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Volume 5. Exterior and Interior Finishes

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THIS VOLUME covers exterior and interior finish related information that you will use in your future work on the job.

Unit 1 addresses roofing: low-slope roofing systems, low-slope roof inspection and management, and steep-slope roofing systems. Unit 2 covers metal roofing and gutter systems. Unit 3 focuses on exterior and interior construction: exterior siding and fences, interior wall coverings, protective coatings, and floor and ceiling coverings. Unit 4 explains woodworking: interior trim, and cabinetry.

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 do the unit review exercises.

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Unit 1. Roofing

THIS UNIT HIGHLIGHTS the most common types of roof finishes used in the construction industry for low-slope and steep-slope roofs. It also covers roof inspection and maintenance techniques for these types of roof finishes. Through periodic inspections, we can identify problems that lead to early roof system failures. This unit includes preventive and corrective measures that you can take to correct or prevent those problems. Certainly we can't cover every situation you might run across in the field. You'll find more information and more detailed descriptions in AFI 32–1051, *Roof Systems Management*, *RIEI Roofing Maintenance Manual*, and www.nrca.net, which is the National Roofing Contractors Association. (**NOTE:** As with all roofing projects, safety is paramount.) Along with ladder and fall protection systems, a warning line system must be in place. As with any roofing job, you should wear cuffless pants, steel-toed boots with smooth soles—not deep lugs, work gloves, and eye protection. If it is a sunny day and you are on a roof with a white or reflective surface, dark glasses are a good idea. You should take precautions to prevent sunburns—the sun's heat is immense. Throughout your course of study in this volume, review the safety precautions for roofs you learned in other volumes.

1–1. Low-Slope Roofing Systems

We identify roofs according to their slope. Low-slope roofs slope 3 inches or less in rise per every foot of run. The minimum slope is ¼"- per foot to allow for water drainage. Low-slope roofs are found on many commercial buildings and on most Air Force bases. This section discusses the types of materials used to waterproof low-slope roofs and cover inspection and repair techniques to help you keep the roofs on your base in good repair.

801. Built-up roof systems

A built-up roof (BUR) is a roof system that has been used at most Air Force bases for decades. It starts with a low-slope roof deck that has felt layers (plys) installed. Each felt layer is mopped with hot asphalt or coal tar coating (the felt must be saturated with the same material as the coating). By reading and studying this lesson, you become familiar with the components and installation methods that make a BUR.

Built-up roof components

A built-up roof is composed of various components that work together to provide a strong, leak-tight roof. It is important for you to know each component and how it is used in the roof.

Deck

A roof deck is the foundation or base for the built-up roof system. It provides the hard surface for the entire roof. It must be strong enough to support the roofing felts, asphalt or coal tar pitch, gravel that

covers it, roof top equipment, and environmental loads such as wind, snow, and water. Most decks are also sloped to allow water drainage. Some typical deck materials include steel, poured reinforced concrete, precast concrete panels, prestressed concrete sections, precast blocks, lightweight insulating concrete, wood panels, plywood, poured gypsum, precast gypsum plank and structural cement, and wood fiber.

Nailers

Nailers are treated wood members that are bolted or otherwise anchored to a non-nailed deck or wall. They provide nailing anchorage for flashing or membranes.

Cant strip

A cant strip is a triangular strip that fits into the angle formed by the intersection of a horizontal surface and a vertical surface. It helps to avoid breaking, puncturing, or damaging the roof membrane and helps in water runoff. It is often considered part of the flashing system, but it is placed beneath the roof membrane before the membrane or the flashing systems are applied. Cant strips are fastened mechanically with hot or cold adhesives. They are formed from organic fiber or wood, and are most often placed directly over the insulation. They are butted firmly together against the wall, end-to-end, with no gaps. Following are some items to consider when using cant strips:

- Make sure you install cant strips at all parapet walls or on items with vertical walls.
- Make sure the cant strips are the same type or compatible with the roofing materials with which they are used.

Cant strips are usually attached to the deck surface or substrate—not to the vertical wall. The only time a cant strip is attached to a vertical surface is when there is possibility that the deck and the vertical surface will have differential movement, such as penthouse walls or expansion joints. In that case, the vertical member should have compressible insulation behind it.

Vapor retarder

A vapor retarder is a material that does not readily permit the passage of water. Moisture vapor forms inside of buildings and rises up toward the roof. Vapor retarders are installed between the deck and the insulation to help keep the moisture vapor from getting into the insulation from the interior.

Vapor retarders are not required on every roof. It depends on the building and outside climate. They are generally installed if the average outside winter temperature is 40°F or less, the building's inside humidity is 45-percent or greater, or the attic's airspace is used for a return air plenum.

If the specifications call for a vapor retarder, then use a good one. The most effective vapor retarder is one that can be mopped down solidly to the structural decking. This is not always possible depending on the decking type used. Some examples of vapor retarders include aluminum foil, plastic sheets, red rosin, or wax-coated kraft paper and spray on type. There are also vapor retarders made of glass fiber or organic felts saturated with asphalt. The red rosin and wax-coated kraft papers also serve as a separation sheet placed over a wood deck.

Vapor retarders must be protected from puncture; even small openings can reduce or eliminate their effectiveness. Repair punctures and tears carefully to assure a good seal. The vapor retarder also serves as the interface between the deck and the rest of the roofing system. Deck and component irregularities can produce a partially attached system. To minimize this, strive for substrate uniformity and proper attachment. On poured or precast concrete, you may need to prime the surface with asphaltic primer before placing an asphalt-based vapor retarder. Apply prime coats by brush, rollers, or spray.

Over wood or other nailable decks, a built-up vapor retarder should be multi-layered with the first layer nailed. The second layer you then apply with mopped on bitumen with 2- inch or 4-inch laps. Plastic retarders are sometimes loose-laid and edge sealed with tape. If you use plastic retarders, *don't* allow hot bitumen to touch them because the plastic can melt.

If a wide steel flute deck is used or if mechanical insulation fastening is required, you can mop the retarder on top of a fire-rated layer of insulation that you fasten to the deck mechanically. This layer protects the retarder from accidental puncture and allows mechanical fastening without penetrating the retarder. Then place enough insulation above the retarder to keep the temperature at the retarder above the dew point. Follow the retarder immediately with the roof insulation and membrane, and don't expose it to moisture, which could be trapped in the system.

Carefully flash any intentional penetrations through the retarder. Punctures defeat the retarder's purpose, so you must repair them at once. Roof insulation placement should follow closely for abuse protection.

Insulation

Insulation serves many purposes. The primary purpose is to reduce energy cost by reducing heating and cooling loads. It also functions as a base for built-up roof membranes, and provides a thermal barrier which has a smooth surface to support the relatively flexible (BUR) membrane. Sometimes, the insulation is installed with a slope to help the membrane surface drain water off more effectively. The insulation material can be cellular glass, extruded-expanded polystyrene foam, wood fiberboard, field-mixed composition/perlite insulating fill, or various composite boards.

Base sheet

The base sheet is the first ply used in multi-ply bituminous roofing membrane system. It is usually a saturated or coated felt.

Membrane

The membrane is the waterproofing part of the roof system. On a built-up roof, it is composed of two elements—felt and bitumen. The bitumen is the waterproofing agent. The felts stabilize and reinforce the membrane, giving the BUR system 90- percent of its tensile strength. The membrane is installed on top of the insulation for most applications.

Felt

Felt layers in a built-up roof are there to hold the bitumen layers in place; they do not contribute materially to waterproofing, and they are not suitable for prolonged exposure to the weather. The most common weights for roofing felts are 15-pounds and 30-pounds (per square of felt). Built-up roofs are designated by the number of plies (three-ply, five-ply, etc.) or by a number of years (10-, 15- , or 20-year roofs). A 20-year roof usually has 5-felt plies, a 15-year roof has 4-plies, and a 10-year roof has 3-plies.

Figure 1–1 shows a 5-ply, 20-year, built-up roof. Remember that asphalt and coal tar pitch are not compatible; always use asphalt and asphalt-saturated felt for an asphalt built-up roof, and coal-tar pitch and coal tar saturated felt for a coal-tar-pitch roof. They will not bond to each other, so do not mix them.

Bitumen

Hot- and cold-applied bitumen (asphalt and coal tar) is the waterproofing layer that we usually mop onto a built-up roof. Other purposes include the following:

- Cohere the insulation to the deck.
- Hold surfacing aggregate in place.
- Adhere the roofing felt to the substrate.
- Affix the felt to the surfaces to be flashed.
- Protect roof surfaces from deterioration by sunlight and moisture.

NOTE: Never mop bitumen directly to the decking.

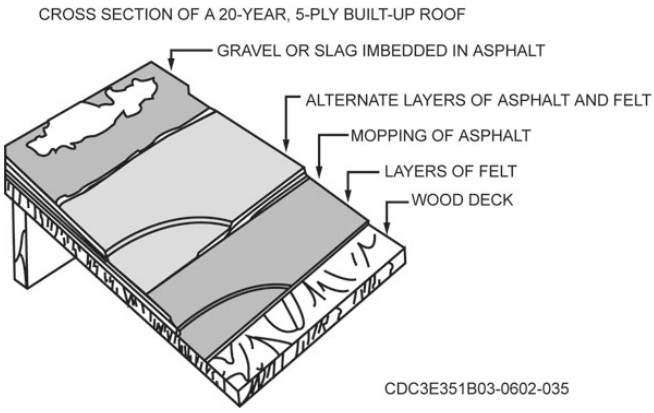

Figure 1–1. 5-ply, 20-year built-up roof.

You can use either asphalt or coal tar pitch as plying cement and as coating for saturated felt. Coal-tar pitch is particularly adaptable for "*dead level*" roofs, where water tends to stand. Asphalt is better suited for steeper slopes. Since these bitumens are not compatible, they do not bond to each other. This fact makes it critical for you to know which type you are dealing with before you make any repairs. You can usually distinguish between them by their odors. Asphalt smells oily, (like diesel fuel); coal-tar pitch smells pungent, (like a creosote telephone pole). You can smell these odors best in specimens that have been broken recently or have been heated. A more reliable test is a solvent test. Pour clear solvent (paint thinner, mineral spirits, etc.) in a container, leave a small bitumen piece in it for about 20-seconds, and then stir the solution. If the solvent turns brownish-black, you have asphalt; if it is transparent and yellowish-green, you have coal tar.

Surface materials

The last part of a built-up roof is the surface. Depending on the type of surface used, it can provide one or more of the following benefits.

- Add protection from hail damage to the membrane.
- Provide a reflective surface and thus reduce heat transfer during the cooling season.
- Protect the waterproof layer or membrane from heat (direct sun) and ultra-violet rays (UV).
- Become part of the overall visual architectural design.
- Add fire resistance to the roof system.
- Add structural integrity to resist wind damage.

Surfacing materials, such as gravel, are embedded in a thick bitumen coat (flood coat). The gravel surfacing materials are not intended to carry heavy foot traffic; you have to use tile surfacing or wooden walkways in areas that are subject to regular traffic. Three of the most common ways to surface a roof include: aggregate, mineral surfaced cap sheets, and liquid-applied (smooth surfaced).

1. Aggregate is the surfacing system most widely used on conventional built up roofs. It is used with a flood coat of bitumen to protect the roofing membrane. The most commonly used types of aggregate are gravel, slag, crushed stone, limestone, marble ships, and volcanic rock.
2. Mineral surfaced cap sheets are factory produced roll roofing that is surfaced with mineral granules. The surfacing granules are the same as those used on conventional asphalt shingles.
3. Liquid applied surfacing is a smooth surfacing of some type of coating. The most common is a thin layer of roofing asphalt (glaze coat) that is spread over the built-up roofing membrane's surface, sealing the exposed ply felts edges. Asphalt is a suitable material for smooth surfacing while coal tar pitch is not. You must use the same grade asphalt on the surface that was used on the inter-ply mopping.

Primer

Primers for BURs are usually solvent-thinned bituminous liquids. All primers used must be compatible with the bitumen or roofing cement that you are using. In all situations, follow the manufacturer's instructions closely.

Roof cement

Roof cement is only used for membrane repairs and flashing cement only to repair flashing. Both types are available in an asphalt or coal tar pitch base. Since they are not compatible, be sure you have the right one for your job.

Flashing

Flashing provides a continuous watertight connection between the roofing membrane, other structural parts, and between roof sections. Flashing seals joints wherever the membrane is either pierced or terminated. It makes a watertight seal at such places as chimneys, vents, parapet walls, expansion joints, and skylights. Flashing materials must resist weathering for long time periods. They almost always outlast the roofing, and they are usually effective for the building's lifetime. It is not uncommon to replace a roof without removing the original flashing. Some flashing break or pull loose (as in composition or membrane flashing) and need replacing because of framework movement. A stronger choice is metal, which resists breaking and movement better.

Even with the strongest flashing, it is still the most vulnerable roof component to leak. Whether you're installing flashing or repairing it, you need to be very careful. You will be well rewarded later when you don't have to respond to a roof-leak call when conditions are less-than-ideal. Below are some types of flashings and where they are used:

- Base flashing—protects and seals the upturned edges of the membrane. It is used at joints between the roofing surface and a vertical surface such as a parapet wall. It is usually made of some type of bituminous felt or fabric, elastomeric or some other nonmetallic material. **NOTE:** Never use metal for the base flashing.
- Counter flashing—(cap flashing) usually a strip of sheetmetal used to cover the exposed edges of the base flashing. It is often built into the side of a masonry wall and turned down over the top of the base flashing. Most commonly used to shield exposed edges and joints of the base flashing.
- Gravel stop—(fascia or gravel guard) flashing that is used around the entire roof perimeter. It serves two proposes—it provides a continuous finished edge by sealing the terminated edges of the membrane and prevents loose aggregate from washing off the roof. (fig. 1–2).

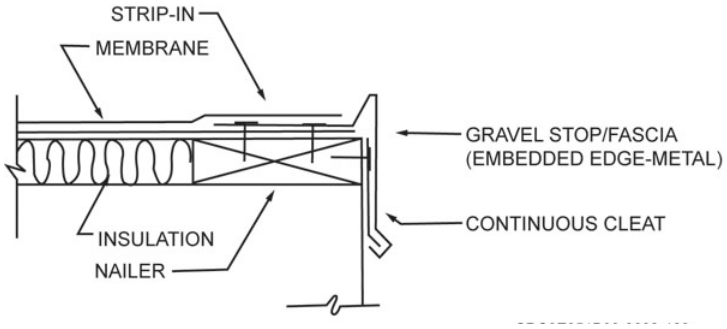

Figure 1–2. Roof edging.

- Strip-ins—strips of felt that seal the exposed edges of metal flashing. They are installed over top of the flashing and the roofing membranes.
- Subflashing—used around anything that penetrates or protrudes from the roof surface. Two typical places are around pipe penetrations and roof drains.

Expansion joint

Expansion joints are structural separations between two building components. They are designed to minimize building stresses and movements to control splitting or ridging in the roof membrane. Joints in the roof system must coincide with the building's structural expansion joints. However, you can place them anywhere differential movement may occur between horizontal and vertical surfaces. Each building component has varying expansion and contraction forces along with temperature changes that have a great effect on the BUR.

Expansion joints must extend across the entire roof width; they must never stop short of the roof edge or perimeter. They should be designed to accommodate contraction as well as expansion. Let's look at some scenarios where you would want to use expansion joints.

- Whenever expansion or contraction joints are provided in the structural system.
- Where movement between vertical walls and the roof deck may occur.
- When additions are connected to existing building.
- Where the type or direction of decking changes.

Area dividers

Area dividers are used to divide roof sections into manageable areas. The sections created should be rectangular in shape and spaced uniformly where possible. An area divider is constructed with double wood members (curb) fastened vertically to nailers. The curbs should be high enough to allow for the installation of cant strips and base flashing. Make sure that water drainage is not impeded by the installation of area dividers.

Area dividers are located between structured roof expansion joints, usually 150-to 200- feet. The exact spacing depends on climatic conditions.

Built-up roof membrane and flashing installation

The care that you take to prepare the site and deck surface is critical to installing the BUR membrane and flashing. In the rest of this lesson, we explain these steps and other methods needed in order for you to have a watertight roof system.

Site preparation

Before starting work on a built-up roof, you must prepare the work site and arrange to keep it safe for the work crew and people in the area. In a typical site preparation you should do the following:

1. Look over the work site to determine if you need to do anything to make the area safe.
2. Arrange for safe and secure storage of tools and equipment.
3. Find a convenient delivery point for materials.
4. Consider using a hoist or crane to raise equipment and tools to the roof.
5. Post a flag warning system around the building perimeter and around the tar kettle.

NOTE: Review information from other volumes on all safety and personal protective equipment needed, such as personal fall arrest systems, safety nets, warning lines, lifting manually, ladders, and scaffolds.

Deck preparation

If you are doing repair work or reroofing, you must evaluate the roof to make sure that the deck is:

1. Structurally sound and can support the added weight from the crew, tools, equipment, and all repair materials.
2. Compatible with the work that is to be done.
3. Cleaned and dry as necessary.

Bitumen heating

Begin heating the bitumen as soon as possible to ensure it is hot enough to flow properly and fuse when spread onto the felt. You heat the bitumen in a tar kettle. The application temperature is not just the temperature in the bitumen spreader, it is the temperature at the time the bitumen contacts the felt. Time is of the essence in the application. In cold or windy weather, insulate the bitumen transporting equipment. If possible, do not store bitumen on the roof deck.

Do not heat deal level asphalt or coal tar bitumen above 400°F or steep asphalts above 475°F and never mop or apply deal level or coal tar bitumen at temperatures below 350°F or 400°F for steep asphalts. Dense yellow fumes from the heating kettle mean that the bitumen is too hot. Always pour the final coat on an aggregate-surfaced roof to be sure you have enough to embed the surfacing. Needless to say, you must follow the manufacturer's instructions for the heating pot (tar kettle) and follow all base and manufacturer safety instructions.

Using modified asphalt for interply mopping in conventional built-up roofs reduces interply delamination and splitting failures, and improves self-healing qualities. Factory-laminated assemblies laminate modified bitumen to polyethylene reinforcing sheets, embossed aluminum foil, polyester mats, or glass fiber felts. Application methods for these new systems vary with the manufacturer; there are too many to discuss here. If you work with any new roofing system, follow the manufacturer's instructions.

Bitumen application

In general, adhesive strength increases as film thickness decreases. Translated into built-up roofing, this implies bitumen that is applied too thickly could be weaker than thinly applied bitumen. Hot bitumen you apply interply with mops or mechanical dispensers. Interply bitumen quantities can vary considerably, even when properly applied to roofs, no matter which method is used.

Hand mopping

Mops are made of cotton or fiberglass yarn. In hand mopping, place the bitumen cart 10-feet to 20-feet in front of the roll. Move the mop in front of the roll and complete mopping first so that you can immediately place the roll into the hot bitumen. Continue to mop hot bitumen just ahead of the roll. To avoid bare spots, the mopping bitumen must flow into the V formed by the roll's interface and the substrate at the beginning of the run. In cold weather, you must do the mopping closer to the roll to maintain an ideal bitumen temperature as the roll is placed. Of course, this means the mop cart should be closer too.

Mechanical dispensers

A mechanical dispenser places bitumen and a layer of felt in one operation. You can adjust the valves to control the bitumen flow rate and set a desirable application speed. As the bitumen is applied, the felt is placed immediately, keeping the bitumen at the right temperature. The major defect in a mechanical dispenser is the possibility of a plugged valve, which may cause skips in the bitumen layer. These skips may be hard to detect since the felt drops immediately into the bitumen. The operator must monitor the bitumen flow constantly.

Brooming

Brooming presses out air pockets and assures that felts come in full contact with the hot bitumen. It should follow no more than 6-feet behind the unrolling felt. Continuous brooming may not be needed in the hand-mopping method because the roll's weight serves this purpose.

Felt installation

In laying felts, the roofer must take a heavy felt roll, place it in hot bitumen (which is cooling rapidly), and unroll it closely parallel to other felts. You keep the felts aligned with the ply lines printed on the felt by the manufacturer. Check these printed lines because they are sometimes printed wrong. The operator must establish certain margins for error in the application.

On occasion, the felts do not run straight. As the felt rollers see the space between the line and felt edge widen, their reaction is to kick the felt back to the line. However, a few feet behind them the bitumen has probably hardened and the felt cannot move. You can make minor corrections in the felt by applying pressure on the roll, letting the felt slide in the molten bitumen. When the felt requires major corrections, it's better to cut it off and start over. Repair other defects, such as cuts or tears in the felt, as they occur or mark them prominently for later repair.

Start felt installation at the roof's low points (drain points or eaves), and roll out plies perpendicular to the water flow. On steeply sloped roofs, felts may run parallel to the water flow. Some manufacturers' specifications may require that you back nail the felt plies on slopes of ½ inch to 2 inches per foot to avoid slippage. Check these requirements by consulting the manufacturers' specifications.

Flashing

There are several flashing types used in BUR construction. The most common ones are base flashing, counter flashing, gravel stop, and subflashing.

Base flashing

We place base flashing where the roof comes in contact with a vertical intersection such as a wall (fig. 1–3). The base flashing is normally bituminous, plastic, or some other nonmetallic material applied separately from the membrane itself. Fiberglass flashing materials or modified bitumen cap sheets are often used. You just need to make sure that the base flashing is compatible with roof membrane.

Install the base flashing over the cant strips. The flashing must extend up a parapet or vertical wall 8 to 10 inches. It must also extend over the roof membrane at least 5 inches. Install two layers of base flashing using either roofing cement or steep hot asphalt. Make sure that you lap the ends at least 3 inches and cement the laps. On the top layer, nail it one inch from the edge and 12 inches on center to prevent it from sliding down the wall. Once the flashing is installed, apply an aluminum roof coating over It. (**NOTE:** If you must attach felt base flashings to any metal, use roofing cement. Hot asphalt does not allow for movement as roofing cement does).

Counter flashing (cap flashing)

Counter flashing is usually sheet metal installed above the base flashing as a cap to shield the base flashing joint from water flow coming down the vertical surface (fig. 1–3). On concrete walls, bend the upper edge of the flashing and insert it into a reglet (kerf cut into the wall). On masonry walls, place a 1½-inch slot into a masonary joint. After the flashing is in place, seal the top of the reglet or joint with roofing cement of mortar.

Another type of counter flashing is surface-mounted. If you install this type, it's usually placed 8 to 12 inches above the roof surface. It must extend down over the base flashing at least 4 inches. You need to make sure that you use a good sealant on this type of flashing to keep the water from running behind it.

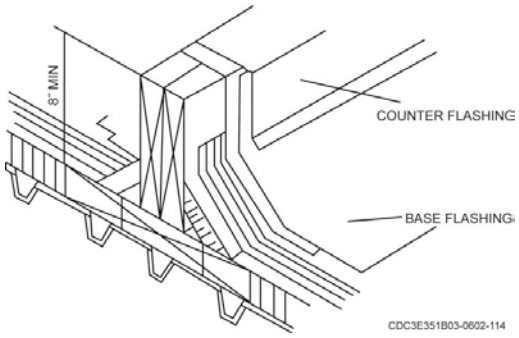

Figure 1–3. Base and counter flashing.

Gravel stop (fascia or gravel guard)

Gravel stops keep aggregate from rolling off the roof, act as a termination point for the membrane, and deflect rainwater. They are made from a rigid material, either premolded plastic or metal. All end laps, expansion joints, and membrane connections must be watertight (fig. 1–2).

The flashing's nailing flange must not be wider than the nailer to which it is to be secured—usually 3½ inches. It must have at least a ¾-inch V-crimp when used with an aggregate-surfaced roof. Place the flashing over the roof membrane and secure it with nails. Place the nails in two rows spaced 3 to 4 inches on center. Cover the nailing flange with two strips of 15-pound felt. The strips should be approximately 8-and-12 inches wide and hot-mopped over the flange.

You can secure the bottom of the metal fascia flashing with a continuous strip that you nail to the bottom of the fascia board. Form the bottom edge of the fascia flashing into a 1-inch pocket over the strip, and bend it 45 degrees to form a drip edge. Use expansion joints at intervals specified on the drawings to allow for a ¼-inch of expansion and contraction. The expansion joint must extend 4 inches over the roof and cover the fascia flashing's full width. You can use a butt joint to splice fascia flashing. If you do, conceal the butt joint with a cap strip that overlaps the butt joint by 2 inches in each direction.

Strip-ins

Strip-ins are strips of felt that seal the exposed edges of metal flashing. Install them over the top of the flashing and the roofing membranes.

Subflashing

Subflashing is used around anything that penetrates or protrudes from the roof surface. Two typical places are around pipe penetrations and roof drains. Pipe penetrations must have a flanged metal roof jack subflashing, and roof drains must have lead or other specifically designed subflashing. In both cases, install the subflashing over the top ply of membrane and set it into a bed of roof cement. Once you set it, prime it and strip it in with flashing felts.

Surfacing applications

All roofs (except some presurface systems) require surfacing material. Aggregate, such as gravel, is applied in hot bitumen and is the most common. If you cannot apply aggregate surfacing soon after the membrane is installed, protect the membrane from moisture with thin bitumen coatings that you mop on. The specifications sheet shows when you must apply aggregate. The aggregate that you use must not be saturated with water, but minor amounts are usually acceptable.

Because warm felts are more susceptible to damage, you usually apply aggregate when the roof is cool. This requires installation in the morning. During the afternoon, a hot sun can keep the roof membrane so hot that applying aggregate may tear the finishing felts and produce puncture damage.

NOTE: Gravel installed in Type I bitumens and coal tar pitch continues to embed as the bitumen is softened by normal sunlight. Aggregate installed in harder bitumen cannot embed later on—place it quickly, while the flood coat is still hot.

With machine application, apply the bitumen and gravel parallel to the roofing felts. Apply bitumen continuously over the surface with no skips or voids. You control the bitumen flow by maintaining the temperature and applying enough bitumen to create a "*wave*" in front of the gravel applicator. Excess bitumen is forced ahead of the gravel.

You can apply bitumen and aggregate manually for small areas. Pour the bitumen in rectangular patterns to ensure uniform coverage. Manually poured bitumen can produce a higher quantity flood coat than machine deposited bitumen, but it is less uniform. Neither method is superior to the other. Keep roofing felts clean during gravel spreading by sweeping loose particles from the felts before you apply bitumen.

End-of-day preparation

At the end of the workday, you must clean your work area to get ready for the next day's work. It is especially important to clean the tar from your tools and equipment. The tar kettle must be cool before you can move it. Place your tools and equipment in a secure area. Safeguard materials to protect them from the elements as well as to keep them from being stolen. Leave the area clean and neat so that you can start the next day's work quickly and easily.

802. Single-ply roof systems

Single-ply roof systems were originally referred to as non-conventional roof systems; however, their use is quite common today. They get their name (single-ply) because a single ply or coating is used as the main roof covering. They are economical and can last 20-years or more. These systems have particular chemicals that make them different. In this lesson, we look at the various roof systems that might be in use at your base and their installation procedures.

Thermosets

This name is synonymous for membranes that are compounded from rubber polymers. Thermosets have chemicals that are cross-linked. This cross-linking creates a curing process we refer to as vulcanization; thus, these membranes we also refer to as vulcanized and non-vulcanized thermosets (cured and uncured thermosets). Once a thermoset membrane completes the curing process, it sets or becomes solid; it cannot be resoftened with heat or other means.

Cured thermosets

Cured thermosets cannot be reshaped, molded, or heat-welded. A distinguishing characteristic of a cured (vulcanized) thermoset is that it can only be bonded to itself with an adhesive because, once it cures, new molecular linkages cannot be formed. The most common types of vulcanized thermosets are ethylene propylene dienne monomer (EPDM), epichlorohydrin (ECH) and Neoprene. (**NOTE:** We must consider climate and use of building for proper choice of membrane.)

Ethylene propylene dienne monomer

EPDM is a thermoset compound that is generally used for roofing as a vulcanized material, although it is also possible to formulate EPDM membranes that are non-vulcanized.

EPDM membranes display a high degree of stability under conditions of exposure to the ozone, ultraviolet light, and extremely high and low temperatures. They also provide good weathering and abrasion resistance.

The sheets are resistant to some chemicals found on roofs, such as acids, alkalis, oxygenated solvents, and certain oils. On the other hand, they are not resistant to many solvents, including animal and vegetable oils, grease and fats. That being the case, EPDM is *not* a good choice to use on top of a dining facility. They are also *not* compatible with plastic cement or dead-level asphalt.

Epichlorohydrin

ECH sheets are classified as cured thermosets. The sheets are available in 60-mil thicknesses and are not reinforced. They are currently reported to have good resistance to hydrocarbons, solvents, grease, and oil. They were not designed for use by themselves, but rather to be used in conjunction with EPDM sheets around mechanical units and heat vents that may emit substances harmful to the EPDM. The typical installation method is fully adhered and sealed with the manufacturer's adhesive.

Neoprene

Neoprene was the first commercially available synthetic rubber product formulated from chloroprene polymers. It may be used in numerous thermoset applications.

Uncured thermosets

Uncured thermosets (non-vulcanized) are not physically cured during manufacturing. However, they cure or vulcanize naturally over a period of time upon exposure to the elements, such as ultraviolet light and heat. Once they cure, their behavior is similar to that of vulcanized elastomers. These materials are often used as flashing on some single-ply systems. The most common types of non-vulcanized thermosets used are chlorinated polyethylene (CPE), chlorosulfonated polyethylene (CSPE), and polyisobutylene (PIB).

Chlorinated polyethylene

CPE may be formulated for use as roofing membranes as both cured and uncured thermosets. They may be non-reinforced or reinforced with scrim. CPE is resistant to ultraviolet and infrared radiation, ozone, oil and many chemicals, and microorganisms. It is also fire resistant and retains flexibility at below freezing temperatures. CPE can withstand temperatures up to 150°F. CPE membranes are compatible with many substrates including asphalt and coal tar pitch. Although usually produced in white or light gray for reflectivity and energy efficiency, CPE can also be pigmented to a variety of colors.

Chlorosulfonated polyethylene

CSPE is a combination of plastic and synthetic rubber. It is a self-curing, non-vulcanized thermoset and is available as a liquid coating or in sheet form for single-ply membrane application.

CSPE materials are compatible with bituminous materials. They are also resistant to water, ozone and ultraviolet light, plus many types of chemicals and pollutants. Most sheets are white; however, they may be produced in many custom colors. The seams on CSPE membranes are usually sealed by hot air welding with a heat gun.

Polyisobutylene

PIB is a thermoset compound made of butyl-based compounds. The sheets are available with a non-woven polyester fleece backing with an unbacked prefabricated sealing edge to seal the side laps.

PIB displays good resistance to weathering, ultraviolet light, and radiant heat. It is compatible with asphalt, but is *not* resistant to petroleum distillates, organic oil and fats, or substances containing tar. The sheets are usually available in white color and can be installed with hot asphalt or cold adhesives.

Thermoplastics

Thermoplastics are distinguished from thermosets in that there is no cross-linkage or molecule vulcanization in the manufacturing process. Thermoplastics can be welded together with heat or solvent and develop strengths in these weld bonds that equal or surpass the strength of the base material. The most common thermoplastics used are thermoplastic polyolefins (TPO) and polyvinyl chloride (PVC).

Thermoplastic polyolefins

TPOs are the newest single-ply system available. It provides the best of EPDM and PVC by offering the weathering and cold temperature flexibility of EPDM and the heatwelding characteristics of PVC. Unlike PVCs, TPOs do not contain any plasticizers that eventually leave the membrane.

Reinforced or non-reinforced sheets are available in a variety of colors, but usually are either white or black. The seams are heat-welded. TPO membranes are not inherently fire resistant; however, they can be manufactured with fire and ultraviolet resistant properties. They are not as chemical resistant as CSPE, CPE, and some PVC sheets, but they can endure animal fats, vegetable oils, and acids/bases. They also resist microbial attacks and can be installed directly over expanded polystyrene (EPS) insulation and asphalt-based products.

Polyvinyl chloride

Polyvinyl chloride (PVC) polymers are among the most versatile thermoplastics for industrial and commercial applications. PVC membranes tested have shown that 20-year old membranes have retained 80-to 90-percent of their original plasticizer content. PVC is less chemical resistant than TPO and CSPE, but is less sensitive to animal fats and vegetable oils than EPDM. PVC membranes properly formulated have shown excellent fire resistance and seaming capabilities and resistance to bacterial and plant root growth. PVC membranes are chemically *incompatible* with bituminous materials and need a separator sheet when installed over EPS insulation. The sheets are available in a variety of colors.

Safety

The use of a single-ply system requires different types of personal protective equipment, depending on the installation method and membrane type. Be sure to protect yourself from any chemicals that you may be using. This includes wearing rubber/nitrile gloves and respirators. (**NOTE:** You can only use respirators you are fitted for and trained to use).

As far as equipment safety goes, one item of concern is the hot-air welder. It uses super-heated air that reaches temperatures from 200°F to 800°F (hand-held units). Not only is this a burn hazard, but it is also a fire hazard. Since you cannot see the air, you need to be extra careful where you point this welder.

The single-ply rolls themselves pose other concerns. Not only are they extremely heavy and hard to maneuver, but they are also a fall hazard. Just as pencils roll off a roof, the same is true for the single-ply rolls if you are not careful.

Job preparation

After all safety items are in place, it is time to prepare for the job itself. The first step is to ensure that the deck area is clean. The substrate should be clean, smooth, and dry. Make sure that all nailers are in place and all roof penetrations have been identified. The next step is to prepare the rolls. You must strap the rolls properly to prevent any damage to the membranes. Plan the roll layout and position the rolls accordingly. Depending on the membrane used, you may need to unroll the membrane and allow it to relax. This gets rid of tension created from the manufacturing process.

Installation procedures

There are three common installation methods for single-ply membranes—loose-laid ballasted, mechanically attached, and fully adhered. With loose-laid ballasted, there are actually two ways to install.

Loose-laid ballasted

As the name implies, a loose-laid ballasted membrane lies loose on the substrate to prevent tensile stress. Ballast material is used to hold down the membrane. As we mentioned above, there are two installation methods using the loose-laid concept—loose-laid ballasted and protected membrane roof (PMR). We discuss the standard loose-laid ballasted method first.

A loose-laid ballasted membrane is anchored at the perimeter and openings (true for all three methods). The loose-laid concept prevents three major problems—splitting, blistering, and ridging—that are common to adhered roof systems. It reduces the splitting risk by isolating the membrane from substrate movement that results from structural deflection, temperature change, or drying shrinkage, all of which can produce stress concentrations at critical spots.

You can use the suggested steps below to install membrane using the loose-laid ballasted method:

1. Ensure the substrate is smooth, clean, and dry.
2. Install a slip sheet (if required).
3. Install insulation per job specifications.
4. Unroll the membrane onto the surface. If needed, allow it to relax.

5. Cut penetration holes (if any).
6. Mechanically attach the membrane to the perimeter and around all penetrations.
7. Install flashings around all membrane penetrations and terminations.
8. Seal all lap joints.
9. Install a protection mat or filter fabric on top of the membrane (if required).
10. Install the ballast (gravel or crushed rock)

Procedures for protected membrane roof (PMR) are very similar to the loose-laid ballasted membrane. The main difference is that you install the membrane first. Then, install a protected mat on top, followed by the insulation. Then, install another mat, followed with the ballast. A PMR system protects the membrane from UV light, foot traffic and the weather.

Mechanically attached

Membranes used for mechanically attached systems are smaller than the sheets used for looselaid ballasted. They are typically 5'- to 10'- wide and various lengths. You can use the suggested steps below to install single-ply membranes mechanically:

1. Ensure the substrate is smooth, clean, and dry.
2. Install a slip sheet (if required).
3. Install insulation (if required).
4. Layout the membrane on top of the substrate.
5. Allow the membrane to relax (if necessary).
6. Cut holes for any penetrations.
7. Mechanically attach the membranes on the upslope edges.
8. Mechanically attach around perimeter and all penetrations.
9. Mechanically attach the membrane using the manufacturer's recommendations.
10. Install all flashings around the terminations and penetrations.
11. Install a surfacing on the membrane and flashing (if required).

Fully adhered

Just as the name implies, these membranes are fully adhered to the substrate. Once again, these membranes are usually 10'- or less in width. This allows for easier handling. You can use the suggested steps below to install membrane using the fully adhered method:

1. Ensure the substrate is smooth, clean and dry.
2. Install insulation (if required).
3. Layout the membrane on top of the substrate.
4. Allow the membrane to relax (if required).
5. Cut any holes for penetrations.
6. Adhere the sheets to the substrate using bonding adhesive.
7. Mechanically attach the membrane around the perimeter and all penetrations.
8. Mechanically attach the membrane using the manufacture's recommendations.
9. Install flashings around the terminations and penetrations.
10. Seal all membrane laps.
11. Install a surfacing on the membrane and flashing (if required).

Surfacing

Surfacing is not a mandatory item for most single-ply membrane installations; however, it provides many advantages to a single-ply roof. It helps protect the membranes from the weather and sun. It also provides an added protection against leaks. While the single-ply membranes are waterproof, they have seams that may fail if not properly installed. A liquid-applied surfacing provides a monolithic covering over the membrane, giving it added protection and an extended life span.

803. Composition roll roofing

Many Air Force bases have roof systems that have been installed on temporary and permanent buildings. In this lesson, we discuss what roll roofing is and the installation and repair methods.

Roll roofing

We often use rolled roofing for temporary construction because it is inexpensive and easy to install.This composition material comes in rolls about 3 feet wide and in various lengths, depending on its thickness. A roll usually weighs 90 pounds. It is usually made from an organic felt (cellulose) base or an inorganic fiberglass mat. The felt or mat is covered with mineral stabilized asphalt coating on the top and bottom. The topside is coated with mineral granules that could be slate, sand, mica, or some similar material to help prevent damage from hot sparks and the sun's heat. They are also available in different colors. The bottom side is covered with sand, talc, or mica or other materials that are saturated with a waterproof compound.

You should always store roofing rolls standing on end to keep them from shifting (rolling) or flattening. Install roll roofing when the weather is clear, the outside air temperature is above 45°F (for pliability), and the deck surface is completely dry. When the temperature nears 85°F, be careful not to mar the surface as you are walking or working on it. The roof deck must have solid sheathing or sound lumber. Cover knotholes or loose knots with sheet metal. If any nails extend above the roof, drive them flush with the surface or remove them completely so they will not puncture the roll roofing. **NOTE:** Roll roofing is used on roofs that slope less than four inches; however, do *not* use roll roofing on a roof with less than a 2:12 slope if the roof is installed with exposed-nails.

Installing roll roofing

Install roll roofing in courses, starting at the eaves and working up the roof. One method used to install roll roofing with concealed fasteners is to:

1. Cut the roll roofing into 12-to 18-foot lengths and allow them time to flatten out.
2. Nail metal drip edge to the roof deck along the rake and eaves, and then flash any valleys. **NOTE:** Nail the metal drip edge 8 to 10 inches on center and lap the end joints at least 3 inches.
3. Install a 9-inch wide strip of roll roofing (edge strip) on top of the drip edge. Nail it down 4 inches on center and 1 inch from the edge. Overhang the roof edges ¼ to ⅜ inch.
4. Snap a chalkline above the eave so that the first sheet of roofing will be flush with the edge strips.
5. Nail the top edge of the first sheet with the nails staggered and placed 4 inches on center. You should have two rows along the top placed ¾ inch and 2 inches from the edge of the sheet.
6. Embed the edges of the sheet over the 9-inch edge strips and into roofing cement. (**NOTE:** If you need more than one sheet to complete a course, overlap the end (end lap) 6 inches.) Nail the bottom sheet to the deck with two rows of nails placed 1 and 5 inches from the end and spaced 4 inches on center. Embed the upper sheet into a bed of roofing cement.
7. To prepare for the next course, snap a chalkline 3 inches down from the top edge of the first sheet. Lay the second course to the line. This gives you a 3-inch top lap.
8. Nail the second course in place following the same guidelines you used on the first course.

9. Embed the edges into roofing cement. The bottom edge gets embedded into a 3-inch wide strip of cement placed on the upper edge of the lower sheet.
10. Continue these steps throughout the roof. Trim off excess material as it reaches any hips or ridges.

Installing valley flashing

As with most types of roofing, you start at the low point. Start at the bottom and place nails 6 inches on center and ¾ inch from the edge of the flashing. If the flashing is too short to cover the entire valley, you must make sure the upper strip laps at least 6 inches over the lower strip. To do this, nail the lower strip down and embed the upper strip into roofing cement. Remember, too much roofing cement may cause the lap to blister.

Pipe flashing

There are two common methods we use to flash around pipes or other penetrations. The method we use depends on whether the roll roofing was installed single- or double-coverage.

Single-coverage method

When you use the single-coverage method adhere to the following steps.

1. Cut the roll roofing to slip over the pipe.
2. Install roofing cement around pipe and slip the vent-pipe flashing over the pipe.
3. Nail the edges of the flashing 2 inches on center.
4. Cover the edges of the flashing with roofing cement.

Double-coverage method

Follow these steps when you use the double-coverage method.

1. Cut lower layer of roll roofing to slip over the pipe.
2. Cut a sheet of mineral-surfaced roll roofing to slip over the pipe. Embed this sheet into a layer of roofing cement.
3. Install roofing cement around pipe on top of mineral-surfaced roll roofing and slip the vent-pipe flashing over the pipe.
4. Cover the flashing with roofing cement, cut the top layer of roll roofing to fit over the pipe and set in place.

Hips and ridges

Cut the sheets of roll roofing into 12 by 36 inch strips for the hips and ridges. Snap a reference line 5½ inches on each side of the hip or ridge centerline. Next, you need to apply roofing cement along the entire 5½ inch space on each side of the centerline. Bend the strips lengthwise and lay them over the hips and ridges.

One method we use to install the units is to:

1. Start at the hip; apply roofing cement within the lines.
2. Embed a strip into the cement and place two nails 5½ inches from the top.
3. Overlap the first strip at least 6 inches and repeat the above step.
4. Continue up to the ridge and install the ridge units in the same manner.

NOTE: Do not apply the roofing cement too thick or it may cause the roll roofing to blister.

Repairing rolled roofing

Many temporary or semi-permanent buildings use roll roofing as their primary waterproof covering. Although these buildings are only designed to last from 1– to 4- years, they may stay in the Air Force inventory much longer. You may find some “temporary buildings” that were constructed during

World War II. These buildings usually require only minor maintenance or repair to keep them leak proof (fig. 1–4)

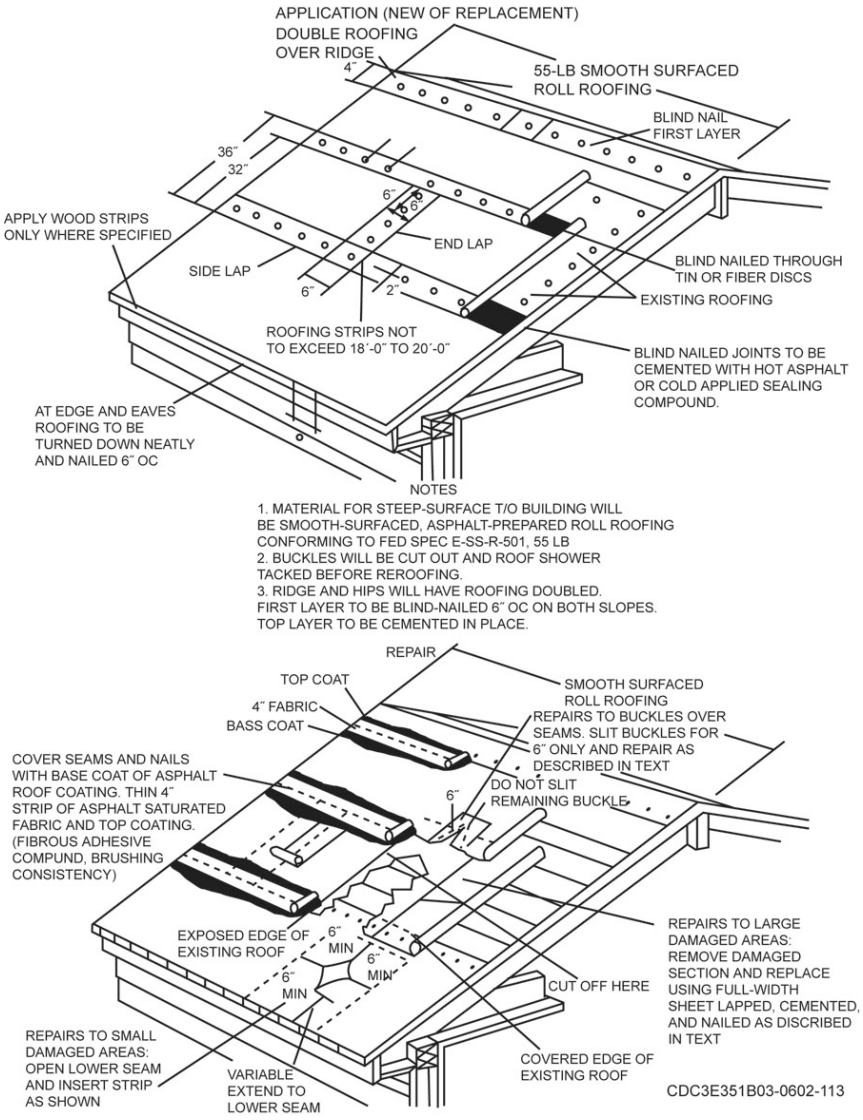

Figure 1–4.Rolled roofing repair methods.

You can repair small breaks and enlarged nail holes by applying plastic roofing cement and fiberglass mesh over the damaged area. To repair larger breaks, install new roofing material under the damaged area. To make a repair in roll roofing, perform the following steps:

1. Open the horizontal seam directly below the damaged area.
2. Insert strip of roll roofing.
3. Cut the repair strip so that it extends 6 inches beyond the edges of the break.
4. Coat the repair strip liberally with lap cement (bitumen) where it contacts the damaged area.
5. Insert the repair strip and press down the edges.
6. Nail around the break about ¾ inch from the edges and 2 inches apart.
7. Apply lap cement to the horizontal seam, press down firmly, and secure as the original seam was sealed (exposed or concealed).

Large area repair

When a considerable area has been damaged, but the main area remains intact, you can make repairs by removing the roofing from the damaged area and applying new rolled roofing that matches the original type. Apply full-width strips in the same manner as the original roofing.

After you have completed all other necessary repairs, repair any leaky seams. These leaks usually result from loose nails and fishmouths (upturned felt edges) or from inadequate lapping, nailing, or cementing. For leaky seams, the best repairs are made using asphalt saturated woven cotton fabric, woven glass fabric, or lightweight smooth-surfaced roll roofing cemented over the seam. Apply roofing cement to the seams approximately 6”- wide and embed a 4”- strip of fabric into the coating until it is smooth. Apply a second coat over the fabric until it is completely covered. Maintain the seams every two to three years.

Self-Test Questions

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

801. Built-up roof systems

1. What materials could you use as decking for a built-up roofing system?

2. What would you use a cant strip for?

3. What is roof insulation’s purpose? What materials are often used as roof insulation?

4. Would you mix coal tar and asphalt bitumen together or apply one over the other? Why?

5. What reliable test can you do to tell if a built-up roof is made from asphalt or coal tar?

6. Why do you add gravel-surfacing material to a built-up roof?

802. Single-ply roof systems

1. What is the common life expectancy of a single-ply roof?

2. List the three common vulcanized (cured) thermosets.

3. Which of the three vulcanized thermosets is *not* a good choice to use on top of dining facility?

4. List the three common non-vulcanized (uncured) thermosets.

5. List two thermoplastic materials that can be welded together with heat or solvent.

6. What is the first step in installing a single-ply roof membrane?

803. Composition roll roofing

1. On what type of construction would you use rolled roofing? Why?

2. How do you store roll roofing? Why?

3. How would you repair a large area of damaged roll roofing?

4. What usually causes leaks in rolled roofing seams?

1–2. Low-Slope Roof Inspection and Management

As with many things in life, a little tender loving care goes a long way. This holds true for roofs. The life expectancy of a typical roof is increased through periodic maintenance and repair. In this section, we discuss how to inspect low-slope roofs, and some repair methods for bituminous and single-ply membranes.

Periodic inspections are necessary to evaluate a roof's condition and show where maintenance or minor repair is needed. With a good inspection program, you can correct minor problems before they become major jobs. Without periodic inspections, the roof is neglected until it starts to leak and by then, it can cause serious damage to the structure or to sensitive electronic equipment. Even with a good inspection program, you still need to know how to make emergency repairs, as well as permanent repairs. Finding the leak source is often the hardest task that you face, so let us start with inspection procedures.

804. Inspecting and managing low-slope roofs

Every Civil Engineer Squadron has a roof maintenance program that meets base requirements. The primary way to make sure that these requirements are met is with periodic roof inspections. These inspections document a roof's condition and when the inspections were made. It can also show maintenance and repair frequency and costs for a particular roof. Most maintenance programs require a yearly inspection, but some special inspections may be needed after unusually severe weather (strong winds, hail, or heavy rain). You may be tasked to inspect a roof's current condition. In this lesson, we explain what you should look for.

Basic roof inspection guidance

Before making the actual inspection, consider the structure type (permanent or temporary), and the roof's type, age, and how many times it has been repaired. A good place to start your inspection is from the underside. Here is where you may find damage from leaks, deteriorated decking, structural cracks, movement, or defects. Next, examine the walls and parapets for deterioration, cracking, efflorescence, and water leaks. Now, move onto the roof and inspect the flashing carefully.

NOTE: Failed flashing causes most roof leaks. By using this basic roof inspection guide along with AFI 32–1051, *Roof Systems Management*, and any specific roof inspection guide that your base may have, you can make an accurate inspection.

Roof categories

To help determine inspection and maintenance requirements for roofs, all Air Force bases classify roofs into color-coded categories that include red, yellow, or green. (**NOTE:** Some roofs fall into more than one category. If a building has several modules or wings, the roof on one module or wing may be much older than the others and may require repair or replacement.)

Red category

Red category roofs have one or more of these conditions:

1. The roof's annual maintenance and repair costs consistently exceed 5-percent of its replacement cost.
2. Roof leaks persist despite maintenance and repair efforts.
3. Moisture or other elements have weakened the roof system or supporting structure to the point where it is unsafe.
4. The insulation has lost at least 20 percent of its original insulating ability because of moisture in the insulation core. Take a core sample and send it to a laboratory to confirm the amount of moisture. (**NOTE:** Some closed cell insulation can show reduced thermal resistance as it ages.) Make safety inspections on low-slope red category roofs at least annually. Check the drainage system and remove all debris from the roof to prevent water from excessively ponding and possible roof collapse. A detailed inspection is not necessary since these roofs are on the repair or replacement list.

Yellow category

Yellow category roofs are under a warranty, performance agreement, or some other contractual tie to a contractor or manufacturer. Inspect all yellow category roofs according to the warranty, guarantee, or performance agreement, but not less than once annually. Inspect these roofs as you do green category roofs (see below). At the very minimum, check the flashing, embedded metal, and ply laps in single-ply membranes. The warranty covers most leaks and defects in the membrane.

Green category

Green category roofs are all other serviceable roofs that base civil engineer (BCE) personnel maintain. Make a detailed inspection of all low-slope green category roofs in early spring, using the *Roofing Industry Educational Institute (RIEI) maintenance inspection checklist.*Here are some suggestions to help make the inspection safer and more complete:

1. Use at least two people for the inspection; inspecting roofs can be dangerous.
2. Be alert when you walk on the roof, and never back up without looking first.
3. If areas within a roof were installed at different times, group the areas according to age. Record the new areas on the roof plan.
4. Be careful not to damage the roof during the inspection. Specifically, do not step on blisters, kick base flashing, or step on edge flashing.
5. Mark the distress type, location, and extent on the roof using spray paint. Mark the roof plan with a pencil.
6. Use the definitions of typical roof construction and defects in the *RIEI Roofing Maintenance Manual* to point out a roof area.
7. Plot each deficiency on the roof plan and submit an AF Form 332, *BCE Work Request*. Figure 1–5 shows the standard roofing symbols.

