. (202) What is the recommended way to seal a diffuser to the ceiling to prevent air leaking and smudging?
    a. Install a gasket.
    b. Install a trim ring.
    c. Apply silicone sealant.
    d. Apply caulking compound.

14. (202) Which items would you install where directional control of airflow *is not* important?
    a. Grilles.
    b. Registers.
    c. Round ceiling diffusers.
    d. Square ceiling diffusers.

15. (203) Which seam is *best* suited for a corner lock seam on rectangular duct?
    a. Pittsburgh.
    b. Grooved.
    c. Flanged.
    d. Double.

16. (203) Which seam is *best* suited for a lock seam on round sheet metal duct?
    a. Double.
    b. Flanged.
    c. Grooved.
    d. Pittsburgh.

17. (203) How much material is allowed for the slip joint crimp on a sheet metal duct?
    a. ½ inch.
    b. 1 inch.
    c. 1½ inches.
    d. 2 inches.

18. (204) Most heating, cooling, and ventilating ducts are fabricated using
    a. tin plate.
    b. aluminum.
    c. stainless steel.
    d. galvanized steel.

19. (204) The two *most* frequently used widths of galvanized steel sheet metal for making sheet metal ducts are
    a. 1′ or 2′.
    b. 3′ or 4′.
    c. 5′ or 6′.
    d. 7′ or 8′.

20. (204) How much allowance is required for the S-and-drive connections on each end of a sheet metal duct section?
    a. ½″.
    b. ¾″.
    c. 1″.
    d. 1¼″.

21. (205) What is the *first* step in breaking down a sheet metal duct trunk line?
    a. Determine the duct sizes.
    b. Make an elevation drawing.
    c. Make a scale drawing of the plan view.
    d. Determine the type joint connection used.

22. (205) What is suggested for you to use to keep track of the numerous components that you will be fabricating for a sheet metal duct system?
    a. Layout plan.
    b. Detailed drawing.
    c. Bookkeeping system.
    d. Special material storage rack.

23. (205) To save time in laying out and cutting small similar-shaped patterns for a sheet metal duct, you
    a. group the patterns together.
    b. cut the patterns with straight snips.
    c. put each pattern on a different sheet.
    d. make one pattern and mark the other patterns with it.

24. (205) Duct joints used to connect the elbows in the branch lines to ceiling diffusers in a sheet metal duct are
    a. straight sections.
    b. dampers.
    c. louvers.
    d. drops.

25. (206) When do you set dampers in each diffuser for the designated cubic feet per minute of airflow in a sheet metal duct system?
    a. In the shop before taking them to the job site.
    b. At any convenient time before installation.
    c. At the job site before they are installed.
    d. After the system is installed.

26. (206) What protects a cooling duct in a sheet metal duct system from condensation and possible water drips?
    a. Duct tape.
    b. Insulation.
    c. Drain lines.
    d. Spray paint.

27. (206) Foil-backed insulation can be acquired in rolls up to
    a. 20 ft.
    b. 25 ft.
    c. 100 ft.
    d. 50 ft.

Please read the unit menu for unit 2 and continue ➔

Unit 2. Duct Fabrication, Installation, and Repair

IN THIS unit, we move into the construction, installation and repair stages of duct systems. Not only do we discuss the sheet metal duct systems that you just learned about in unit 1, but we also discuss installation methods for flexible duct. At the end of this unit, we also cover repair methods used for fiberglass duct systems. Fiberglass duct systems are not commonly used for new construction on most Air Force bases; however, many older buildings already have them installed.

2–1. Layout and Fabrication

This section deals with layout, cutting, notching, and forming patterns into sheet metal duct system components. We continue to use the heating and air-conditioning duct system in foldout 1 to explain the procedures. By now you should have a good understanding of the system and should be ready to learn about layout and fabrication.

207. Pattern development methods

We discussed the three pattern development methods earlier in volume 1. They are the parallel line, radial line, and triangulation methods. Most duct components shown in foldout 1 are rectangular and have parallel sides. These parallel sides make the parallel line layout method your recommended choice for pattern development. As you examine the patterns illustrated in this unit, remember, the bending instructions are written so they're on the inside of the duct when it's assembled.

Rectangular duct joint patterns

We use the parallel line method to lay out the rectangular duct patterns. Start with duct sections 4 and 5 of trunkline "A" (fig. 1–18 [unit 1]); each section is 24" high × 14" wide × 35" long. Duct sections 2 and 6, also in trunkline "A", are laid out the same except for length; duct section 2 is 8 inches long, and duct section 6 is 26 inches long. The first step in laying out the pattern for the two-piece rectangular duct as shown in fig. 1–18 is to determine the amount of material required to make it. The information that you need is the height, width, and length of the duct including allowances. You can start with the width and height of the duct (14" + 24" + 14" + 24" = 76"). Next, add an allowance for the Pittsburgh lock seam (pocket and flange). In this case, it's 1″ for the pocket and ¼" for the flange for a total allowance of 1¼". You add these all together to get your height and width requirement (76" + 1" + ¼" = 77¼"). You are now ready to determine the material required for the duct length. First, take the length of the duct (35") and add an allowance for the S and drive slip. In this case, you add ½" to each end length for a total of (1"). When you add it all together, you get (35" + 1") = 36"). *Exception:* Duct section 6 has the ½-inch joint allowance on one end only.

You are now ready to begin drawing out the pattern. You can begin by drawing a straight line equal to the perimeter of the four sides, which in this case is 76 inches long. Draw the five element lines 35 inches long, perpendicular to the stretchout line, and space them 14, 24, 14, and 24 inches apart. When you add the upper stretchout line, you've a 76") × 35") rectangle. Next, add the Pittsburgh lock seam allowances (1 inch on one edge and ¼ inch on the other edge). Then add the ½-inch S-and-drive slip allowances for the joint connections. Remember that the 76-inch length of the stretchout won't be the length of the assembled joint. The joint will be 35 inches long, plus allowances. The final step is to mark the notches.

Round duct patterns

All round ducts in the branch lines are made in the same way except for the dimensions. In figures 1–22 and 1–25, most of the round duct has a 6- or 8-inch diameter, with the length made on a 34½" center. Since the sides of the pattern are parallel, the parallel line method of layout is the recommended method to use. Without allowances, the pattern for a 6-inch round joint on a 34½-inch center is a rectangle 18⅞" × 34½" (fig. 2–1). The 18⅞-inch side of the pattern is the circumference of the 6-inch duct, and each edge has ½-inch allowance for the $^{5}/_{16}$-inch grooved seam. Notice how one edge is to be bent up and the other is to be bent down. The pattern length is 34½ inches plus 1½ inches for the crimped slip joint, making a total length of 36 inches. The patterns for the other round ducts in the branch lines are like this one, except for their dimensions. The seam and joint allowances are the same for all round duct sections, except for the ones attached to the trunkline with dovetail seams.

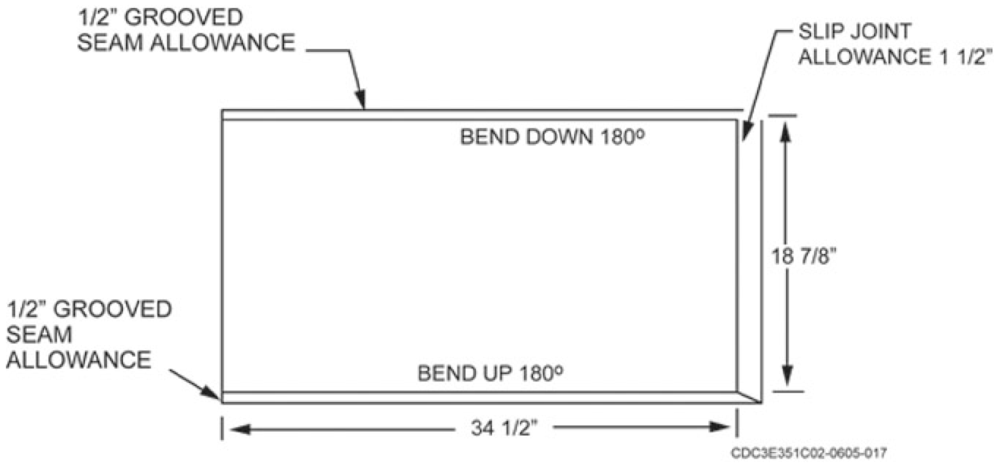

Figure 2–1. Pattern for 6-inch round duct joint.

Transition patterns

Trunklines "B" and "C" in figures 1–22 and 1–25 have three transitions each. These six transitions are similar, and their development is shown in figure 2–2. These patterns are developed by using the triangulation method as follows. First, draw a plan view of the larger (16"× 10") rectangle (fig. 2–2). Next, draw the smaller 14" × 8" rectangle inside the larger rectangle. Note the corner diagonals and the centerlines. The next step is to draw the elevation view. The height of the transition is 11 inches, but you must add ½" allowance at each end so the S-and-drive slips connect properly. This makes the elevation view height (plus the straight portion) 12 inches (fig. 2–2). When you transfer the length of the element lines to the true length chart, you find the true length of the sloping sides is 11$^{1}/_{16}$ inches. When you add this to the ½-inch allowance on each end and the ½-inch S-and-drive allowances, the total length of the pattern is 13 $^{1}/_{16}$ inches.

The patterns for the top and bottom, before the S-and-drive allowances are included, are identical to the elevation view except that you use true length. To the top and bottom pattern in figure 2–2, you must make ½-inch S-and-drive allowances at each end and 1-inch Pittsburgh seam pocket allowances on both edges. Notice how the straights are bent, one up 5° and one down 5°. The patterns for the two sides of the transition are identical. In both patterns, we show the bending and notching instructions, as well as the cross-brake lines.

We develop the patterns for transitions 3 and 12 of trunkline "B" and transitions 2 and 13 of trunkline "C" in a similar manner. The one exception is that only the width of these transitions reduces; the height remains the same.

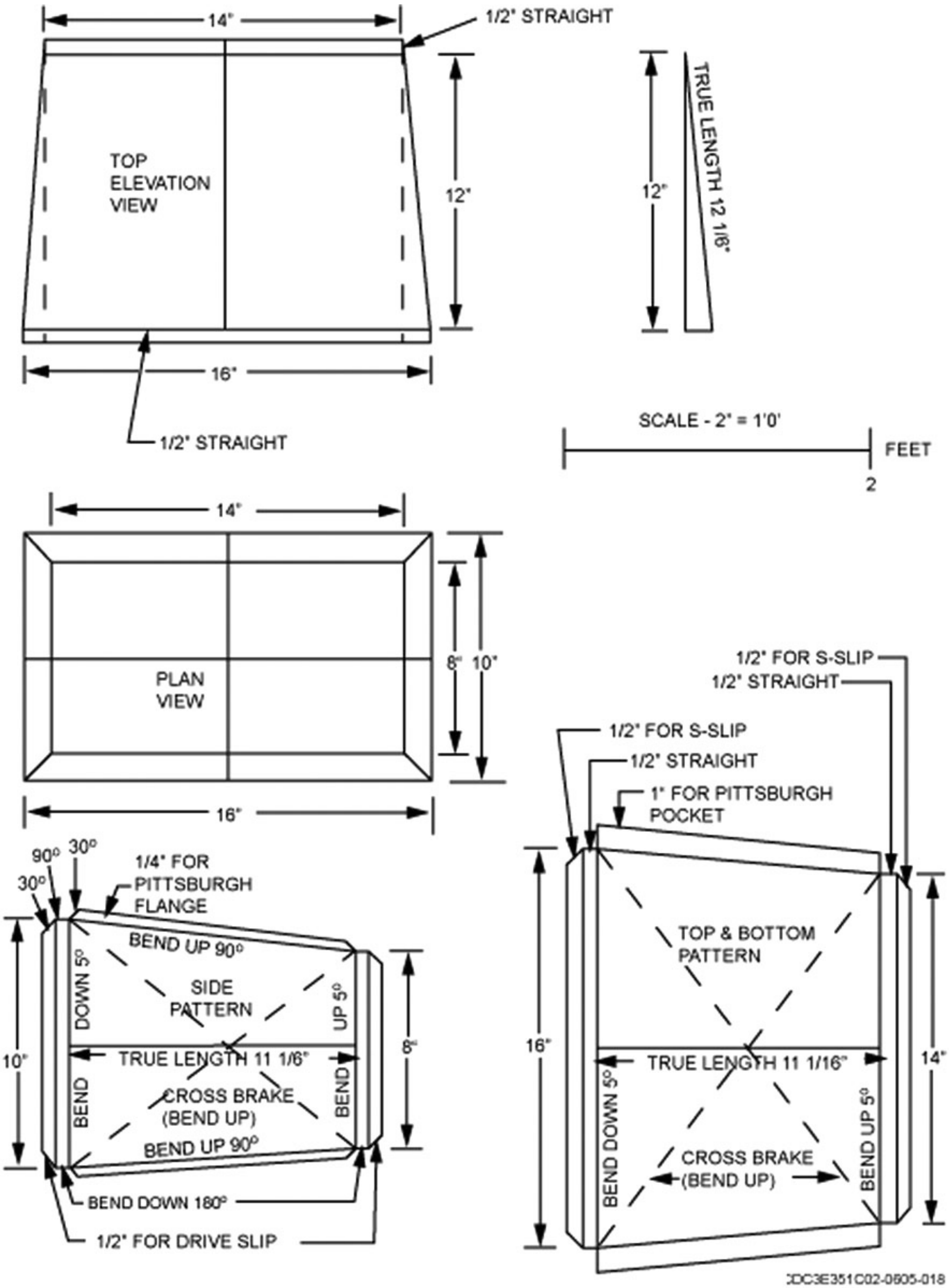

Figure 2–2. Patterns for 16" × 10" to 14" × 8" transition for trunklines "B" and "C."

Plenum top and duct end patterns

We show the pattern for the top of the plenum in figure 2–3. This pattern, except for its dimensions, is the same as the patterns for the trunkline end covers. This piece, with standing seams on all four sides, fits tightly over the 24" × 24" opening in the plenum (fig. 2–4). To install the plenum top, we usually use four standing seams to provide a good seal and to add strength and stiffness to the plenum. In figure 2–3 you can see how 2 inches are allowed on all four sides for the four standing seams, and the instructions for bending, corner notching, and cross braking are given. This pattern is developed by the parallel line method of layout.

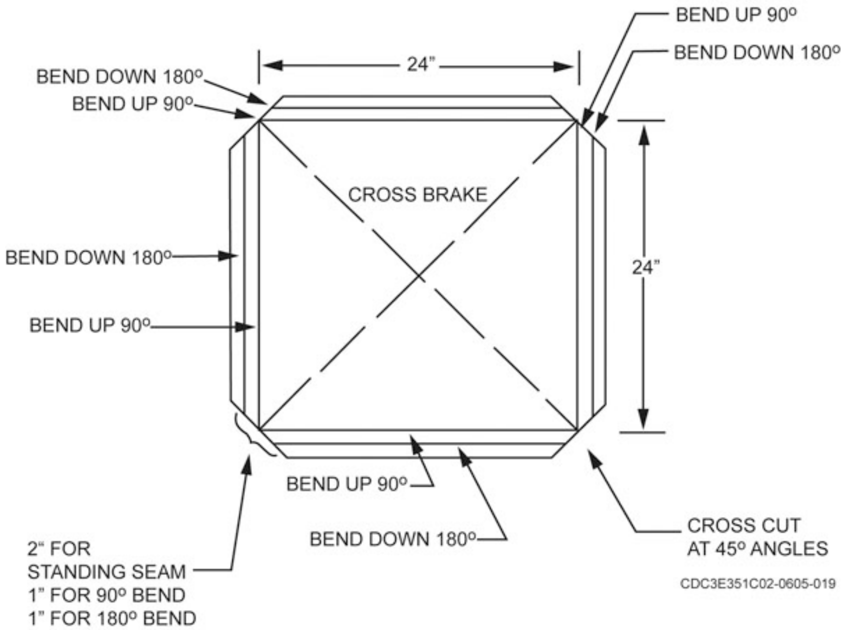

Figure 2–3. Pattern for plenum top or end cap.

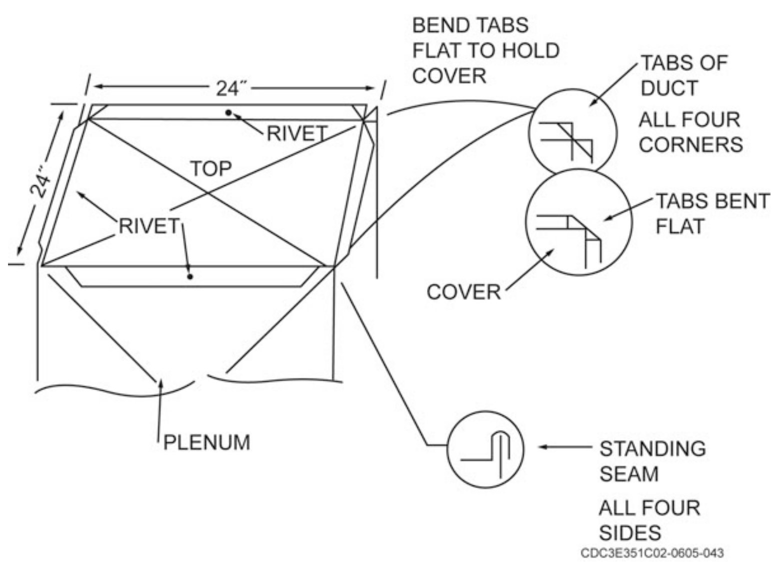

Figure 2–4. Standing seam used with plenum top.

Elbow patterns

The branch lines of the duct system in foldout 1 have similar elbows except for size. We won't consider the pattern development for elbows because of their availability on local markets (costing less to buy than for you to fabricate them). If you do make the elbows in the shop, you can find the instructions in volume 1 of this course.

Turn vane patterns

In an earlier unit, you learned how to determine the width, length, spacing, and number of turn vanes needed to achieve maximum airflow through a 90° rectangular elbow. This information is needed before you can make the pattern. Figure 2–5 is an enlarged plan view of joint 6 of trunkline “A.” As you can see, it contains two sets of turn vanes. This illustration comes from the breakdown of trunkline “A” in figure 1–18. Remember, for best airflow, turn vanes must be spaced so that they have an aspect ratio of 5. Using the formula H/W = 5 and substituting the height of the duct (14 inches), we get 14/W = 5, or $2\frac{4}{5}$ inches as the spacing between the turn vanes.

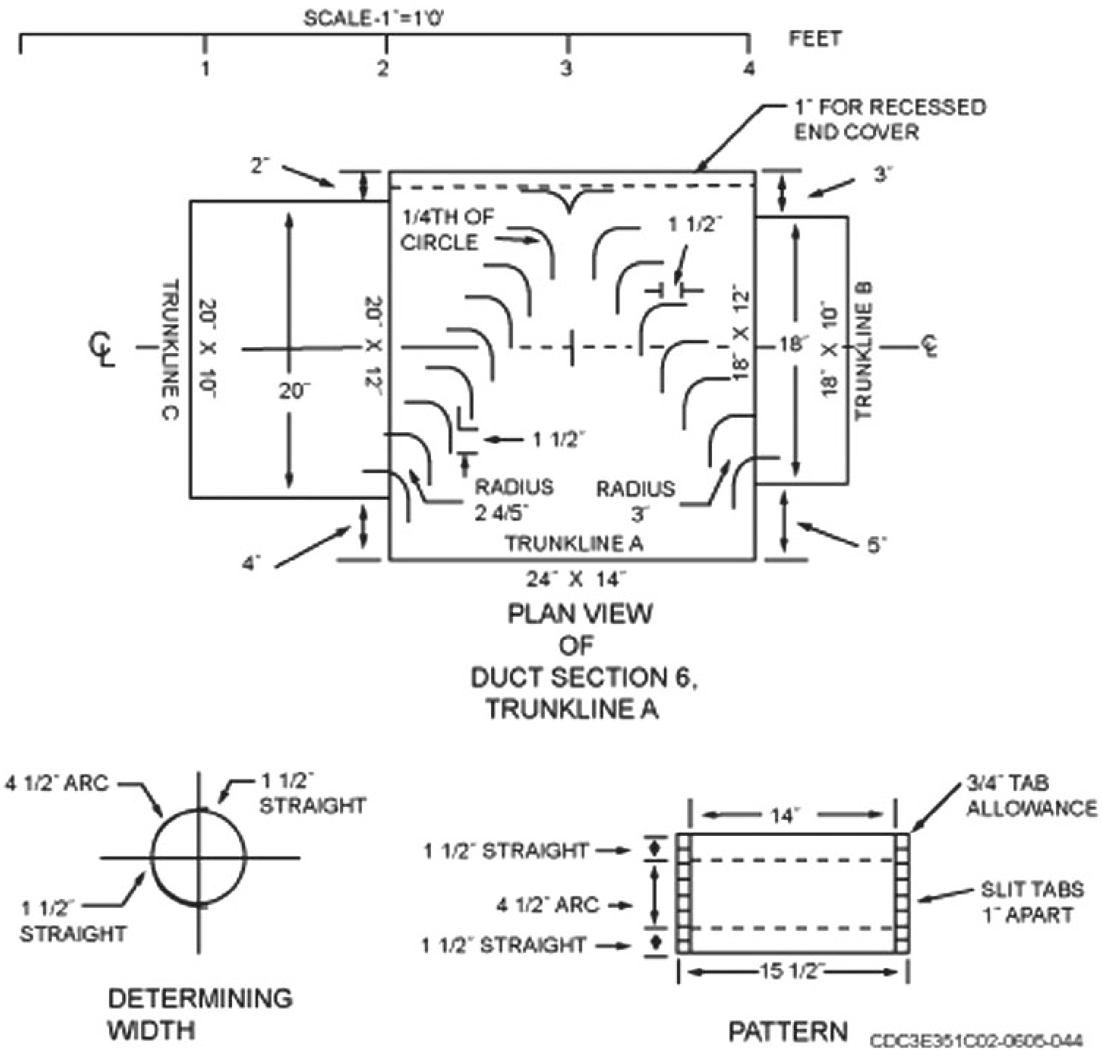

Figure 2–5. Pattern for turn vanes.

The next step is to determine the number of turn vanes needed. Divide the $2\frac{4}{5}$-inch (2.8-inch) spacing into the length of the turn vane rows. As you can see in figure 2–5, the row for trunkline “B” has eight turn vanes and the row for trunkline “C” has nine turn vanes. In both computations, the actual number of turn vanes is a mixed number that’s rounded to the nearest whole number. In this step you also find the curved part of the turn vane is 4½ inches and each straight is 1½ inches. So, the dimensions for each turn vane are 7½" × 14". (If necessary, refer to figure 1–6 to refresh your memory about turn vane dimensions.) When you add the ¾-inch tab allowance to each end of the pattern, the total dimensions become 7½" × 15½". In figure 2–5, we marked the ¾-inch tab allowance to show the cutouts, which are approximately 1 inch apart. During installation, these tabs are bent 90° and attached inside the elbow with screws, rivets, or spot-welds.

208. Fabrication procedures

In this lesson, we discuss the common procedures we use to cut, notch, form, and assemble sheet metal used for ducts and metal components. As with any project you work on, safety is of utmost concern. Be sure to identify potential hazards, such as sharp metal edges and cutting equipment, and take the appropriate steps necessary to avoid being injured.

Cutting and notching

Patterns like those shown in figures 2–2 and 2–3 contain information you can use for cutting and notching. For example, figures 1–20 and 1–24 show how patterns can be placed on full-size sheets so that leftover material is kept to a minimum. This information, combined with what you learned about sheet metal cutting equipment, should help you cut and notch patterns of all shapes. Most patterns for this duct system can be cut with squaring shears or unishears and notched with straight snips.

Cutting patterns

The patterns for duct sections 4 and 5 of trunkline "A" are cut from sheets 2 and 3 (fig. 1–20). You can cut duct patterns quickly from the metal sheets with power or manually operated squaring shears. After marking the pattern on the 3' × 10' sheet, place the sheet in the squaring shear and cut along the 77¼-inch line. You'll find the front and back gauges on the shear the most helpful when you are cutting several pieces the same size.

When you cut patterns, be sure to include the seam and joint connection allowances. For example, before you include allowances on this pattern, its size is 35" × 76". The completed pattern with allowances is 36" × 77¼".

Several rectangular ducts in foldout 1 require holes for the takeoff fittings. The plenum must have a 24" × 14" opening to accept duct section 2 of trunkline "A." Duct section 6 of trunkline "A" must have openings for the trunkline "B" and "C" takeoff fittings. Several joints in trunklines "B" and "C" have round openings for the 6- and 8-inch round takeoff fittings. You can make the rectangular cutouts with straight snips or portable unishears, and the round cutouts with aviation snips or portable unishears. It's recommended that you cut the openings for the branch lines after you install the trunklines. By cutting them after the trunklines are in place, you can install the branch lines in exactly the right places.

The patterns for the round ducts are easy to cut because they're rectangular and don't have notches. Figure 2–1 shows the pattern for the 6-inch round joint used extensively in the branch lines. **Note:** the size of the pattern, including allowances, is 19⅞" × 36". You can cut patterns this size from 3′ × 8′ or 3′ × 10′ sheets with very little leftover material. Since several duct sections are to be made, you can save time by setting the back gauge of the squaring shear for 19⅞ inches and cutting all of the pieces from whole sheets of metal. Cut the patterns for the transitions shown in figure 2–2 from sheet 6 in figure 1–24. The top and bottom patterns were estimated to be 13" × 18", but because of the true length of the sloping sides, the pattern requires $13\frac{1}{16}$" × 18". This additional $\frac{1}{16}$ inch you can obtain from the leftover material on sheet 6 (fig. 1–24) without affecting the other patterns. This same additional $\frac{1}{16}$ inch is needed for the 2 side patterns, which have an actual size, including allowance, of 10½" × $13\frac{1}{16}$". When you cut this extra $\frac{1}{16}$ inch for the top and bottom pieces, it also provides the extra $\frac{1}{16}$ inch for the two sidepieces. You can cut sheet 6 easily with the squaring shear by making the first 36-inch cut along the line between duct sections 2 and 8. Make the next 36-inch cut between the four pieces of duct section 8, but allow $13\frac{1}{6}$-inch width instead of the 13 inches shown. The next cut makes another piece that is $13\frac{1}{16}$" × 36". Make the other 36-inch cuts across sheet 6 as marked.

Now, go back to the 26⅛" × 36" piece cut for the transition. Three cuts are needed to separate the four pieces of the transition and the 7½" × 26⅛" leftover piece. Remember to use the $13\frac{1}{16}$-inch measurement instead of the 13-inch measurement.

