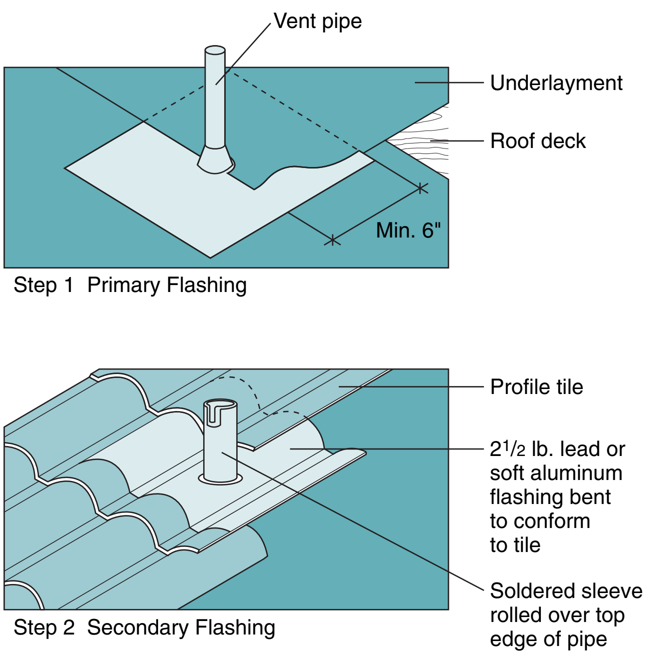
FIGURE 2-33 Pipe Flashings for Tile Roofs.



Vent pipes in tile roofs generally get a primary flashing, when the underlayment is installed, and a secondary soft-metal flashing that conforms to the tile surface.

Replacing Broken Tiles. If a tile is cracked, gently lift the overlapping tile and wiggle loose the damaged tile. Remove the tile nail, screw, or clip with a slate ripper or hacksaw blade. Seal any nail holes with roofing cement and slip a new tile into place, securing the butt end with an L-hook or bent copper wire (as shown in Figure 2-35).

METAL ROOFING

Residential installations of metal roofing have more than doubled in the past several years, and they are now estimated to account for over 10% of residential roofs. Originally associated with agricultural and commercial buildings, new metal roofing products aimed at the residential market are designed with simplified installation systems and offer more choices in materials, finishes, and design. The installed cost of premium metal roofing is three to four times more than asphalt shingles, but metal roofing offers a variety of attractive benefits:

- ***Fire resistance:*** Many metal roofs carry a Class A fire rating.
- ***Low weight:*** Most metal roofing products range from 125 to 175 pounds per square. Some lightweight aluminum shingles weigh as little as 40 pounds per square.
- ***Wind resistance:*** Many systems have earned a Class 90 wind-uplift rating, UL's highest rating.
- ***Impact resistance:*** Metal roofing systems offer moderate to excellent resistance to impact from hail, some earning UL's Class 4 rating.
- ***Mold-resistant:*** Metal roofing resists the type of algae and mildew growth that attacks asphalt and wood roofs.
- ***Energy efficiency:*** In a test conducted by the Florida Solar Energy Center, white metal roofing showed the greatest reductions in cooling loads of all roofing types, with 23 to 30% savings (compared to a control home with dark asphalt shingles).
- ***Recycled content:*** Many metal roofing products use recycled material, ranging from 25% with some steel products to over 90% with some aluminum modular shingles.
- ***Longevity:*** Metal roofs typically carry a 30-to 50-year warranty.

Noise Transmission. One frequently cited disadvantage of metal roofing is that it generates a noticeable noise when struck by rain, hail, or even dropping acorns. If installed directly to purlins with no roof sheathing, the noise might be heard in the building interior. However, when installed over a solid substrate, with normal levels of insulation, the noise should not be noticeably different than with other roofing types.

Walkability. Panels laid flat on solid decking are generally walkable. However, if panels are installed on battens, workers should be careful to step directly over battens or to use planking that spans multiple battens. Modular shingle panels generally use fairly light-gauge material, but it is stiffened somewhat by the stamped textures. In general, modular steel panels are walkable, but aluminum ones should be reinforced by foam inserts in sections expected to see a lot of foot traffic.

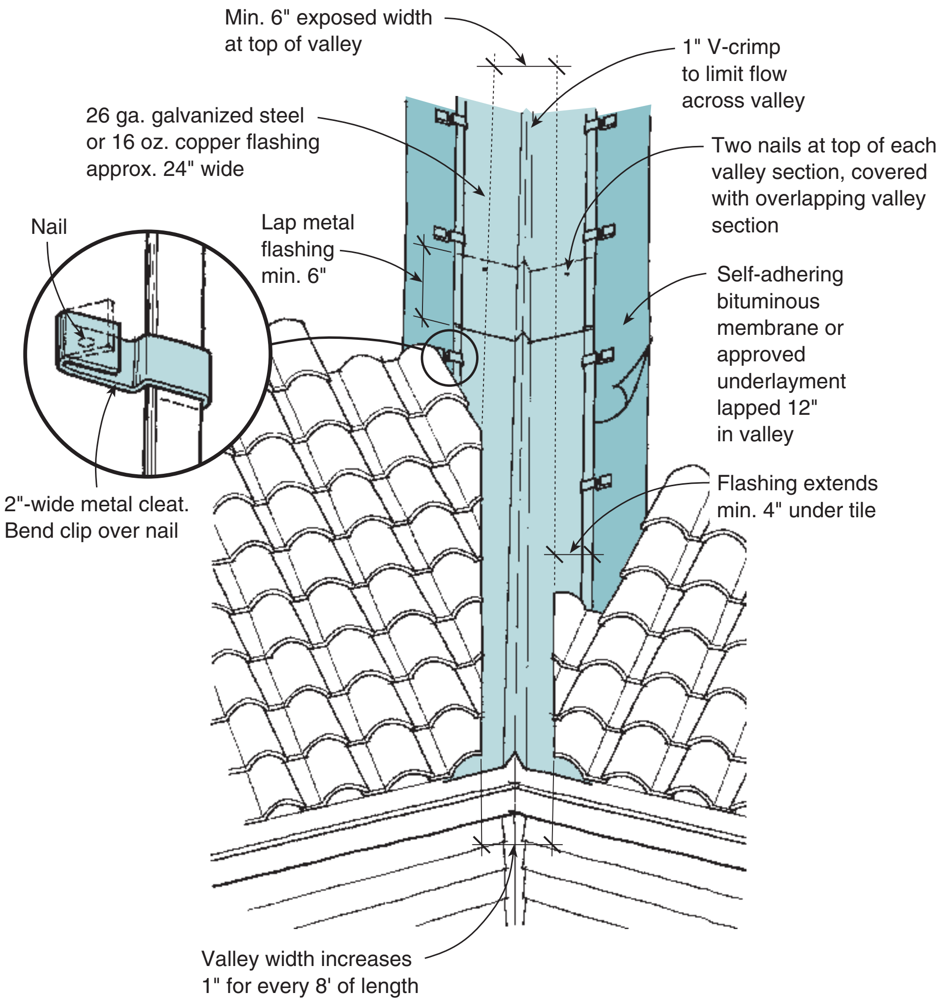
Minimum Slopes. Most metal roofing systems can be installed on slopes of 3:12 and greater and standing-seam systems from 2:12 and greater. Special standing-seam systems designed for slopes as shallow as $\frac{1}{2}$:12 require field crimping machinery and have sealant in all seams. The height of the ribs at seams and whether they are protected with a sealant affect how weathertight a roof will be under extreme weather.

There are three general types of residential metal roofing: Exposed-fastener panels, standing-seam, and modular panels.

Exposed-Fastener Panels

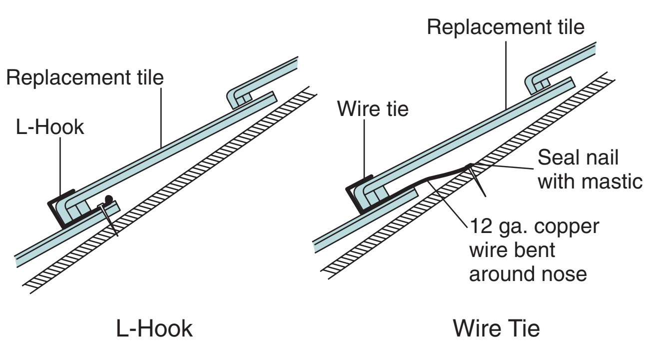
Steel and aluminum panel roofing with exposed fasteners has been a popular choice on agricultural buildings for decades. In recent years, these "ag panels" have grown increasingly popular for rural homes as well, since they can provide a long-lasting roof at a cost comparable to asphalt shingles. The products installed on homes, while essentially the same material as the agricultural panels, generally use better metal coatings, and installers pay more attention to sealing and watertight detailing.

FIGURE 2-34 Open Valleys in Tile Roofs.



Open valleys provide clear drainage and are recommended for areas subject to tree debris. Code requires fully waterproof underlayment and a flow area free of nail holes. Secure cut tile pieces with adhesive, clips, or wires.

FIGURE 2-35 Replacing Damaged Tiles.



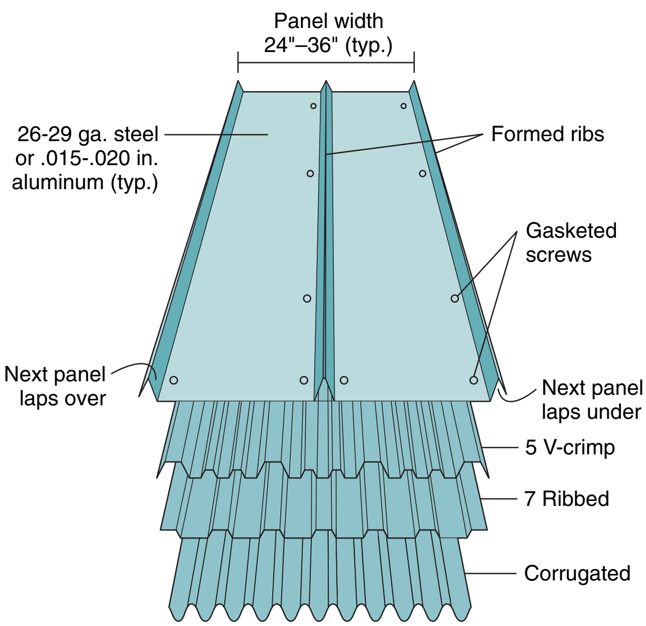
Gently lift the overlapping tile and twist loose the damaged tile. After filling any nail holes, slip in a new tile and secure with an L-hook (left) or bent copper wire (right).

While a carefully installed exposed-fastener roof should be free of leaks upon completion, small installation errors can result in leakage later as the metal panels undergo normal thermal movement that places stress on the fasteners. With so many exposed holes in the panels, periodic inspections are recommended. Also, the exposed fastener heads, in addition to lending a rural look to the building, tend to catch leaf debris and restrain sliding snow.

Materials. Exposed-fastener panels are typically 26 to 29 gauge, compared to the heavier 22 to 26 gauge used in standing-seam roofing. The ribs in exposed fastener roofing are also lower and closer together than in standing-seam roofing and may be squared, rounded, or v-shaped (see Figure 2-36). Most panels are 2 to 3 feet wide and formed with galvanized steel, Galvalume®, or aluminum.

- ***Panel length.*** While some stock sizes are available, ordering panels factory-cut to exact lengths simplifies installation and reduces corrosion at field cuts. Panels can be ordered in any shippable length, although excessive thermal movement can be a problem for steel panels longer than 40 feet or for aluminum panels

FIGURE 2-36 Exposed-Fastener Metal Panels.