Make a follow-up inspection in the late fall on all low-slope green category roofs. Discuss previously corrected problem areas with building managers to determine whether or not roofs are performing satisfactorily. Make sure the drainage system is free of debris. Follow-up inspections may not be necessary or practical in locations with short summers (such as Alaska).

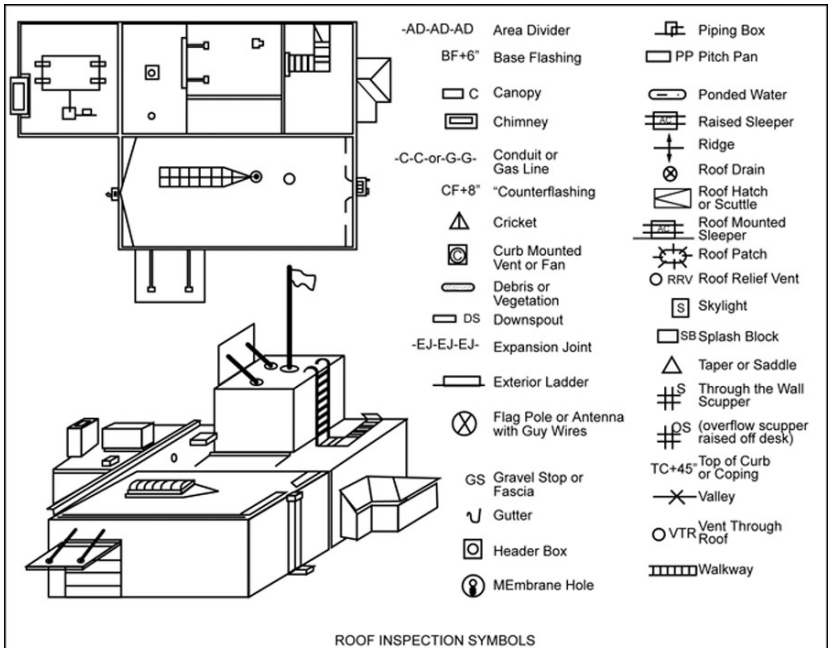

Figure 1–5. Roof inspection symbols.

Low-slope roof inspection

When inspecting low-slope roofs, you inspect certain parts of the roof; however, you look for different defects depending on the type membrane or application method. We cover some of the areas that you must inspect. For more information, refer to the RIEI *Maintenance of Membrane Roofing Systems* manual.

Field or roof

Look for signs of wear and tear. If the roof has an aggregate surface, you do not want to remove it to inspect the membrane. Look for membrane defects, backed out fasteners, loss of surfacing, water ponding and other signs of damage.

Base flashings

Base flashings are the terminations located at vertical surfaces. You should find them at curbs, walls and penetrations. Base flashings are subject to physical damage caused by differential movement or rooftop traffic. Seal these and secure them at the top and make sure they are properly adhered to the substrate or field membrane. Look for any voids and deteriorated or cracked material.

Edge metal flashing

Edge metal is used at the edge of the roofing system to terminate the roof and provide waterproof flashing at this junction. Look for missing fasteners or strip-in flashing. Check to see if metal flashing is corroded and if there are any splits. Also look for any open-end sections or missing sealants.

Cap flashing

Cap flashings are metal or other rigid coverings located at membrane terminations. These can include metal counterflashings, expansion joint covers and copings. Look for the same defects as we mentioned for edge metal flashing.

Penetrations

Penetrations are pipes, drains, and other items that penetrate the roof membrane. Inspect the following items:

1. Ensure the drain-clamping ring and drain strainer are properly secured.
2. Ensure pitch pockets have an adequate amount of fill material to prevent water from collecting in them.
3. Ensure the pipe boot flanges have a tight seal with the membrane.
4. Ensure the top of pipe boots are sealed around the pipe.

805. Built-up roof defects and repair procedures

There are a number of defects that plague a built-up roof. Your skill in identifying and correcting them could save thousands of dollars and add years to the roof's lifespan. This lesson covers the most common types of defects found on a built-up roof and describes common repair procedures to correct them.

Membrane defects

There are numerous defects that are associated with the membrane. We discuss eight of the more common defects in this lesson.

Bare areas

A BUR can have bare areas when the aggregate (usually gravel) was not bonded to the flood coat. Any loose gravel can be moved by wind or water to create bare spots. The gravel coating is needed to protect the bitumen and felts from exposure to ultraviolet radiation and deterioration. To repair the damage, you must first remove the aggregate, dirt, and debris so that you can repair any damage beneath it. Trim and discard any loose or curled felt. Apply cold-process recoating and re-embedded gravel to match the rest of the roof or prime it with asphalt primer and repour it with the appropriate hot bitumen for that slope and climate. If the bare spots are very small (such as on the crowns or ridges or the tops of blisters), prime them, apply roof mastic, and re-embed the loose gravel. Use the same steps for coal-tar roofing, except that you use tar-based products in place of asphalt and you usually do not need the primer.

Alligatoring

This pattern of cracks in the bitumen surface of a built-up roof looks something like an alligator's hide. The cracks may or may not extend through the bitumen. They are most pronounced in thick applications of exposed bitumen (such as where material has flowed out of laps in felt or in flashing applications). For light checking or crazing, clean the surface and remove thick bitumen deposits. Apply a thin asphalt primer coat (about a gallon per 10- foot by 10- foot area) and let it dry. Apply clay stabilizer asphalt emulsion, making sure you fill all fissures. For heavy checking or cracking (down to the membrane), clean the area and apply the primer and emulsion the same way. While the emulsion is still wet, embed resin- or bitumen-treated, porous, glass mat or glass fabric. Lap the fabric 2 inches, pressing gently to wet it thoroughly, and apply additional emulsion or primer as above. Do not add more hot asphalt to an alligatored roof surface; it just makes the cracking worse.

Eroded or abraded bituminous surfaces

These areas are characterized by foot traffic patterns, wind-scoured corners, water-washed bare spots, or deteriorated felt due to bitumen loss from chemical or physical attack. You can protect foot traffic patterns with asphalt planks or wood walkways. You may have to double-pour and double-gravel wind-scoured corners with hot bitumen. When you use coatings on restaurants, be sure to follow the manufacturer's instructions and always cover with gravel. You can reduce water washing by using splash pans to reduce the water's speed. Divert condensation from air-conditioners and other sources to drains or locate new drains to pick up the water.

Blisters

A blister is a spongy, raised roof membrane part (fig. 1–6), ranging from a barely detectable height to a much larger and more pronounced raised area. This condition is caused by pressure built up from moisture and air trapped in the membrane system. While most blisters are still watertight, they can be broken by foot traffic or hail. It is best to leave small, unbroken blisters alone; do not step on them or puncture them intentionally. When you must repair blisters, cut out the whole blister, clean and dry the surfaces, and apply bituminous primer with a brush to penetrate loose dust and promote adhesion. Then fill the depression with mastic and felt layers. On aggregate-surfaced roofs, it is important to remove all aggregate around the patch perimeter. An easy way to do this is to chip out the aggregate in cool weather or early in the morning, but repair the blister in the warm part of the day when the felt is ductile and less likely to be harmed by foot traffic.

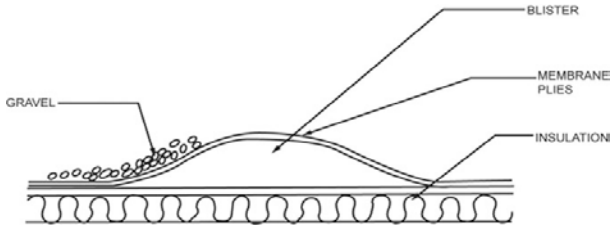

Figure 1–6. Membrane blister.

An acceptable warm-weather repair involves making an X-cut, peeling back the corners of the cut, letting the interior dry, then working mastic into the cavity. Finally, you pull the membrane "*ears*" back into place and tap them down until mastic completely fills the cavity and extrudes out of the cut edges. You can then patch the X-cut or apply new felts to cover the cut area completely. The problem with this technique is making sure that you have not left voids at the back edges of the ears, and that you have removed all water.

Splitting

Splits (fig. 1–7) provide a ready opening for water to quickly pass through the roof and into a facility. In cold-weather areas, leaks at splits and other penetrations may go unnoticed until thawing. Before you can make a satisfactory and permanent repair, you must evaluate the structural and roofing system condition and make an emergency repair. You can eliminate tension splits from contraction of poorly attached elements by driving fasteners through the roof membrane and insulation into the deck to re-secure the roof elements. You can use area dividers to control tension splits that start at equipment corners, curbs, and wall area projections.

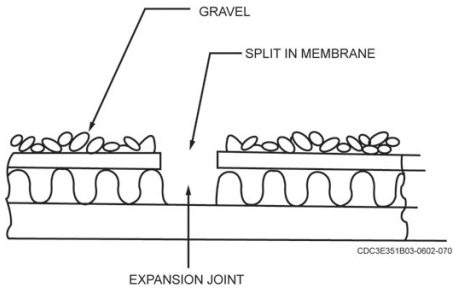

Figure 1–7. Membrane split.

Membrane slippage

You cannot repair the membrane to its original condition after it slips; you can only try to stop the slippage. One way to stabilize a slipping membrane is to strap it. If the felts run perpendicular to the slope, you can run rows of fasteners parallel to the slope and fasten them through strips of new roofing felt. Place the fastener rows 20-feet apart if the plies have slipped less than 6 inches and 10 feet apart for 12-inch slippage. Replace wrinkled felts that have slipped more than 12 inches. You may have to remove the wrinkled felt and all surfacing material, then lay a two-ply felt layer parallel to the slope and back nail it to prevent slippage.

Ridging

Ridges are narrow ripples in the membrane (fig. 1–8). If there is only one ridge, it might be best to cut it out and apply a multi-ply basic repair. To prevent weathering if ridges are numerous, clean and re-coat them with roof coating or mastic and aggregate (as required).

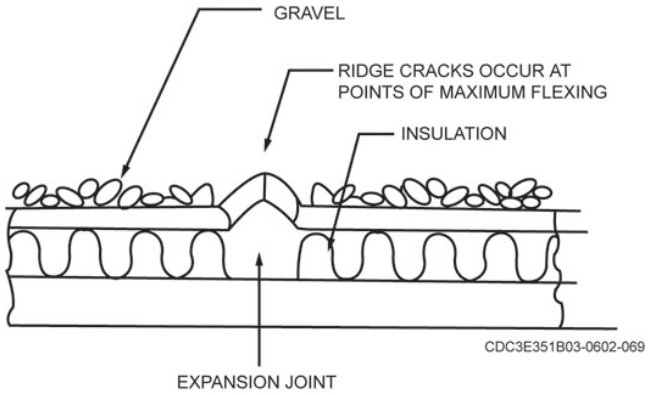

Figure 1–8. Ridging.

Penetrations

Penetrations are openings made through the roof's waterproof surface to accommodate vents and other roof-mounted equipment.

Flashing repairs

Since failed flashing is the most likely area for water leaks in a roof system, you need to know how to install it properly. Many times the flashing failed because it was not installed properly during the initial construction. You can prevent failure for many years with quality materials and good craftsmanship. As time passes, even the best flashing may need repair.

Bituminous base flashing

Always check the flashing to make sure it is supported and in contact with the cant strip and the wall (fig. 1–9). If the roof membrane is shrinking and pulling the flashing apart, it is under great tension. You can make a temporary repair by coating the puncture with plastic flashing cement, embedding a saturated felt or fabric strip, and then topcoating it with another plastic flashing cement coating.

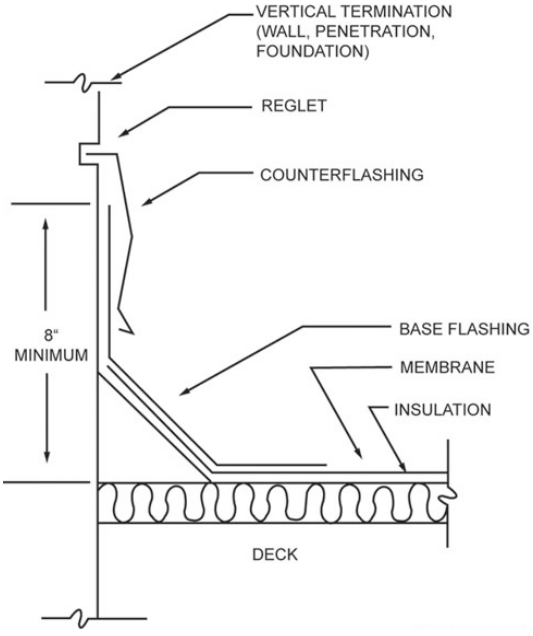

Figure 1–9. Vertical wall flashing.

Open laps

If vertical flashing laps are open, smooth them back in place, cement them in with plastic flashing cement, and coat the whole lap with plastic flashing cement. For permanent repairs, use heavy flashing cement to re-embed loose laps.

Buckled base flashing

Bend the metal out of the way (be careful not to damage it). Remove the aggregate and the membrane that covers the cant strip top and remove the base flashing from the wall. Nail the remaining membranes to the cant strip, and apply two-ply flashing secured with flashing cement.

Separated base flashing

If the base flashing separates from a wall or chimney, you can refasten it by nailing and cementing it to the wall. Then, you coat it with flashing cement before bending the counter flashing back into place. Once the flashing is installed, apply an aluminum roof coating over it.

Wall flashing

When the flashing becomes separated from a vertical wall, refasten it by nailing or cementing and then coat the area with plastic flashing cement. If the surface coating has disintegrated, brush off all loose coating and apply a trowel coat of asphalt or coal tar plastic cement like that used in the original coating. If the coating on a metal flashing has deteriorated, but the flashing is not severely damaged, remove all rust, moisture, loose scale, grease, and dirt and apply a fresh protective coating.

Vent flashing

The most common roof leaks near vents are seams broken by expansion and contraction, exposed nails working loose, standing water around the vent, and deteriorated flashing. Re-solder the broken seams and install more expansion joints, if needed. For separated flashing flanges and exposed nails caused by loose flashing, raise the flange just enough to force plastic flashing cement under it and re-drive the loose nails. Then cement two felt or fabric plies to each other and to the flange with asphalt, pitch, or plastic flashing cement. Extend the first ply's outer edge at least 3 inches beyond the flange, and extend the second ply at least 6 inches. Try to match the finished surface to the older roofing. If you suspect a leak because water is standing around a vent or it is staining the roof, remove all flashing and install new flashing. If the protective coating is missing and the flashing is deteriorating, remove all rust, moisture, loose scale, grease, and dirt before you add a new protective coating. If the metal is seriously deteriorated, install a new vent.

Metal base flashing

Using metal base flashing in built-up roofs is not recommended. If you happen to discover metal base flashing on a built-up roof, when feasible, replace it with bituminous flashing. When replacement is not feasible, make repairs.

Flashing flange exposed

When you discover exposed flange flashing, scrape the slag or gravel surfacing back about 8 inches beyond the flange edge. Now, remove the old felt stripping and re-nail the metal flashing back to its original position. Spread a bituminous plastic cement coat over the area to be repaired. Next, cut reinforced felt strips about 12 inches wide to the desired length and firmly embed them into the plastic cement covering the flange. Coat the felt stripping and the scraped area with aluminum pigmented coating and then broom the aggregate back to the new stripping edge while the coating is still wet.

Slightly deteriorated metal flashing

You can restore slightly deteriorated metal flashing. First, you must remove all rust, moisture, loose scale, grease, and dirt. Then, you can prime and paint the flashing.

Severely deteriorated flashing

When metal flashing has deteriorated to the extent that there are holes present, remove it and replace it with new flashing to prevent roof leaks. It is usually best to select flashing that matches the original type. In some instances, you can select replacement flashing that is better than the original type. For example, you can replace deteriorated galvanized metal flashing in a gravel-surfaced roof with a non-rusting metal such as copper or aluminum. If you are replacing membrane, provide cant strips and use bituminous base flashing rather than metal base flashing.

Counterflashing

Counter flashing is usually made from sheet metal and is installed into the masonry wall or chimney where it passes through the roof. When loose counter flashing is not damaged in any way, clean out the mortar joint and, if necessary, enlarge it. Now, replace the flashing to its original position and secure it with lead wedges. After you set the wedges, caulk the top of the flashing with construction grade caulking compound. Counter flashing that is placed either too high or too low loses effectiveness.

When repairs to a wall are needed, it is sometimes necessary for you to remove the counter flashing. When you reflash, follow the specifications for new roof construction.

Rooftop repair procedures

As hard as roof leaks are to find on a pitch roof, they are twice as hard to find on a built-up roof. Remember safety first in roof repair. Always have at least two people work together on any roof job. Before stepping onto the roof, you and your partner must check for fallen electrical lines or other dangerous situations. If the membrane cannot drain freely, water may back up into flashing, roof drain flanges, pitch pockets, or wall surfaces. Check the drains first; clear the strainers and remove any obstructions from clogged downspouts. Sometimes leaks are caused by punctures from wind-toppled equipment. Look for missing hatch covers, loose guy wires, broken branches, and any other clues to concealed punctures. Use brooms, squeegees, pumps, or siphons to remove standing water from the roof. Since shovels damage the roof surface, use them only to remove built-up snow that might damage the building. The usual areas that cause leaks are failed flashing. Look carefully around flashing where equipment (such as air-conditioning units) is mounted to the roof. After you find the leak, you are ready to make repairs.

Temporary repairs

Temporary repairs include emergency and wet weather repairs. All temporary repairs are considered "*stop-gap*" methods and must be replaced with permanent repairs as soon as weather conditions allow repairs. Emergency repairs normally require quick reaction time. Usually made under severe working conditions, they might involve electric shock hazards, water damage to sensitive equipment, loose roofing, weakened deck, downed tree limbs, and concerned occupants. Wind-torn roofing requires fast action to prevent more extensive damage. You can use batten strips, sandbags, concrete blocks, or any other suitable material that you can apply safely. On nailable decks, you can fasten wood batten strips directly through the membrane. You might have to use tarps or other covers to seal areas where the membrane has been lost. Because reaction time is so important, your shop must have adequate supplies for such emergencies.

Wet condition repairs

Wet condition repairs are also made under hurry-up situations and are regarded as temporary only. Dry out the surface as much as possible; even "*wet-patch*" materials work better with less water.

Permanent repairs

Permanent repairs must make the roof watertight and roughly equal the existing expected service life. They are often just "*patches*" on the existing roofing system. The decision to repair a roof must include evaluating the roof's overall condition and age, or the repairs may deal only with effects or symptoms, rather than with their causes.

Superimposing

Superimposing means that you place a new roof directly over the old roof. This alternative involves considerable risk. Consider it only when the insulation is dry, the roofing components are well attached to each other and to the roof deck, the membrane surface is basically intact, and the roof frame and structure can carry the added weight safely. The superimposing risks on a given roof are sometimes hard to identify. There is always some expense involved in preparing the existing roof, and some defect, such as nonattachment or moisture, may affect the new roof adversely. The benefits are generally easier to spot. Superimposing increases the watertight integrity, it usually takes less time than removal and replacement, it retains the present insulation's thermal resistance value, and you can add more insulation if you need to.

Removal and replacement

Removing and replacing a roof is the most reliable way to stop water leaks. On the negative side, it is risky in that you expose the building and its contents during the removal, the construction takes longer, and you might lose the existing insulation's thermal value during the replacement. The debris, dust, and tear-off noise can seriously affect the building's internal operations. You also risk damage to the deck- and roof-mounted equipment. Perhaps the greatest challenge is working at an elevated height under windy conditions. On the positive side, the exposed roof deck lets you inspect for damage and defects closely. You can eliminate defects and moisture within the existing roof insulation or membrane, and you can add new insulation to have a roof that provides years of trouble free service.

806. Repairing single-ply membranes

The first step in repairing a single-ply roof is to determine what type of roofing membrane it is. In a perfect world, you can check the installation documentation to determine the exact type of roofing system; however, this is not always the case. In this lesson, we describe how to distinguish between certain membranes and cover the most common single-ply membrane repair procedures.

Identification procedures

Many of the single-ply thermoset/thermoplastic systems look very much alike. Some manufacturers of single-ply membranes emboss their trademark on the membrane. As well, there may be printed labels visible on the membrane. If these identification methods fail, you can use the procedure described below to determine the type of membrane and, consequently, the appropriate repair procedure. Unfortunately, with the development of new systems, this procedure is not foolproof; however, it is relatively accurate.

Membrane sampling

You need a sample piece of membrane to begin the identification process. Cut out an 8-to 10-inch square piece of roof membrane near the defect. This allows you to check the substrate for signs of water damage and repair the whole area with a single patch.

Carry out the following tests on the sample membrane:

1. Is membrane rubber-like? Try to stretch the membrane. Does it stretch easily and snap back when released? If reinforced, does it bend easily? If either answer is YES, skip to number 5. If the answer is NO, go to test 2.
2. Is membrane very stiff and nonflexible? Try to fold the sample. Is the membrane difficult to bend, do cracks appear on the surface, or does the membrane snap when folded? If the answer is YES, the membrane is probably PVC that has lost the plasticizers. Use the PVC repair method. If the answer is NO, go to test 3.
3. Is membrane soluble in xylene? Scrub the sample with a stainless steel scouring pad and xylene solvent using a vigorous circular motion (the xylene solvent must be from a tightly sealed container). Does the membrane begin to dissolve and become tacky? If the answer is YES, the membrane is CSPE. Use the CSPE repair method. If the answer is NO, go to test 4.

4. Is membrane soluble in Tetrahydrofuran (THF)? Wipe the sample with a cotton rag and THF solvent. Does the membrane begin to dissolve and become tacky? If the answer is YES, the membrane is PVC or CPE. Use either the PVC or CPE repair method. Note that PVC can be repaired with CPE and vice versa. If the answer is NO, the membrane type is unknown. Use any repair method that works and refer to Maintenance Engineering for a roof assessment and/or replacement.
5. Is the membrane white with a fleece backing? If the answer is YES, the membrane is PIB. Use the PIB repair method. If the answer is NO, the membrane is either EPDM or Neoprene. Use the EPDM repair method.

NOTE: Some types of EPDM are available with a fleece backing.

Materials required

Repairing single-ply roofing systems requires some materials and tools that may not be in the typical toolbox. Obtain these items beforehand and store them together so they are readily available when a repair is needed. Keep a stock of expendable supplies (e.g., solvents and cleaners) on hand.

The following items are needed for single-ply membrane roofing repairs.

- Clean all-cotton rags (do not use any synthetic materials).
- General purpose spray cleaner.
- Household scouring powder.
- Stiff natural bristle scrub brush.
- Wire brush (stainless steel).
- Metal or plastic pail.
- Several stainless steel scouring pads.
- Several 3” wide (approximately) natural bristle paint brushes.
- Sharp scissors.
- Blunt screwdriver or other probe to check integrity of seams.
- Solvents (xylene, tetrahydrofuran, and toluene).
- Solvent-resistant gloves.
- Several small hard-surfaced rollers (metal and rubber-covered metal, 1– to 2- in. wide).
- Seaming adhesives and seaming tapes.
- Hot air gun and electric extension cord (100 ft).
- Sealants.
- Sandbag (for weighting down patches).

CAUTION: Solvents and adhesives may be toxic. Refer to cautionary statements on containers and material safety data sheets for proper protective measures, use, and storage.

Emergency repairs

The best time to prepare for emergency repairs is before they occur. To do this, keep a supply of basic repair materials on hand. You might also consider special leak-plugging chemicals such as expanding bentonite clay.

Emergencies, by definition, require quick action, usually in adverse weather conditions. Severe weather conditions lead to a dangerous work environment, both on the roof, as well as inside. Electricity and water are a hazardous combination. Protect occupants by closing-off areas that are endangered or shut off electrical service, if necessary.

Occasionally, a single-ply roofing system needs an emergency repair. The purpose would be simply to seal the roof until a permanent repair can be made. Make a permanent repair to replace an emergency repair within *one* week. To complete an emergency repair, use the following steps:

1. Use a broom or stiff brush to sweep any debris away from the area to be repaired.
2. Dry the area as much as possible.
3. Cut a patch of any available roofing membrane 10- to 12- in. larger in each direction than the damaged area.
4. Apply a 4”- to 6”- band of wet/dry roofing mastic around the damaged area. Apply it so all edges of the patch are embedded in mastic. Take care not to get any mastic on the substrate (insulation or roof deck).
5. Embed the patch firmly in the mastic.
6. Spread mastic on the edges of the patch.

Long-term exposure to roofing mastic can damage many single-ply roofing systems. Make sure to remove all traces of the roofing mastic when you make the permanent repair. Normally, you must cut out all areas to which you applied the roofing mastic before you make the permanent repair.

Permanent repairs

Make permanent repairs as soon as weather conditions permit. The following are suggested repair methods. Refer to the membrane manufacturer for specific repair criteria—if available.

Chlorinated Polyethylene (CPE)

CPE membranes do not vulcanize or cure when exposed to the weather. You can solvent- or heat-weld a CPE membrane that has been in place for many years without worrying about poor adhesion to the existing membrane. Except for preliminary cleaning to remove environmental dirt, patching an existing CPE membrane is the same as seaming a brand new membrane.

Repair procedures are as follows:

1. Clean the area to be repaired with a general purpose cleaner.
2. Scrub the membrane thoroughly with a stiff-bristled brush to loosen surface contamination.
3. Wipe up the residue with a clean wet cotton rag, rinsing the rag frequently.
4. Dry the area thoroughly with a clean dry cotton rag.
5. Cut a patch from a roll of new CPE material, rounding all corners. Make the patch approximately 4 inches larger in both dimensions than the defect being repaired. Clean the back of the patch using the same procedure you used to clean the roof membrane.
6. Using a hot air gun, tack a strip along the center of the patch to hold it in place.
7. Start at the center of the patch and weld it to the roof using a rubber-faced roller and a hot air gun.
8. Continue welding the patch, working from the center to the edges to avoid wrinkling the patch.
9. To complete the repair, apply a bead of lap sealant around the edges of the patch to keep water from leaking into the reinforcing seam.

Ethylene propylene diene monomer (EPDM)

You must use either contact adhesives or seaming tape to make repairs to vulcanized thermosets, such as EPDM. We discuss both of these methods.

Contact adhesive repair method

1. Clean the existing membrane using a scrub brush or a plastic scouring pad with a household scouring powder. It may be necessary to rinse the membrane and repeat the cleaning process several times to ensure that the membrane is clean.

2. Rinse the surface with clean water to remove the detergent residue. It is important that you wipe the membrane clean.
3. Let the membrane air-dry before continuing.
4. After the membrane is completely dry, clean it again with splice cleaner.
5. Cut a patch from new EPDM, making sure the corners are rounded and the patch is approximately 4 inches larger than the defect area. Clean the back of the patch with splice cleaner (although the patch is cut from new material, it is often coated with talc and other residue that you must clean to achieve a proper bond).
6. After the splice cleaner on the patch completely dries, apply splicing cement evenly to the patch using a roller or brush (an adhesive primer is sometimes applied first). It is important that you spread the splicing cement evenly. If you do not apply the cement evenly, the thicker areas will not dry as fast as the thinner areas and the patch might not bond completely.
7. Apply splicing cement evenly to the existing roof membrane.
8. Let the patch and the membrane dry until tacky.
9. When both surfaces are tacky, lift the patch and prepare to place it.
10. Carefully align the patch over the area where you applied the splicing cement to the roof membrane, but do not put the patch down.
11. Place one end of the patch on the roof while holding up the other end of the patch.
12. Begin working the patch down by hand while continuing to hold the opposite end up. This process helps prevent wrinkling or trapping air under the patch.
13. Smooth the patch down with hand pressure to ensure that the patch is adhered to the existing membrane. Roll the entire patch with a metal roller.
14. Clean the edge of the patch and the adjacent membrane surfaces with splice cleaner. After the splice cleaner dries, apply a bead of lap sealant at the seam edge to complete the repair.

Seaming tape repair method

1. Clean the existing membrane using a scrub brush or a plastic scouring pad with a household scouring powder. It may be necessary to rinse the membrane and repeat the cleaning process several times to make sure that the membrane is clean.
2. Rinse the surface with clean water to remove the detergent residue. It is important that you wipe the membrane clean.
3. Let the membrane air-dry before continuing.
4. After the membrane is completely dry, clean it again with splice cleaner.
5. Cut a patch from new EPDM, making sure the corners are rounded and the patch is approximately 4 inches larger than the defect area. Clean the back of the patch with splice cleaner (although the patch is cut from new material, it is often coated with talc and other residue that you must clean to achieve a proper bond).
6. Apply strips of seaming tape about ½”-longer than the edges of the patch. The tape should overhang the edges of the patch.
7. Fold back the release paper on the first two strips of tape and apply the remaining strips to the other two edges of the patch. Once again, the tape should be about ½”- longer than the patch and positioned so that it overhangs the edges.
8. Apply seaming tape diagonally across the center of the patch. Use hand pressure to be sure all pieces of seaming tape are well adhered.
9. With all release paper still attached, position the patch on the roof over the area to be repaired. Fold back one edge of the patch and remove the release paper from that edge. Carefully attach that edge to the roof, rolling it in so air bubbles are not trapped. Fold back the rest of the patch and remove the rest of the release paper. Carefully roll the patch back

down onto the roof, working from the adhered edge towards the opposite edge to avoid trapping air bubbles.

10. Apply firm pressure to the entire patch with a small steel roller. Complete the repair by applying a bead of lap sealant around the patch.

Chlorosulfonated Polyethylene (CSPE)

During production before the membrane cures, the seams are heat-or solvent-welded. After it cures, adhesive or heat/solvent are needed to seal seams or make repairs. Because cross-linking occurs as the membrane cures, a successful repair depends on proper preparation of the existing roof membrane. The recommended procedure requires that you first clean the membrane with xylene and a scouring pad—this removes the membrane's surface cure. Then, adhere the patch with seaming adhesive. If seaming adhesive is not available, an alternate procedure is simply heat-welding the patch to the roof after you remove the surface cure from the roof membrane. We do not describe this procedure because it is usually not successful if the CSPE membrane has been exposed on the roof for more than *one* year.

Seaming adhesive repair method

1. Clean the area to be repaired using a clean cotton rag soaked in xylene. (**NOTE:** Do not use detergent and water to clean the membrane, use only xylene.)
2. If the membrane to be repaired is anything but brand new, its top surface will have cured from exposure to the elements. Remove this cured layer using a stainless steel scouring pad and xylene.
3. Dip the scouring pad in xylene and scrub the membrane, using firm pressure and a circular motion. The slightly rough surface will become smoother as the surface cure is removed and forms "*crumbs*."
4. It may be necessary to rewet the scouring pad once or twice before the entire surface cure is removed. A properly prepared surface will be quite tacky. Use a clean cotton rag dampened with xylene to remove all surface cure "*crumbs*" and any other debris.
5. Cut a patch from new CSPE material 4"- larger than the defect to be covered and round all the corners. Liberally apply xylene to the back of the patch using a clean cotton rag soaked in xylene to activate the patch. If you are working on the roof, use a sheet of cardboard to protect the existing membrane from the solvent. (**NOTE:** The xylene should begin to dissolve the black CSPE on the underside of the patch. This is evident if you are using a white rag.)
6. If you are making the repair during cold weather, use a hot air gun to warm the roof surface before applying the adhesive. Use a paintbrush to apply a liberal coat of seaming adhesive to the roof membrane. The seaming adhesive is not contact cement; it is Hypalon dissolved in xylene.
7. Lay the patch in place over the defect. The adhesive allows you to reposition the patch, if necessary.
8. Roll the patch vigorously with a small hard-surfaced roller to set it and to remove trapped air bubbles.
9. Thoroughly coat the edges of the patch with seaming adhesive or CSPE-compatible seam caulk. This step is required if the patch has a reinforcing scrim, and optional (but still recommended) if the patch is unreinforced.

NOTE: The patch does not achieve full strength until all of the xylene evaporates from the adhesive. The patch is weather tight within minutes, but allow at least 24- hours before you probe the edges of the patch for unadhered areas.

Polyvinyl chloride (PVC)

This category includes thermoplastic alloys, thermoplastics, and other materials with similar descriptions such as copolymers and interpolymers.

Thermoplastic materials are modified with heat. They soften when heated and harden when cooled. Temperatures outside the range of normal conditions are required to soften the material. Heat or solvent welding forms the seams. The seams will melt when exposed to flame but will not burn or support combustion.

PVC repair techniques are basically the same as for applying a new fully adhered system, except that you must thoroughly clean the existing roof membrane before you begin the process. Cut the patch from new PVC membrane and heat- or solvent-weld it to the existing roof. Protect the edge of the patch with lap sealant just as you would any field joint in a new application, unless the manufacturer specifically states otherwise.

Solvent repair method

1. Clean the area to be repaired using clean rags and a general-purpose spray cleaner or methylethyl-ketone (MEK).
2. Use a clean wet rag to rinse away all cleaning residue. The membrane should be close to its original color after cleaning.
3. Cut a PVC patch with rounded corners that is at least 4”- larger than the damaged area.
4. Lay the patch over the damaged area and apply tetrahydrofuran (THF) welding solvent to both surfaces simultaneously using a paintbrush. Store the solvent in a tightly sealed bottle or it will absorb moisture and become useless. Work the brush filled with solvent all around under the patch to ensure adhesion.
5. Weigh the patch with a sandbag to promote adhesion.
6. Remove the sandbag after about 5- minutes and check the patch carefully for lack of adhesion.
7. Use a hot air gun to weld any unadhered areas. Keep the hot air gun moving to avoid scorching or excessively melting the membrane.
8. Use a small metal roller in conjunction with the hot air gun to secure the patch.
9. Apply lap sealant around the patch edges to complete the repair.

Heat welding repair method

1. Clean the area to be repaired using clean white all-cotton rags and a general-purpose spray cleaner or methyl-ethyl-ketone (MEK). Repeat if necessary.
2. Use a clean wet rag to wipe away all residues from the defect area.
3. Cut a PVC patch with rounded corners that is at least 4”- larger than the damaged area.
4. Lay the patch over the damaged area and use a hot air gun to weld the patch to the membrane. Start at the center and work towards the outer edge to avoid trapping air under the patch. Be sure to keep the hot air gun moving to avoid scorching or excessively melting the membrane/patch.
5. Use a small metal roller in conjunction with the hot air gun to secure the patch.
6. Probe the patch edges for any unadhered areas. If you find any, use the hot air gun and roller to adhere the area.
7. Apply lap sealant around the patch edges to complete the repair.

Polyisobutylene (PIB)

You can use any one of the repair techniques mentioned below on PIB membranes, depending on the materials available and the size of the defect to be repaired. To repair small defects, use 5”- wide cover tape. For repairing large defects, fleece-backed flashing membrane with a double-sealing edge is available. For even larger defects, you can use a piece of unreinforced flashing (the edges of which are sealed to the roof with sealing tape); however, we do not describe this method. Use a solvent-welded PIB patch to cover any size defect.

Five-inch wide cover tape repair method

1. Clean the PIB with abrasive cleanser and water to remove surface dirt. Once you remove the surface dirt, wipe the PIB membrane with a rag soaked with toluene solvent.
2. Wipe the membrane with toluene again.
3. Cut a piece of PIB self-adhering repair tape long enough to extend well beyond the defect ends. Round the tape corners. Remove the backing paper from the patch and lay one end on the membrane. Work the patch down carefully with a small steel roller, starting at one end and working towards the other to avoid trapping air bubbles under the patch.
4. After you thoroughly roll out the patch, check around its perimeter to be sure it is bonded to the roof membrane.
5. If portions are not bonded, use a clean rag or paintbrush to reapply solvent between the two surfaces.
6. Use the steel roller to apply pressure and bond the two surfaces together.

Fleece-backed flashing membrane with a double-sealing edge repair method

1. Cut a strip of the flashing membrane 4”- larger than the defect. Use household scouring powder and water to clean surface dirt from the defect area. Let the area dry, and use toluene solvent to clean the area where the patch sides are to adhere.
2. Remove the backing paper from one edge of the patch. Carefully place this edge on the cleaned roof membrane, working it down from one end to the other to avoid wrinkles and trapped air bubbles.
3. Roll the edge with a small steel roller to bond the patch to the existing membrane. Repeat the same procedure on the opposite side of the patch.
4. After the two parallel sides of the patch are sealed to the existing membrane, you must seal the two ends of the patch. Cut a piece of 5”- wide cover tape long enough to extend about 3”- past the edges of the patch. Round the corners of the cover tape.
5. Clean the end of the patch and the existing membrane with toluene solvent thoroughly extending well beyond the area to be covered by the cover tape.
6. Apply a lap sealant bead near the flashing membrane’s adhered side’s ends so that when you apply the cover tape, the inside seam created by one patch lapping over the other will be sealed.
7. Remove the backing paper from the cover tape and place one end down carefully over the patch end.
8. Work the tape down, smoothing it out from one end to the other to avoid trapping air.
9. Roll the patch thoroughly with a small steel roller. Repeat this same procedure at the other end of the patch to complete the repair.

Solvent welding repair method

1. Thoroughly clean the surface to be repaired with a stiff-bristled brush and general-purpose spray cleaner.
2. Wipe up the cleaning residue with a wet rag. Rinse the rag frequently.

3. Dry the surface with a clean dry rag. Make sure the surface is completely dry before continuing.
4. Using a paintbrush, apply a liberal coat of welding solvent to the cleaned roof membrane.
5. Using a circular brushing motion, work the solvent into the surface of the membrane.
6. Cut a patch from unreinforced flashing material at least 4”- larger than the defect being repaired. Round the corners. Apply a liberal coat of welding solvent to the back of the patch. **NOTE:** If the back of the patch is dirty, clean it using the same procedure you used on the roof membrane.
7. Work the solvent into the patch using a circular motion.
8. Lay the patch in place on the roof membrane.
9. Roll the patch in place using a steel roller. Use firm pressure to make sure the patch is well adhered.

Neoprene

The repair procedure for a neoprene roofing membrane is similar to the initial installation procedure. The only difference is that you must clean the weathered membrane before repairing. Use contact adhesives, rather than solvent- or hot air-welding, to join cured neoprene to itself. The repair technique is the same as that for EPDM. You can also cover a defect area using uncured neoprene and polyester scrim.

Self-Test Questions

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

804. Inspecting and managing low-slope roofs

1. What is needed to evaluate a roof’s condition and to show where maintenance or minor repair is needed?

2. Where is a good place to start the actual roof inspection? What should you be looking for?

3. List four reasons to list a roof in the red category.

4. When is a green category roof to be inspected?

5. During an inspection, how do you group roof areas that were installed at different times?

805. Built-up roof defects and repair procedures

1. Match each roof surface condition or defect in column B with a built-up roof phrase in column A. Use each selection only once.

Column A	*Column B*
____(1) Aggregate movement that is not properly bonded to the flood coat.	a. Blisters.
____(2) Provides a ready opening for water.	b. Bare areas.
____(3) Cracks in the bitumen surface.	c. Alligatoring.
____(4) Spongy raised roof membrane.	d. Eroded bituminous surfaces.
____(5) Bitumen loss from traffic patterns or water-washed bare spots.	e. Splitting.
____(6) Membrane cannot be repaired to the original condition.	f. Membrane slippage.
____(7) Openings made through the waterproofing surface of a roof.	g. Ridging.
____(8) Narrow ripples in the membrane.	h. Penetrations.

2. How do you repair vertical open laps in a flashing on a built-up roof?

3. How do you repair base flashing that is separating from the wall on a built-up roof?

4. What type material is not recommended for built-up roof flashing?

5. If replacement is not feasible, how do you repair a metal flashing that is slightly deteriorated? severely deteriorated?

6. From what material is counter flashing usually made? Where is it installed?

7. What severe working conditions might an emergency repair involve?

8. What materials can you use to make emergency repairs to wind torn roofing?

9. When do we consider superimposing a built-up roof repair method?

10. What are the advantages and disadvantages of repairing a built-up roofing system by removal and replacement?

806. Repairing single-ply membranes

1. What would be your first step before repairing a single-ply roof?

2. How soon must a permanent repair replace an emergency repair?

3. When do you make permanent repairs?

4. What is the most important factor for a good repair on all single-ply membranes?

5. Why do we use a small roller on all single-ply membrane repairs?

1–3. Steep-Slope Roofing Systems

In this section, we discuss the installation and repair of composition asphalt shingles. We also cover some basic repair techniques for other types of roofing materials. As a structural journeyman, you may encounter one or more of these type-roofing systems during your career in the Air Force.

807. Installing composition asphalt shingles

One of the most common roof coverings used on residential buildings is asphalt shingles. In this lesson, we discuss the types of shingles, and the installation and repair methods.

Types of shingles

The two most common types of composition asphalt shingles are organic and fiberglass. They are available in different colors and shapes. They come in strip form or as individual shingles and are made similar to the way that rolled roofing is made. Each type has certain characteristics for particular applications. We start with what makes them different.

Organic

Organic shingles are made from an asphalt-saturated roofing felt that is coated on both sides with asphalt and surfaced with mineral granules. The normal life expectancy is 15- to 20- years.

Fiberglass

As the name implies, fiberglass shingles have a base mat that is fiberglass. The mat is saturated and covered with flexible asphalt and surfaced with mineral granules. Fiberglass shingles weigh less and are thinner than organic shingles. They also contain more asphalt than organic-based asphalt shingles. The life expectancy for these shingles is typically 20- to 30- years. However, many manufacturers are now offering 40- to 50- year warranties on their products.

Strip shingles

The 3-tab strip shingle is the most common shingle on the market today. It is a 12-inch by 36-inch strip (fig. 1–10), with the exposed surface cut or scored to resemble three 6- inch by 12-inch shingles. They are usually laid with 5 inches exposed to the weather.

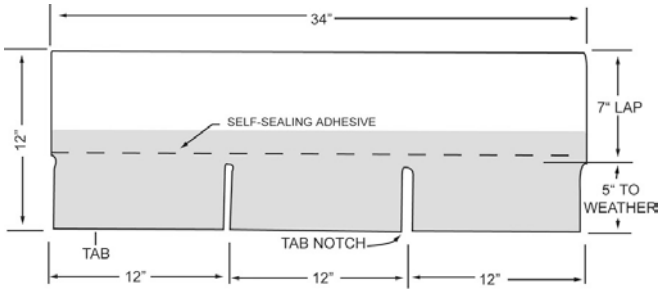

Figure 1–10. 12-inch by 36-inch shingle.

Strip shingle thickness may be uniform throughout or, as with laminated shingles, notched at the butts to give the illusion of individual units. Strip shingles are produced with either straight-tab or random-tab design to give an individual unit illusion or to simulate wood shakes. Most strip shingles have factory-applied adhesive spaced at intervals along the concealed strip portion. These adhesive strips are activated by heat from the sun and hold the shingles firm through wind, rain, and snow. Most strip shingles are laid over a single thickness of asphalt-saturated felt on roofs sloped 4:12 or greater. Under certain installation methods, you can apply strip shingles to decks that are sloped as low as 2:12; however, special underlayment construction procedures are necessary. For the rest of this lesson, we limit our discussion to 3-tab strip shingles.

Shingle installation

When roofing materials are delivered to the building site, handle them with care and protect them from damage. Try to avoid handling asphalt shingles in extreme heat or cold. They are sold in one-third-square bundles (33 ⅓- square feet) with 27- strip shingles per bundle. Store bundles flat so the strips do not curl after the bundles are opened. To get the best performance from any roofing material, always read the manufacturer's directions and install as directed.

Drip edge

Install metal drip edge along the roof's perimeter at the rakes and eaves (fig. 1–11). You must install the drip edge under the felt (underlayment) at the eaves and over the felt at the rakes. Nail the drip edge 8 to 10 inches on center and lap the end joints at least 3 inches. Reduce the spacing to 4 inches on center in areas prone to high winds. Here are the suggested installation steps:

1. Install the drip edge to the eaves, allowing it to overhang the ends 4 to 6 inches.
2. Make an angle cut at the top and fold the drip edge up the rakes.
3. Install roofing cement between the metal folds.

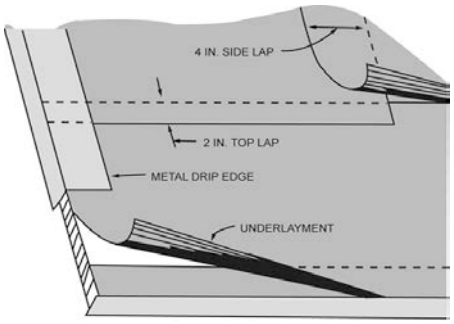

Figure 1–11. Drip edge.

Underlayment

Begin installing the underlayment in any valleys before doing the main area (make the underlayment in the valley extend at least 6 inches beyond the ridge and cut it so it lays flat). Place nails 24 inches on center in rows using 1⅝-inch diameter roofing caps for better holding power. Use galvanized roofing nails that are at least ¾ inch long or long enough to penetrate the roof sheathing.

Begin installing the felt parallel to the eaves. Allow at least ⅜ inch overhang over the drip edge to help prevent water from getting underneath the drip edge. Begin by nailing the felt 3 to 4 feet on center. Then, once the first row is in place, nail in rows—12 to 18 inches on center along the edges and 18 to 24 inches on center throughout the field. Nail all end laps 6 to 8 inches on center. Overlap all felt on the ridge, hip or valley at least 6 inches and extend 3 to 4 inches up any vertical surfaces.

NOTE: For single coverage, use a 2-inch-top lap and a 4-inch-side lap.

Shingle layout

There are various ways to layout shingles. It all depends on personal preference. Once you determine the exposure and pattern desired, snap reference lines. The required exposure determines where you

snap the horizontal reference lines. For example, snap lines every 5 or 10 inches if you are using a 5-inch exposure. Snap the first line at 11¾ inches (if you're using a ¼-inch overhang) for 12-inch wide shingles. Then snap succeeding lines 5 inches apart. (**NOTE:** You can snap the lines in multiples of 5 to save time.)

The desired pattern determines the location of the vertical lines. Three-tab strip shingles are manufactured in one of three ways—4-, 5- and 6-inch patterns. The vertical joints are broken into thirds with the 4-inch pattern; the 5-inch pattern creates random joints; and the 6-inch pattern divides the vertical joints into halves. Once you determine the pattern, snap vertical chalklines. For example, if you're using the 6-inch pattern, snap two vertical chalklines 6 inches apart. This serves as a reference point when starting the courses; you must alternate lines every course (fig. 1–12).

Starter course (strip)

As with most jobs, there is more than one way to do them—this is no exception. On gable roofs, you can begin installation at either end or start at the center and work both ways. If you can view both ends of the roof at the same time, it is a good idea to start in the center; however, there is no set rule.

Begin installing the shingles at the eave with the starter strip (starter course) (fig. 1–12). Its function is to provide a mineral surface for the space between the first shingle course. There are two methods:

1. Install a strip of mineral-surfaced roofing that is 9 inches or wider along the eave. Match it to the shingles' weight and color (starter strip).
2. Cut off the shingle tabs and install the remaining shingle with the factory-applied sealing strip along the eave (starter course). Cut about 3 inches from the length of the first starter course shingle. This keeps the end joints from lining with the shingles placed above it. Be sure to install the starter course with the appropriate overhang over the drip edge—¼ inch to ⅜ inch. Most shingle manufacturers recommend this method.

NOTE: Many roofers use the second method; however, instead of cutting the tabs off, they simply rotate the shingle to where the tabs are facing up. Place dabs of roofing cement to bond the shingle tabs to the starter course (strip), if you use this method (or roll roofing),

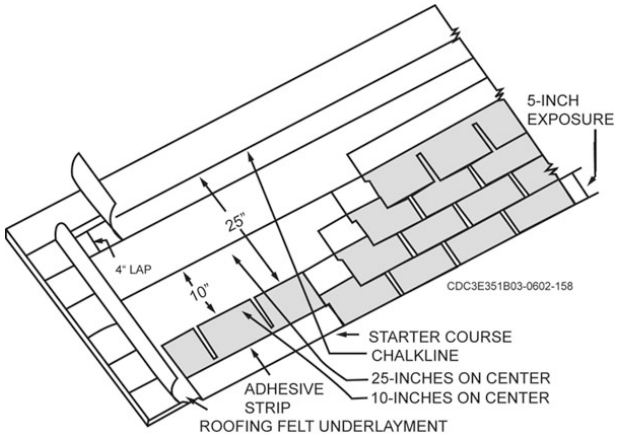

Figure 1–12. Laying out a shingle roof.

NOTE: New on the market are starter course shingles and starter course rolls. Each is about 7 inches wide and has a factory-applied sealant installed along the edge. This saves the time needed for cutting off the tabs or applying dabs of roofing cement.

Shingle courses

Once the starter course (strip) is in place, you can begin installing the shingles. Start installing the first course based on your vertical reference line. Lay the next course to the other vertical reference line. Continue installing the courses all the way to the ridge.

Valleys

You may have to shingle a valley. If so, there are three methods:

1. Open valley.
2. Closed-cut valley.
3. Woven valley.

The most popular method used is the closed-cut valley, sometimes referred to as a California cut. This method is easier and faster than the other two. To use this method, you:

1. Install the shingles in each course along one side of the valley, being sure that they extend at least 12 inches across the center of the valley. The end joints must be at least 10 inches from the centerline of the valley.
2. Secure the end of each shingle that crosses the valley with two nails.
3. Install shingles from the other side working towards the valley.
4. Snap a chalkline two inches from the valley centerline and cut the shingles to this line.
5. Cut 1– inch from the upper corner of the last shingle in each course at a 45° angle. This aids in deflecting any moisture that may get under the shingle.
6. Apply a 3-inch strip of roofing cement under the cut ends of the shingles and seal them in place.

Vertical surface flashing

On many roofs, you may have to flash around a vertical surface such as a chimney or adjoining wall. To help you understand the concept behind this, we discuss one way to flash around a chimney (fig. 1–13).

1. Install shingles up to the bottom edge of the chimney.
2. Install base flashing on the lower part of the chimney. Place it on top of the shingles, overlapping the shingles at least 4 inches and extending up the chimney at least 12 inches. **NOTE:** Set the flashing into a bed of flashing cement. You may have to prime the chimney before you apply the cement. You only have to install a few nails (in the mortar joints) just to hold the flashing in place until the cement sets.
3. Install step flashing on the sides.
4. Install rear base flashing at the bottom of the chimney. Extend it 6 inches up the chimney and 6 inches onto the shingles. Set this piece the same as the lower base flashing.

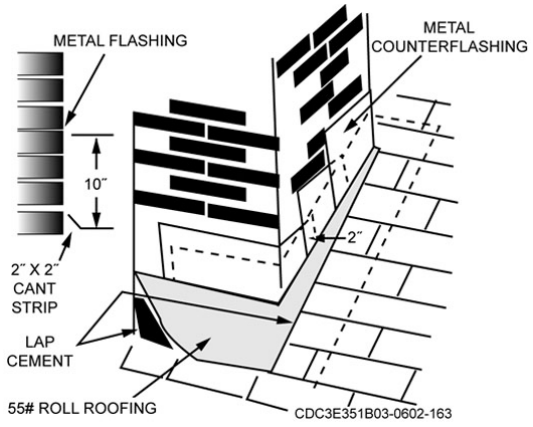

Figure 1–13. Flashing around a chimney.

Although not used on many residential homes, step flashing is the correct type to use around chimneys or other vertical items (walls); see (fig. 1–14). To fabricate step flashing, make the pieces 3 inches wider than the shingle's exposure. Thus, a 5-inch exposure would require at least an 8-inch wide piece of metal. Cut and bend the flashing to form a 90°- angle. Make the flashing large enough to run up the vertical surface at least 4 inches and onto the roof at least 4 inches.

To install step flashing:

1. Install the first course (lower) of shingles up to the vertical surface.
2. Place step flashing over the unexposed portion of the shingle.
3. Install the next course of shingles butting up to the flashing's lower edge.
4. Install the next step flashing and repeat until flashed.