Notching patterns

Make the slits and notches in patterns with straight snips or throatless shears. Straight snips are used most often, but throatless shears have more leverage and require less effort. When using either of these, be careful to make the cuts only as deep as the pattern specifies.

Notching patterns is necessary for a number of reasons. Notching makes it easier to bend the sheet metal along the pattern brake lines, assemble the Pittsburgh lock seams, and assemble S-and-drive connections.

Most sheet metal workers develop a notching method that works for them. There are no set-in-stone rules for notching. Until you develop your own method, we recommend that you cut V-notches and slant notches at 30° angles, and square notches at 90° angles. In figure 2–2 you can see examples of these notches. You use V-notches along the ½-inch allowances for the S-and-drive connections, slant notches at each end of these ½-inch allowances, and square notches at each end of the 1 inch Pittsburgh seam allowance. You can cut all of these with straight snips. Notice at the right end of the pattern how one cut makes the slant notches for two sides at one time. The same notching guidelines followed here are used for the allowances on square and rectangular duct.

The patterns for round duct joints (fig. 2–1) don't require any notches, but the corners of the patterns for the plenum top in figure 2–3 are cut at 45° angles. See how a single cut at each corner makes the slant notches for two sides of the pattern. These slant notches can be easily made with squaring shears.

The ¾-inch slits in the pattern for the turn vane shown in figure 2–5 are spaced approximately 1 inch apart so the tabs can be bent 90°. When you cut slits like these, be careful to make them all ¾-inch long so you can easily bend the tabs.

Forming and assembling

Forming patterns into shape is the next step in fabricating sheet metal components. In an earlier volume, we covered the 1–2–3–4 sequence of pattern forming. Remember, forming operations consist of the following four steps:

1. Cross braking.
2. Seam allowance bending.
3. Joint connection allowance bending.
4. Corner bending.

Rectangular ducts

We sometimes change the regular sequence for forming sheet metal components to make the operation easier. For example, to form the metal for rectangular duct, you may find it easier to do the folding in a 1–4–2–3 sequence because of the length or width of the component. By forming the corners second, the metal is easier to feed through the *Pittsburgh lock-forming machine*. To form the rectangular duct, you first use the *cornice brake* to bend the metal up along the cross-brake lines. A 5° to 10° bend should be sufficient on the cross-brake lines of any square or rectangular duct.

Next, use the *cornice brake* to make the 90° corner bends along the three element lines and the ¼-inch Pittsburgh flange line. This changes the flat sheet into a rectangular shape. Now, go back to step 2, making the bends for the Pittsburgh pocket by feeding the 1-inch allowance for the pocket through the Pittsburgh machine.

In step 3, make the 180° bends for the drive-slip connections. You can make the drive connections on rectangular duct with a *hand seamer* or a shop made *hand folder*. Figure 2–6 shows the layout of a hand folder and how it is used. Figure 2–6, A shows that the layout pattern for the hand folder is made from a 9" × 14" piece of 18-gauge metal. View B shows how the completed hand folder is placed over the edge of a duct to be folded. In view C, the ½-inch allowance of the duct joint is folded to 160°. In view D, the hand folder is turned around and used as a spacer while the folded edge is flattened to 180° with a mallet. When you make a hand folder, it's a good idea to make several sizes so that you can make folds in one operation. Some popular sizes to make are 6, 8, 10, 12, 14, and 16 inches.

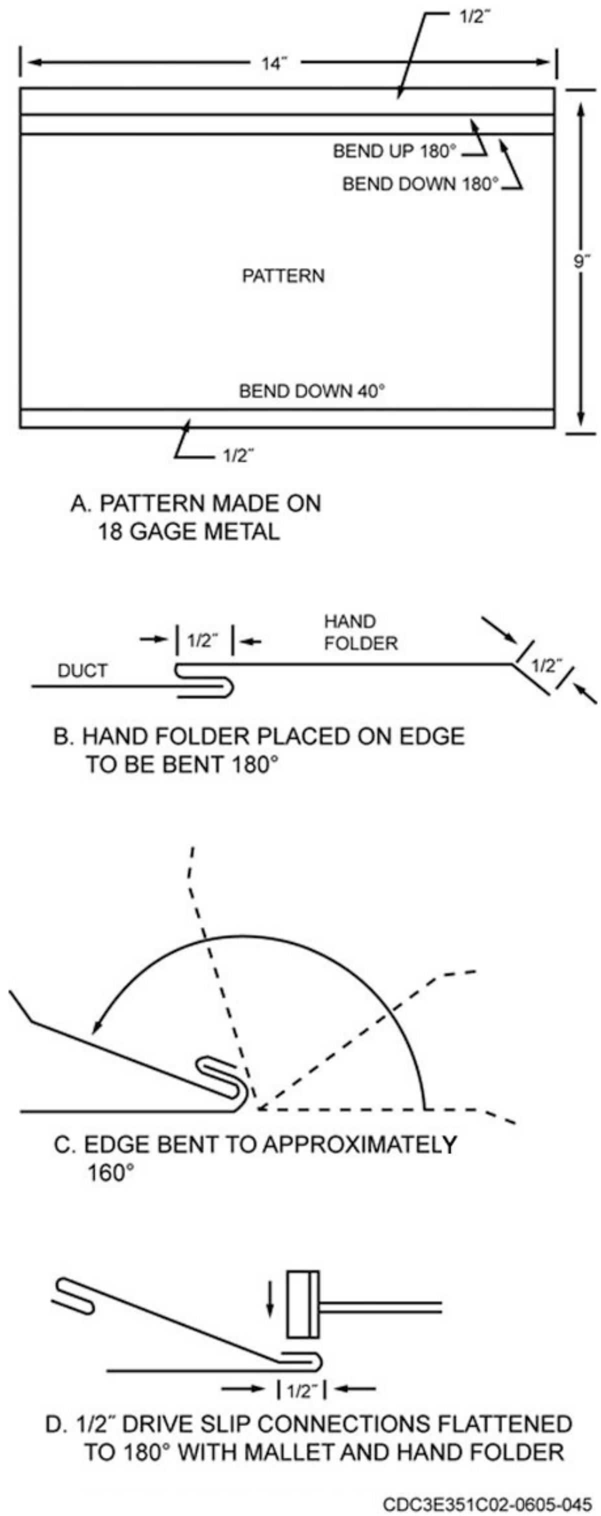

Figure 2–6. Hand folder layout and use.

Assembling the 24" × 14" joint is quite simple, because the only remaining task is to join the Pittsburgh lock seam. In figure 2–7 you can see the steps we use to *lock* the Pittsburgh seam. Start by inserting the ¼-inch flange at one end (view A of fig. 2–7). Start the flange by hand, but after a few inches you may need to use a hammer and rivet set to seat the flange in the pocket.

As you insert the flange, flatten the locking edge of the pocket (view B of fig. 2–7). After the flange is completely seated, flatten the locking edge (view C). This completes the assembly of one rectangular duct section.

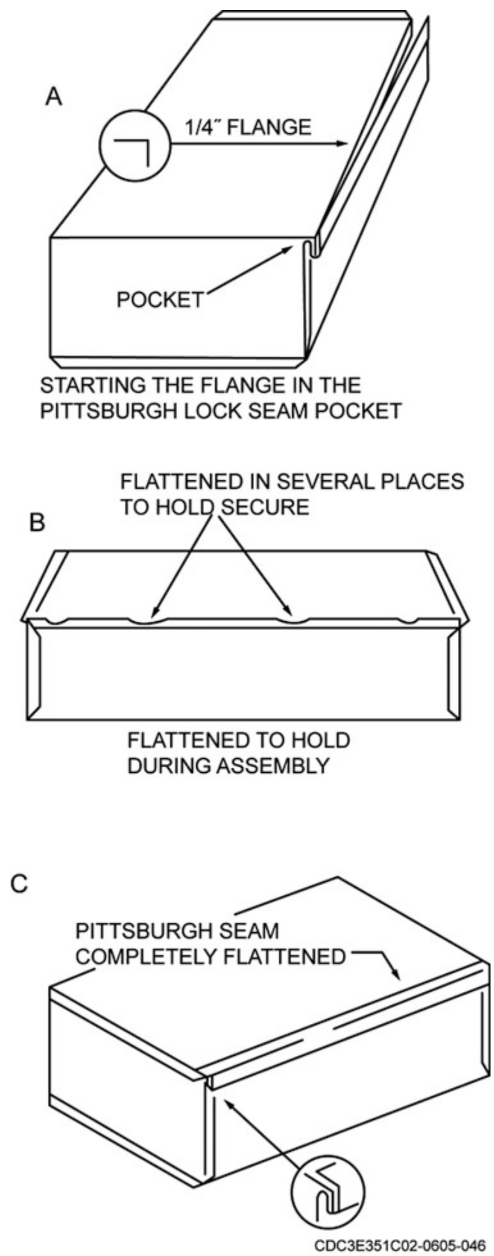

Figure 2–7. Assembling a Pittsburgh lock seam.

All of the other rectangular ducts in the system in foldout 1 are formed and assembled in the same way, except duct section 6 and duct section 2 of trunkline “A.” During the assembly of duct section 6, install the turn vanes by riveting, spot welding, or using sheet metal screws. You attach the two takeoff fittings to duct section 6 by bending the tabs of the tapped connections. The attachment of duct section 2, a takeoff fitting in trunkline “A”, is somewhat different because only the top and bottom have flanges and tabs. This is because the plenum and trunkline “A” are the same width. To compensate for this, form the two sides of the takeoff fitting into a shape similar to an S-slip instead of a flanged tapped connection. When you attach duct section 2 to the plenum, the S-shaped portion slips over the plenum sides. Bend the tabs on the top and bottom like normal tapped connections.

Round duct joints

Forming and assembling a round duct joint is the next task. Although you can make round duct sections with hand tools, there are machines to make the job easier. Cut the patterns with squaring shears and then form them with the following machines:

1. Pittsburgh machine to make the grooved seams.
2. Slip-roll machine to form the sheet into cylindrical shape.
3. Crimping and beading machine to make the crimp and bead of a slip-joint connection.

The pattern shown in figure 2–1 is assembled with a grooved seam. You should remember how to form the grooved seam. Turn up one edge of the pattern and turn the other edge down so they lock together when you roll up and join the piece. When you use the Pittsburgh machine, the turned-back edges fit snugly so you can lock the seam with a mallet and hollow mandrel bench stake. You can form all of the round duct sections in foldout 1 the same way with only the pattern dimensions differing.

Transitions

Forming and assembling the transition patterns shown in figure 2–2 is more complex than forming and assembling round or rectangular duct sections. If you first determine the best sequence for making the bends, the job isn’t difficult. The pattern forming operation steps are as follows:

1. Cross braking.
2. Seam allowance bending.
3. Joint connection allowance bending.
4. Corner bending.

NOTE: Transitions made from four separate sheets of metal do not require corner bending.

First, use the cornice brake to bend the metal up 5° to 10° along the cross-brake lines on all four patterns.

Second, make the Pittsburgh seam pockets on the top and bottom patterns with the Pittsburgh machine, and make the ¼- inch flanges on the side patterns with the cornice brake (or bar folder).

Third, make the 5° bends for the straight portions of the four pieces and the 180° bends for the drive-slip connections. You can make both with the cornice brake. Assemble the four pieces by fitting and locking the Pittsburgh lock seams in each of the four corners.

Plenum top and duct ends

Form the top for the plenum and the ends for the three trunklines by cross braking and making the bends indicated in figure 2–3 with a cornice brake. These components don’t need to be assembled because they’re one piece.

Turn vanes

Make the seventeen turn vanes for duct section 6 in trunkline “A” from the pattern shown in figure 2–5. After you’ve done the cutting and slitting, bend each turn vane to a radius of 2.8 inches with 1½- inch straight edges. Then bend the ¾-inch tabs 90° so you can fasten the turn vanes inside the duct joint. Use rivets, screws, or spot welds to attach the turn vanes to the top and bottom of duct section 6.

Flexible connection

The flexible connection can be shop made or purchased preformed in lengths up to 50 feet. We show the 24" × 14" × 6" flexible connection used in trunkline "A" in figure 1–21. For shop fabrication, we show the patterns for the flexible connection material and metal connector pieces in figure 2–8. Instructions for forming and assembling are included in this illustration. As you can see in view A, the flexible material pattern is 77¼ inches long (including a 1-inch seam allowance) and 6 inches wide. The overall dimensions of the pattern for the two metal connector strips are 3½" × 77¼", which includes seam and S-and-drive connection allowances (view B). The ends of the metal patterns include Pittsburgh seam allowances. One side has a ½-inch allowance for S-and-drive connections, and the other side has a 1-inch allowance for the double seam. The 45° and 90° notches make it possible to bend the corners after making the double folded seams.

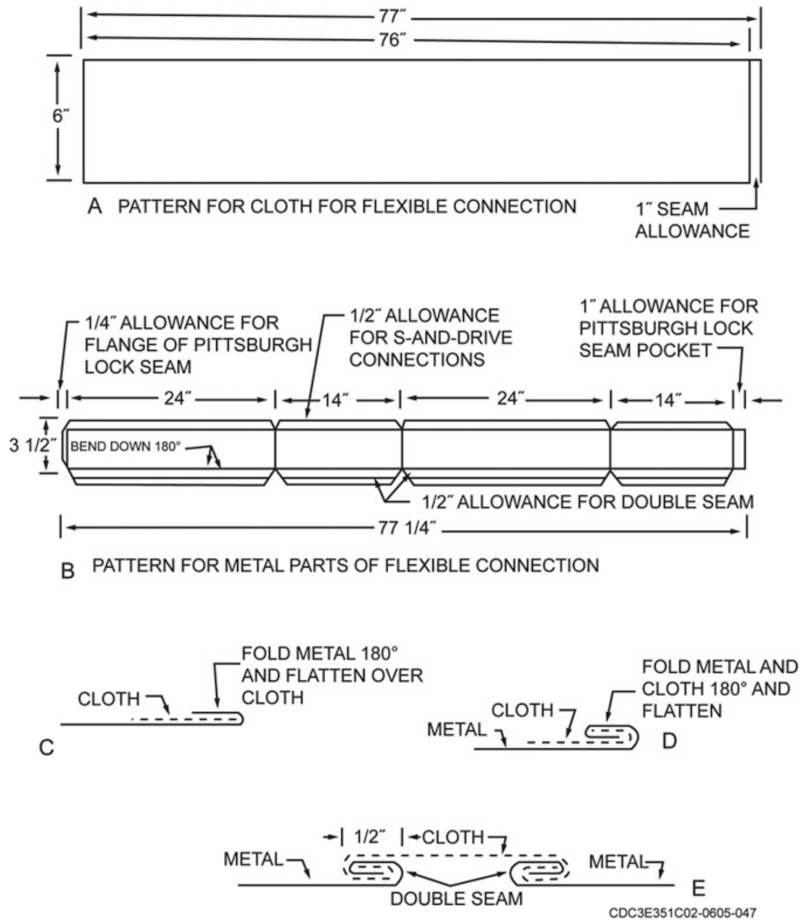

Figure 2–8. Making a flexible connection.

Flexible connection patterns are small and don't require cross braking. Therefore, your first forming step is to make the pocket for the Pittsburgh lock seam. Next, use the cornice brake to make the 90° flange for the Pittsburgh seam and the 180° fold, and flatten the metal with the cornice brake. In view D of figure 2–8, you use the cornice brake to make another fold, then flatten the metal to secure the flexible material with a double seam. Repeat these steps to attach the other metal connector strip.

Your next step is to use the cornice brake to make the corner bends (along the element lines) and the ¼-inch flange for the Pittsburgh seam. Since the flexible material and both connector strips are attached, (view E), the cornice brake can make the 90° bends across all three pieces. Next, assemble and lock the Pittsburgh seams on both metal connector pieces. Your last step is to use a hand seamer or a shop-made hand folder (fig. 2–6) to form the drive-slip connections. This completes the flexible connection, which should now look like the drawing in figure 1–21.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

207. Pattern development methods

1. List three methods of pattern development.

2. Which layout method do we use for the round duct sections?

3. Which patterns are developed using the triangulation method?

4. How do you install the plenum top and trunkline end covers?

5. Why do we use turn vanes in 90° rectangular elbows?

6. What formula do we use to determine turn vane spacing?

7. How much tab allowance do we add to each end of a turn vane pattern?

208. Fabrication procedures

1. What do we use to quickly cut the duct patterns from the metal sheets?

2. What type of snips do we use to cut holes for round takeoff fittings?

3. When is the best time to cut the openings for the branch lines?

4. How can you save time when you must cut several sheet metal pieces of the same size?

5. Why are sheet metal patterns notched?

6. What notches are cut at a 45° angle?

7. What are the four steps in the 1–2–3–4 sequence of pattern forming?

8. What machine do we use to cross-brake the duct sections?

9. What shop-made tool do we use to fold the edges for the drive slips?

10. What forming step do we *not* use when we make four-piece transitions?

2–2. Duct System Installation and Repair

After the duct system components are fabricated, they're taken to the job site and installed. Installation procedures include locating centerlines for duct routing; hanging and joining duct sections; insulating; and installing registers, grilles, and diffusers.

209. Installing and repairing duct systems

This lesson covers the preinstallation steps, along with the actual installation procedures we use for sheet metal ducts and duct components. We also cover the most common repair procedures used on sheet metal duct systems. Installing duct systems is not difficult work; however, you must exercise good judgment and practical safety guidelines from start to finish. This work involves the use of power tools, ladders and overhead work. Be sure you take the necessary precautions to identify and resolve any potential hazard before beginning any project.

Centerline and duct routing

You can determine the duct system's routing and centerline from the working drawings or blueprints. The centerline is an imaginary line passing through the horizontal and vertical center of all of the ducts. For example, if you stretch a chalkline (without sagging) through trunkline "B" from the center of the first 18" × 10" duct section to the center of the end 12" × 8" duct section, the chalkline passes through the center of each duct and transition. The transitions are designed to maintain the same centerline. The horizontal centerline is determined from an elevation view drawing, and the vertical centerline is determined from a plan view drawing.

In foldout 1 you can see the vertical centerline of trunklines "B" and "C" is halfway between the walls of the hallway. Using a rule and the drawing scale, you can find the centerline to be 22 inches from each side of the hall. Later when you're hanging and aligning ducts in the building, you'll use a chalkline (chalk marks) to locate the vertical centerline in the attic of the building. If the building in foldout 1 has a pitched roof with the ridge running parallel to the building length, you can use a plumb line to locate the vertical centerline, because the centerline of trunklines "B" and "C" will be directly below the ridge.

You determine the horizontal centerline of the duct system by using the elevation view in foldout 2. This shows the centerline of trunkline "A" to be 20 inches above the ceiling. In figure 1–26, this horizontal centerline is also shown going through the round duct. You can see that it's also 20 inches above the ceiling. Although all of the ducts on this job are installed with their centerlines 20 inches above the ceiling, you find in some situations the horizontal centerlines change. In these cases, the working drawings or blueprints include the information you need to locate the horizontal centerlines.

Hangers

Hangers are primarily designed to install and level heating, ventilation and air-conditioning ducts. We determine the size and shape of the hangers by the size, weight, and material of the duct, along with how and to what the hangers are attached. We usually use hangers made of angle iron for heavy duct joints that need extra support. The ducts on foldout 1 are supported with strap hangers made of 16-gauge sheet metal cut in 1-inch strips, or of lighter gauges (such as 24 gauge) cut in 2-inch strips and folded like a drive slip to make double-thickness 1-inch strips. Nail these hangers at one end to the rafters or to other structures in the attic (fig. 2–9). Notice how the ends of the hangers are turned around the lower corners of the duct and secured with sheet metal screws. Use a hand punch to make the holes in the hangers, then use a portable electric drill to make the holes in the duct for the sheet metal screws.

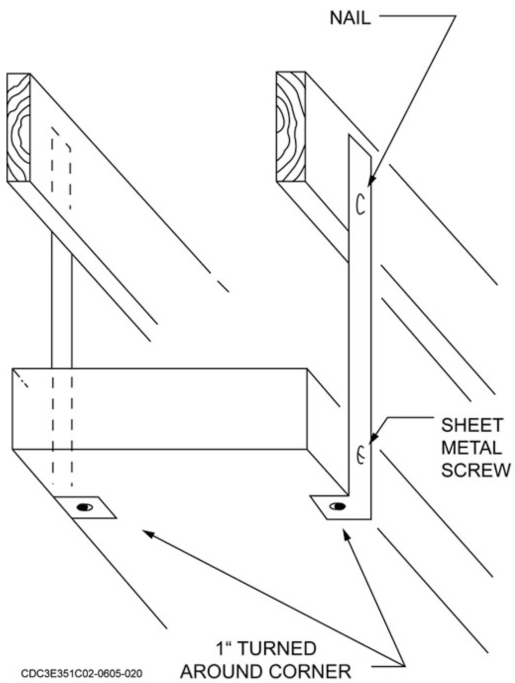

Figure 2–9. Strap hangers.

Figure 2–10 shows two hangers for round duct. These hangers are made of 16 gauge metal 1-inch wide or from a double thickness of thinner gauge metal. Note how each hanger is looped around the pipe and fastened with stove bolts. One type (on the right in the illustration) has a single strap nailed to a rafter; the other type has a double strap, which is also nailed to a rafter.

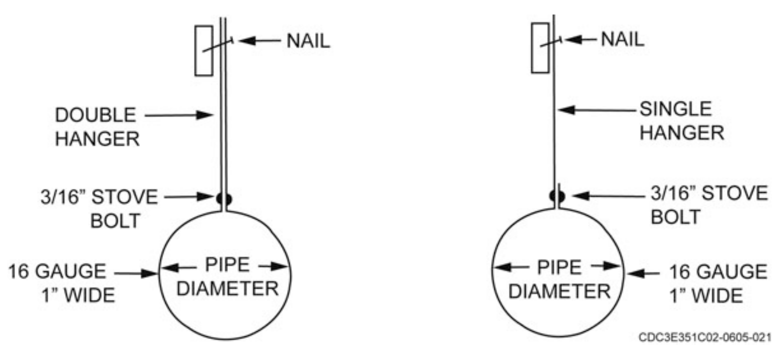

Figure 2–10. Hangers for round duct.

Planning for the installation

Planners, shop supervisors, and crew leaders are usually responsible for making plans to install a duct system. You're responsible for taking the needed tools, equipment, and materials to the job site. It's important to have everything needed at the job site to eliminate wasted time making extra trips back to the shop.

Most of the duct system shown in foldout 1 is in the attic of the building. As with any duct system, it is usually recommended to install the duct to the exposed ceiling joists before the finished ceiling is installed. If the duct is installed after the finished ceiling, it usually results in taking additional time and labor to install the duct system. You can hang and align the ducts more rapidly and safely while standing on scaffolds than you can working in the attic or working from ladders. Some suggested items for your duct installation job include the following:

- Toolkits (one per worker).
- Portable drill and twist drill bits.
- Electric extension cords.
- Hand punch.
- Chalkline and chalk.
- Scaffold or ladders.
- Prefabricated duct joints for the job.
- S-and-drive slips.
- Hangers.
- Sheet metal screws, nails, and stove bolts.
- Insulation and fasteners.

Installing joints and insulation

Up to this point we've covered duct system layout, fabrication, centerline, duct routing, and the tools, equipment, and materials needed at the job site. Now let's see how to install the duct joints.

Duct joints

If the heating and cooling unit is already installed when you get to the job, install the plenum first. If the heating and cooling unit hasn't yet been installed, install the flexible connection first. Figure 1–18 (which is a breakdown of trunkline "A" in FO 1) shows the installed location of a 6" flexible connection. In this example, the flexible connection is joined to both the duct section and an 8" takeoff fitting with standing S-slips. In turn, tapped connections are used to connect the 8" takeoff fitting to the plenum.

If you're installing the plenum first (FO 2), set it on top of the cooling coils of the heating and air-conditioning unit. The coils are in a housing with a 1-inch turned-up flange. Set the 24" × 24" plenum over this flange. Then, fasten the plenum to the flange with sheet metal screws. Before you install the plenum top cover, install the 8" takeoff fitting (joint 2 in fig. 1–18). (This takeoff fitting is usually installed at the shop before we take the plenum to the job site.) The takeoff fitting is attached to a 14" × 24" side opening in the plenum. The tabs along the top and bottom edges of the takeoff fitting are bent to hold the fitting in place. However, the sides aren't bent because, when this takeoff fitting was made, the sides were formed slightly different from a regular tapped connection. These sides are S-shaped to fit over the plenum like S-slips. When the takeoff fitting is installed on the plenum, this S-connection makes a tight fit along the sides. The tabs along the top and bottom hold the fitting to the plenum. You don't need to support the takeoff fitting with hangers because it's firmly attached to the plenum.

The flexible connector (duct section 3) is attached to the takeoff fitting and to duct section 4 with S-and-drive slips. It's a good idea to install hangers on four sides of duct section 4 of the flexible connector to keep from tearing the flexible material when you make the joint connection. The alignment of trunkline "A" begins with these first two hangers, which must be installed so the duct is on the centerlines. You can connect joints 4 and 5 with S-and-drive slips before hanging and connecting them to the flexible connection.

Remember a key point in installing a duct system is maintaining the vertical and horizontal centerline. You can use a chalkline to locate the vertical centerline of trunkline "A." As you install each duct section, make sure the cross-brake intersections are directly over the chalkline. Suspend the hangers from the rafters so the horizontal centerline of the duct is 20 inches above the ceiling. Attach the first hangers (fig. 1–18) to the duct section 4 end of duct section 3. Install the remaining hangers on 48-inch centers (or less). When you're securing the hangers to the duct with sheet metal screws, be sure to punch (or drill) holes in the hangers so they're larger than the screws. If the holes in the hangers aren't larger than the screws, the screws will tighten in the hangers before the hanger is tightened against the duct. Join, align and hang the remaining rectangular duct sections of trunklines "A", "B", and "C" in the same way you did the previous duct sections. Install the plenum top and trunkline ends as shown in figure 2–4.

Install the branch lines after trunklines are in place. Begin by attaching the round takeoff fittings to the trunklines by bending the tabs of the dovetail seams. Hang the other joints of the branch lines by connecting the slip joints and fastening them with three sheet metal screws at each joint connection. These ducts are supported on 48- inch centers (or less). Make sure you maintain the centerlines shown on the working drawings.

If the ceiling hasn't been installed, place the ends of the drops so they're flush with the ceiling when it's installed. If the ceiling has already been installed, cut a hole and install the drop with a flush fit. In either case, the outlets should be in the location designated by the working drawing or blueprint.