Exposed panel roofing typically uses light-gauge stock and stiffens it with square, round, or V-shaped ribs. Some patterns imitate standing-seam roofing, but most have more frequent ribs to provide greater rigidity.

FIGURE 2-37 Gasketed Screws.

Exposed-fastener panels are vulnerable to leaks if screws are installed poorly or if excessive thermal movement loosens the screws or stretches the screw holes. To minimize leaks, place screws in the flat sections between ribs, and drive screws straight and snug but not overtight. Also, do not exceed the maximum panel length recommended by the manufacturer.

longer than 16 feet. In regions with very wide temperature swings, contractors should use shorter lengths (see "Thermal Expansion" in Table 2-10, page 83).

Installation. While traditionally installed over battens, most panels in residential installations are now installed over a solid plywood deck with minimum No. 30 felt underlayment. Metal roofing manufacturers recommend plywood over oriented-strand board (OSB) due to plywood's better screw-holding ability. Roofing felt should be installed with plastic cap nails rather than metal buttons, which can deteriorate the metal roofing by galvanic action (see "The Galvanic Scale," page 83).

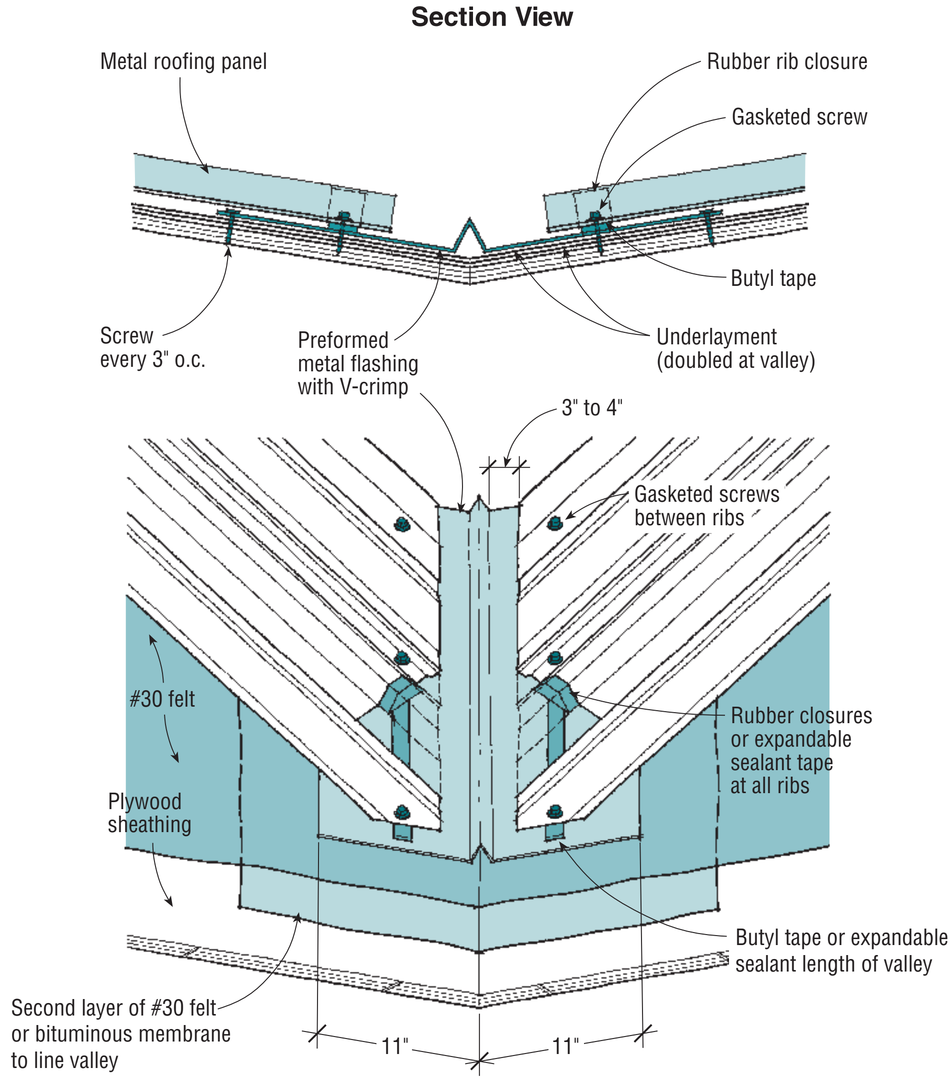
- ***Align to eaves.*** After installing drip edges and valley flashing, the first panel is fit along one rake, square to the bottom edge of the roof. If the roof is not square, the first panel may need to be cut at a bevel along the rake. Start at the downwind end of the roof, so the edge of each overlapping panel faces away from the prevailing winds.
- ***Cutting panels.*** Where panels need to be cut, use snips or shears rather than an abrasive blade, which overheats the steel coatings and leaves a rough edge prone to rust. Abrasive blades also produce hot metal filings that can embed in the paint and cause rust on the face of the panels.
- ***Side and end laps.*** After the first panel is screwed down, the next panel is set in place, lapping over the first. Side laps are typically sealed with butyl tape and held together with gasketed sheet-metal screws. Where more than one panel is used up the run of the roof, the upper panel laps the lower by 6 inches and is sealed with butyl tape.
- ***Fasteners.*** Fasteners are typically special wood screws with integral EPDM or neoprene gaskets that compress under the screw head to seal the hole. Fasteners should be driven at a right angle to the roof plane and should be snug but not so tight as to deform the washer (see Figure 2-37). Nearly all manufacturers recommend placing screws in the flat sections between ribs. Although making holes in the flat section may seem unwise, placing screws in the ribs is discouraged for two reasons. First, the long exposed screw shaft passing through the rib is prone to snap over time due to thermal movement of the panels. Second, it is easy to overdrive the screws and crush the panels. Higher-cost EPDM washers are less likely to leak than neoprene.

Reroofing. Panels can go directly over a single layer of asphalt shingles in good condition. If the shingles are curled or uneven, install 2x horizontal purlins at 16 inches on-center. In either case, put down a new layer of No. 30 underlayment before installing the panels.

Flashings and Accessories. Most manufacturers supply preformed flashings, drip edges, rake moldings, and ridge caps color-matched to their roofing panels, as well as color-matched coil stock for fabricating custom pieces onsite. They also provide rubber closure strips or expandable foam tapes to seal panel ends against water and insect intrusion at eaves, valleys, ridges, and other terminations.

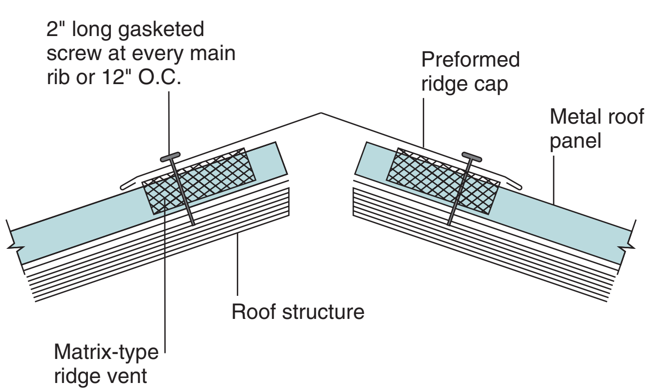
Pay particular attention to panel ends at valleys. Some manufacturers supply special closures for the angled cuts through ribs, but closures may need to be fashioned by cutting up standard closure strips. Some manufacturers also provide an expandable foam sealant tape that conforms to the rib pattern for a tight seal up the valley. Depending on the panel profile, the end treatment will vary, but ends should be fully sealed. Remember to place screws in flat sections and to use extra screws up the valley (Figure 2-38). For a vented ridge, place short sections of a matrix-type ridge vent between the ribs and secure with a preformed metal cap (Figure 2-39).

FIGURE 2-38 Valley Flashing for Exposed-Fastener Panels.



Line valleys with bituminous membrane or two layers of No. 30 roofing felt. To seal the open ribs facing into the valley, manufacturers provide self-adhesive neoprene closures or an expandable asphalt-impregnated tape that conforms to the profile of the roofing.

FIGURE 2-39 Vented Ridge for Exposed-Fastener Panels.



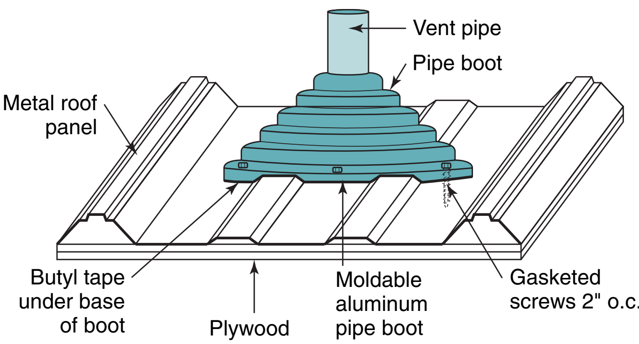
For a vented ridge, use a preformed ridge cap with short sections of matrix-type ridge vent installed between the ribs.

For plumbing vents, most manufacturers recommend a moldable aluminum jack bent to conform to the profile of the roofing (Figure 2-40).

Rectangular openings, such as skylights and chimneys, typically require both base and counterflashing so roof panels are free to move with changes in temperature. Depending on the panel profile, either use a pan flashing or an L-flashing sealed to the top surface of the roofing panel with sheet metal screws and butyl tape. On large openings, a cricket is needed on the upslope to divert water around the penetration. Custom-made, one-piece curbs with built-in diverters simplify this type of installation. All flashing joints should be sealed with butyl tape or a manufacturer-recommended sealant.

Sealing. For the watertight performance required on homes (as opposed to barns), metal roofs need careful

FIGURE 2-40 Plumbing Vents for Metal Roofing.



At plumbing vents, most exposed-panel manufacturers recommend a surface-mounted soft aluminum jack that molds to the profile of the roofing.

sealing around all penetrations, side laps, and end laps. On side seams and lap joints, the sealant should always go on the uphill, or "dry," side of any fasteners (Figure 2-41). Sealant should also be used at ridge caps, valleys, and wherever flashings lap over or under the metal roofing.

The preferred sealant for most concealed seams in roof panels is butyl tape, which absorbs movement and will not shrink. Gunnable terpolymer butyl or urethane caulk can also be used, as specified by the manufacturer. But never use acid-cure silicone caulking (the common type with vinegar odor) or asphalt roofing cement, as they will damage most metal coatings.

Panel Movement. Metal panels were originally designed for installation on purlins that can absorb the normal movement as the panels expand and contract from temperature changes. The thermal movement of a long panel installed over solid plywood, however, can cause problems. Typically, either the hole in the roofing elongates—creating a potential leak—or the screw becomes loosened, making the roof vulnerable to blow-off. The problems are greatest with aluminum, which has 70% more thermal movement than steel and less tensile strength. To avoid problems, experts recommend the following:

- With exposed-fastener panels, avoid lengths over 40 feet for steel or 16 feet for aluminum—less for climates subject to wide temperature swings. Break the run into two panels.
- On long runs of painted roofing, choose lighter shades, preferably white.
- Use screws in the flat part of the panel, not on the ribs. Screws should penetrate the sheathing fully, plus $\frac{1}{4}$ to $\frac{1}{2}$ inch.
- Where leak-free performance is critical, fasten the roofing to Z-shaped metal purlins screwed horizontally across the plywood sheathing. Or switch to a concealed fastener system.