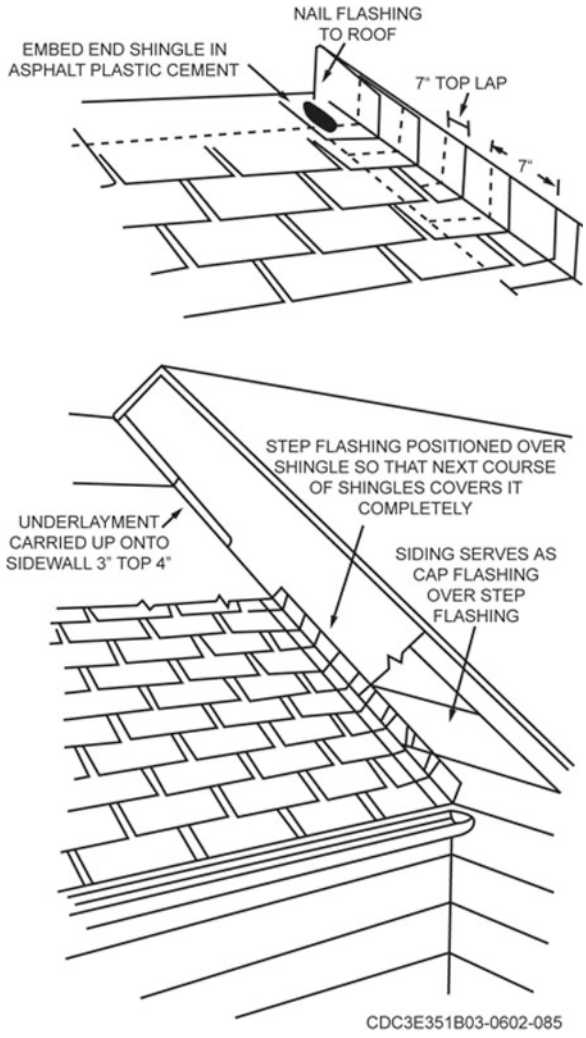

Figure 1–14. Step flashing.

Pipe flashing

You usually use a pipe boot to flash around pipes. To flash around a pipe, install the shingles up to the bottom edge of the pipe—trim the top of the shingle if it hits the pipe. You might have to cut a hole to slip the shingle over the pipe. From this point, slip the flashing over the pipe. Embed the flashing's flange and the overlying shingle into roofing cement.

NOTE: Make sure that there are not any joints in the shingles above the pipe—offset if necessary (fig. 1–15).

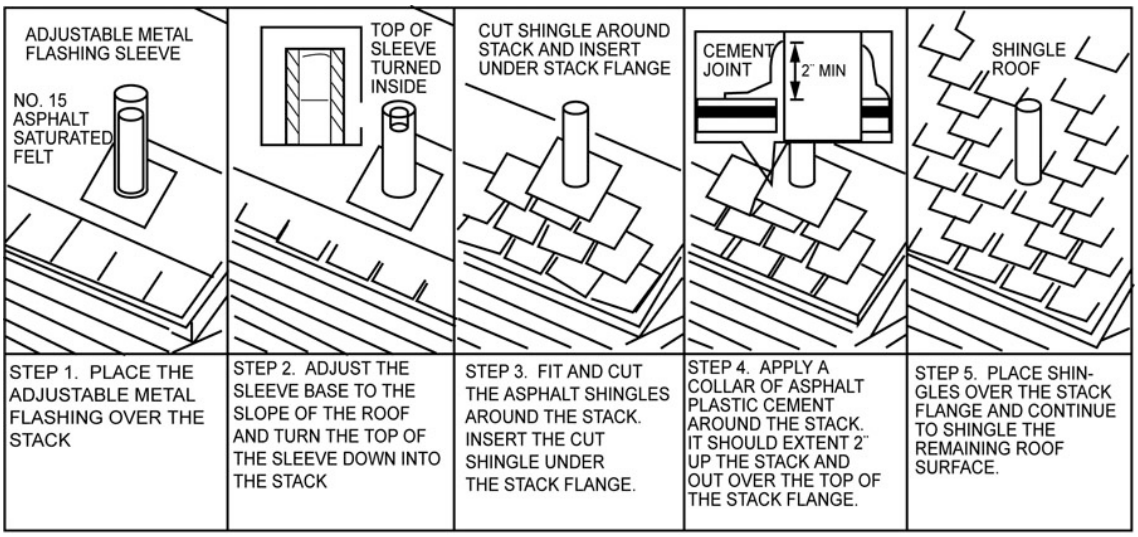

Figure 1–15. Flashing around a roof projection.

Hips and ridges

Make any hips and ridges follow the same exposure as the shingles (3-tab shingles). You can cut hip and ridge shingles (units) from shingle strips—approximately 12- by 12-inch squares. Cut the shingles from the top of the cutout towards the top edge of the shingle with a slight taper. This leaves the top edge narrower than the bottom (exposed) portion (fig. 1–16). An easy way to install the units is to:

1. Center the shingles on the hips and ridge. Snap a chalkline along the hip or ridge as a reference.
2. Start at the bottom of the hip and work up. Place one fastener on each side of the hip or ridge.
3. Once the hip is shingled, start shingling the ridge at the end away from the prevailing wind. This keeps the wind blowing over the shingle butts and not against them.
4. Cut the last ridge shingle to size and nail it in the same manner. You must cover the exposed nails with roofing cement to keep it from leaking.

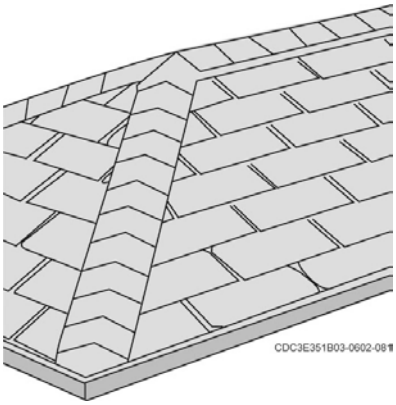

Figure 1–16. Ridge and hip finish.

Nails

The nails you use to apply asphalt roofing must have a large head (⅜ inch to $^{7}/_{16}$ inch in diameter) and a sharp point. Most manufacturers recommend 12- gauge galvanized steel nails with barbed shanks. Aluminum is also used. The length must be sufficient enough to penetrate the sheathing or ¾ inch into the wood. Space the nails so they are not exposed at the cutouts between the shingle tabs in the first course. Approximately 2 ½- pounds of nails are required per square for asphalt shingles.

Where you place these nails is vital for proper shingle application. For three-tab square-butt shingles, use a minimum of four nails per strip. Specifications may require six nails per shingle in windy conditions (fig. 1–17).

Align each shingle carefully and start the nailing from the end next to the one previously laid to prevent buckling. Drive nails straight to keep the head from cutting into the shingle. Drive all nails flush, but do not sink them into the surface. If, for some reason, the nail fails to hit solid sheathing, drive another nail in a different location but try to keep it in the same nailing pattern.

NOTE: Many manufacturers recommend driving the nails just below the factory-applied sealing strip.

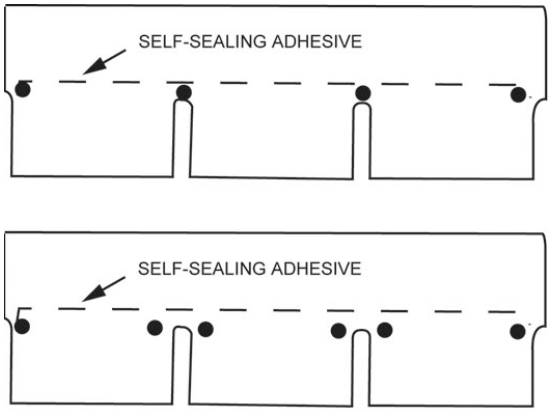

Figure 1–17. Nail placement.

808. Miscellaneous roof repair techniques

In this lesson, we discuss how to repair asphalt shingles and tile roofs. Depending on the size of your unit, you may not accomplish a new installation project; however, there is a good chance you will have to make roof repairs. Let’s begin with shingles.

Repairing asphalt shingles

Composition asphalt shingles have different treatment alternatives, depending on the type of damage. No special maintenance or repair is usually required for asphalt shingles when they are installed properly.

Weathering

Normal weathering usually occurs after the shingles have fulfilled their expected service life. It is characterized by the loss of mineral surfacing granules. It begins slightly, but accelerates as the granule loss exposes more asphalt coating to the weather.

Weathering varies depending on the direction of exposure, the climate, and the roof slope. It is more rapid in hot, humid climates. It is also prevalent on roofs with southern and western exposures and on low-pitched roofs. On double-coverage shingles, there is usually no concern of leaks; however, the shingles do become brittle as the weathering gets worse. This makes them more susceptible to wind damage.

Clawed shingles

“Clawing” is a term that refers to the lack of sufficient asphalt coatings on the underside of the shingle. It occurred more often in the 1950s and 60s than today. Clawed shingles do not need to be replaced just because of their appearance. You can leave them alone until they become deteriorated; unfortunately, clawed shingles have a shorter life expectancy and will deteriorate sooner.

Recoating

Never recoat asphalt shingles. Shingles that have weathered to the point of needing recoating are probably too brittle to recoat. Besides that, since they are probably weathered unequally, they would not absorb the coating material equally. Another downfall to recoating is that there is not really any cost savings compared to re-roofing.

Maintenance

Improper nail placement is usually the main defect associated with asphalt strip shingles. If nails are placed too high, place a dab of asphalt plastic cement under the center of each tab and press it down firmly. This method is also helpful to prevent wind damage to shingles that do not have factory-applied adhesives or shingles that are located in areas where strong winds are prevalent.

Asphalt shingles may become damaged from hailstorms. If the damage is severe, repair is not feasible. For minor damage, you can cover the bare areas with an asphalt-based roof coating, plastic cement or a clay-type asphalt emulsion.

Repairing tile roofs

Although not covered previously and not of composition material, tile roofs are located on some Air Force installations. For this reason, it is important for you to know how to replace broken tiles.

To replace a field tile that is broken or cracked, break up the tile so it is easier to remove. You can use a hammer for this—just be sure to wear personal protective equipment to protect yourself from flying pieces. Drive in any nails flush with the sheathing or batten strips. The next step is to apply about one square inch of tile adhesive to the tile in the course below. Apply beads 3/8 inch thick along the edges of the new tile and the tile it will lay next to. Place the new tile over the adhesive.If you have to install small tiles next to a hop or valley, lift up the tile nose in the course above the broken tile. Apply adhesive beads 3/8 inch thick along the head of the replacement tile and set it in place.

Self-Test Questions

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

807. Installing composition asphalt shingles

1. What are the two most common composition roof shingles?

2. When laying 3-tab shingles, how much surface do you leave exposed to the weather?

3. What is the minimum roof slope required to install strip shingles over a single thickness of asphalt-saturated felt?

4. How are asphalt shingles sold?

5. When you install felt underlayment, how much overhang over the drip edge do you allow? Why?

6. What size and type nails are recommended by most manufacturers to apply asphalt roofing?

808. Miscellaneous roof repair techniques

1. On what factors does the varying weathering of composition asphalt shingles depend?

2. Why do you never recoat asphalt shingles?

3. What is usually the main defect associated with asphalt strip shingles?

4. When replacing a tile, what size adhesive/cement beads do you apply to surrounding tiles?

Answers to Self-Test Questions

801

1. Steel, poured and precast concrete, wood panels, plywood, poured and precast gypsum, and wood fiber.
2. Cant strip is a triangular strip that fits into the angle formed by the intersection of a horizontal surface and a vertical surface. It helps to avoid breaking, puncturing, or damaging the roof membrane and helps in water runoff.
3. Provides a thermal barrier, a smooth surface to support the roof membrane, and sometimes it is installed with a slope to help the membrane surface drain water. Cellular glass, polystyrene foam, wood fiber, perlite, or various composite boards.
4. No, because they are not compatible with each other and do not bond.
5. By using a solvent test, pour a clear solvent into a container; place a small piece of bitumen in the solvent for about 20- seconds and then stir. If the solvent turns brownish-black, the bitumen is asphalt; if it is transparent and yellowish-green, the bitumen is coal tar.
6. To provide weathering protection (especially heat and ultra-violet rays). It also increases the roofs fire resistance.

802

1. They can last 20- years or more.
2. Ethylene propylene dienne monomer (EPDM), epichlorohydrin (ECH), and neoprene.
3. EPDM is not resistant to many solvents, including animal and vegetable oils, grease, and fats.
4. Chlorinated polyethylene (CPE), chlorosulfonated polyethylene (CSPE), and polyisobutylene (PIB).
5. Thermoplastic polyolefins (TPO), polyvinyl chloride (PVC).
6. Ensure that the deck area is clean, and the substrate is clean, smooth, and dry.

803

1. Temporary construction, because it is inexpensive and easy to install.
2. Store roofing rolls standing on end to keep them from shifting (rolling) or flattening.
3. By removing the roofing from the damaged area and applying new rolled roofing that matches the original type.
4. Usually loose nails and fishmouths (upturned felt edges) or from inadequate lapping, nailing, or cementing.

804

1. Periodic inspection.
2. From the roof’s underside. Here is where you may find damage from leaks, deteriorated decking, structural cracks or movement, or defects.

3. (1) When the annual maintenance and repair costs consistently exceed 5 percent of roof replacement costs.
   (2) When a roof leak persists despite maintenance and repair efforts.
   (3) When the moisture or other elements weakened the roof system or supporting structure to the point where it is unsafe.
   (4) When the insulation has lost at least 20 percent of its original insulating ability because of moisture in the insulation core.
4. In early spring, using the RIEI maintenance inspection checklist.
5. According to their age.

805

1. (1) b.
   (2) e.
   (3) c.
   (4) a.
   (5) d.
   (6) f.
   (7) h.
   (8) g.
2. Smooth them back in place, cement them in with plastic flashing cement, and coat the whole lap with plastic flashing cement.
3. You can refasten it by nailing and cementing it to the wall.
4. Metal.
5. Slightly deteriorated metal flashing can be restored. First, you must remove all rust, moisture, loose scale, grease, and dirt. Next, you prime and paint. Severely deteriorated metal flashing should be removed and replaced with new flashing to prevent roof leaks.
6. Sheet metal. It is installed into the masonry wall or chimney where it passes through the roof.
7. Electric shock hazards, water damage to sensitive equipment, loose roofing, weakened deck, downed tree limbs, and concerned occupants.
8. You can use batten strips, sandbags, concrete blocks, or any other suitable material that you can apply safely.
9. Only when the insulation is dry, the roofing components are well attached to each other and to the roof deck, the membrane surface is basically intact, and the roof frame and structure can carry the added weight safely.
10. The negative side: it is risky in that you expose the building and its contents during the removal, the construction goes longer, and you might lose existing insulations thermal value during replacement. The debris, dust, and tear-off noise can seriously affect the building's internal operations. You also risk damage to the deck and roof mounted equipment. The greatest risk it working at an elevated height and under windy conditions. The positive side: the exposed roof deck lets you inspect for damage and defects closely. You can eliminate defects and moisture within the existing roof insulation or membrane, and you can add new insulation to have a roof that provides years of trouble free service.

806

1. Determine what type of roofing membrane it is.
2. Within one week.
3. As soon as weather conditions permit.
4. Clean surface.
5. Applying pressure, bonding the two surfaces together, smoothing out, and avoiding trapping air.

807

1. Organic and fiberglass.
2. They are usually laid with 5 inches exposed to the weather.

3. 4:12 or greater.
4. They are sold in one-third-square bundles (33 ⅓-square feet) with 27-strip shingles per bundle.
5. At least ⅜-inch. To help prevent water from getting underneath the drip edge.
6. They must have a large head (⅜ inch to $^{7}/_{16\ \text{inch}}$ in diameter) and a sharp point. Most manufacturers recommend 12-gauge galvanized steel nails with barbed shanks.

808

1. Direction of exposure, the climate and the roof slope.
2. Too brittle to recoat. They would not absorb the coating material equally. There is not really any cost savings compared to re-roofing.
3. Improper nail placement.
4. One square inch of tile adhesive to the tile in the course below. Apply cement beads 3/8 inch thick along the edges of the new tile and tile it will lay next to. Place the new tile over the adhesive. Apply adhesive beads 3/8 inch thick along the head of the replacement tile and set in place.

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. (801) What built-up roof member provides the hard surface for the entire roof and *must* be strong enough to support the roofing felts, asphalt or coal tar pitch, and gravel that covers it?
   a. Purlins.
   b. Trusses.
   c. Drip edge.
   d. Roof deck.

2. (801) How many felt layers does a 10-year built-up roof have?
   a. Three.
   b. Four.
   c. Five.
   d. Six.

3. (801) What component would you install that would provide a continuous watertight connection between the roofing membrane, other structural parts, and between roof sections?
   a. Felt.
   b. Flashing.
   c. Insulation.
   d. Silicone sealant.

4. (801) What would you do to make a *major* correction when installing felt on a built-up roof?
   a. Cut off the felt and start over.
   b. Remove the felt and start over.
   c. Lift the felt and make the necessary correction.
   d. Apply pressure to the roll and slide the felt in the bitumen.

5. (801) Which flashing would you install around anything that penetrates or protrudes from the roof surface?
   a. Base.
   b. Eave.
   c. Subflashing.
   d. Counterflashing.

6. (802) Which roof system can be welded together with heat or solvent?
   a. Thermoplastics.
   b. Composition.
   c. Thermosets.
   d. Asphalt.

7. (802) What are the three common installation methods for single-ply membranes?
   a. Coal tar pitch, asphalt, and fully adhered.
   b. Loose-laid ballasted, coal tar pitch, and asphalt.
   c. Coal tar pitch, mechanically attached, and fully adhered.
   d. Loose-laid ballasted, mechanically attached, and fully adhered.

8. (802) The three major problems loose-laid ballasted concept prevents are
   a. splitting, alligatoring, and bubbling.
   b. splitting, blistering, and ridging.
   c. blistering, bubbling, and ridging.
   d. blistering, alligatoring, and bubbling.

9. (802) What is the first step when installing membrane using the loose laid ballasted method?
   a. Ensure that the deck area is clean, and then unroll the membrane onto the surface.
   b. Ensure the rolls are prepared, then layout and position them.
   c. Ensure the rolls are prepared, and the deck area is clean.
   d. Ensure the substrate is clean, smooth, and dry.

10. (803) On a rolled roof, what two common methods do we use to flash around pipes or other penetrations?
   a. Thermoset and Thermoplastic.
   b. Double coverage and Thermoset.
   c. Single coverage and Thermoplastic.
   d. Single coverage and Double coverage.

11. (803) You would repair small breaks and enlarged nail holes on a rolled roof by applying
   a. coal tar pitch and fiberglass mesh over the damaged area.
   b. asphalt bitumen and fiberglass mesh over the damaged area.
   c. plastic roofing cement and fiberglass mesh over the damaged area.
   d. coal tar pitch and asphalt with fiberglass mesh over the damaged area.

12. (804) When a roof continues to leak despite maintenance and repair efforts, it is assigned to what roof category?
   a. Red.
   b. Blue.
   c. Yellow.
   d. Grey.

13. (804) At least, how often do you inspect a low-slope roof in the red category?
   a. Monthly.
   b. Quarterly.
   c. Annually.
   d. Semi-annually.

14. (804) When a roof is under a warranty, performance agreement, or some other contractual tie to a contractor or manufacturer it is assigned to what roof category?
   a. Red.
   b. Blue.
   c. Grey.
   d. Yellow.

15. (804) During what season do you make a follow-up inspection made on a green category roof?
   a. Late fall.
   b. Early spring.
   c. Late winter.
   d. Early summer.

16. (805) What roof condition can be controlled or stabilized by installing straps?
    a. Abraded bituminous surfaces.
    b. Membrane slipping.
    c. Alligatoring.
    d. Splitting.

17. (805) What is generally the *most common* roof leak cause that is related to flashing failure?
    a. Poor support.
    b. Poor construction.
    c. Excessive moisture.
    d. Accumulated grease and dirt.

18. (805) What is the *last* action that you take to repair separated base flashing before bending the counter flashing back into place?
    a. Resolder the broken seams.
    b. Coat it with flashing cement.
    c. Refasten it by nailing or cementing.
    d. Paint it with an aluminum roof coating.

19. (805) How do you repair metal flashing that has deteriorated to the extent that there are holes present?
    a. Replace it with new flashing.
    b. Fill the damaged areas with solder.
    c. Coat it with plastic roofing cement.
    d. Fill the damaged areas with silicone sealant.

20. (805) Counter flashing is usually made from
    a. plastic.
    b. cement.
    c. sheet metal.
    d. bituminous fiber.

21. (805) A permanent repair to a roof should last at least
    a. 3 years.
    b. 5 years.
    c. up to its remaining service life.
    d. up to half its remaining service life.

22. (806) When should you make permanent roof repairs?
    a. In early spring cool weather.
    b. When convenient for your shop.
    c. In early summer warm weather.
    d. As soon as weather conditions permit.

23. (807) The two *most* common types of composition asphalt shingles are
    a. organic and single-coated.
    b. organic and fiberglass.
    c. fiberglass and single coated.
    d. single-coated and double-coated.

24. (807) What size are 3-tab strip shingles?
    a. 6-inch by24-inch.
    b. 6-inch by 36-inch.
    c. 12-inch by 24-inch.
    d. 12-inch by 36-inch.

25. (807) What is the *minimum* roof slope required to install strip shingles over a single thickness of asphalt-saturated felt?
    a. 2:12 or greater.
    b. 4:12 or greater.
    c. 6:12 or less.
    d. 8:12 or less.

26. (807) How many square feet are in one bundle of shingles?
    a. 33 1/3.
    b. 50.
    c. 66 2/3.
    d. 100.

27. (807) How much overhang do you allow for when installing the drip edge to the eaves?
    a. 1/4-inch to 3/8-inch.
    b. 3/8-inch to ¾-inch.
    c. 4-to 6-inches.
    d. 6-to 10-inches.

28. (807) When installing the shingle starter course, allow it to overhang the drip edge?
    a. 1/16-inch to 3/16-inch.
    b. ¼-inch to 3/8-inch.
    c. 5/16-inch to 7/16-inch.
    d. ½-inch to 5/8-inch.

29. (808) What three factors affect weathering of composition asphalt shingles?
    a. Heat, wind, and high pitch.
    b. Rain, humidity, and roof slope.
    c. Direction of exposure, rain, and high-pitch.
    d. Direction of exposure, climate, and roof slope.

30. (808) What is the usual installation defect associated with asphalt strip shingles?
    a. Installed upside down.
    b. Improper nail placement.
    c. Flashing placed incorrectly.
    d. Improper amount of adhesive used.

31. (808) When replacing a tile, what amount of adhesive do you apply to surrounding tiles?
    a. 3/8-inch bead and 1-square inch.
    b. 3/8-inch bead and 3/8-inch square.
    c. 1-inch bead and 3/8-inch square.
    d. 1-inch bead and 1-square inch.

Please read the unit menu for unit 2 and continue ➔

Student Notes

Unit 2. Metal Roofing and Gutter Systems

METAL IS A CONSTRUCTION material we use for strength and durability. Your ability to understand the different ways that metal can be used is an important part of your job as a structural specialist. In this unit, we explain a few metal characteristics and ways that you can install and repair metal roofing, flashing, gutters, and downspouts. The examples covered are typical of what you're likely to face on the job.

2–1. Metal Roofing

Metal roofing is part of a conventional roof system that is designed to cover a roof and make it watertight. The metal that is most often used is copper, aluminum, or galvanized steel. We briefly review these metal types and the characteristics that you ***must*** consider before installing them or making repairs.

809. Installing metal roofing systems

In this lesson, we discuss the most common materials used for metal roofing panels. We briefly discuss the types and characteristics of each. Then we discuss the conventional roof seams used and how to install the panels themselves. We begin with the types of materials used.

Types of roofing panels

Copper, aluminum, and steel are used for metal roofing. These materials expand when they are exposed to heat and contract when they are exposed to cold. An 8-foot copper sheet expands or contracts as much as $^{9}/_{64}$ inch; aluminum expands or contracts as much as $^{3}/_{16}$ inch; and steel, as much as $^{3}/_{32}$ inch. Thus, you can see that seasonal changes have some bearing on installing metal roofs. For example, when you are installing metal roofing in cold weather, you have to allow for considerable expansion, but for very little contraction.

Another concern is how to place dissimilar metals together without causing galvanic action. Briefly described, galvanic action is the reaction between dissimilar metals that produces an electric current; unfortunately, it also eats away one of the metals. Because galvanic action causes corrosion, avoid joining different metals. If you must join them, use a layer of waterproof building paper, a layer of asphalt-saturated felt, or a coating of asphalt paint between the two metals. Copper, aluminum, and galvanized steel are the metals used most often as roofing material to cover buildings, and they all come in the shapes shown in figure 2–1, as well as in flat sheets.

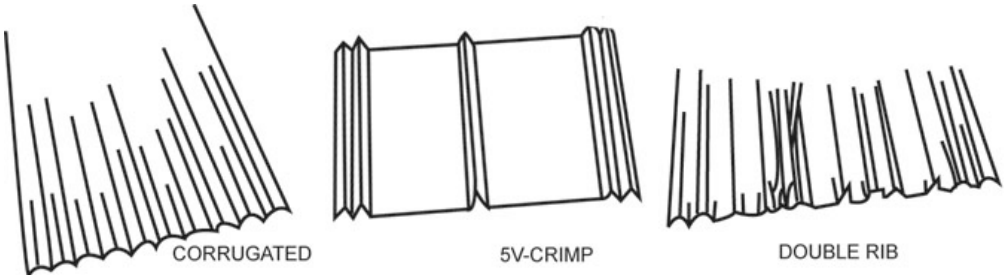

Figure 2–1. Metal roofing shapes.

Copper sheets

Copper roofing sheets vary in thickness. Copper sheet thickness is designated by ounces per square foot, so we call copper that is 0.022-inch thick 16-ounce copper. Copper roofs are usually installed with grooved flat seams, batten seams, or standing seams, with cleats fastened to the roof deck and formed into the seam. A copper roof is very resistant to corrosion, which gives it an advantage over other metals such as steel. When new copper sheets are exposed to the atmosphere, an oxide coating called *patina* forms. The coating helps make the surface resistant to further corrosion. Use brass or bronze nails, screws, or bolts to fasten copper.

Aluminum sheets

Aluminum sheets we use for roof coverings are available in flat, corrugated, or double-ribbed shapes. The corrugated and double-ribbed shape is stronger than the flat sheet. The extra-strength is usually needed to cover roofs that do not have a solid deck underneath. The corrugated and double-ribbed sheets have other advantages over flat sheets in that they help drain water from the roof, and their seams do not require soldering. Use aluminum, cadmium-plated steel, or stainless steel nails, screws, or bolts to fasten aluminum.

Galvanized steel sheets

The galvanized sheets we use on roofs are either flat, corrugated, or 5V-crimp. Galvanized steel does not have as much corrosion resistance as aluminum or copper, but it is very good for covering roofs. Two advantages over aluminum and copper are lower cost and greater strength. Properly installed, galvanized metal roofs render satisfactory service. We often install them on sheds and warehouses. Use cadmium-plated or galvanized steel nails, screws, or bolts to fasten galvanized steel.

Metal roof seams

Seams on metal roofing are like those in other sheet metal fabrication work, but some are used differently. Figure 2–2 shows these roof parts. When two ridges join at a 180 degree or less angle, a valley is formed. Seams running parallel to the roof slope are *parallel seams*; those running across the slope are *cross seams*. When cross seams are necessary to join the sheets (fig. 2–2), use a grooved seam. We seldom solder these grooved cross seams, but if you must, make allowance for expansion and contraction at the eaves or ridge.

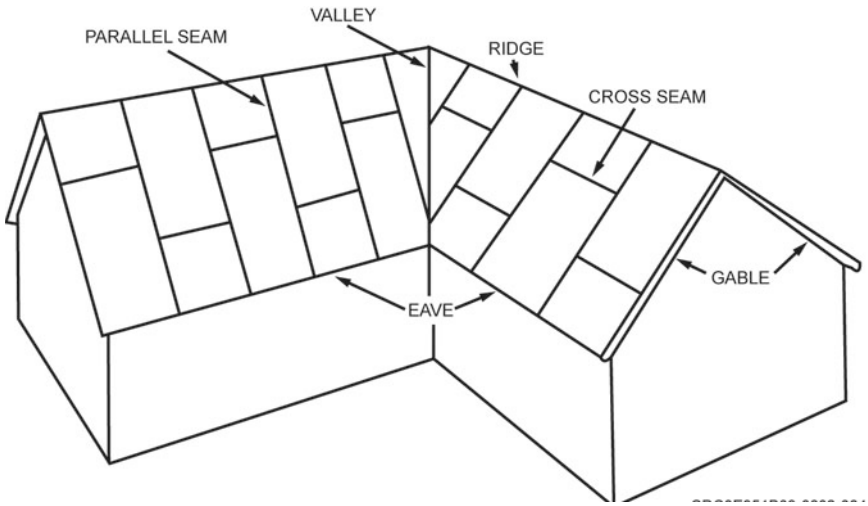

Figure 2–2. Roof parts.

Roofing standing seams

Standing seams are generally used with flat sheets on pitched roofs. These seams are *not* soldered and, therefore, should *not* be used on a roof that slopes less than 3-inches per foot. A 4-inch roof slope or more (per foot) is desirable. Standing seams allow for expansion and contraction if you leave

a $^{1}/_{16}$-inch space (fig. 2–3, step B). The installation method we describe below is the traditional method used; however, many manufacturers have developed standing seam roofing systems with specialized installation methods—always refer to the manufacturer's instructions for the system you are installing.

Traditional standing seam installation

Traditional installation methods call for you to fasten the metal to the roof with cleats spaced 12 inches apart. Nail the cleat to the roof so the upright part of the cleat is flush against the 90 degree flange of the preceding sheet. After nailing the cleat to the roof, bend the cleat's remaining flat part over the nail heads. This keeps the heads from working through the top sheet that you install next.

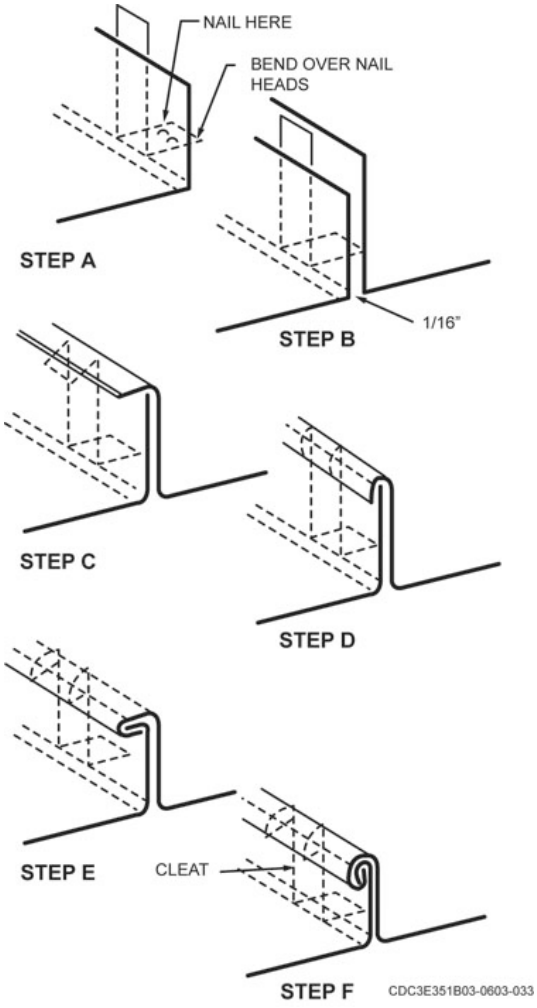

Figure 2–3. Roof standing seam.

As in figure 2–3, step B, place the second sheet to be installed. It also has a flange turned up 90 degrees, but this flange extends above the flange on the first sheet. Bend this longer flange over the shorter flange to form the standing seam. In step C, you can see how to start this 90 degree bend. In step D, bend the metal to 180 degrees to form the standing seam. In steps E and F, you can see how to bend the standing seam another 180 degrees to complete the double seam.

NOTE: Many systems on the market today require the use of an electric metal seamer designed with rollers. This seamer is unique to a particular roofing system.

Installing a roof with standing seams

We show the procedures for installing a roof with standing seams in figure 2–4. Figure 2–4, A, shows a metal roof installed with double-lock standing seams (fig. 2–3 shows how to make the seam).

In figure 2–4, B, you can see how we install the eave flashing to prevent leaks. The continuous eave strip in this example is formed into a Z-shape and nailed to the roof deck; it extends over the eaves ¾ inches. Place the metal roofing on the deck so that you can form a ¾-inch pocket over the ¾-inch eave strip that extends past the eave edge. Turn the standing seams ends 180 degrees and flatten them to prevent leaks.

We show flashing for the gable edge in figure 2–4, C. Cut a strip equal to the entire gable length. Nail it to the gable edge so it extends ¾ inches below the gable's bottom edge. Cut flashing wide enough to cover the roof deck's thickness and to form a ¼-inch pocket with a cornice brake. Form the double seam with the double seamer when you install the flashing.

Cap the ridge (fig. 2–4, D) by nailing cleats to the roof deck and forming them into the standing double seam. Flatten the standing seam which runs up the roof slope, and form it into the ridge seam where they meet on the ridge (fig. 2–4, E). Join the cross seams with ½-inch grooved seams (fig. 2–4, F) and seal the cross seams with solder. Be sure to seal the cross seam where it is formed into the standing seam's double fold.

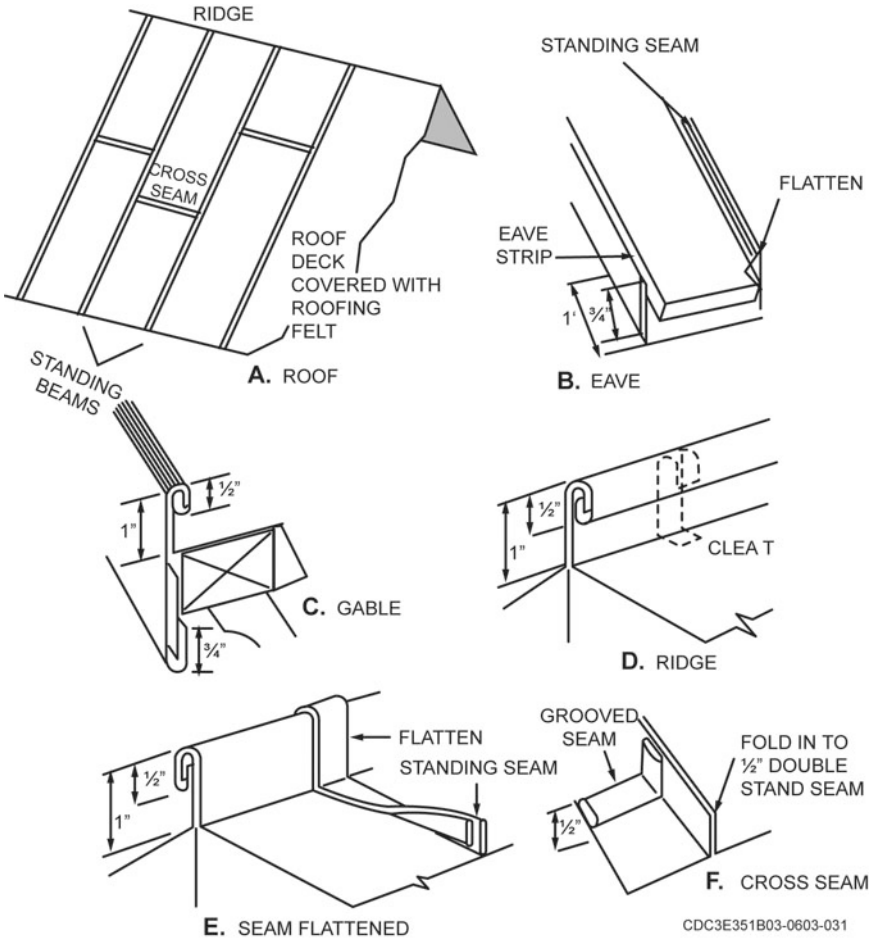

Figure 2–4. Standing seams used with metal roofing.

Roofing grooved seams

The roofing grooved seam (flat seam) is adaptable for roofs with very little slope (less than 3-inch slope per foot). Normally, this seam is used for 14-inch by 20-inch sheets. Fasten the sheets to the

roof deck with cleats spaced 12 inches apart. Nail the cleats to the roof deck and then form them into the grooved seam. In figure 2–5, you can see how to fasten metal sheets to a roof with cleats.

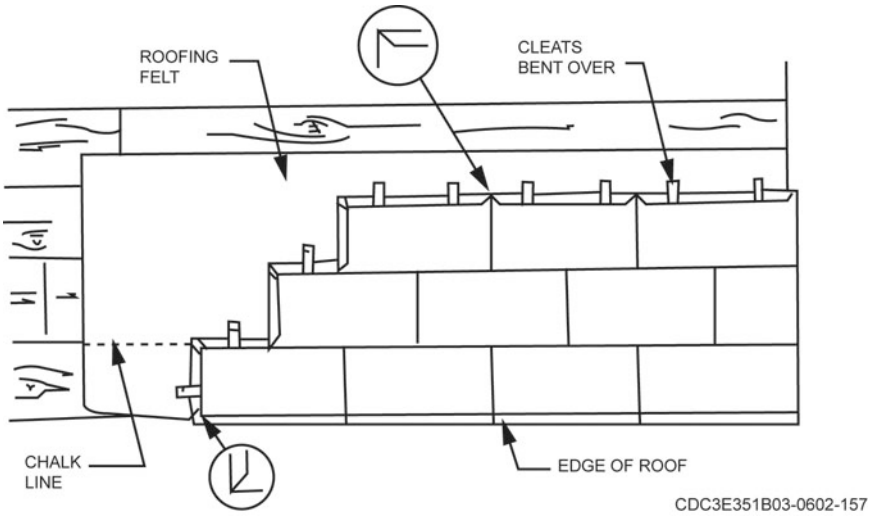

Figure 2–5. Metal roofing installed with cleats.

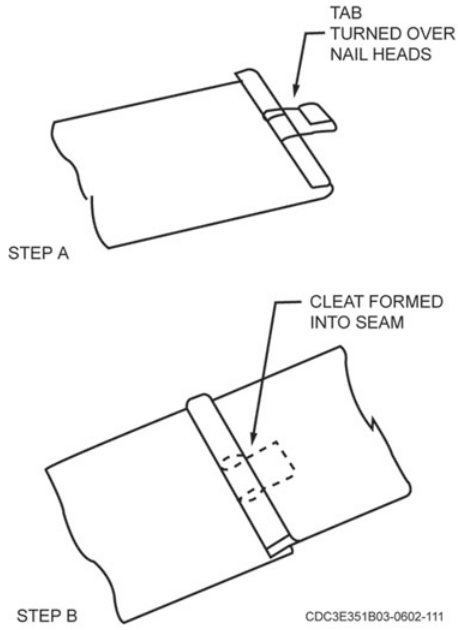

Figure 2–6. Installing a cleat in a grooved (flat) seam.

Figure 2–6, step A, shows a roof sheet section with a cleat installed. To install the cleat, insert the bent cleat's end into the pocket formed by the roofing sheet's upturned flange. After you pull the cleat tight and lock the sheet into the other roof sheets, nail the cleat to the roof deck and turn the end back over the nail head. This keeps the nail from backing out and damaging the roof. Then, install the next sheet, which covers the cleat as shown in figure 2–6, step B. After you install the sheets, solder all grooved seams to seal them.

Installing a roof with grooved seams

Grooved seams, sometimes called flat seams, we normally use on low-slope roofs (½ inches to 3 inches). When you are cutting and notching seams, make sure you get a good notch; otherwise, you may have a difficult time when you seal the joint with solder. Figure 2–7, A shows a good notch. It

looks like figure 2–7, B after you position the edges. Notice that two edges are turned up, and two are turned down. This lets you hook the “down” edges over the “up” edges.

In laying a flat seam, nail the eaves and gable strips as shown in figure 2–7, C and D. Install the flashing for the eaves with cleats and a continuous strip, as shown in figure 2-7, C.

Do not nail the flashing to the roof deck. Notice that a ¾-inch pocket is turned over the strip. After you install the eaves flashing, insert the flat sheet into the pockets of the flashing with two edges turned down. Figure 2–7, D shows the gable edge. Lap the sheet and grooved (flat) seam over the gable and turn a ¾-inch pocket. Covered this way, the roof deck’s eaves and gables are sealed from moisture.

When you install the flat sheets on a roof, make sure the cleats are spaced correctly and the seams are well grooved. Flatten them with a mallet and set the grooves with a hand groover. Cover the whole roof to within 7¼ inches of the ridges (fig. 2–7, E). You can cut and form the ridge cap in the shop with squaring shears and a cornice brake. Make the ridge cap in two halves; one half with the allowance for a standing seam pocket and the other half with a flange. Turn down the other edges of both halves for a groove (flat) seam.

Fasten the roof cap to the roof deck with cleats. Insert the grooved (flat) seam edges of the ridge cap halves into the pockets of the roofing sheets and flatten the seams. Using a double seamer, turn and flatten the pocket for the standing seam on the ridge. However, you must use a conventional seamer and a mallet to fold the seam completely over (fig. 2–7, E).

Seal all the seams on a grooved (flat) seam roof with less than a 3-inch slope with solder, usually with tin and lead solder. You need solder, flux, soldering coppers, or a propane torch to do this. Carefully sweat the solder into the seams to ensure a well-sealed joint.

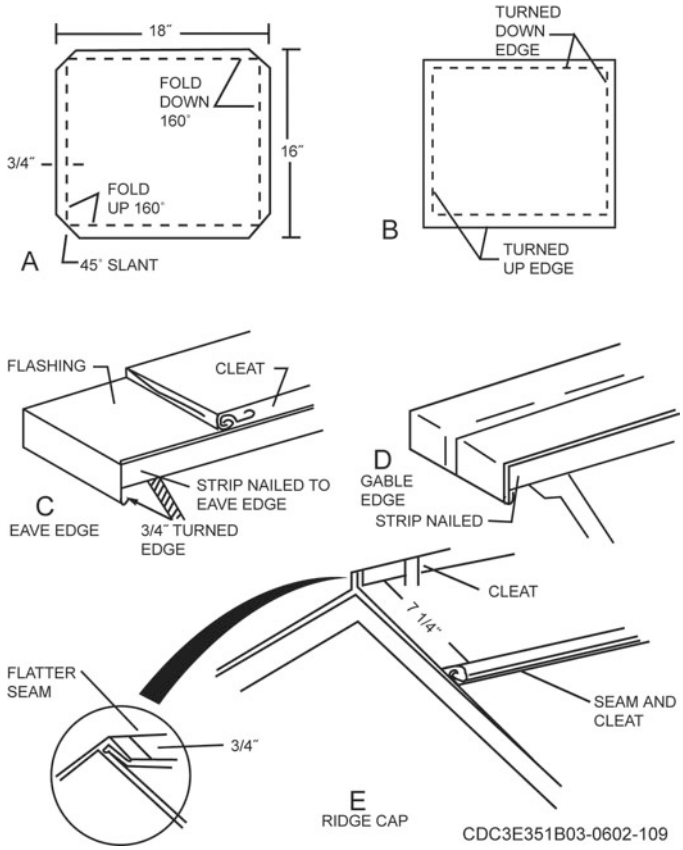

Figure 2–7. Grooved (flat) seams used with metal roofing.

Roofing lap seams

We use roofing lap seams to install corrugated, 5V-crimp, or double-ribbed sheets on a roof. The lap seams in roofing are somewhat different from those in other fabrication because the seams are lapped more. In installing corrugated, rib, or 5V-crimp sheets, you must use a definite sidelap number. Figure 2–8, A shows the crowns and valleys in a corrugated sheet. A 1½ sidelap corrugation means that one crown and one valley are lapped. View B shows a 1½ sidelap corrugation, and view C shows a 2-corrugation sidelap (notice that two crowns and one valley are lapped).

In view D, there is a single sidelap on V-crimp roofing sheets, and one crown is covered. In view E, there is a 2-corrugation sidelap where both crowns and one valley are covered. Never make sidelaps on corrugated sheets less than 1½ corrugations. Sidelaps for V-crimp and rib sheets should not be less than 1-corrugation.

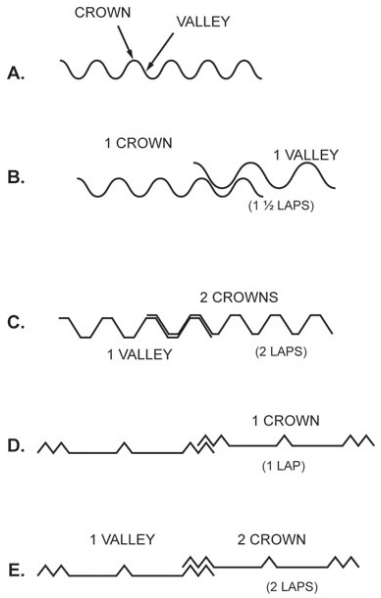

Figure 2–8. Sidelaps used with metal roofing.

Installing a roof with lap seams

Lap seams (fig. 2–9) we use with roofing sheets of corrugated, 5V-crimp, or ribbed metal. We use endlaps so the metal laps over the previous sheet's top in the downward water flow. We make sidelaps so the metal laps over into the prevailing wind direction. The sidelaps are usually 1½ corrugations and the endlaps are usually 6 inches.

To begin installing a metal roof, you start with sheet A. (**NOTE:** In this example, we use sheet A because it is downwind from the prevailing wind.) Position sheet A and fasten it to the purlins with No.14-gauge self-drilling screws that are 2 inches long, except where it joins the sheet laps in B, C, and E locations. Lay sheet B over sheet A to make a 1½ corrugation sidelap and fasten it to the purlins just as you did sheet A. Fasten the sidelap with No.12-gauge self-drilling screws that are ¾ inches long. Be very careful when you lay the sheets to keep them aligned.

Next, lay sheet C so you have a 6-inch endlap. Fasten sheets A and C to the purlins with No. 14-gauge self-drilling screws that are 2-inches long, except where sheet E is to overlap. Then, lay sheet D and fasten it to the purlins. Lay sheet E over sheet C to make a 1½ corrugation sidelap, and lay it over sheet B to make a 6 inch endlap. Continue this sequence until you reach an expansion joint. The installation procedure for 5V-crimp or ribbed sheet metal is the same as for corrugated sheet metal.

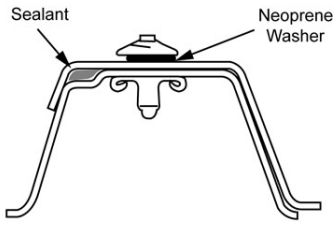

Figure 2–9. Installing a corrugated roof with lap seams.

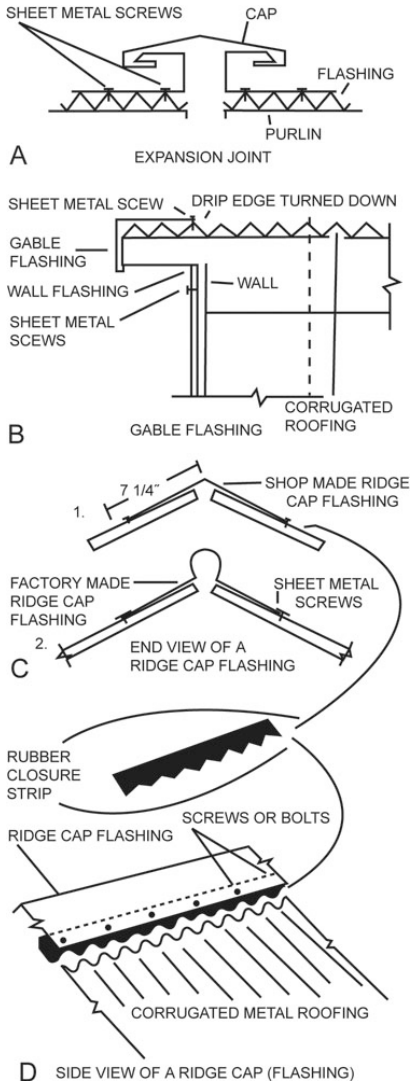

Figure 2–10. Installing roofing joints and sealers.

Figure 2–10, A shows an expansion joint end view that runs the roof slope's full length. To install the expansion joint, fasten the flashing to the corrugated roofing with sheet metal screws spaced 12 inches apart. Use sheetmetal screws with neoprene washers to prevent water seepage around the heads. After the flashing is fastened to the roofing sheets, install the cap over the flange. The cap has a slight pitch so that water runs off. Figure 2–10, B (flashing end view) shows flashing installed at the roof's gable edge. Seam the gable flashing to the wall flashing, and fasten it to the roof with sheet metal screws. Install the flashing so it overlaps with the roof slope direction. Notice the drip edge on the gable flashing, where it overlaps the corrugated roofing. This drip edge allows the water to run into the valley of the corrugated metal and off the roof.

Ridge caps (fig. 2–10, C) seal the ridge after the roof is laid. The ridge cap in "C–1", is shop-made and extends over the ridge 7¼ inches. The cap shown in "C–2", is factory-made and is rolled on the top. The factory cap usually extends over the ridge about 7¼ inches on each side. Install both cap strips with sheet metal screws and a rubber closure strip. One closure strip edge is cut out for corrugations. Set this edge on the corrugated metal so the cap strip rests on the flat edge, opposite the cutout. Figure 2–10, D shows a cap installed with a closure strip. The sheet metal screws or bolts pass through the ridge cap and closure strip and into the corrugated roofing.

Roofing batten seams

Roofing batten seams (fig. 2–11) are formed over wood battens. (A batten is a wood strip nailed to the roof deck.) Batten seams run parallel to the roof slope and let the metal expand and contract. Cleats fasten the roofing to the batten seam much the same way as the cleats fasten them on standing and grooved (flat) seams.

In figure 2–11, step A, you can see the cleats nailed to a batten. Step B shows the metal sheet formed 90° and placed along the side of the batten. Step C shows how you form the metal along both sides of the batten and bend the tabs over one edge of each channel. Make a cap piece into a channel and place it over the batten, as shown in step D. Turn both edges 90 degrees to make a single seam, as shown on step D on the right side. After making this single seam, make another seam, as shown in step E.

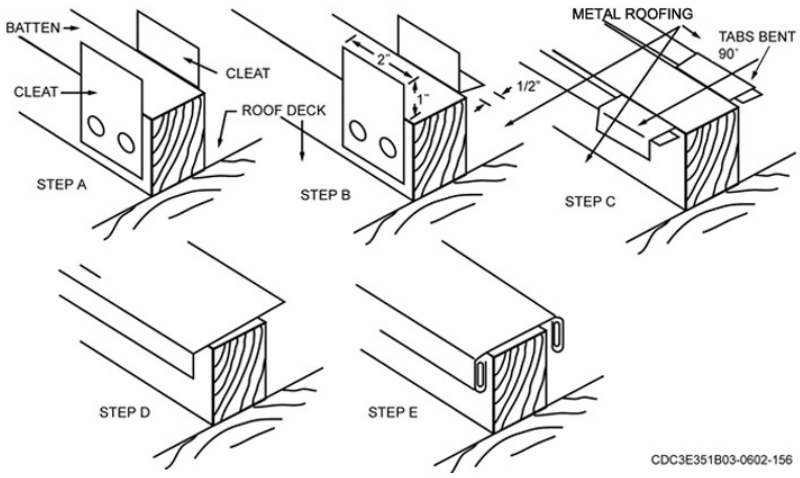

Figure 2–11. Making a batten seam.

810. Repairing metal roofing systems

Metal roof repair is seldom necessary if the roofing was installed right, but sometimes a seam may crack or the metal may break. When this happens, you must make repairs. In this lesson, we discuss some common repair methods for metal roofing systems.