Duct insulation

The ducts are insulated before or after installation. You install the insulation either inside or outside the duct depending on the type of insulation you're using.

To install insulation inside a duct, use a duct liner that won't pick up odors or shred into small pieces under high air velocities. Duct liner insulation can be attached inside of a duct with adhesive, metal pins and clips, or a combination of all of them. The best time to install duct liner is just before the duct sections are assembled. To install insulation inside the duct, start by cutting the insulation to size. The next step is installing the metal pins inside the duct. The pins you can install with glue or a pin welder. The two types of pins are different, so make sure you get pins that work with your installation equipment. After the pins are installed, put adhesive on the inside duct surface. You can brush, spray or roll the adhesive, depending on the type of adhesive and application method you decide to use. The final step is to press the insulation over the pins until it touches the duct wall, then install the metal clips on the pins. To keep from stabbing your hand with one of the pins, be careful when pressing the insulation into place.

Figure 2–11 shows a cutaway of a half duct section with insulation installed using adhesive, pins, and clips.

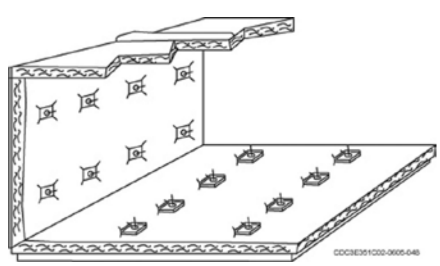

Figure 2–11. Insulation installed with adhesive, pins, and clips.

To insulate the outside of a duct system, you must install the duct first. Since the insulating is to be done on the job, it's a good idea to have three workers on the job. If you have three workers, one can cut the insulation while the other two install it.

To install the insulation on the outside of a duct, you must first decide how to attach it to the duct. In many cases, you can simply staple and tape the seams, or you may decide the additional support of wire or glue is needed. No matter how you attach the insulation, remember that insulation with an outside cover or backing forms a vapor barrier and must be sealed to prevent condensation on the duct. Also follow any instructions the manufacturer of the insulation provides.

When installing insulation, don't pull it too tight. The material insulates better if it isn't compressed. Also, if it's wrapped too tight, the standing edges of the S-slips can punch through and damage the insulation. Be sure to cover the entire duct surface as any exposed portion is subject to condensation when the air-conditioning system is in operation. You can wrap irregularities in the duct, such as transitions, by shaping or cutting the foil-backed insulation to fit the duct and folding the excess material. The foil makes the insulation easy to form, since it holds almost any shape. Tape all joints and seams to ensure a complete vapor barrier. Insulate the remaining trunklines and branch lines using the same procedures you used for trunkline "A" you can wrap each of the 12" × 8" sections of trunklines "B" and "C" with one long piece. Apply the insulation for the elbows carefully because of the 90° turn. If the insulation is cut to cover only the elbow, you can crease it across the throat radius to make a good wrap. The insulation around the straight joints can lap the elbow insulation to make a good fit. Remember to staple and tape where the pieces join to secure the insulation.

To install insulation with adhesive, cut the insulation to the proper size and then apply the adhesive to the duct. Next, carefully place the insulation around the duct, making sure you get it in the proper place the first time. If you have to move the insulation, it may pull apart before the adhesive lets go. After the insulation is in place, staple and use duct tape to seal all of the joints and seams.

To install insulation with the wire tie method, cut and install the insulation by stapling and taping the seams and joints. After you've installed the insulation; use 20-gauge wire and wrap or tie it around the duct as needed to hold the insulation in place. Twist the ends of the wire together and bend them flat so they won't damage the insulation or snag workers and clothing.

Installing registers, grilles, and diffusers

Your final steps in a duct installation job are to install the registers, grilles, and diffusers. Normally, you install these components after you complete the painting and wall finishing. Registers, grilles, and diffusers are often purchased factory-made from a variety of materials that includes wood, metal, and plastic. They are available in many finishes to include highly polished, color pigmented, painted, and primered. Make sure the type you choose is completely finished before installation and its finish and style matches the area where it is to be installed.

Registers

The duct system we cover here has one register. It's the 18" × 36" return air register shown in the return air duct (return air and outside air plenum) in FO 2. The return air register has fixed louvers that differ from the supply register, which has adjustable louvers. The 18" × 36" return air register (FO 2) has fixed louvers very much like those in return air grilles. (You'll find that some manufacturers call return air registers with fixed louvers return air grilles). The return air register to be installed in the return air duct has fixed louvers with a 35° down deflection. From the front, the register looks like view B in figure 1–15, but the louvers are flat instead of V-shaped. The face frame has screw holes, and the register attaches to the wood frame in the wall with screws.

Grilles

Grilles are installed as we explained in unit 1 and illustrated in figure 1–15. The explanation we gave in unit 1 didn't cover how you determine the location of the holes for the fixed louvered grilles. The location information is usually given on the working drawings or blueprints. These show the vertical and horizontal location. Grilles we normally install 6 inches above the floor if the height isn't specified. In some cases, you may need to make minor changes in the location of the door grilles if panel doors are used instead of hollow core doors. In panel doors, make the opening for the grilles in the panel nearest the floor instead of 6 inches above the bottom of the door. If the grilles must match the color of the rooms, paint them before installation. To install grilles in metal doors, use the same procedure shown in figure 1–15, using sheet metal screws instead of wood screws to hold the grilles in place.

The return air grilles for the walls in rooms 2, 3, 5, 6, 9, 10, 11, and 12 in FO 1 are boxed in (framed) and are located at floor level between the wall studs. Use screws to install the front and back frames (fig. 1–15). Install the door grilles in rooms 1, 7, 8, 13, and the latrine in essentially the same way as shown in figure 1–15. They must be 6 inches above the bottom of the hollow core doors.

Diffusers

Figure 1–13 shows a typical diffuser and damper assembly used at the supply outlets of round ducts. These factory-made units are easily installed if the round duct ends are flush with the ceiling. Like the installation of registers, and grilles, installing diffusers is one of the last jobs in the installation of a complete duct system. Fit the damper assembly (fig. 1–13, B) into the round duct and mark the location of the screw holes. After you drill the holes in the round duct, attach the damper assembly with sheet metal screws. Next, attach the diffuser (fig. 1–13, C) to the damper assembly with sheet metal screws that come with the assembly. After tightening the screws, adjust the damper blades to about half open. Make the final adjustment of these dampers when the system is balanced for the specified airflow.

Installing flexible fiberglass duct

This type of duct, commonly called flex duct, differs from the rigid fiberglass duct you will read about in this unit. Flex duct is round and has a flexible liner reinforced with a spiral steel wire. Outside of the liner is a layer of fiberglass to insulate the duct. Around the fiberglass insulation is a plastic outside covering. From this description, you can see the basic duct construction consists of an aluminum liner and a plastic covering, with fiberglass insulation in between. It is available in diameters from 4" to 18" and is usually sold in 25' lengths.

Flex duct is commonly used for branch lines running from round tap connections to diffusers. The diffusers used with this type of duct must have round metal sleeves to attach the duct. Flexible duct is versatile and can be installed very quickly, but it can be crushed easily and shouldn't be used in places where it could be stepped on.

To install flex duct, stretch it out and cut it to the length that you need. Connect the duct to the tap and diffuser with duct tape. To get a good seal and secure attachment, you must tape the aluminum liner and the plastic covering separately. Do this by pushing the insulation and plastic cover of the duct back to expose the liner. Pull the liner over the round tap or sleeve on the diffuser and tape it securely with pressure-sensitive aluminum tape. Next, pull the fiberglass insulation and plastic covering up over the liner and tape them in place using duct tape.

You can support the duct with wire, heavy-duty plastic cable ties, or sheet metal straps. A key point to remember when hanging this type of duct is to *spread the load* at the point where the hanger is attached to the duct. Spreading the load means to reinforce the duct at the point where the hanger attaches. This keeps the hanger from cutting the duct. You can do this by wrapping the duct with tape at the point where the hanger attaches or by using wide sheet metal straps to support the duct.

Making repairs

You'll find that duct systems are very reliable and require very little repair. Some duct systems have been in buildings for many years and are still functioning properly. There are occasions, however, when small portions, complete duct sections, or the entire duct system may need to be repaired or replaced. The ducts in an air-conditioning system may have the insulation removed or torn, which can cause condensation. If the condensation is allowed to continue, the metal duct will rust and eventually develop rust holes. The exhaust duct system in some shops may need repair or replacement because of corrosive fumes, or a duct may need to be patched to cover a hole left when a branch line is removed.

Patching

Patching usually is done on small repair jobs not requiring the replacement of whole duct sections. For example, suppose you must cover a hole in a 26-gauge duct joint because a 6-inch branch line has been removed. In this case, you can make a patch from 26-gauge metal (same kind as the duct) to cover the hole. The patch must be large enough to cover the hole plus the amount needed for the seam. From your study of this course, you know a riveted lap seam is satisfactory for fastening the patch over the hole. Remember, when you're using rivets with lap seams, the allowance is ¼ inch from the center of the rivets to each edge of the metal patch. Therefore, for a ¼-inch lap seam, you need a ½-inch allowance on the circular patch. The rivet holes should be ¼ inch from the outside edge of the patch and spaced 2 inches apart. If you need a square or rectangular patch to cover a square or rectangular hole, the allowance and rivet spacing is the same as for round patches.

You could also attach the patch with sheet metal screws. Using sheet metal screws doesn't change the requirements for the patch size or the spacing of the holes, but the holes punched in the patch must be larger than the screws. Use the patch as a template to mark the duct for drilling.

Replacing

The procedures for replacing a duct are the same as for installing a new duct. The basic rule to follow is to replace the duct with components that are the same as the original system. Ensure the replacement items are similar in material quality and the replacement components are the same size as the items being replaced.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

209. Installing and repairing duct systems

1. What's the centerline of a duct system?

2. How can you determine the vertical centerline?

3. How can you determine the horizontal centerline?

4. How do you determine the size and shape of the hangers?

5. What is your responsibility in preparing to install a duct system?

6. What do you install first if the heating and cooling unit is already installed? If the unit is not already installed?

7. What type of fastener do you use to install the plenum to the flange of the unit?

8. Why must the holes in the hangers be larger than the screws?

9. How do you attach insulation to the inside of duct sections?

10. Why must you be careful when pressing insulation onto metal pins?

11. Why must you tape *all* joints and seams in the insulation?

12. What are the final steps in completing a duct installation?

13. When do you paint unpainted grilles?

14. What's the standard grille installation height when no height is specified?

15. What allowance is needed for a ¼-inch lap seam on a circular patch?

16. On a riveted lap joint, what is the centerline for the rivet holes, and what should be the distance between the rivets?

17. What's the basic rule to follow when replacing duct system components?

2–3. Fiberglass Duct Systems

This section covers fiberglass duct systems. We provide a brief overview of how fiberglass duct systems are constructed, and then discuss some common repair methods.

210. Repairing fiberglass duct

Fiberglass duct systems are an alternative for sheet metal duct systems to heat, cool and ventilate buildings. The fiberglass ducts are made from flat, semi rigid fibrous glass sheets with a reinforced aluminum backing. These flat sheets we refer to as duct boards. You will most likely spend some time repairing damaged fiberglass ductwork. In this lesson, we discuss minor and major damage, and the methods you use to make repairs.

Minor damage

The repair to be made is based on the extent of damage to the duct board panel. The first repair we discuss is for minor damage to the panel facing material without loss or damage to insulation. There are two ways to make this repair; the way you use depends on the width of the damaged area. The first repair shown in figure 2–12 is for damage up to ½ inch wide to the aluminum backing or panel facing material. To make this repair, simply place a single piece of aluminum foil tape over the damaged area so that it overlaps the damage area at least one inch on all sides.

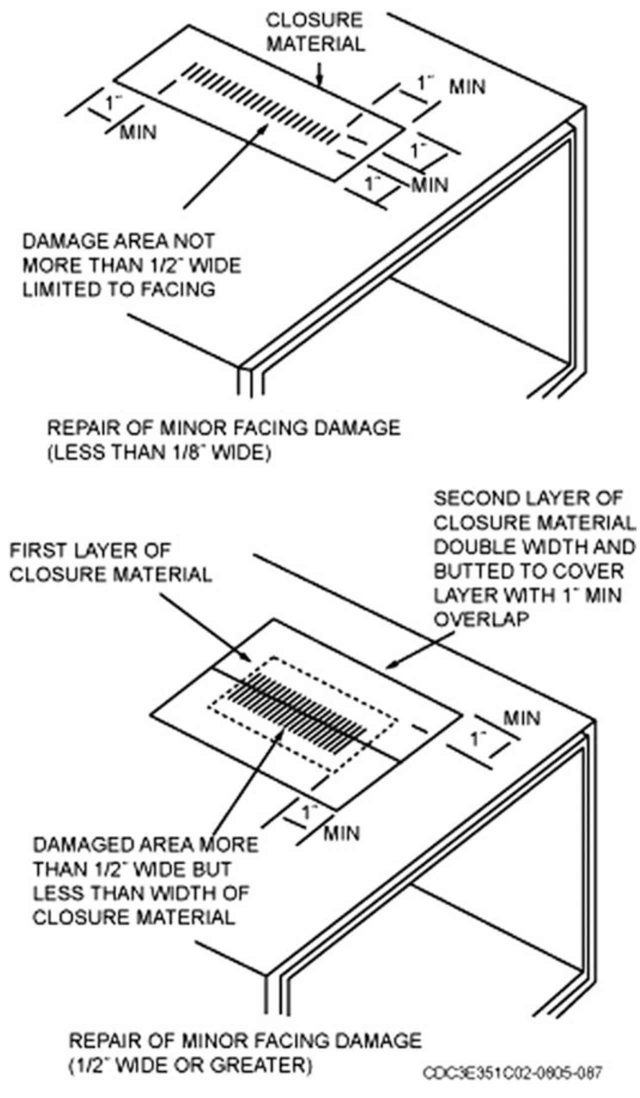

Figure 2–12. Repairing minor damage.

The next damage repair is for damage greater than ½ inch but less than the width of the aluminum foil tape. For this repair, place a single piece of tape over the damage as shown in the lower part of figure 2–12. After smoothing the first layer of tape, place two more pieces of tape over the first piece of tape to overlap the entire repair area.

NOTE: To get a good bond, the surface where you apply the tape must be clean. In most cases, wiping the duct with a cloth cleans the surface but follow the manufacturer's specifications (if any are given).

Major damage

The next repairs covered involve fixing major damage to fiberglass panels. View A on figure 2–13 shows how to repair damage that doesn't come within 6 inches of the edge of the panel. For this repair, cut the damaged section, remove it, and replace it. Fiberglass duct board we usually cut with hand tools. These hand tools have a sharp cutting blade that is set into a handle; we refer to them as an insulation knife.

The difference between the repair in figure 2–13, A and the one shown 2–13, B, is how close the damage comes to the edge of the panel. If the damaged area extends to within 6 inches of the edge of the panel, cut, remove, and replace the entire width of the panel. If larger sections of duct are damaged, you'll have to use your best judgment to determine your repair method. If only one side of a duct is damaged, you may be able to simply replace the damaged side. If two or more sides are damaged, you probably have to replace the section of duct. Fiberglass duct won't take the abuse steel duct takes, so when it's damaged it can seldom be reused.

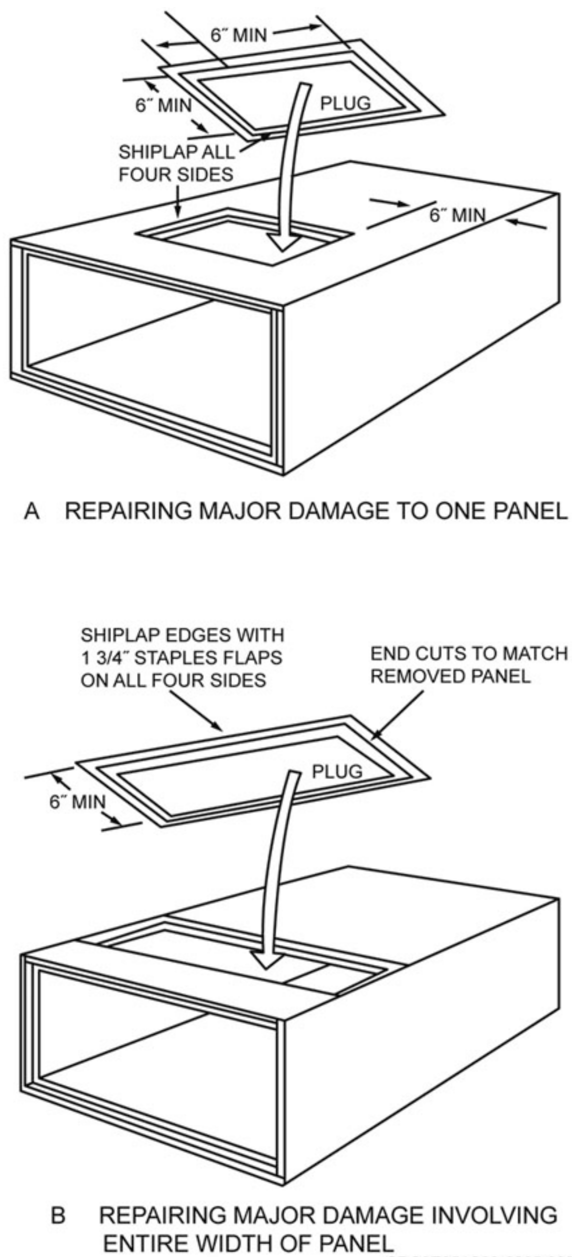

Figure 2–13. Repairing major damage.

After making major damage repairs, you must ensure the duct is sealed to prevent leaks. To ensure the duct is sealed, you must use aluminum foil tape with pressure sensitive tape applied over it on all seams.

NOTE: To get a good bond, the surface where you apply the tape must be clean. In most cases, wiping the duct with a cloth cleans the surface but comply with the manufacturer's specifications (if any are given).

Use only pressure-sensitive tape that's at *least* 2½ inches wide. Install the tape so that it laps over each side of the seam at least 1 inch. Make sure there are no wrinkles or air bubbles in the tape. After the pressure-sensitive tape is in place, take a plastic squeegee and apply pressure at an angle until you can see the impression of the reinforcement on the duct backing through the tape (fig. 2–14). This is your signal that the tape has bonded securely. If you hold the squeegee at a slight angle so that the pressure is distributed over a larger surface area, you can minimize that chance of cutting through the tape or duct backing.

If the pressure sensitive tape has been stored at a temperature below 50 degrees F, it will not bond properly. You need to warm the tape up to at least 50 degrees F before you install it. The tape bonds better if the tape and duct are heated. You can improve the tape's initial tack (attachment) by warming the duct surface with an electric heating iron designed for industrial use. Heat the iron to about 400 degrees F to warm the area where you apply the tape. After you apply the tape, run the iron over it rapidly three or four times and immediately use the plastic squeegee to rub the tape to complete the bond.

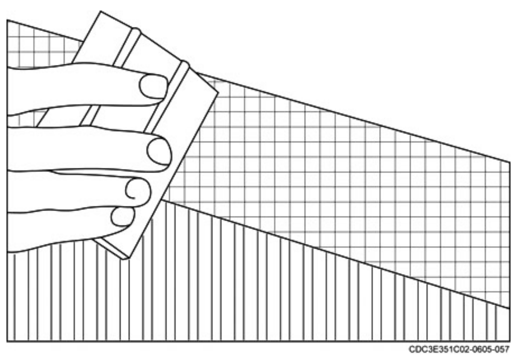

Figure 2–14. Using a squeegee to secure tape.

NOTE: Make sure you restore any reinforcement members that may have been lost due to damage or removed to facilitate repair.

If you routinely work with fiberglass duct, it would be a good idea to get a fabrication and installation handbook. Make sure to purchase the handbook referenced in your CFETP. These handbooks give detailed information on fabrication, installation, and reinforcement.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

210. Repairing fiberglass duct

1. What type of damage can you repair with a single piece of aluminum foil tape?

2. How do you repair panel damage if the damage doesn't come within 6 inches of the edge of the panel?

3. How do you repair panel damage if the damage comes within 6 inches of the edge of the panel?

4. At what temperature must the tape and duct be for pressure sensitive tape to adhere properly?

Answers to Self-Test Questions

207

1. Parallel line, radial line, and triangulation methods.
2. Parallel line.
3. Transition patterns.
4. With standing seams.
5. To achieve maximum airflow.
6. H/W = 5.
7. ¾ inch.

208

1. Squaring shears.
2. Aviation snips or portable unishears.
3. After the trunklines are installed.
4. By setting and using the back gauge on the shear.
5. To make it easier to bend the patterns on the brake lines, assemble the Pittsburgh lock seams, and assemble the S-and-drive connections.
6. The corners of the patterns for the plenum top.
7. (1) cross-braking, (2) seam allowance bending, (3) joint connection allowance bending, and (4) corner bending.
8. Cornice brake.
9. A hand folder.
10. Corner bending.

209

1. An imaginary line passing through the middle of the duct sections as their horizontal and vertical center.
2. From a plan view drawing.
3. From an elevation view drawing.
4. By size, weight, and material of the duct and how and to what the hangers are attached.
5. To take all needed tools, equipment, and materials to the job site.
6. Plenum; flexible connection.
7. Sheet metal screws.
8. So the screws won’t tighten against the hanger before the hanger tightens against the duct.
9. With adhesives, metal pins, clips, or a combination of all of them.
10. You don’t want to get stabbed in the hand with a pin.
11. To ensure a complete vapor barrier.
12. Install the registers, grilles, and diffusers.
13. Before installation.
14. 6 inches.

15. ½-inch allowance.
16. ¼ inch from edge; 2 inches apart.
17. Replace the duct with components made of the same material as the original system.

210

1. Damage to the aluminum backing that’s less than ½-inch wide.
2. Cut out and replace the damaged section.
3. Cut, remove, and replace the entire width of the panel.
4. 50 degrees F.

Do the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

28. (207) The *recommended* layout method to use for rectangular sheet metal ducts is the
    a. short method.
    b. radial line method.
    c. parallel line method.
    d. triangulation method.

29. (207) The *recommended* layout method to use for round sheet metal ducts is the
    a. short method.
    b. radial line method.
    c. parallel line method.
    d. triangulation method.

30. (207) The *recommended* layout method to use for transitions is the
    a. short method.
    b. radial line method.
    c. parallel line method.
    d. triangulation method.

31. (207) For the *best* airflow, turn vanes must be spaced so they have an aspect ratio of
    a. 1.
    b. 3.
    c. 5.
    d. 7.

32. (207) How much material do you add to each end of a sheet metal turn vane for a tab allowance?
    a. ¼″.
    b. ¾″.
    c. 1½″.
    d. 1¾″.

33. (208) What squaring shear item is the *most* helpful when you are cutting several sheet metal pieces of the same size?
    a. On and off switch.
    b. Front and back gauge.
    c. Treadle and side gauge.
    d. Safety guard and hold down.

34. (208) When is the *recommended* time to cut the branch line opening in a sheet metal trunkline?
    a. After the trunkline is installed.
    b. Before the trunkline is installed.
    c. At the same time the branch lines are made.
    d. As soon as the branch line dimensions are known.

35. (208) What is the *recommended* angle to cut square notches in sheet metal duct?
    a. 15 degrees.
    b. 30 degrees.
    c. 45 degrees.
    d. 90 degrees.

36. (208) What would you use to cut slant notches on a sheet metal plenum top?
    a. Unishears.
    b. Aviation snips.
    c. Squaring shears.
    d. Double cutting shears.

37. (208) The *first* step in forming a rectangular sheet metal duct joint is to
    a. determine the bend joint allowances.
    b. determine the end seam allowances.
    c. make the corner bends.
    d. make the cross brake.

38. (208) To cross brake and form a rectangular sheet metal duct joint, use a
    a. bar folder.
    b. cornice brake.
    c. slip roll machine.
    d. Pittsburgh machine.

39. (208) To seat a Pittsburgh sheet metal flange in the pocket, use a
    a. bar folder.
    b. cornice brake.
    c. hammer and rivet set.
    d. rawhide mallet and anvil.

40. (208) Which equipment item can you use to transform a flat sheet of metal into a cylindrical shape for ductwork?
    a. Cornice brake.
    b. Circel shears.
    c. Turning machine.
    d. Slip roll machine.

41. (208) What step is *not* needed to form duct transitions when four separate sheet metal pieces are used?
    a. Cross brake.
    b. Corner bends.
    c. Bend seam allowances.
    d. Bend joint allowances.

42. (209) Where do you get information about the centerlines of a sheet metal duct system?
    a. Side and top of the duct.
    b. Chalk line on the ceiling joists.
    c. Plan view and elevation view drawings.
    d. Detail view and elevation view drawings.

43. (209) What are hangers *primarily* designed to provide for heating ducts?
    a. Level duct installation.
    b. Add strength and rigidity to the ducts.
    c. Reduce the need for duct joints and insulation.
    d. Increase air pressure with less pressure loss in the duct.

44. (209) Hangers made from angle iron are *usually* used in duct systems to
    a. support heavy ducts.
    b. repair duct transitions.
    c. prevent damage to branch lines.
    d. provide a mounting base for air registers.

45. (209) You can hang and align the duct joints to the ceiling more rapidly and safely if you perform work from
    a. a stool.
    b. an attic.
    c. a ladder.
    d. a scaffold.

46. (209) If the heating and air conditioning unit is already installed, which sheet metal duct system section do you install *first*?
    a. Flexible connection.
    b. Trunkline elbow.
    c. Branch line.
    d. Plenum.

47. (209) If the heating and air conditioning unit is *not* already installed, which sheet metal duct system section do you install *first*?
    a. Flexible connection.
    b. Trunkline elbow.
    c. Branch line.
    d. Plenum.

48. (209) Foil-backed insulation used on ducts *must* cover the entire duct surface to
    a. reduce noise.
    b. prevent air leaks.
    c. enhance appearance.
    d. prevent condensation.

49. (209) The items you install during the *final steps* of a sheet metal duct installation job are
    a. registers, grilles, and diffusers.
    b. diffusers, butterfly dampers, and plenums.
    c. trunklines, butterfly, louver, and splitter dampers.
    d. flexible connections, grilles, and inspection plates.

50. (209) Return air registers *normally* have
    a. on and off switches.
    b. adjustable louvers.
    c. fixed louvers.
    d. fusible links.

51. (209) When repairing a hole in a sheet metal duct system, make sure all patches are
    a. large enough to cover the hole plus a seam allowance.
    b. the same size as the duct branch removed.
    c. as wide as the duct being patched.
    d. as long as the duct being patched.