Oil-Canning. Thermal expansion in light-gauge metal panels can cause a wavy appearance called "oil-canning" in the flat areas. In general, this does not signal a performance problem, but it may be visually objectionable. Oil-canning tends to be most visible in bright light from a close distance, and it is generally more noticeable on shiny metals, such as Galvalume®, than on colored metal panels. It is primarily a problem in profiles with few ridges to stiffen the panels. To reduce the effect, some manufacturers provide self-adhesive foam strips that are attached lengthwise to the bottom of metal panels.

Standing-Seam Roofing

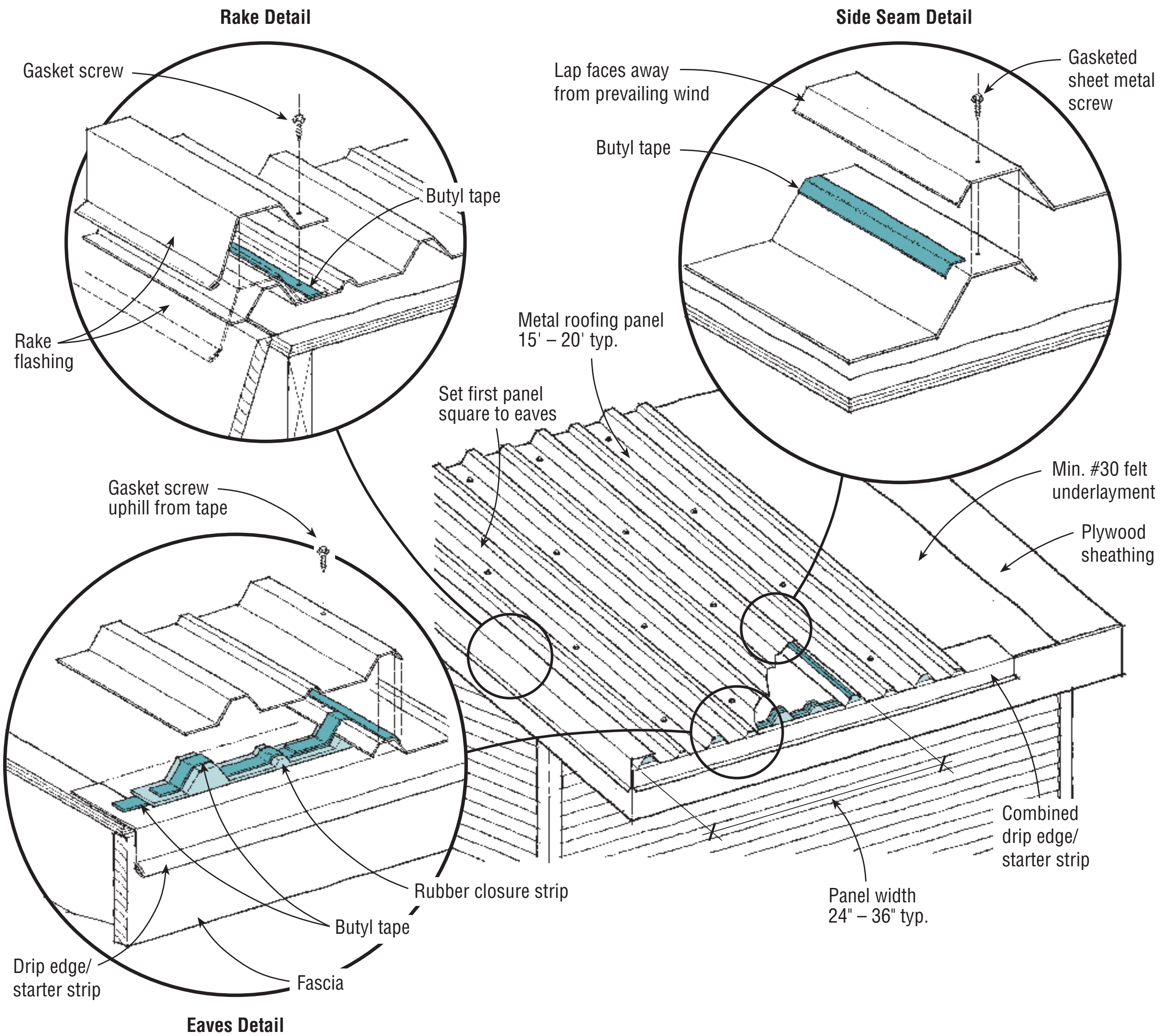
Standing-seam roofing consists of individual panels that run the length of the roof with a high rib up each side of the panels. The ribs overlap and lock together, concealing the fasteners and giving the roofing its name. The hidden fasteners allow thermal movement in the panels and are less likely to leak than exposed fasteners. However, some trim pieces are still fastened with exposed screws.

The smooth surface of a standing-seam roof provides a cleaner appearance and is easier to keep clear of leaf debris than tile, wood, or other textured roofing surfaces. Also, it can be walked on when necessary. Snow slides off easily as well, making this a popular choice in high snow regions. The cost is generally 25% to 50% more than an exposed-fastener roof of similar materials.

Materials. Standing-seam panels are 8 to 24 inches wide and available in steel, copper, and aluminum with a wide array of finishes (discussed below). Stiffening ribs may be added to wider panels to reduce waviness (oil-canning). Thicknesses for quality residential applications are typically 24 or 26 gauge, but lighter and heavier stock is also available. Installers can form panels on-site from coil stock with portable roll-forming equipment, or they can order factory-made panels from a growing number of metal roofing manufacturers. Most factory-made panels have snap-together seams, eliminating the need for special crimping equipment used by site fabricators. In most cases, panels are fabricated to run from eaves to ridge, eliminated the need for end lap joints.

- ***Clips vs. flange.*** Standing-seam panels either have an integral screwing flange (through-fastener panels) or are installed with clips placed 20 to 24 inches on-center (Figure 2-42). Clip systems are more costly to manufacture and to install, but they have better wind resistance and a higher water-lock at the seams. Also, because the clips allow unlimited panel movement, panels can be fabricated to any length. The flange type should be limited to 40 feet for steel and 20 feet for aluminum for normal climate conditions.
- ***Site vs. factory fabrication.*** For those with the equipment, site fabrication provides flexibility and saves on shipping costs, which can be high. Site fabricators can

FIGURE 2-41 Exposed-Fastener Metal Roofing—Typical Details.



For profiles with deep ribs, manufacturers provide rubber closure strips to seal ends at eaves, valleys, and other terminations. Butyl tape is the preferred sealant for panel laps, joints, and flashings. Position panels carefully on the tape, as they are difficult to adjust afterward. Note that screws go either through the sealant or on the "dry side" of the butyl tape.

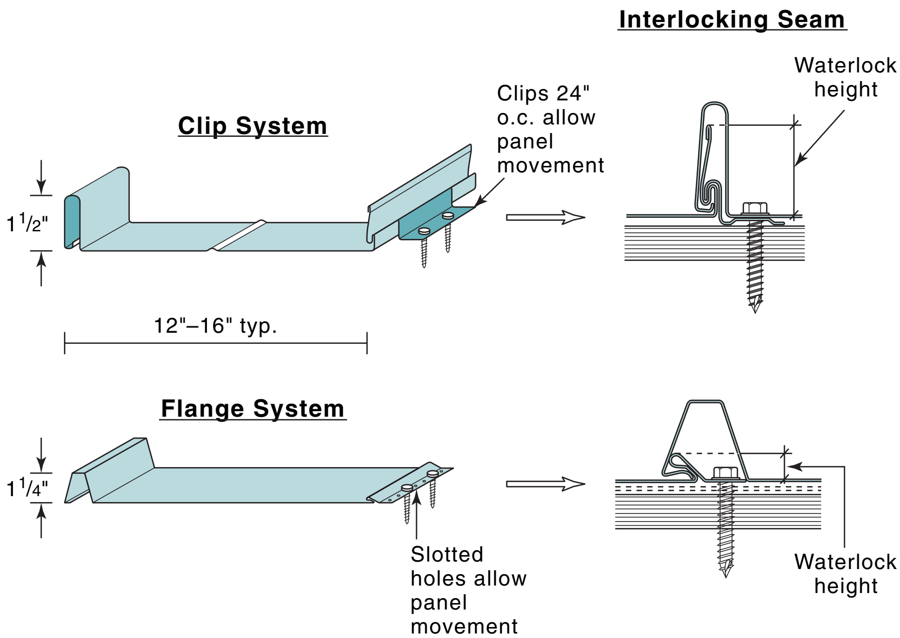
also produce matching flashings and accessories to match the specific needs of the job. Factory-made panels, on the other hand, offer consistent quality, as well as preformed flashings and fittings that simplify installation. Using factory-produced panels, however, requires detailed planning since every piece of roofing must be preordered to length.

Installation. On new homes, most panels are installed over a solid plywood deck with minimum No. 30 felt underlayment. Metal roofing manufacturers recommend plywood rather than OSB due to plywood's better screw-holding ability. Install the felt with plastic cap nails rather than metal buttons, which can cause corrosion when in contact with the roofing panels (see "Galvanic Corrosion," page 83).

After installing the drip edge, install the first panel, making sure it is square to the bottom edge of the roof. If the roof is not square, pull the panel away from the rake so the first rib does not overhang the rake edge. Later, the rake trim piece will cover any small discrepancies. If the panels have an integral screw flange, keep the screws just snug so the panels can move with temperature changes. The clips are designed to allow thermal movement.

The next panel fits over the first with an overlapping rib. Fit each panel to a line snapped up the roof, marking the edge of each panel. Without layout lines, the panels can build up an incremental error, throwing off the layout.

FIGURE 2-42 Standing-Seam Fasteners.



Factory-made standing-seam panels are secured with either clips (top) or an integral nailing flange (bottom). Both systems interlock at seams, using hand pressure. Clip systems are more costly but have better wind resistance and a higher water lock. Also they can better accommodate thermal movement, allowing longer panel lengths.

As panels are installed and secured, the joints are easily locked together with hand pressure. Traditional standing-seam roofing required special motorized crimpers to lock the seams. While these are still used on some low-slope systems, most residential installations now use snap-together panels. Unless the layout works perfectly, the last panel will need to be cut along the opposite rake and bent with a hand seamer to form the end rib.

Reroofing. Many installers will not install standing-seam roofing over existing asphalt shingles since the rough surface will tend to bind the panels and cause "oil-canning," as the panels move with temperature changes. One option is to install the new metal roofing over 2x4 purlins nailed through the old roofing and shimmed to form an even plane. Follow manufacturer's recommendations for spacing of purlins, typically no more than 24 inches on-center.

Flashing and Sealing. Manufacturers of preformed roofing panels provide eaves and rake flashings, ridge caps, and sidewall flashings in matching finishes, as well as coil stock for site fabrication. Many flashings are designed with hidden fasteners; others require exposed gasketed screws. Typical details are similar to those found in Figure 2-41. Follow manufacturers' recommendations regarding which sealants to use for compatibility with the roofing (typically butyl tape, or gunnable terpolymer butyl or urethane sealant). In general, avoid acid-cure silicone (the type that smells like vinegar) as it can be corrosive to many metal finishes.

MODULAR SHINGLES

Modular metal shingles comprise the fastest growing segment of the metal roofing industry. Using light-gauge steel, copper, or aluminum, panels are stamped to imitate slates, shakes, asphalt shingles, or tiles. Some have aggregate stone finishes that closely resemble asphalt shingles. Most carry warranties from 20 to 30 years against fading and from 50-year to "lifetime" warranties against cracking or delamination of the shingle itself.