Copper roofing

Copper roofing we usually install with grooved (flat) seams, batten seams, or standing seams. Therefore, the most common cause of roof leaks is inadequate expansion joints. If cracks occur, install an expansion joint. Repair small holes and breaks in copper by soldering. Clean the surface around the break with a wire brush or emery cloth, apply flux, and then solder the break. Repair large breaks by soldering a patch over the break.

Galvanized steel roofing

Galvanized steel roofing is durable and strong with a long service life. When repairs are needed, it is usually to seal small punctures. There are various ways to make these repairs, but soldering is the recommended way. If the puncture is too large to repair by soldering, it is usually best to replace the entire sheet with a new one made of like material.

Aluminum roofing

Aluminum roofing is popular in many areas. It does not rust, but it can corrode and it can be damaged. The damage ranges from small holes and cracks to large holes and severe deterioration. If you make a patch on aluminum roofing, then use aluminum as your patching material to help prevent corrosion from galvanic action. Since roofs with steel purlins normally do not have decking, you can reach the roofing from both sides to rivet a patch to the metal. For extensive damage, replace the entire sheet with one that matches the original.

Standing seam panels

Standing seam panels are typically produced with either a two-piece or three-piece seam. Snapping together or mechanically crimping the edges of two adjacent panels creates the two-piece seam. Butting the edges of two adjacent panels, then either snapping or mechanically crimping a seam cap over the joint creates the three-piece seam. A sealant is usually included in either type of seam to increase the weather-tightness of the joint.

Safety precautions

Metal roofing panels are a concern for a variety of reasons. Damaged edges are very sharp and can cause serious cuts. Severely rusted panels pose danger to workers that walk on it. You never know when you might step through a rust hole. Depending on the repair techniques you use, always wear proper personal protective equipment and follow the material safety data sheets of whatever product you are using.

Two-piece seam repair

The following techniques describe the basic repair procedures for a two-piece seam. As we discussed earlier, there are many different manufacturers with unique installation methods for their systems.

1. Obtain a replacement roof panel from the manufacturer.
2. If the panel to be replaced runs continuous from ridge to eaves, then remove any fasteners that tie the ends of the panel to the ridge and/or eaves. Make note of any beads of caulk or sealant strips that need to be replaced.
3. If the panel to be replaced is not continuous from ridge to eaves, then remove any fasteners that seal end laps between panels. Make note of any beads of caulk or sealant strips that need to be replaced.
4. A tool to open the longitudinal seam is sometimes available from the manufacturer. If such a tool is not available, use a makeshift tool to pry open the two longitudinal seams on the panel. Work carefully to avoid damaging the adjacent panels.
5. Lift out the damaged panel.
6. Cut the replacement panel to the same length as the damaged panel. Check the ends of the damaged panel for any copes or swaging and prepare the ends of the replacement panel in a like manner.
7. Lay the new panel in place.
8. Replace any sealant strips or caulking which were present on the original panel.
9. Install end lap and/or ridge and eave fasteners.
10. Snap or crimp the longitudinal seams together.

Three-piece seam repair

The following techniques describe the basic repair procedures for a three-piece seam. As we discussed earlier, there are many different manufacturers with unique installation methods for their systems.

1. Obtain a replacement roof panel and seam caps from the manufacturer.
2. If the panel to be replaced runs continuous from ridge to eaves, then remove any fasteners that tie the end of the panel to the ridge and/or eaves. Make note of any beads of caulk or

sealant strips that need to be replaced.

3. If the panel to be replaced is not continuous from ridge to eaves, then remove any fasteners that seal end laps between panels. Make note of any beads of caulk or sealant strips that need to be replaced.
4. Using an air chisel or metal nibbler, carefully split longitudinally both seam caps holding the damaged panel in place.
5. Lift out the damaged panel.
6. Cut the replacement panel to the same length as the damaged panel. Check the ends of the damaged panel for any copes or swaging and prepare the ends of the replacement panel in a like manner.
7. Lay the new panel in place.
8. Replace any sealant strips or caulking that were present on the original panel.
9. Install end lap and/or ridge and eaves fasteners.
10. Snap or crimp new seam caps in place.

Alternate repair techniques

There are many repair alternatives versus panel replacement. A variety of thermosets or other compounds are produced specifically to give metal roofing panels an extended life span. You can apply seam sealers to metal seams, fasteners and roof penetrations to provide waterproof protection, plus allow for expansion and contraction. You can then cover the entire roofing panel with acrylic or aluminum fiber coatings to provide a monolithic protective layer.

Covering the roof with acrylic or aluminum fiber coatings has numerous advantages. Not only do the coatings provide a monolithic layer, but they also reduce energy costs by reflecting UV rays from the roof. A monolithic layer provides rustproof protection, reduces labor cost, and extends the roof life for many years. Most of these new systems from reputable companies come with 5- to 7-year warranties. The roof can then be recoated, which provides additional protection and extended warranties.

Self-Test Questions

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

809. Installing metal roofing systems

1. What three metal types do we commonly use for metal roofing?

2. What happens when two dissimilar roofing metals are placed in contact with each other?

3. What helps make copper roofing surfaces resistant to corrosion?

4. What advantages do galvanized sheets have over copper or aluminum sheets?

5. What are parallel seams and cross seams?

6. How is a grooved seam (flat seam) roof held to the roof deck, and what do we use to seal the roof?

7. Why is it necessary to make a good notch when you are cutting sheets for grooved seam roofing?

8. What three roofing sheet shapes do we install with a lap seam?

9. What is a lap seam's usual sidelap overlap?

10. What is a lap seam's usual endlap overlap?

11. When you install lap seam corrugated roofing, which sheet do you install first and in what direction?

12. What function do cleats serve with batten seams on a roof?

810. Repairing metal roofing systems

1. How do you prepare a crack in a copper roof for repair?

2. How do you repair a small hole or break in a grooved-seam copper roof?

3. What do you use to repair most breaks and cracks in galvanized roofing?

4. How do you repair a large break in a galvanized roof?

5. What material do you use to patch a small hole in an aluminum roof? Why?

6. What is an alternative roof repair technique that reduces energy costs and extends the life of the roof?

2–2. Gutter Systems

We install gutters and downspouts under building eaves to collect rainwater from the roofs. They are made from galvanized steel, stainless steel, copper, or aluminum. In this section, we discuss gutter components and some of the installation and repair methods used.

811. Installing and repairing gutter systems

You can purchase ready-made gutters cheaper than you could build your own. In this lesson, we discuss the main components and common installation and repair procedures of gutter systems, so you can install most gutter systems on your own.

System components

There are various components used to make a gutter fit together and form a complete system that can effectively carry water from the roof to the downspouts. In this lesson, we identify the components used and how you can install them. Figure 2–12 shows the different components that make up a typical system.

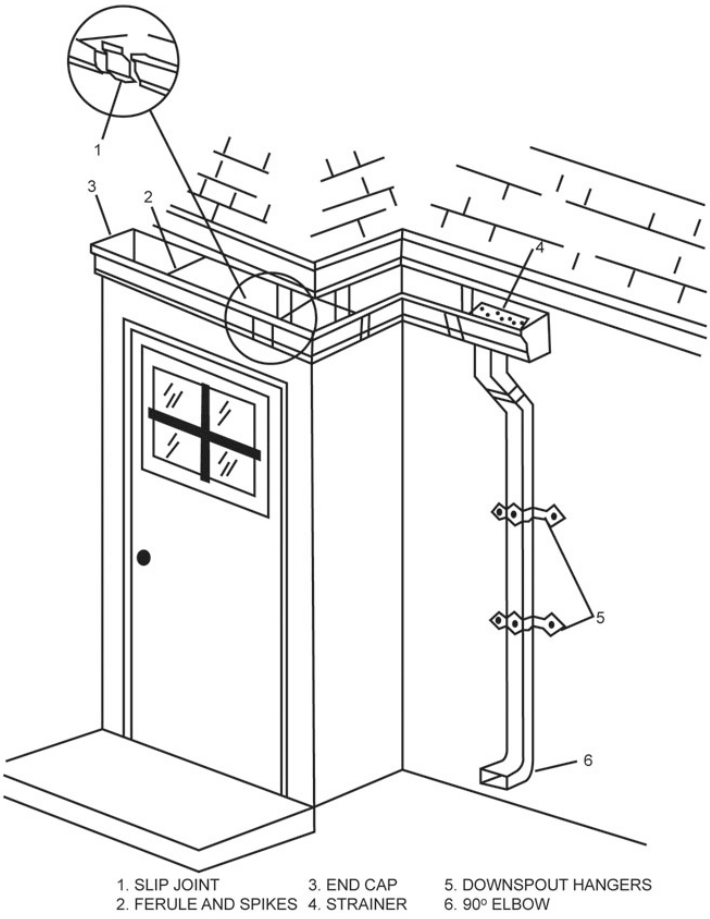

Figure 2–12. Gutter and downspout parts.

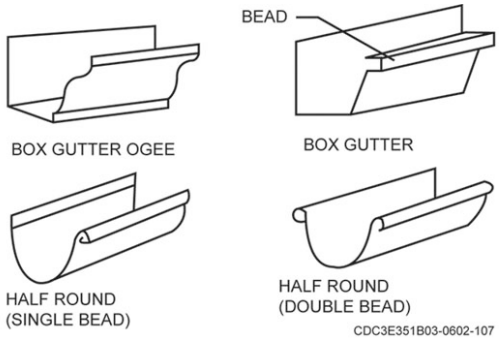

Figure 2–13. Gutter shapes.

Straight joints

Gutters are made in several different shapes (usually to the specification on the working drawings) to fit special needs. Figure 2–13 shows four basic gutter shapes, from which many variations are possible. The ogee box gutter is commercially available in standard 10-foot lengths. The widths can

be 4, 5, 6, or 7 inches (the width is the distance across the gutter's top). An alternative is a shop-made box gutter with a single bead. The gutter length is determined by your job requirements, the metal length used, and the cornice brake machine size. Ten-foot lengths (joints) are probably the maximum that can be made in your shop. Half-round gutters, like the ones shown in figure 2–13, may have a single bead or a double bead on the edges. A bead adds strength to the gutter and improves the appearance. You can purchase half-round gutters in standard sizes, such as 4, 5, 6, and 7 inch widths and 10 foot lengths. Other components used with straight gutter joints are slip joints, end caps, corner mters, hangar parts, strainers, and downspout drop outlets.

Slip joints

Slip joints join straight sections and corner miters. They can be made or purchased in galvanized steel, stainless steel, copper, or aluminum. The joint connection must match the gutter's size and shape. When you use slip joints to join gutters, use a non-hardening silicone sealant. Slip joints (fig. 2–14) allow for gutter expansion and contraction during temperature changes.

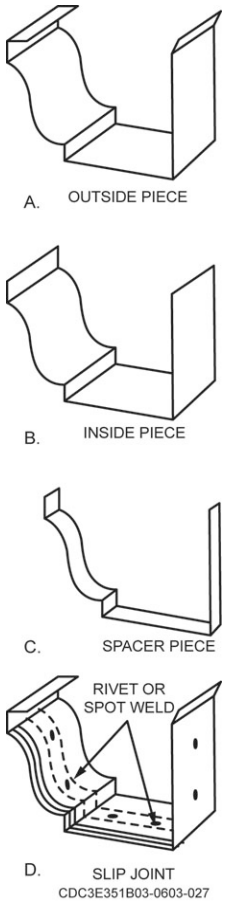

Figure 2–14. Pieces to fabricate a gutter slip joint.

End caps

End caps plug the gutter's ends. They are sometimes called friction caps because the edges are folded into a pocket. On galvanized and copper gutters, the caps are soldered during installation; on aluminum gutters, they are sealed with silicone sealant during installation. You can buy or make end caps to fit the gutter that you install.

Corner miters

You can buy inside and outside corner miters (fig. 2–15) in standard sizes for box and half-round gutters. Bought corner miters are usually 6 inches long on each side of the turn. They are joined to the gutter with slip joints or lapped, riveted, and sealed. If they are lapped, make the lap in the water flow direction and at least an inch wide to ensure a strong joint.

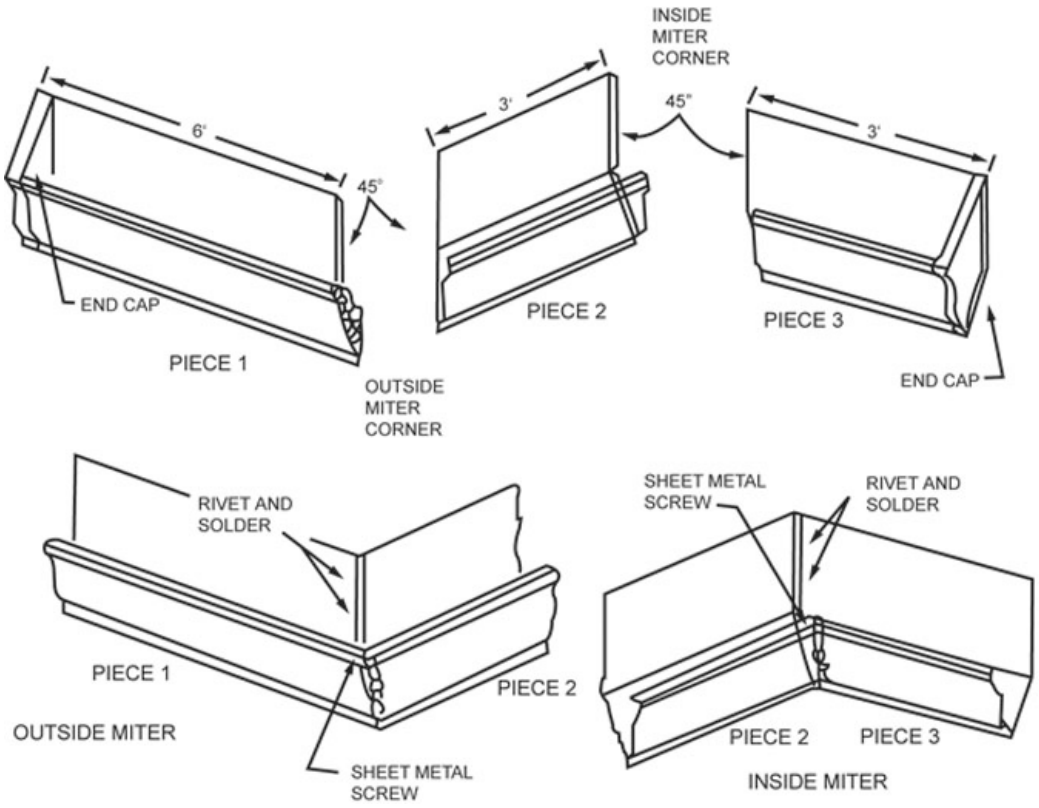

Figure 2–15. Inside and outside corner miters.

Hangers

Hangers in (figs. 2–12, 6 and 2–16) support and hang box and half-round gutters. The hanger in figure 2–16, A acts as a hanger and a brace. The two parts that make up this hanger are called the hanger and the fastener strap. Nail the hanger to the fascia board and into the rafter; then slip the gutter under the hanger's back lip and fit it into place. Next, hook the slot in the fastener straps over the front lip on the hanger and snap it over the gutter bead.

Ferrules and spikes (fig. 2–16, B) are also used to hang gutters. The gutter width determines ferrule length and ferrule length determines the spike length. For example, a 4-inch gutter requires a 4-inch ferrule with a 7-inch spike. The spike needs to be this length to extend past the ferrule approximately 3 inches to embed securely into a wood rafter. To install a ferrule and a spike, insert the ferrule between the gutter beads and drive the spike through the outside gutter bead, the ferrule, the gutter's backside, the fascia, and into the rafter. When a ferrule is installed, it should look like the one in figure 2–16, B.

The hanger in figure 2–16, C is for a single-bead, half-round gutter. Notice that it is made in two parts—the hanger and a half-circle brace—and is fastened with nails to the fascia board and the rafter. The hanger part has several vertical holes for height adjustment. The half-circle brace for single-bead; half-round gutter can be used with several gutter types, as shown in C, D, and E in figure 2–16.

Notice the hanger in D is for a double-bead, half-round gutter. It has a lip on the brace's back. The hanger in E is adjustable and is used when the roof has a slope and the hanger is being installed under the eaves. Figure 2–16, E shows how the hanger is adjusted to the roof pitch.

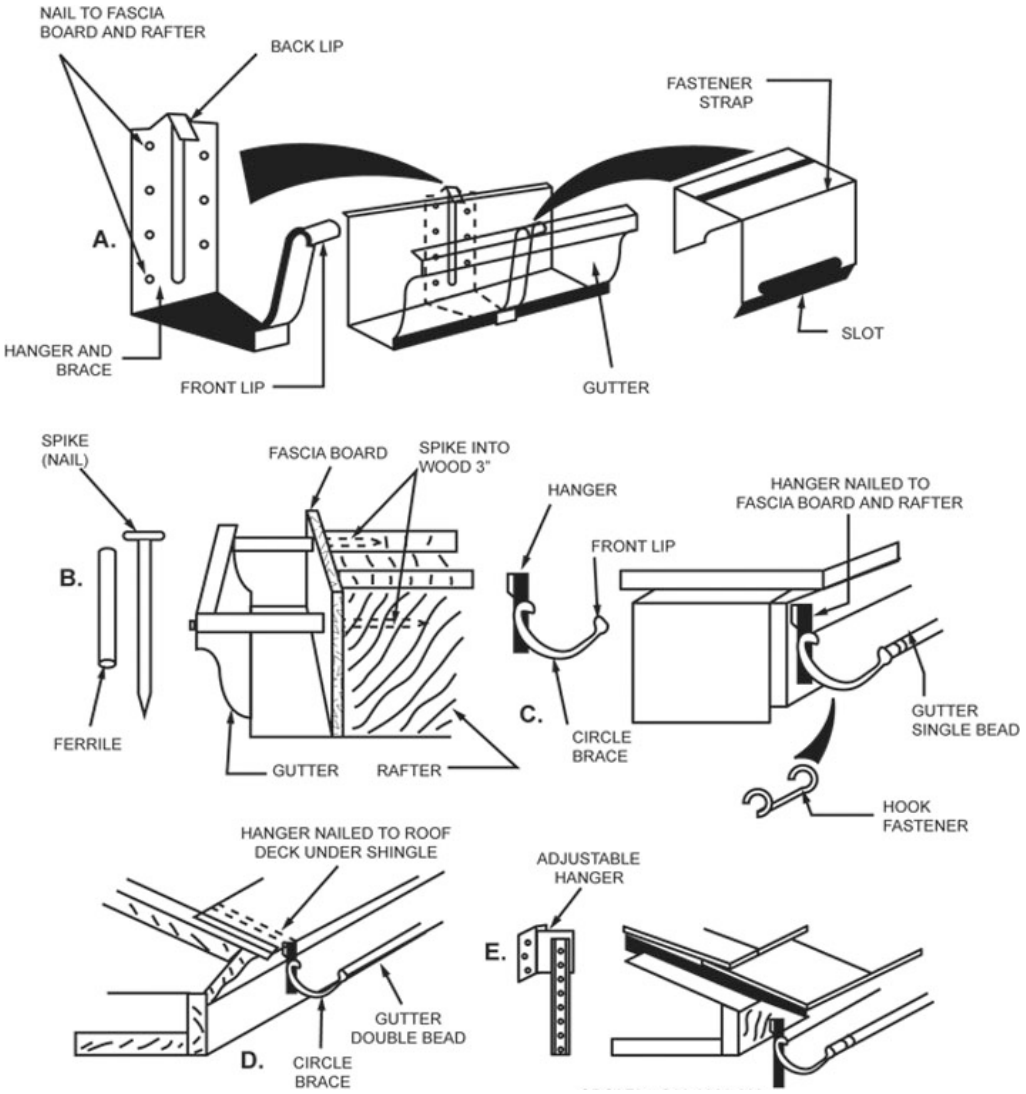

Figure 2–16. Gutter hangers and braces.

Other hangers, such as a straphanger, may be shop-made or commercially made. They are nailed to the roof deck and bolted to the bead on the gutter. Install this hanger with a brace for extra strength.

Gutters on metal buildings are supported from the roof and extend well under the eaves. Figure 2–17 shows a cutaway view of a typical metal building gutter. If the building is insulated, the rubber closure strips must be in place. You must be especially careful in removing or replacing this gutter, because of its large size.

Strainers

The Strainers in (fig. 2–12) can be shop-made or commercially made. Install a strainer at each downspout drop outlet to keep the downspout from being clogged with leaves or trash. Make the strainer so you can remove it easily for cleaning. The strainer in figure 2–12 is wedged into the gutter to hold it in place.

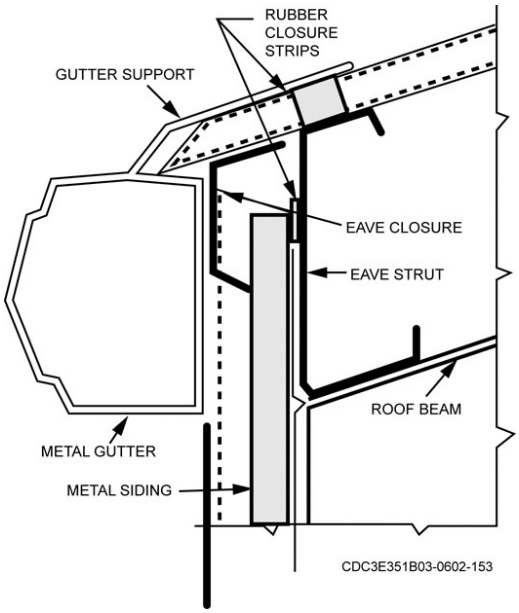

Figure 2–17. Gutter on a metal building.

Downspout drop outlets

Downspout drop outlets (figs. 2–12 and 2–18, A and B) are fastened to flat-bottom gutters. The round shape in figure 2–18, A can be used with a square or round downspout. The downspout outlet in 2–18, B is for a square downspout only. The oval downspout outlet in 2–18, C is for a round or rectangular downspout, but it is only used with a half-round gutter. All outlets taper so that the downspout pipe fits over the outlet. When you make a drop outlet in the shop, make it about 1/8 inch smaller than the downspout so that the downspout fits over the outlet. To fasten the downspout drop outlet to the gutter's bottom, solder the flanges on the inside of galvanized gutters. For copper gutters, rivet the flange to the gutter and then solder it. On an aluminum gutter, rivet the flange then seal it with silicone sealant.

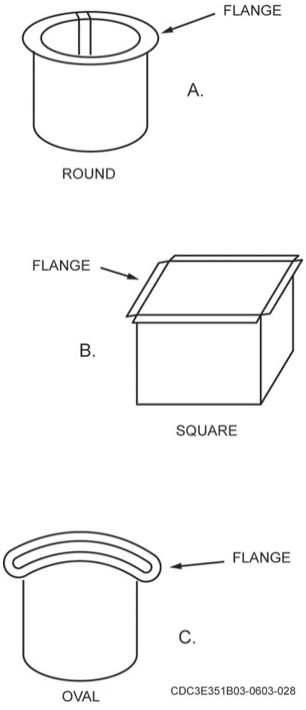

Figure 2–18. Downspout drop outlets.

Sources and materials

Downspouts route water from a gutter to the drainage system or to ground level. They are also called *conductor pipes* or *rain pipes*. You can usually make square and rectangular downspouts in your shop, but it is probably cheaper to buy them commercially made. The downspout shapes and sizes in figure 2–19, are the types that are usually commercially made. Plain and corrugated rectangular downspouts are usually 2 inches by 3 inches or 3 inches by 4 inches. Square corrugated downspouts are available in 2, 3, 4, and 5 inch sizes. Round corrugated downspouts are available in 2, 3, 4, 5, and 6 inch sizes. The standard commercial downspout length is 10 feet. The metals used to make these downspouts include galvanized steel, stainless steel, copper, or aluminum. Use the same metal for the entire system so all gutters share the same characteristics and to prevent possible galvanic action from taking place. Corrugated downspouts are normally used in cold areas where the water may freeze in the downspout. The corrugations allow for expansion when water freezes. Under such freezing conditions, plain downspouts may split because the pipe *cannot* expand.

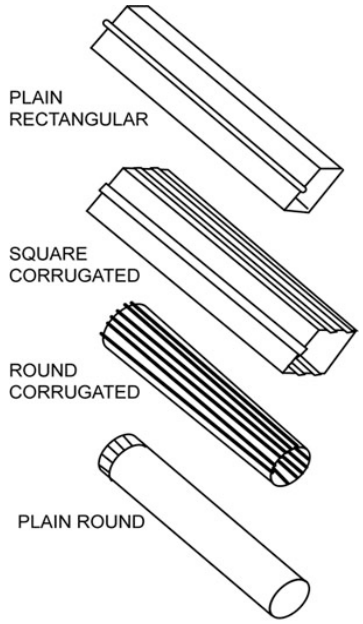

Figure 2–19. Downspouts.

Components

Downspout components include straight joints, elbows, and hangers. The elbows are used to make offsets and turns for routing the downspout. Elbows are available in different angles, such as 30°, 45°, 60°, and 90°. Avoid making sharp turns in your gutter and downspout system. Your goal is to have a smooth and continuous waterflow. The elbow at the downspout's bottom is sometimes called a *shoe*; it turns the water away from the building. Place a concrete pad at this outlet to keep the water from washing soil away from the building.

Use straphangers to support the downspout. They may be commercially made or made in the shop from galvanized steel, stainless steel, copper, or aluminum to match the downspout metal. The straps are usually 2 inches to 4 inches wide and long enough to fit around the downspout and make two flanges to fasten to the wall.

You fasten straphangers to the wall with nails, sheet metal screws, or anchor bolts, depending upon the wall type. If the wall siding is wood, use nails; if the siding is metal, use sheet metal screws and if the wall is brick, use anchor bolts. The spacing for the hangers should be specified on the working drawings. If it is *not* specified, a good rule to follow is two hangers for each 10-foot length of downspout.

Gutter installation general information

Install a gutter and downspout as specified on the working drawings. This discussion deals with a typical specification you might find on a working drawing. Install a gutter with the high end opposite the downspout so the water flows to the downspout outlet. Install hangers for the gutters no more than 30 inches apart on center. Install expansion joints at 40 foot intervals for 16 ounce copper and at 48 foot intervals for 20 ounce (and thicker) copper. When the gutter is aluminum 0.032 inches thick, install the expansion joints at 32 foot intervals (40 foot intervals for aluminum that is 0.040 inches or thicker).

Downspout installation specifications may also require that slip joints telescope ½ inch in the water flow direction. Fasten these joints with sheet metal screws and seal them with silicone sealant. Make the downspout plumb with the wall, but *not* against it; use straps to hold it away from the wall. Fasten the straps to the downspout with three screws and to the wall with two screws.

Gutter installation

To see how installation specifications are applied, let's go through a typical installation. Suppose your gutter is to be installed over a building entrance that is 6 feet across the front, 3 feet between corner miters, and extends 3 feet from the inside corner miter to the end. The gutter is galvanized steel and was commercially made, and is to be installed with hangers.

Start the installation by making a chalkline on the fascia board. Start the chalkline on the end opposite the downspout location. Hold the chalkline as close to the eave overhang as possible. On the other end, lower the chalkline ¼ inch so that the gutter has enough drop to let the water flow toward the downspout. Pull the line straight out, and then release it to make a straight chalk mark.

Next, place one end of the chalkline on the ¼ inch mark at the outside corner and stretch the line to the inside corner, lowering it ¼ inch more. Pull the string tight and make another chalk mark. Make the last chalkline, with another ¼ inch drop, from the inside corner to the gutter's end where the downspout is.

You can now start installing the hangers by putting sheet metal screws through the first hanger into the fascia and rafters about 3 inches from the gutter's high end. Make sure the hanger's top is on the chalkline. Install the next hanger 3 inches from the outside corner. Since specifications require hangers on not more than 30 inch centers, install two hangers 22 inches apart between the end hangers. Next, install the hangers between the outside corner and inside corner, 3 inches from the corners. The next hangers to be installed are between the inside corner and the gutter's outlet end. One hanger is 3 inches from the inside corner, and one is about 2 inches from the gutter end. Do not place the end hangers too close to the end caps.

Install the inside corner miter next. Place it in the hanger, with the top edge on the gutter's backside, and under the hanger's lip. Apply silicone sealant in the two slip joint pockets, and install the slip joints on each inside corner miter end. Install the outside corner miter the same way. Next, measure the distance from the two pocket bottoms on the two corner miters (add ½ inch to this measurement for installing a spacer). Cut a straight gutter piece to 23 inches, remove the outside corner miter, and slip the straight piece into the pocket at the inside corner miter. Now, reinstall the outside corner miter by slipping its joint pocket over the straight gutter piece's edge. You can now install the snap locks on the hangers to hold the gutter in position.

Now install the front gutter. First, you have to measure from the slip joint pocket (at the outside corner miter) to the end of the building. This measurement should be close to 65½ inches long. Cut the straight gutter piece to this length, and install the end cap (with solder) to the straight gutter. Install the gutter by placing the back edge under the lip on the hangers and pressing down on the front of the gutter. Slide the straight gutter into the outside corner slip joint, and install the snap locks on the hangers. The last gutter piece to install is the straight piece with the downspout drop outlet. Start by cutting a straight gutter piece 29½ inches long. Now you measure 6 inches from the outside edge

for the center of the drop outlet. Cut a hole for the drop outlet, install the drop outlet (with the flange inside), and solder around the flange. With the outlet and the end cap soldered into place, the gutter is ready to install in the hangers. Do this by inserting the back edge of the gutter under the lip on the hangers, pushing down on the front, slipping the edge into the slip joint, and installing the snap locks. Check all slip joints to see that they are well sealed. Apply sealant where necessary.

Downspout installation

Now lest's discuss how to install the downspout. Measure the distance from the gutter's bottom (drop outlet top) to the ground. The measurement is 11 feet 6 inches, and so we need one 10-foot straight downspout length and three elbows—one 90 degrees and two 45 degrees. Figure 2–20 shows a downspout assembly. (In this case, the assembled downspout is short enough to be held in place to check the fit.) Fasten the pieces together with sheet metal screws or blind rivets, and seal the joint connections. Position the assembled downspout with the upper elbow fitting over the gutter drop outlet, fasten with sheet metal screws, and install three hangers to support the downspout.

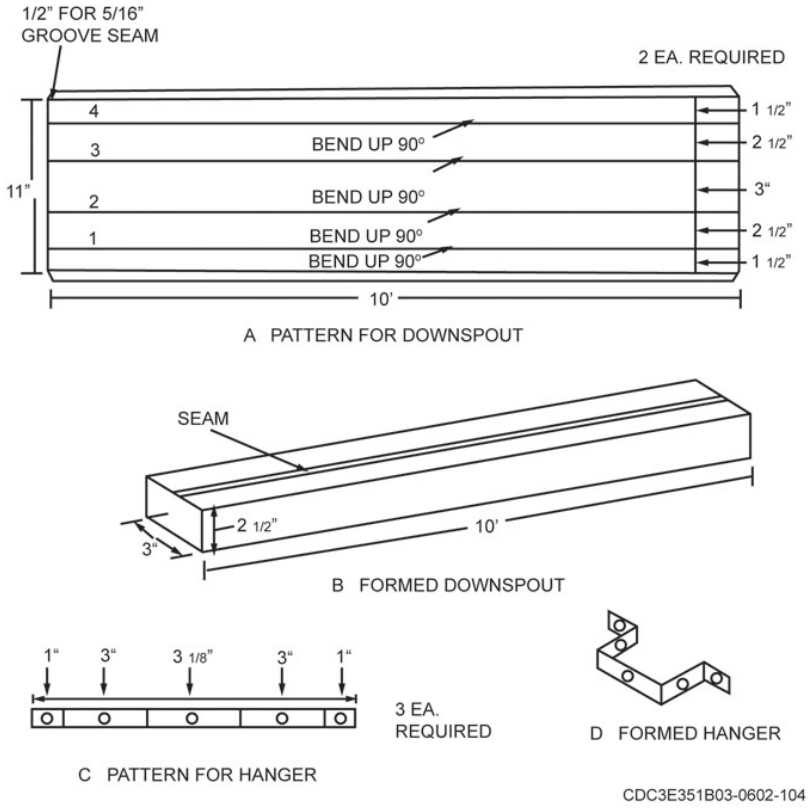

Figure 2–20. Making a downspout and hanger.

Minor gutter and downspout repair

Gutter and downspout repairs are usually only minor, such as resealing joints and refastening hangers. You may have to replace a small section from time to time. This lesson discusses the basic steps needed for repair.

Resealing gutters

Before you reseal a joint connection, remove the old sealant so the outside joint edges are clean. Apply new sealant with a putty knife or caulking gun. To re-solder seams, first clean the seams by heating the solder and wiping it with a clean, dampened cloth. Then apply flux and tin the seam. After you clean and tin the seam, solder it with a soldering iron (or a hot soldering copper) and solder.

The recommended way to repair small holes in gutters and downspouts is with solder. Larger holes may require a patch (made from the same material as the gutter to reduce galvanic action). You can refasten loose hangers with sheet metal screws, nails, or bolts. If a hanger is missing, make a new one to match the others or get a commercially available replacement.

When you find small holes in gutters or downspouts, examine the damaged area carefully for corrosion. Look for small pits in the metal. These pits show where corrosion is beginning to take hold. Painted gutters can have corrosion under the paint, which sometimes appears only as a bubble or a small pinhole on the surface. If you remove the bubble with a putty knife, you may find a large rusted area or a hole that has corroded deeply into the metal. Check the area thoroughly to find out how deep the corrosion is. You can test the metal's strength by pressing against the corroded surface with your putty knife blade. If the metal gives way, replace the damaged section.

Installing replacement gutter and downspout

Imagine that you need to replace a piece of gutter and downspout and the replacement parts are on hand. If the gutter hangers are still on the building, all you have to do is to place the gutter in the hangers and insert the snap locks. Before installing additional components, pour some water into the gutter's high end to see if it flows to the outlet on the low end. The drop should be enough to let the water flow from the gutter to the downspout. If the water does not flow smoothly, reposition the gutter hangers to increase the drop on the downspout side. With the gutter in place and working properly, you can install the replacement downspout.

1. Install the upper section over the drop outlet; then put sheetmetal screws in the downspout's three outside surfaces.
2. Install the straphanger just below the second offset.
3. Measure from the downspout's bottom to 3 inches above the ground level. This measurement, plus 1½ inches for a joint connection, is the downspout's lower section length. Cut a small notch in each corner of the upper downspout to make a slip joint.
4. Slip the lower downspout portion over the upper downspout portion and put sheet metal screws in three sides of the slip joint.

Put one hanger just above the shoe, put another hanger halfway between the top and bottom hangers, and you are ready for cleanup.

Self-Test Questions

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

811. Installing and repairing gutter systems

1. What factors determine a shop made box gutter's length?

2. What purpose does a bead serve in a gutter?

3. What sealant do you use to connect gutter sections with a slip joint?

4. What plugs the gutter's end? What holds it in place?

5. What is a ferrule and spike used for?

6. What component keeps a downspout from clogging?

7. What is a downspout's purpose?

8. Why do we not make downspouts from different metals than the gutters?

9. Why do we install corrugated downspouts in cold climates?

10. How do you get smooth waterflow in downspouts?

11. Why do you place a concrete pad under a downspout shoe?

12. How do you secure a downspout to a brick wall?

13. Why do you install a gutter with the high end opposite the downspout?

14. At what interval do you place hangers for a gutter?

15. What do you use to seal a slip joint connection on a downspout?

16. When laying out a 6-foot long gutter with a chalkline, why do you lower the end with the downspout ¼ inch?

17. What are the two points that you measure to determine downspout length?

18. What fasteners can you use to secure downspout components?

19. How do you repair a gutter's leaking slip joint?

20. How do you repair small holes in gutters?

21. What do you do if a hanger is missing?

22. How, why, and when do you test a newly installed gutter?

23. After installing a gutter, you discover that the water does not flow smoothly to the downspout, how do you correct it?

Answers to Self-Test Questions

809

1. Copper, aluminum, and galvanized steel.
2. Galvanic action.
3. An oxide coating (patina) that forms when copper is exposed to air and weather.
4. Lower cost and greater strength.
5. Parallel seams run parallel to the roof slope, and cross seams run across the slope.
6. With cleats; the seams are soldered.
7. Corrugated, 5V-crimp, or double ribbed.
8. Cleats fasten the roofing to the batten seam.
9. The lower sheet is placed downwind from the prevailing wind direction.
10. 1½ corrugations.
11. 6 inches.
12. So you can seal the joint with solder more easily.

810

1. Clean it with a wire brush or emery cloth and apply flux.
2. Solder the hole or break.
3. Solder.
4. By replacing the entire sheet with a new galvanized one.
5. Aluminum. To help prevent corrosion from galvanic action.
6. Covering the roof with acrylic or aluminum fiber coating.

811

1. Your job requirements, the metal length used, and the cornice brake machine size.
2. It adds strength to the gutter and improves appearance.
3. A non-hardening silicone sealant.
4. The end cap. Friction, solder, or silicone sealant.

5. To hang a gutter.
6. A strainer.
7. To route water from the gutter to the drainage system or to ground level.
8. So they share the same characteristics and prevent possible galvanic action from taking place.
9. To allow for expansion when water freezes.
10. By avoiding sharp turns.
11. To keep from washing the soil away.
12. With anchor bolts and a strap hanger.
13. So the water flows to the downspout outlet.
14. Not over 30 inches apart on center.
15. Sheetmetal screws and silicone sealant.
16. To allow enough drop for water flow to the downspout when the gutter is installed.
17. Measure the distance from the gutter's bottom (drop outlet top) to the ground.
18. Sheet metal screws or blind rivets.
19. Remove the old sealant and reseal with new sealant.
20. Clean the area around the hole and solder.
21. Make a new one to match the others or get a commercially available replacement.
22. With water. To be sure water flows from the gutter's high end to the outlet on the low end. As soon as the gutter is installed and before you install any other components.
23. Reposition the gutter hangers to increase the drop on the downspout side.

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).

32. (809) Two advantages of using galvanized steel sheets for roofing, rather than using aluminum or copper it is
    a. lower in cost and more rust resistant.
    b. lower in cost and greater in strength.
    c. less corrosive and greater in strength.
    d. more rust resistant and greater in strength.

33. (809) What seam do we use when a cross seam is necessary to join metal roofing sheets?
    a. Grooved.
    b. Standing.
    c. Parallel.
    d. Flat lap.

34. (809) On a grooved (flat) seam metal roof, be sure you make proper notches so that
    a. the seams will join evenly.
    b. you can set the seams easily.
    c. the cleat will fit into the seam.
    d. you can get a good solder joint.

35. (809) When you install metal roofing with lap seams, the sidelap directions are determined by the
    a. water runoff.
    b. prevailing wind.
    c. pitch of the roof.
    d. number of crowns in the seam.

36. (809) What is the *minimum* sidelap in installing corrugated roofing?
    a. 1-corrugation.
    b. 1 ½ corrugations.
    c. 2 ½ corrugations.
    d. 3 corrugations.

37. (810) We usually install copper roofing with which type seams?
    a. Grooved (flat), lap, and batten.
    b. Lap, batten, and standing.
    c. Standing, grooved (flat), and lap.
    d. Batten, standing, and grooved (flat).

38. (810) How would you repair galvanized roofing if a puncture is too large to solder?
    a. Apply a patch.
    b. Use roofing cement.
    c. Replace the entire sheet.
    d. Cover damaged area with a sheet of copper.

39. (810) What are some of the advantages of covering a roof with acrylic or aluminum fiber coating?
    a. Looks appealing, increases insulation factor, and reflects UV rays.
    b. Reduces energy costs, reduces labor costs, and extends life of the roof.
    c. Looks appealing, reduces energy costs, and increases life of roof by 4 years.
    d. Increases insulation factor, reflects UV rays, and increases life of roof by 4 years.

40. (811) Gutter and downspouts are typically made from what types of metal?
    a. Aluminum, copper, titanium, and magnesium.
    b. Aluminum, copper, stainless steel, and magnesium.
    c. Galvanized steel, stainless steel, copper, and aluminum.
    d. Galvanized steel, stainless steel, titanium, and magnesium.

41. (811) Strainers in a gutter system keep the
    a. birds from nesting.
    b. gutter from clogging.
    c. downspout from clogging.
    d. downspout from freezing.

42. (811) In a gutter system downspout, we use elbows to
    a. create shoes.
    b. make offsets and turns.
    c. join two or more downspouts.
    d. make offsets and reduce the downspout size.

43. (811) How far apart are gutter hangers installed?
    a. More than 36 inches on center.
    b. More than 30 inches on center.
    c. No more than 36 inches on center.
    d. No more than 30 inches on center.

44. (811) Minor gutter and downspout repairs include
    a. refastening hangers and resealing joints.
    b. resealing joints and replacing downspouts.
    c. replacing splash blocks and gutter sections.
    d. replacing downspout drop outlets and refastening hangers.

45. (811) After you replace a section of gutter,
    a. check the level with a chalk line.
    b. fill with water to check for hanger strength.
    c. pour water in the gutter to check for drainage.
    d. raise the hangers to ensure they are securely attached.

46. (811) What do you do to increase water flow from the gutter to the downspout?
    a. Increase the drop.
    b. Decrease the drop.
    c. Use a larger downspout.
    d. Level the gutter to the eave.

Please read the unit menu for unit 3 and continue ➔

Unit 3. Exterior and Interior Construction

EXTERIOR and interior building finishes include coverings for walls and floors. In this unit, we discuss some of the more common types of wall and floor coverings and how to install them. Depending on your current job assignment, you may not do much of these now, but there is a good chance that you will need to know how to install these finishes at a forward location someday.

3–1. Exterior Siding and Fences

Exterior siding is made from different metals, wood, vinyl, and various other types of materials. In this section, we only discuss metal and wood siding along with some attic ventilation techniques. Siding installation is part of the finished product. Your ability to install it correctly not only enhances the finished appearance of the structure, but it protects the structure's inner framework from the elements.

812. Installing and repairing metal siding

The Air Force uses metal buildings for such things as hangars, warehouses, and civil engineer or flight line shops. With so many metal buildings in use, you can see why there could be a high demand for maintenance and repair. Steel or aluminum siding is often used in constructing these metal buildings. The siding is usually sold in sheets that come in lengths up to 38-feet long; most are 3-feet wide. Figure 3–1 shows the standard and four-corrugation siding.

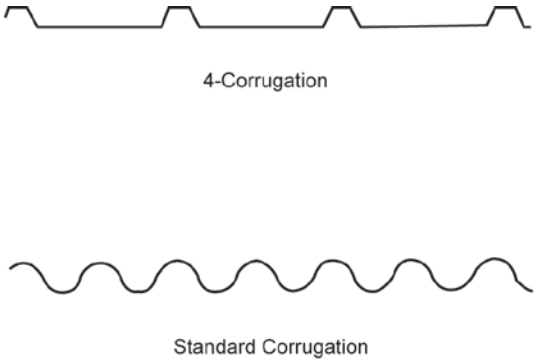

Figure 3–1. Metal siding types.

Aluminum

Manufacturers supply aluminum siding in various thicknesses and alloys. These sheets are normally coated (clad) with zinc or zinc/aluminum and painted to reduce corrosion and to improve appearance.

Steel

Steel sheets are zinc coated (galvanized) to reduce corrosion. To improve appearance, the siding can be primed and painted. Steel siding is more common because of its lower cost and it has greater strength than aluminum.

Installation

Lap seams are used on steel siding. For standard corrugated metal siding, the lap should be one and a half corrugations (fig. 3–1). To secure the sheet laps, use blind rivets or screws.

The most common fasteners for building siding are hex head, self drilling screws. Figure 3–2 shows a hex head, self drilling screw and the hex head bit we use to install it. These hex head bits are similar to a nut driver, but are used with an electric or battery powered drill that has a screwdriver setting. The screws selected should be zinc or cadmium plated to resist corrosion and be able to drill its own hole in siding and metal girts. Many have a neoprene washer under the screw head to provide a watertight seal.

NOTE: Make sure that you know the maximum metal thickness recommended for your self drilling screws. If the metal is too thick, use a twist drill bit to make a pilot hole first. After you do this, be careful when installing the self drilling screw to keep from snapping its head off.

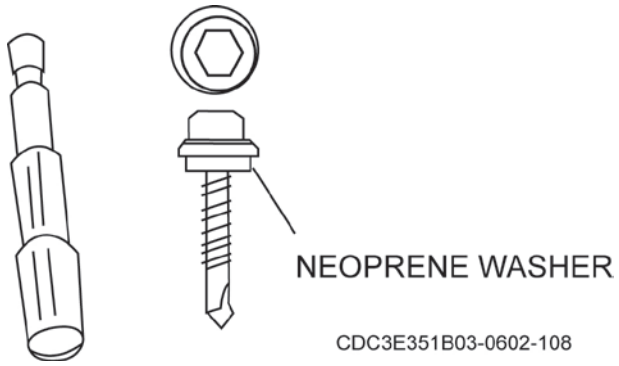

Figure 3–2. Self drilling hex head screw with matching installation bit.

NOTE: Start installing the siding at the end of the building in the direction the prevailing winds blow. This action ensures that the exterior joint in the side laps is away from the blowing of the prevailing winds.

Repair

Metal siding repair includes patching holes, replacing partial sheets, and replacing entire sheets. Your repair choice depends on the damage done to the siding. For a small hole, a patch is sufficient, but for large damaged areas, you may need to replace entire sheets or partial sheets. Use your judgment and experience to find the most effective, cost efficient repair method.

To prevent galvanic action (corrosion), make sure the patch or replacement siding sheet is the same metal as the original siding. To get a good seal, drill the holes in the patch and siding first. Use clecos to hold the patch while you’re drilling. After you drill the holes, remove the patch to deburr its back, thereby removing the metal chips from between the patch and the siding. Finally, apply silicone sealant or caulking compound to the patch’s back and install it with compatible fasteners (screws or rivets).

813. Installing and repairing wood siding and trim

The previous lesson discussed metal siding. In this lesson, we discuss wood siding and exterior trim. Wood siding is designed for either horizontal or vertical application. We begin with discussing both types of applications.

Wood siding

Wood siding can be obtained in many different patterns and can be finished naturally, stained, or painted. Wood shingles, plywood, wood siding (paneling), fiberboard, and hardboard are some types of material that are used as exterior coverings. The essential properties required for siding are good painting characteristics, easy working qualities, and freedom from warp. Such properties are present to a high degree in cedar, eastern white pine, sugar pine, western white pine, cypress, and redwood; to a good degree in western hemlock, spruce, and yellow popular; and to a fair degree in Douglas fir and yellow pine.

Material

The material we use for exterior siding that is to be painted should be of a high grade and free from knots, pitch pockets, and uneven edges. Vertical grain and mixed grain (both vertical and flat) are available in some species, such as redwood and western red cedar. Check to see that the moisture content at the time of application is the same as what it will attain in service. To minimize seasonal movement due to changes in moisture content, choose vertical grain (edge grain) siding. While this is not as important for a stained finish, the use of edge grain siding for a paint finish results in longer paint life.

If a preservative is not already applied, dip the siding into a water repellent preservative before you install it. This results in longer paint life and resists moisture entry and decay. Brush treat freshly cut ends on the job.

Patterns for horizontal application

The wood siding patterns we discuss here are designed for horizontal application. When these types of siding are applied directly to the studs, install diagonal bracing to stiffen the building and help the structure hold up against strong winds and other twist and strain forces.

Plain bevel

Plain bevel siding (fig. 3–3) can be obtained in sizes from ½ by 4 inches to ½ by 8 inches and also in sizes of ¾ by 8 inches and ¾ by 10 inches. “Anzac” siding is ¾ by 12 inches in size. Usually, the finished width of bevel siding is about one half inch less than the size listed. One side of beveled siding has a smooth planed surface, whereas the other has a rough sawn surface. For a stained finish, the rough or sawn side is exposed because wood stain works best and lasts longer on rough wood surfaces.

Dolly varden

Dolly Varden siding is similar to bevel siding except that it has shiplap edges. The shiplap edges have a constant exposure distance (fig. 3–3). Because Dolly Varden lays flat against the studs, it is sometimes used for garages and similar buildings without sheathing.

Drop siding

Regular drop siding can be obtained in several patterns, two of which are shown in figure 3–3. This siding, with matched or shiplap edges, is available in 1 by 6 inch and 1 by 8 inch sizes. It is commonly used for low cost homes and for garages, usually without sheathing. Tests have shown that the tongue and grooved (matched) patterns have greater resistance to the penetration of wind-driven rain than the shiplap patterns when both are treated with a water repellent preservative.

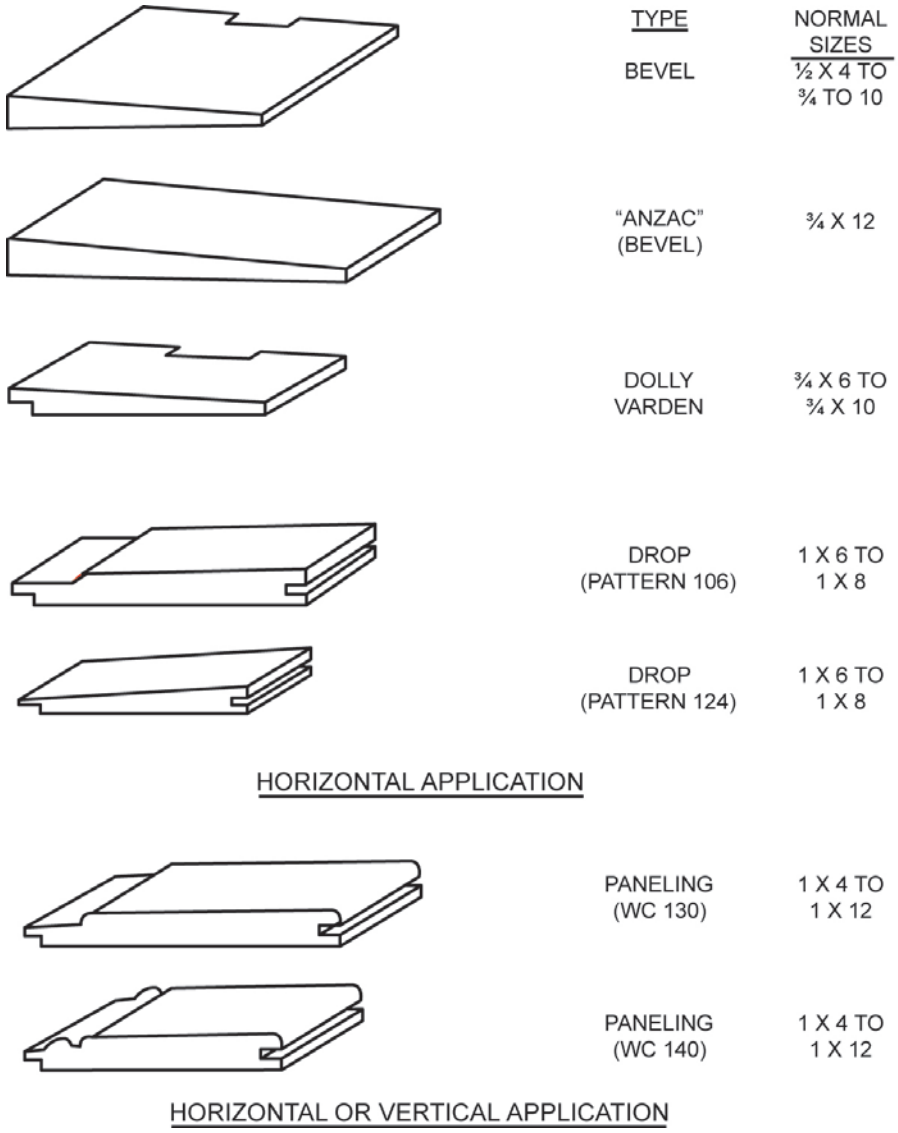

Figure 3–3. Types of wood siding.