52. (210) How much of a fiberglass duct panel do you remove if damage extends to within 6 inches of the edge of the panel?
    a. Half the width of the panel.
    b. The entire width of the panel.
    c. A 6-inch radius around the damage.
    d. A 12-inch radius around the damage.

53. (210) Pressure sensitive tape must overlap seams at *least*
    a. ¼″.
    b. ½″.
    c. ¾″.
    d. 1″.

54. (210) What temperature *must* pressure sensitive tape be for it to adhere properly?
    a. 40 degrees F.
    b. 50 degrees F.
    c. 60 degrees F.
    d. 70 degrees F

Please read the unit menu for unit 3 and continue ➔

Student Notes

Unit 3. Stacks, Ventilators, and Hoods

IN THIS unit, we deal with how to make, install, and repair stacks and ventilators. Stacks exhaust heated gases from stoves, furnaces, and hot water heaters; ventilators remove hot air and harmful or unpleasant fumes. You'll repair and replace stacks and ventilators quite often. Why? Mainly because they're installed on the outside of buildings and are exposed to moisture, temperature changes, and wind. Stacks and ventilators can also be damaged by the heat, moisture, and vapors they exhaust.

The knowledge and skill you've gained working with sheet metal should be useful when you work with stacks and ventilators. Their layout, fabrication, and assembly are similar to those of other round duct components. The main exceptions are the fire safety precautions you must take with stacks used to exhaust heated gases from stoves and furnaces.

3–1. Stacks and their Components

To get started in your study of stacks, we identify the specific items that you'll work with. Stacks are sometimes called by other names, such as heating vents, vertical flues, and chimneys. In this text, the term *stack* means the sheet metal round duct (pipe) used to exhaust hot gases from stoves, furnaces, and hot water heaters. By *components*, we mean the items used with the stacks. This includes items such as draft diverters, thimbles, roof jacks, storm collars, and vent caps. In our first lesson we describe in detail two kinds of stacks and the components that comprise them.

211. Stack and component identification

There are two types of stacks (single-wall and double-wall) used for ventilation or exhaust. Let's take a look at these stacks along with their associated components.

Single-wall stacks

As the name suggests, single-wall stacks have only one wall. An example of a single-wall stack is shown on figure 3–1. As you can see, the single-wall stack illustrated has joints of round pipe made like the round duct we covered earlier. The joints in the single-wall stack are available in straight pipe, elbows, and tee joints. In operation, the hot exhaust gasses passing through the single-wall stack radiate a lot of heat. You must always consider this radiated heat when determining if a single-wall stack should be used.

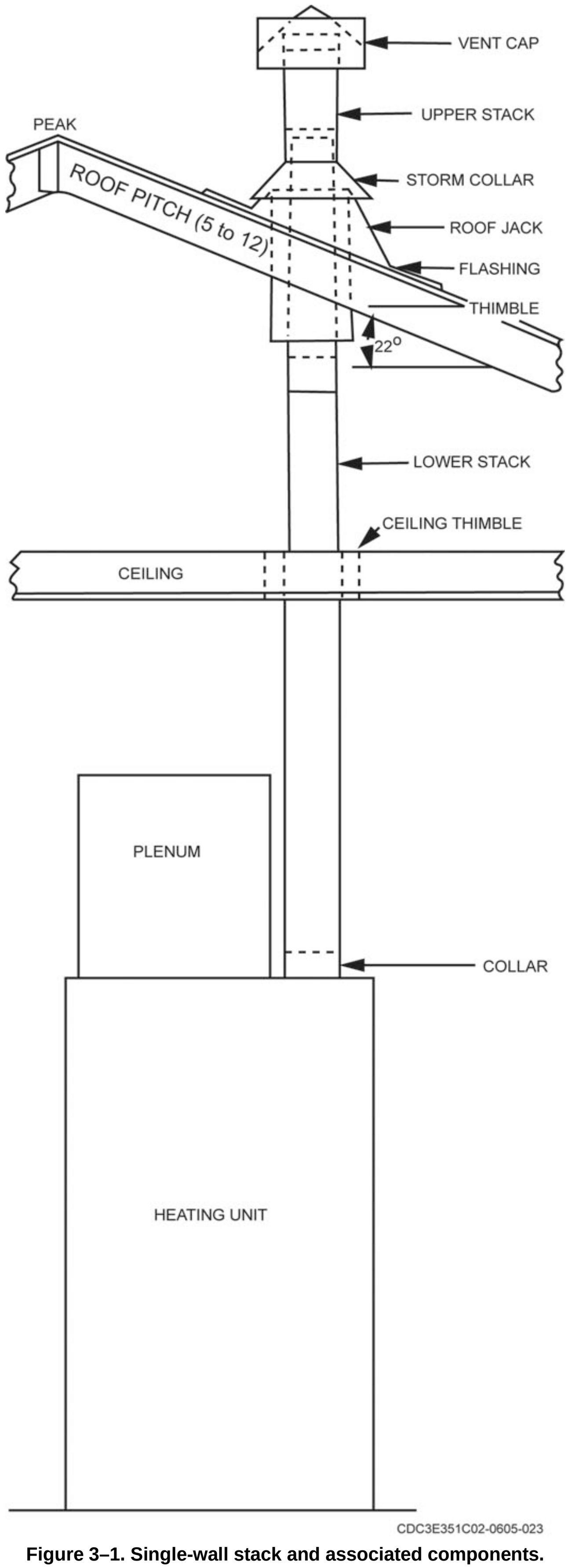

Figure 3–1. Single-wall stack and associated components.

Double-wall stacks

Several examples of double-wall stack components are shown on figure 3–2. Basically, a double-wall stack has one single-wall joint installed inside another with about ½ inch of airspace between them. The airspace is shown at the ends of several of the joints in figure 3–2. This space acts as insulation to reduce radiated heat, prevent condensation, and allow the outer wall to stay much cooler than the inner wall. The inner wall usually is made of aluminum, while the outer wall may be made of aluminum or galvanized steel. Double-wall stacks are the best choice to vent hot exhaust gasses from gas-fired heaters, furnaces, and water heaters because there is less chance for building components to overheat and the double-wall stacks last longer than single-wall stacks.

You can make double-wall stacks in the shop, but you usually get them ready made. Instead of the slip joint used with single-wall pipe, a locking slip joint is used on double-wall stacks. Because most manufacturers have their own patented joint connection for double-wall stacks, be sure to specifically order the joint type you need. Doing this ensures you can connect the new joints to the existing exhaust stack.

You can get the joints of double-wall stacks in various shapes, diameters, and lengths. Some of the shapes are shown in figure 3–2. The round joints are available in diameters (of the inside pipe) from 3 to 12 inches and in lengths from 6 to 60 inches. For in-between lengths, use the adjustable length straight joint. This is a straight joint made in two sections and these telescope to make the length you need.

Other joints shown in figure 3–2 are tee joints, offsets, transitions, and elbows. They're available in the same sizes as straight pipe.

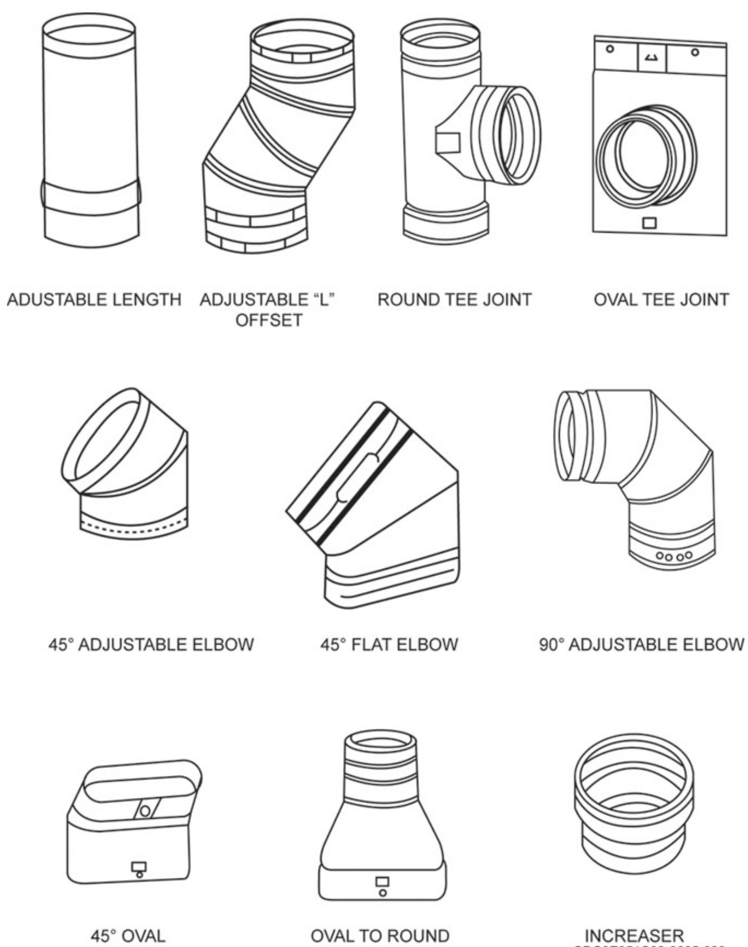

Figure 3–2. Double-wall stack components.

Draft diverters

Draft diverters keep downdrafts from blowing into the furnace or heater. They're available in common straight pipe sizes. These devices prevent excessive updrafts or downdrafts in the vent stacks. The draft diverter in view A of figure 3–3 has no moving parts. It consists of the frustum of a cone with collars at each end to act as slip-joint connections. Clips are used to center the bottom of the cone to achieve equal airspace around the lower collar. This draft diverter is the first joint in the stack. In the case of a strong downdraft, the air flowing down the stack can escape through the diverter.

Double-acting diverter

The double-acting draft diverter shown in view B of figure 3–3 is a type of diverter used for gas-fired furnaces. It's installed in the exhaust stack close to the heating unit. It has a hinge that allows the blade to swing in to dampen updrafts. It also swings out to dampen downdrafts. The blade has an adjustable knob to balance it. Always install the hinge on the blade parallel to the floor.

Single-acting diverter

The single-acting draft diverter shown in view C of figure 3–3 is used for oil-fired furnaces. The blade on this type swings inward only. This draft diverter also is installed in the exhaust stack close to the heating unit.

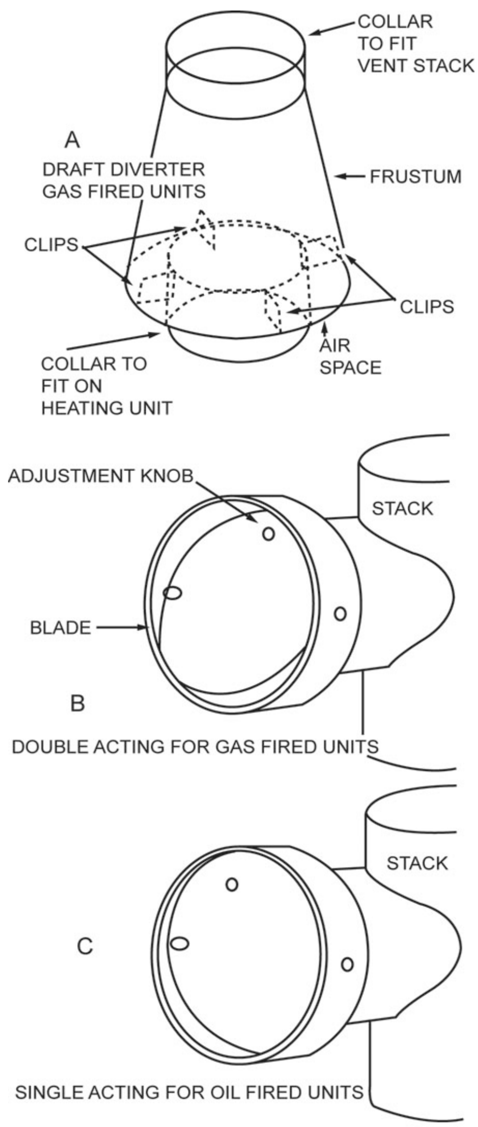

Figure 3–3. Three types of draft diverters.

Wall thimbles

Wall thimbles are a stack assembly safety feature. They're designed to let air circulate between the stack and the wall. We show a shop-made, double-wall thimble in figure 3–4. We can use this assembly in ceilings as well as in walls. To make this type of thimble, use a section of stack and an outside piece 4 inches shorter than the section of stack. This allows the 1½-inch slip joint to give a smooth joint connection. After you've made thimble parts "A" and "B," join them with Z-clips. The Z-shaped clips are 2 inches wide with 1-inch spaces on each end. Then, use the Z-clips to join the inside and outside parts of the thimble. The thimble is easier to assemble if you rivet the Z-clips to the outside piece first.

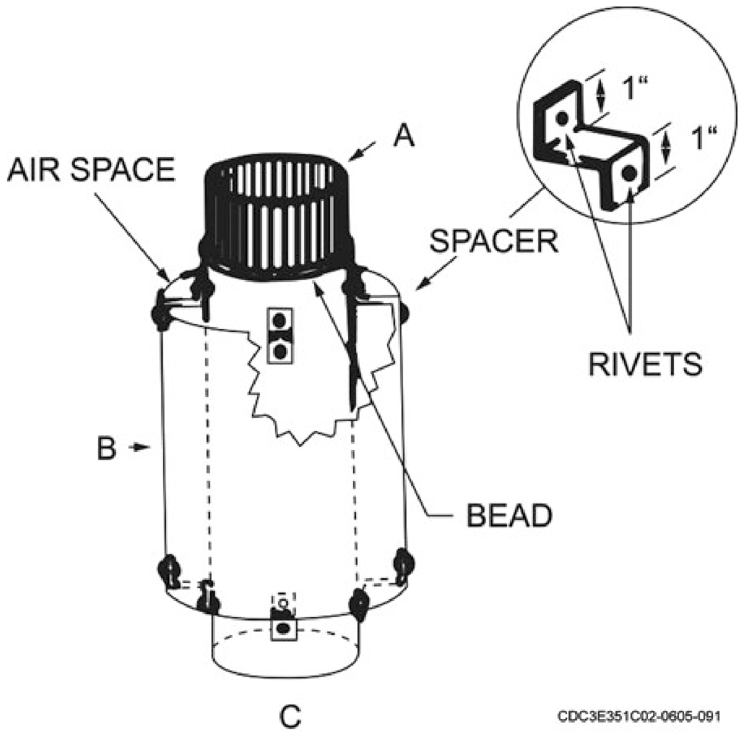

Figure 3–4. Shop-made double-wall thimble.

Roof jacks

A roof jack, like the one we show in figure 3–5, is the part of a vent system that we attach to the roof. The roof jack weatherproofs the opening through which the stack passes. Roof jacks may be shop-made or purchased ready made for different sizes of vent stacks and roofs of a different pitch. (The roof jack in FO 2 is for a flat roof.) The dimensions for new roof jacks are shown on the working drawing. If you're replacing a deteriorated roof jack, you can take the dimensions from the old roof jack. As you can see in figure 3–5, the base of the roof jack acts as flashing and secures the jack to the roof deck.

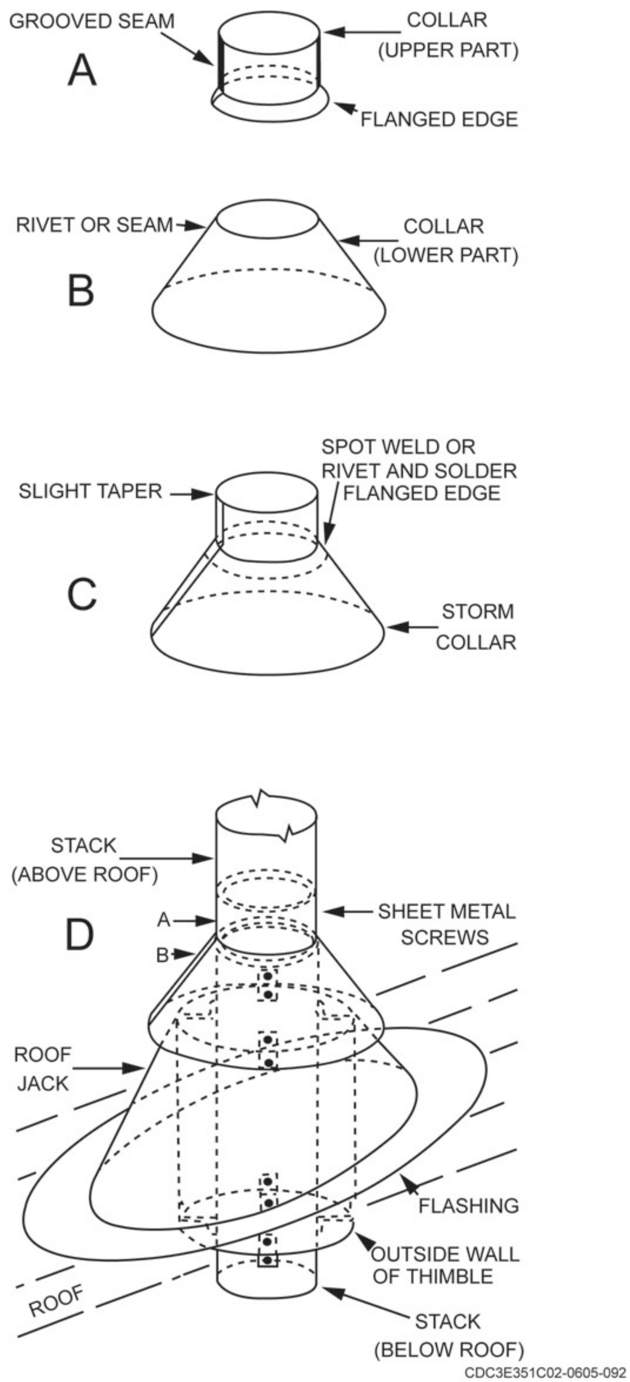

Figure 3–5. Storm collar, roof jack, and double-wall thimble.

Storm collars

A storm collar prevents leaks around the top of a roof jack. Storm collars used on double-wall vent pipe usually are purchased as ready-made items, but storm collars for single-wall vent pipe are usually shop made.

To make a storm collar, get the dimensions from the working drawing or from the old collar. Make piece A (fig. 3–5) with a slight taper to fit over the top of the stack. On the bottom edge of piece A, use a flange about ⅜ inch wide. This flange should have the same angle as the lower collar. Next, make piece B and join A and B to make C. Spot weld or rivet the joint, and then solder it to prevent leakage.

Next, install the collar, as shown in view D. With the thimble installed on the roof jack, the top of the outside piece of the thimble should fit flush with the top of the roof jack. The storm collar should completely cover the top of the thimble opening to prevent rain from blowing in through the airspace. In view D you can see the vent stack is installed through the storm collar with a tight fit to keep rain out.

Vent caps

Vent caps are installed at the outlet end (top) of a stack. Several types are used on heating equipment stacks, five of which are shown in figure 3–6. Vent caps A and B are usually ready made. These are used with double-wall stacks. Vent caps C, D, and E can be purchased or made in the shop. These are used with single-wall stacks.

Vent caps are often known by their names. For example, the vent cap in view A is often called a Belmont cap. Vent caps in views B and D are called rainproof or draftproof caps. The vent cap in view C is known as an "A" cap because of its shape. Vent cap E is sometimes called a china cap because of its shape and the opening all around the top.

The type of stack used for each installation is specified on the working drawing (FO 2). Because a weatherproof downdraft diverter is specified, a vent cap like the one shown in view D of figure 3–6 is required.

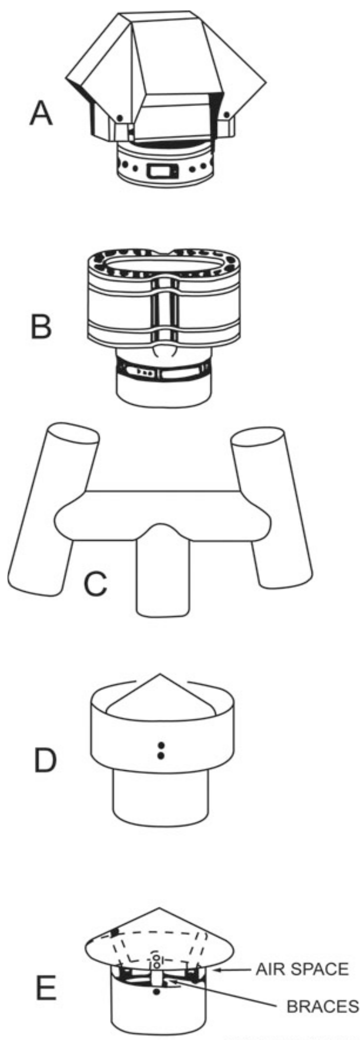

Figure 3–6. Vent caps.

Another type of vent cap you can make is the T-shaped cap shown in figure 3–7. This cap is fast and easy to make, leaving almost no scrap. The T-vent cap has proven to be particularly good for applications requiring a lot of caps in a short time. Examples are deployments in which a large number of tent heaters need vent caps, and replacements for caps damaged by natural disaster such as tornadoes and typhoons.

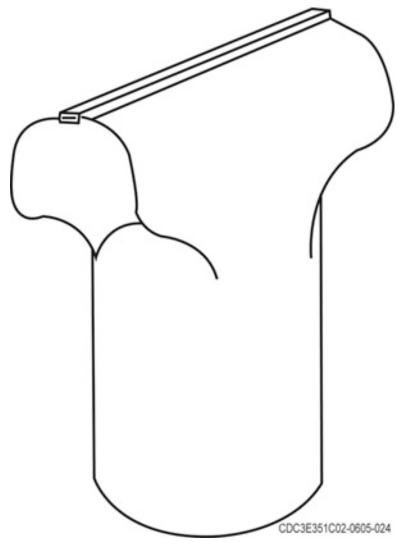

Figure 3–7. T-vent cap.

Figure 3–8 illustrates the layout of the T-vent cap. As you can see this is a simple procedure. Start by drawing a rectangle for the collar portion of the vent cap. This rectangle should be as wide as the height of the collar portion of the cap, and as long as the circumference of the vent stack it will be installed over. Four to six inches is high enough in most cases and the length will vary based on the stack diameter (remember the circumference formula $C = \pi d$).

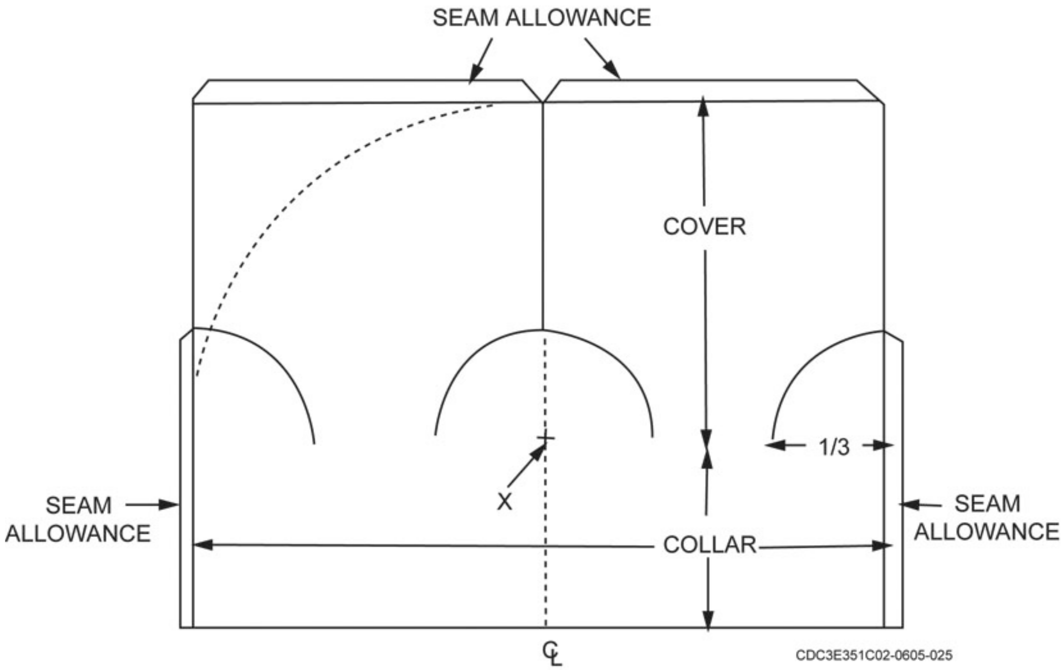

Figure 3–8. Layout of a T-vent cap.

After drawing the rectangle for the collar portion of the cap, you need to determine how high to make the cover part of the cap. Do this by swinging an arc from the center point of the collar rectangle. The length of this arc is half the length of the base rectangle. Use X as the center point, with the dotted line showing how the arc is swung. After determining how high to make the cover portion of the cap, extend the lines up from the collar portion to complete the pattern outline.

The next step is to mark the arcs where the pattern is cut. These arcs are equal to ⅓ of half the pattern. The last step in layout is to add the seam allowance. For this cap, the groove seam works well, but you can also use a lap seam. After you lay out the pattern, cut the pattern on the bold lines.

After cutting out the pattern, your next step is to form the vent cap. The forming sequence is shown in figure 3–9. Roll the pattern in the slip-roll machine and set the grooved seam on the collar portion of the cap (view A). Next, straighten the cover portion of the cap (view B). Then, form the grooved seam pockets on each edge of the cover portion. Last, roll the edges of the cover portion of the cap and set the grooved seam. The finished product should look like figure 3–7.

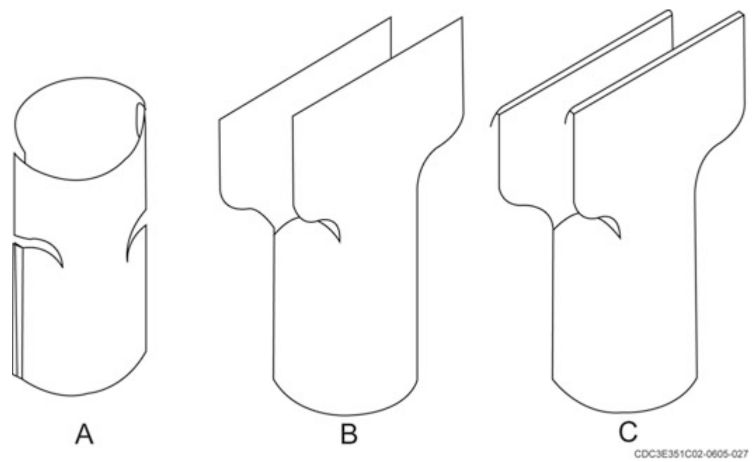

Figure 3–9. Fabricating a T-vent cap.