Modular shingles carry a Class A or B fire rating, depending on the material and installation details, and are highly resistant to wind uplift and damage from hail. Installed prices range from two to three times the cost of premium asphalt shingles. Installers accustomed to asphalt shingles or tile should have little trouble adjusting to metal shingles.

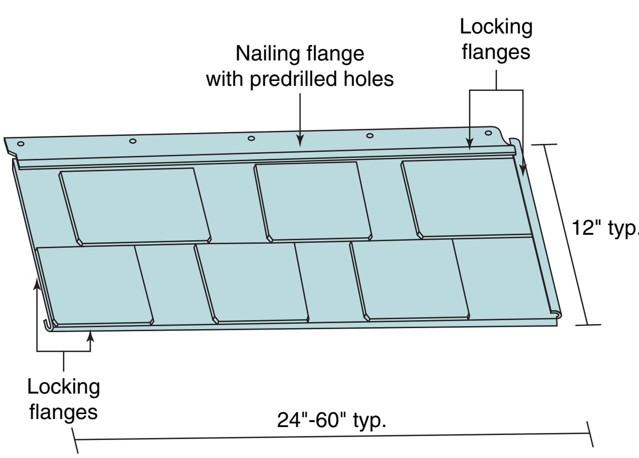
Materials. Modular shingles are typically stamped from lightweight .0165-inch metal, which is thinner than other types of metal roofing but stiffened by the textured patterns. Typical rectangular panel sizes range from 24 to 48 inches long by 12 to 16 inches wide, but they also include tile and diamond shapes and other specialty patterns. Weights range from 40 pounds per square for aluminum shingles to 140 pounds per square for steel shingles with a heavy stone aggregate. The lightweight patterns are well-suited to reroofing where weight is a concern. Most panels can be walked on, if done with care, but areas with heavy foot traffic should be reinforced with foam backers provided by the manufacturer.

Installation. Modular shingles are either nailed directly to the wood deck or attached to 2x2-inch battens installed at the exposed panel width, usually about 15 inches. Installation on battens allows more deeply etched patterns, such as simulated tiles. Either type can be installed with pneumatic nailers.

Underlayment is minimum No. 30 asphalt felt held with plastic caps to avoid contact between incompatible metals. Many manufacturers recommend proprietary laminated underlayments, such as VersaShield (Elk Premium Building Products, Inc.), which are tougher and less slippery than felt and provide better fire ratings. Aluminum shingles require fire-resistant underlayments to achieve an A or B fire rating.

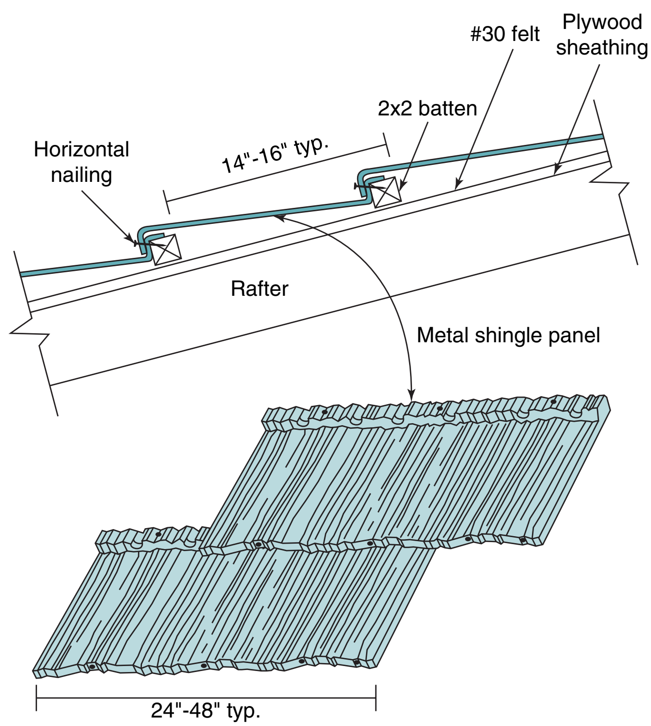
- ***Direct to deck:*** Shingle panels installed directly to the deck are attached with concealed nails, either through clips or a nailing flange along the top, and have interlocking edges along all four sides (Figure 2-43). As they are installed, each panel locks to the panel below and to the left.
- ***Over battens:*** Modular panels designed for installation on battens have a nailing flange along the bottom of each shingle panel with nails going horizontally into the batten (Figure 2-44). Battens are useful for retrofits where the surface is irregular. Also, the air space boosts energy savings, especially when using shingles with solar-reflective surfaces.

FIGURE 2-43 Modular Metal Shingles Installed Direct-to-Deck.



Shingle panels installed directly to the deck are attached with concealed nails either through clips or an integral nailing flange. Panels interlock along all four sides, providing excellent wind resistance.
SOURCE: Photo courtesy *of Accel Roofing Products.*

FIGURE 2-44 Modular Metal Shingles to Battens.



Modular shingle panels with deep profiles typically install over battens. Nails are driven horizontally into the batten through predrilled holes at the bottom lip of each shingle. The air space created boosts energy savings, especially when combined with new solar-reflective finishes.

Both systems begin with the installation of a drip edge and gable trim designed for the specific system. Working from left to right, the first shingle panel hooks into the drip edge, which also serves as a starter strip. Successive courses are staggered as specified by the manufacturer.

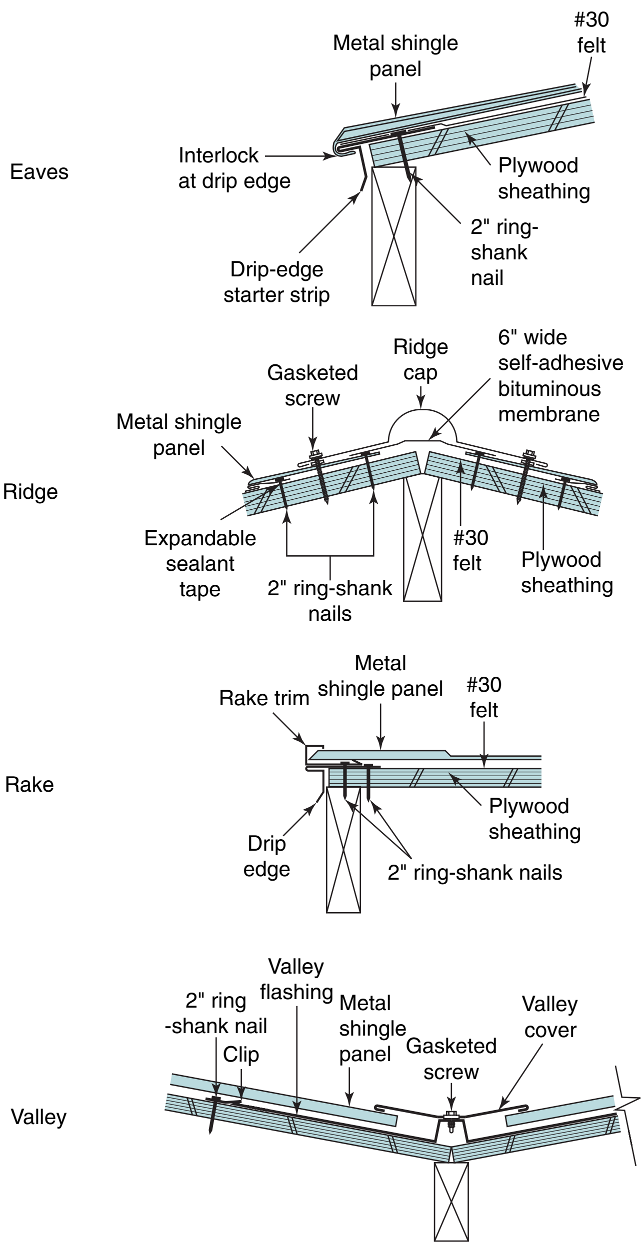
Reroofing. In general, most modular shingles can be installed over existing asphalt shingles if they are in good condition without excessive curling and deformation. Shingles designed to go over battens have more flexibility, since the battens can be shimmed to create a level surface.

Flashing and Sealing. Manufacturers provide standard flashings similar to those for standing-seam products. Eaves and rake flashings typically have concealed fasteners and lock the shingles in place. Ridge and headwall flashings often require exposed fasteners. Depending on the shingle profile, sidewall, chimney, and skylight flashings are either pan or step flashings. Typical details are shown in Figure 2-45.

Metal Choices

While some companies offer roofing products in copper, zinc, and stainless steel, the vast majority are coated steel

FIGURE 2-45 Modular Metal Shingles—Typical Details.



Modular metal shingle systems include prefinished flashings, sealing tapes, and accessories to handle most common details. For some situations, installers may need to bend prefinished coil stock on site.

and aluminum. Coated steel products are the most common and least expensive. In its favor, steel moves relatively little with temperature changes, has good structural characteristics, and resists denting. Its high melting point gives it a Class A fire rating. All coated steel materials, however, are vulnerable to corrosion at field-cut edges—although Galvalume® is the least affected (Table 2-10).

Galvanized Steel. To protect against corrosion, the steel is bonded to a layer of zinc, which works as a sacrificial coating on the surface and also offers some protection to cut edges and nicks by flowing to these areas. The heavier the zinc coating, the longer the protection. The Metal Roofing Alliance recommends G-90 galvanized steel for roofing, which has 90 ounces of zinc per square foot. Unpainted G-90 galvanized steel is typically warranted against corrosion for 20 years under normal conditions. It often lasts longer, but it may show visible corrosion in as few five years under harsh conditions, such as salt spray, significant air pollution, or low-slope applications in wet climates. Field cuts made with an abrasive saw are prone to corrosion.

Aluminized Steel. Developed in the 1950s, this is similar to galvanized steel, but it uses aluminum as the coating instead of zinc. The aluminum provides a physical barrier against corrosion and creates a reflective surface that helps reduce heat transfer to attics. However, aluminum does not have the self-healing properties of zinc, so exposed edges and scratches are more susceptible to rust. Aluminized steel generally outlasts galvanized steel but has largely been replaced in the market by Galvalume®.

Galvalume. Also sold under the tradenames Zincalume® and Galval®, Galvalume® was developed in the early 1970s. The underlying steel is coated with a zinc-aluminum alloy that combines the long-lasting protection of aluminum with the self-healing properties of zinc. It also has the reflective qualities of aluminum, reducing attic temperatures and cooling loads. The most common application weight is AZ 55, which has about a 1-mil-thick coating on each side. Unpainted Galvalume® is warranted against corrosion for 20 years, but it has stood up well in weathering tests for 30 years and is projected to last up to 40 years under normal conditions. Cut edges hold up very well, but cutting the material with an abrasive blade is discouraged as the filings will mar the surface. Galvalume® costs about 10% more than standard galvanized steel.

Aluminum. Aluminum that is anodized or painted is highly resistant to corrosion, making it well-suited to coastal environments (although lightweight aluminum flashings tend to pit and oxidize in salty air). Its light weight is an advantage in reroofing. Because of its high coefficient of expansion, however, attachment systems must be designed to accommodate the movement of long panels. And since it has a lower tensile strength than steel, more fasteners may be required to achieve wind ratings comparable to a steel roof. Also, aluminum has a low melting point so it relies on two layers of fire-resistant underlayment, such as VersaShield, to get a Class A fire rating. Most aluminum used in roofing has a baked-on paint finish rather than an anodized finish. Although anodized aluminum is less costly, new paint technologies such as Kynar® and Hylar® carry better warranties and are available with a low-gloss finish generally favored on roofs. Some coated aluminum products come with transferable lifetime warranties.