Fiberboard and hardboard

Fiberboard and hardboard sidings are also available in various forms. Some have a backing to provide rigidity and strength, whereas others are used directly over sheathing. Plywood horizontal lap siding, with a medium density overlaid surface, is also available as an exterior covering material. It is usually ⅜ inch thick and 12 or 16 inches wide. It is applied in much the same manner as wood siding, except that a shingle wedge is used behind each vertical joint.

Treatment

Treating the edges of drop, matched, and shiplapped sidings with water repellent preservative helps prevent wind=driven rain from penetrating the joints that are exposed to the weather. In areas under wide overhangs or in porches or other protected sections, the treatment is not as important. Some manufacturers provide siding with this treatment already applied.

Siding for vertical applications

Some popular architectural styles use rough sawn boards and battens applied vertically. These can be arranged in three ways: board and batten, batten and board, and board and board (fig. 3–4).

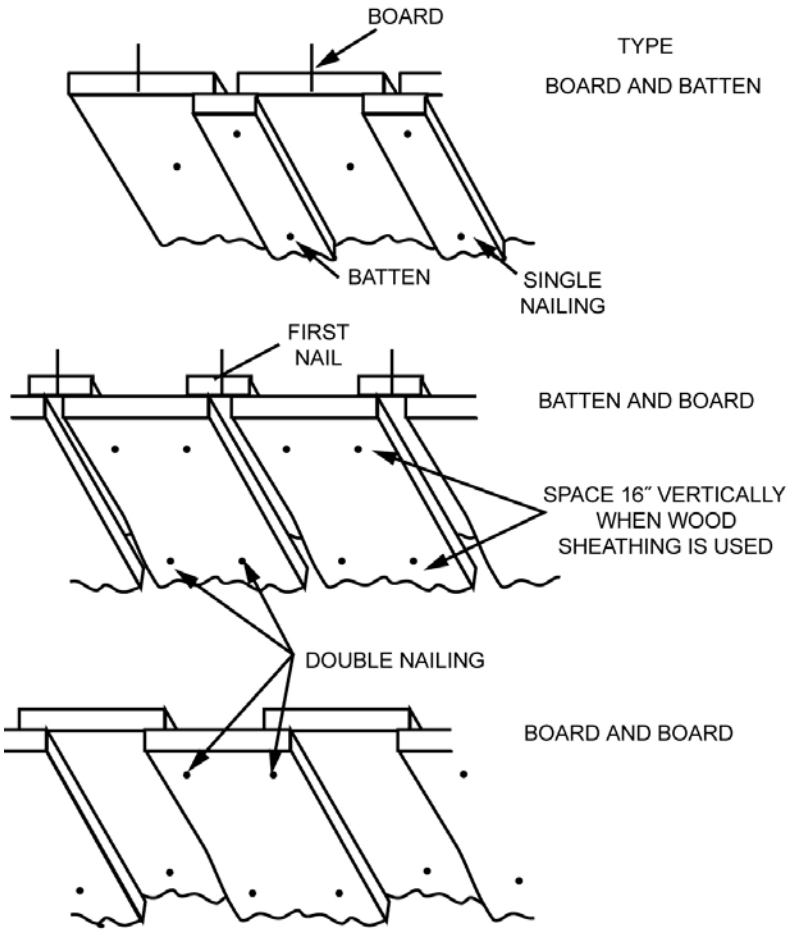

Figure 3–4. Vertical board siding.

Sheet materials

A number of sheet materials are now available for use as siding. These include plywood in a variety of face treatments and species, and hardboard. Plywood or paper overlaid plywood, also known as panel siding, is sometimes used without sheathing. Paper overlaid plywood has many of the advantages of plywood besides providing a satisfactory base for paint. If you apply panel siding directly to studs spaced 16 inches on center, the panel siding must be a minimum ⅜ inch thick. However, ½ or ⅝ inch thick sheets perform better because of their greater thickness and strength.

Standard siding sheets are 4 by 8 feet; larger sizes are available. Most types of siding sheets are applied vertically with intermediate and perimeter nailing to provide the desired rigidity; however, some types are designed for horizontal or vertical application.

Where horizontal joints are necessary, use simple flashing (Z bar) to protect the top of the lower sheet. Always use exterior grade plywood for siding; you can obtain it in grooved, brushed, and saw textured surfaces. These surfaces are usually finished with stain. If shiplap or matched edges are not provided, waterproof the joints. Waterproofing often consists of caulking and a batten at each joint and a batten at each stud if closer spacing is desired for appearance. An edge treatment of water repellent preservative also aids in reducing moisture penetration. When plywood is being installed in sheet form, allow a $^{1}/_{16}$ inch edge and end spacing.

Fasteners

One of the most important factors in the successful performance of various siding materials is the type of fasteners we use. Nails are the most common; don’t use them sparingly. Galvanized,

aluminum, and stainless steel corrosive resistant nails may cost more, but their use ensures spot free siding. Do not use ordinary steel wire nails to attach siding since they tend to rust in a short time and stain the face of the siding. In some cases, the small head nails will show rust spots through the putty and paint.

We commonly use two types of nails with siding: the small head finishing nail and the moderate size flathead siding nail:

1. Set the small head finishing nail (driven with a nail set) about $^{1}/_{16}$ inch below the face of the siding. Fill the hole with putty after you apply the prime coat of paint.
2. Nail the flathead siding nails (used more commonly) flush with the face of the siding and cover them with paint.

If the siding is to be natural finished with a water repellent preservative or stain, fasten it with stainless steel or aluminum nails. In some types of prefinished sidings, nails with color matched heads are supplied.

Nails with modified shanks are available. These include the annularly (ring) threaded shank nail and the spirally threaded shank nail. Both have greater withdrawal resistance than the smooth shank nail, and, for this reason, you can often use a shorter nail. In siding, drive exposed nails flush with the surface of the wood. Overdriving may not only show the hammer mark, but may also cause splitting and crushing of the wood. In sidings with prefinished surfaces or overlays, drive the nails so as not to damage the finished surface.

Building paper

Before you install the siding, apply a breathable-type building paper to the walls. This is only necessary if housewrap has not already been applied. To install the paper:

1. Start at the bottom of wall and apply it horizontally.
2. Fasten at the bottom, center and top with large head roofing nails.
3. Install the upper layer by lapping the lower layer at least 4 inches.

NOTE: Apply the building paper over any flashing placed on the sides and above any doors and windows and the corner boards. Also, be sure to tuck it under any flashings placed below windows or frieze boards to keep water from running behind the paper.

Installing horizontal wood siding

You can install siding only after you install the window and doorframes. In order to present a uniform appearance, the siding must line up properly with the drip caps and the bottom of the window and doorsills. At the same time, it must lineup at the corners. Siding must be properly lapped to increase wind resistance and watertightness. In addition, it must be installed with the proper nails and in the correct nailing sequence.

Exposure

The minimum lap for bevel siding is 1 inch. The distance from the underside of the windowsill to the top of the drip cap usually determines the average exposure distance (fig. 3–5). From the standpoint of weather resistance and appearance, the butt edge of the first course of siding above the window should coincide with the top of the window drip cap. In many one story structures with an overhang, this course of siding is often replaced with a frieze board. It is also desirable that the bottom of a siding course be flush with the underside of the windowsill. However, this may not always be possible because of varying window heights and types that might be used in a structure.

One system we use to determine the siding exposure width so that it is approximately equal above and below the windowsill is as follows:

1. Divide the overall height of the window frame by the approximate recommended exposure distance for the siding used (4 inches for 6-inch-wide siding, 6 inches for 8-inch-wide siding, 8 inches for 10-inch-wide siding, and 10 inches for 12-inch-wide siding). This result is the number of courses between the top and the bottom of the window. For example, the overall height of our sample window from the top of the drip cap to the bottom of the sill is 61 inches. If we use 12-inch-wide siding, the number of courses would be 61/10 = 6.1, or six courses. To obtain the exact exposure distance, divide 61 by 6 (10.17) and the result would be $10\ ^{3}/_{16}$ inches.
2. Determine the exposure distance from the bottom of the sill to just below the top of the foundation wall. If this distance is 31 inches, follow the same formula as we mentioned above. Thus, you would use three courses of $10\ ^{5}/_{16}$ inches each—the exposure distance above and below the window would be almost the same (fig. 3–5).

When this system is not satisfactory because of big differences in the two areas, it is preferable to use an equal exposure distance for the entire wall height and notch the siding at the windowsill. Make sure the fit is tight to prevent moisture from entering.

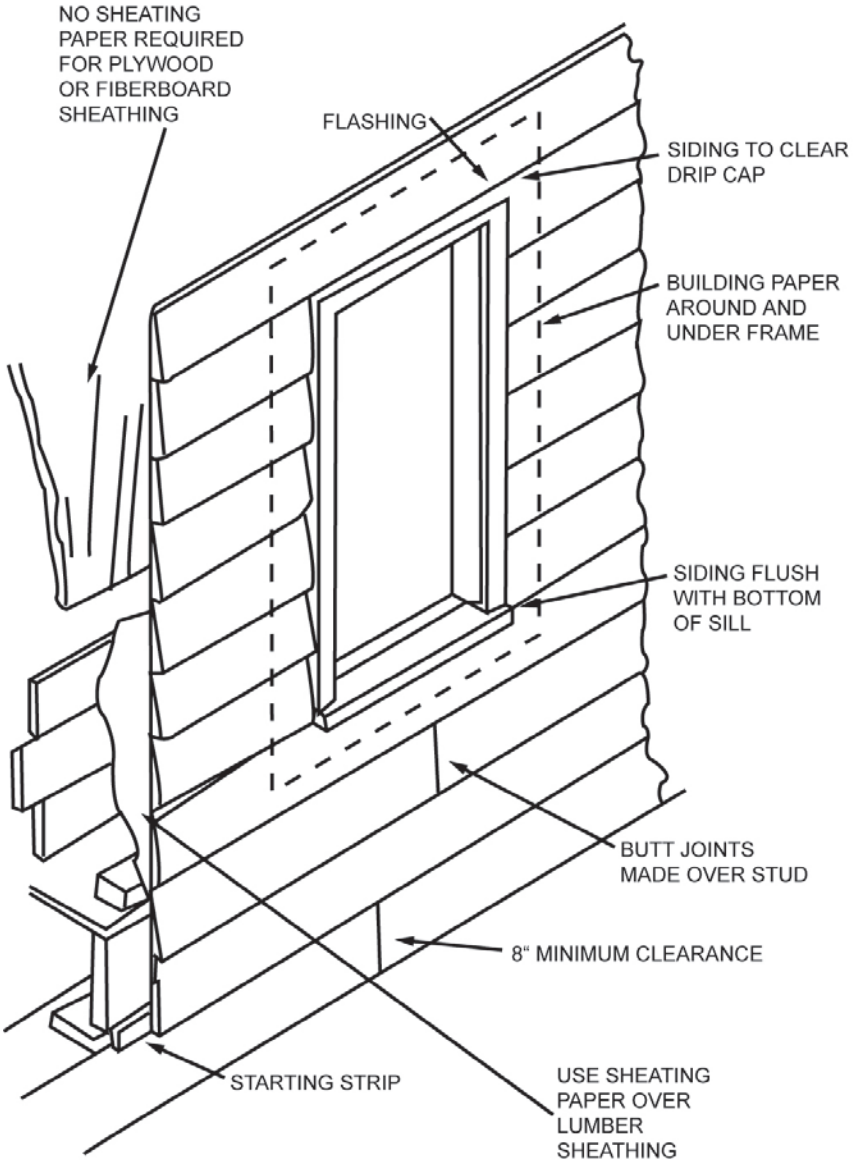

Figure 3–5. Installation of bevel siding.

Corner treatments

You can finish the outside corners of a wood framed structure in several ways. Siding boards can be miter joined at the corners. Shingles can be edge lapped alternately. The ends of siding boards can be butted at the corners and then covered with a metal cap.

Corner boards

You can use this type of corner finish with almost any kind of outside wall covering. Apply it to the corner with the siding butted against the boards.

A corner board usually consists of two pieces of stock: one piece 3 inches wide and the other 4 inches wide. Cut the boards long enough to extend from the top of the water table to the bottom of the frieze.

It is best to edge butt and nail them together before you nail them to the corner. This ensures a good tight joint. Tack a strip of building paper over the corner before you nail the corner board in position. **NOTE:** Always allow an overlap of paper to cover the subsequent crack formed where the ends of the siding butts against the corner board.

Interior corners

Butt interior corners against a square corner board of nominal 1¼ or 1⅜ inch size, depending on the thickness of the siding.

Mitered corners

Mitering the corners of bevel and similar sidings is often not satisfactory, unless you do it carefully to prevent openings. A good joint must fit tightly the full depth of the miter. Also, treat the ends with a water repellent preservative before nailing.

Metal corners

Metal corners give a mitered effect, and are perhaps more commonly used than the mitered corner. You can easily place them over each corner as you install the siding. Make sure the metal corners fit tightly; nail them on each side to the sheathing or corner stud beneath. If the metal is galvanized iron, clean it with a mild acid wash and prime it with a metal primer before you paint the structure. This prevents the paint from prematurely peeling.

Bevel siding installation method

We usually install siding starting with a bottom course; however, bevel (lap) siding can be installed from the top. Since installing from the bottom is more common, we only cover this installation method.

The following is one method we use to install bevel siding starting at the bottom:

1. Fasten a furring strip (same thickness and width as the top of the siding) along the bottom edge of the sheathing.
2. Snap a line along the wall where the top edge of siding is to be placed. Snap all lines according to the desired exposure.
3. Start installing the siding from one end. Fasten the siding to each stud or approximately 16 inches on center. On bevel siding, place the nail through the bottom edge of the upper board high enough so that it just misses the top edge of the board below (usually ⅛ inch). (**NOTE:** Do not place nails through the lap.)
4. Continue installing each succeeding course by overlapping the upper edge of the course below.

Joints

Avoid butt joints whenever possible. Use the longer sections of siding under windows and other long stretches, and use the shorter lengths for areas between windows and doors. When a butt joint is necessary, place it over a stud and stagger it between courses. Square cut the siding to provide good joints. Open joints permit moisture to enter and often lead to paint deterioration. It is a good idea to brush or dip the fresh cut ends of the siding in a water repellent preservative before you nail the boards in place.

NOTE: We install drop siding in much the same way as bevel siding except for spacing and nailing. Drop, Dolly Varden, and similar sidings have a constant exposure distance. Normally, we use one or two nails at each stud, depending on the width (fig. 3–6). The length of the nail depends on the type of sheathing used, but penetration into the stud or through the wood backing should be at least 1½ inches.

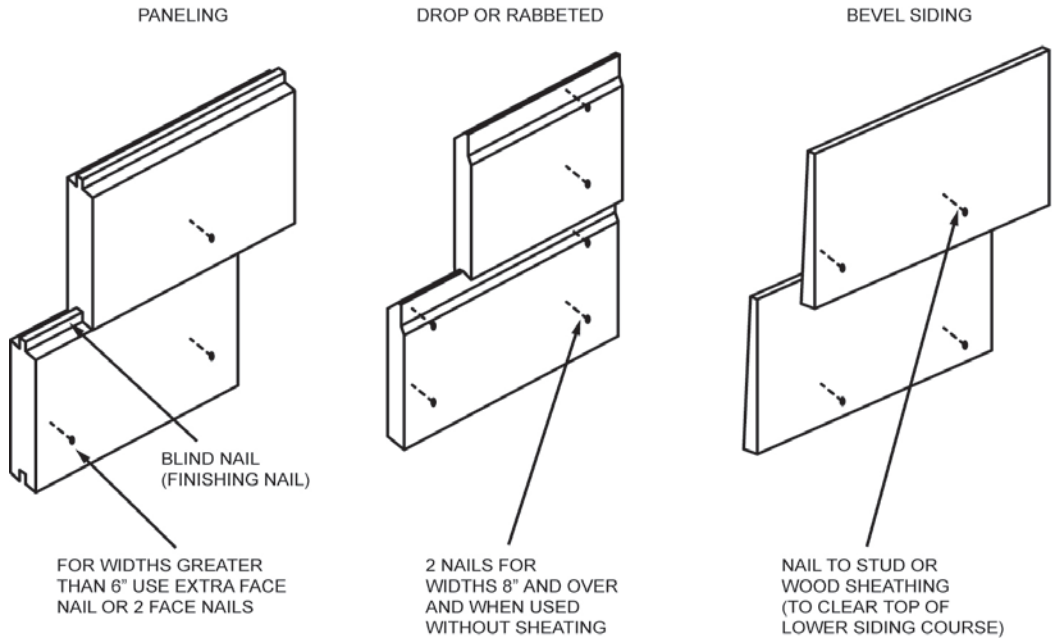

Figure 3–6. Nailing the siding.

Installing vertical tongue and groove siding

You can install this siding in the same manner as you do horizontally applied siding. However, nail it to the blocking used between studs or to plywood sheathing. Place the blocking 16 to 24 inches on center (OC). If you are installing it on plywood or board sheathing, place the nails 16 to 24 inches on center, unless specifications state otherwise.When you install this type of siding vertically, you do not need to use corner boards. You can fit the siding boards around the corner. To install:

1. Rip the grooved edge from the first piece.
2. Place it on the wall with the tongue facing away from the corner and the bottom placed about 1 inch below the sheathing or top edge of the foundation. Ensure it is plumb and secure it in place.
3. Install a temporary piece on the other side and fasten a stringline along the bottom to use as a guide. Install the next piece to the line and toenail through the tongue.
4. Repeat steps for succeeding boards.
5. On the last piece, rip the board to the desired width (cut off the tongue side).

Installing panel siding vertically

Panel siding we usually apply vertically. It is relatively easy to install. Depending on the type, there may be different installation or fastening methods; however, we discuss one suggested method:

1. Place a panel on the wall with one edge square and flush with the corner (center the inner edge on a stud).
2. If the panels are ½ inch or less, fasten them with 6d siding nails. Use 8d siding nails for panels thicker than ½ inch. Place the nails 6 inches on center on the perimeter and 12 inches on center throughout the intermediate studs.

Drive the nails into the studs; have them penetrate into the wood at least 1½ inches. Caulk the joints of all types of sheet material with mastic unless the joints are shiplapped or covered with batten strips.

NOTE: Place a strip of 15-pound asphalt felt under the joints.

Flashing

Install flashing at the junction of material changes, chimneys, and roof wall intersections. Use it over exposed doors and windows, roof ridges and valleys, along the edge of a pitched roof, and any other place where rain and melted snow may penetrate.

To prevent corrosion or deterioration where unlike metals come together, you must use fasteners that are made of the same kind of metal as the flashing. For aluminum flashing, use only aluminum or stainless steel nails, screws, hangers, and clips. For copper flashing, use copper nails and fittings. Fasten galvanized sheet metal or terneplate with galvanized or stainless steel fasteners. (**NOTE:** Terneplate is a steel plate coated with an alloy of lead and a small amount of tin.)

One wall area that requires flashing is at the intersection of two types of siding materials. For example, we flash a stucco finish gable end and a wood siding lower wall (fig. 3–7). A wood molding, such as a drip cap, separates the two materials and is covered by the flashing, which extends at least 4 inches above the intersection. When we use sheathing paper, it should lap the flashing (fig. 3–7).

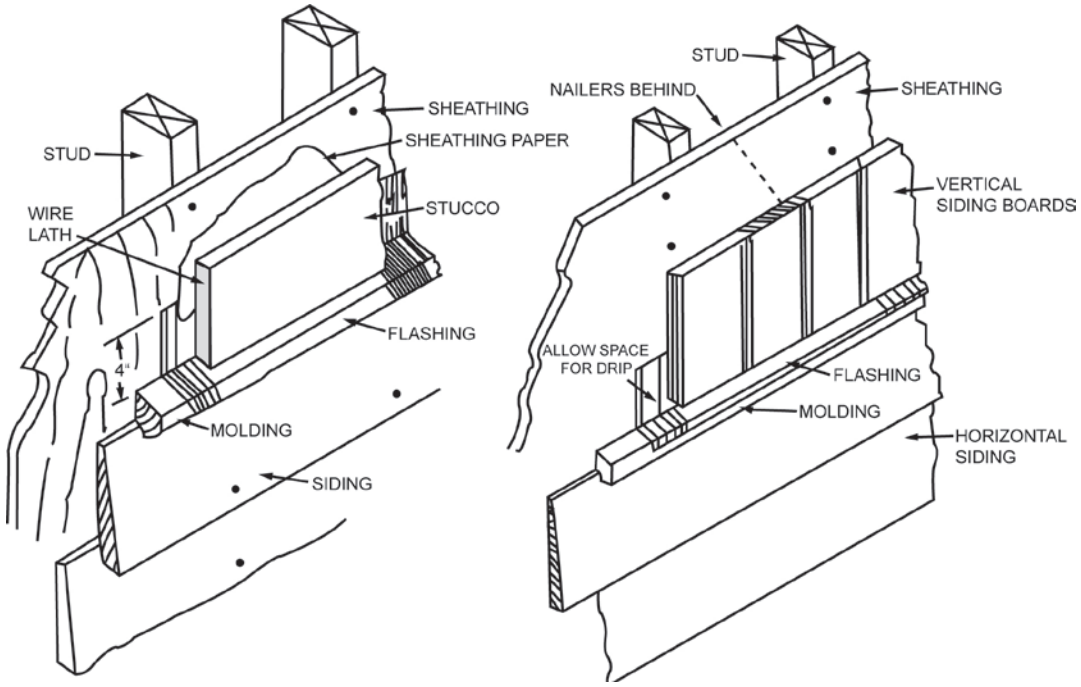

Figure 3–7. Flashing of material changes.

Flash the intersection when a wood siding pattern change occurs on the same wall. A vertical board sided upper wall with horizontal siding below usually requires some type of flashing (fig. 3–7). A small space above the molding provides a drip for rain. This prevents paint peeling, which could occur if the boards were in tight contact with the molding. We sometimes use a drip cap (fig. 3–8) as a terminating molding.

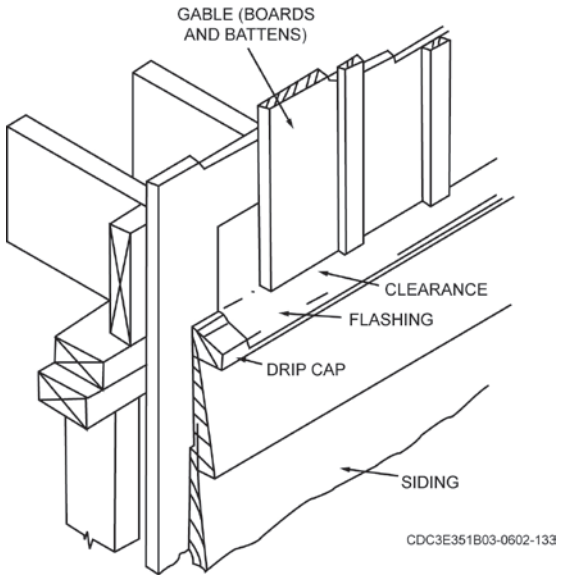

Figure 3–8. Gable end finish (material transition).

Door and window flashing

Use the same type of flashing shown in figure 3–7 over door and window openings that are exposed to driving rain. However, window and door heads protected by wide overhangs do not ordinarily require flashing. When you use building paper on the sidewalls, make it lap the top edge of the flashing. To protect the walls behind the windowsill in a brick veneer exterior, extend the flashing under the masonry sill up the underside of the woodsill.

Repairing wood siding

To repair wood siding, you must first make sure that you have the same kind of replacement material on hand.

Lap siding

To replace lap type siding, you need to:

1. Remove the nails from the piece of siding above the damaged siding.
2. Remove the nails from the damaged siding.
3. Install new piece of siding and secure in place.
4. Resecure existing siding above new piece.

Panel siding

To replace panel siding, you need to:

1. Remove the nails from the damaged siding (and adjacent panel if lapped over).
2. Replace entire damaged member.
3. Fasten in place using original fastening methods.

814. Ventilation techniques

We discussed thermal insulation in a previous volume. We install insulation to conserve energy by controlling heat flow. Unfortunately, the insulation's effectiveness is reduced when moisture becomes trapped in it. Attics must be well ventilated to help remove the condensation (moisture). In this lesson, we discuss some effective ventilation techniques.

General information

Condensation of moisture vapor may occur in attic spaces and under flat roofs during cold weather. Even where vapor barriers are used, some vapor will probably work into these spaces around pipes and other inadequately protected areas and through the vapor barrier itself. Although the amount might be unimportant if equally distributed, it may be sufficiently concentrated in some cold spots to cause damage. While wood shingle and wood shake roofs do not resist vapor movement, such roofings as asphalt shingles and builtup roofs are highly resistant. The most practical method of removing the moisture is by adequate ventilation of roof spaces.

A warm attic that is inadequately ventilated and insulated may cause formation of ice dams at the cornice. During cold weather after a heavy snowfall, heat causes the snow next to the roof to melt. Water running down the roof freezes on the colder surface of the cornice; this will often form an ice dam at the gutter that may cause water to backup at the eaves and into the wall and ceiling. Similar dams often form in roof valleys. Ventilation provides part of the solution to these problems. With a well insulated ceiling and adequate ventilation attic temperatures are low and melting of snow over the attic space is greatly reduced.

In hot weather, ventilation of attic and roof spaces offers an effective means of removing hot air and lowering the temperature in these spaces. Insulation is used between ceiling joists below the attic or roof space to further retard heat flow into the rooms below and materially improve comfort conditions.

Ventilating gable roofs

It is common practice to install louvered openings in the end walls of gable roofs for ventilation. Air movement through such openings depends primarily on wind direction and velocity. No appreciable movement can be expected when there is no wind. You can obtain positive air movement by providing additional openings (vents) in the soffit areas of the roof overhang (fig. 3–9, view A) or ridge (view B).

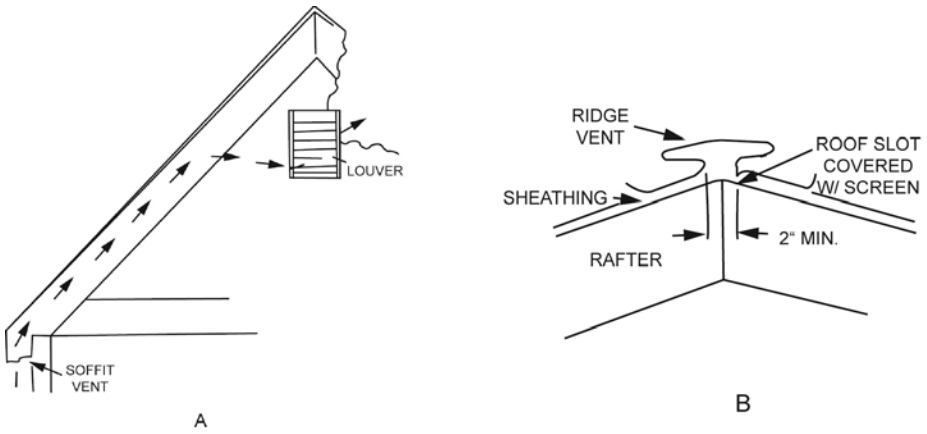

Figure 3–9, A and B. Attic outlet vents.

Gable end ventilators

Various styles of gable end ventilators are available. Many are made with metal louvers and frames, whereas others may be made of wood to more closely fit the structural design. However, the most important factors are to have properly sized ventilators and to locate ventilators as close to the ridge as possible without affecting the appearance of the structure.

Ridge vents

One of the easiest and best ways to vent an attic is to install a continuous ridge and soffit vents. To do this:

1. Cut the roof sheathing back from the ridge approximately 1 inch on each side.
2. Nail the ridge vent over the slot you have created. Remember to use compatible materials. For example, use aluminum nails with aluminum vent material. Because the ridge vent also covers the top of the roofing, be sure the nails are long enough to penetrate into the rafters. Caulk the underside of the vent before nailing.
3. Fasten ridge shingles (ridge units) directly to the vent.

Ventilating hip roofs

Hip roof structures are best ventilated by soffit vents and by outlet ventilators along the ridge. The differences in temperature between the attic and the outside create an air movement independent of the wind, and also a more positive movement when there is wind. We also use turbine type ventilators to vent attic spaces (fig. 3–9, view C).

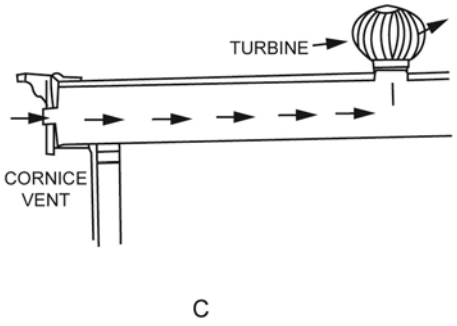

Figure 3–9, C. Attic outlet vents.

Another method you can use is to install vents along the hip in a similar fashion to those used on the ridge:

1. Cut slots 2½ inches wide by 24 inches long and spaced 12 inches apart the entire length of the rafter. The hip rafter is 1½ inch wide, so this leaves a ½ inch slot on each side of the rafter.
2. Install vent material over the hip rafter.
3. Fasten hip shingles (hip units) directly to the vent.

Ventilating crawl spaces

Where there is a crawl space under the house or porch, ventilation is necessary to remove the moisture vapor rising from the soil. Such vapor may otherwise condense on the wood below the floor and cause decay. As we mentioned earlier, a permanent vapor barrier on the soil of the crawl space greatly reduces the amount of ventilation required. Tight construction (including storm windows and storm doors) and the use of humidifiers have created potential moisture problems that must be resolved by adequate ventilation and the proper use of vapor barriers. Avoid blocking soffit vents

with insulation, for example, because this can prevent proper ventilation of attic spaces. Inadequate ventilation often leads to moisture problems, which result in unnecessary maintenance costs.

Louvers

The openings for louvers and in the wall fans (fig. 3–9, view D) are quite similar. In fact, fans are usually covered with louvers. Louver slats should have a downward pitch of 45 degrees to minimize water blowing in. A backing of corrosion resistant screen is needed to keep insects out, as with soffit vents. Ventilation fans may be manual or thermostatically controlled.

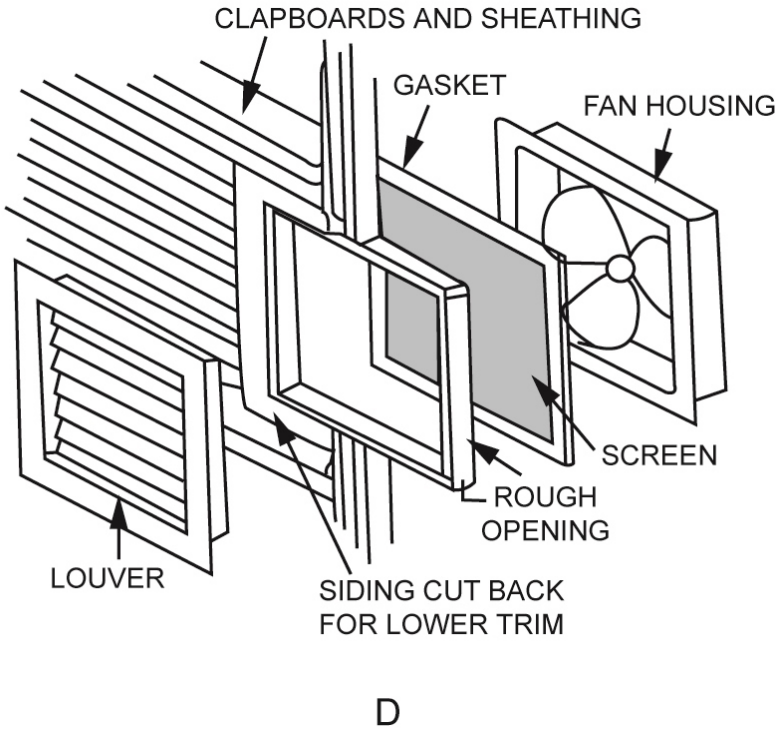

Figure 3–9, D. Attic outlet vents.

When installing a louver in an existing gable end wall, disturb the siding, sheathing, or framing members as little as possible. Locate the opening by drilling small holes through the wall at each corner Snap chalk lines to establish the cuts made with a reciprocating saw. Cut back the siding to the width of the trim housing the louver (or the louver with fan), but cut back the sheathing only to the dimensions of the fan housing. Box in the rough opening itself with 2-by-4s and nail or screw the sheathing to them. Flash and caulk a gable end louver as you would a door or a window.

Soffit vents

Small, well distributed vents or continuous slots in the soffit provide good inlet ventilation. These small louvered and screened vents (fig. 3–10, view A) are easily obtained and simple to install. You only need to cut small sections out of the soffit to install these vents, which you can saw out before you install the soffit. It is better to use several small, well distributed vents than a few large ones. Install any blocking that might be required between rafters at the wall line to provide an airway into the attic area.

Locate a continuous screened slot vent near the outer edge of the soffit near the fascia (fig. 3–10, view B). This location minimizes the chance of snow entering. We also use this type of vent on the overhang of flat roofs.

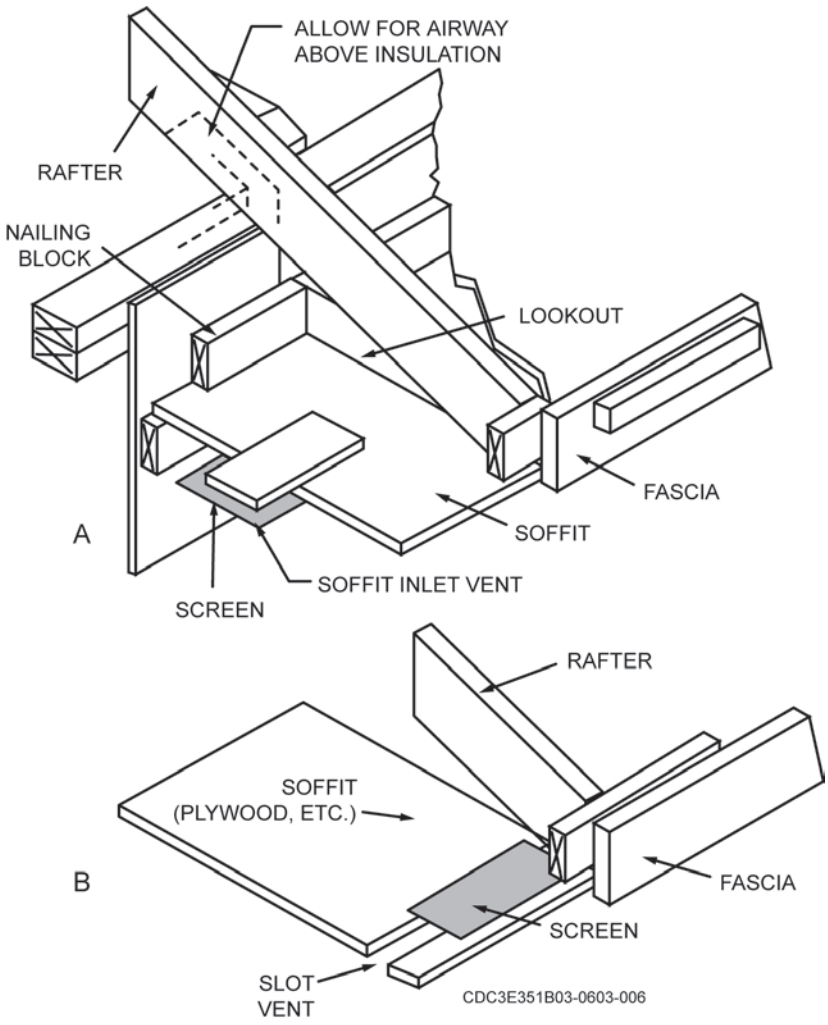

Figure 3–10. Inlet vents.

815. Constructing wooden fences

In this lesson, we discuss the various components involved in constructing wooden fences. Your ability to install and maintain a fence correctly not only enhances the appearance of the surrounding area, it provides added security for the structure within it. Depending on your current job assignment, you may not do a lot of new wooden fence construction now, but there is a good chance that you will need to know how to in the future, possibly at a new assignment, or a forward location. We start with types of wooden fences.

Types of wooden fences

The first step in constructing a wooden fence is determining what the purpose of the fence is going to be. The next step is choosing a type of fence to suite that purpose. We discuss four of the most common types of fences and their uses.

Boundary fence

Boundary fences are designed to mark territories and perimeters. They are used more for a psychological barrier than a physical one. These types of fences do not have to be substantial in size to be effective. Boundary fences range as small as 3 feet 6 inches tall (used to direct traffic flow, and personnel, but does not restrict access) to as tall as 8 feet. These types of fences are typically used to enclose a building or area.

Security fence

Security fences are used primarily to keep something in or out. To be effective, a security fence must be tall, strong, and hard to climb over. Wooden fences are typically used for low to moderate security; whereas, barbed wire, chain link, and brick or block are used for high security.

Privacy fence

The main purpose of a privacy fence is to screen activities within the enclosure from the view of those outside of it. These types of fences are usually made up of closely spaced, tight fitting, or overlapping boards or panels. Privacy fences discreetly separate areas and are most effective when they cannot be seen over, under, around, or through.

Screening fence

Screening fences add some privacy but still allow the breeze to pass through. This type of fence can block out noises or undesirable views just as well as a privacy fence.

Design constraints

After choosing the type of fence you are to use, you must then think about how you are going to design it to meet its' intended purpose. Some factors that you might want to consider are: is there an object or building you wish to screen out, unforgiving terrain (hilly or uneven), an immovable object to work around, weather, and local laws or base regulations. When you are designing your fence, take each of these into consideration equally.

Sightline

The effectiveness of a fence depends not only on the height, but also on the distance between the observer and the object that you wish to screen out, or, to put it another way, the angle of your line of sight (sightline). You must make sure that you design and build the fence high enough to block the intended view.

To design a fence tall enough to screen or block the view of buildings or objects from your point of view, begin by studying your site, and measuring off the necessary distances. Then on graph paper, draw a horizontal line (assuming the area is flat); otherwise, draw the actual contour of the land. Plot the intended object and your desired point of view. The line that connects these dots represents your true line of sight (sightline). Now extend a vertical line up from the ground line at your proposed fence line until it intersects the sightline. Scale off the length of the vertical line to find out how tall your fence has to be in order to block the view.

To verify your calculations in the field, stand or sit where you would normally view or approach from. Have a helper stand on the proposed fence line with a plumbed storypole (a length of 1 by 2 inches will do) and mark the height at which the view of the object or building is blocked. If the mark appears higher than the object you wish to block, the fence will be effective.

Terrain

The terrain of the building site for the fence is a major design consideration. Design and build the fence to accommodate any slopes in the terrain. Figure 3–11 shows examples of different infills for an incline in the terrain. Major slopes could change the amount of material needed. You must survey the area for any obstructions that fall in line with the fence that may cause problems. The easiest option is to build the fence following the contour of the terrain. (**NOTE:** If an obstruction falls in line with the fence, you can build around it or remove it).

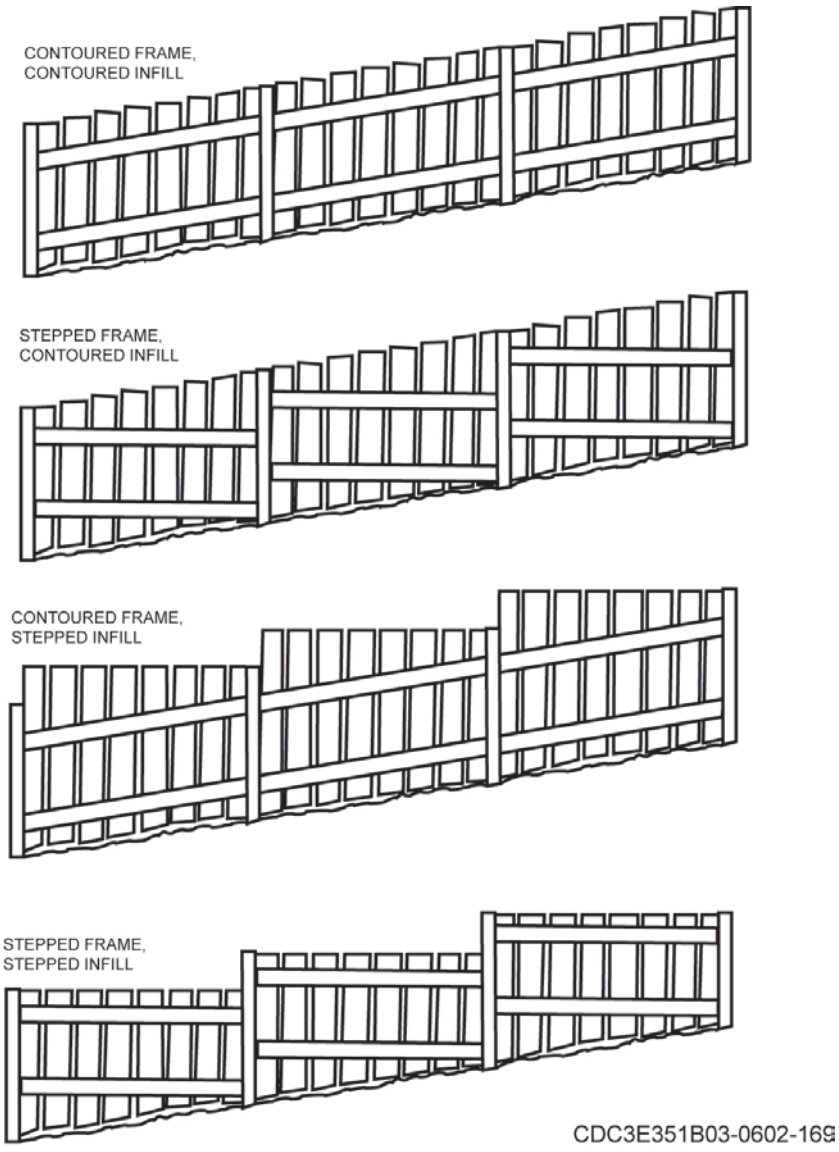

Figure 3–11. Types of infill for incline terrain.

Local weather

You must consider the local weather (rain, snow, and heat) when planning your fence. Types of materials, fasteners, finishes, and structural design are determined by their ability to withstand the local weather. (**NOTE:** You must make sure that your construction complies with local, base, and any federal laws or regulations that apply.)

Parts of wooden fences

The fences that you may work on vary, but the fences use basically the same components. To install your fence properly, you must know how and where these components are installed. We start by looking at the various components that you may use.

Gate posts

Gate posts must bear a greater load than line posts and terminal posts. The normal practice is to dimension these posts one size larger than the line posts, which require a deeper footing. Gate posts (also referred to as hinge posts) are the posts on which the gate is hung. The post to which the gate is latched we call the latch post.

Line posts

Place line posts between terminal or corner posts. They are used to support the stringers or rails, and the infills.

Terminal posts

We place terminal posts at corners, end, and gates. Terminal posts are usually larger than line posts.

Post footings

We make post footings by digging a hole in the ground, adding gravel for the drain bed (allows water to drain away from the post), placing a post in the center, and filling the hole with concrete. Post footings give you a strong and stable base that adds to your security and carries the weight of the fence components. Figure 3–12 shows examples of various post footings.

The rule of thumb is to set fence posts at least one third of their length: 2 foot for a 6 foot post, leaving 4 feet above grade; and at least 3 feet for a 10 foot post, leaving 7 feet above grade; the average size footing used with most fences is 12 inches in diameter and 1/3 length deep. All posts must be a minimum of 2 feet deep.

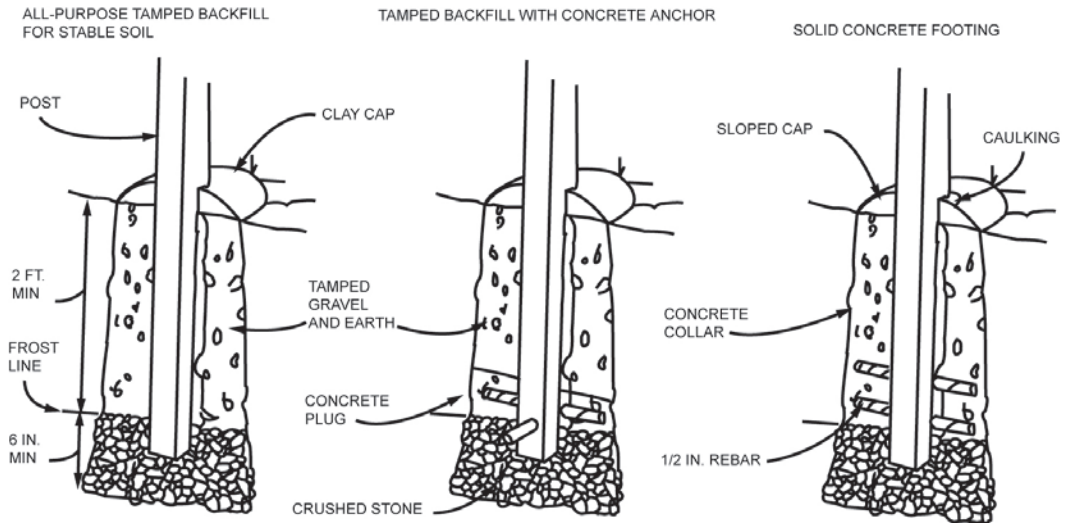

Figure 3–12. Post footings.

NOTE: Because gate, corner, and terminal posts provide additional support, set them at least one foot deeper than the line posts. The basic principle is that the posts must be thick enough and close enough together to bear the weight of the stringers or rails, and the infill they carry. Remember, that as you increase post spacings, the stringers must be wider to prevent sagging. Eight-foot centers are generally considered the upper limit for 2 inch by 4 inch rails. If you have a heavy infill, try not to use 2 inch by 4 inch for spacing over 6 feet. Use 2 inch by 6 inch instead. 2 inch by 6 inch stringers are definitely a requirement for spacing over 8 feet. Use the guideline below to calculate post size and spacing for poles:

- Four inch by four inch posts on six foot centers work well with light or heavy infills and low fences, or with light infills and tall fences.
- Four inch by four inch posts on eight foot centers work for light infill and slightly heavier infills with rails on edge.
- Four inch by four inch posts on 10 foot centers mark the upper limit of full inch thick horizontal board fencing.
- Six inch by six inch posts on eight foot centers are structurally and visually strong. They are good for heavy board or plank infills, both vertically and horizontally, and for through

mortised peeled pole rails. Use two inch by four inch, two inch by six inch, or four inch by four inch rails.

- Six inch by six inch posts on 10 foot centers can easily carry heavy infills and rails for both low and tall fences. Use two inch by six inch or four inch by six inch rails. The criterion for choosing eight foot or 10 foot spacing is visual rather than structural.

Stringers

Stringers carry the load of the infill and join the posts to each other. Sometimes we refer to the stringers as "rails". The three types of stringers (rails) we use are the top, middle, and bottom (which get their names from their positions). We can place stringers two ways: flat and on edge. When we use them in the flat position, they are more susceptible to sagging. Figure 3–13 shows examples of stringer types.

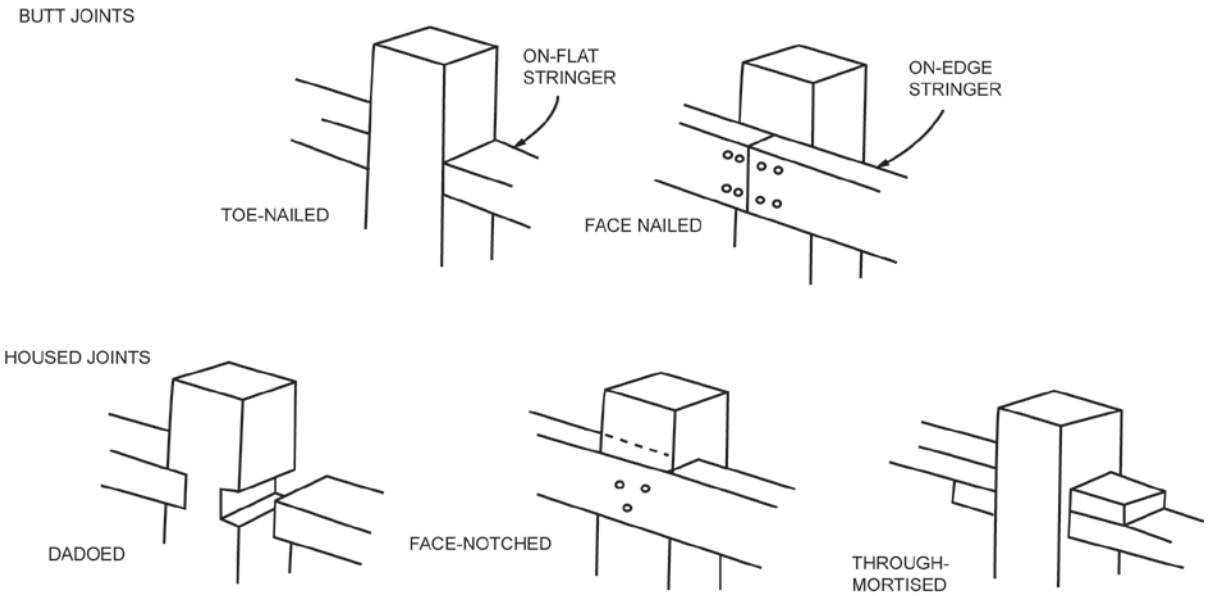

Figure 3–13. Types of stringers.

Infill

The filler or (infill) is the visually prominent surface that we usually see. Pickets, boards, and panels are just three of the most common types of infill constructed (fig. 3–11).

Hardware

Hardware includes but is not limited to: screws, nails, metal brackets, hangers, anchors, and gate hardware (hinges, latches, and stops). The most common fasteners are hot dipped galvanized nails. To prevent nails from backing out, use spiral threaded (annular) or ring shanked nails. The very best nail to use is a stainless steel ring shanked siding nail (they will not rust or break as easily). For ultimate holding power and ease of construction, use screws (decking screws). If you have an extremely heavy fence or gate you may have to use heavy duty fasteners such as: carriage bolts, machine (hex head) bolts, and lag bolts.

NOTE: An extremely heavy gate requires heavy duty hinges, latches, and stops.

Hinges

There are three basic kinds of hinges for gates: butt, strap, and lag. We briefly describe each and their uses. We begin with the butt hinge.

Butt hinge

Butt hinges are the familiar flat, rectangular plates (leaves) linked together by a hinge pin inserted through the hinge barrel. They can be either face mounted or mortised door style into the edge of the gate stile and the side of the post. In either position, butt hinges swing only one way. Since they make gate installation more convenient, loose pin butts (the hinge pin is removable) are preferred over fixed.

NOTE: be sure to install them right side up so that the hinge pin does not fall out. Most *"utility"* butt hinges are fixed pin only. Butt hinges are not a good choice for gates that are over three feet wide.

Strap hinge

Strap hinges are a much better choice for all kinds of gates. Their long plates distribute the load over a much wider area with much less angular leverage than butt hinges. T strap hinge is the normal, and more elegant solution. The long strap of this combination hinge bears the heavy load of the gate, while its rectangular leaf fits the post. All strap hinges have fixed pins. A wide choice of sizes, styles, and finishes are available to suit just about any type of gate.

Lag hinge

Lag hinges (also known as pintle-type lag hinges) are the no nonsense workhorses of the gate hinges. They are the ideal choice for use with round posts. The stout (3/8 inch and up) L shaped male half, or pintle, screws into a pilot hole drilled into the gatepost. The female eye half is either through-bolted to the face of the gate or threaded into its stile. Either way, the eye is simply dropped down onto the projecting pintle. Because there are no small screws and hinge barrels to come loose, lag hinges can carry very heavy gates without sagging. Their sheer heft requires an equally strong gate frame and post anchorage. A 1 inch stile is too thin for edge attachment. Use a through bolted strap style lag hinge instead. The same goes for a 4 inch by 4 inch post. Setting a pintle type lag hinge in the gate stile allows the gate to swing in either direction in almost a full circle. The swing arc of a face mounted lag is limited to 180 degrees.