212. Forming and installing stacks and components

Foldout 2 shows an illustration of a double-wall aluminum vent pipe specified from the furnace stack outlet to the top of the roof jack. The working drawing also specifies 24-gauge galvanized steel for the roof jack, upper stack, and vent cap. Make the thimble from 20-gauge galvanized steel. For repair jobs, use the old assembly to determine the metal thickness.

After you know the material specifications, you need to know the length and size of the double-wall stack. For this example, assume the vent outlet on the heating unit is 6 inches in diameter, and 6 feet from the top of the heater stack outlet to the top of the roof jack. With these requirements in mind, you can see how two 3-foot joints of 6-inch double-wall stacks should be purchased or fabricated in the shop.

Making patterns for stacks and components

The vent stack shown in FO 2 must be fabricated and installed. The assembly is similar to the one we saw in figure 3–1, except the base isn't cut at an angle. The roof jack is 10 inches high, and a 6-inch flashing is needed for the base; the sides of the roof jack will have a 60° angle.

Pattern for a roof jack, base, and collar

You can see patterns for the jack, base, and collar in figure 3–10. To develop the pattern for the roof jack frustum, use the radial line layout method. The diameter of the top opening is 7 inches, and the diameter of the base opening is 18 inches. You need the 7-inch top opening because the double-wall vent stack includes a ½-inch airspace. After you develop the pattern, you should also make allowances for the seams, as shown in the illustration. The pattern for the roof jack base (flashing) is 30" × 30", with an 18-inch-diameter cutout in the center. The collar for the top of the roof jack is 1⅞" × 23" with allowances added.

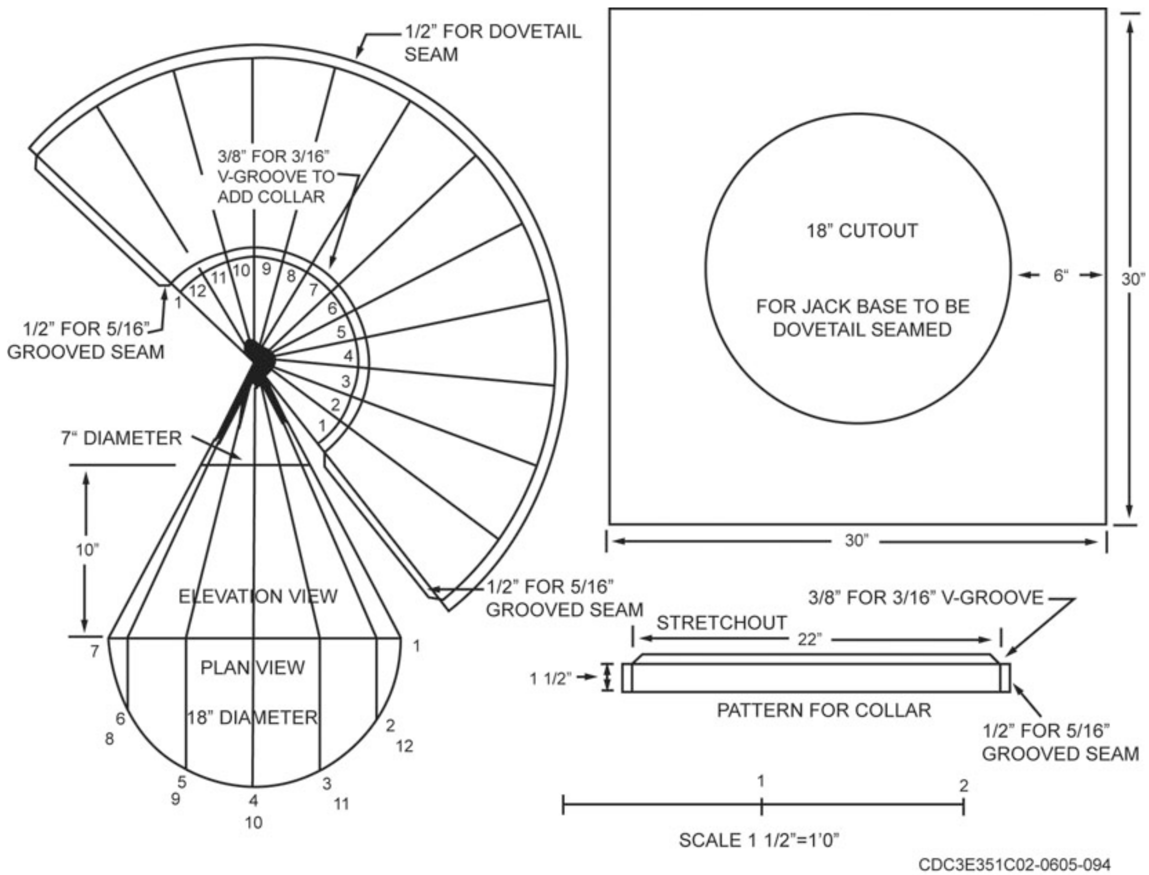

Figure 3–10. Patterns for a roof jack.

Pattern for a stack joint

The next pattern for the vent assembly is the top stack joint shown on figure 3–11. This single-wall stack joint is 20 inches long because the roof jack is 10 inches high and you must maintain a distance of 30 inches from the bottom of the vent cap to the roofline. The diameter must be 7 inches so it fits over the roof jack collar. The stretchout is 22 inches long and 20 inches high plus the allowances. Make a 1½-inch slip-joint allowance for the connection with the vent cap.

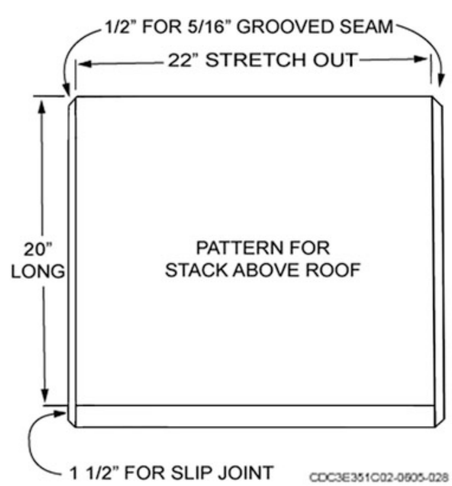

Figure 3–11. Pattern for a single-wall stack joint.

Pattern for a vent cap

The next stack assembly pattern, shown in FO 2 and figure 3–1, is the vent cap, which contains several parts. The vent cap is a draftproof and weatherproof type with a top, ring, collar, and braces.

The cover (top) is the first pattern of the vent cap. It's shown in view A of figure 3–12. To lay out the cover, draw an elevation view 9 inches in diameter and 2 inches high. Notice the slant height on the elevation view, represented by line "AB." Set a pair of dividers equal to the distance of line "AB" and draw a circle. This is the beginning of the pattern for the vent cap cover. To get the dimensions for the cutout, set your dividers equal to the distance of ½ the cap's diameter (from the elevation view). Next, use point "B" as a radius point and strike an arc on line "AB" to form line "CB." Measure the distance from point "A" to point "C," which in this example is ½ inch. Now multiply ½ inch by 6.28 ($6.28 = 2\pi$) to get the length of the arc for the cutout. In this case, it's 3.14 inches (3⅛ inches). Mark this distance in the pattern, as shown, and make the seam allowance. As you can see in this example, an allowance of ½ inch is required on each edge for the riveted lap seam. The same seam allowance is used for spot welding.

The next pattern for the vent cap is the ring shown in view B of figure 3–12. The ring is 5½ inches wide and 11 inches in diameter, so the stretchout is 5½" × 34 $^{9}/_{16}$". Make a seam allowance of ½ inch on each end of the stretchout for the grooved seam, and make a ¼-inch hem allowance on the top and bottom.

The next pattern is the collar, which is 4 inches high and 7 inches in diameter. The stretchout is 4" × 22", as shown in view C of figure 3–12. Make the grooved seam allowance of ½ inch at each end as shown in the example.

View D of figure 3–12 shows the brace pattern. The vent cap needs four braces made from 16 gauge metal. Each brace is 1 inch wide and 9¾ inches long. The braces hold the vent cap assembly together and are riveted to the top, collar, and ring.

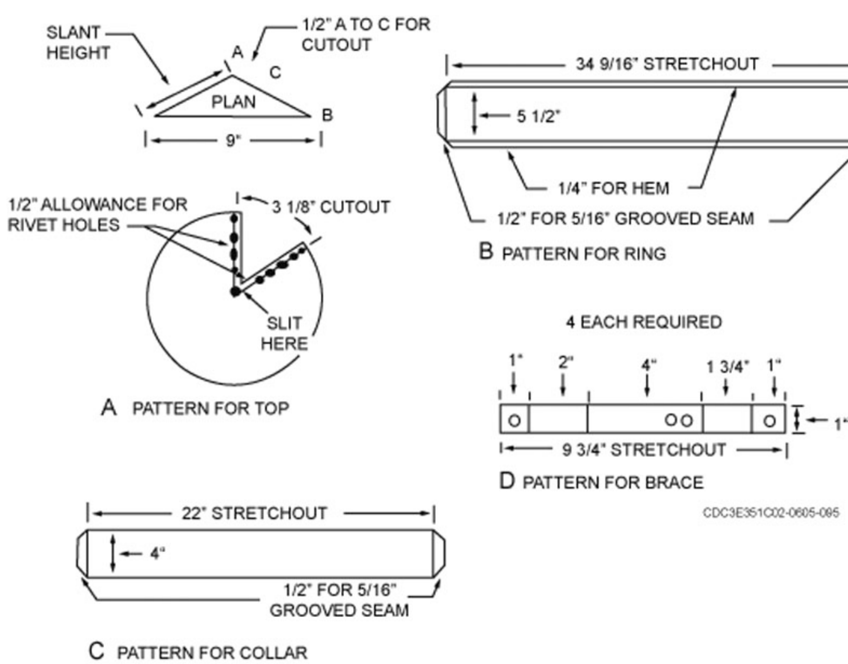

Figure 3–12. Patterns for a vent cap.

Pattern for a ceiling thimble

The ceiling thimble shown in FO 2 and figure 3–1 may be purchased ready made. However, in some cases, you may need to make one. The ceiling thimble shown in the foldout permits the heating unit stack to run through the ceiling. The same type of thimble can be used to run a stack through a wall.

The procedure for making a ceiling thimble is shown in figure 3–13. To begin, make two rings, as shown in view A. The inside hole of the rings should be 7$^{1}/_{16}$ inches in diameter so that a 7-inch diameter stack can pass through the opening. A 2-inch airspace, shown in view D, is needed between the stack and sleeves. To cover the airspace, add 2 inches on each side of the 7$^{1}/_{16}$-inch hole. A ½-inch flange goes around the perimeter of the ring to attach it to the ceiling. Punch screw holes in the ½-inch flange on centers of ¼ inch from the outside edge and spaced 5⅝ inches apart (center-to-center). Punch the $^{5}/_{16}$-inch air holes 2$^{1}/_{16}$ inches apart (center-to-center).

Views B and D show how to make two sleeves for the thimble. Note the tabs added only to the outside sleeve. Spotweld or rivet the tabs to the sleeve and space them to match the screw holes in the ring. The tabs should be set back ½ inch or ⅝ inch from the end of the sleeve. The setback distance is determined by the thickness of the sheetrock used in the ceiling. Make the diameter of the outside sleeve $^{1}/_{16}$ inch larger than the diameter of the inside sleeve so the inside sleeve slides inside the outside sleeve. Both sleeves should be 6 inches long. Turn a ⅜-inch flange on one end of each sleeve so one of the rings can be spotwelded to each of the sleeves. View B shows how the inside sleeve looks with the tabs installed and the flange turned on one end. View D shows the position of the ceiling thimble after installation.

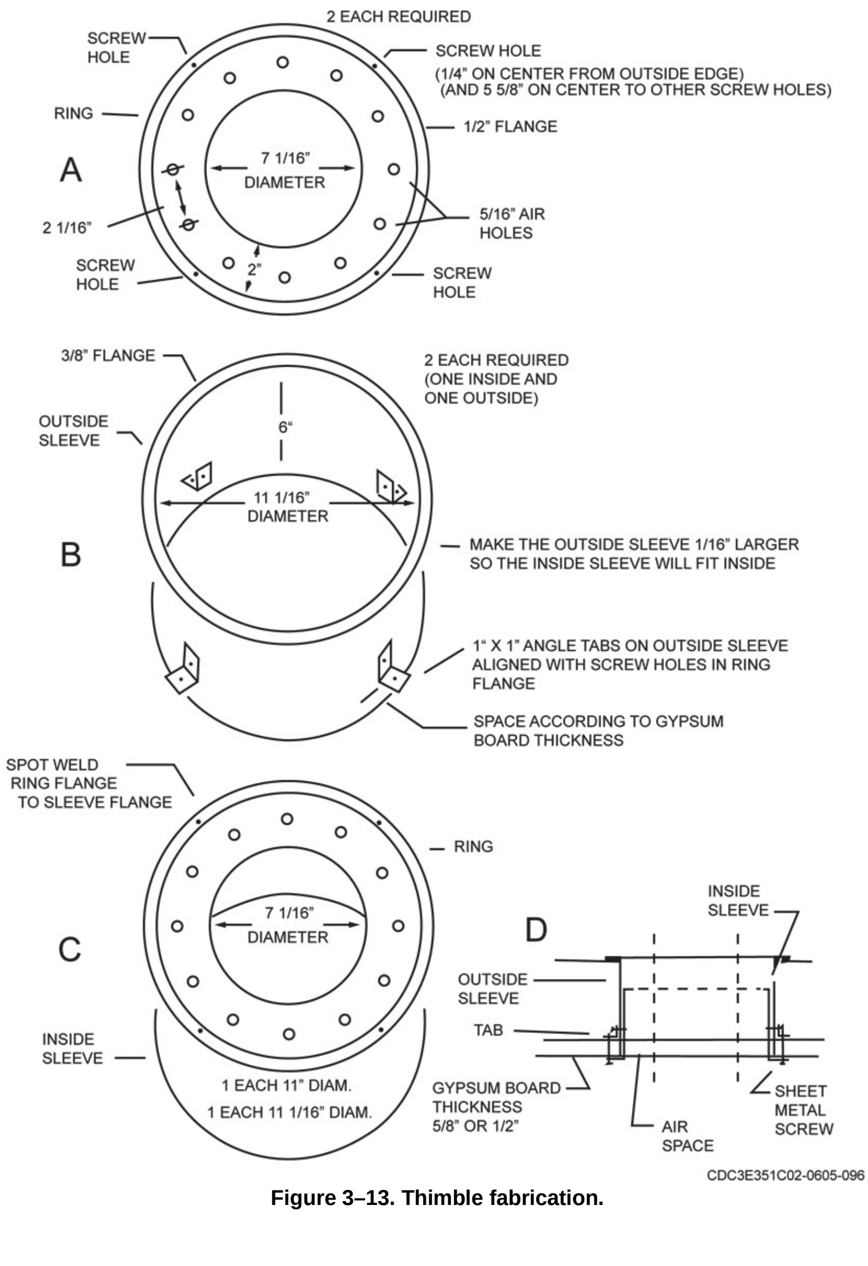

Figure 3–13. Thimble fabrication.

Pattern for a vent stack brace

The next part of the vent stack assembly is the brace, shown in FO 2 and figure 3–14. It's made of flat bar stock. Use a vise to make the 90° bends, and a slip-roll machine to form the half-round radius bend. Piece 2, the other side of the brace, is also formed with a vise and slip-roll machine. After both pieces have been formed, drill the four $^{5}/_{16}$-inch holes.

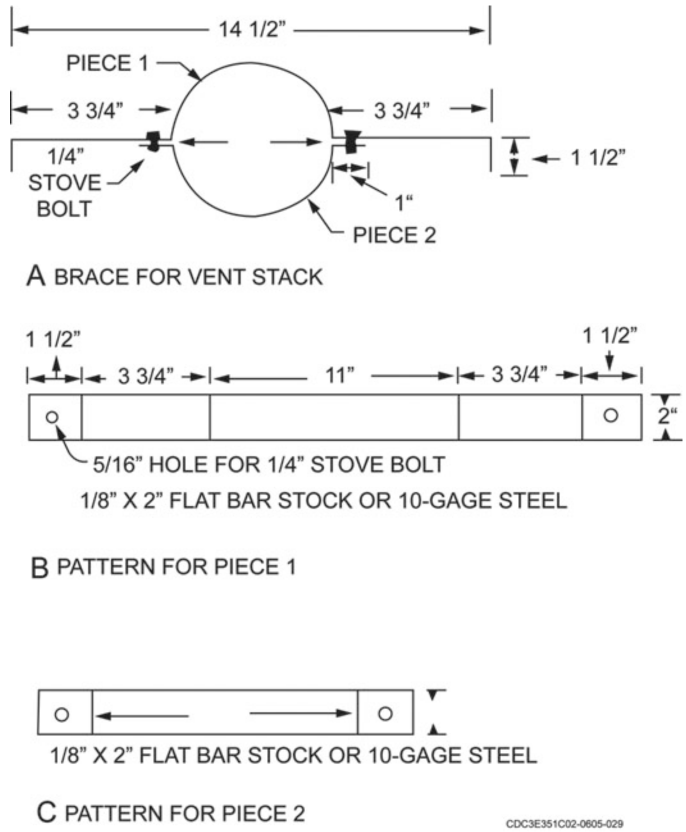

Figure 3–14. Making a brace for a vent stack.

Cutting patterns for stacks and components

To make a roof jack, you must first make a pattern. Figure 3–10 shows the typical patterns used to make a roof jack. After making and transcribing your pattern to sheet metal, you are then ready to cut it out. You can make the outside radius cut with straight snips, the inside radius with aviation snips, and the straight cuts with straight snips. Cut the pattern for the flashing and base with ring and circle shears and squaring shears. Cut the collar with straight snips or squaring shears, and cut all notches with straight snips.

The pattern for the roof stack, shown in figure 3–11, is cut with squaring shears and notched with straight snips. Almost all of the patterns in figure 3–12 can be cut with squaring shears and notched with straight snips. The exception is the top pattern, which you must cut with ring and circle shears or circle shears. The cutout should be made with straight snips.

Cut the patterns for the pieces shown in figure 3–13 with ring and circle shears and squaring shears. If you're using a ⅛" × 2" flat bar, the patterns illustrated in figure 3–14 only need to be cut to length. If a flat bar isn't available, use power squaring shears to cut the braces from 10 gauge metal.

Forming patterns for stacks and components

The next step after cutting out the pattern is to form the patterns. The patterns for the roof jack, shown in figure 3–10, are formed with the bar folder, slip-roll machine, hand groover, and elbow-edging machine.

First form the grooved seam pockets on the frustum, and then form the frustum in the slip roll. When forming the frustum, set the slip-roll machine to form a larger radius on one end, then the other end. After slip rolling, the frustum will probably need some hand forming on the bench stake, then set the seam with a hand groover on the bench stake. Form the V-groove on the elbow-edging machine and use it to join the frustum and collar. Remember, when the V-groove is formed, one component should have the V-groove inside and the other on the outside. It's better to place the outside V-groove on the component that will be on top to help the seam be more water resistant.

You can form the roof stack, which is shown in figure 3–11, with a Pittsburgh lock-forming machine and the slip-roll machine. First, make the groove seam pockets with the Pittsburgh lock-forming machine. Second, run the sheet through the slip-roll machine to make it round. Third, join the pockets and flatten the seam.

You are now ready to form the vent cap patterns as shown in figure 3–12. To form the vent cap patterns, you use a cornice brake, bar folder, slip-roll machine, and bench stake. You form the top pattern on a blow horn stake by placing the center of the pattern on the point of the horn and lightly bending the top. To assemble it, pull the pattern so one lap joint allowance slips over the top of the other allowance. Then rivet or spotweld the lap seam.

Hem the pattern for the ring (B in fig. 3–12), and form the grooved seam on the bar folder. Then roll the pattern into a cylinder on the slip-roll machine. After joining the grooved seam, make a bead around the ring with a beading machine. The bead gives the ring additional strength. Form pattern C the same as pattern B, except for the hems and bead. Form the brace (pattern D) on the cornice brake by making two 90° bends, one 125° bend, and one 55° bend. In FO 2, there's a side view of this brace showing how it should look when completed.

Form the ceiling thimble patterns, figure 3–13, with the Pittsburgh lock-forming machine, slip-roll machine, hollow mandrel stake, bar folder, and burring machine. Two sleeves are required. Form them by making the grooved seam on the Pittsburgh machine, forming the cylinders on the slip-roll machine, locking the grooved seam on the hollow mandrel stake with a mallet, and turning the ⅜-inch flange on the burring machine. You can form the clips for the outside sleeve on the bar folder.

Assembly of stack components

Next in the fabrication process is the assembly of the formed parts of the stack assembly. Join the roof jack, shown in figure 3–10, to the base (flashing) with a dovetail seam. Clip the ½-inch allowance on the frustum base at ½-inch intervals to make ½" × ½" tabs, and bend every other tab 90°. After joining, bend the remaining tabs 90°. Solder the dovetail seam to seal it from rain and moisture. Install the collar at the top of the frustum by placing the V-grooves together. It is best to solder all of the roof jack seams to provide a waterproof seal.

Assemble the vent cap components, shown in figure 3–12, by riveting the top and collar to the braces. There are two rivets in the collar and one in the top of each brace. After you've riveted the four braces, install the ring with sheet metal screws.

To assemble the ceiling thimble illustrated in figure 3–13, spot weld the rings to the flanges of both sleeves. Align the 1" × 1" tabs with the screw holes in the ring, ½ inch or ⅝ inch from the edge (according to the ceiling thickness), and spotweld or rivet the tabs to the outside sleeve.

Conditions affecting stack placement

Natural updraft is a characteristic of heated air that makes it flow upward through a stack or ventilator. In essence, it's simply the tendency of warm air to rise above cold air. A good example is a gas furnace. A gas furnace produces hot combustion fumes (exhaust) that rise upward through an attached vertical stack that usually extends from the furnace to above the roof line where the exhaust is released into the atmosphere.

Wind is another force that can assist or increase the natural updraft. However, its effect varies as wind direction and velocity change. Figure 3–15 shows the airflow over a building. The area of greatest suction on top of the building is at point B, which is located near the *upwind* edge where the wind is forced upward to have a suction effect on the stack. If possible, locate the outlet of a stack in this suction area.

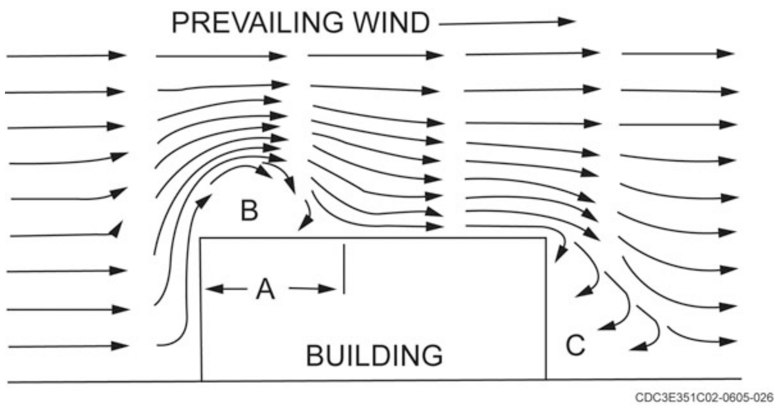

Figure 3–15. Airflow over a building.

At the end of area "A" in figure 3–15, the wind is flowing downward and flows into any stacks located there. To keep air from flowing into a stack (air flowing in the wrong direction) and preventing the desired airflow, place the stack in a better position or raise it to a point where the wind flows straight across the opening. This straight across wind flow creates a suction effect that increases the airflow out of the stack.

As we said, a stack located at point B has the greatest suction from the wind. Second best is any location where the wind is flowing straight across the roof. The worst location is at the end of area "A," where the air is turbulent and flowing downward. In all cases, the opening of the stack should be above the highest part of the roof to take advantage of the wind from any direction.

Installation of stack components

You begin stack component installation as shown in FO 2 by locating the center points where the stack passes through the ceiling and roof. A *plumb bob* locates the ceiling hole center point when you suspend it from the ceiling. As you hold the string of the plumb bob against the ceiling, align it with the center of the exhaust outlet on the heating unit. With the center located, cut an 11⅛- inch hole. You can find the roof jack location by the same method. Cut the roof jack outlet 14½ inches in diameter. Then set the roof jack directly over the roof outlet and nail it to the roof. Don't install the jack until you install a layer of roofing felt.

When the roof jack is in place and the ceiling thimble is installed (view D, fig. 3–13), place the double-wall stack over the exhaust outlet of the heating unit. Then, install the double-wall stack through the thimble and into the roof jack, fastening the joints together. Fasten the brace to the stack and ceiling rafters as shown in FO 2. Install the single-wall roof stack through the roof jack and fasten it with sheet metal screws. Your last step is to fasten the vent cap to the roof stack with sheet metal screws. This completes the stack component installation.

213. Installing and repairing ventilators

Having the proper amount of ventilation in an attic is very important. It helps to prevent condensation of moisture. A well-ventilated attic removes moisture through evaporation. In this lesson, we discuss metal ventilators that aid in ventilating roofs.

Types of ventilators

View A of figure 3–16 is a turbine (spin cap) ventilator. When the wind blows, the vaned top rotates, and the centrifugal action pulls air out of the building.

The conditions that affect ventilator placement are similar to those for stacks that we covered earlier in this volume except that hot gasses are not exhausted through a ventilator. The ventilator shown in view B operates like a stack, with air removal depending on the wind and the temperature difference inside and outside the building. Install this ventilator on the peak of the roof so wind can blow across it from any direction.

In the ventilator shown in view C, a motor-driven fan pulls the air out of the building. Because it’s powered, it doesn’t rely on the wind or temperature differences. Power ventilators are normally installed in locations requiring a steady flow of exhaust, such as kitchen range or laboratory hoods.