TABLE 2-10 Metal Roofing Characteristics

Material	Advantages	Drawbacks	Incompatible Materials	Longevity*	Thermal expansion** (10^{-6} in/in/°F)
Galvanized steel	Least expensive. Strong and dent-resistant. Zinc coating heals small cuts and scratches.	Rusts after zinc wears away from oxidation. Field-cut edges vulnerable to corrosion.	Brass, bronze, untreated iron and steel, redwood, cedar, pressure-treated (PT) lumber.	Unpainted: 15 to 30 years. Exposed to salt spray: 5 to 10 years.	7.5
Aluminized steel	Provides a true barrier to corrosion rather than sacrificial coating.	Cuts and nicks not self-healing and prone to corrosion.	Brass, bronze, lead, copper, wet mortar, redwood, cedar, PT lumber, graphite (e.g., pencil marks).	Unpainted: 20 to 40 years.	7.5
Galvalume	Combines barrier protection of aluminum with healing characteristics of zinc. Reflects solar radiation.	Field-cut edges vulnerable to corrosion in coastal areas.	Lead , copper, unprotected steel, wet mortar, PT lumber, and graphite.	Unpainted: 30 to 40 years.	7.5
Aluminum	Superior corrosion resistance. Lightweight. Good for coastal areas.	Expensive. High level of thermal expansion. Relatively soft. Low melting point.	Brass, bronze, lead, copper, unprotected iron and steel, wet mortar, redwood, cedar, or PT lumber, and graphite.	Unpainted: 30 to 40 years	12.7
Copper	Easily roll formed. Superior corrosion resistance. Attractive green patina.	Very expensive. Greenish runoff can stain building. Avoid contact or runoff from cedar shingles.	Aluminum, stainless steel, zinc, unprotected iron and steel, galvanized steel, lead, brass, bronze.	60+ years	8.8
Zinc	Easily formed into intricate patterns. Superior corrosion resistance. Bluish-white patina.	Very expensive. Runoff can stain building.	Brass, bronze, copper, untreated iron and steel, stainless steel, redwood and cedar.	60+ years	15.1

* Longevity is affected by many variables, including slope of roof, wet vs. dry climate, air pollution, and exposure to salt spray.
**Average values. To find predicted expansion in inches, multiply the length of the metal (inches) times the change in temperature (°F) times the number in the chart. Divide the answer by 1,000,000.

Copper. This high-end material is highly resistant to corrosion and easily formed into panels. Copper roofs have been known to last for over a century and are a common sight on churches and historic buildings. Left unfinished, the material will oxidize to the familiar green patina that protects the underlying metal. In arid areas, the color may be more reddish-purple. Special clear acrylic coatings can be applied that will help copper retain its original color. One concern is that runoff from a copper roof can stain building components below if not managed with gutters. Also, premature failure of copper flashing and roofing has been linked to acid rain and runoff from cedar shingles (see “Flashings” under “Wood Shakes and Shingles,” page 92).

Clients interested in copper should consider a newly developed proprietary sheet metal called Suscop™, which has copper plating over a stainless-steel core. The material combines the strength and durability of steel with the natural patina of real copper . Because of its greater strength, a lighter-weight sheet (0.4mm) can be used in place of 16-ounce copper, significantly reducing material costs.

Zinc. Zinc roofs are similar to copper in their durability but weather to a bluish-white color rather than green. The material is very malleable and can be formed into intricate patterns for metal shingles.

Galvanic Corrosion

With metal roofing or any metal building components, the safest strategy is not to mix metals that come in direct contact with one another. Use aluminum flashing and fasteners with aluminum roofing, copper flashing and copper nails with copper roofing, etc. When this is not possible, choose a second metal that is not likely to lead to galvanic corrosion or use a physical barrier to separate the two metals.

The Galvanic Scale. The galvanic scale (see Table 2-11) ranks a metal’s tendency to react in contact with another metal in the presence of an electrolyte, such as water or even moisture from the air. Metals at the top of the chart are called *anodic,* or active, and are prone to corrode;

metals at the bottom are *cathodic,* or passive, and rarely corrode. The farther apart two metals are on the chart, the greater their tendency to react and cause corrosion in the more active metal. Metals close to each other on the scale are usually safe to use together.

The Area Effect. The rate of corrosion is controlled by the area of the more passive metal. For example, a galvanized steel nail (active) will corrode quickly if surrounded by a large area of copper flashing (passive). If a copper nail is used in galvanized steel flashing, however, the corrosion of the steel will be slow and spread over a large area, so it may not be noticeable. In each case, the active metal corrodes, and the passive metal is protected.

Galvanic Corrosion of Roofing. Because they are made from active metals, aluminum and zinc roofing panels, as well as steel roofing with aluminum and zinc coatings (galvanized steel, Galvalume®, etc.), are vulnerable to galvanic corrosion if allowed to come in contact with more passive metals. For example, never use copper or lead flashings with aluminum, zinc, or galvanized roofing materials. Even water dripping from a copper pipe, flashing, or gutter can lead to corrosion of coated-steel or aluminum roofing materials. How common flashing materials react with metal roofing and other metal building materials is shown in Table 2-12.

Where incompatible metals must be used in close proximity, use the following precautions:

- Separate the two dissimilar metals with building paper, bituminous membrane, durable tapes, or sealants so they are not in direct contact.
- Coat the cathodic (less active) metal with a nonconductive paint or bituminous coating.
- Avoid runoff from a cathodic metal (e.g., copper gutters) onto an anodic metals (such as galvanized steel).

TABLE 2-11 The Galvanic Scale

Most anodic or active (likely to corrode)	Zinc
	Aluminum
	Galvanized steel
	Mild steel, cast iron
	Lead
	Tin
	Brass, bronze
	Copper
	Silver solder
	Stainless steel (passive)*
	Silver
Most cathodic or passive (protected from corrosion)	Graphite
	Gold

*Most stainless steel used in light construction is passive, typically Type 304. Type 316 is recommended for exposure to salts or saltwater.
Note: Avoid placing dissimilar metals in direct contact unless they are close together on the galvanic scale.

Other Incompatible Materials

In addition to galvanic corrosion, a number of other common building materials can harm the finishes on metal roofing or lead to etching or corrosion of the material itself:

Wet Mortar. Aluminum roofing materials and aluminum-based coatings can be damaged by alkali solutions such as wet mortar. Where contact with wet mortar cannot be avoided, one option is to spray the metal with lacquer or a clear acrylic coating to protect it until the mortar is dry.

Pressure-Treated Wood. Roof panels treated with aluminum and zinc coatings should not come into direct contact with pressure-treated (PT) wood, which can damage the finish and accelerate corrosion.

Sealants. Use only sealants recommended by the manufacturer. Never use acid-cure silicones (the most common type, with a vinegar smell) or asphalt roofing cement with coated-steel roofing, as these will mar the finish. Commonly recommended products include butyl tape and gunnable terpolymer butyl or urethane sealant.

Salt Spray. Saltwater spray is very hard on metallic-coated–steel products and may lead to corrosion within

TABLE 2-12 Galvanic Corrosion Potential Between Common Metals

	Zinc	Alum.	Galvanized Steel	Iron/Steel	Lead	Brass, Bronze	Copper	Stainless Steel (passive)
Zinc	—	low	low	high	low	high	high	high
Aluminum	low	—	low	medium	medium	high	high	low
Galvanized steel	low	low	—	medium	low	medium	medium	medium
Lead	low	medium	low	low	—	medium	medium	medium
Copper	high	high	medium	high	medium	medium	—	high
Stainless steel	high	low	medium	medium	medium	high	high	—

Low: No significant galvanic action is likely to occur.
Medium: Galvanic corrosion may occur under certain conditions or over a long period of time.
High: Galvanic corrosion is likely so avoid direct contact.

5 to 7 years. In these areas, the best choices are copper, stainless steel, or painted aluminum. Hylar/Kynar® finishes hold up best.

Paints and Coatings

While unpainted metal roofs are common on utility buildings and some rustic homes, most homeowners prefer a painted surface. In addition to improving the appearance, a high-quality factory finish can significantly extend the life of metal roofing. In general, factory finishes are durable and flexible enough to tolerate factory roll-forming and bending on-site. The best finishes carry decades-long warranties against cracking and peeling, and "excessive" chalking and fading (as defined by the manufacturer). The quality of the finish is determined by the type of resin and the stability of the pigments.

Polyester. Polyester-resin paints are the least expensive and are commonly used on exposed-fastener panels. These have a medium to high gloss when applied, but they will fade significantly within 5 to 7 years on surfaces exposed to direct sun. Bright red, for example, may fade to pink. Fading will be less noticeable on light colors, making them a better choice. Warranties are typically for 3 to 5 years and rarely cover fading or chalking.

Silicone-Modified Polyesters. SMPs (silicone-modified polyesters) use polyester resins blended with silicone additives to improve performance. In general, the higher the silicone content, the more durable the finish. These are available in medium- and high-gloss colors, and they resist fading and chalking much better than standard polyester paints. Warranties against excessive fading and chalking typically run from 10 to 20 years, depending on the formulation.

Fluoropolymers. Based on a fluorocarbon-based resin called PVDF, these are the most technically advanced and most expensive finishes. Sold under the trade names Kynar 500® and Hylar 5000®, fluorocarbon-based paints provide a smooth and dense medium-gloss finish that offers excellent durability and long-lasting resistance to fading and chalking, even under intense sun exposures. The Teflon-like coating also resists dirt retention and holds up better in coastal environments than other finishes. The finish is softer than SMPs, however, and can be damaged by the roofing installers, if they are not careful. Typical warranties run 20 years or greater, with 10- to 20-year protection against excessive fading.

Reflective Finishes. White metal roofs can reduce cooling loads by as much as 30%, according to tests conducted by the Florida Solar Energy Center. More modest savings are now available with dark colors as well by using metal shingles coated with special paints formulated to selectively reflect the sun's infrared and ultraviolet radiation. These "Hi-R" paints are now standard options with Hylar/Kynar® finishes. Tests indicate that aluminum shakes with a reflective brown finish reject 30% to 40% of the total solar radiation compared to 67% for a white metal roof.

Granular Coatings. Some metal shingles are available with a textured finish consisting of crushed stone or ceramic granules blended into an acrylic resin. These are applied over a special primer and sealed with a clear acrylic sealer. The multicolored granules give the appearance of an asphalt shingle and protect against scratching from foot traffic. The finishes also help protect against denting from hail and help conceal any small dents.

WOOD SHAKES AND SHINGLES

Wood shakes and shingles are traditional American roof coverings dating back to Colonial times. They remain popular in many coastal areas and are common or even mandated in certain historic districts. Traditionally, wood roofs were laid on spaced sheathing, which provided good ventilation around the shingles and contributed to a service life of 30 years or more. New wood roofs set on solid sheathing have been known to fail in 10 years or less unless the installer takes adequate precautions to allow for good drainage and drying of the wood roofing materials. With installed costs of over $600 per square for premium materials, it is important to design a roof that will last.

Materials

Wood shakes and shingles soak up water through their end grain, dry unevenly in the sun, and slowly erode on the surface from a combination of ultraviolet radiation, wind, and precipitation. In humid conditions, wood shingles may become a breeding ground for moss, lichen, and decay fungi. To survive those harsh conditions, wood roofing should be made from a durable wood species that is either naturally decay-resistant or pressure-treated.