Latches

There are three basic kinds of latches, each differentiated by how they are mounted to the gate: face mounted, through mounted, and bailed. When choosing a gate latch, consider: style, visual appeal, mounting requirements (how much of the hardware is to be concealed or revealed), convenience of operation, security requirements, and the thickness of the gate stock. Some latches can only be face mounted, while others only mount on the back of the gate.

Thumb latches are most commonly used. Thumb latches and other sorts of through latches will not work in thick panels (such as box frames), unless the lever is custom lengthened. Face mounted latch styles range from hooks to slide bolts and include door style knob handled lockset. They all mount on either face of the gate and post. String operated pivots ("latch strings") and thumb latches are two of the most traditional types of through latches, which operate by opening a catch on one side of the gate from the other by means of a lever inserted in a hole bored through the gate.

Stops

The stop is typically a vertical piece of wood attached to the latch post or gate face. The stop reduces stress on hinges by stopping the gate before it can over swing its normal operational arc. Although you can use the same sort of wood for the stop as you do for the gate, since the stop is subjected to considerable abuse from repeated collisions with the gate stile, a hardwood strip might be a better choice.

Gate

The gate provides passage through the fence. You must consider the primary use of the gate to establish its size (people, vehicles, and maintenance equipment). Gates must not only be correctly braced but also be braced in the right direction. Figure 3–14 shows examples of the wooden and wire

braces. When the brace runs from the bottom of the gate at the hingepost to the top at the latchpost end, the downward load is exerted against the strongest and most stable point of the post.

A gate can also be braced in tension, by pulling the opposing sides together. You can complete this by running a threaded steel rod and a turnbuckle diagonally from latchpost to hinge post, exactly opposite to the correct direction of a wooden brace. Tightening the turnbuckle pulls the corners of the gate together. If well built and correctly hung, the gate will withstand loads without sagging.

NOTE: A significant advantage of this kind of tension brace over a wooden compression brace is it is lightweight. Another advantage is the ability to adjust the brace to take up slack.

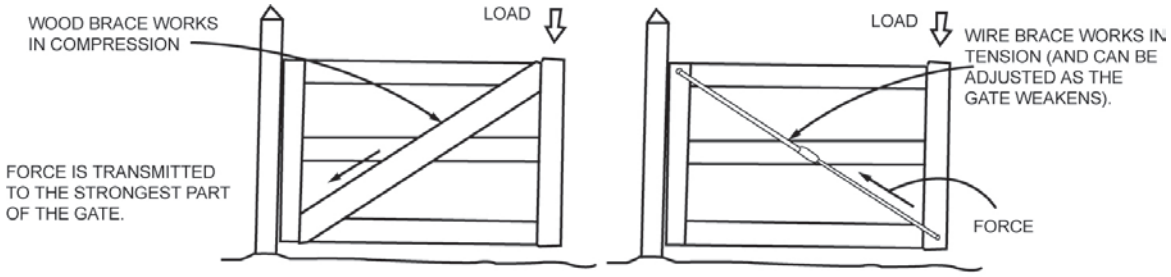

Figure 3–14. Gate bracing.

A strong frame is the most critical component of a well built gate. The two most common type gates are the Z frame and the perimeter (box) frame.

Z frame gate

Because the Z frame gate is not as rugged as the box frame, only use it for small (3 foot wide or less), lightweight gates. Build the Z frame gate with on edge lumber (frame lumber is vertical or on edge).

Perimeter (box) gate

Build the box gate with an on flat frame (frame lumber is horizontal or flat). It is more rugged than the Z frame gate, but needs more clearance to close without binding on the latch post.

Installation of wooden fences

There are numerous methods you can use to install a fence. We recommend that you start by knowing the quantities of materials needed, have the proper tools to do the job, and know the exact location of the fence. Use your graph paper with the sketch and an Engineering assistant with a transit to stakeout the fence line. Accurate layout is needed in order for you to erect a fence in the right location. (**NOTE:** You must complete an Air Force Form 103 *Base Civil Engineering Work Clearance Request*, before you begin to layout/stakeout your fence.) The purpose of this form is to prevent you from accidentally striking an electrical, phone, or water line that is underground or overhead, by having them identified and marked for you.

Area layout

For straight sections of fence, you must install batter boards a few feet from the termination points. You then stretch a string (for a reference line) between the batter boards to make sure you have a straight and level line. To achieve a level reference line, you can use a line level (which is the least accurate method because of the long distances involved with the fence). For a more accurate reading you can use a water level. The most accurate method is to have an engineering assistant with a transit shoot your lines.

Corners

When you get to a corner, you can use the 3 4 5 method to ensure a true right angle corner or have an engineering assistant stake it out for you. If you have angles other than a right angle, have the

engineering assistant stake it out. You then install batter boards at least 3 feet from the fence line and repeat the steps you used for a straight line.

Once you stretch a reference line along the fence line, drive a wood or steel stake at predetermined increments (pole spacing) along the reference line to mark the post locations for your fence. One method for doing this is to mark your pre-determined increments (pole spacing) on your reference line then use a 4 foot carpenters' level to plumb the line to the ground and drive a wood or steel stake. A quicker method is to cut a piece of 1 inch by 2 inch wood (gauge pole) to the pre-determined length (pole spacing). Lay the gauge pole on the ground under the reference line, and then drive a wood or steel stake at one end. Repeat this step for the length of the fence. (**NOTE:** You need to be sure that you carefully measure the distance between any gateposts.)

Tools and equipment

You have no doubt heard the statement, "*Use the right tool for the right job.*" It holds true for fences. There are many tools that you can use to make the job easier, faster, and safer. Some may be more practical to use than others, depending on the fencing job size. For large fencing jobs, a tractor mounted earth auger would dig the postholes easier and faster than manual posthole diggers. Using a ready mix truck or portable concrete mixer is faster than manual mixing. Of course, you must have shovels to place the concrete.

Here are some other tools required to erect a fence:

- Carpenters' level, line level, or water level. String line. Sledgehammer for stakes.
- Claw hammer, cordless drills with apex bits, circular saw, miter saw, hand saw, extension cords.
- Hoe, wheelbarrow, pry bar, steel tape, 100-ft. reel tape, combination square, speed square, saw horses.
- Personal protective equipment such as hardhat, long sleeve shirt, safety glasses, hearing protection, steel toed boots, and leather gloves.

Installation

Installing a wooden fence is not a difficult task. Below is one method that you can use:

1. Dig post holes 12 inches in diameter and to a predetermined depth.
2. Set each post in the center of a post footing and fill the hole with concrete. Make sure that the posts are braced and plumbed until the concrete sets.
3. Install top stringers. Middle stringer next, if they are used. Bottom stringer last.
4. Attach the infill.
5. Mount hinges on the gate first. Check fit. Hang gate.
6. Install the stop on the latchpost. Add any supplemental tension braces. Install the latch.

Finish

Determine what type of finish to apply to your fence. The primary purpose of the finish is to protect and prolong the life of the fence. Painting, staining, and water repellant clear protective finishes are the most common choices. There is no clear advantage of one over the other. The main difference is appearance. The key to a long lasting finish is proper surface preparation. It is important to clean the surface of all loose grime, dust, oil, and grease and let the wood dry before priming. Wait until dew or rain evaporates before you apply the finish. The more care you take in the surface preparation and application of the finish, the longer it will last.

Maintenance and repair

You must maintain fencing as needed. A vehicle may run through the fence, requiring immediate repair to secure government property. A section of fence may deteriorate over time, requiring you to replace or repair it. Loose, broken, and missing fence components are some common defects in fencing. Repair and maintenance is most often done on posts, stringers (rails) and infill, gates, and finish.

Good fence maintenance promotes safety and security of people and wildlife, and it prevents minor fence defects from becoming major failures. Preventive maintenance begins with an annual inspection. Check the following components during your inspection:

- Posts.
- Stringers and infill.
- Gates.
- Finish.

Post repairs

Fence problems are most often post problems. Posts are the first things to go. A few options for repairing posts include:

- Adding a post brace.
- Reanchoring and aligning (using wedges).
- Repairing split posts with scabbed material, splicing with like material, or through bolting.
- Digging out the old post and replacing it.

Stringer and infill repairs

Broken, rotten, or missing stringers and infill are easy repairs. Replace missing or damaged components with like material. A result of damaged or missing stringers and infill is the fence becomes crooked. One of the most difficult repairs is truing (straightening out) the fence.

After replacing or repairing the fence components, work as a team to true the fence. Pushing on one section may cause another section to move, so you will have to counteract that movement with diagonal bracing. Use a stringline stretched between two end or corner posts to ensure a true straight line in your fence. It may be necessary to dig up old post footings and reset the posts with new concrete to ensure the fence stays in position.

Gate repairs

The most common repair for gates is sagging. Gates usually sag due to a problem with the hardware. If the problem stems from hinges that are too small, replace them with beefier ones. Replace screws that are too small with larger, longer ones. If hinges and screws are tight and strong, check the hinge post for lean.

If the hinge post is leaning, you must plumb the post by repairing or replacing its footing if necessary. To reduce the chances of future recurrence, add a tension brace from the hinge post to the bottom of its adjoining line post.

If the gate's sag is not caused by the hardware or the hinge post, it must be the gate frame. You can true up the gate frame with a threaded turnbuckle tension rod (with flattened ends for screws). Squaring a gate is easier than taking it apart and rebuilding the joints.

NOTE: If the gate binds after a damp spell, you can plane ¼ inch from its leading edge. In hot dry weather, if the latch falls short of the catch, reposition the latch or replace the bolt with a longer one.

Finish

When you replace or repair a fence component, you must finish it to match the rest of the fence. To keep the fence from being damaged, you must replace it if the finish of the fence is deteriorated or falling off. Surface preparation is the key to properly replacing the finish. It is important to clean the surface of all loose grime, dust, oil, and grease and let the wood dry before priming. Wait until dew or rain evaporates before you resurface. The more care you take in the surface preparation and application of the finish, the longer it will last.

NOTE: To repair most defects, follow the steps for installing the fence. Be sure to follow applicable safety precautions. Always replace parts with like materials.

Self-Test Questions

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

812. Installing and repairing metal siding

1. What two metals do we commonly use for metal building siding?

2. What fastener do we use to fasten steel metal siding to a building?

3. What are the three most common repairs to metal building siding?

813. Installing and repairing wood siding and trim

1. What are the three essential properties required for wood siding?

2. Which side of beveled siding do you use for a stained finish? Why?

3. What type of siding do we usually use for low cost homes and garages and usually install without sheathing?

4. Why do you treat the edges of drop, matched, and shiplapped sidings with water repellant preservative?

5. What type of plywood should you always use for siding?

6. What type of nails cost more, but ensures spot-free siding?

7. What two types of nails with modified shanks are available? Why can you use a shorter nail of these types?

8. What is the minimum lap for bevel siding?

9. How do you usually apply panel siding?

814. Ventilation techniques

1. What results during cold weather if a warm attic is inadequately ventilated and insulated?

2. In hot weather, what does ventilation of attic and roof spaces offers an effective means of doing?

3. What can you install between ceiling joists below the attic or roof space to further retard heat flow into the rooms below and improve comfort conditions?

4. What is common practice to install in the end walls of gable roofs for ventilation?

5. What is one of the easiest and best ways to vent an attic?

6. What can you install on hip roof structures to ventilate them best?

7. Where there is a crawl space under the house or porch, why is ventilation necessary?

815. Constructing wooden fences

1. Which type of fence is designed to mark territories, and perimeters?

2. Wooden fences are typically used for what level of security?

3. If an obstruction falls in line with the fence you are constructing, what are your options?

4. How much larger than line and terminal posts do you dimension gate posts?

5. Where do you place line posts? What do they support?

6. How deep do you set a fence post?

7. Gate, corner, and terminal posts provide additional support, so how much deeper than line posts do we set them?

8. What is the purpose of stringers (rails)?

9. Pickets, boards, and panels are just three of the most common types of what fence component?

10. What type of fasteners do you use for ultimate holding power and ease of construction?

11. Which of the two gate types is the most rugged?

12. What is the most common reason for repairing gates?

13. What does the more care you take in the surface preparation and application of the finish ensure?

3–2. Interior Wall Coverings

This section covers some of the most common materials used for interior wall coverings. The finished appearance of a wall is not only based on the type of covering, but how well that covering is installed. This section provides you with common installation and repair procedures for these coverings.

816. Installing gypsum board

Gypsum board we often refer to as drywall, plasterboard, or other trademarked names. We use it to cover the walls and ceilings in most buildings. In this lesson, we discuss how to install, finish, and repair gypsum board, but first, we discuss the different types available.

Types of gypsum board

Gypsum board is a flat, fire retardant sheet made from gypsum covered with paper (the gypsum is fireproof). It is available in a standard width of 4 feet but the thickness and length measurements vary. It is available from ¼ to 1 inch thick with a length from 8 to 16 feet. The most common size sheet is ½ inch thick, 4 feet wide, and 8 feet long. Because it is inexpensive and easy to install and repair, gypsum board reduces the need to build wet walls from lath and plaster. The gypsum sheets are strong, but brittle and need to be handled carefully during installation. Along both long edges, each sheet has about a 2½ inch wide area that is less than ⅛ inch thinner than the rest of the sheet. When you place these edges side by side, they form a recess that is ready to receive perforated tape (usually paper) and joint compound, which conceals the joints between the sheets. We discuss how to do this later.

Regular

You use regular gypsum panels for single or multilayer applications.

Eased edge

Eased edge panels have a rounded edge with a special taper. We use them when a stronger, more concealed joint is required than we can achieve with the regular panels.

Type X

You might hear Type X gypsum board referred to as fire code board. That is because it has a greater resistance to fire. The gypsum core is mixed with special additives to increase its fire resistance. The panels look the same as regular gypsum; however, the edge or back is labeled Type X.

Water resistant

MR (moisture resistant) or WR (water resistant) board we also call greenboard. Since it is water resistant, we use this board for bathrooms, laundries, and similar areas with high moisture. It also provides a suitable base for embedding tiles in mastic. MR or WR board is commonly ½ inch thick.

Plasterboard

We use plasterboard or gypsum lath plaster base. It is faced with a specially treated blue paper and is sometimes called blueboard. It is available in thicknesses starting at ⅜ inch, widths of 16 and 24 inches; its length is usually 48 inches. It has many advantages over metal and wood lath; it comes in manageable sizes, receives a specially formulated veneer plaster that can be installed in one $^{1}/_{16}$ inch coat or two ⅛ inch coats and it dries in about 48 hours.

NOTE: This material is not compatible with Portland cement plaster.

Special purpose panels

There are a variety of panels that are designed for special applications. Let’s take a look at just a few.

Sound deadening board

Sound deadening board is a sub layer we use with other layers of drywall (usually type X); this board is often ¼ inch thick.

Backing board

Backing board has a gray paper lining on both sides. We use it as a base sheet on multilayer applications. Backing board is not suited for finishing and decorating. It is manufactured with regular and Type X cores.

Foil backed board

Foil backed board serves as a vapor barrier on exterior walls. This board is available in various thicknesses.

Vinyl surfaced board

Vinyl surfaced board is available in a variety of colors. We attach it with special drywall finish nails and leave it exposed with no joint treatment.

Tools

Commonly used tools in gypsum board application include a tape measure, chalk line, level, utility and drywall knives, straightedge, and a 48 inch T square (drywall square) or framing square. Other basic tools include a keyhole saw, gypsum board hammer (or convex head hammer), screw gun, gypsum board trowel, corner trowel, and a foot lift (fig. 3–15).

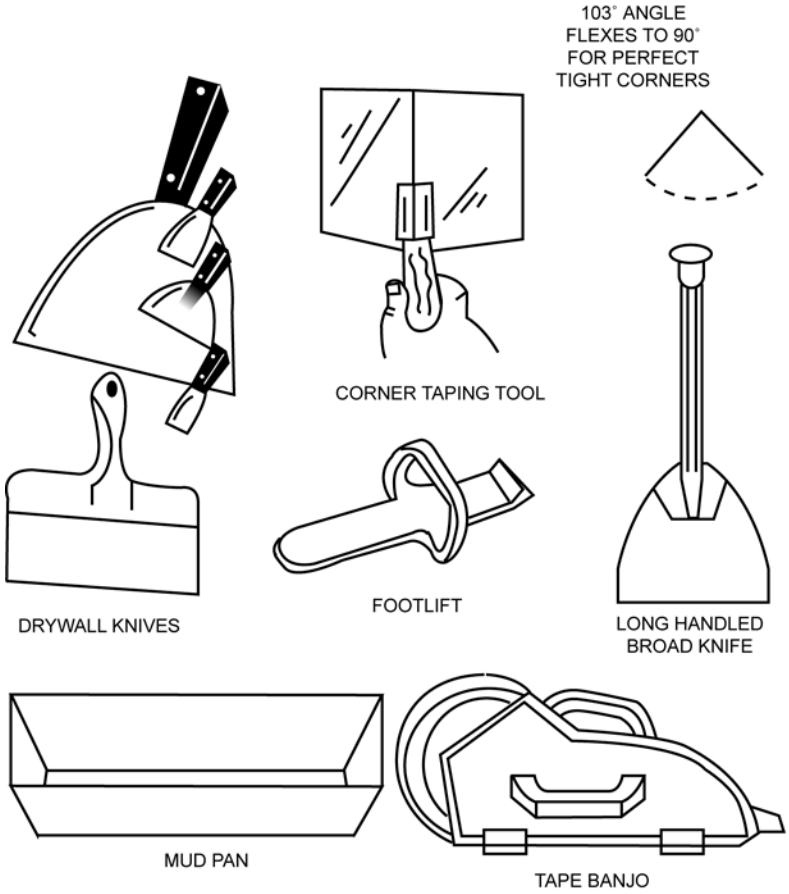

Figure 3–15. Tools.

We use the tape measure, chalk line, and level for layout work. We use the utility and gypsum board knives, straightedge, and squares for scoring and breaking the panels. We use the keyhole saw for cutting irregular shapes and openings, such as outlet box openings. A convex head or drywall hammer we use for drywall nails "*dimple*" the material without tearing the paper. The screw gun quickly sinks drywall screws to the adjusted depth and then automatically disengages.

Gypsum board knives have a variety of uses and sizes. There is no required rule as to which knife to use for the first coat. The main concern is for each subsequent coat to feather out about 2 inches beyond the previous coat. Some craftsmen prefer to start with a 5-inch knife for the first coat, while others prefer a 6-inch knife (fig. 3–15).

The gypsum board trowel resembles a concrete finishing trowel and is manufactured with a $^{3}/_{16}$ inch concave bow. We use this trowel, also referred to as a "*flaring*," "*feathering*," or "*bow*" trowel, when we apply the finish layer of joint compound. A corner trowel is almost indispensable for making clean interior corners.

For sanding dried joint compound smooth, use 220-grit sandpaper. Wrap sandpaper around a sanding block or use an orbital sander. When sanding, ensure you are wearing the required personnel protective gear to prevent dust inhalation (fig. 3–16).

Figure 3–16. Common dust mask.

A foot lift helps you raise and lower drywall sheets while you plumb the edges. Be careful when using the foot lift—applying too much pressure to the lift can easily damage the gypsum board (fig. 3–15).

Fasteners

Depending upon the material underneath, there are various fasteners that you may choose to use. For the most part, you will probably be fastening into wood or metal studs, although gypsum is occasionally used as a base. We normally use adhesives in tandem with screws or nails. This allows the installer to use fewer screws or nails, leaving fewer holes that require filling.

Nails

Gypsum board nails are specially designed, with oversized heads, for greater holding power. Casing or common nail heads are too small. Further, untreated nails can rust and stain a finish. The gypsum board (drywall) nail we most frequently use is the annular ring nail. This nail fastens securely into wood studs and joists. When purchasing such nails, consider the thickness of the layer or layers of gypsum board, and allow additional length for the nail to penetrate the underlying wood ¾ inch. Example: ½ inch gypsum board plus ¾ inch penetration requires a 1¼ inch nail. A longer nail does not fasten more securely than one that is properly sized; the longer nail is subject to the expansion and contraction of a greater depth of wood (fig. 3–17).

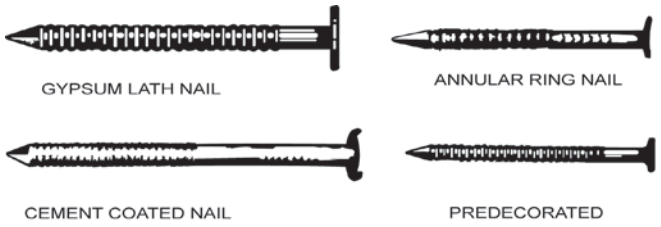

Figure 3–17. Drywall fasteners.

We commonly use smooth shank, diamond head nails to attach two layers of gypsum board. Smooth shank nails should penetrate the base wood 1 inch.

Screws

Drywall screws are the preferred method of fastening among many professional builders and renovators. These screws are made of high quality steel and are superior to conventional wood screws. Use a power screw gun or an electric drill to drive in the screws. Because this method requires no impact, there is little danger of jarring loose earlier connections. There are four types of drywall screws we commonly use: type S, type S–12, type G, and type W.

Type S

Type S screws are designed for attachment into light gauge metal studs. The screws are self drilling and self tapping. The point is very sharp to help penetrate the metal with little pressure, since metal studs can flex away. At least ⅜ inch of the threaded part of the screw should pass through a metal stud. Although other lengths are available, we commonly use 1 inch type S screws for single ply drywall.

Type S–12

We use Type S–12 screws for metal studs that are 20 gauge or heavier. The drill point is designed to penetrate this heavier material.

Type G

We use type G screws to fasten into base layers of gypsum board. The thread on these screws is deeper to securely fasten gypsum board panels together. The screws should penetrate into the base layer at least ½ inch.

Type W

We use type W screws to fasten gypsum board to wood studs. They should penetrate studs or joists at least ⅝ inch. If you are applying two layers of drywall, the screws holding the second sheet need to penetrate the wood beneath only ½ inch.

Adhesives

We use adhesives to bond single ply gypsum board directly to the framing members, furring strips, masonry surfaces, insulation board, or other gypsum board. We must use adhesives with nails or screws. Because adhesives are matched with specific materials, be sure to select the correct adhesive for the job. Read and follow the manufacturer’s directions.

Miscellaneous accessories and materials

A number of accessories have been developed to finish off or protect drywall. We will discuss just a few of them here.

Trim

There are numerous types of trim pieces designed to cover the edges of gypsum board panels. They are made of metal, plastic, vinyl, or paper covered metal. The types you see most often are corner beads and trim beads.

Corner beads

Corner beads are available for both inside and outside corners. Regardless of their location, we must cover all outside corners with corner beads to protect the surface and to provide a slightly raised beaded edge. The beaded edge keeps the corners straight and acts as a screed when you finish the joints. You can purchase outside corner beads that are designed not only for straight corners, but also for arches. These we refer to as *archway bead*.

Most drywall finishers use joint tape to finish the inside corners; however, there are inside corner beads available for different applications, such as finishing out of square corners.

Trim beads

We refer to these beads with many names, such as *casing beads*, *stop beads*, *J trim*, and *L bead.* We use them to cover the edges of gypsum board panels where the sheets abut at wall intersections, wall and exposed ceiling intersections, or where otherwise specified, such as on window jambs. We match trim beads to the thickness of the drywall used.

Tape

Joint tape varies little. The major difference between tapes is whether they are perforated or not. Perforated types are somewhat easier to bed and cover. New self sticking fiber mesh types (resembling window screen) are becoming popular. Having the mesh design and being self sticking eliminates the need for the first layer of bedding joint compound.

Joint compound

Joint compound comes ready mixed or in powder form. The powder form must be mixed with water to achieve a putty consistency. Ready mixed compound is easier to work with, though its shelf life is shorter than the powdered form. Joint compounds vary according to the additive they contain. Always read and follow the manufacturer's specifications.

Single layer gypsum board installation

We install most gypsum board panels using the single layer application method. Before you start installing the panels, you need to learn some basic procedures we use with gypsum board.

Cutting and fitting

The two methods we use to cut gypsum board are by sawing or scoring and snapping (fig. 3–18). The scoring and snapping method we describe as follows:

1. Mark a line on the finish side for the intended cut.
2. Score the line with a utility knife just enough to cut through the paper covering into the core.
3. Snap the gypsum board at the scored line.
4. Hold the gypsum board carefully because the paper on the other side is still holding it together.
5. Cut the paper from the backside for a clean cut.
6. Snap the board in the reverse direction.

NOTE: You can use a drywall rasp to smooth the ragged edges left behind from the cut.

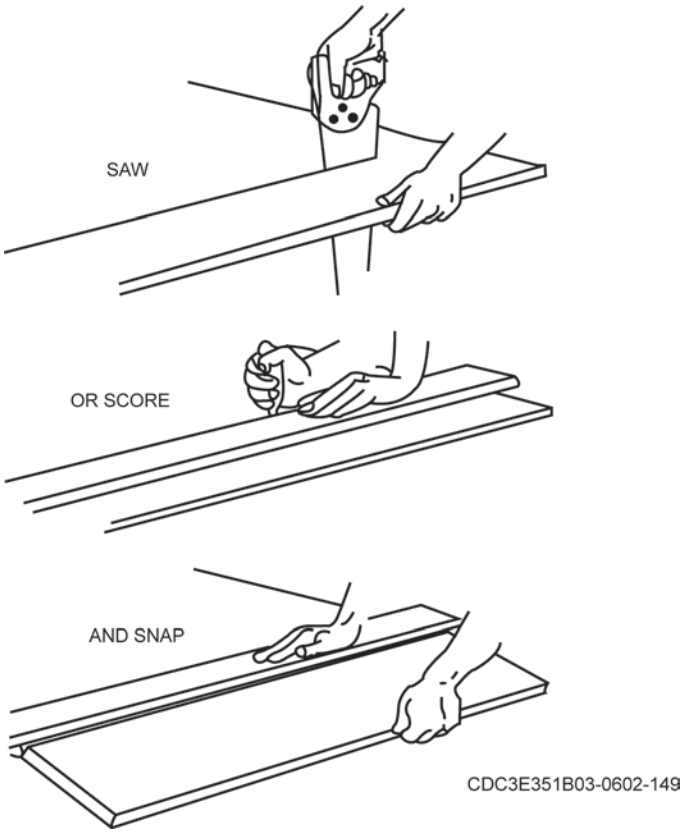

Figure 3–18. Cutting gypsum board.

Sometimes more intricate cuts are needed. For these cuts, use a saw. Always cut gypsum board with the finish side up to keep from damaging the finished surface. You can mark the openings for pipe and electrical receptacles and cut them with a utility knife. Always leave an ⅛ inch space between the joints to help hold the joint compound in place.

Aligning framing members

When using wood framing members, you have the inherent risk that some of the members may be bowed. The edges of the framing members should not be more than ⅛ inch out of alignment with the adjacent members. If they are, there are a couple of ways to correct this, depending on the area.

Walls

To straighten a bowed stud:

1. Cut a kerf into the concave side of the stud (approximate ½ the width of the stud).
2. Pull to straighten out the stud and drive a wedge into the kerfed side (squeeze glue into the kerf before you drive the wedge).
3. Trim the shingle flush to the edge of the stud.
4. Install 1 x 4 scabs on each side or a 2 x 4 scab along one side to keep it straight. Make the scabs at least 24 inches long.

Ceiling

To bring ceiling joists into alignment, you can install a strongback across the tops of the joist around the center of the span. A strongback is a 2 x 4 laid flat with a 2 x 6 nailed along the edge of the 2 x 4. Nailing the two boards together like this forms a 90 degree angle when viewed from the end. To install the strongback, lift (jack) the joist into position and screw through the 2 x 4 into the top of the joist. Repeat for each joist.

Another method we used for ceilings is to install furring strips at right angles to the ceiling joists. You can use 1 x 3 inch lumber for the strips. As you install the strips, install shims under them where needed to bring everything into alignment.

Fastening methods

The fastening methods are different based on the gypsum board's thickness and location, plus what type of fastener you use.

Single nail method

When using the single nail method, space the nails 6 to 8 inches apart on walls and 5 to 7 inches apart on ceilings. Space the nails at least ⅜ inch from the outside edges, but no more than 1 inch. Drive them slightly below the surface so you can cover them with joint compound.

Double nail method

When double nailing gypsum board, follow the same spacing as you used for single nailing along the edges of the panels. The difference is throughout the field of the gypsum panel where you space the nails about 12 inches. Then, place a second nail 2 to 2½ inches away from the first set. After you drive the second nail in place, reseat the first nail to ensure that the panel is held tightly against the framing members.

Attaching with screws

Place the screws 12 inches on center when using screws to secure gypsum board panels to ceiling joists. On walls spaced 16 inches on center, place the screws 16 inches on center. If the framing members are spaced 24 inches on center, place the screws 12 inches on center.

Ceiling application

When you are covering both walls and ceilings with gypsum board, start with the ceiling and have another person assist with the installation (fig. 3–19). You can install the panels parallel to or at right angles to the ceiling joists or furring strips; however, it is best to install the panels at right angles for the following reasons:

- Less likely to sag.
- Greater strength.
- Allows gypsum board to float over joists that are uneven.

To begin installation, find the best sheet arrangement and install the first sheet in a corner with the long dimension at a right angle to the ceiling joists. You need at least two people to raise the sheets in place. After the two of you raise the sheet into position, you can support the sheet with two deadmen to hold it into position. A deadman is a "T" you build at the jobsite from scrap lumber. Build it with the support leg about ¼ inch longer than the distance between the floor and ceiling. With the sheet of gypsum board in position, you or your partner can nail or screw the board to the ceiling. Stagger the sheets' end joints and center them on the framing members.

NOTE: The nails you use to secure the gypsum sheet must penetrate the framing at least 1 inch.

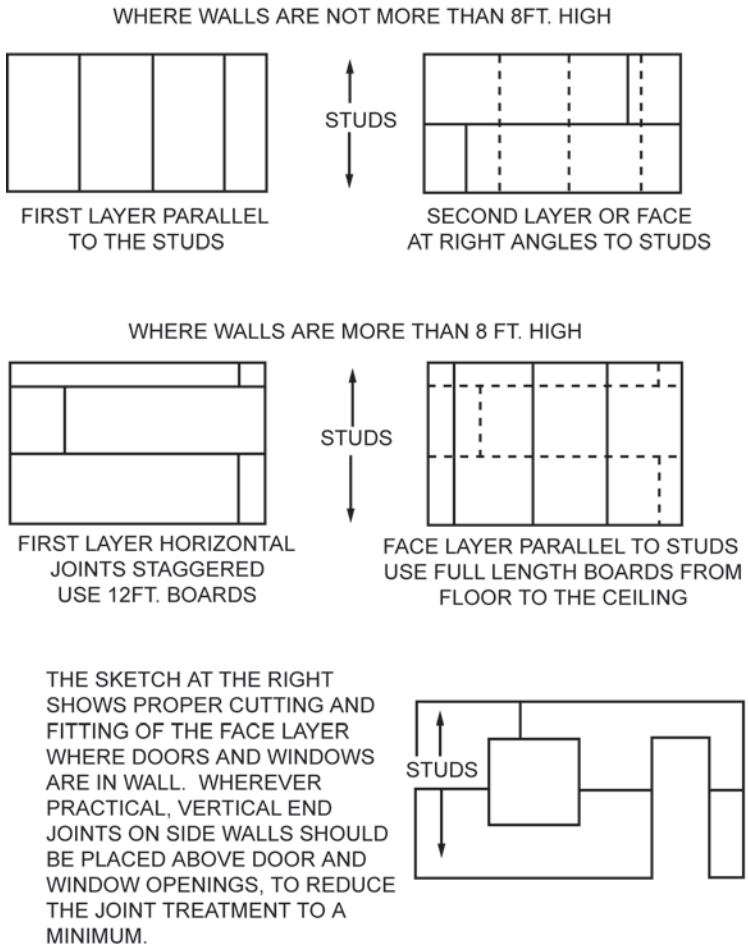

Figure 3–19. Gypsum board placement.

Wall application

After installing the gypsum board on the ceiling, you can install it to the walls either vertically or horizontally. If the walls are less than 8 feet 1 inch high, install the panels horizontally. Use the longest length possible to minimize the amount of end joints. When you install the panels, ensure that you stagger the end joints and place them over doors and windows and below windows. This helps you conceal the joints. You also want to make sure that the end joints on both sides of a wall partition do not fall on the same stud (fig. 3–19).

To begin installation, install the top panel first, then:

1. Cut the board to size, if needed.
2. Stand the board on edge against the wall where it is to be placed.
3. Start fasteners along the top edge where there are studs (do not penetrate the sheets).
4. Raise the sheet in position to where the edge is held tightly against the ceiling.
5. Securely seat the fasteners in place.
6. Install remaining fasteners throughout the sheet using the recommended spacing.
7. Measure and cut the lower panel to size.

   NOTE: Cut the sheet's width about ¼ inch narrower than the distance measured.
8. Lay the sheet against the wall and lift it into place (use a drywall foot lifter if available) so that the upper edge of the lower sheet is held tightly against the lower edge of the upper sheet.

9. Securely fasten the sheet in place.
10. Stagger all end joints and repeat the steps for the remaining sheets.

NOTE: If the building plans call for two layers of gypsum board, nail the base layer to the studs vertically, and then apply the face layer horizontally.

Trim installation

There are different installation methods used depending on the type trim. We discuss some of the most common methods.

Metal beads

The most common type of corner bead used is metal. To install metal corner bead over wood framing, it is best to nail it in place with drywall nails spaced approximately 9 inches apart. To install it on metal framing, you can use a crimper, $^{9}/_{16}$ inch staples, or screws. When using a crimper, crimp the bead 4 to 6 inches on center. Place the nails 9 inches on center when using screws or staples. Alternate the fastener placement from side to side and work from the top down. (**NOTE:** Be sure the corner bead stays plumb as you fasten it in place.)

Vinyl beads

There are three common methods we use to install vinyl beads:

1. Secure with ½ inch long staples spaced 6 to 10 inches on center.
2. Spray vinyl adhesive on the wall and the bead. Immediately press the bead in place.
3. Apply joint compound to the corner and press the bead into it. Keep pressing until the compound squeezes through the holes and the bead is straight. Use a drywall knife to press the legs in place.

Paper faced beads

These beads we usually set with joint compound, regardless if they are plastic or metal. Most types (square and bullnose) are equipped for use with a roller tool designed especially for it. To install:

1. Apply joint compound to the corner of the wall.
2. Align the bead in place.
3. Embed the bead with the roller tool.
4. Remove the excess joint compound with a drywall knife.

817. Taping and finishing gypsum board

To prepare new gypsum surfaces for painting, you must tape and mud all joints and corners, cover all nailheads, and in some cases, apply a stipple coating to the surface. You probably need to apply three coats of joint compound to effectively conceal all the joints and holes. In cold weather, make sure that the interior temperature of the room is at least 50°F. Maintain the room at this temperature at least 24 hours before, during, and for fout days after applying the joint compound.

Taping and mudding procedures

Figure 3–20 shows several tools we commonly use to tape and mud gypsum board. Apply perforated paper tape or fiberglass tape (mesh) over the joints between pieces of gypsum board to help hold the joint compound in place and give the joint tensile strength. Before you begin embedding the tape, pre-fill all joints that are ¼ inch or more and fill any damaged areas and holes. This includes the joints between the panels. You must allow at least 24 hours drying time before you apply the first coat., You can use a setting type compound to speed up the drying time if you cannot afford to wait that long.

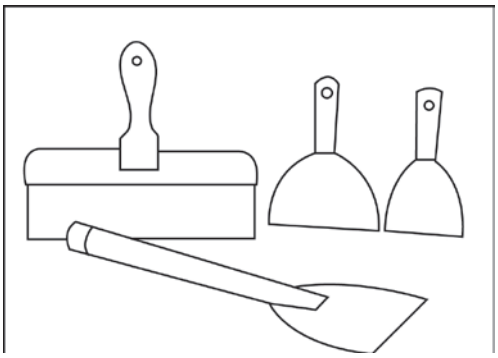

Figure 3–20. Tools for taping and floating.

You can tape the joints and mud the fasteners in whatever sequence works best for you. To speed the job up, you can use the following sequence:

1. Tape (spot) the fasteners.
2. Tape the edge seams.
3. Tape the butted seams.
4. Tape the inside corners.
5. Tape the outside corners.

Spotting fasteners

Run your drywall knife over all fasteners to check if they are set properly. If you hear metal scrapping, they are not set enough. Since most fasteners are installed in a straight row, it is easier (and faster) to spot a row of fasteners in a single strip. Apply just enough joint compound to fill the indention. There should be a very light film of joint compound left on the surrounding surface of the panel. You apply the second and third coats around the same time that you apply the second and third coats to the seams (fig. 3–21).

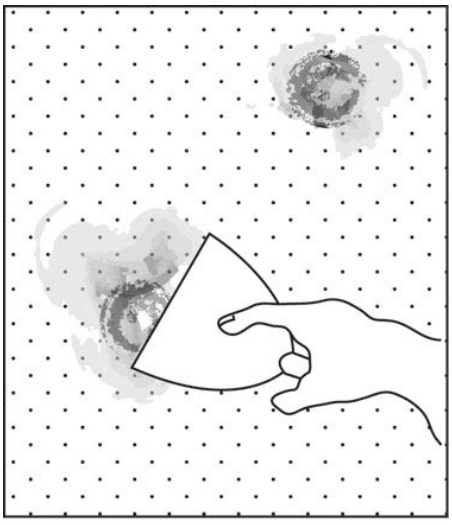

Figure 3–21. Applying compound over nail holes.

First coat using paper tape

Using the following steps, you apply the compound (mud) with a broad knife into the recess along the joint.

1. Center the tape on the joint.
2. Use a broad knife, 5 to 6 inches wide, to embed the tape into the compound. Start at one end and run the knife across and near the end of the tape. Hold that end in place with one hand and pull the knife over the tape with the other hand. Apply enough pressure on the knife to embed the tape into the compound.
3. After the tape is in place, cover it with a thin coating of joint compound. This aids in preventing the edges from wrinkling. It also makes it easier to hide the tape with the succeeding coats (fig. 3–22).
4. Damp sponge the surface after the joint compound sets up, but before it has had a chance to completely harden.

NOTE: Be sure you remove all wrinkles and air bubbles from under the tape. There should not be more than $^{1}/_{32}$ inch of joint compound under the edges of the tape.

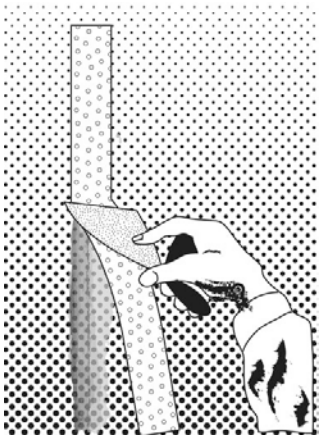

Figure 3–22. Applying paper tape over a wall joint.

First coat using mesh tape

It is faster and easier to use fiberglass tape (mesh) tape than paper tape. When you use mesh tape, there is no need to worry about loose tape or air bubbles. To use this type of tape take the following actions:

1. Firmly apply the tape to all the joints. You must ensure that it is completely flat without any wrinkles.
2. Apply a ¼ inch layer of joint compound over the tape and joint using a drywall knife that is 5 to 6 inches wide.
3. Use a wider trowel to smooth the joint even more. Leave only enough joint compound to cover the tape and fill the joint.

NOTE: A correctly filled joint should be about $^{3}/_{16}$ inch thick and 6 inches or less wide.

First coat over corner bead and trim beads

Use the nose of the bead as a guide to install the first coat. Apply the compound about 6 inches wide starting from the nose of the bead. Be sure that each subsequent coat is at least 2 inches wider than the previous coat.

First coat over inside corners

You tape the inside corners much the same way you do flat joints. Apply the joint compound along the edges of the gypsum board where they meet to form the corner joint. Some craftsmen prefer to use paper tape for the corners. To do this, tear off a piece of tape, fold and crease it along the center so it

fits into the corner. Use a small putty knife, about 3 inches wide (or a corner trowel), to embed the tape into the compound so it forms a square and straight line corner (fig. 3–23).

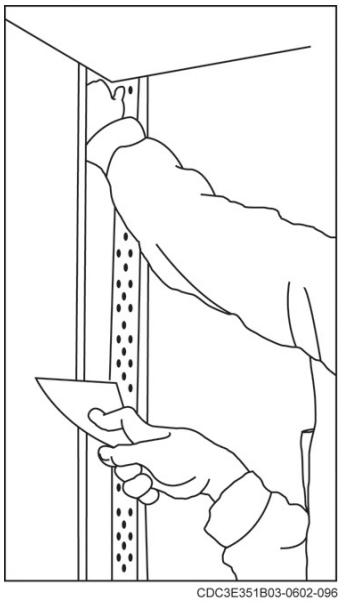

Figure 3–23. Taping a corner.

NOTE: Some drywall finishers use a setting compound to install the paper on one side only. Once all the corners are set on one side with a setting compound, the setting compound should be hardened enough for the finishers to come back and set the other sides into regular joint compound.

Second and third coats

After the first joint compound coat dries, usually within 24 hours, apply a second coat. The second coat we also refer to as the fill coat (fig. 3–24). This coat must be feathered out at least 2 inches beyond the edges of the first coat.As with the first coat, rub a damp sponge over the surface once it sets up to remove any small particles.

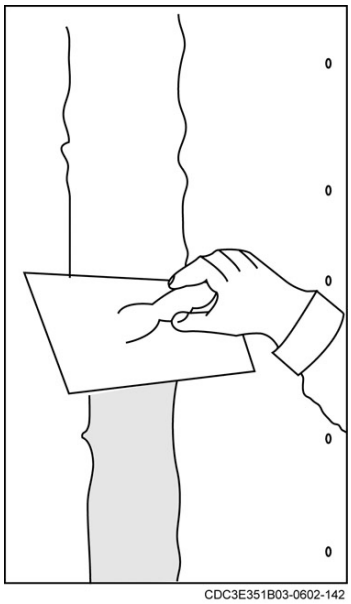

Figure 3–24. Using a trowel to smooth the compound finishing gypsum board.

The second coat must dry the same amount of time—usually within 24 hours. If the finish requires it, apply a third (finishing) coat of joint compound. Once again, feather the edges out at least 2 inches beyond the previous layer. When the final coat is dry, sand the surface using 100 or 120 grit sandpaper or a sanding screen. You want to ensure you remove small ridges, bumps, trowel marks and any edges that are not feathered. **(NOTE:** To check the finished quality, shine a bright light along the wall and ceiling to look for defects.) (**NOTE:** Wear a protective respirator to protect yourself against nontoxic dust and mist.)

There is more than one way to finish gypsum board panels. We cannot cover every method, but we discuss some of the more common methods used to texture gypsum boards. You can apply texturing in a variety of patterns using a brush, roller, trowel, sprayer or a combination of the above. Before you apply texture to any new drywall or areas that you repaired, you must apply a prime coat to the surface.

NOTE: Most textures we apply with special spray equipment. Most often, we use a handheld hopper and air compressor.

Spray on acoustical ceiling textures

You may have heard of this as a "*popcorn*" ceiling. The particles used in the texture come in three different grades (course, medium, and fine); the larger the particle, the rougher the texture. You purchase the texture dry and mix it to consistency with water. Once mixed, you add it to the hopper (or spray gun) and spray the ceiling. Hold the applicator 2 to 4 feet away from the ceiling and keep it moving side to side. Apply a thin layer in one direction, and then apply another thin layer in the opposite direction. This helps to hide streaks or patterns. For a decorative effect, you can blow glitter onto the wet texture to reflect light.

Spray on wall textures

Walls receive more abuse than ceilings. Two common types of texturing for walls are orange peel and knockdown. You can also use these textures on ceilings.

Orange peel texture

You make this kind of texture with joint compound thinned with water. Add the mixture to your applicator and hold it 2 to3 feet away from the wall and apply the texture evenly. Make sure that you keep the applicator a consistent distance away from the wall. You must also ensure that each batch of texture that you mix is of the same consistency.

Knockdown texture

To make a knockdown texture, thin joint compound with water; however, it should be a thicker consistency than that used for the orange peel texture. Apply the compound to the wall using the same procedures as we mentioned above. Wait approximately 10 minutes, and then knock down the raised surfaces of the texture using a large flat trowel with a curved blade. Hold the trowel so that the blade is almost flat and pull it in one direction.

NOTE: You must prime the drywall surface before you apply knockdown texture to keep the absorption of the drywall and taped areas equal.

Hand applied textures

Three types of hand applied textures that we discuss are roller textures, knockdown roller finishes, and hand trowel finishes.

Roller textures

Once again, you need to water down joint compound to a creamy consistency. It should hold its shape, but not run. Apply the joint compound to the entire area with a short nap (½ inch or less) roller. Let the compound stand for approximately 10 minutes, and then go over it with the roller again (fig. 3–25).

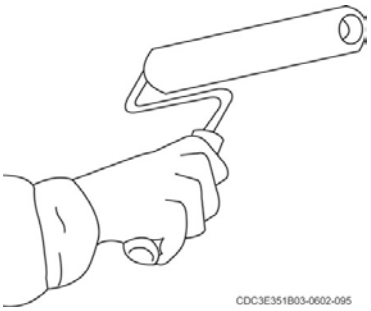

Figure 3–25. Applying texture with a roller.

Knockdown roller finish

Repeat the process above; however, knockdown the surface texture with a large trowel with a curved blade. Use light pressure and pull the trowel in the same direction as you rolled the joint compound.

Hand trowel finishes

It is usually best to use joint compound of regular consistency. Use a 6 inch knife to apply a thin layer of compound to the entire surface. Vary the thickness from bare to as thick as ⅛ inch. You want to achieve trowel marks, ridges, and low areas as part of the design.

818. Repairing gypsum board

Repairing gypsum board is not a difficult task; however, it can be time consuming because it takes time for the joint compound to dry. If you have small repairs to make, it may be beneficial to you to use a fast drying setting type joint compound. Depending on the type, these compounds harden anywhere from 20 minutes to 5 hours. You can also add accelerants to setting type compounds to make them set up faster. In essence, you could make a 180 minute compound set up in 40 minutes.

Popped fasteners

One of the most common gypsum board defects is popped fasteners. Various reasons exist for popped fasteners, such as not attaching the drywall tightly against the framing members or the framing members shrinking, forcing the nails to pop out. The following is one method we use to repair popped fasteners:

1. Place another fastener approximately 1½ inch away from the popped fastener.
2. Remove or reset the popped fastener.
3. Remove any loose material (gypsum, loose paper, etc).
4. Apply a small piece of mesh type tape over the damaged area and apply joint compound.

NOTE: Finish in three coats of joint compound and sand.

Stress cracks

As the name implies, stress cracks are caused by stress—usually the result of structural movement or settling. Stress cracks are often seen around doors and windows. Stress cracks that occur around a joint between the panels may cause the tape to blister or come off.

A commonly used method to repair stress cracks is to:

1. Cutout any loose tape or compound, creating a small V groove.
2. Check the gypsum board for any movement. If there is any movement, place more fasteners through the panel into the framing members closest to the crack.
3. If there are large cracks, fill them with joint compound, and then cover with tape.
4. Apply two to three coats of joint compound and sand.

NOTE: To get better joint compound adhesion, sand at least 12 inches beyond the crack.

Small holes

There are varying ways to repair small holes, depending on their size. For instance, if you removed a nail from the wall, you could repair the hole from the nail with two or three coats of joint compound. Remove any loose material, and then slightly indent the area around the hole.

Larger holes, such as those created from doorknobs, you can usually repair without much work. The easiest method is to cover the hole with a self adhesive metal and fiberglass repair patch. Once the hole is covered, apply two to three coats of joint compound and sand to finish.

You can repair holes the size of an electrical outlet with a small patch. There are a couple of methods you can use.

Paper flange patch

This method uses the face paper on the patch as the reinforcing tape. To use this method do the following:

1. Cut out the damaged area into a square or rectangular shape.
2. Cut a gypsum board patch 4 inches larger than the hole. For example, if the hole is 12 inches square, cut a patch that is 16 inches square.
3. Cut the backside paper 2 inches in from the edge and snap the edge to break through the gypsum with the face paper still attached.
4. Peel off the outer edges, removing the back paper and gypsum. Now you've got a 12 × 12 inch piece of gypsum board with a 2 inch paper flange on the face side. This paper flange acts as your tape.
5. Apply joint compound to the flange, and start finishing the repair immediately.

Beveled patch

This method uses a patch with beveled edges.

1. Cut out the damaged area into a square or rectangular shape as well; except this time you bevel the edges of the opening and the patch. Be sure that the patch fits snugly into the hole and is slightly below the face of the drywall.
2. Apply joint compound to all edges of the hole. Be sure to use a lot of compound.
3. Press the patch into the hole and keep the face of the patch flush with the surrounding surface.
4. Apply joint tape around the seams and finish with normal taping procedures.

Larger holes

You can repair large holes in gypsum board in several ways; the following are three basic methods:

1. Replace the entire sheet. We usually reserve this method for the most severely damaged areas with large holes.
2. Cut out the damaged area from stud to stud and install a new gypsum board section in its place.
3. Install furring strips. If the hole is smaller than the distance between studs, you can cut furring strips (6 inches larger than the hole) to slide into the hole and provide a fastening surface for the patch. Secure the strips and attach the patch to the strips with drywall screws. **NOTE:** You can purchase small metal clips to use in place of furring strips. These metal clips are held in place with drywall screws too.

Finish the joints as you would with new construction.

819. Installing wall paneling

When it comes to wall paneling, there are two basic types—sheets made of various materials and solid wood boards. In this lesson, we discuss some of the types available and how to install them.

Sheet paneling

Sheet paneling consists of prefinished plywood, hardboard, particleboard, plastic laminate, and various other types of sheet materials used to panel walls.

Wood paneling (plywood)

Wood paneling is probably the most common type of sheet paneling. There are many types available made of both hardwoods and softwoods. The better quality products are faced with real wood; whereas, the least expensive sheets have a wood design printed on a thin vinyl covering.

The sheets are scored lengthwise at 16, 24, and 32 inch intervals from the edge to imitate solid wood paneling and to provide a place through which to fasten. These panels come in various thicknesses with $^{3}/_{16}$ and ¼ inch the most common. The standard size is 4 feet wide and 8 feet long; however, other sizes are available. They are manufactured with square, beveled or shiplapped edges. They are available with matching trim pieces and color matched ring shanked nails.

Hardboard

Hardboard paneling is made in various textures and designs. Some designs resemble real stone, brick, stucco, wood, and so forth. You can also obtain it unfinished solid or with designs punched through it. Typical sizes are 4 feet wide and 8 to 12 feet long with common thicknesses of ⅛ to ¼ inch.

A form of hardboard, *tileboard*, is made with a baked on plastic finish that looks like wall tile. We use it in bathrooms, kitchens, and other areas where we might place tile.

Particleboard

Many types of furniture are made of particleboard, so it should be no surprise that some types of wall paneling are also made of it. It is available with wood grain or other designs. Normal size sheets are 4 by 8 feet and ¼ inch thick. Since particleboard sheets are brittle, you must handle these panels carefully; you can only install this type of paneling over a solid backing.

Board (solid wood) paneling

Board paneling comes in various widths and thicknesses, depending on its use, with either tongue and groove or shiplap edges. We usually install it vertically to the wall framework with horizontal blocks spaced at 2, 4, and 6 feet between the wall studs of an 8 foot wall.

Sheet paneling installation

Before you install any type of wall paneling, you need to be sure what your local building codes require. You can fasten panels at least ⅜ inch thick directly to the studs; however, your local building codes may require you to install some type of backer board to add fire resistance and strength. You must apply panels less than ⅜ inch thick to a solid backing for strength and rigidity.

Preparation

If you are going to install the panels the full height of the wall, mark the floor and ceiling at each stud location. Most panels are installed with adhesive and colored pins, so the panels' edges must fall on the center of stud.