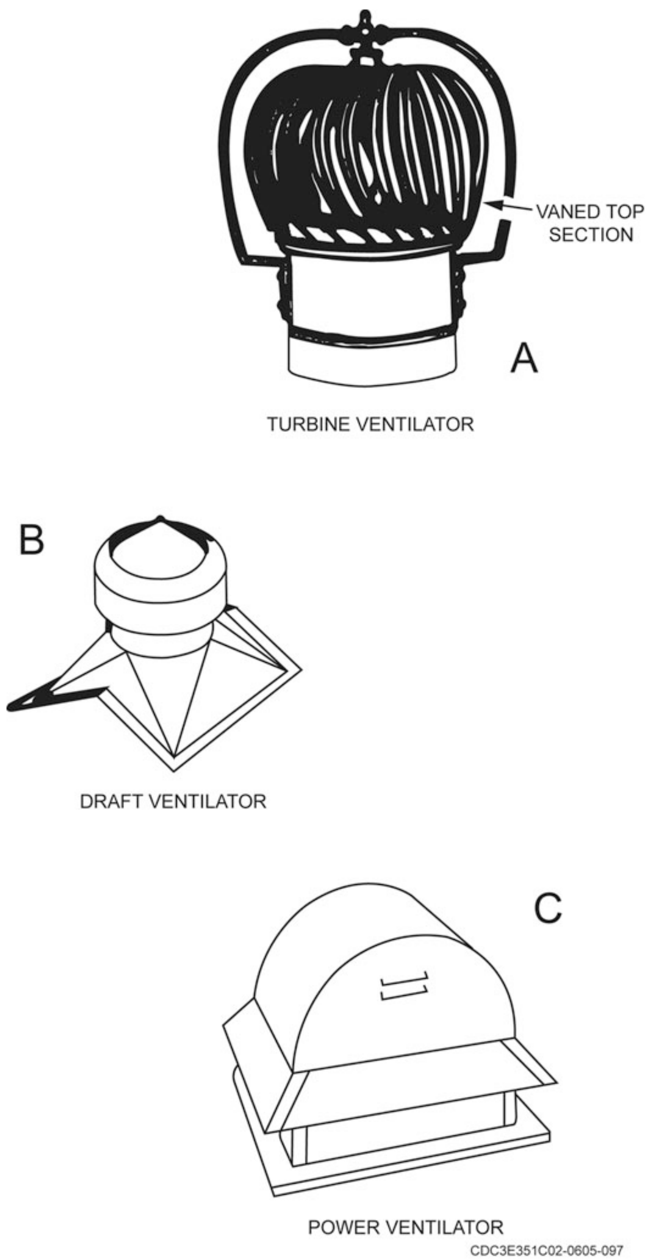

Figure 3–16. Ventilators.

Attics with ventilators usually have louvers on the gable ends of the building. The louvers let cooler outside air in as the warmer inside air passes out through the ventilator.

In most ventilators, dampers regulate the airflow. In the summer, the dampers are usually left open. In the winter, they're opened or closed as required. Most power-operated ventilators, such as the one shown in view C of figure 3–16, have automatic dampers that open or close when the motor is turned on or off. This operation controls the backdraft in the system.

Ventilator installation

As with most things, there are different situations and circumstances that determine where to install a ventilator. The information provided here is general in nature and does not apply to all types of ventilators or situations. It is good information for most situations.

Determining location

When determining the location for a ventilator, you must consider the following:

1. Mount the ventilator as close to the center of the building as possible. If more than one ventilator is installed, space the ventilators accordingly.
2. Mount the ventilator as near to the ridge as possible without being able to see it from the front of the building.

Installing the ventilator

Use the following suggested steps to install a ventilator in a wood-framed roof:

1. Measure the location on the roof (from ridge and edge) for the desired location of the ventilator.
2. Transfer measurements inside the attic. Measure an equal distance (center) between roof rafters or trusses. Mark the location and drill a pilot hole through the roof.
3. Place the template on the roof using the pilot hole for the center. Most purchased ventilators come with a template.
4. Mark around the template and cut through the roofing material and decking with a reciprocating saw (or suitable substitute) with the appropriate type blade.
5. Center the ventilator over the hole. Be sure to look for any markings that specify "up" or "down." You want to place the base flange marked "up" toward the ridge and under the roofing material.
6. Seal around the roof and ventilator. Fasten the base flange securely to the roof. Seal the roofing material around the base flange as you would flashing. Procedures vary depending on the type of roof material.

Ventilator repair

Ventilator repair is similar to the repair of other sheet metal components; that is, according to the damage caused by such things as wind, hail, and corrosion. When damage is discovered, you must inspect the damaged ventilator parts and decide whether to repair or replace. In some cases, it may be possible to repair the damage with a simple patch. However, if the damage is severe, replace the ventilator.

In some cases, you must fabricate a replacement ventilator. For example, assume you must make the draft ventilator shown in view B of figure 3–16. Notice how it consists of a square base that gradually changes to a round pipe. This ventilator is covered with a draftproof vent cap, such as the one shown in view D of figure 3–6 and in FO 2. In this example, the transition is 10 inches high with a 12" × 12" base. The base fits over the ridge of a roof with a 5 to 12 pitch. The collar portion of the ventilator, between the base and the vent cap, is a straight piece of sheet metal stack 8 inches in diameter and 6 inches long. The vent cap has a 2-inch airspace between the collar and cap and a

2-inch airspace between the cap and ring. To fabricate the replacement ventilator, apply the layout, fabrication, and installation techniques covered throughout this course.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

211. Stack and component identification

1. How are double-wall stacks usually constructed?

2. Double-wall stacks are the best choice to vent what?

3. What's the purpose of a draft diverter?

4. What's the purpose of a roof jack?

5. What purpose does a storm collar serve?

212. Forming and installing stacks and components

1. What layout method do you use for making a roof jack frustum?

2. Why is the opening at the top of the roof jack 7 inches if the double-wall pipe is 6 inches?

3. What material do you use to make vent stack braces?

4. What hand tool do you use to cut the inside radius of a roof jack?

5. Name the hand tool you use most often for notching.

6. List the equipment you use to form patterns for a roof jack.

7. What kind of seam do you use to assemble the roof jack frustum to the base?

8. What heated air characteristic makes air flow upward through a ventilator?

9. What's a good rule for deciding the height of a roof stack or ventilator?

10. What tool do you use to locate the point where the vent stack will pass through the ceiling?

213. Installing and repairing ventilators

1. Under what conditions does the turbine (spin cap) ventilator pull air from a building?

2. How do ventilators exhaust air from a building?

3. Where are power ventilators normally installed?

4. Why do power ventilators have automatic dampers?

5. What factors determine the repair that must be done on a damaged ventilator?

3–2. Hoods

Hoods are used to funnel fumes and gases from paint spray booths and kitchen equipment that includes cooking ranges and dishwashing machines. A hood is installed overhead and is connected to an exhaust fan and duct system to function properly.

214. Hood pattern layout

Knowing hood construction features, helps you to layout the pattern that you need to fabricate the hood. In this lesson, we look at hood construction features and the layout methods and patterns that assist you in fabricating hoods.

Construction features

A hood is constructed with certain features to provide efficient coverage and air pickup. For example, the typical cooking range hood extends 6 inches beyond the sides of the range and 12 inches beyond the front. Hoods are usually made of 20-gauge stainless steel and have grease filters that can be removed for cleaning. The inside bottom edge of the hood has a flanged edge (lip) that acts as a grease collector or trap. One corner of this grease trap has a drain plug for draining grease that collects. Figure 3–17 shows the location and shape of the grease trap. You'll encounter hoods of various sizes and shapes; however, the fabrication and installation is similar to that for the one shown in figure 3–17.

Adjustable hangers that extend from the hood to the ceiling are usually used to support hoods. They are usually made from a metal flat bar, rod, or chain. A turnbuckle is used for adjusting the height of the front corners of the hood. These adjustable hangers allow a corner to be lowered so that any accumulated grease can drain from the removable grease plug.

The majority of hoods used for commercial purposes such as dining hall kitchens are made from stainless steel because of stainless steel's ability to resist corrosion better than other metals. Hoods fabricated from stainless steel are similar to fabrication of other sheet metal components, except stainless steel is a harder metal and its polished surface scratches easily. Some manufacturers apply an adhesive paper to the surface of stainless steel sheets for scratch protection. During layout and fabrication, pencil lines marked on the paper can be seen better than marks on the surface of the steel. For scratch protection, leave this paper on the metal until the component is assembled and installed.

To fabricate a hood, you need to know the dimensions and shape. Figure 3–17 shows pictorial views and details of a hood that measures 8 feet long and 30 inches wide. The hood also has a filter that fits inside the collar and a drain plug in one corner of the grease trap. The collar at the top of the hood—where the exhaust duct connects—measures 2" × 12" × 20". The corners of the grease trap and the standing seams are secured with monel rivets.

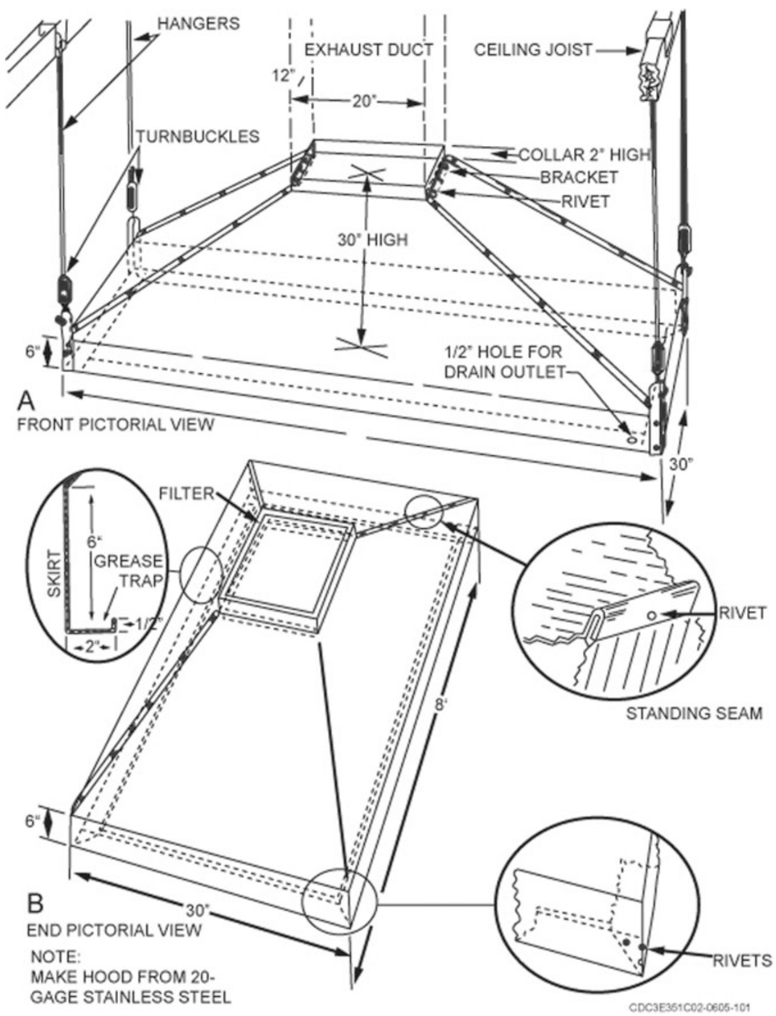

Figure 3–17. Pictorial view of a hood.

Triangulation layout method

In figure 3–17, you can see that the hood is shaped like a transition. The triangulation layout method is used to develop patterns for transitions. This hood can be made in four pieces, as shown in figures 3–18 and 3–19. Notice that the front, back, and two sides are fabricated as individual pieces.

You must draw a plan view of the transition so that you can transfer certain points to the true-length chart. The height of the true-length chart in figure 3–18 is 24 inches, which is the vertical distance from the 6-inch skirt to the collar. (The 6-inch skirt is an addition to the pattern and isn't shown in figure 3–18.) To draw the plan view, draw (to scale) a rectangle 8 feet long and 30 inches wide. Draw the 12" × 20" outlet at the center. A good way to find the center is to locate the middle of each side of the 8" × 30" rectangle and draw lines F–E and 1–6. These lines cross at the center of the large rectangle. On line 1–6, mark off 6 inches (half the width of the small outlet rectangle) on each side of the center; on line F–E, mark 10 inches (half the length) on each side of the center. Then, draw the sides of the small rectangle through these points (as in figure 3–18). After you've drawn the two rectangles and numbered them as shown in figure 3–18, then draw connecting lines between the letters and numbers.

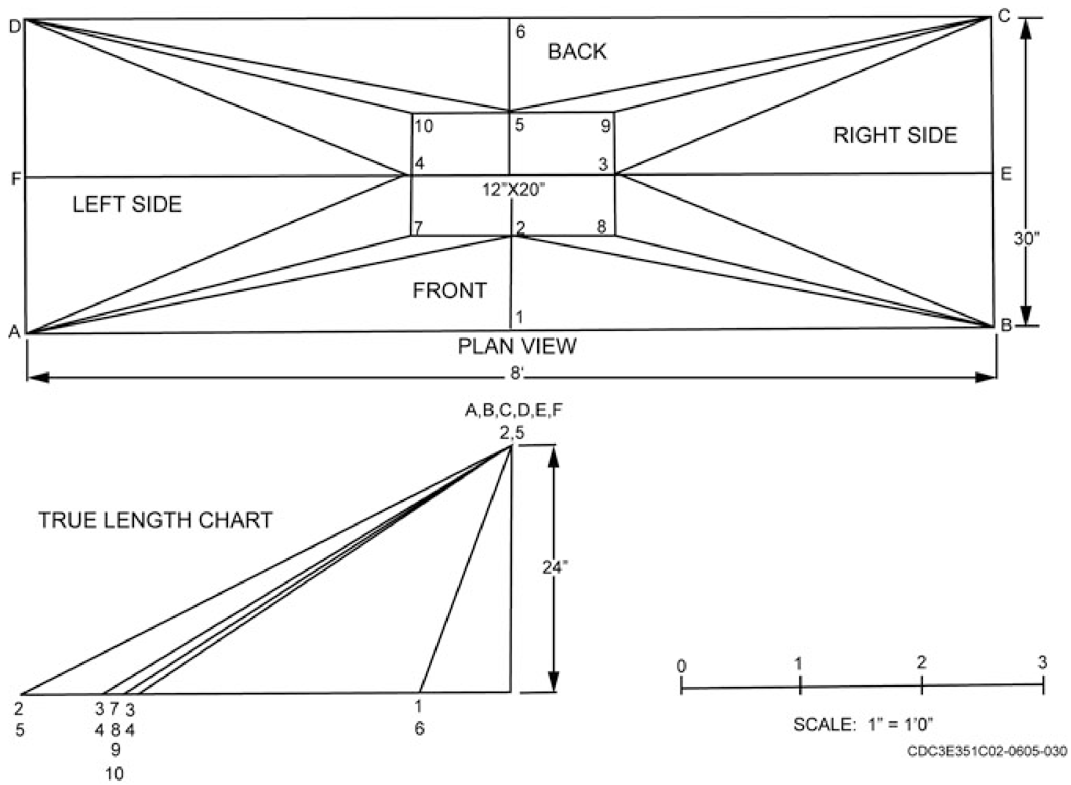

Figure 3–18. Plan view for developing patterns for a hood.

The next step in developing the patterns is to find the true length of the lines between the rectangles of the plan view. Begin the true-length chart with a 90° angle that has the vertical leg 24 inches high to represent the vertical height from the skirt to the collar. Use dividers or trammel points and measure the lengths of lines 1–2 and 6–5 on the plan view. Make sure these lines are the same length. Transfer this distance (the length of line 1–2) to the baseline of the true-length chart, measuring from the far right, and identify the end as point 1,6.

Draw a line from point 1,6 on the baseline to the top of the 24 inch vertical line. Mark this top end point as 2,5 to identify the vertex point. The length of slant line 1,6 to 2,5 is the true length of the front and back pieces for the hood. Next, transfer the distance from 3 to "E" (or 4 to "F") to the true-length chart, draw the slant line, and label the bottom end 3,4 and the top end "E, F." This slant line is the true length of the two side pieces of the hood.

Now, transfer the distance from point 2 to point “A” to the true-length chart, draw the slant line, and label the ends. This line is the same for 2–B, 5–C, and 5–D. You’ll use it later to develop the pattern for the front and back. Transfer line 3–B (or 4–A) to the true-length chart, draw the slant line, and label it. On the true-length chart, don’t confuse 3–B, 4–A, on the left, with 3–E, 4–F, on the right. The last line to be transferred is 7–A, which is the true length of the edge of the pattern along the standing seams. The four corner lines should all be the same length.

Front and back patterns

The true-length chart is now complete enough to develop the patterns shown in figure 3–19. Since the patterns are identical, except for bending instructions, you only need to develop one pattern. Begin by drawing a straight line 8 feet long; letter one end “A, D” and the other end “B, C.” Notice how this line corresponds to lines “AB” and “DC” in the plan view of figure 3–18. Label the midpoint 1,6. The length from “AD” to 1,6 represents line A–1 on the plan view of figure 3–18. Then, set the dividers or trammel points to the length of line A–2 in the plan view. Transfer it to the pattern, with one end at point “AD” and the other end precisely above point 1,6. Draw a short arc above point 1,6. Keep the same setting and move the “AD” tip of the divider to point “BC.” Swing another arc precisely above point 1,6. The point where these two arcs meet is point 2,5.

Next, transfer line 1–2 from the true-length chart to the pattern; the top of this line should be at point 2,5. Connect points 1,6 and 2,5 with a dashed line. This is the height (slant height) of the front and back pieces of the pattern. Draw a 20-inch line through point 2,5, parallel to line “AD–BC.” Transfer the length of line 2–8 from the plan view to the 20-inch line of the pattern. With one end at point 2,5, swing an arc on both sides of the point 2,5. The arcs establish points, 7,10, and 8,9, which are end points for the 20-inch sides of the collar. Next, transfer the length of line A–7 from the plan view to make lines A–7 and B–8 on the pattern. This completes the pattern, except for the additions and seam allowances.

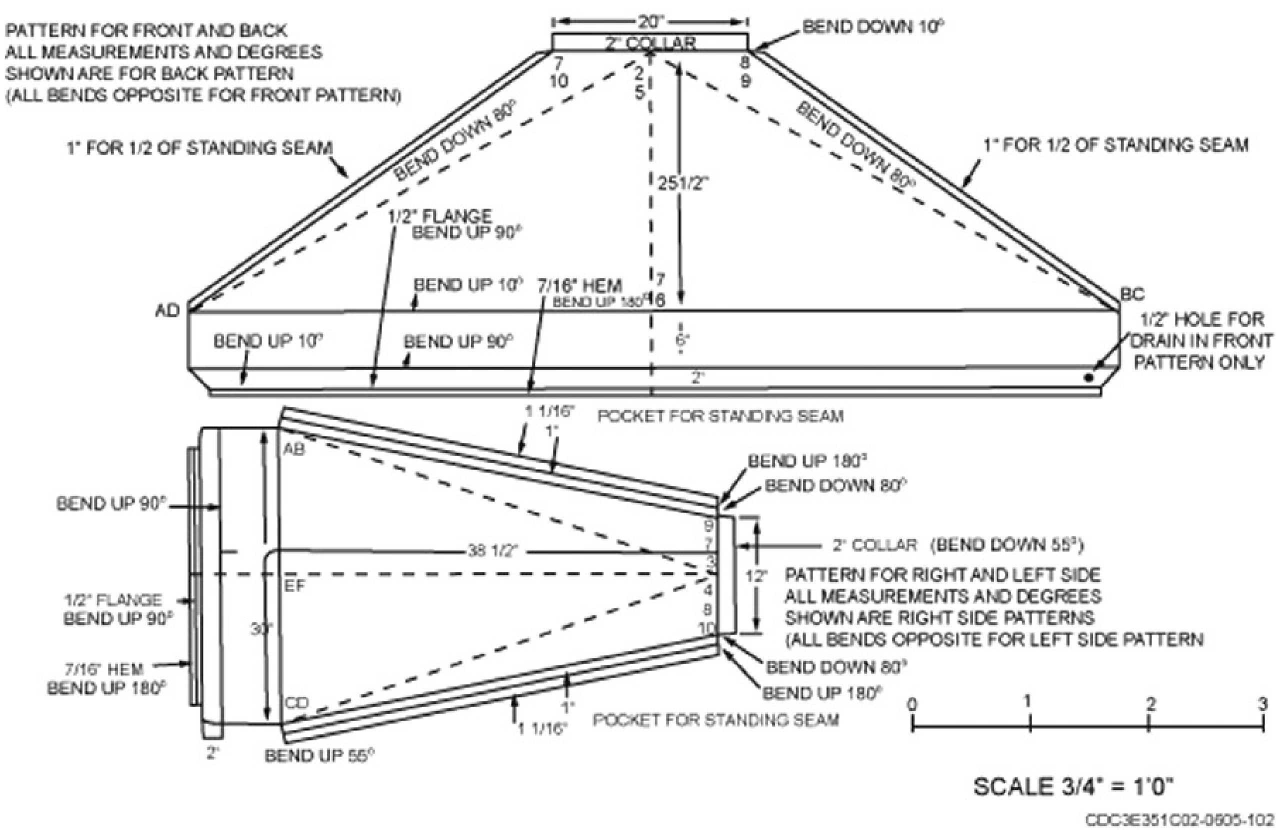

Figure 3–19. Hood patterns.

The additions and seam allowances for the front and back pattern shown in figure 3–19 are made from information contained in the pictorial views of figure 3–17. Make the additions below the 8-foot line on the pattern, as follows:

- 6 inches for the skirt.
- 2 inches for the grease trap lip.
- ½ inch for the grease trap flange.
- $^{7}/_{16}$ inch for the hem.
- 2-inch addition for the collar at the top of the pattern.
- 1-inch allowance on each side for the 90° standing seam-flange portion.

The next step is to write the bend instructions for the lines on the pattern. Notice figure 3–19 has bending instructions for the back pattern, and a statement that the bends for the front pattern are opposite.

Notches for the front and back pattern are somewhat different from those for other patterns discussed previously in this course. Notice in figure 3–19 that the 2-inch addition for the grease trap is notched at each end and that the same addition on the side pattern isn't notched because when the corners are joined, the 45° cut will be on the outside of the lap joint; the mitered cut makes a more attractive corner. (Figure 3–17 shows how the finished corner looks and where the rivets are located.) Notice that the ½-inch flange additions and the $^{7}/_{16}$-inch hem allowances (fig. 3–19) are notched at 90° so that they make butt joints when the corners are joined. The 2-inch allowance for the collar has 90° notches. The standing seam allowance on the front and back pattern is slant-notched at each end.

Side patterns

As we noted earlier, the pattern for the two sides of the hood is also developed from the true-length chart of figure 3–18, using procedures similar to those we used to make the front and back patterns. The completed pattern for the sides is shown in figure 3–19 and includes the following:

- Dimensions.
- Additions.
- Seam allowances.
- Bend instructions.
- Notching instructions.

The pattern illustrated is for the right side of the hood. Again, the pattern for the left side is identical, except the bends, which are opposite to those for the right side.

215. Hood fabrication and installation procedures

After laying out the pattern onto metal, you are now ready to start fabricating the pattern into actual hood components. Let's see how we perform this transformation.

Cutting and notching

Cutting and notching the patterns for the hood shown in figure 3–19 requires squaring shears and straight snips. Use squaring shears to cut the outside edges of the side patterns and the front and back patterns, except for the edge of the standing seam. If you cut this edge seam with the squaring shears, you'll clip the corners of the 2-inch collar; so use straight snips for this edge as well as for the notches on both patterns.

Forming

The bending instructions in figure 3–19 are for the backside and right side patterns shown. Notice that the bending instructions for the front side and left side patterns are opposite to the instructions written on the illustration. Starting with the back pattern, use the cornice brake to produce the 80° bend of the standing seams. Then, use a mallet and wood block to straighten about 2 inches of each seam near ends “C” and “D.” This is necessary so that the cornice brake won’t damage the metal when it’s clamped to make the 10° bend along line “C–D”. After this is done, make the 180° bend for the hem addition and the 90° bend for the 2-inch grease trap addition. Next, make the 10° bends for the 6-inch skirt and 2-inch collar additions. After you make all of these bends, use a mallet and wood block to reshape the ends of the standing seams that were temporarily straightened out. Make the front pattern just like you made the back pattern, except for reversing the direction of the bends and making a hole for the drain plug with a rotary punch.

You’ll need two forming machines—the cornice brake and the box and pan brake—to bend the patterns for the side pieces. The bending instructions are shown on figure 3–19. To form the pattern for the right side, use the cornice brake to make the 180° and 80° bends for the pocket of the standing seams. It isn’t necessary to temporarily straighten the ends of the seam because you’ll use the box and pan brake to make the remaining bends. Arrange the fingers of the box and pan brake to make bends 30 inches long, and then make the following bends:

- 180° for the hem addition.
- 90° for the ½-inch flange addition.
- 90° for the 2-inch grease trap addition.
- 55° for the 6-inch skirt addition.

To make the 55° bend, you must turn the pattern over in the box and pan brake (along the outside edge of the bending leaf) and bend it down with a mallet so that the standing seam won’t be damaged. Arrange the fingers of the box and pan brake to make a bend 12 inches long; then, using only the machine, make the 55° bend for the 2-inch collar addition.

Hood assembly

Now that the pieces are cut, notched, and formed, you can assemble the hood shown in figure 3–17. You can begin at any one of the four corners and insert the grease trap of the sidepiece into the grease trap of the front (or back) piece. The 45° miter cut on the front (and back) piece should be on the outside of the lap seam. It’s necessary to hold the sidepiece at an angle to insert the 1-inch flange into the pocket of the standing seam.

When the two pieces are joined and the corners of the skirt and collar are square, use a small C-clamp or vise grip pliers at each end of the standing seam to hold it together temporarily while you assemble the other pieces. Be sure to use cardboard or small blocks of wood to keep the clamps from scratching the metal. Continue this procedure until all four pieces of the hood are assembled. Inspect each seam and butt joint for proper fit, and adjust them as needed. Next, secure each of the standing seams with monel rivets.

Locate the first three rivets as follows: one at the midpoint and one 2 inches from each end of the standing seam. For good appearance and holding strength, space the remaining rivets on 8 to 10 inch centers. After riveting, remove the clamps from the standing seams.

The next part of the assembly procedure is to install monel rivets at the corners of the grease trap. Make sure that the corners are square before you install the rivets. Carefully lay the hood on its front or back and use a carpenter’s square. Install clamps at each corner to hold the corners until you install the rivets. You can doublecheck the squareness of the skirt corners by measuring the corners diagonally. The diagonals should be the same if all corners are square. After you’re certain that the hood is square, install monel rivets in each of the four corners of the grease trap, as shown in figure 3–17. Solder the inside of the corner lap joint with soft solder.