Wood Species. The most commonly used wood on roofs today is western red cedar. The heartwood of red cedar is rich in extractives that provide natural decay resistance. Eastern white cedar also has good decay resistance and is commonly used on the East Coast. However, white cedar is typically flat-sawn and has a mix of heartwood and sapwood, making it less durable on a roof and more prone to cupping and splitting. Other less common species with good track records are Northern white cedar, Alaskan yellow cedar (actually a cypress), and white oak.

Whatever species is selected, use the best grade available. With red cedar and other decay-resistant species, the heartwood is far more decay-resistant than the sapwood.

Edge-grain wood is more stable and less prone to cupping and splitting than less expensive flat-grain wood. The best choice for wood roofing is all-heart, edge-grained shakes or shingles.

Grades. Make sure the lumber to be purchased has been graded under the authority of a recognized grading agency such as the Cedar Shake and Shingle Bureau for red cedar or the Southern Pine Inspection Bureau for yellow pine. A blue label on the packaging, for example, may simply be a marketing tactic and does not necessary indicate that the shakes or shingles are certified as Grade 1.

Warranties. If installed in accordance with the Cedar Shake and Shingle Bureau's specifications by a certified installer, the CSSB will guarantee wood roofing for 20 to 25 years, depending on the thickness of the shake or shingle. Some pressure-treated shakes and shingles carry warranties of up to 50 years.

Preservative Treatment. If premium red or white cedar is too expensive, consider pressure-treated southern yellow pine shakes and shingles. In its favor, yellow pine is a tougher and stronger wood, and although not as pretty as red cedar when new, over time they will both weather to a similar silver gray. Because penetration of the treatment is nearly 100%, pressure-treated pine shingles carry guarantees against decay for up to 50 years, making them well-suited to high-moisture environments, shallow slopes, and shady wooded sites where organic matter may collect on the roof. The preservatives should not leach out over time.

One drawback to yellow pine shingles and shakes is that many are flat-grained, so most come pretreated with a water repellent to help them resist cupping and splitting. However, retreatment with a water repellent at some point may be required for optimal performance. Western red cedar shingles are also available pressure-treated for severe applications where standard cedar shingles are prone to decay.

Shingles. Shingles are sawn from blocks of wood, which gives them two smooth faces. They are relatively thin and cut to a taper. Red cedar shingles come in four grades, but most roofs use No. 1 or No. 2, which are all edge-grain heartwood (Table 1-6, page 16). They are available rebutted and rejointed (R&R), where a uniform appearance is desired, or machine-grooved for a textured surface.

Eastern white cedar shingles are also available in four grades. Most roofing work uses Grade A (Extra), which is all-clear, all-heartwood, or Grade B (Clear), which has no knots on the exposed face (see Table 1-7, page 16).

Shakes. Shakes are split from large blocks of wood and may be resawn to create a taper. They are heavier than shingles, less uniform in thickness, and are generally rough-textured on one or both sides creating a more rustic appearance. Grades and characteristics for red cedar shakes and shingles are found in Table 1-6, page 16. Red cedar shakes come either tapered or untapered and are usually installed on roofs in Premium or No. 1 grade.

Fire-Retardant Treatment. Once popular on the West Coast, wood roofs have been banned in many residential areas by fire regulations designed to slow the spread of wildfires. Fire-retardant treated (FRT) shingles and shakes have been developed to address these issues and can obtain a Class B or C rating when combined with other components in a fire-resistant roof system. With pretreated shingles, consult with the treating company regarding fastener requirements and any special application instructions.

Slope and Exposure

Recommended exposures for shakes and shingles are shown in Tables 2-13 and 2-14.

TABLE 2-13 Wood Shingle Roofing Weather Exposure

Shingle Length (in.)	Grade (label)	Maximum Exposure (in.)	
		3:12 to < 4:12 Slope	4:12 or Steeper Slope
16	1	$3\frac{3}{4}$	5
	2	$3\frac{1}{2}$	4
	3	3	$3\frac{1}{2}$
18	1	$4\frac{1}{4}$	$5\frac{1}{2}$
	2	4	$4\frac{1}{2}$
	3	$3\frac{1}{2}$	4
24	1	$5\frac{3}{4}$	$7\frac{1}{2}$
	2	$5\frac{1}{2}$	$6\frac{1}{2}$
	3	5	$5\frac{1}{2}$

SOURCE: Based on the 2003 International Residential Code and recommendations of the Shake and Shingle Bureau.

TABLE 2-14 Wood Shake Roofing Weather Exposure (4:12 and steeper)

Type of Shake	Size (in.)	Grade	Max. Exposure (in.)
Hand-split shakes of naturally durable wood	$24\times\frac{3}{8}$	1	$7\frac{1}{2}$
All other naturally durable wood shakes or pressure-treated taper-sawn shakes	18	1	$7\frac{1}{2}$
	18	2	$5\frac{1}{2}$
	24	1	10
	24	2	$7\frac{1}{2}$

SOURCE: Based on the 2003 International Residential Code and recommendations of the Shake and Shingle Bureau.

- ***Minimum slopes.*** The minimum recommended slope for standard installation of shingles is 3:12, and 4:12 for shakes.
- ***Low slopes.*** On lower slopes, shingles or shakes may be installed over a fully waterproof built-up roof (BUR) or membrane roof. Over the membrane, install vertical 2x4 battens lined up with the rafters, then spaced sheathing as described below.
- ***Climate factors.*** In warm, high-moisture climates, low-slope wood roofs need extra maintenance, particularly in areas with overhanging trees. If pine needles, leaves, or other organic debris is allowed to accumulate on a shaded section of the roof, moss, lichen, and algae will grow and retain moisture. This, in turn, will lead to premature curling, splitting, and decay of the shakes or shingles. Periodic cleaning, as well as chemical treatment, helps to avoid these problems (see "Maintenance," page 93). Pressure-treated shakes or shingles are recommended in these conditions.

Sheathing and Underlayment

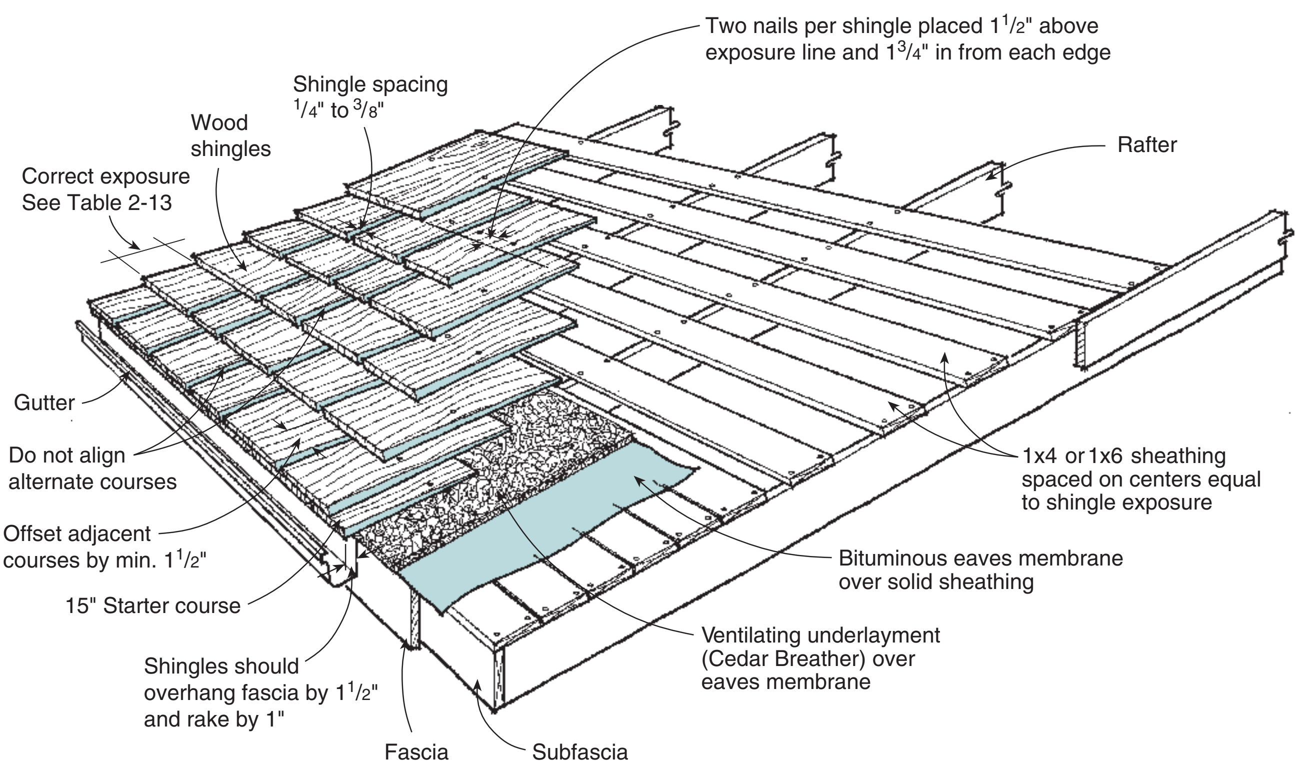
Other than selecting a durable wood, the most important factor in determining a wood roof's longevity is its ability to dry out from both top and bottom when wet. While this was a natural feature of traditional installations over spaced sheathing, new methods and products are required for installation over solid sheathing. The two main approaches are:

- Create a system of spaced sheathing above the solid sheathing using vertical and horizontal battens; or
- Use a breathable underlayment applied over the sheathing.

Spaced Sheathing. The traditional way to lay wood shakes and shingles on spaced sheathing was ideal for wood roof longevity, but it has largely fallen by the wayside. Spaced sheathing is especially beneficial in warm, high-moisture climates, since the gaps in the substrate allow the shakes or shingles to dry out from both sides. It is not recommended in areas of windblown snow and not always permitted structurally. Where allowed, spaced sheathing typically uses nominal 1x4s for shingles or 1x6s for shakes. Code requires a minimum 1x4, and the spaces between battens should not exceed $3\frac{1}{2}$ inches (Figures 2-46 and 2-47).