In most situations, you only run the paneling up the lower portion of the wall. This is called wainscoting. It is usually installed up about 32 inches from the floor. Thus, an 8 foot piece provides you three pieces. To aid in installation, snap a horizontal chalkline at the desired height across the wall. Cap the wainscot top with chair rail molding for a finished appearance and to give it some protection against damage. Stand the panels on their long edge in the area to be paneled at least 48

hours before installation so they can adjust to room humidity and temperature. Before you start applying the panels, stand them around the room to match their grain and color for the most pleasing pattern.

Application

You can cut the panels with a portable circular saw or with a handsaw. Cut from the backside with a circular saw and from the face side with a handsaw to keep from damaging the panel face; however, a fine toothed crosscut handsaw is recommended when cutting prefinished paneling. When cutting paneling to length, deduct ¼ inch from the wall height. When cutting out for electrical outlets, switches, windows, doors, and so forth, measure up from the floor and over from the edge of the previously installed panel. You can also rub chalk on the outlet box, place the sheet in position, and tap the sheet over the box. The chalk should leave a mark on the back of the sheet. You can use a saber saw to cut the openings—just be sure to cut from the backside to keep from splintering the face.

The first sheet probably needs to be trimmed so that its edge falls on the center of a stud. Trim the edge that is to be placed in the corner. Start in the least visible corner and use one nail to hold the first panel in place while you plumb its edge with a level. This is important since the first panel establishes the vertical alignment for all the rest. A cedar shingle strip under the paneling makes it easier to move the panel and to hold it plumb. Do not force the panels into place; their edges should just touch very lightly. To make sure the stud does not show between panels (when sheets are edge butted); use a black felt tip pen to mark a line on the stud (wall) where they meet. Nail the paneling with color coordinated paneling nails. Start nailing at the corner and move down the stud, placing edge nails 6 inches apart and intermediate nails 12 inches apart for ¼ inch paneling. You can space the nails farther apart on thicker paneling. (**NOTE:** Driving the nails at an angle provides greater holding strength.)

Adhesive application

We sometimes use adhesives to adhere the paneling to studs or backing board. To install paneling using the adhesive method:

1. Apply a ⅛ inch bead of adhesive to the wall where the panel edges and ends are to be.
2. Apply 3 inch long beads at 6 inch intervals on intermediate studs (16 inches on center).
3. Place panel in position and tack it along the top end.
4. Press the panel firmly to ensure that all areas make contact with the adhesive.
5. Carefully pull the bottom of the panel away from the wall (a few inches), wait two minutes, and press it back into position.
6. Recheck in 20 minutes and reapply pressure. Repeat for each sheet.

NOTE: Seal new plastered or gypsum boards walls with a latex wall primer. To help the adhesive bond to painted plaster or gypsum board walls, roughen the walls up by sanding with medium grit sandpaper.

Board (solid wood) paneling installation

The most common method we use to install solid board paneling is vertically. To install board paneling vertically in wood framed walls, you must install blocking between the studs. On other types of walls, such as masonry, install furring strips horizontally. The normal spacing for blocking or furring strips is 24 inches on center.

As with sheet paneling, you also want to stand the board paneling around the room to allow it to adjust to the room temperature and to match the color and patterns. When installing tongue and grooved boards that have to be stained or painted after installation, treat the tongue with the same finish before you install the boards. If the boards shrink after installation, this prevents the unfinished portion from being noticeable.

Application

Follow these steps to install tongue and grooved board paneling the entire height of the wall:

1. Cut the panel to size (total height minus ¼ inch).
2. Tack board in place (place grooved edge in corner). **NOTE:** Face nail the corner edge in place approximately 16 inches on center. On the other edge, fasten through the tongue (blind nail).
3. Install additional boards (blind nail through tongue only).
4. Check the panels for plumb as you install them. You may have to adjust the tops or bottoms accordingly.

Panel repair

You can often cover scratches by rubbing them with furniture polish. You can remove other marks with a liquid cleaning agent. To repair a badly damaged panel (hole or split), there is normally no other choice than to replace the whole panel. Just about any repair you could make will look like just that—a patch job. You may be able to cover the area with molding or place furniture in front of it, but usually your best choice is to replace the panel.

Self-Test Questions

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

816. Installing gypsum board

1. Briefly describe gypsum board.

2. What are two advantages that drywalls have over wet walls?

3. What types of gypsum panels are in current use?

4. What type of gypsum board is also known as "*blueboard*"? What is it used for?

5. What type nail do we most frequently use for installing gypsum board (drywall)?

6. What is the Type S screw designed for? How much of the screw should pass through a metal stud?

7. What is the purpose of corner beads on outside corners on a gypsum board wall?

8. What two methods do we use to cut gypsum board?

9. Why do you leave at least 1/8 inch between the gypsum board sheets?

10. How do you install the second (face) layer of wallboard if the walls are less than 8 foot 1 inch high?

817. Taping and finishing gypsum board

1. What does perforated paper tape or fiberglass tape do when you tape and float gypsum board?

2. How long does it usually take for a coat of joint compound to dry?

3. What must you remove from under the tape?

4. What are two advantages of using fiberglass tape?

5. How do we refer to the second coat? When do you apply it after the first coat?

6. What do you wear to protect you against nontoxic dust and mist?

7. What are the two common types of spray-on wall textures?

8. What are the three types of hand-applied textures?

9. Which type of hand-applied texture is applied in an irregular and random pattern?

818. Repairing gypsum board

1. What is one of the most common gypsum board defects?

2. Where do we most often see stress cracks?

3. What is one method for repairing a hole from a nail you removed from the wall?

4. Which method of hole repair uses the face paper on the patch as the reinforcing tape? How much larger than the hole do you make the patch?

5. What method of repairing large holes is usually reserved for the most severely damaged areas?

819. Installing wall paneling

1. Which is the most common type of sheet paneling?

2. What form of hardboard is made with a baked on plastic finish that looks like wall tile and is used in bathrooms, kitchens, and other areas where we may place tile?

3. Board paneling comes in various widths and thicknesses, and with what types of edges?

4. How must you apply panels that are less than ⅜ inch thick?

5. What must you do before you start applying panels to match their grain and color for the most pleasing pattern?

6. How much do you deduct when cutting paneling to length?

7. When you are doing a panel repair, you can often cover scratches by rubbing them with furniture polish. What can you do to remove other marks?

3–3. Protective Coatings

Protective coatings can be colored or clear. Some choices include paint, varnish, shellac, and polyurethane. These types and others can protect and beautify wood, masonry, and metal surfaces when applied properly. You usually have to prepare the surface first. On surfaces that already have a protective coat, preparing the surface usually means removing loose material, dirt, oil or anything that will prevent the coating from bonding. One way to get a good bond is to use sandpaper to remove a glossy surface and slightly roughen the surface. Sometimes, you apply a sealer or primer coat before

you apply the protective coat. On new material, we recommend you seal and prime the surface first. The basic ways to apply coatings are by brush, roller, or spray. This section covers protective coatings, their purposes, and the ingredients that affect their characteristics.

820. Selecting protective coatings

There are many protective coatings that are made for particular requirements. The choice between clear and colored protective coatings depends on the material and the protection level required. For example, a wood surface may require easy cleaning, abrasion resistance, high gloss, semi gloss, or flat finish, or a certain color. A metal surface may simply need protection against rust. The choice for new concrete and masonry surfaces usually depends on the coating's appearance and service requirements. To meet these requirements, coatings have different ingredients added. We start by looking at them along with some terms that describe their function in this lesson.

Protection

Protecting the surface is the most important purpose of protective coatings. If you choose and apply protective coatings properly, they protect wooden buildings from moisture and sunlight, metal parts from corrosion, and concrete and masonry surfaces from the weather.

Sanitation and cleanliness

Protective coatings provide a smooth, non absorptive surface that seals out dust, dirt, and grease. These materials sometimes do build up on the surface but are easily washed off. Such surfaces tend to keep food from adhering; such food could harbor germs and cause disease. The coating applied on rough or porous areas seals out dust and grease that would otherwise be hard to remove. Protective coatings reveal a buildup of foreign substances, indicating that better housekeeping practices are in order. Protective coatings are an essential part of general maintenance programs for hospitals, dining halls, offices, warehouses, and living quarters.

Illumination and visibility

White and light tinted coatings (paints) on ceilings and walls reflect both natural and artificial light, helping to brighten rooms and increase visibility. On the other hand, darker colors reduce the amount of reflected light. Flat paints diffuse, soften, and distribute illumination more evenly whereas gloss finishes reflect more like mirrors and may create glare. Color contrasts improve visibility, especially when we apply the paint in distinctive patterns. For example, we can see white on black, white on orange, or yellow on black at greater distances than we can single colors.

Appearance

Apply protective coatings smoothly to give a pleasing appearance. You can use color and technique to create an attractive finish that is cost effective.

Composition

Protective coatings are composed from solid and liquid ingredients that are mixed together in specified amounts. These ingredients are added for specific characteristics, for example, *pigments* for color; a *vehicle* for adhesion, toughness, flexibility, and resistance; *solvents* and *thinners* for thinning, *driers* to speed drying; and *resins* to bind it all together. We start by taking a closer look at these ingredients.

Pigments

Pigments are fine, solid particles suspended in the liquid coating. Most inorganic pigments are simple metal oxides, though some are complex compounds based on carbon in combination with hydrogen, oxygen, sulfur, and nitrogen derived from coal tar or petroleum. These pigments in the coating are subject to attack by ultraviolet rays from the sun, by heat, and by chemical attack.

Vehicle

The vehicle is the liquid part, including everything that is in solution or in emulsion. It is the most significant coating part. It provides adhesion, toughness, flexibility, and resistance to adverse environments. It consists of volatile and non-volatile parts that are mixed together. The non-volatiles are the resins, drying oils, and plasticizers that make up the binder for pigment and form a continuous, cured film. The volatile parts are the thinners and solvents that make the paint easier to apply. After you apply them to a surface, the volatile part evaporates, which causes the remaining ingredients to cure into a protective coating. Varnish and lacquer are vehicles that are often used without pigmentation to produce clear films.

Solvents and thinners

At ordinary temperatures, the mixture of oils, pigments, and resins that go into coating materials is too thick to spread easily. Most resins are in a solid state and must be dissolved to reduce the binder's viscosity (thickness). Solvents do not react chemically with the coating and are lost through evaporation. Thinner that you can add to reduce viscosity does not have to be the same type that is used in the coating formula, but it must be compatible with the coating. You can determine the compatibility by checking the SDS (safety data sheet). Sometimes the recommended thinning agent is printed on the label of protective coating can.

NOTE: Never use thinner that is not compatible.

Driers

A drier is a catalytic agent added to oil base paint or varnish to reduce drying time. It may also have an important effect on water resistance, durability, flexibility, and other protective coating characteristics. Adding driers is a very precise procedure that is done at the factory where the paint is made. You can purchase and add driers, but we rarely do it because adding too much drier additives or an improper combination may reduce the coating's durability, flexibility, or other characteristics.

Resins

Natural and synthetic resins have a variety of properties and characteristics. The fact that there are so many resins makes a definition almost impossible. Generally, resins are solid or semi solid, transparent, non-crystalline, electrically non-conductive, and have indefinite melting points. Some resins use drying oils as binders to make up most of the coating's film forming materials. Other resins do not require driers as the principal film forming material.

Alkyd

An alkyd is a binder, which is an oil-modified resin that dries by reacting with oxygen from the air. We usually use it on most surfaces except fresh concrete, masonry, or plaster. An alkyd finish has good color and gloss with excellent durability in clean air, but its durability is only fair in mildly corrosive environments.

Epoxy

An epoxy is a binder that has two components (a resin and a hardener) mixed in a certain ratio before using. The mixed materials have a limited usage time after mixing (pot life), so do not mix more than you can use within the time limit stated in the instructions. Epoxy has outstanding hardness, adhesion, flexibility, and resistance to abrasives, alkali, and solvents. Typical uses are on tile, concrete, and masonry for glaze coatings, and as structural steel coatings in corrosive atmospheres. Epoxy paints have excellent durability, but they do tend to fade and chalk with sun exposure.

Silicone

Silicone is a binder that we use for water repellent coatings and for heat resistant coatings. A concentrated silicone resin that is pigmented with aluminum flakes forms a coating that stands up to temperatures as high as 1200°F.

Rubber based paints

Rubber based paints are lacquer type coatings that cure by solvent evaporation. They are highly resistant to water and mild chemicals, which makes them good choices for painting around swimming pools.

Oil based paints

Oil based paints are basically pigment particles dispersed in a drying oil or varnish vehicle, together with thinners (for consistency and evaporation rate) and driers (for curing characteristics). Never use oil base paints on unpainted concrete or masonry that is damp or highly alkaline. The choice of paint for plaster is the same, except that the surface is smooth. Do not use oil base paints on new plaster until the plaster cures for at least 30 days.

Varnish

Varnish is a clear coating that gives a transparent finish. Many types of varnish yellow over time, giving the wood a golden look. Interior varnishes resist water and alkali fairly well and exterior varnishes are superior in these areas as well as being more durable. One durable exterior type is spar (wood) varnish. It is usually made from tung oil combined with a 100 percent phenolic resin.

Polyurethane

As a clear coating on interior or exterior wood, polyurethane surpasses ordinary varnishes in abrasion resistance, durability, and gloss. If you leave dust, dirt, or body oil on the wood, then the polyurethane will not bond properly. You can apply polyurethane by brushing or by spraying it from an aerosol can. Apply it in several thin coats rather than in one thick one. After each coat dries completely, sand the surface lightly with 400 to 600 grit sandpaper or rub it with 00 to 0000 grade steel wool, then wipe it down with a tack cloth to remove any dust particles and recoat.

Enamel paint

Enamel paint is a pigmented coating composition that yields a smooth film that is free from brush or other tool marks. Most enamel finishes are glossy, but you can also purchase satin or flat finishes. They are available for exterior and interior use and are often used where surfaces require an occasional cleaning such as walls of hospitals, kitchens, and wood trim. You can apply an enamel coating with a brush, roller, or by spraying.

Latex paint

Latex paint is water based and is probably used more than the other types. There are many advantages to using latex paint. By being water based, it is readily available, inexpensive, non combustible, and non toxic. This gives it an advantage over solvent based paints, which require more strict safety and storage procedures. Latex paint is well suited for brush or roller application and can be applied on damp surfaces or in damp weather; rain an hour or two after application does not harm it. You can usually recoat surfaces the same day. After applying it, you can wash your brushes, rollers, and containers in warm soapy water.

Primers

A primer is usually the first coat that you apply to a surface. It serves to seal the surface from possible problems (such as bleeding in cedar, alkalinity in concrete and masonry, and adhesion to galvanized steel). It also helps the topcoat bond better. Primers are especially important in exterior finishes because of exposure to the elements and to extreme temperature and humidity variations.

Wood primers

The required qualities for wood primers are controlled penetration, good adhesion, and flexibility. There must be enough penetration for adequate adhesion, but not enough to affect flexibility. Adhesion and flexibility must withstand extreme stresses (especially across the grain) during changes in temperature, humidity, and rainfall.

Concrete and masonry primers

The essential quality for a concrete and masonry primer is that it is alkali resistant. These primers are based on alkali resistant binders such as latex, cement, and rubber based resin. Since most topcoats are also alkali resistant and compatible with the primer, they can be applied directly over the primer without any special surface preparations such as sanding. Other materials, such as gypsum board, are very porous, so use non-penetrating primers or sealers, and then pick your topcoat to meet service and appearance requirements. For previously painted surfaces, your choice depends entirely on service and appearance requirements as long as your paint is compatible with the old coating.

Handling protective coating products

Environmental awareness is mandatory. You, the structural journeyman, must be familiar with the requirements for safely handling paint products, which you can find in the paint's SDS. Store all paint in a designated paint storage location. Store all flammable paint inside a flammable storage locker. Apply paint that is rated as toxic in a well ventilated area and wear a respirator to protect yourself from the fumes. (**NOTE:** Only wear a respirator you have been fitted for and trained to use.) When you are applying flammable paint, it is a good idea to post no smoking/no open flame signs in the immediate area. Also, turn off any pilot light flames in the area to prevent an explosion.

Paint disposal is an important concern in the Air Force. Each base has specific rules that you must follow. A common disposal method that most structural shops have is an outside drying area where you can place small amounts of left over paint cans until they dry. Once the paint dries, we usually dispose of the cans in a dumpster. For large paint amounts, have available a hazardous waste drum or paint can accumulation point where you can store the paint until it can be disposed of through the Defense Reutilization and Marketing Office (DRMO). Your base may have stricter disposal rules, so check with your supervisor.

821. Applying stains and transparent coatings

There are many ways to apply stains and transparent coatings. In this lesson, we explain how you prepare the surface along with methods you can use to apply stain and transparent coatings.

Surface preparation

You must use top quality materials when you construct interior walls and ceilings that are to receive clear protective coatings. A reasonably priced and attractive choice for office walls in warehouses and shop areas is Number 1 grade, fir veneer plywood. For higher priority areas, use other plywood veneers, such as oak or birch. These materials may come with a factory applied finish or may need a clear protective coating. You can prepare the plywood surface by using sandpaper to remove all marks and blemishes. Be very careful in sanding veneer, or you may cut through the veneer into the center ply. Use either a sanding block or a small vibrating sander (fig. 3–26), never a belt or rotary power sander. When possible, always sand in the direction of the grain.

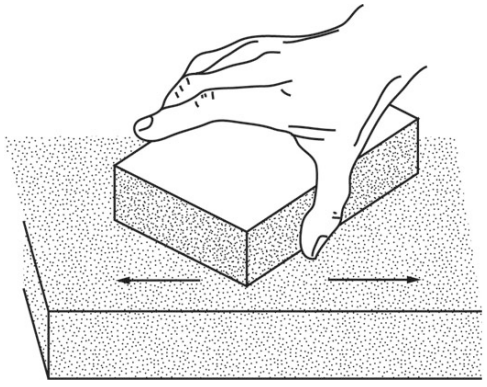

Figure 3–26. Using a sanding block.

Staining interior surfaces

Obviously, stain is not a transparent coating, but we often apply it to interior wood before we apply transparent finishes. We generally stain fir plywood for ceiling and wall panels with either light or dark oak oil stain to add color and richness to the finish. For surfaces such as, windows, doors, and base trim, that have a factory finish, stain them to match the panels. This trim may be either softwood or hardwood. When the trim is softwood, apply pigment oil stain directly to the bare wood. For darker colors, such as walnut, first brush on a coat of sealer or a thin coat of shellac and use steel wool to remove it until the surface looks like bare wood. Then apply the oil stain by brush and wipe it off with rags. The longer you let the stain set before wiping, the darker the color (tone) will be. Always wipe off all excess stain before it dries; if you want darker tones, apply another coat.

Stain hardwoods with pores smaller than those in birch the same way you stain softwoods, it is seldom desirable to apply sealer or shellac. For hardwoods with larger pores, fill those pores with a special type of wood filler (not the type you use to fill nail holes in cabinets). Use a rag to apply paste filler across the grain vigorously, and then let it set from 10 to 30 minutes. Remove the excess filler by wiping with clean rags first across the grain, then lightly along the grain. After you fill and stain the surface, brush on a thin shellac coat. When the shellac dries, rub it with steel wool before proceeding with the finish.

Applying a transparent finish

You usually use either varnish or a sealer as a transparent finish for interior surfaces. After the varnish dries thoroughly, we usually apply wax. The process is pretty much the same. Apply varnish with a flat (or oval), clean brush. Take a full load of varnish on the brush but not enough to drip off. Brush the varnish out well, but brush no more than necessary. Several thin coats give a better finish than one thick one. A thick coat may run, sag, or wrinkle and require longer drying time. Allow at least 24 hours for drying between coats. After one coat dries hard, rub the surface lightly with steel wool before applying the next coat. This removes all dust particles and minor flaws in the surface. The number of coats depends on the absorptive nature of the wood and on how thick you want the protection to be.

If the appearance demands it, you can rub the final coat with pumice stone. After the varnish is thoroughly dry and hard, use a felt pad to rub the surface with pumice and oil. Rub with the grain. Avoid rubbing through the finish at edges or curves. Wipe the surface clean occasionally to check the luster. Finish the job by cleaning the surface with an oil based furniture polish. Most interior varnish surfaces do not require the extra work of hand rubbing—that is usually reserved for fine cabinets and tables. You can get a dull luster finish by using a flat varnish for the final coat. This varnish is self-leveling and dries with a satin finish.

Refinishing transparent surfaces

If the old surface is in good condition and you are not changing the color, there is little preparation for refinishing. Light sanding followed by revarnishing or resealing usually does the trick. If the old surface has deep scratches or areas worn through to bare wood, repair the surface. On light colored woods, apply a coat of hot linseed oil to the damaged areas; on dark colored woods, apply oil satin. Seal the damaged area with shellac. The repaired area will look darker than the old surface, but this condition will correct itself as the oil is absorbed into the wood. As always, be careful not to sand through a veneer coating. Deep sanding is okay on wood planking.

For complete refinishing of stained wood, remove the existing finish with the correct finish remover, such as paint remover for paint. After applying the remover, use a clean cloth to wipe the surface to remove any residue. Use sandpaper or steel wool as the final step before you apply the new transparent coating. If you want a lighter stain or if the existing color is dark and uneven, sand the area thoroughly to where the color evens out.

You can lighten the color if you can uncover some bare wood. You may have to use one or more applications of a bleaching solution of 8 ounces of oxalic acid in 2 quarts of hot water. After the surface dries, remove any raised grain with sandpaper and refinish the area as if it were new wood. (**NOTE**: When you work with any type of finishes, you must read and follow its SDS.)

Self-Test Questions

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

820. Selecting protective coatings

1. How do protective coatings, such as paint, promote sanitation and cleanliness?

2. What paint colors can you apply to ceilings and walls to reflect both natural and artificial light, and why?

3. Match the following paint component in column B to the functions it describes in column A. All options will be used, some more than once.

Column A	*Column B*
____ (1) Essential in reducing the binder's viscosity.	a. Pigment.
____ (2) The most significant coating ingredient.	b. Vehicle.
____ (3) Fine, solid particles suspended in the liquid part of the coating.	c. Solvent/thinner.
____ (4) Hastens film hardening.	d. Drier.
____ (5) Consists of volatile and nonvolatile parts.	e. Resin.
____ (6) Too much or improper combination may reduce durability.	
____ (7) Usually solids or semi solids, transparent, non crystalline, and electrically nonconductive, with indefinite melting points.	
____ (8) Lost from the coating by evaporation.	
____ (9) Subject to attack by ultraviolet rays, heat, and chemical reaction.	

4. Match the coatings in column B to the descriptions in column A. All options will be used, some of them more than once.

Column A	*Column B*

____ (1) Requires a two component binder (a resin and a hardener).
____ (2) Allows for soap and water brush and roller cleaning.
____ (3) Dries by resins reacting with oxygen from the air.
____ (4) Is usually the first coating applied to seal the surface.
____ (5) Provides a transparent coating that sometimes yellows with age.
____ (6) Surpasses varnish in abrasion resistance, durability, and gloss.
____ (7) Is highly resistant to water and mild chemicals.
____ (8) Provides water repellent and heat resistant coatings.
____ (9) Yields a smooth film, free from brush or other tool marks.
____ (10) Has outstanding hardness, adhesion, and flexibility and resists abrasives, alkali, and solvents.
____ (11) Before recoating, sand with 400 to 600 grit sandpaper or rub it with 00 to 0000 grade steel wool, then wipe with a tack cloth to remove dust.
____ (12) May be used on most surfaces except fresh concrete, masonry, or plaster.

a. Alkyd.
b. Enamel.
c. Epoxy.
d. Latex.
e. Polyurethane.
f. Rubber base.
g. Silicone.
h. Varnish.
i. Primer.

5. How much time must a plaster wall cure before you can apply an oil based paint?

6. What are wood primer's essential qualities?

7. What are essential qualities for a concrete or masonry primer?

8. What sheet lists information on how to handle paint safely?

9. What type of surface requires a non penetrating primer or sealer?

10. How do you protect yourself from the fumes when you apply toxic rated paint?

821. Applying stains and transparent coatings

1. In what general direction do you do all sanding?

2. What happens when you leave stain on a piece of bare wood?

3. To produce the best finish using varnish, how do you apply it?

4. What type of finish is usually reserved for your finest cabinets and tables?

3–4. Floor and Ceiling Coverings

Finished floor and ceiling coverings are usually functional, with a pleasing appearance. There are many different types available to meet many different needs. Some factors we consider for choosing a particular type are purpose, initial cost, appearance, durability, and cleaning ease. In this section, we discuss methods used to install and repair asphalt/vinyl floor tiles and suspended ceiling systems. We begin with floor tiles.

822. Installing and repairing asphalt and vinyl tiles

Asphalt and vinyl floor tiles are available in many color combinations and durability ratings to match requirements; they are commonly installed as the finished floor in many Air Force facilities. The common size tile installed is 12 by 12 inches with other sizes available. We discuss what is needed to install and repair them.

Underlayment

Before you start to install floor tiles, you must have a smooth bonding surface for an attractive finished floor. If the bonding surface has imperfections, those imperfections will show through the tile when you install it. Conventional subflooring does not provide a satisfactory surface because it allows these imperfections and slight subfloor movements to show through the finished flooring. To prevent this on concrete subfloors, we sometimes use mastic as a bonding surface for the tile. On wood subfloors, the bonding surface (underlayment) is made from flat sheets of hardboard, particleboard, strandboard, or plywood. These sheets are usually 4 by 8 feet and vary in thicknesses from ¼ up to ¾ inch with ¼ inch the most common. You usually install underlayment just after you install the wall and ceiling surfaces. The underlayment covers small, gaps, cracks, and other subfloor imperfections to provide a smooth and stable base.

Before you install any underlayment, check and repair the subfloor. Sand down high spots and fill in low spots with floor leveling compound. If possible, place the underlayment sheets separately around the room for at least 24 hours before you install them to equalize their moisture content with the room and prevent excessive joint gaps.

Underlayment installation

Usually you start underlayment installation in a corner with a full sheet. Make sure the sheet is fastened securely before you lay the next one in place. Some manufacturers print a nailing pattern on the sheet's face to assure proper nailing. Stagger the joints when you place the underlayment for strength. Make the direction of the long joints at right angles to the long joints in the subfloor. Make sure that underlayment seams *do not* line up with joints in the subfloor. Leave a $^{1}/_{32}$ inch space between the joints to allow for expansion and make sure you stagger the end joints. Fasten the underlayment sheets to the subfloor with approved fasteners. We show examples in figure 3–27. When you use staples as your fasteners, use a type that is corrosion resistant and at least $^{7}/_{8}$ inch long.

Do not place staples over 4 inches apart along the edges. When you use 3d ring grooved or 4d cement coated nails to install plywood underlayment (fig. 3–27), drive the nail heads flush. Space the edge nailing every 3 inches and the middle area nailing every 6 inches. Another method we use to fasten underlayment is adhesives. The adhesive method eliminates any chance of a nail popping up through the finished floor covering.

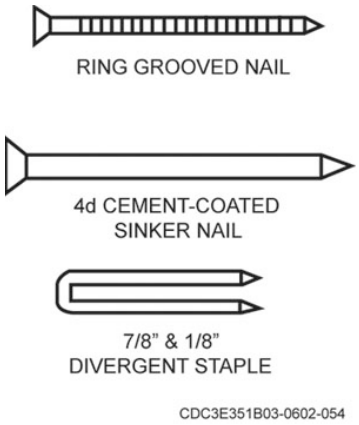

Figure 3–27. Underlayment fasteners.

Asphalt and vinyl floor tile installation

After the underlayment is securely fastened, sweep and vacuum the surface carefully. Check to see that surfaces are smooth and joints are level. Remove rough edges with sandpaper or a block plane. To help provide a smooth bonding surface, you can apply a layer of asphalt coated felt over the underlayment. Because of the many tile types on the market, it is essential that you follow the manufacturer's instructions. The first step in installing your first floor tile is to locate the room's center. You do this by measuring opposite end walls. Disregard any breaks or irregularities in the contour. Establish a main centerline by snapping a chalk line between each two opposite end walls. When snapping long lines, remember to hold the line at various intervals and snap only short sections.

Next, lay out another centerline at right angles to the main centerline. (This line runs between the two remaining opposite end walls). These two centerlines divide the room into four quadrants for laying tile. Check the line for squareness with a framing square or use the right triangle method. As you may recall, the right triangle method involves measuring out from the center point of the room along the two centerlines to form a right triangle as we show in figure 3–28.

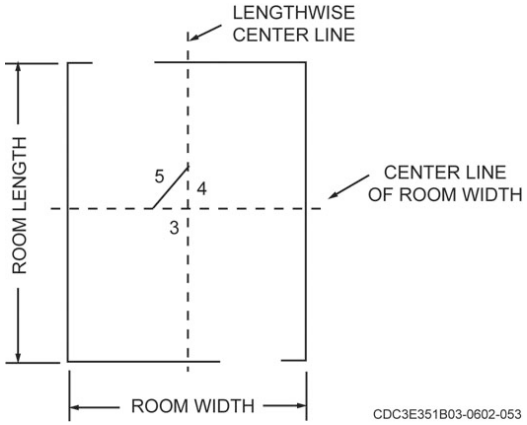

Figure3–28. Establishing centerline to lay floor tiles.

With the centerlines squared, make a trial layout of tile along the centerlines. Measure the distance between the wall and the last row of full size tiles. If the distance is less than half the width of the tile, move the centerline half a tile width (6 inches for a 12 by 12 inch tile) closer to the wall. This adjustment eliminates the need to install narrow border tiles. Check the layout along the other centerline in the same way. Since you move the original centerline exactly half the tile size, the border tile remains uniform on opposite sides of the room. After you establish the layout, you are now ready to spread the adhesive. We recommend working in one quadrant at a time.

Spreading adhesive

Before you spread the adhesive, clean the floor surface and check the bonding surface for smoothness. Use a notched trowel (most manufacturers recommend $^{1}/_{16}$ inch notches) to spread the adhesive over one quadrant up to the chalk line but not covering it. Be sure the adhesive depth matches the manufacturer's instructions. Adhesive spread is very important. If it is too thin, the tile will not adhere properly. If it is too thick, the adhesive will ooze up between the joints. Allow the adhesive to take an initial set. The time required can vary among types. Some may only take 15 minutes and others can take over an hour. You can test the adhesive set with your thumb. Make sure it feels slightly tacky but does not stick to your thumb. If you install the tile before the adhesive dries enough, it may not bond properly.

Installing non-adhesive backed tile

Before you install non-adhesive backed vinyl or asphalt tile, you must make sure your bonding surface is dry, smooth, and completely free of wax, grease, and dirt. Start laying the tile at the room's center. Make sure the tile edges align with the chalk line. If the chalk line is partially covered with the adhesive, snap a new one or tack down a thin, straight strip of wood to act as a guide in placing the tile. Butt each tile squarely to the adjoining tile, with the corners in line. Carefully lay each tile in place. *Do not* slide the tile; this causes the adhesive to work up between the joints and prevents a tight fit. Take time to position each tile correctly. There is usually no hurry since you can "*work with*" most adhesives for several hours. If you are installing vinyl tiles, use a tile roller to remove bubbles that are trapped in the adhesive. Be sure to follow the manufacturer's recommendations. You do not have to roll asphalt tiles. When you install the last row of full tiles near the wall, you are ready to layout, cut, and install the border tiles. To lay out the border tiles, place a full tile (the one that you will cut and use as the border tile) exactly over a tile in the outside row of full tiles. Now, take another full tile and butt it against the wall; mark a pencil line on the border tile (fig. 3–29).

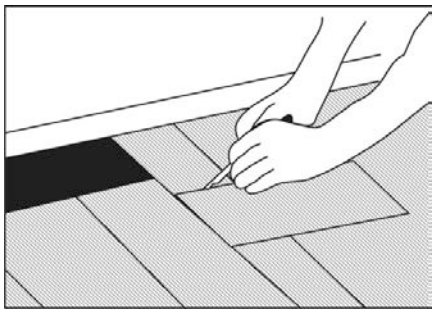

Figure 3–29. Border tile layout.

Cut the tile along the marked line. For straight line cuts, a tile cutting machine works the best for either vinyl or asphalt tile. For vinyl tile, you can use a utility knife or tin snips. For asphalt tile, use a scribing and snapping method. For curved shapes in vinyl tile, use a utility knife or tin snips. For asphalt tiles without a self-adhesive backing, use a propane torch to carefully heat the backside of the tile; this makes cutting curved shapes with a utility knife or tin snips much easier. Continue with each tile in the row until you completely tile that quadrant.

Installing self- adhesive backed tile

The self-adhesive backed tiles are usually made from vinyl. Before you install them, you must make sure the bonding surface is dry, smooth, and completely free of wax, grease, and dirt. Generally, you can lay these tiles over existing smooth faced resilient floors. Remove any embossed, urethane, or cushioned floors. Lay out the centerlines and border tiles the same way that you laid out the non-adhesive backed tiles. Like other floor tile installations, install the first tile at the room's center. To install it, remove the paper backing, place the tile in position on the floor, and press it down. Continue working in each quadrant using the same basic procedures that you used to install the non-adhesive backed tile.

Repairing asphalt and vinyl floor tile

Asphalt and vinyl tiles usually need repair due to damage from foot traffic, heavy objects, or sharp objects. Sometimes all that is needed is to clean the bonding surface, apply adhesive, and press the tile back into position. Usually, though, the tiles are cracked with pieces missing. The suggested repair is to remove the tiles with a hammer and chisel.

CAUTION: Many older tiles contain asbestos, especially the 9 by 9 inch type. If you suspect asbestos, report your concerns to your supervisor before you remove any tile pieces. Your supervisor can arrange to have the tile tested. If no asbestos is present, remove the tiles, clean the bonding surface and make sure that it is smooth.

Next, install new tiles that match the original as close as possible. These new tiles may or may not have a self-adhesive backing.

823. Installing and repairing suspended ceilings

Suspended ceilings (commonly called *drop ceilings*) are inexpensive to install, easily repaired, and attractive to look at. The popular sizes for ceiling tiles are 24 by 24 inches and 24 by 48 inches. We install such tiles where a conventional ceiling would be impractical or cost prohibitive. They can cover pipes, wiring, duct systems, or any number of unattractive things. The track and panel styles vary, but the components and installation method are basically the same.

Suspended ceiling components

The suspended ceiling components are part of a grid system that includes wall moldings (angles), main runners, cross tees, tie wires, and acoustical tiles (panels). The main runners are usually 12 feet long and the wall angles are usually 10 or 12 feet long. The cross tees are either 2 or 4 feet long. They are available in many colors, but most Air Force installations use white. The panels come in many different styles and colors, but many Air Force installations use either the drop-in or recessed type, and they are normally white. Identify the ceiling components before you lay out and install a suspended ceiling.

Suspended ceiling layout

A good starting point is to determine the suspended ceiling’s installation height. Next, snap a chalk line on all walls that intersect the ceiling. This chalk line provides a straight and level reference line for the wall angle installation (the first suspended ceiling component to be installed). To keep the chalk line from showing after you install the wall angle, do not snap the chalk line at the installed suspended ceiling’s height. Instead, snap the line where the wall angle's top edge is to be installed.

Install the main runners at right angles to the ceiling joists. Next, locate the ceiling center to determine where to place your first main runner. Remember to measure from the ceiling's center (centerline) to each wall intersection to determine border tile width. You may need to move your first main runner over half a tile width from the centerline to get a wider border. The panel direction is strictly a matter of taste. Some people prefer the longest dimension of the panel to go with the shortest dimension of the room; others prefer just the opposite.

Determining the border tile width is another important layout task that adds to the ceiling's appearance. It is desirable to have wide borders with each border having an equal width between opposite walls. A basic way to do this is to do the following:

1. Measure the ceiling length and width.
2. Divide each measurement by 2 to determine the true ceiling center (centerline).
3. Compare the true ceiling center measurements to the tile used.
4. Move each centerline to make opposite borders as wide as possible.
5. Mark the moved centerline on the ceiling for aligning the main runners in one direction and the cross tees in the other.

To give you a better understanding, we determine the border tile measurement using 2 by 4 foot ceiling tiles. The room measures 17 feet, 2 inches by 27 feet, 8 inches. Starting with the smaller measurement, divide it by 2 to find the true center to be 8 feet, 7 inches. Assume that the length of the tile (4 feet) is to run in this direction. This gives you four whole 4 foot panels with a 7 inch border, not the widest border possible. To get a wider border, add or subtract half of one ceiling tile (6 inches or 2 feet) from the true centerline measurement. If you add 2 feet to 8 feet, 7 inches, it gives you 10 feet, 7 inches for the first main tee. Now, you have three full tiles plus a wide 2 foot, 7 inch border. Now, you are ready to figure the other border. Divide 27 feet, 8 inches by 2 to give you a true centerline of 13 feet, 10 inches. Since you are dealing with width now, divide 13 feet, 10 inches by the tile width (2 feet) and you get six full panels with a 1 foot, 10 inch border, a wide border. Now that you have laid out your borders and the first main runner, you are ready to install the wall molding (wall angle).

Wall molding installation

Keep the wall molding's top edge in alignment with the chalk line you snapped on the wall to remain level. Nail the molding directly to the wall (fig. 3–30); if you can not do that, use a main runner instead of wall molding. Be careful not to bend long pieces of molding and watch how you nail so that you do not hit the bottom edge of the molding with your hammer. Figure 3–31 shows inside and outside corner cuts for rooms that are not rectangular. When you cut molding, main runners, or cross tees, cut the vertical part first with a pair of snips, bend the piece down, and cut as shown.

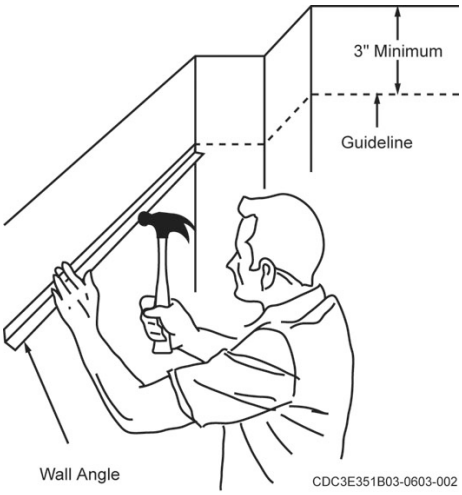

Figure 3–30. Nailing wall molding to a wall.

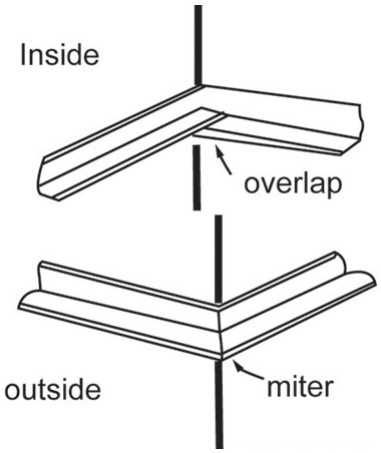

Figure 3–31. Corner moldings for walls.

Installing main runners

Say you are ready to install the main runners and you are using 24 by 24 inch ceiling tile with a border of 22 inches. A suggested way to lay out the main runners to match the borders is to do the following:

1. Measure from the end of the main runner to find the first 24 inch cross tee slot.
2. From this cross tee slot, measure toward the end of the main runner and mark it at 22 inches.
3. Cut the main runner at this mark.
4. Cut the remaining main runners. (**NOTE:** Before cutting, make sure that the room is square. You may need to add or subtract to the border length to compensate.)
5. Secure the main runners in place with hanger wires.

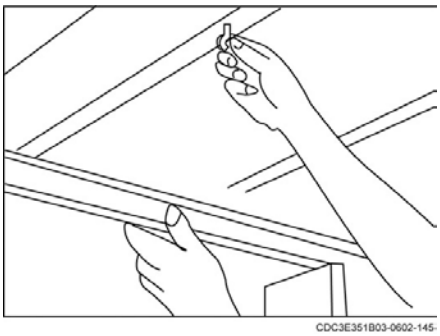

Figure 3–32. Installing screw eyes for hanger wires.

Rout the hanger wires through a slot in the main runner and then to a fastening device on the original ceiling. These fastening devices can be screw type nails with an eyelet on the end for the wire to pass through (fig. 3–32). They could be 12d or 16d common nails driven at a 30° angle from the side of a ceiling frame member. (**NOTE:** Never drive wire tie fasteners straight up into the bottom of a framing member; the weight of the ceiling can literally pull them out and collapse the ceiling.) After you rout the wire, twist it around itself to hold the main runners in place. Tie off the first tie wire above the first cross tee, in this case, 22 inches off the end wall. Space other tie wires every 4 feet. Now, place all your tie wires, letting about a foot hang below the ceiling height. To help in leveling the grid, stretch a line the length of the room exactly where the main runners are to be, but 1⅛ inches (the height of the runner) higher than the ceiling height (fig. 3–33). Now use pliers to make sharp 90° bends where the tire wires and string intersect. Do the same for each of our four main runners. Now, you are ready to install the main runner, since you have already established the ceiling height. Place the wire through holes in the main runner and twist the wire to secure the runners (fig. 3–34).

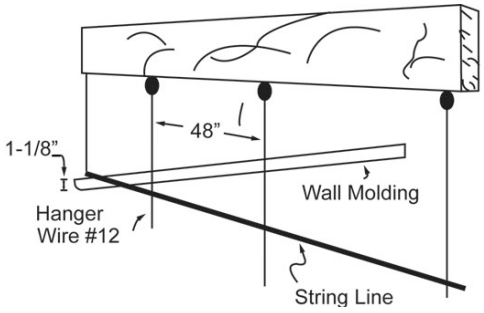

Figure 3–33. Installing hanger wires.

Figure 3–34. Tying hanger wires to main runners.

Cross tee installation

Before you start installing your cross tees, stretch a line the length of the room to help you keep the main runners straight. In our example, the cross tees going down both side walls are about 31 inches long, but measure each one before you start cutting—especially in older buildings. Start installing the cross tees in any corner and continue down the wall and then down each row until you finish. In this case, we are using 2 × 4 foot panels and only 4-foot cross tees; but when you install 2-foot-square panels; you can use both 2- and 4-foot cross tees. If you use both lengths, install them at right angles to form a 2-foot square. This style seems to be getting more popular. Figure 3–35 is a detail of cross tee installation and a completed grid system.

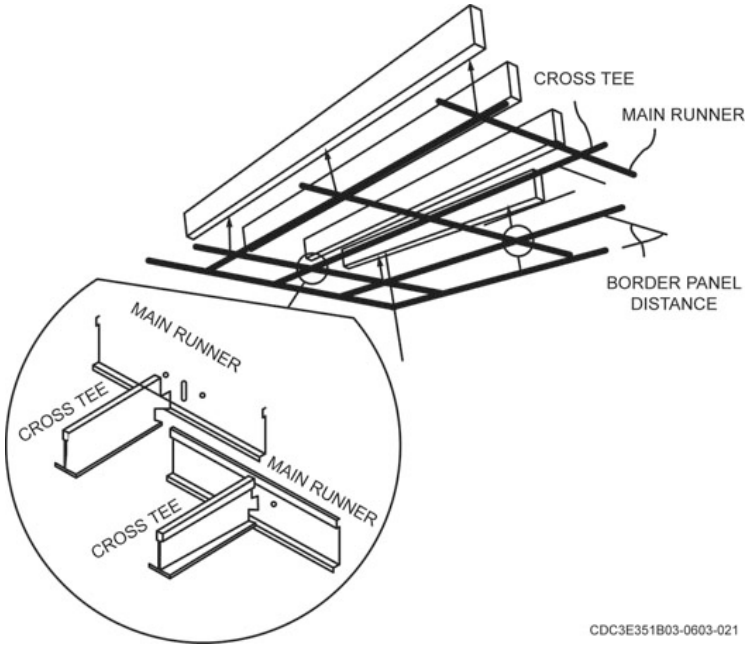

Figure 3–35. Installing a cross tee.

Panel cutting and installation

The acoustical panels (tiles) show dirt easily and are not very strong, so with clean hands and with care, you can start installing the full panels. The panels rest on the flanges of the main runners and the cross tees (fig. 3–36). After you install the full panels, you are ready to use a keyhole saw or utility knife to cut the border panels and then place them. Measure each individual panel before you cut; never assume the next tile will be the same size.

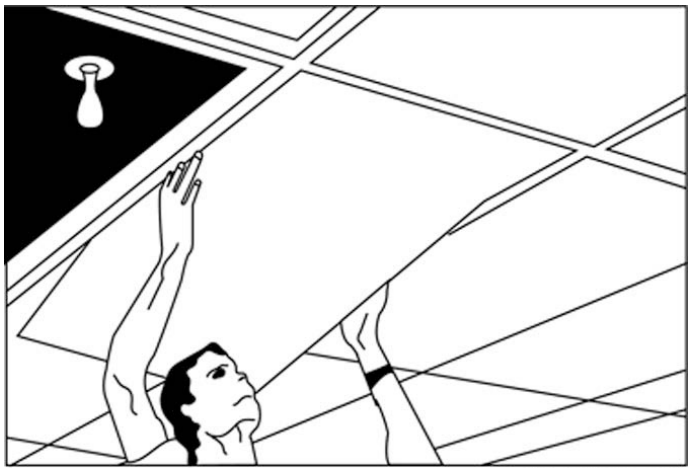

Figure 3–36. Installing a ceiling panel.

Installing a suspended ceiling usually takes coordination and cooperation among several shops and using organizations. Your supervisor, noncommissioned officer in charge (NCOIC), or foreman is normally the primary coordinator for your shop. Your ability to explain installation status to them can help keep the job on schedule, so keep this in mind and plan ahead.

Self-Test Questions

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

822. Installing and repairing asphalt and vinyl tiles

1. What purpose does underlayment provide for floor tile installation?

2. Where do you place the first full underlayment sheet and how much space is needed between joints for expansion?

3. What happens if you apply floor tile adhesive too thinly or too thickly?

4. How do you lay out border tiles for cutting?

5. What three causes are usually responsible for needed floor tile repairs?

823. Installing and repairing suspended ceilings

1. What are the advantages of a suspended ceiling?

2. How do you place the main runners for a suspended ceiling?

3. What's the procedure for installing wall molding for a suspended ceiling?

4. What can you use in place of the wall molding for a suspended ceiling?

5. What could happen if you drive the wire tie fasteners straight up into the bottom of the framing members?

6. Where do you locate the wire ties for a suspended ceiling?

Answers to Self-Test Questions

812

1. Steel and aluminum.
2. Self drilling hex head screws.
3. Patching holes, replacing partial sheets, and replacing entire sheets.

813

1. Good painting characteristics, easy working qualities, and freedom from warp.
2. The rough or sawn side is used/exposed because wood stain works best and lasts longer on rough wood surfaces.
3. Drop siding.
4. It helps prevent wind-driven rain from penetrating the joints exposed to the weather.
5. Exterior grade.
6. Galvanized, aluminum, and stainless steel corrosive resistant nails.
7. Annularly (ring) threaded shank nail and the spirally threaded shank nail. Both have greater withdrawal resistance than the smooth shank nail.
8. One inch.
9. Vertically.

814

1. May cause formation of ice dams at the cornice.
2. Removing hot air and lowering the temperature in these spaces.
3. Insulation.
4. Louvered openings.
5. Install a continuous ridge and soffit vents.
6. Soffit vents and outlet ventilators along the ridge.
7. To remove the moisture vapor rising from the soil. Such vapor may otherwise condense on the wood below the floor and cause decay.

815

1. Boundary.
2. Low to moderate.
3. You can build around it, or remove it.

4. One size.
5. Along the fence line between terminal or corner posts. To support the stringers or rails, and the infills.
6. The rule of thumb is to set fence posts at least one third of their length.
7. At least one foot.
8. To carry the load of the infill and join the posts to each other.
9. The filler or (infill).
10. Screws (decking screws).
11. The box gate.
12. Sagging.
13. The longer the finish will last.

816

1. A flat, fire retardant sheet made from gypsum covered with paper (the gypsum is fireproof).
2. Inexpensive and easy to install.
3. Regular, eased edge, Type X, water resistant/moisture resistant, plaster board. Special purpose panels: sound deadening, backing, foil backed, and vinyl backed.
4. Plasterboard. Used for plaster base.
5. Annular ring nail.
6. Attachment into light gauge metal studs. At least ⅜ inch of the threaded part of the screw should pass through a metal stud.
7. Protect the surface and to provide a slightly raised beaded edge.
8. Sawing or scoring and snapping.
9. To hold the joint compound in place.
10. Horizontally.

817

1. It holds the joint compound in place and gives the joint tensile strength.
2. Twenty four hours.
3. Wrinkles and air bubbles.
4. Faster and easier to use.
5. The fill coat. Usually within 24 hours.
6. Protective respirator.
7. Orange peel and knockdown.
8. Roller texture, knockdown roller finish, hand trowel finish.
9. Hand trowel finishes.

818

1. Popped fasteners.
2. Around doors and windows.
3. Apply two or three coats of joint compound.
4. Paper flange patch. Cut a gypsum board patch 4 inches larger than the hole.
5. Replace the entire sheet.

819

1. Wood paneling.
2. *Tileboard.*
3. Either tongue and groove or shiplap edges.
4. To a solid backing for strength and rigidity.
5. Stand them around the room.

6. ¼ inch from the wall height.
7. You can remove other marks with a liquid cleaning agent.

820

1. Paint provides a smooth, non absorptive surface that seals out dust, dirt, and grease. These materials sometimes do build up on the surface but are easily washed off.
2. White and light tinted paints; because they help brighten rooms and increase visibility.
3. (1) c.
   (2) b.
   (3) a.
   (4) d.
   (5) b.
   (6) d.
   (7) e.
   (8) c.
   (9) a.
4. (1) c.
   (2) d.
   (3) a.
   (4) i.
   (5) h.
   (6) e.
   (7) f.
   (8) g.
   (9) b.
   (10) c.
   (11) e.
   (12) a.
5. 30 days.
6. Control penetration, good adhesion, and flexibility.
7. Alkali resistant.
8. SDS.
9. Very porous.
10. By wearing a respirator and applying the paint in a well ventilated area.

821

1. With the direction of the grain.
2. The longer it sets, the darker the wood will be.
3. In several thin coats.
4. Hand rubbing with pumice.

822

1. Covers small gaps, cracks, and other subfloor imperfections to provide a smooth and stable base.
2. In a corner, 1/32 inch.
3. Too thin, the tile will not adhere properly. Too thick, the adhesive will ooze up between the joints.
4. Place a full tile (the one that you will cut and use as the border tile) exactly over a tile in the outside row of full tiles. Take another full tile and butt it against the wall, make a pencil line on the border tile.
5. 1. Damage from foot traffic, 2. Heavy objects. 3. Sharp objects.

823

1. Inexpensive to install, easily repaired, and attractive to look at.
2. At right angles to the ceiling joist.
3. Keep the top of the molding aligned with the chalk line and nail directly to the wall. Be careful not to hit the bottom edge with your hammer.
4. Main runner.
5. The weight of the ceiling could pull them out and collapse the ceiling.
6. Locate the first tie wire above the first cross tee, and the rest spaced every 4 feet.

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).

47. (812) What is the head shape of the self drilling screws that we use to install metal siding?
    a. Hex.
    b. Phillips.
    c. Common.
    d. Star pointed.

48. (812) At which end of a building do you start installing metal siding?
    a. The end of the building facing northeast.
    b. The end of the building facing southwest.
    c. The end of the building in the direction the prevailing winds blow.
    d. The end of the building away from which the prevailing winds blow.

49. (812) To prevent galvanic action (corrosion), you must make sure the patch or replacement metal siding is
    a. the same length.
    b. the same length and width.
    c. made of the same material.
    d. made of different material.

50. (813) If you are installing vertical tongue and groove siding on plywood or board sheathing, how many inches on center do you place the nails?
    a. 8 to 12.
    b. 12 to 16.
    c. 16 to 24.
    d. 24 to 28.