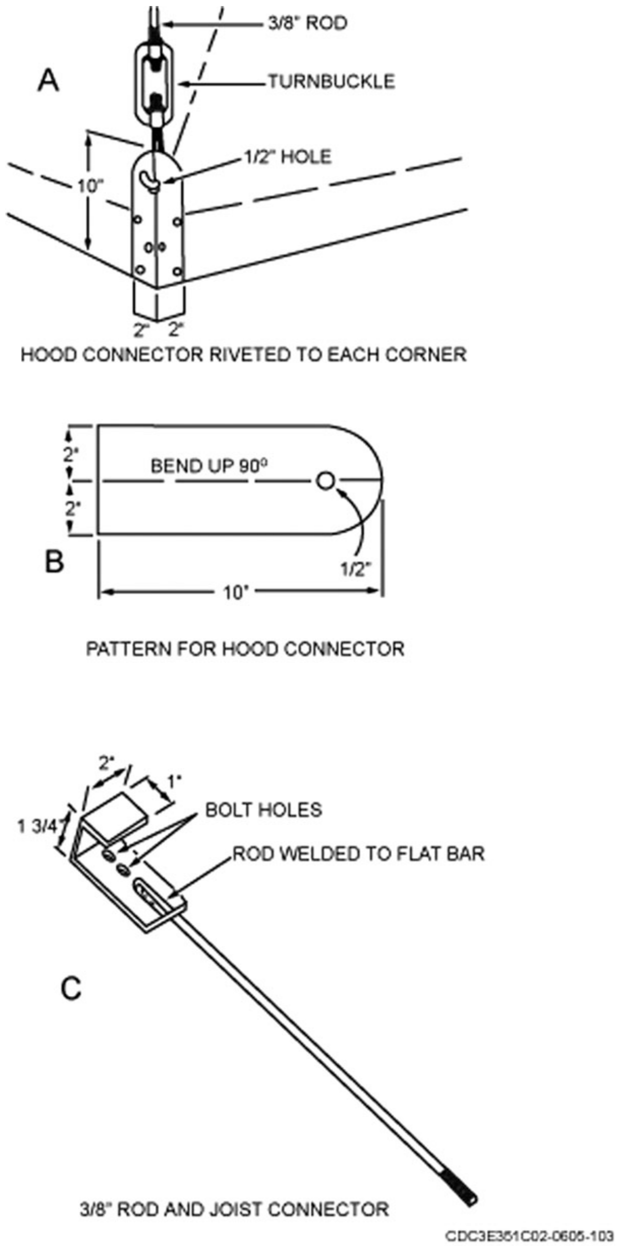

Figure 3–20. Hanger parts.

For the drain outlet, get a ½- inch stainless steel pipe coupling and solder it over the outlet opening with silver brazing. (Silver brazing material is much stronger than soft solder.) The two brackets to hold the filter are each made of 11" × 1" stainless steel and are bent 35° along the 11-inch centerline. Fasten these brackets to the sides of the hood with three monel rivets near the collar (fig. 3–17). The filter rests on the ½-inch edge of metal that extends into the opening and is removed by raising one end until the other end clears the bracket.

The corners of the hoods are supported with hanger parts, such as those shown in figure 3–20. Notice that the parts include a corner connector, turnbuckle, rod, and joist connector. The corner connector is made of 16-gauge steel, using the pattern shown in figure 3–20, view B, and is made long enough to extend 4 inches above the skirt of the hood. Cut the straight sides with the squaring shears, cut the rounded end with throatless shears, punch the ½-inch hole with a rotary punch, and make the 90° bend with a cornice brake. Then, attach each corner connector to the hood with monel rivets, as shown in view A of figure 3–20.

The remaining hood hanger parts are shown in figure 3–20, view C. You'll thread one end of a ⅜-inch rod and weld the other end to a piece of 2-inch flat bar which is formed to fit over the ceiling joist. You'll also thread a short piece of ⅜-inch rod at one end, heat the other end and bend it to form a hook. The threads on each piece of ⅜-inch rod must fit the turnbuckle. To determine the length of the rods, measure the distance from the ceiling joists to the desired installation height of the hood.

Hood installation

Before installing a hood, such as that shown in figure 3–17, determine the location from the drawings or blueprints and then place the joist connectors (fig. 3–20) over the ceiling joists. With the hangers located so that you can insert the round rod hooks into the corner connectors when the hood is raised into position, have three or more workers raise the hood and insert the hooks into the corner connectors. Level the hood by adjusting the turnbuckles; then slightly lower the drain corner and slightly raise the diagonally opposite corner so that the grease drains when the plug is removed. Use wood screws to fasten each joist connector to the ceiling joists. The final steps of installation are to connect the exhaust duct, remove the adhesive paper from the stainless steel, and install the grease filter.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

214. Hood pattern layout

1. How far does a kitchen hood extend beyond the sides and front of the range?

2. Of what type of metal are hoods usually made?

3. How do you secure the corners of a hood’s grease trap and standing seams?

4. What method of layout do you use for making a hood?

5. What view must you draw to develop the pattern for a hood?

6. What instrument do you use to transfer lengths from the drawing of the hood to the pattern?

7. For what part of a standing seam do we add a 1-inch seam allowance?

8. How do you notch the standing seam allowance on the front and back?

9. What do you use to develop the patterns for the sides of the hood?

215. Hood fabrication and installation procedures

1. With which tool do you cut the edge of the standing seam? Why?

2. What do you do to the standing seam before making a 10° bend? Why?

3. What two forming machines do you use to make the sidepieces?

4. Where do you place the first three rivets in a standing seam?

5. How do you check the hood for squareness before you rivet the corners?

6. What materials do you use to attach the corner lap joint and the drain outlet (pipe coupling), and why are they different?

7. Once the hood is installed, what adjustment do you make to the levelness, and why?

Answers to Self-Test Questions

211

1. With an inner and outer wall that have about ½ inch of airspace between them.
2. Gas-fired heaters, furnaces, and water heaters.
3. To prevent excessive updrafts and downdrafts in the vent stacks.
4. To weatherproof the roof opening through which the stack passes.
5. It prevents leaks around the top of a roof jack.

212

1. Radial line.
2. Because the double-wall pipe has ½-inch airspace all around.
3. Flat bar stock.
4. Aviation snips.
5. Straight snips.
6. Bar folder, slip roll machine, hand groover, and elbow-edging machine.
7. Dovetail.
8. Natural updraft.
9. Make sure it’s above the highest part of the roof.
10. Plumb bob.

213

1. When the wind blows and causes the vaned top to rotate.
2. Centrifugal action, windblown, and forced-air ventilation.
3. In locations requiring a steady flow of air, such as a kitchen range or laboratory hood.
4. To control backdraft in the system.
5. The type and extent of the damage.

214

1. 6 inches on each side and 12 inches in front.
2. 20-gauge stainless steel.
3. With monel rivets.
4. Triangulation.
5. Plan view.
6. Dividers or trammel points.
7. The 90° standing seam-flange portion.
8. Slant-notched at each end.
9. The true-length chart.

215

1. Straight snips, so you *won't* clip the 2-inch collar.
2. Straighten about 2 inches of each seam end so the cornice brake won't damage the metal when you clamp it.
3. Cornice brake and box and pan brake.
4. One at midpoint and one 2 inches from each end of the standing seam.
5. Measure distances between diagonally opposite corners to make sure they're equal.
6. Soft solder for the corner lap joint, but silver brazing material for the outlet; because silver brazing is stronger.
7. Use a carpenter's square.

Do the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

55. (211) A draft diverter is installed in a stack to
    a. replace the stack cleanout.
    b. reduce moisture in the stack.
    c. keep side drafts from hampering the updraft.
    d. eliminate excessive updrafts or downdrafts in the stack.

56. (211) What is the purpose of a roof jack?
    a. Reduce moisture in the stack.
    b. Keep the vent cap and wind ring in place.
    c. Prevent rain from entering the vent or stack.
    d. Weatherproof the opening through which the stack passes.

57. (212) Natural updraft is the
    a. draft created by an exhaust fan.
    b. draft created by an in-line heater.
    c. tendency of warm air to rise above cold air.
    d. tendency of cold air to rise above warm air.

58. (212) Which item do you use to find the ceiling hole center point for a stack installation?
    a. Nail.
    b. Level.
    c. Plumb bob.
    d. Framing square.

59. (213) Which roof stack component has a vaned top that rotates when the wind blows to pull out hot air from a building?
    a. Turbine ventilator.
    b. Power ventilator.
    c. Draft ventilator.
    d. T-vent cap.

60. (213) Where are power ventilators normally installed?
    a. Shops or offices.
    b. Attics or bedrooms.
    c. Garages or bedrooms.
    d. Kitchen ranges or laboratory hoods.

61. (213) What type of dampers are installed in power-operated ventilators to control backdraft in the system?
    a. Heat link.
    b. Automatic.
    c. Manual-on.
    d. Manual-off.

62. (213) What should you do to a *severely* damaged ventilator?
    a. Patch it.
    b. Replace it.
    c. Plug the opening.
    d. Repair the damage.

63. (214) Range hoods are *usually* supported by adjustable straps to allow
    a. removal of the hood or damaged parts for repair.
    b. access to the hood or its parts when inspections are made.
    c. a corner to be lowered to drain grease from a removable plug.
    d. lowering or raising of the hood for best exhaust performance.

64. (214) From what type of material are the majority of commercial-sized hoods made?
    a. Copper.
    b. Aluminum.
    c. Stainless steel.
    d. painted carbon steel.

65. (214) You are cutting and notching a hood pattern. What cuts make more attractive corners when the hood is assembled?
    a. End.
    b. Square.
    c. Curved.
    d. Mitered.

66. (215) To cut and notch parts of a hood, use squaring shears and
    a. circle snips.
    b. straight snips.
    c. double cut snips.
    d. compound lever snips.

67. (215) Why do you put rivets 8 to 10 inches apart when assembling a hood designed with standing seams?
    a. To maintain uniformity.
    b. To reinforce the welded seam.
    c. For good appearance and holding power.
    d. Only for appearance since the seams are welded.

68. (215) What do you use to attach a stainless steel drain outlet coupling to a hood?
    a. Rivets.
    b. Screws.
    c. Soft soldering.
    d. Silver brazing.

Please read the unit menu for unit 4 and continue ➔

Unit 4. Rollup and Overhead Doors

THE AIR FORCE has many types and sizes of doors that are used in daily operations. In this unit, we discuss the basic rollup and overhead door components and functions. Also, we discuss the ways that you maintain and repair rollup and overhead doors. We explain how to adjust some of the types of operators that are used on these doors. The material presented in this unit is intended solely to provide you with an understanding of these items. Always follow the manufacturer's instructions for the door or operator on which you are working. There are some variations within the different manufacturers.

4-1. Overhead and Rollup Doors

Overhead and rollup doors on an Air Force installation are usually installed on hangars or facilities (such as a warehouse) that need a large opening so that items such as vehicles and forklifts can easily enter and exit. Because most of the work that you must do on them is above ground level, you must follow the appropriate ladder, scaffold, or mobile work platform safety precautions during these tasks. In this section, we describe general procedures for installing and maintaining rollup and overhead doors.

216. Overhead door installation and maintenance

In this lesson, we discuss installation and maintenance procedures for overhead doors. As with the rollup doors, always follow the manufacturer's instructions for installation and repair. The material presented in this lesson is general in nature and is designed to familiarize you with the basic operations of these type doors.

Overhead doors

Overhead doors differ from rollup doors in that they are usually made up of large panels that ride on rollers in a track that moves them from a vertical to an overhead (horizontal) position, as shown in figure 4–1. These doors have a shaft similar to the rollup doors, including the torsion springs and gear assemblies. The difference in the lifting mechanism lies in the cable drum (or spool) and cable that attach to the bottom of the door, as shown in figure 4–2.

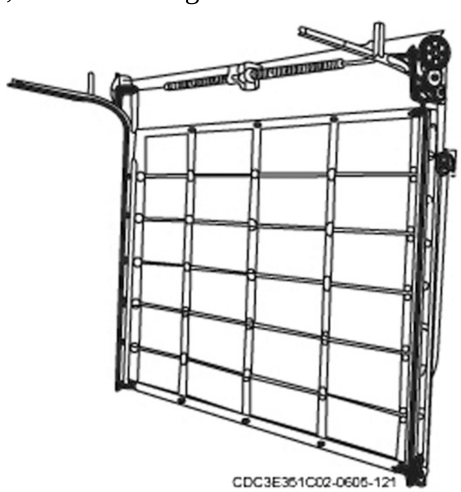

Figure 4–1. Overhead door.

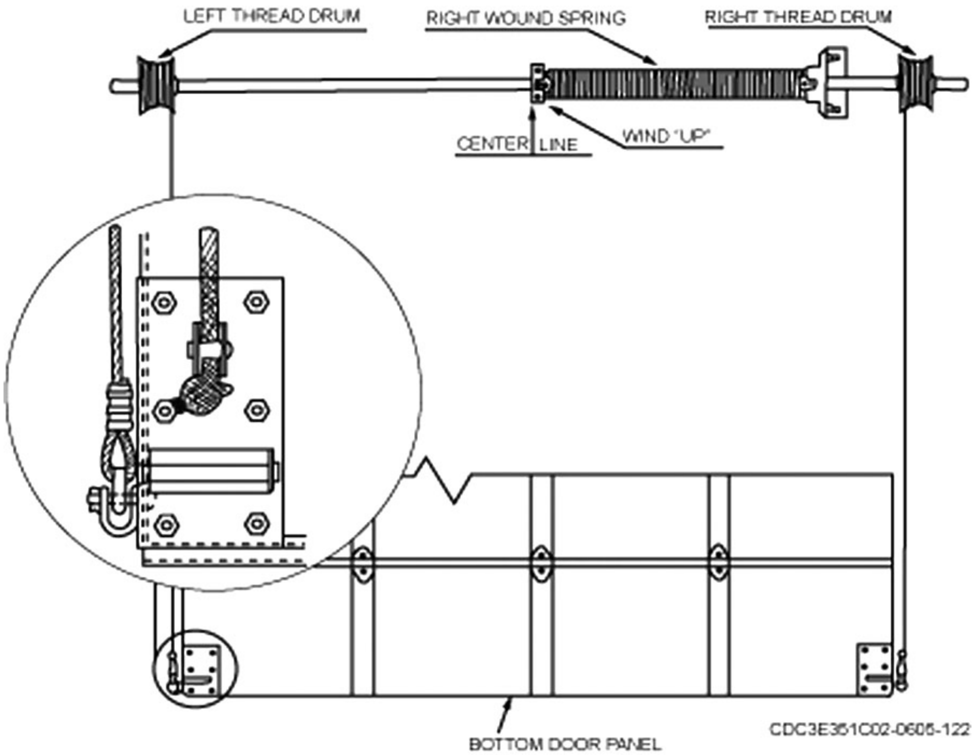

Figure 4–2. Overhead door counterbalance.

The track for these doors is offset from the wall to give it clearance from the wall and to allow it to open and close easily (fig. 4–3). To compensate for this offset, the hinges are different between each panel pair to make the door fit tight to the frame when it is closed (fig. 4–4). One variation of overhead doors rises straight up the wall and does not change to a horizontal position when it's opened. This type is sometimes found in hangars. The lifting mechanisms are the same as those on the other types.

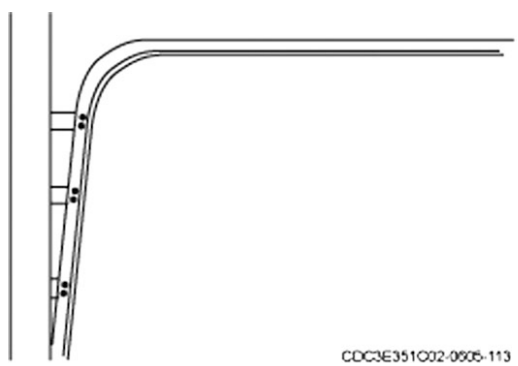

Figure 4–3. Track offset (typical).

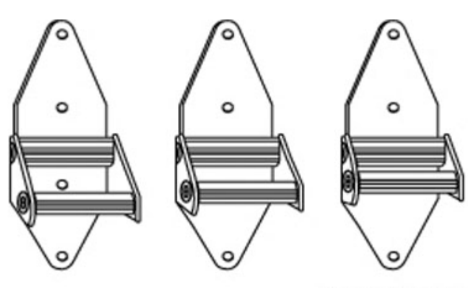

Figure 4–4. Overhead door hinges.

Maintenance and repair

Much of the same maintenance and repair on overhead doors apply to rollup doors because the components are essentially the same. Although the track in which the door rides is designed differently, it still requires lubrication for smooth door movement. On most light-duty moving overhead door components, the recommended lubricants to use are those that do not collect dust or dirt, such as paraffin wax or silicone spray. Other, more heavy-duty components, such as the rollers, require a more durable lubricant, such as machine oil. To be sure that you use the correct lubrication and place it in the correct location, always follow the information that is in the manufacturer's guide.

You must check the door for operation ease (manually and electrically), adequate lubrication, and components that are excessively worn, damaged, or broken. The following are items to check when you do maintenance and repair on an overhead door:

1. Door panels.
2. Hinges and rollers.
3. Door tracks.
4. Cables and cable drums.
5. Shafts and torsion springs.
6. Operator and drive chain.
7. Door alignment.

NOTE: Make sure that the chain slack from the operator to the door is not excessive.

Door alignment

Before you align a door, you must check certain components in the open and closed positions. First, check to see if the door is centered in the track by checking the space on each side of the door between it and the track. This space should be even the full length of the door. If it's not, either the door is hung improperly or the track is mounted incorrectly. With the door in the full down position, check the space at the door bottom. This space should be even (if the floor is flat) for the full width of the door. Overhead and vertical doors commonly need adjustment to square them in their track. They can become misaligned for several reasons. The cable may not be wound correctly on the drum (caused by abuse in unwinching the drum too far). The cable drum may have slipped on the shaft, or the centerline coupler may have slipped. Check this first! Why? Most doors have two springs; the center coupler ties them together. If one door side binds or hits something, then the spring torque on that side passes through the coupler. After a few hits, the door usually becomes misaligned and may not open or close properly, if at all.

To level overhead doors with one solid shaft, you must adjust the cable drums. You do this by adjusting the level of an overhead door—that is, you raise or lower one side of the door. Each door requires its own technique.

The cable has a nonadjustable eye at the lower end (fig. 4–2). This adjustment is at the top. Before you start undoing connections, remember that there's a lot of tension on the torsion shaft assembly. We recommend that you secure the drum before you loosen the setscrew that holds the cable drum in position.

To adjust doors at the grooved cable drum, slightly raise the low side of the door and secure the torsion shaft. Loosen the setscrews and rotate the drum until the cable is tight; then tighten the setscrews. Raise the door 2 or 3 feet. Now close it and recheck the alignment.

You can easily align doors that have two springs and a split shaft. Just loosen the coupling bolts and raise the door slightly until it is level or parallel with the floor; then retighten the coupling bolts. You don't need to worry about tension, since you're not making any break in the tension line (door, cable drum, shaft, and spring). Be very careful when you must remove the coupling bolts to allow enough adjustment between the two shafts. Once you remove all the bolts, you must support the shaft ends—holding them in place until the coupling bolts are replaced.

Torsion spring adjustments

Once a door is level, you must adjust the torsion springs for proper lift. First, draw a horizontal line on the spring from plug to plug with chalk. As the spring is wound, the chalk spirals indicate the turns on the spring. The turns needed depend on the door's height and weight.

Consult the manufacturer's installation procedures for the turns required for your particular door. You wind the springs with an extension rod that fits snugly into the spring plugs. Next, you secure the spring with the setscrews in the plug. (**NOTE:** Some shafts may have a flat side to assure a tight fit.) When the shaft has more than one torsion spring, you should wind each spring the same amount. As you wind the spring, notice that the diameter of the spring gets smaller and the spring gets longer. If the wound spring is shorter and fatter, it's wound in the wrong direction and won't function.

Now you are ready to test the door for balance. If the door is heavy to lift and binds before it is completely up, wind the springs tighter. On the other hand, the tension is too great when the door has a tendency to jump off the floor and rise rapidly. You must check all of these adjustments with the door bottom sitting on the floor. A correctly adjusted door should snap into the head assembly (up position) and barely tend to lift off the floor (down position). It should also fall through the midrange of its travel.

You check overhead door alignment with the door in the fully open position. Look closely at the clearance between the door and track to see if it is equal and not excessive. Make sure the doorstop is in place and functional. If the tracks are not parallel and aligned properly, the door could fall out of the track when it's opened.

Hinge replacement

Occasionally, a hinge may break or become worn enough to require replacement. Remember that the hinges are designed for specific panels on the door and can't be interchanged. Consult the proper manufacturer's manual for correct parts replacement.

Overhead door replacement

When you need to replace an overhead door, your first step is to verify that the replacement door is the correct size and type. You must also identify the door features that are needed and then order the door. With this verified, make your plans for removing the old overhead door. Before removing it, consider how your work affects the building's security and worker/occupant safety. Try to plan the job so that you *don't* leave a hole in a building overnight, and make sure you have all the tools and equipment (ladders, forklift, hoists, etc.) available to handle the door components for removal and installation. With the old door removed, you can start the replacement's installation. The following is one method that you can use:

1. Mount the wall tracks in position.
2. Mount the overhead tracks, shafts, springs, and cable drums.
3. Install the door panels by starting with the bottom panel.
4. Install hinges and rollers to hold the panel in the tracks.
5. Assemble the door by installing the panels one on top of the other.
6. Connect the cables to the door and cable drum.
7. Wind the torsion springs.
8. Install the operator.
9. Check the door for proper operation.

NOTE: The most critical overhead door installation task is the alignment of the door tracks.

Most manufacturers ship a specifications and instructions list with their doors. After the door is installed, maintain this list in a shop file, which you can use for reference when making repairs or ordering replacement parts.

217. Rollup door installation and maintenance

In this lesson, we discuss installation and maintenance procedures for rollup doors. As with anything mechanical, always follow the manufacturer's instructions for installation and repair. The material presented in this lesson is general in nature and designed to familiarize you with the basic operations of these type doors.

Rollup doors

There are many different rollup door designs and manufacturers, but they all function basically the same. A rollup door has a curtain that rolls up around a tube (door barrel) or shaft as it is opened. The door barrel also has torsion springs inside that counterbalance the door weight to help raise the door (fig. 4–5).

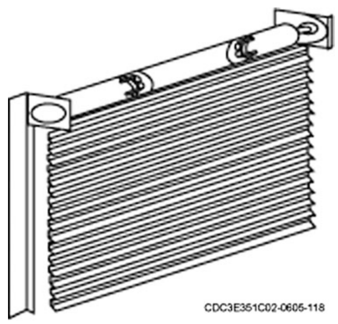

Figure 4–5. Rollup door.

The various components vary in design, but their function is the same. The slats making up the curtain are different shapes (fig. 4–6), depending on the manufacturer. This is important to remember when you order new slats.

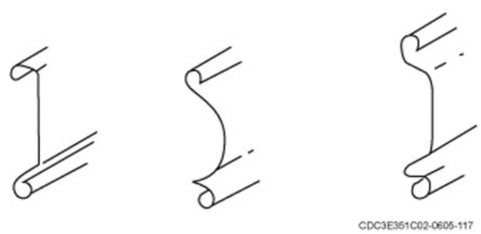

Figure 4–6. Door slat shapes.

There are also specialized mechanisms used to turn a shaft that raises the door. Typically, a chain-operated gear reduction assembly, like the one shown in figure 4–7, is used. There are many variations of this assembly. Some use direct gearing rather than chains, some are power-driven, and some use gear reductions to raise the door.

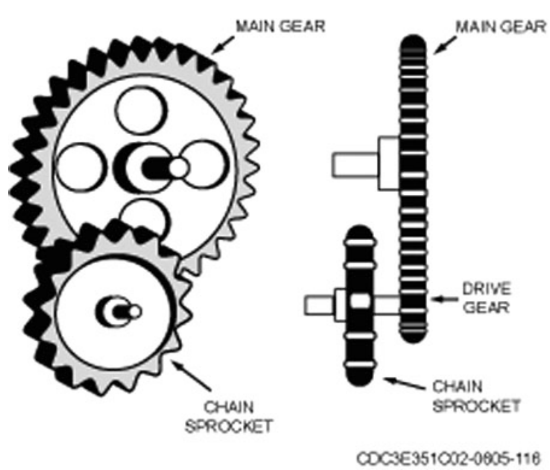

Figure 4–7. Gear reduction drive mechanism.

The basic rollup door uses a shaft with torsion springs to counterbalance the door weight. The number and size of springs vary, depending upon the door type and size. The springs are normally found inside a steel tube (door barrel). To wind the springs, you use extension rods to turn the winding wheel. The winding wheel is on the door shaft end opposite the operator (fig. 4–5).

Maintenance and repair

On rollup doors, check for gear alignment, operation ease, curtain alignment, adequate lubrication, and components that are excessively worn, damaged, or broken. To check gear or sprocket alignment, lay a straightedge across the two gear faces (sprockets) as shown in figure 4–8. The straightedge must contact the full face of both sprockets for proper alignment. If the sprockets aren't aligned properly, adjust them by loosening the sprocket setscrew, moving the sprocket into alignment, and retightening the setscrew. (**NOTE:** Make sure that the chain slack is not excessive.) With the sprockets aligned, make sure that all needed keys are installed, and then lubricate the chain and guides.

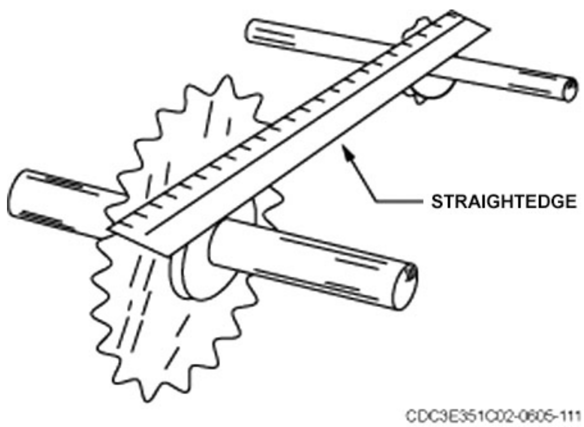

Figure 4–8. Sprocket alignment.

The next component on which to check alignment is the curtain. Pay close attention to the spacing on the sides between the curtain and the track; it should be about even on both sides. If you know the floor is level, check the door level by raising the curtain up about 6 inches and measuring the clearance between the bottom of the door and the floor. If the floor isn't level, raise the door and check the door alignment by placing a level on the bottom edge of the door. If the curtain isn't plumb, you must realign it. To correct a misaligned curtain, rotate the barrel rings on the barrel to bring the door into alignment. Once the alignment is correct, operate the door through a full cycle to check operation. Any sticking or jerking usually indicates that the guides need lubrication; lubricate them with a paraffin wax or silicone spray. These lubricants provide a smooth operation without attracting dirt and debris.

Most repairs on rollup doors involve the slats in the curtain. These slats are interlocking and can be removed and replaced without disassembling the entire door. You can usually remove damaged slats from the curtain by separating them from their end locks, prying them clear of the guide, and sliding them out. With the damaged slats removed, slide in the new slats and lock them to the end locks. Follow the specific instructions on slat replacement in the manufacturer's manual.

Door replacement

When you must replace a rollup door, make sure that you take careful measurements based on the door's opening height and width (fig. 4–9), and identify the door features that are needed. Once you do this, then order the door. When the new door arrives, check its measurements and features before you remove the old door. You *don't* want to remove the old door and discover that the new door is the wrong size or that it does not have the required features.

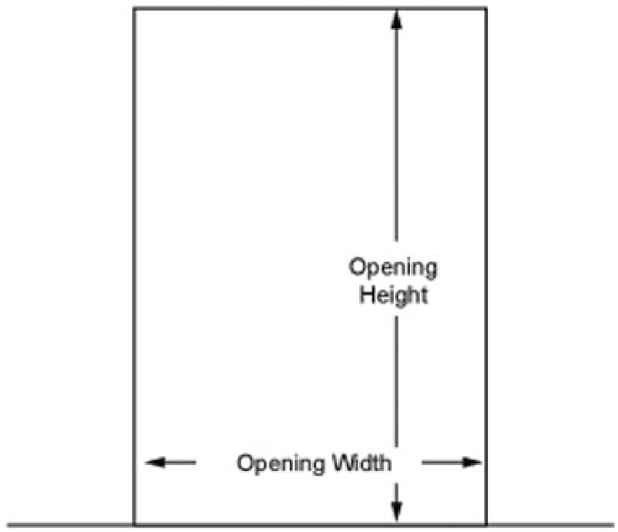

Figure 4–9. Door opening dimensions.

After verifying the door size and features, you're ready to remove the old door. Before removing it, consider how your work affects the building's security and occupant and worker safety. Try to plan the job so that you *don't* leave a hole in a building overnight, and make sure that you have all the tools and equipment (forklift, hoist, etc.) available to handle the door components for removal and installation.

The most critical rollup door installation task is the alignment of the door tracks. The tracks must be plumb (vertical) and parallel to each other. Floors are *not* always level; *don't* use them to align the tracks. If the floor is *not* level, mount the first track to the jamb on the side where the floor is higher. You must make sure that the track is plumb. Next, install the other track parallel to, and at exactly the same elevation as, the first track. To get the right elevation, use a line level attached to the tops of the tracks. After the tracks are mounted, you verify that they are plumb and parallel by measuring diagonally from the top of one track to the bottom of the other track (fig. 4–10). If the tracks are installed properly, measurements A and B are the same. If the measurements are *not* the same, recheck the tracks for plumb and elevation.

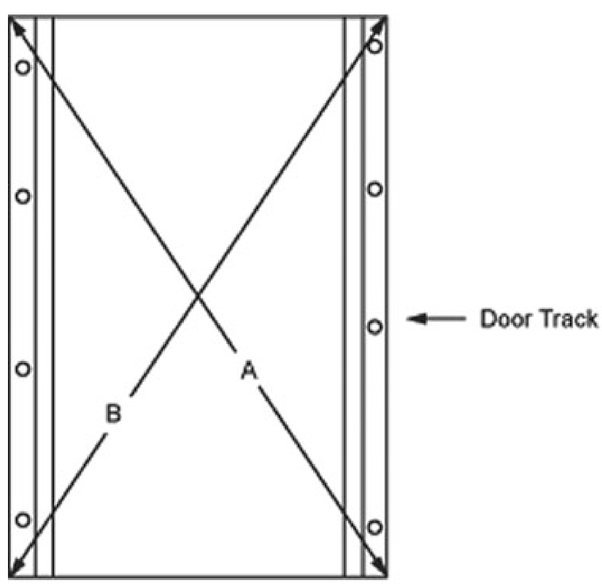

Figure 4–10. Verifying door tracks are plumb and parallel.

After you install the track, raise the door barrel and mount it to the tracks with the support brackets. Then assemble the curtain and raise it up to the door barrel. You can bolt the door curtain directly to the door barrel or to barrel rings. The way the curtain is attached to the door barrel varies with different manufacturers. Now you can wind the door spring. As the spring is wound, the curtain rolls up around the door barrel. When the curtain is as high as the top of the track, install it in the track and lower it.

To complete the installation, you must install the operator. If the operator is electric, you'll need to mount it to the door and have the electric shop wire it to the building's electrical system. After the operator is hooked up electrically, check the door for proper operation.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

216. Overhead door installation and maintenance

1. Why do we offset the track for an overhead door from the wall?

2. Why are the hinges different between each panel on an overhead door?

3. What do you use to lubricate guide tracks on an overhead door? Why?

4. Why do you draw a line with chalk across an overhead door's torsion spring?

5. How can you tell an overhead door's torsion springs are adjusted to the right tension?

6. What do you check before you remove an old overhead door?

7. What must you consider in preparing to replace an overhead door?

8. What component do you install last on an overhead door?

9. What is the *most critical* task in installing a new overhead door?

217. Rollup door installation and maintenance

1. Around what component does a rollup door curtain roll up?

2. What does a rollup door use to counterbalance the door’s weight?

3. How do you check gear or sprocket alignment on a rollup door?

4. How can you correct a misaligned curtain on a rollup door?

5. What do you use to lubricate guide tracks on a rollup door? Why?

6. What do you check before you remove an old rollup door?

7. What must you consider in preparing to replace a door?

8. What is the *most critical* task in installing a new rollup door?

9. What component do you install last on a rollup door?

4–2. Door Operators

Automatic operators are used on many doors and gates for convenience and security. They are used interchangeably on doors and gates, so we refer to them in the text as if they were only used on a door. In this section, we cover electric, hydraulic, and pneumatic operators.

218. Installing and maintaining electric door operators

Electric operators are perhaps the most common type used. There are many different door operator brands which all require specific maintenance and repair procedures; therefore we just cover general procedures. We recommend that you refer to the manufacturer’s instructions for the specific operator that you have. Before working on electric operators, you must lock out/tag out the power to keep the operator from being accidentally energized. You *don’t* want any surprises while you’re working on the operator. The motor, limit switches, and drive equipment are the main equipment on an electric operator.

Motor

Normally, the motor is a self-contained unit. If you think it's defective, call a qualified electrician to check it. Never attempt to troubleshoot or repair motor problems yourself.

Limit switch

The limit switch stops the operator when the door is fully opened or closed. To adjust the limit switch, you raise and lower the door under power in a trial-and-error operation. The limit switch (fig. 4–11) has cams that contact the limit switch arms. When the switch is adjusted properly, the cams contact the limit switch arms when the door is fully open or closed. This cuts the power to the operator and stops the door. If the door does *not* stop when it should, you must adjust the limit switch. You loosen the setscrew, which allows the cam to move. Doing this allows you to make a coarse adjustment. To make a fine adjustment, turn the fine adjustment screw on the cam with a screwdriver.

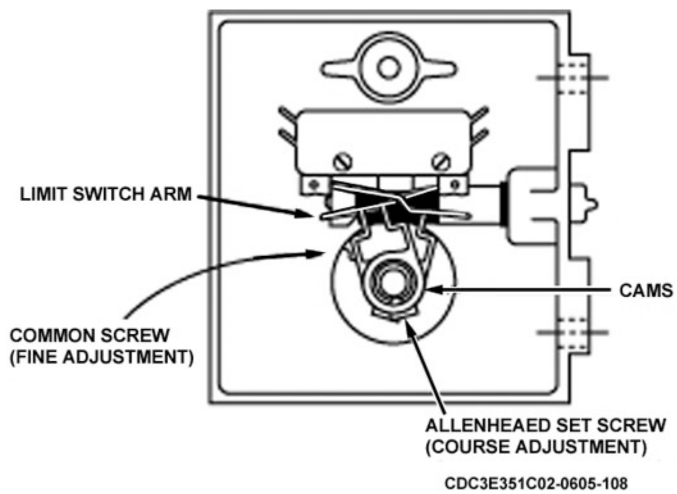

Figure 4–11. Cam-type limit switch.

The limit switch in figure 4–12 operates by having a limit nut move along the limit shaft. When the nut contacts the limit switch, it stops the operator. To adjust this switch, depress the limit nut-retaining bracket and move the limit nut.

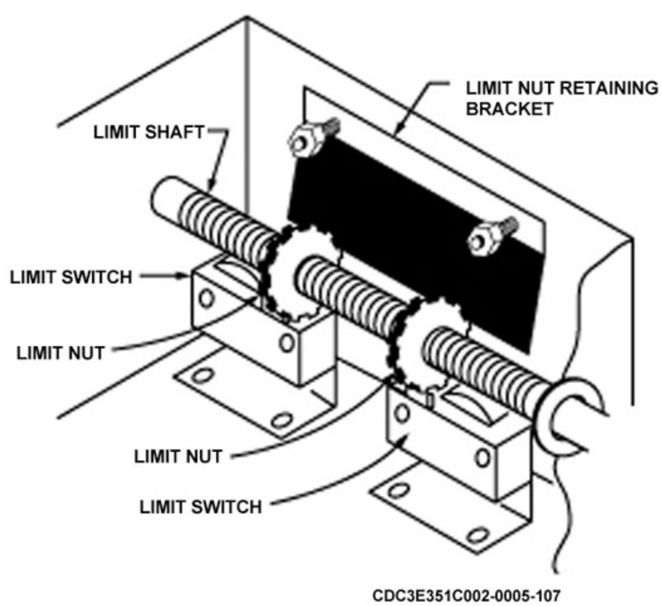

Figure 4–12. Nut-type limit switch.

Drive equipment

The drive equipment that transmits power from the motor to the door includes brakes, clutches, pulleys, belts, sprockets, and chains. Conduct the following preventive maintenance tasks on these items:

1. Inspect belts and roller chains for wear and lubricate roller chains with oil.
2. Replace worn or damaged belts or chains. A worn belt or chain may indicate misaligned pulleys or sprockets.
3. Realign pulleys and sprockets according to the manufacturer's instructions.
4. Adjust the clutch so that it operates smoothly to open and close the door, but slips (disengages) if the door hits an obstacle. To adjust the clutch, as shown in figure 4–13, you tighten the adjusting nut to increase the spring tension that affects the pressure on the clutch plates.

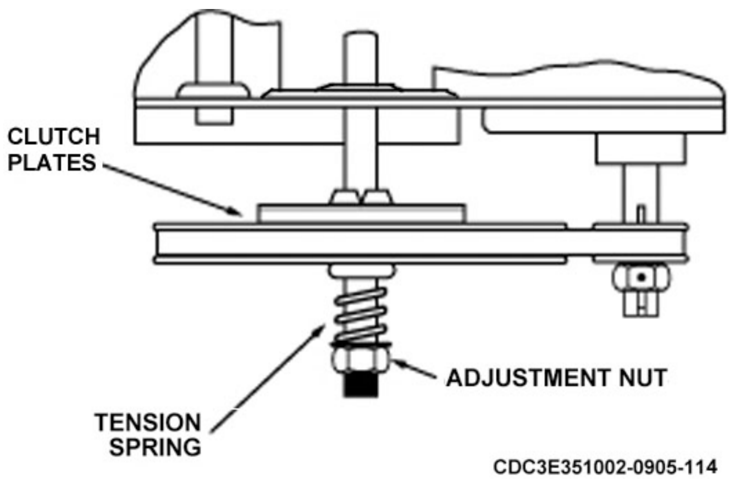

Figure 4–13. Clutch assembly.

Electric operators use a solenoid to activate the brake that stops the door whenever the operator stops. Figure 4–14 shows a typical brake assembly. When the solenoid is energized, the solenoid plunger is pulled into the solenoid, releasing the brake.

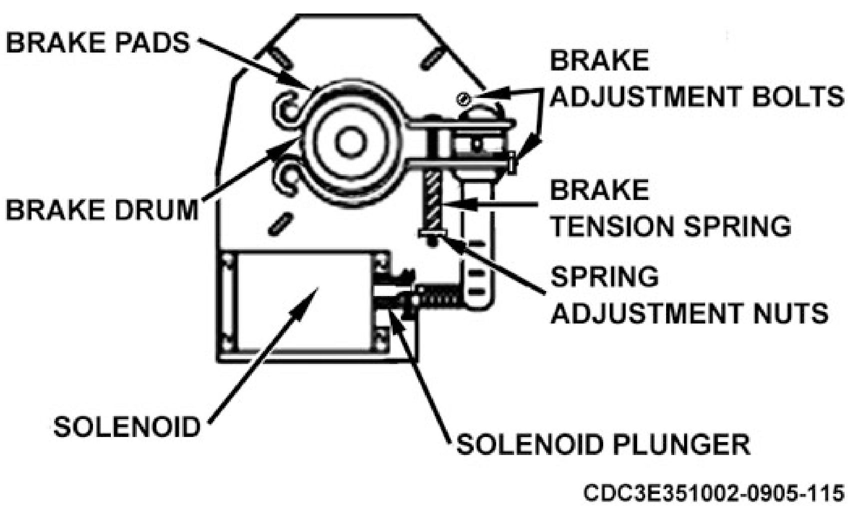

Figure 4–14. Brake assembly.

You must have clearance between the brake shoes and drum when the solenoid is energized for the brake to work properly. Also, the brake must be able to hold the door when the solenoid is not energized. You can perform the following adjustments on a brake assembly:

1. Turn the brake adjustment bolts to change the brake clearance.
2. Adjust the brake tension with the spring adjustment nuts. Listen to the solenoid to ensure proper operation by doing the following:
   a) If the solenoid makes excessive noise when the solenoid plunger pulls in, the spring tension is too loose.
   b) If the solenoid hums loudly when the solenoid plunger is fully seated, the spring tension is too tight.

As we said earlier, these are general procedures. Always refer to the manufacturer's instructions for specific repairs.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

218. Installing and maintaining electric door operators

1. What must you do before working on an electric operator?

2. What component stops the door when it is fully open or closed?

3. How can you determine if a clutch is adjusted right?

4. What component controls brake operation?

Answers to Self-Test Questions

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1. To give it clearance from the wall and allow it to open and close easily.
2. To compensate for the offset of the track and make the door fit tight to the frame when it is closed.
3. Paraffin wax or silicone. Because they don't attract dirt or debris.
4. To get an accurate count of how many revolutions the spring has been wound.
5. A correctly adjusted door should snap into the head assembly (up position) and barely tend to lift off the floor (down position). It should also fall through the midrange of its travel.
6. The door's opening height and width and the door features that are needed for installation.
7. Security of the building and worker/occupant safety.
8. The operator.
9. Alignment of the door tracks.

217

1. A tube (door barrel).
2. A shaft with torsion springs.
3. Place a straightedge across the face of the gears or sprockets. The straightedge must contact the full face of both gears or sprockets for proper alignment.
4. Rotate the barrel rings on the door barrel.
5. Paraffin wax or silicone. Because they don’t attract dirt and debris.
6. The door’s opening height and width and the door features that are needed for installation.
7. Security of the building and worker/occupant safety.
8. Alignment of the door tracks.
9. The operator.

218

1. Lock out/tag out the power.
2. The limit switch.
3. Check to see if it smoothly opens and closes the door, but slips (disengages) if the door hits an obstacle.
4. Solenoid.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

69. (216) What type of door is usually made from large panels that ride on rollers in a track that moves them from a vertical to horizontal position?
    a. Rollup door.
    b. Overhead door.
    c. Utility service door.
    d. Hardened aircraft shelter door.

70. (216) Which component is installed on an overhead door to compensate for the tracks being offset from the wall?
    a. Hinges.
    b. Door panels.
    c. Cable drums.
    d. Torsion springs.

71. (216) If a torsion spring on an overhead door is being wound properly, it becomes
    a. shorter in length, and larger in diameter.
    b. longer in length, and smaller in diameter.
    c. shorter in length, and smaller in diameter.
    d. longer in length, and larger in diameter.

72. (216) What could happen if an overhead door's tracks are *not* parallel or aligned properly? The door may
    a. not fully open.
    b. not fully close after opening.
    c. fall out of the tracks when it is fully closed.
    d. fall out of the tracks when it is fully opened.

73. (217) What type of door has a curtain with a tube or shaft?
    a. Rollup.
    b. Overhead.
    c. Utility service.
    d. Hardened air craft shelter.

74. (217) What would you use to check gear or sprocket alignment on a rollup door?
    a. Level.
    b. Plumb bob.
    c. Straight edge.
    d. Line of sight.

75. (217) What lubricant is recommended for the guides on a rollup curtain door?
    a. Motor oil.
    b. Silicone spray.
    c. Penetrating oil.
    d. Bearing grease.

76. (217) The two tracks on a new rollup door *must* be
    a. level and balanced.
    b. plumb and counterbalanced.
    c. level and parallel to the wall.
    d. plumb and parallel to each other.

77. (217) You can verify that a rollup door's tracks are plumb and parallel by measuring
    a. between the tops of the tracks.
    b. between the bottoms of the tracks.
    c. from the top of each track to the floor.
    d. from the top of each track to the bottom of the other track.

78. (218) Which component stops the operator when the door is fully opened or closed?
    a. Clutch.
    b. Solenoid.
    c. Limit switch.
    d. Motion sensor.

79. (218) If the door does *not* stop when it should after you have installed an electric door operator, you must adjust the
    a. solenoid.
    b. relief valve.
    c. limit switch.
    d. motion sensor.

80. (218) What component activates the brake on an electric operator for a door?
    a. Clutch.
    b. Solenoid.
    c. Limit switch.
    d. Motion sensor.

Student Notes

Glossary of terms, abbreviations, and acronyms

Terms

Alloy—A combination of metal and one or more elements mixed together to create specific properties.

Bar folder—A machine that folds metal from 0 to 165 degrees.

Beading machine—Makes beads in sheet metal objects such as cans, buckets, and pipes.

Black iron—Low-carbon steel that is available in various forms such as sheets and angle.

Blueprint—A photographic reproduction that shows drawings in a white on blue background. They are used for architectural and engineering plans for construction.

Box and Pan brake—A machine that has removable fingers to fold metal into various sized pans and boxes.

Braces—Metal strips that are fabricated into a shape that adds strength and support to large sheet metal ducts. A brace can be installed either inside or outside of ducts.

Cleat—A fastener used with roofing nails to secure metal flashing and roofing.

Clip—A fastener used to dress and strengthen sheet metal corner assemblies.

Circle cutters—A tool used with a drill press to cut circular shaped holes in metal.

Condensation—A physical process that involves a liquid being removed from a vapor. It usually occurs in air duct when the air duct is much colder than the room air. This is how water can form and drip from the duct.

Converging—To come together or tend to come together at a point.

Cornice brake—A machine that folds metal and can be used for simple to complicated tasks such as complex seams and round bends.

Countersink—A tool used with a hand, battery, or electrically powered drill to bevel the edges of metal for rivets or bolts with countersunk heads for flush to the surface installation.

Crimping machine—Makes one end of a pipe joint smaller than the other end so that the two sections can be slipped together.

Damper—A flat plate in the flue of a stove or furnace that can be adjusted to control the draft.

Dies—1. Tools that resemble a hex head nut and are used to cut external threads on metal and to re-thread screws, and bolts. 2. A form used to form metal in the drawing or extruding process.

Diffusers—A component of an air duct system that diffuses air for even air distribution.

Diverging—To go or move in different directions from a common point or from each other, branch off (paths that diverge).

Dollies—Portable, heavy, and thick metal tools that are available in various shapes to form metal and serve as a bucking bar for riveting.

Draft—Air movement in a duct system.

Drawings—The art of representing something by lines and can be done by hand with pencils and paper or can be done on a computer.

Drawing process—Shapes metal by pulling it through a die.

Elbow edging machine—Fabricates interlocking edges on metal elbows to join together.

Friction—Represents the resistance that an object has to moving or rubbing against another surface.

Flux—A compound used prior to soldering to clean metal, aid solder flow, and reduce oxidation.

Folding equipment—Machines that folds metal to specific angles.

Forging process—Requires metal to be heated to a plastic like state so that it can be hammered into shape.

Forming equipment—Forms distinctive shapes in sheet metal.

Galvanized iron—Low carbon steel that has a coating of zinc for corrosion resistance.

Grille—A relatively flat component that can have basic to artistic designs cut into it for air circulation. A grille can be made from metal, wood, or plastic, and is usually installed as part of an air duct system.

Grooved seam—Modified Pittsburgh lock seam that is used to secure two pieces of metal together.

Hand forming equipment—Tools that are used by hand to shape sheet metal.

Hand groover—A hand operated tool used to groove seams after they have been formed.

Hand seamer—A hand operated tool that can be used to form seams, make joints, or produce folds in light gauge metal.

Hanger—A metal component that supports and levels heating and air conditioning ducts.

Height—This term indicates a dimension of an object, or a part of it, that rises above either the surface of the object being described or the one on which it stands.

Insulation—Material used to insulate, separate, or cover with a nonconducting material to prevent the passage or leakage of electricity, heat, sound, and so forth.

Lap seam—A seam in which one piece of metal partially extends or laps over another. There are three general types: flat, offset, and corner.

Length—Refers to the greatest dimension of an object or the greatest dimension of any part of the object being described.

Limit switch—An electrical safety mechanism that stops the operation of a door or gate when fully opened or closed.

Lock seams—A metal allowance which is formed into a series of bends which interlock. Many times lock seams act as stiffeners in sheet metal components.

Louvers—A series of slats arranged to admit light and air but shed rain water outward, used to control ventilation, light intensity, and so forth.

Mensuration—The particular branch of geometry which deals with *measurement* of lines, angles, surfaces, and solids.

Metrics—First established in France following the French Revolution the metric system consists of three principal units of measurement—meter, liter, and gram. The metric system is based on units of ten.

Notes—Similar to portions of the specifications and are used to explain the drawing.

Offset—A curve or bend in a metal bar, pipe, and so forth, to permit it to pass an obstruction.

Peel test—Used to check spot weld quality by placing a metal strip above another and then spot welding near one end. The loose end is then peeled apart. A quality weld is indicated if the weld peels out without breaking.

Perforated—To make a hole or holes through, as by punching or boring; pierce; or penetrate.

Pittsburgh lock forming machine—Forms Pittsburgh lock seams on corners of rectangular or square ducts, and grooved seams for round ducts.

Pittsburgh seam—A locking seam that is used to join two pieces of metal together.

Plans—Also known as blueprints or working drawings. They show lines, dimensions, symbols, specifications and notes. They also convey ideas concerning fabrication, assembly, and installation of structural components.

Plenum—An air distribution enclosure located above or below the air handler unit.

Propane tinner's furnace—A portable propane-gas-fired furnace that heats soldering coppers.

Punches, hand—Hand operated tools used for marking metal before drilling, for removing pins, for aligning and piercing holes.

Punch, rotary—A machine that has two cylindrical turrets, one mounted over the other and supported by a metal frame. A rotary punch is designed to punch various sized holes in metal.

Radius—Any straight line extending from the center to the periphery of a circle or sphere.

Register—A device that meters or controls airflow in a duct system.

Rivets—A metal fastener with a head on one end. Rivets are placed in holes so that the plain end can be hammered down to join metal or other materials together. If blind rivets are used, a lever action rivet gun is used instead of a hammer.

Rivets, drawing—A process used to install rivets in light gauge metal without drilling or punching a hole first.

Rotary burring machine—Turns flanges and edges on circular discs and cylinders. A rotary burring machine can be used to turn edges on elbows and make double seams or single hems.

Shear test—Checks internal spot-weld quality. The shear test requires spot welding two identically sized metal strips together with a 1/8- inch offset. After cooling, the strips are placed in a vice to be sheared apart at the offset sections to observe the weld.

Slip roll forming machine—Forms flat metal sheets into various sized cylinders.

Snap lock machine—Fabricates snap lock seams in metal for air ducts.

Snips—Hand operated tools that utilize scissor cutting action to cut flat metal sheets.

Soldering—A welding process to join metal by heating and melting a filler metal or alloy to a temperature of less than 840 degrees and less than the melting point of the metal to be joined.

Soldering coppers—Tools that are fire heated and then used to heat metal for the soldering process.

Soldering irons —Tools that are electrically heated and then used to heat metal for the soldering process.

Specifications—Indicate clearly the quality and quantity of materials, the methods of construction, the nature of the workmanship, the manner of conducting the work, and the general conditions and agreements. Specifications consist of two types; general and specific.

Spot welding—A welding process that confines the fusion of the molten pool to a spot sized area by using heat and pressure in a controlled sequence.

Stainless steel—A steel alloy that contains nickel, chromium, carbon, manganese and silicon. It is hard and resists scratches and corrosion. It is available in sheets that have a dull or polished finish.

Stakes—Small anvils that are used to shape metal by hand. They can be secured in a bench vise or mounted to a work bench. There are many types available and all of them have a horn, head, and shank.

Stove bolts—Metal fasteners used to secure material where accuracy, strength, and vibration resistance are not important.

Sweating—A soldering process where metal is heated and solder is flowed into a joint or seam.

Tap—Tool used to cut threads on the inside of a round hole.

Thickness—Refers to the smallest dimension of any part of the object being described. Thickness can apply either to the main part of the object or to some separate part attached to the object being described.

Tinning—A process to apply a solder coating to soldering coppers and other metals that are to be soldered; reduce oxidation, and aid in solder flow.

Tinner's furnace—A gas fired furnace installed in a shop to heat soldering coppers.

Torsion springs—Springs that act to counterbalance the weight in rollup and overhead doors. The number and size of springs depend on the size and type of door.

Transition—A passing from one condition, form, stage, activity, place, and so forth, to another.

Turbulence—Full of commotion, violent, irregular motion, or swirling agitation of water, air, gas, and so forth.

Turning machine—Forms rounded flanges for wired edges on sheet metal. A turning machine can also be used to turn double seams on elbows.

Twist test—Checks spot-weld quality. The twist test requires placing two metal strips in the form of a "v" and spot welding at the overlap. The loose ends are then pushed together. A quality weld is indicated if the weld twists or tears out and leaves the weld intact.

Ventilator—A device used to bring in fresh air and drive out foul air.

Visual test—A critical look at spot welds for external or internal welding defects.

Water gauge—A measurement in inches that is used to represent the negative air pressure found in air duct systems. Twenty-seven inches of water gauge is equal to one psi.

Width—Usually refers to the dimension of an object from side to side, or in a direction at right angles to the length.

Zerk—A grease fitting located on bushings, bearings, and axle shafts or roller hubs for lubrication. Generally anywhere there is a pivot point or area of repetitive motion, you should look for a grease zerk.

Abbreviations and Acronyms

cfm	cubic feet of air per minute
FO	foldout
R	radius
W	width

Student Notes

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