51. (813) To prevent galvanic action (corrosion) when installing flashing, you *must* use fasteners that are
    a. spirally threaded.
    b. annularly (ring) threaded.
    c. made of the same kind of metal as the flashing.
    d. made of a different type of metal than the flashing.

52. (814) A warm attic that is inadequately ventilated and insulated during winter may cause
    a. ice dams at the cornice.
    b. ice formations on the soffits.
    c. snow accumulation in gutters.
    d. sweating on the interior of the house.

53. (814) What do you install between ceiling joists below the attic or roof space to further retard heat flow into the rooms below and improve comfort conditions?
    a. Insulation.
    b. Ridge vent.
    c. Vapor barrier.
    d. Breathable building paper.

54. (814) One of the easiest and best ways to vent an attic is to install
    a. soffit and louvered vents.
    b. ridge, louvered, and soffit vents.
    c. continuous ridge and soffit vents.
    d. continuous ridge and louvered vents.

55. (814) Moisture vapor rising from the soil in a crawl space under the house or porch may condense on wood below the floor and cause
    a. decay.
    b. condensation.
    c. ice accumulation.
    d. sweating on the interior of the house.

56. (815) Which type of fence is designed to mark territories and perimeters?
    a. Privacy.
    b. Security.
    c. Boundary.
    d. Screening.

57. (815) Following the contour of the terrain when building your fence is the
    a. easiest option.
    b. most difficult option.
    c. most time consuming option.
    d. least time consuming option.

58. (815) If an obstruction falls in line with the fence you are constructing, what are your options?
    a. Build around it, or over it.
    b. Remove it, or build over it.
    c. Remove it, or build up to it.
    d. Build around it, or remove it.

59. (815) The normal practice is to dimension gate posts one size larger than line posts, because they
    a. bear less of a load.
    b. bear a greater load.
    c. are deeper in depth.
    d. are longer in length.

60. (815) The rule of thumb is to set fence posts in the ground at least
    a. one-fourth of their length.
    b. one-third of their length.
    c. half of their length.
    d. two-thirds of their length.

61. (815) How much deeper than line posts do we set gate, corner, and terminal posts?
    a. 4 to 6 inches.
    b. 6 to 8 inches.
    c. 8 to 10 inches.
    d. 12 inches.

62. (815) In constructing fences, what type of fastener do you use for ultimate holding power and ease of construction?
    a. Decking screws.
    b. Galvanized nails.
    c. Ring shanked nails.
    d. Spiral threaded nails.

63. (815) What is the *most* common reason for repair of gates?
    a. Sagging.
    b. Splicing.
    c. Refinishing.
    d. Through bolting.

64. (816) Which wall panel serves as a vapor barrier on exterior walls?
    a. Backing board.
    b. Foil-backed board.
    c. Vinyl-surfaced board.
    d. Sound-deadening board.

65. (816) The recommended way to cut gypsum board with a saw is to cut with the finish side
    a. down to keep from damaging the finished surface.
    b. up to keep from damaging the finished surface.
    c. down to keep from damaging the unfinished surface.
    d. up to keep from damaging the unfinished surface.

66. (816) How much space do you leave between the joints of gypsum board?
    a. 1/16 inch.
    b. ⅛ inch.
    c. 3/16 inch.
    d. ¼ inch.

67. (816) What purpose does leaving a space between the joints of gypsum board serve?
    a. Allows for expansion.
    b. Allows for contraction.
    c. Helps hold the tape in place.
    d. Help hold the joint compound in place.

68. (816) You install gypsum board on a ceiling so that the long dimension
    a. runs parallel to the joist and the end joints are aligned with each other.
    b. runs parallel to the joins and the sheets are staggered at the end joints.
    c. is at a right angle to the joist and the sheets are staggered at the end joints.
    d. is at a right angle to the joist and the end joints are aligned with each other.

69. (816) If the building plans call for two gypsum board layers, how do you install them?
    a. Both layers vertical, with the joints staggered.
    b. Both layers horizontal, with the joints staggered.
    c. The first layer horizontal and the second layer vertical.
    d. The base layer vertically and the face layer horizontally.

70. (817) After the first joint compound coat dries, how long is it before you can apply a second coat?
    a. An hour.
    b. Thirty minutes.
    c. Twenty four hours.
    d. Forty eight hours.

71. (817) After applying the third coat of joint compound, what can you do to check the finished quality, and to look for defects?
    a. Rub a damp sponge over the surface.
    b. Sand with 100- to 200- grit sand paper.
    c. Feel the wall and ceiling with your hands.
    d. Shine a bright light along the wall and ceiling.

72. (817) How do we refer to the second coat of joint compound and how much must it be feathered out beyond the edges of the first coat?
    a. Fill coat—at least 2 inches.
    b. Fill coat—at least 4 inches.
    c. Finishing coat—at least 2 inches.
    d. Finishing coat—at least 4 inches.

73. (817) What are the two most common types of spray-on acoustical ceiling textures for walls?
    a. Fill and finish.
    b. Feathering and knockdown.
    c. Orange peel and feathering.
    d. Orange peel and knockdown.

74. (818) The easiest method to repair larger holes, such as those created from doorknobs, is to cover the hole with a self adhesive
    a. wooden and panel repair patch.
    b. panel and wooden repair patch.
    c. metal and fiberglass repair patch.
    d. wooden and fiberglass repair patch.

75. (818) If you are using the paper-flange patch repair method, how many inches larger do you cut the gypsum board patch if the hole is 12-inches square?
    a. 3.
    b. 4.
    c. 6.
    d. 8.

76. (818) What method is *usually* reserved for the most severely damaged areas with large holes?
    a. Beveled patch.
    b. Paper-flange patch.
    c. Replace half the sheet.
    d. Replace the entire sheet.

77. (819) What are the *most* common thicknesses of wood paneling?
    a. 1/8 inch and 1/4 inch.
    b. 1/4 inch and 1/2 inch.
    c. 3/16 inch and 1/2 inch.
    d. 3/16 inch and 1/4 inch.

78. (819) How *must* you install brittle particleboard sheets?
    a. With adhesives.
    b. Over 2- by 4- studs.
    c. Over a solid backing.
    d. With sheet rock screws.

79. (819) How do we install board (solid wood) paneling in relation to the wall framework?
    a. Butted.
    b. Lapped.
    c. Vertically.
    d. Horizontally.

80. (819) What is the *thinnest* wood panel that you can install directly to the studs without backing material?
    a. 1/16 inch.
    b. 1/8 inch.
    c. 1/4 inch.
    d. 3/8 inch.

81. (819) How many hours before installation do you place wood paneling in the installation area?
    a. 24.
    b. 48.
    c. 72.
    d. 96.

82. (819) When you are doing a panel repair, what can you use to cover scratches?
    a. Paint.
    b. Boot polish.
    c. Furniture polish.
    d. Felt tipped marker.

83. (820) Which ingredient gives paint its color?
    a. Drier.
    b. Vehicle.
    c. Solvent.
    d. Pigment.

84. (820) Which paint ingredient is added to provide adhesion, toughness, flexibility, and resistance to adverse environments?
    a. Drier.
    b. Resin.
    c. Solvent.
    d. Vehicle.

85. (820) If a manufacturer uses too much drier in paint, the paint *will not*
    a. cure.
    b. bond.
    c. be durable.
    d. be water resistant.

86. (821) During surface preparation, in what general direction do you do all sanding?
    a. Circular.
    b. Back and forth.
    c. Direction of the grain.
    d. Against direction of the grain.

87. (821) When applying transparent finishes, how long should you allow for drying between coats?
    a. 8-hours.
    b. 12-hours.
    c. 16-hours.
    d. 24-hours.

88. (821) To produce the *best* finish using varnish, how do you apply it?
    a. One thick coat.
    b. Several thin coats.
    c. One thick coat and several thin coats.
    d. Several thick coats and one thin coat.

89. (821) After one coat dries hard when applying transparent finishes, what do you rub the surface lightly with before you apply the next coat?
    a. File.
    b. Sponge.
    c. Sandpaper.
    d. Steel wool.

90. (822) How many hours before you install the underlayment sheets do you place them separately around the room to equalize their moisture content with the room and prevent excessive joint gaps?
    a. 6.
    b. 12.
    c. 24.
    d. 48.

91. (822) When you are installing asphalt or vinyl floor tile where do you place the first tile?
    a. In a corner.
    b. In the center.
    c. Next to the baseboard.
    d. Anywhere along the chalkline.

92. (823) The first suspended ceiling component to be installed is the
    a. cross tee.
    b. wall angle.
    c. ceiling tile.
    d. main runner.

93. (823) In relation to a chalkline you snap on the wall, how do you install the wall molding for a suspended ceiling?
    a. Nailed with the top edge aligned with the chalkline.
    b. Nailed with the bottom edge aligned with the chalkline.
    c. Suspended with tie wires with the top aligned with the chalkline.
    d. Suspended with tie wires with the bottom aligned with chalkline.

Please read the unit menu for unit 4 and continue ➔

Student Notes

Unit 4. Woodworking

THIS UNIT COVERS the most common types of woodworking that you may encounter as a structural journeyman. We discuss installation and repair procedures for interior trim and the basic cabinet making procedures. With a little practice and some patience, you will be able to install trim and build cabinets like a professional craftsman.

4-1. Interior Trim

This section covers some of the most common types of trim used in buildings, along with the installation and repair procedures. There is more than one way to do tasks as with many construction tasks. We discuss the most common aspects used in the structures career field.

824. Installing interior trim

As a structural journeyman, you are responsible for installing the finishing trim in the building's interior—including casings, around doors and windows, baseboard (with base and shoe mold), picture mold, chair rail, cornice mold, and panel mold (fig. 4–1 and fig. 4–2). There should be a definite architectural relationship between these members and the doors and windows.

You can purchase most interior wood trim and moldings already milled to size. Sometimes it may be necessary to use shop equipment to duplicate a particular design.

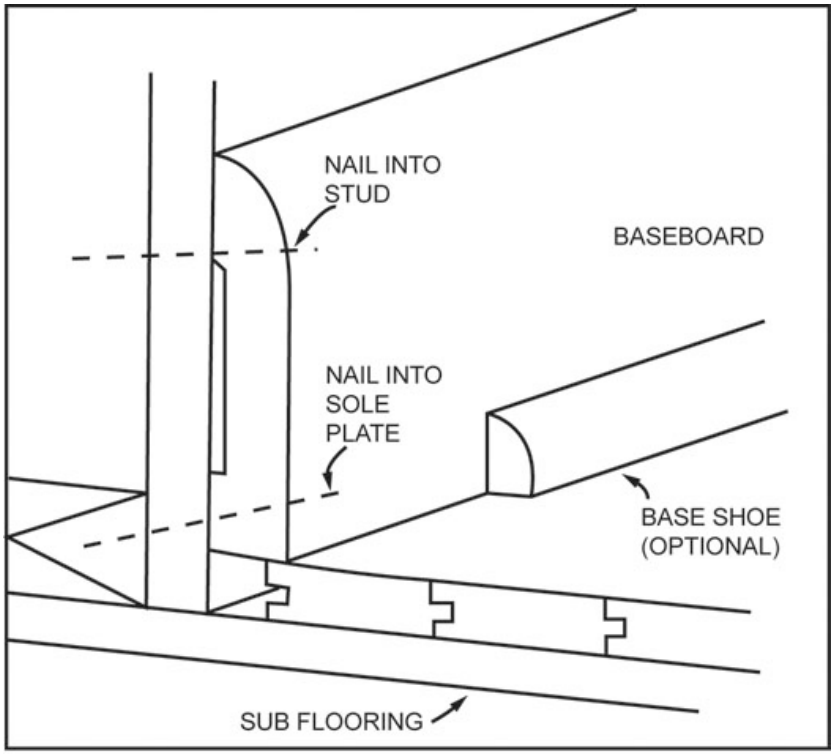

Figure 4–1. Finish trim, baseboard, and base shoe.

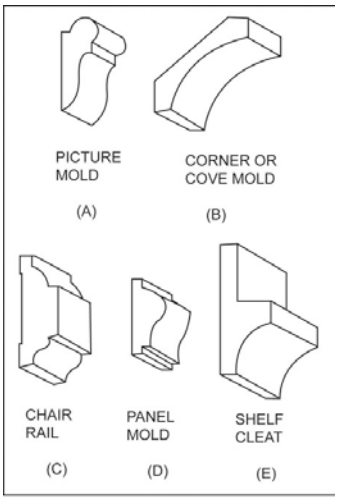

Figure 4–2. Finish trim for ceilings and walls.

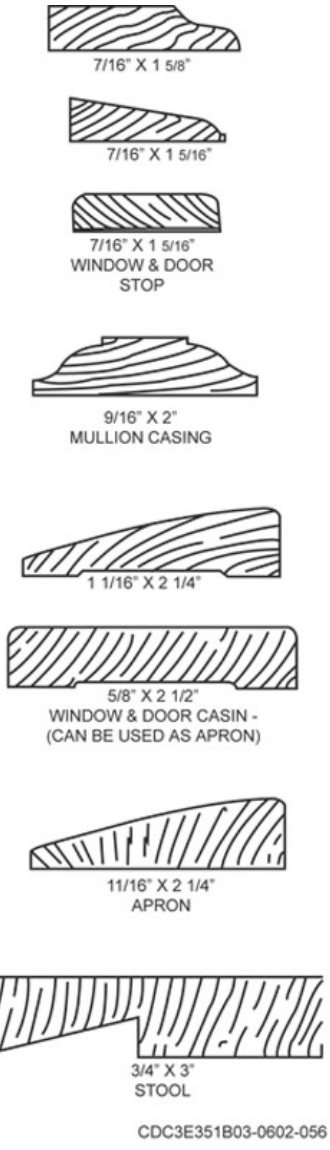

Figure 4–3. Finish trim for windows and doors.

There are many wood types available. We choose some for their natural color and wood grain. Woods such as walnut, oak, and cherry fall into this category and usually have a clearcoat finish applied. Other woods such as poplar and pine are lower in cost and are usually painted a solid color. Another option is to change the natural wood color with a wood stain, and then apply a clearcoat finish. For example, you could apply a cherry stain to pine or a dark oak stain to oak. By doing this, you change the color of the wood and often make the grain more noticeable. Other times you may want a solid color finish. We recommend a close-grained wood, such as poplar, for this. Figure 4–3 shows typical molding patterns for interior window and door trim. The apron, casing, and stool patterns are peculiar to window trim, while we can use the mullion, casings, and stops for both window and door trim. Apply interior window and door trim after you install the finish wallboard.

Interior door trim

Interior doorframes have casing (trim) applied to the head casing (top) and to each side jamb (fig. 4–4). The casing covers the air space around the frame and provides strength with an attractive finished appearance. You can mark it and apply it to the frame much the same as you do exterior trim. To start, scribe a light pencil line along the jamb (edge) about $^{3}/_{16}$- inch back from the face (this is called a $^{3}/_{16}$- inch *reveal*). Then, place the side trim pieces along the line and mark the miter joint position joint at the top where the head jamb line joins the line on the side jamb. Using a miter box or a combination square and finish handsaw cut a 45 degree angle on each piece. Nail the side casings in place temporarily with 6d casing or finish nails along the jamb edge and 8d casing or finish nails along the outer edge. Mark, cut, and apply the head casings the same way. If the miters do not fit, trim them with a block plane, fine handsaw, or file. Then, nail the trim in the pattern as we show in figure 4–4.

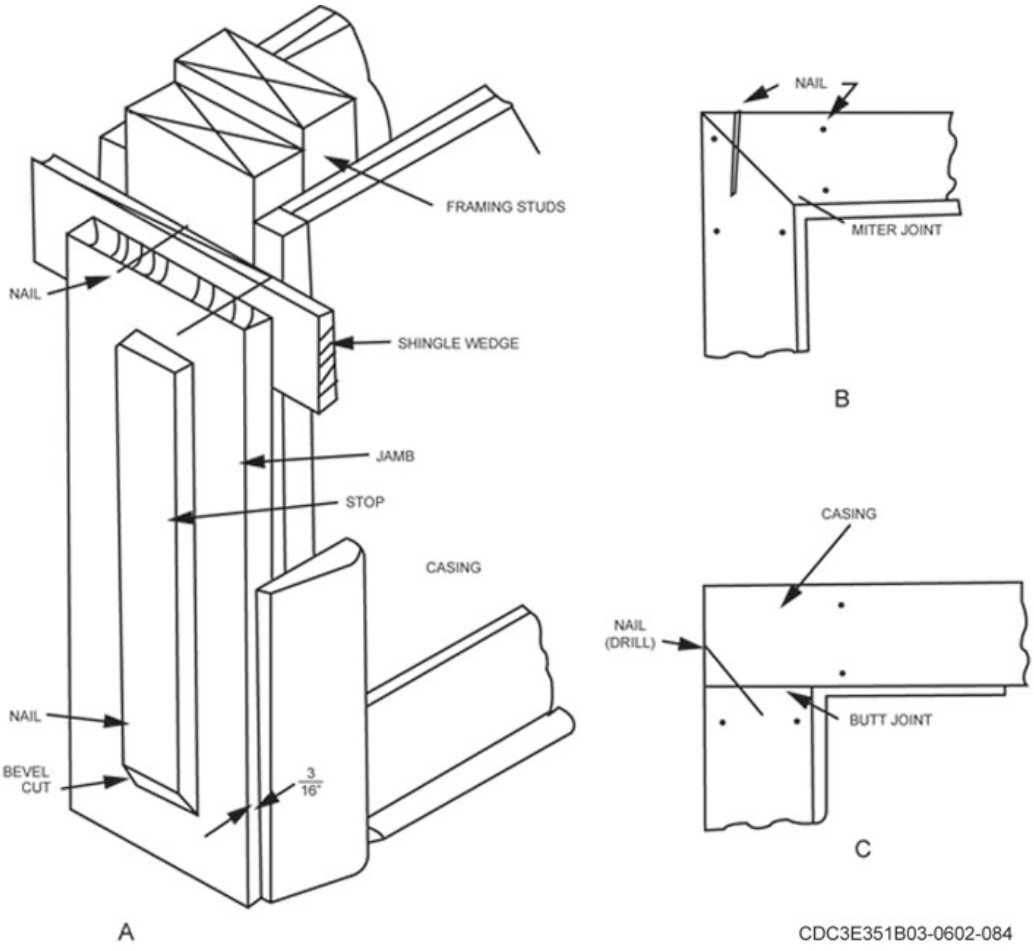

Figure 4–4. Door trim.

Interior window trim

You apply interior window casings the same way, except that you install a sill stool first. In cutting and fitting a stool, be sure to allow about 1/16- inch clearance between the front of the lower window sash and the stool (fig. 4–5). Notice that the stool projects about ¾ inch past the side casing. Once you cut and secure the stool, you apply the side casings, head casing, and apron in that order. On double-hung windows, nail the interior trim or casing to the jambs with finish nails. Casement windows usually have a sill stool and an apron installed without any interior trim or casing. Continue the wall covering material around the window jamb until it is up against the casement sash frame.

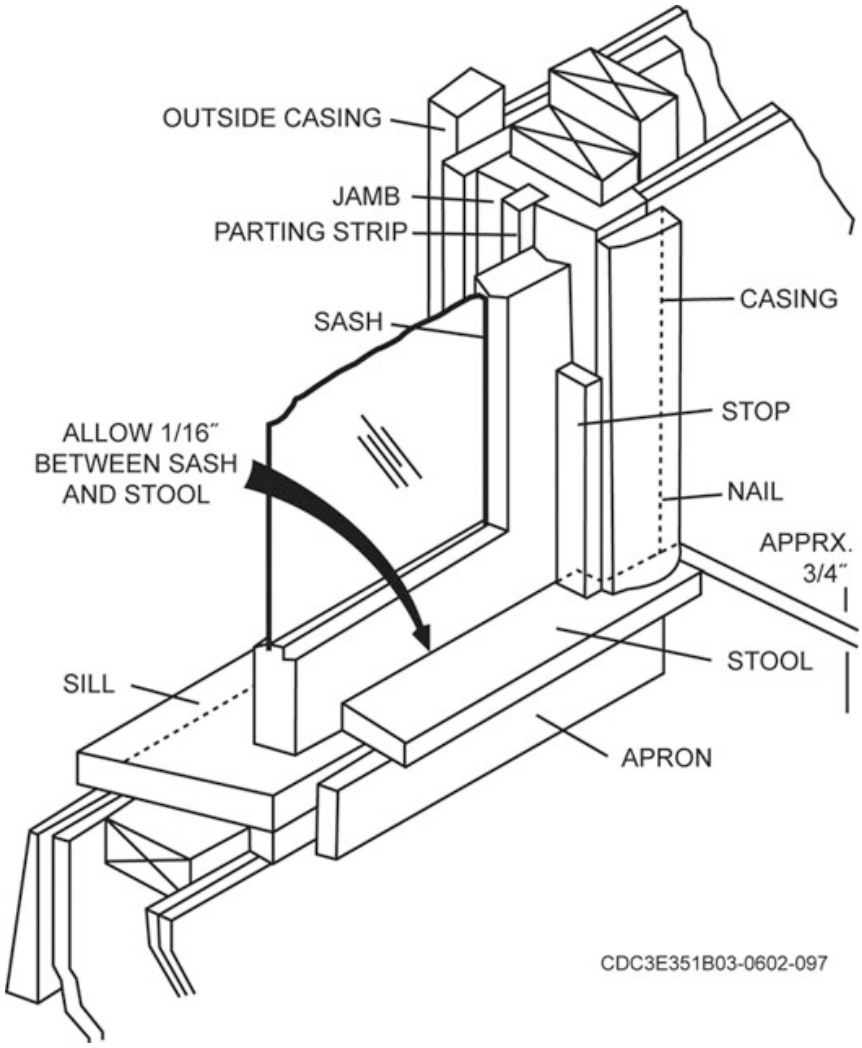

Figure 4–5. Window trim.

Base trim

The base trim fits against the wall on top of the finished floor. It is usually made up of a baseboard and a base shoe later. We usually install the base shoe between the baseboard and the finished floor. You can also use it with a base-cap molding, which fits on top of the baseboard. All of these members you nail with 6d casing or finish nails. You can miter or cope the baseboard inside corners, but you will find that coping a joint is much easier and quicker for the same results. Figure 4–6 shows a cope joint we use for the inside corner and a mitered joint we use for the outside corner.

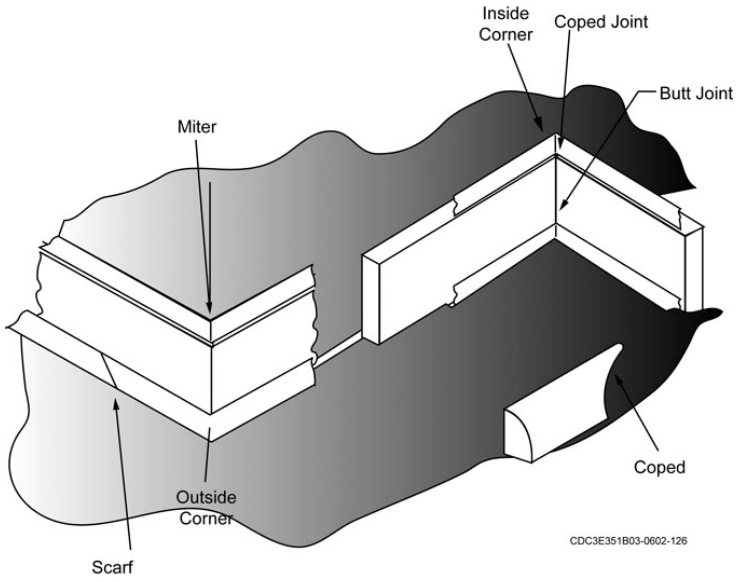

Figure 4–6. Base molding cuts.

Ceiling and wall trim

Picture mold runs along the wall, usually flush against the ceiling, but sometimes 12 or 16 inches below it (fig 4–2, A). We usually nail cornice mold against both the ceiling and the wall of a room (fig 4–2, B). Chair rail runs along the wall, usually at the height of a chair back, or about 32 inches from the floor. We use it for decoration and to protect the wall from damage (fig. 4–2, C). Panel mold divides wall space into panels (fig 4–2, D). Cleats allow easy shelf removal (fig 4–2, E).

Trim repair

When it comes to trim repair, you will more than likely have to replace the piece of trim. For small gauges or cracks, you can apply wood putty and try to match the finish. For larger defects, it is best to replace the entire trim piece and reinstall using original installation procedures. Just be sure to match the replacement piece to the original using the same design and type of material.

Self-Test Questions

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

824. Installing interior trim

1. Match the trim in column B with its use in column A. The items in column B are used only once.

Column A	*Column B*
____ (1) First trim member applied against the wall on top of the finished floor.	a. Base shoe.
____ (2) Divides wall space into panels.	b. Baseboard.
____ (3) Nailed against both the ceiling and the wall.	c. Base cap.
____ (4) Added to the top of the baseboard.	d. Picture mold.
____ (5) Usually installed at the top of wainscot paneling or about 32 inches from the floor.	e. Cornice mold.
____ (6) Trim between the baseboard and finished floor.	f. Chair rail.
____ (7) Sometimes installed 12- or 16- inches below the ceiling.	g. Panel mold.

2. What types of wood trim are best for painting? What is one reason why we use them?

3. When do you apply the interior window and door trim?

4. What is the purpose of interior door casing?

5. What size nails do you use on the baseboard?

4–2. Cabinetry

In this section, we discuss the basics of cabinet installation. As a structural journeyman, you do not usually have to construct cabinets, but there will probably be times when you have to install them. We discuss common installation procedures for wall units, base units, countertops, hardware and plastic laminate application.

825. Installing cabinets, countertops and laminated plastics

As a structural journeyman, there may come a time when you have to install cabinets. Cabinets must be straight, level, and plumb. This action requires skill because floors and walls are often not level or plumb, especially in older buildings. The two ways to make sure base cabinets are level and plumb are to either shim the cabinets from the high points or cut the bottom of the cabinets to fit the floor from the lowest point. This lesson only discusses the procedures that use shims.

When both wall and floor cabinets are to be installed, many installers prefer to mount the wall units first, so the work does not have to be done over the base units. We begin this discussion with the installation of a kitchen cabinet. Figure 4-7 shows typical wall and base kitchen cabinets.

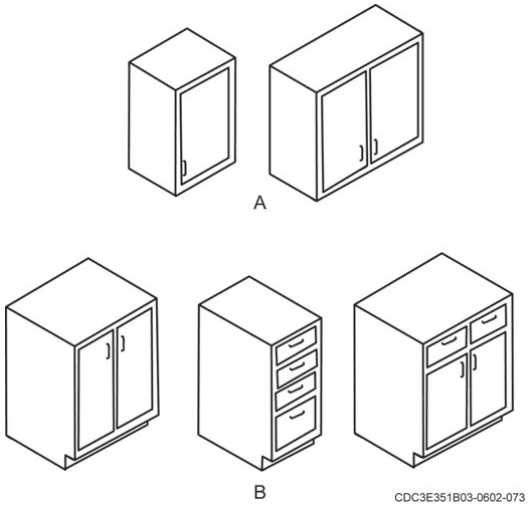

Figure 4-7. Typical kitchen cabinets: (A) wall (B) base.

Wall unit (cabinet) installation

In preparation for wall unit installation, you can follow these suggested steps:

1. Locate the bottom of the wall unit. To determine the appropriate height, measure the height of the base unit, plus the thickness of the countertop, and then add 18 inches (usually this gives a total of 54 inches). Measure up from the highest point of the floor the height for the bottom of

the wall unit and place a mark. With a 36 inch high base cabinet, this leaves an 18 inch space between the counter top of the base unit and the bottom of the wall unit.

2. Draw a level line from the mark across the wall using a level and straightedge. Install the bottom of the wall units to match this line.
3. Locate the wall studs. When you find a stud, mark the location with a pencil; and then measure 16 inches in both directions from the first mark to locate the next stud. Drive a finish nail to test for solid wood. If you do not find studs at 16-inch intervals, then tap the wall with a hammer or use a stud finder to locate additional studs.
4. At each stud, use a level and draw a plumb line down below the line for the bottom of the wall cabinets. Projecting below the wall units makes it easier to locate the studs when you are installing both wall and base units.
5. Mount a temporary ledger board (1 by 2) to the wall along the bottom of the cabinet line. This action helps level and support the wall unit.
6. Mark the cabinet outlines on the wall to ensure the cabinet locations are correct and to get a visual to plan for any unusual circumstances.

The following procedures are a guide to installing wall units:

1. Start the installation in the corner. Measure from the line representing the outside of the wall unit to the center of the stud. Transfer the measurements to the wall units and drill pilot holes through the top and bottom mounting rails on the wall unit.
2. Place the unit on the ledger board or a stand that holds it on the layout line.
3. Test the front edge of the unit with a level for plumbness. If the unit is not plumb, shim it between the wall and its back edge with wood shims until it is plumb. If the unit is not plumb to the wall, either cut the back edge of the cabinet or install a filler (strip of molding) for any visible sides where the cabinet meets the wall.
4. To cut the cabinet, scribe the back edge by riding a set of dividers against the wall and marking the back edge of both end panels to the contour of the wall.
5. Take the cabinet down off the ledger board, and then cut the back edges to the scribed line with either a handsaw or a plane. Use a plane if you have to take off less than ⅛ an inch. Use a handsaw, rather than the saber or circular saw, because these saws cut on the upstroke and can splinter out the face side. The handsaw cuts on the down stroke and that does not splinter the face.
6. Place the cabinet back into position; then fasten the wall unit with mounting screws to hold the cabinet in place (do not fully tighten).
7. Install the next wall unit in like manner. Align the stiles of each unit so that their faces are flush with each other, clamp the stiles together, and screw them together. Continue this process for the remaining wall units.
8. Fully tighten all mounting screws after all wall units are in place with stiles secured to each other.

Base unit (cabinet) installation

Before you install base cabinets, draw a level line the height of the cabinets minus the thickness of the countertop. This should be around 19½ inches below the line you previously drew for the location of the wall units. This marks the location for the top of the base units without the countertop. However, check your plans and specifications for the proper height on the countertop because it may vary.

1. Locate and mark the location of all wall studs where the cabinets are to be hung. Find and mark the highest point in the floor. This ensures the base cabinet is level on uneven floor surfaces (use shims to maintain the cabinet at its designated leveled height).

2. Start installing the base cabinet with a corner or end unit. Place the shims along the bottom and sure the cabinet top is on the layout line.
3. Check the cabinet for level. Place the shims from back to front when leveling. Fasten the cabinet loosely to the wall.
4. Install the remaining base cabinets in the same manner. As with the wall units, align and clamp the stiles together and fasten with screws.
5. After you secure all cabinets to each other, recheck for level/plumb, and fasten all units securely to the wall.

Here are some helpful hints for the general construction of cabinets:

1. Fasten cabinet parts together with screws or nails set below the surface; fill the holes with putty. Use glue at all joints. Use clamps to produce better fitting glued joints.
2. A better quality cabinet is rabbeted where the top, bottom, back, and sidepieces come together. However, butt joints are also used. If panels are less than ¾- inch thick, use a reinforcing block with the butt joint. Fixed shelves are dadoed into the sides.
3. Screws should go through the hanging strips and into the stud framing. Never use nails. Toggle bolts are required when studs are inaccessible. Join units by first clamping them together and then, while you hold them aligned, install bolts and T-nuts.

Countertop installation

After you fasten the base units in position, lay the countertop on top of the units and against the wall. Here are some helpful hints for installing countertops:

1. Move the counter top, if necessary, so that it overhangs the same amount over the face frame of the base cabinets.
2. Adjust dividers for the difference between the amount of overhang and the desired amount of overhang. Scribe this amount on the backsplash if it has a scribing strip.
3. Plane or belt sand the backsplash to the scribed line and fit it to the wall.
4. Fasten the countertop to the base cabinets with screws you insert up through the top skeleton frame of the base units. Most cabinets have triangular blocks located in the top corners for this purpose. Use a stop on the drill bit so you do not drill through the counter top.

In some cases, backsplashes are not built with scribing strips. To fit the backsplash to the wall, hold the countertop in the desired position. Press the backsplash against the wall at intervals and mark its outside face on the countertop. Remove the countertop and fasten the backsplash to the countertop on the marked lines. Fasten the countertop and backsplash in position.

Another method is to leave off the laminate on the face of the backsplash. Fasten the countertop in position. Hold the backsplash down tight on the countertop and nail it to the wall through its face. Then laminate the face of the backsplash on the job after you fasten it in position. The disadvantage of this method is that it is difficult to remove the backsplash if you have to replace the counter top.

Making sink cutouts

You may have to cut an opening for the sink. One method that you can use is to:

1. Mark the sink pattern on the countertop. Most sinks come with a pattern.
2. Use a saber saw with a fine tooth blade to prevent chipping the surface of the countertop. (**NOTE:** Place duct tape on the base of the saw to keep from scratching the surface of the countertop.)

Door installation

Cabinet doors you can install as overlay, lipped, flush, and sliding. *Overlay doors* cover the opening, usually by ⅜ inch on all sides, and swing on overlay hinges. *Lipped doors* are rabbeted over the opening and swing on offset hinges. *Flush doors* fit inside the opening and swing on either surface hinges or butt hinges. *Sliding doors* roll on tracks of metal or plastic.

Hinges

Hinges are made in many styles and shapes. If the hinge is not already provided with the door, select a design that blends well with the cabinet. Some types of hinges are the surface, butt, offset, semiconcealed, pivot, piano hinge, and the new European-style hinge.

The *surface hinge* mounts on the exterior surface of the door and frame. It is made straight for flush doors or offset for lipped doors. This type of hinge is used when it is desirable to show the hardware, such as early American furniture.

We use the *butt hinge* on flush doors when little hardware must show. When we install it properly, only the pin of the butt hinge shows when the door is closed. These hinges require a little extra time to install. It is recommended that you recess or mortise the hinge into the wood.

We use the *offset hinge* on lipped doors that are made from plywood. The offset hinge comes in various sizes to match the thickness of the plywood. The offset hinge must be mortised, rather than surface-mounted.

The *semiconcealed hinge* is designed for lipped and overlapping doors. This hinge has one leaf exposed on the face of the cabinet and the offset leaf is mortised into the door. Before you rabbet the door, check the hinge to ensure that you rabbet the door to the proper depth.

We use the *pivot hinge* on overlay doors. Fasten it to the top and bottom of the door and to the inside of the case. We use such hinges frequently when there is no face frame on the case. The doors completely cover the face of the case.

The continuous or *piano hinge* is a one-piece hinge that usually extends the whole length of the door. We install it like a butt hinge; only the hinge pin is exposed. Use this type of hinge when the door is subjected to heavy use.

We can use the *European hinge* on overlay or flush doors; it is an excellent hinge for frameless cabinets. This hinge has two leafs—the hinge cup leaf and the adjustable leaf. The hinge cup fits into a 1⅜ inch hole (use a forstner bit to drill hole) on the cabinet door. The other leaf we screw to the side panel of the cabinet. This leaf has an oval adjustment screw that allows the hinge to adjust up and down while the center mechanism adjustment has two screws that adjust the hinge left and right.

The number and size of hinges depend on the dimensions of the door. There are two rules to follow:

1. On any door that is longer than 2 feet, install three hinges.
2. The total length of the hinges should equal at least one sixth of the length of the hinged edge. For example, if the door is 24 inches in height, use two 2 inch hinges; if the door is 34 inches, use three 2 inch hinges. When only two hinges are required, we usually place them one quarter of the way from the top and bottom of the door. When three hinges are required, install the first hinge in the center and place the other two hinges 4 to 5 inches from the top and bottom.

Catches

Some hinges are self-closing; therefore, they eliminate the need for installing catches to hold the door closed. Others require catches. There are many kinds of catches available for holding doors. Place catches in the most out-of-the-way position possible. For instance, place them on the underside of shelves instead of on top.

Magnetic catches are used widely. They are available in single or double magnets of varying holding power. Attach an adjustable magnet to the inside of the case and a metal plate to the door. Other types of catches are the roller type and the friction type.

We use *elbow-type catches* to hold one door of a double set. You release the catch by reaching in back of the door. Use these when one of the doors is locked against the other.

Bullet catches are spring-loaded and fit into the edge of the door. When the door is closed, the catch fits into a recessed plate mounted on the frame.

Laminating countertops

In cabinetwork, the countertops are usually covered with a $^{1}/_{16}$ inch layer of high-pressure plastic laminate. Although this material is very hard, it does not possess great strength and is serviceable only when it is bonded to plywood, particleboard, or wafer wood. This base, or core material, must be smooth and is usually ¾ inch thick.Plastic laminate is a very tough material. It is widely used for surfacing countertops, kitchen cabinets, and many other kinds of cabinetwork. An open flame will scorch it; but it resists heat, alcohol, acids, and stains. Another advantage of plastic laminate is that no finishing is required. It also cleans easily with mild detergent.

Laminates are known by various trade names. They are manufactured in many colors and designs, including many wood grain patterns. Surfaces are available in gloss, satin, textured, and other finishes. The distributor supplies samples or chips of the different colors and finishes to help the customer decide which to use.

Material dimensions

Plastic laminates are available in a variety of thickness and sizes.

Thickness

Generally we use one of two thicknesses of laminates: thick or thin. Thick laminate is about $^{1}/_{16}$-inch thick. We use it on horizontal surfaces, such as countertops, tables, dressers, and desktops. Thin laminate is about $^{1}/_{32}$-inch thick. We use it on vertical surfaces, such as the sides and front of kitchen cabinets. This is because vertical surfaces take less wear than horizontal surfaces. Thin laminate makes a more pleasing appearance because of the thin edge line it presents when we trim it. It is also less expensive than the thick laminate. A thinner laminate, called backer laminate, is also available. We use it to cover the inside of doors and the underside of tabletops to provide a balanced appearance.

Width and lengths

Plastic laminate sheets come in widths of 24, 30, 36, 48, and 60 inches and lengths of 5, 6, 8, 10, and 12 feet. Sheets are usually 1 inch wider and longer than the size indicated.

Most distributors cut sheets in half through their width or length. This actually increases the range of sizes available. Since the material is relatively expensive, it is wise to carefully plan and order the most economical sizes.

Inspecting the surface

Before you laminate a countertop, make sure all surfaces are flush. There should be no indentations where the pilot of the router bit will ride. Check for protruding nailheads and points. Plane or sand surfaces that are not flush. Fill in any holes and sand them smooth. Drive nailheads flush, and then fill and sand them level.

Cutting laminate to rough size

There are a number of ways to cut laminate. Whatever method you decide to use, cut the pieces ¼ to ½ inch wider and longer than the surface to be covered. Handle laminate carefully because it is very brittle. It may crack if you drop or handle it roughly.

Cutting with router

The best way to cut plastic laminate is to use a straightedge clamped to the sheet and a router with a flush trimming bit made of solid carbide. It is easier to run the cutting tool across a larger sheet than to move a large sheet across the cutting tool. The router bit leaves a smooth edge.

Cutting with a table saw

The table saw can produce a smooth edge when you use a 60 tooth, triple-chip carbide blade. You can also cut laminate with a portable circular saw, saber saw, or band saw. However, these tools might not give a clean, chip-free edge.

Cutting with portable saws

You can cut plastic laminates to rough size with a portable saw or saber saw. Use a fine-tooth blade, and support the material close to the cut. If no electrical power is available, you can use a finish handsaw or a hacksaw. When you cut laminates with a saw, place masking tape over the cutting area to help prevent chipping the laminate. Make your cut markings on the masking tape.

Measure and cut a piece of laminate to the desired size. Allow at least ¼ inch extra to project past the edges of the countertop surface.

Adhering laminates

To fasten the plastic laminate to the countertop, mix and apply the contact cement to the underside of the laminate and to the topside of the countertop surface. Be sure to follow the manufacturer's recommended directions for application. Allow the contact bond cement to set or dry. If the countertop is porous, such as large grain plywood or the edges of particleboard/plywood, you must apply two coats to the surface. You know that you have applied enough cement when you see a glossy film over the entire surface.

Before you set the laminate in place, check the material to make sure it is ready for bonding. Press a piece of waxed brown paper on the cement-coated surface. When no adhesive residue shows, the surface is ready to be bonded. Begin with the following steps:

1. Lay a few strips of wood spacers on the surface about a foot apart. This allows you to adjust the laminate into the desired position without permanent bonding.
2. Start at one end and press the laminate to the countertop to make contact. Start removing the wood spacers from under the laminate one-by-one. The laminate becomes bonded to the countertop surface. (**NOTE:** When using wood spacers, some craftsmen prefer to start removing them from the center and work out.)
3. Roll or tap the laminate to apply pressure to the entire surface. You can use a 3-inch J-roller or tap a small block with a hammer. This removes any air bubbles and ensures a good, firm bond.
4. After the laminate is sealed to the countertop surface, trim the edges with either a router with a flush trimming bit or a small, block plane.
5. A last optional step is to bevel the countertop edge using a mill file.

Self-Test Questions

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

825. Installing cabinets, countertops and laminated plastics

1. How much space do you leave between the countertop of the base unit and the bottom of the wall unit?

2. Where do you start when installing wall units?

3. Which saw do you use when trimming wall units? Why?

4. With which unit do you start when installing the base cabinet?

5. What do you *never* use in the hanging strips when installing cabinets?

6. When making sink cutouts, what type of saw do you use? What do you do to the saw to keep from scratching the surface of the countertop?

7. When three hinges are required on cabinet doors, where do you install them?

8. What are some of the advantages of using plastic laminates for countertops?

9. What are the two thicknesses of laminate and what are their uses?

10. How much wider and longer than the surface to be covered do you cut laminate? How do you handle it?

11. What are the advantages of thin laminate?

12. What three ways can you cut laminate? Which is best?

Answers to Self-Test Questions

824

1. (1) b.
   (2) g.
   (3) e.

(4) c.
(5) f.
(6) a.
(7) d.

2. Close-grained wood such as poplar, and pine. Lower in cost.
3. After you install the finish wallboard.
4. The casing covers the space around the frame and provides strength with an attractive finished appearance.
5. 6d casing or finish nails.

825

1. 18 inches.
2. In the corner.
3. Use a handsaw, rather than the saber or circular saw, because these saws cut on the upstroke and can splinter out the face side. The handsaw cuts on the downstroke and that does not splinter the face.
4. A corner or end unit.
5. Nails.
6. Use a saber saw with a fine tooth blade to prevent chipping the surface of the countertop. (**NOTE:** Place duct tape on the base of the saw to keep from scratching the surface of the countertop.)
7. Install the first hinge in the center and place the other two hinges 4 to 5 inches from the top and bottom.
8. An open flame will scorch it; but it resists heat, alcohol, acids, and stains. Another advantage of plastic laminate is that no finishing is required. It also cleans easily with mild detergent.
9. Thick laminate is about $^{1}/_{16}$ inch thick. We use it on horizontal surfaces, such as countertops, tables, dressers, and desktops. Thin laminate is about $^{1}/_{32}$- inch thick. We use it on vertical surfaces, such as the sides and front of kitchen cabinets. This is because vertical surfaces take less wear than horizontal surfaces.
10. ¼ to ½ inch wider and longer than the surface to be covered. Handle it carefully, because it is very brittle. It may crack if you drop or handle it roughly.
11. Thin laminate makes a more pleasing appearance because of the thin edge line it presents when we trim it. It is also less expensive than the thick laminate.
12. Cutting with a router, cutting with a table saw, cutting with portable saws. Cutting with a router.

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).

94. (824) When temporarily nailing side casings in place, what size casing or finish nails do you use along the jamb edge and along the outer edge?
    a. 6d jamb edge and 6d outer edge.
    b. 8d jamb edge and 6d outer edge.
    c. 6d jamb edge and 8d outer edge.
    d. 8d jamb edge and 8d outer edge.

95. (824) How many inches from the floor should you install chair-rail molding?
    a. 32.
    b. 36.
    c. 42.
    d. 48.

96. (825) Where do you start when installing wall units?
    a. On top.
    b. In the corner.
    c. In the center of the wall.
    d. On top in the center of the wall.

97. (825) How many hinges do you install on any cabinet door that is longer than 2 feet?
    a. 2.
    b. 3.
    c. 4.
    d. 5.

98. (825) What are the two *most* common thicknesses of laminate?
    a. 1/32 and 1/16 inch.
    b. 1/32 and 1/8 inch.
    c. 1/16 and 1/8 inch.
    d. 1/8 inch and 1/4 inch.

99. (825) How many inches wider and longer than the surface to be covered do you cut laminate?
    a. 1/32 to 1/16.
    b. 1/16 to 1/8.
    c. 1/8 to ¼.
    d. ¼ to ½.

100. (825) Which is the *best* of the three ways to cut laminate?
    a. Router.
    b. Hand saw.
    c. Table saw.
    d. Portable saw.

Glossary of Terms, Abbreviation, and Acronyms

Terms

Anchor bolts—Bolts used to fasten columns, girders, soleplates, or other members to concrete or masonry.

As-built drawings—Drawings made during or after construction, illustrating how various elements of the project were actually installed.

Bird's mouth—A notch cut in the lower edge of a rafter, to fit over the top wall plate. Formed by a level line and a plumb line.

Blemish—A flaw that mars the appearance of lumber but has no effect on the utility value.

Bridging—Crossed or solid supports installed between joists (floor or ceiling) to help evenly distribute the load and brace the joists against side sway.

Cantilevered—When a portion of a structure projects outward beyond the structure below.

Cant strip—A beveled strip of wood or wood fiber that fits into the angle formed by the intersection of a horizontal and vertical surface.

Casing—The trim around doors and windows.

Chase—Opening in a metal stud through which pipe is routed.

Cornice—The area under the eaves where the roof and sidewalls meet.

Cripple studs—A stud used with wall openings. Its length runs from the top plate to the header (above wall openings) or from the sole plate to the rough sill (below wall openings).

Crown—The outside curve of a twisted, bowed, or cupped board.

Dead load—The material weight used to construct the roof such as rafters, sheathing, insulation, shingles, and so forth.

Defect—Any flaw in lumber that tends to affect the strength, durability, or utility value of the lumber.

Drop—An angle used when installing a gutter to allow smooth water flow to the downspout.

Eave—The part of a roof projecting over the sidewall.

Elastomer—A rubber like synthetic polymer; as silicone rubber.

Escutcheon—A protective, often ornamental shield or plate, as that around a keyhole.

Expansion joint—Structural separations that are designed to minimize stress movement between two building elements.

Fascia—The flat outside horizontal member of a cornice placed in a vertical position.

Fishmouth—Upturned felt edge that appears on an installed roll roof.

Flashing—Provides a continuous watertight connection between the roofing membrane and the other roof sections such as valleys.

Furring—Any extra material added to another piece or member to bring an uneven surface to a true plane and to provide additional nailing surface.

Gang nail plates—Metal plates made with formed metal teeth. During truss construction, they are usually hammered into position at each joint on both truss sides. Are sometimes used instead of plywood gussets.

Girder—A supporting beam laid crosswise to the building; a long truss.

Gusset—A plate connecting members of a truss together.

Jalousie—A window formed of overlapping, horizontal slats, or louvers, of wood, metal, or glass that can be adjusted to regulate the air of light coming in between them.

Joist—Heavy pieces of lumber laid on edge horizontally to form the floor and ceiling support system.

Knocked down—A complete group of parts that is cut to size and sold as a kit that is ready for assembly.

Laminated lumber—Made of several pieces of lumber, either nailed, bolted, or glued together to form a single unit with the grain of all pieces running parallel with each other.

Lateral strength—The ability to withstand side-to-side forces or loads.

Lintel—A support beam place over an opening in a wall.

Live load—Weight from snow, personnel, and so forth. that a roof is subjected to support.

Lumber—Wood that has been cut and surfaced for use in construction work.

mil—Measurement used to indicate one thousandth of an inch.

Miter—A kind of joint formed by fitting together two pieces, beveled to a specified angle to form a corner.

Mortise—A hole or recess cut, as in a piece of wood, to receive a projecting part.

Mullion—A slender, vertical dividing bar between the lights of windows, doors, and so forth.

Muntin—The small members dividing glass panes in a window frame; vertical separators between panels in a panel door.

Parapet—The part of a wall above the roofline.

ply—A single material layer.

Plywood gussets—Plywood strips used to hold truss joints in place. During truss construction, they are usually nailed on at each joint on both truss sides. Are sometimes used instead of gang nail plates.

Polymer—A naturally occurring or synthetic substance consisting of giant molecules formed from polymerization: the process of chaining together many simple molecules to form a more complex molecule with different physical properties.

Purlin—Horizontal members of a roof supporting common rafters. Also, members between trusses supporting sheathing.

Rabbet—A groove or recess cut in the edge of a board, plank, and so forth.

Rafter—A sloping roof member supporting the roof covering and extending from the ridge or the hip of the roof to the eaves.

Rake—The inclined position of a cornice; also the angle of slope of a roof rafter.

Reglet—Kerf cut into the wall.

Ridge—The long joining members placed at the angle where two slopes of a roof meet at the peak.

Rise—In a roof, the vertical distance between the plate and the ridge. Roof angle incline or amount expressed in inches per foot of run. In a stair, the total height of the stair.

Rolled roofing—Similar to felt paper, this composition material comes in rolls about 3-feet-wide and in various lengths. The surface has a slate, sand, mica, or some similar material coating to help prevent damage from the sun’s heat. Generally used for temporary construction.

Run—Construction term that refers to the horizontal distance covered by a rafter. The run is ½- the span distance.

Sash—The movable part of a window.

Scrim—A fabric used for reinforcing or strengthening membranes.

Seasoning—The removing (drying) of moisture from the small and large cells of wood. Wood is considered dry enough for most uses when the moisture content is reduced to around 12-to-15 percent.

Sills—The first members of a frame set in place.

Soffit—The underside of a subordinate member of a building.

Soleplate—The lowest horizontal wall-framing member that rests on a subfloor or finish floor. It also provides support to wall studs.

Span—Construction term that refers to the distance from the outside of one double top plate to outside of the opposite double top plate. The span is twice the run distance.

Specifications—Written instructions containing information about the materials, style, workmanship, and finish for the job.

Stitch bolt—Truss repair method where bolts are placed vertically. This method can only be used on two-inch thick or thicker trusses. Always follow engineering guidelines when repairing trusses.

Stud—The vertical members of wooden forms or frames.

Superimposing—To place something on or over something else.

Thermoset—Becoming permanently hard and rigid when once subjected to heat; aid of plastics.

Timber—Lumber that is 5inches or more in both thickness and width.

Trimmer stud—A stud used with wall openings. Its length runs from the sole plate to the bottom of the header. It also runs in parallel contact with a full-length stud.

Truss—A wood framed support system that takes the place of rafters in supporting a roof. A truss can span a wide distance and is built to withstand various conditions including wind and live loads. A combination of members, such as beams, bars, and ties; usually arranged in triangular units to form a rigid framework for supporting loads over a span.

Vulcanized—The process of treating crude rubber with sulfur or its compounds and subjecting it to heart in order to make it nonplastic and increase its strength and elasticity: a process for hardening some substance.

Abbreviations and Acronyms

AFI	Air Force instruction
AFMAN	Air Force manual
AFOSH	Air Force Occupational Safety and Health
ANSI	American National Standards Institute
BCE	base civil engineer
BUR	built-up roof
CPE	chlorinated polyethylene
CSPE	chlorosulfonated polyethylene
d	penny
DRMO	Defense Reutilization and Marketing Office
ECH	epichlorohydrin
EIP	ethylene interpolymers
EPDM	ethylene propylene dienne monomer
EPS	expanded polystyrene
KD	knocked down
MEK	methyl ethyl ketone
SDS	Safety Data Sheet
OC	on center
OSB	oriented strand board
PEB	pre-engineered building
phy	felt layers
PIB	polyisobutylene
PMR	protected membrane roof
PS	product standard
PVC	polyvinyl chloride
RIEI	Roofing Industry Educational Institute
RPM	revolutions per minute
T&G	tongue and groove
THF	tetrahydrofuran
TPO	thermoplastic polyolefins

Student Notes

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