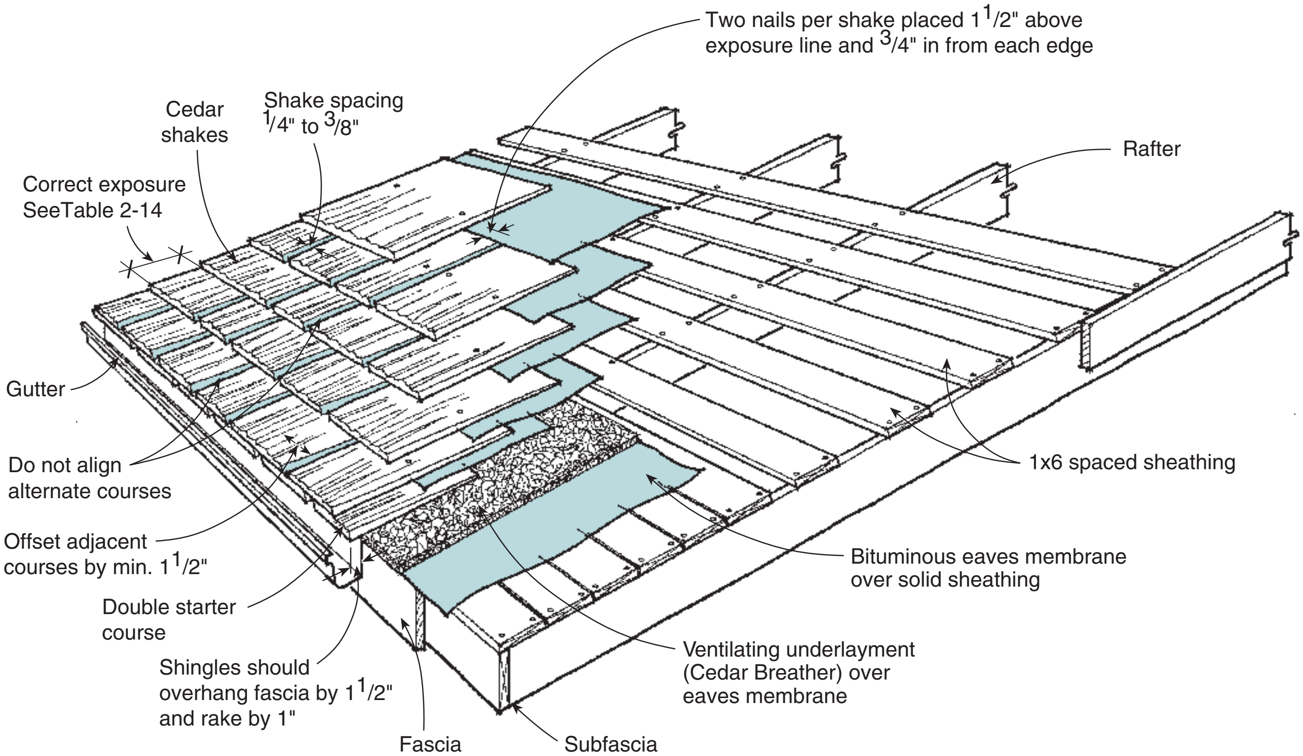
The boards are spaced on centers equal to the weather exposure of the shakes or shingles, and they are lined up so the nailing falls in the center of each board. In areas where the average daily temperature in January is 25°F or less, solid sheathing is required on the lower section of the roof to support an eaves membrane. The eaves membrane

FIGURE 2-46 Wood Shingles Over Spaced Sheathing.



Where permitted by code, spaced sheathing provides the longest life to cedar shingles, but it is not recommended in areas of windblown rain or snow. Where an eaves membrane is required, use a ventilating underlayment to promote drying over the area of solid sheathing.

FIGURE 2-47 Shakes Over Spaced Sheathing.



Because their irregular surface provides some self-ventilation, shakes can be installed over solid sheathing. However, in warm, humid climates, spaced sheathing is recommended for best performance. Interlaid strips of roofing felt are required in all installations to keep out windblown snow and rain.

should extend into the house 24 inches past the interior face of the outside wall.

Solid Sheathing. This is required in areas of high wind or seismic activity and wherever else a solid roof diaphragm is required by code. Solid sheathing is also recommended in areas subject to windblown snow. Because of their irregular surface, rustic-style shakes are partially self-ventilating and may perform adequately on solid sheathing in relatively dry climates. Pressure-treated shingles or shakes can also be installed over solid sheathing. Shingles or smooth-surface (taper-sawn) shakes, however, are more prone to moisture buildup over solid sheathing, so a batten system or a ventilating underlayment is recommended, as described below.

Battens Over Solid Sheathing. This provides the full benefit of spaced sheathing on top of a solid roof deck. After laying down No. 30 felt underlayment, install vertical 2x battens lined up with the rafters beneath for solid nailing. Next, place horizontal 1x4 or 1x6 battens (see “Spaced Sheathing,” above) and nail into the vertical battens (Figure 2-48).

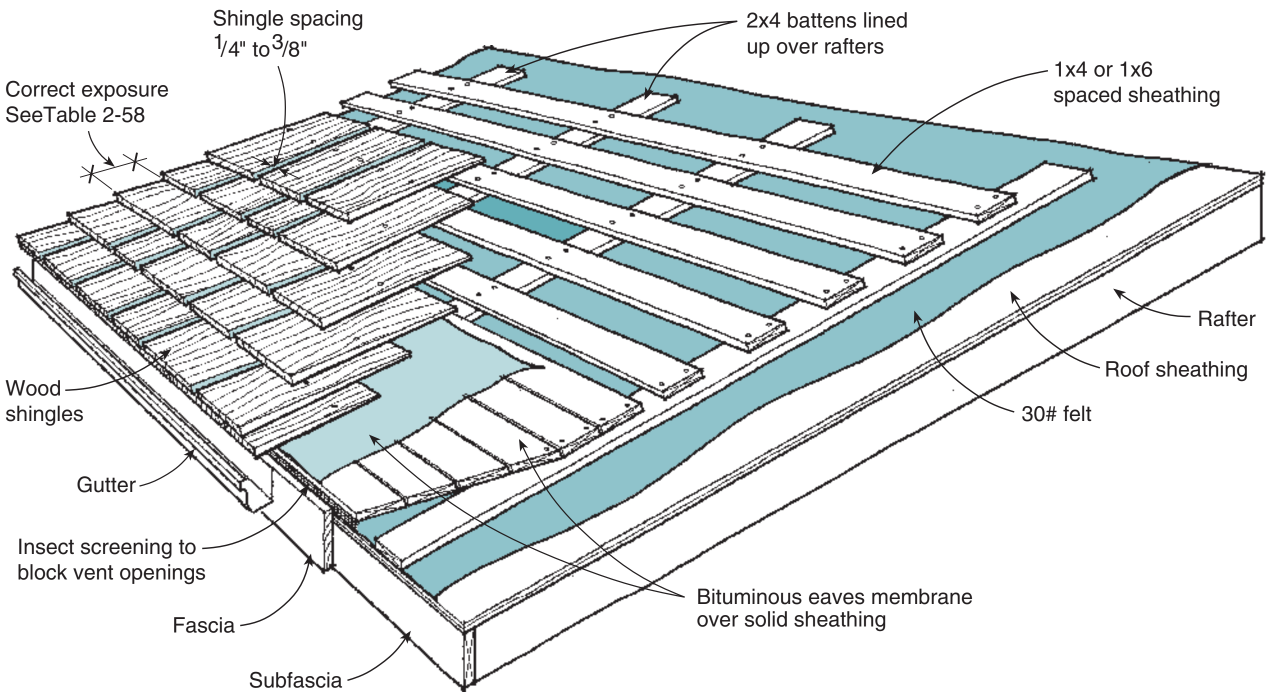
At the upper and lower edges of the roof, use insect screening or matrix-style roof vent material to block the entry of insects and other pests. Shake and shingle installation proceeds as for spaced sheathing.

Underlayment

- ***Shingles:*** Over solid sheathing, use minimum No. 30 felt lapped at least 3 inches horizontally and 6 inches at end laps. Over spaced sheathing, no underlayment is used except at the eaves if eaves flashing is required.
- ***Shakes:*** Over solid or spaced sheathing, use 18-inch-wide “interlayment” strips of No. 30 felt installed between shakes, as described below (Shake Installation, next page).

Ventilating Underlayments. Many installers are shifting to a ventilating underlayment such as Cedar Breather (Benjamin Obdyke), which is easy to install and only adds about 10% to the cost of a wood roof. Cedar Breather is three-dimensional nylon matrix with dimples on the bottom and a smooth top surface. It lays over the felt paper and is tacked in place. It creates a continuous air space below the roofing, helping the shingles to dry out more rapidly and evenly. Although the air space is only about $\frac{1}{4}$ inch, contractors report that it reduces cupping and splitting. And by speeding up drying time, the air space should also help reduce the growth of decay fungi. However, ventilating underlayments are too new to draw conclusions about long-term performance. Installation details are shown in Figure 2-49.

FIGURE 2-48 **Wood Shingles Over Solid Sheathing with Battens.**



Where solid roof decking is required, it is best to provide ventilation under the shingles or use pressure-treated shingles. A system of spaced sheathing laid over 2x4 vertical battens provides optimal ventilation for either shingles or shakes.

Eaves Flashing. Apply eaves flashing to either spaced or solid sheathing in regions with an average daily temperature of less than 25°F (under the IRC) or in other areas prone to ice and snow buildup. The eaves flashing should extend up the roof to a point 24 inches inside the building. Where eaves flashing is required with spaced sheathing, install solid sheathing along the bottom section of the roof to support the eaves flashing.

Fasteners

All nails should be either stainless steel (type 304 or 316), hot-dipped galvanized, or aluminum. Staples should be either stainless steel or aluminum. Galvanized staples will not last the life of the roof. Treated shingles may require stainless steel or other special fasteners. Consult with the treatment company for recommendations. Stainless steel is also the first choice in coastal environments.

- ***Nails*** should be box type and penetrate the sheathing by $\frac{3}{4}$ inch (Table 2-15, page 91).
- ***Staples*** should have crowns between $\frac{7}{16}$ and $\frac{3}{4}$ inch wide and penetrate the sheathing by $\frac{3}{4}$ inch.
- ***Drive flush.*** Do not drive nail heads or staple crowns below the surface of the shingle. Underdriving or overdriving weakens the shingle attachment.
- ***Placement.*** Each shake or shingle should receive only two nails. Place one fastener $\frac{3}{4}$ inch in from each edge and about $1\frac{1}{2}$ inches above the exposure line (Figure 2-50).

Shingle Installation

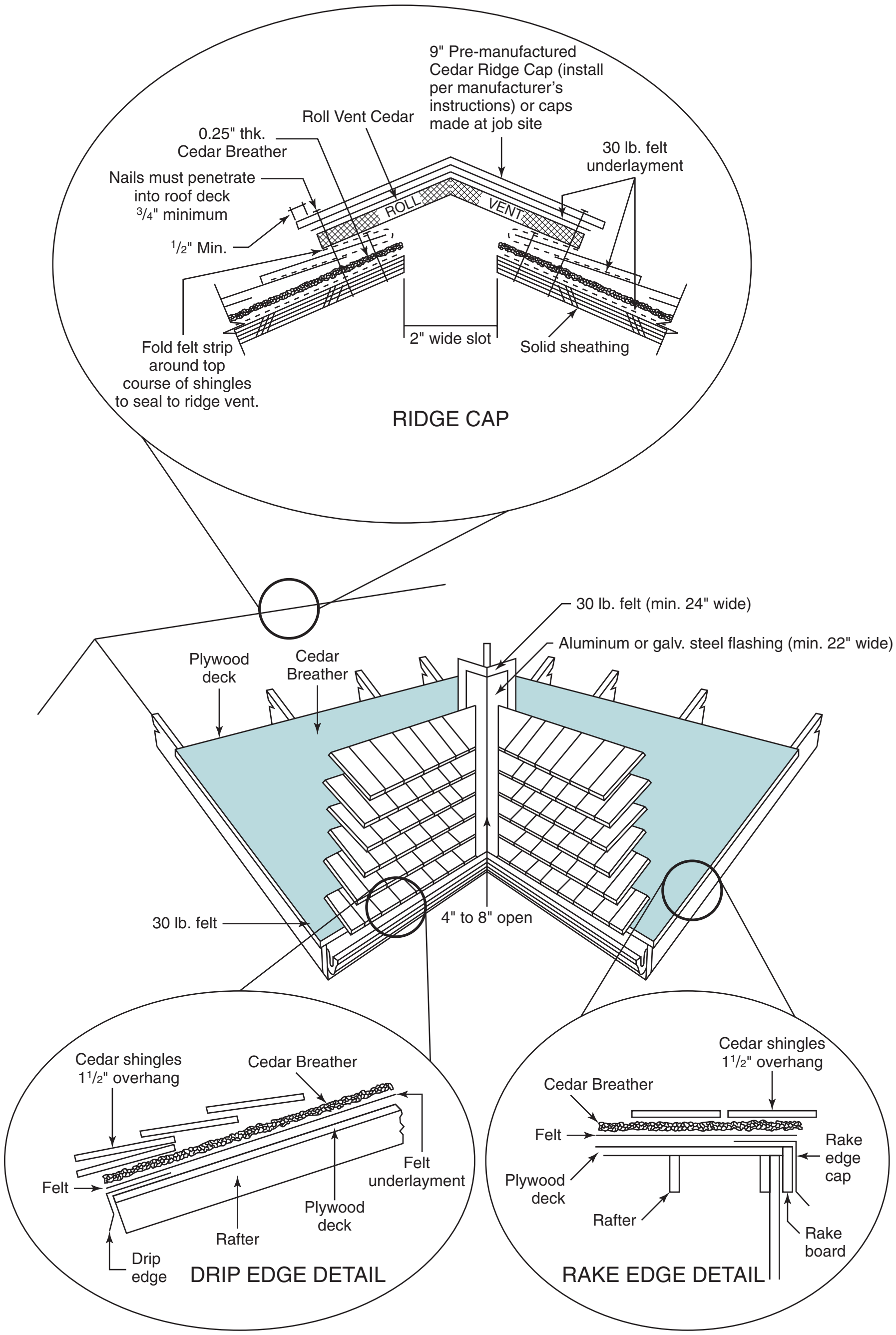
Whether installed over solid sheathing or spaced sheathing, follow these guidelines:

- For the starter course, double or triple the shingles in the first row.
- Each shingle gets two nails about $\frac{3}{4}$-inch in from each end, and $1\frac{1}{2}$ inches above the butt line of the overlaying shingle.
- The first course should overhang the fascia by $1\frac{1}{2}$ inches. All courses should overhang the rake by about 1 inch.
- Leave a gap of $\frac{1}{4}$ to $\frac{3}{8}$ inch between adjacent shingles for expansion when wet.
- Offset joints in successive courses by at least $1\frac{1}{2}$ inches (Figure 2-50). Also, no more than 10% of joints should line up with joints in alternate courses (two courses away).
- Flat-grain shingles wider than 8 inches should be split into two shingles before installing.
- Treat knots, similar defects, and centerline of heart as if they were joints between shingles, and locate the defect $1\frac{1}{2}$ inches from joints in the row above or below.

Shake Installation

Whether installed over spaced or solid sheathing, shakes should always be interlaid with 18-inch-wide strips of No. 30 roofing felt. The felt strips acts as baffles to keep

FIGURE 2-49 **Wood Shingles with Ventilating Underlayment.**



New ventilating underlayments have simplified the job of creating a vent space below wood shingles and shakes. Cedar Breather, shown above, is a three-dimensional nylon matrix that creates a $\frac{1}{4}$-inch air space, helping to reduce cupping, splitting, and premature failure of shakes and shingles. Increase roofing nail lengths by $\frac{1}{4}$ inch.

SOURCE: Drawings courtesy of Benjamin Obdyke Inc.

windblown snow and other debris from penetrating the roof system during extreme weather. The felt "interlayment" also helps shed water to the surface of the roof. It is important to locate each felt strip above the butt of the shake it is placed on by a distance equal to twice the weather exposure (Figure 2-51).

Placed higher, the felt strips will be ineffective. Placed too low, they will be visible in the keyways and will wick up water, leading to premature failure of the shakes. In addition, follow these guidelines:

- For the starter course, use either a single layer of shakes or two layers separated by a strip of felt interlayment (installed up from the eaves by a distance equal to the weather exposure). Fifteen-inch shakes are available for the bottom layer of a double starter course.

- Each shake gets two nails about $\frac{3}{4}$ inch in from each end and $1\frac{1}{2}$ inches above the butt line of the overlaying shake.
- The first course should overhang the fascia by $1\frac{1}{2}$ inches.
- All courses should overhang the rake trim by about 1 inch.
- Leave a gap between adjacent shakes of $\frac{3}{8}$ to $\frac{5}{8}$ inch for expansion when wet.
- Offset joints in successive courses by at least $1\frac{1}{2}$ inches.

TABLE 2-15 Fasteners for Red Cedar Shakes and Shingles on Roofs

Type of Certi-label Shake or Shingle	Nail Type and Minimum Length
Certi-Split & Certi-Sawn Shakes	
18 in. Straight-split	5d box ($1\frac{3}{4}$ in.)
18 in. and 24 in. Handsplit-and-Resawn	6d box (2 in.)
24 in. Tapersplit	5d box ($1\frac{3}{4}$ in.)
18 in. and 24 in. Tapersawn	6d box (2 in.)
Certigrade Shingles	
16 in. or 18 in. Shingles	3d box ($1\frac{1}{4}$ in.)
24 in. Shingles	4d box ($1\frac{1}{2}$ in.)

Reroofing

Under some conditions, shakes and shingles can be installed over existing roofing, as follows:

Existing Asphalt Shingles. If the existing asphalt shingles are not overly cupped or deteriorated, split or rough-sawn shakes can be installed over the shingles using interlaid strips of felt, as described above. Installing wood shingles over asphalt, however, requires a ventilating underlayment such as Cedar Breather or a system of battens (as shown in Figures 2-47 and 2-48).

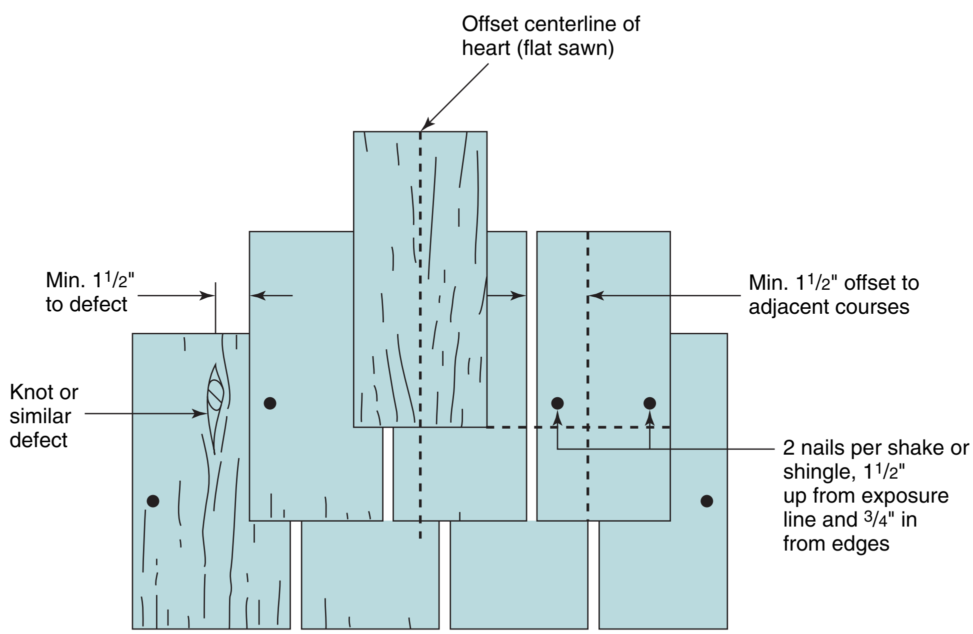
Existing Wood Shingles. If the shingles are not badly curled or deteriorated, they can form an adequate surface for new shingles or shakes. Do not place building felt under the new shingles as that could inhibit drying, but if there is a high risk of decay (moist environment, low slope, overhanging trees), a layer of Cedar Breather is recommended. Shakes should be installed in the normal fashion with interlaid felt. Use nails long enough to penetrate the sheathing.

Existing Shakes. In most cases, these will need to be removed before reroofing, as the surface is too irregular, and nailing through the shakes into solid sheathing is impractical.

Hip and Ridge Details

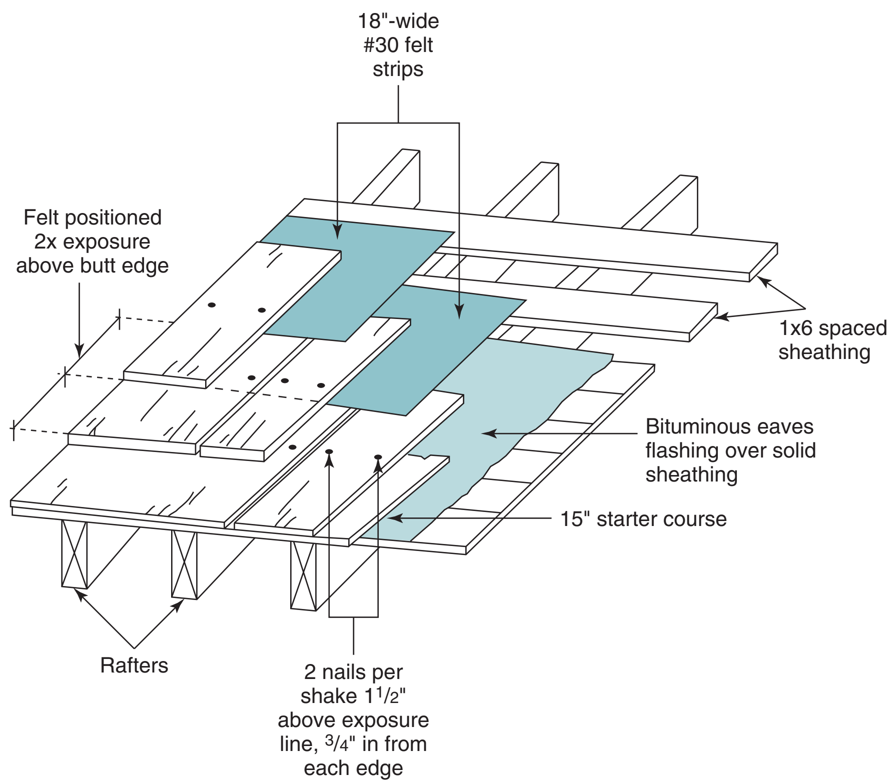
The traditional treatment at hips and ridges is a labor-intensive "woven" cap, consisting of alternating sets of

FIGURE 2-50 Shake and Shingle Alignment and Nailing.



Joints in successive rows should be at least $1\frac{1}{2}$ inches apart and the same distance from knots and other defects. In lower grade shingles with flat grain, do not align joints with the center-line of heart. Only use two nails per shingle, as shown.

FIGURE 2-51 Shake Installation.



Whether installed over spaced or solid sheathing, shakes are always interlaid with strips of roofing felt. The felt interlay helps shed water to the roof surface, and keeps windblown rain and snow from penetrating the roof system during extreme weather.

two beveled shingles. Many installers now use factory-assembled cap pieces that speed up the process.

Hips. Lap the underlayment over the hip before installing the shingles. Then install a strip of roofing felt or metal flashing up the hip on top of the shingles before nailing the caps in place. Use nails or staples long enough to penetrate the sheathing by $\frac{3}{4}$ inch.

Ridge. For a vented ridge, use a plastic, matrix-type ridge vent. Cover the ridge vent with a strip of roofing felt and install factory-assembled ridge cap pieces. To prevent splitting of ridge-cap shingles, it is best to install them with a pneumatic nailer or stapler.

Flashings

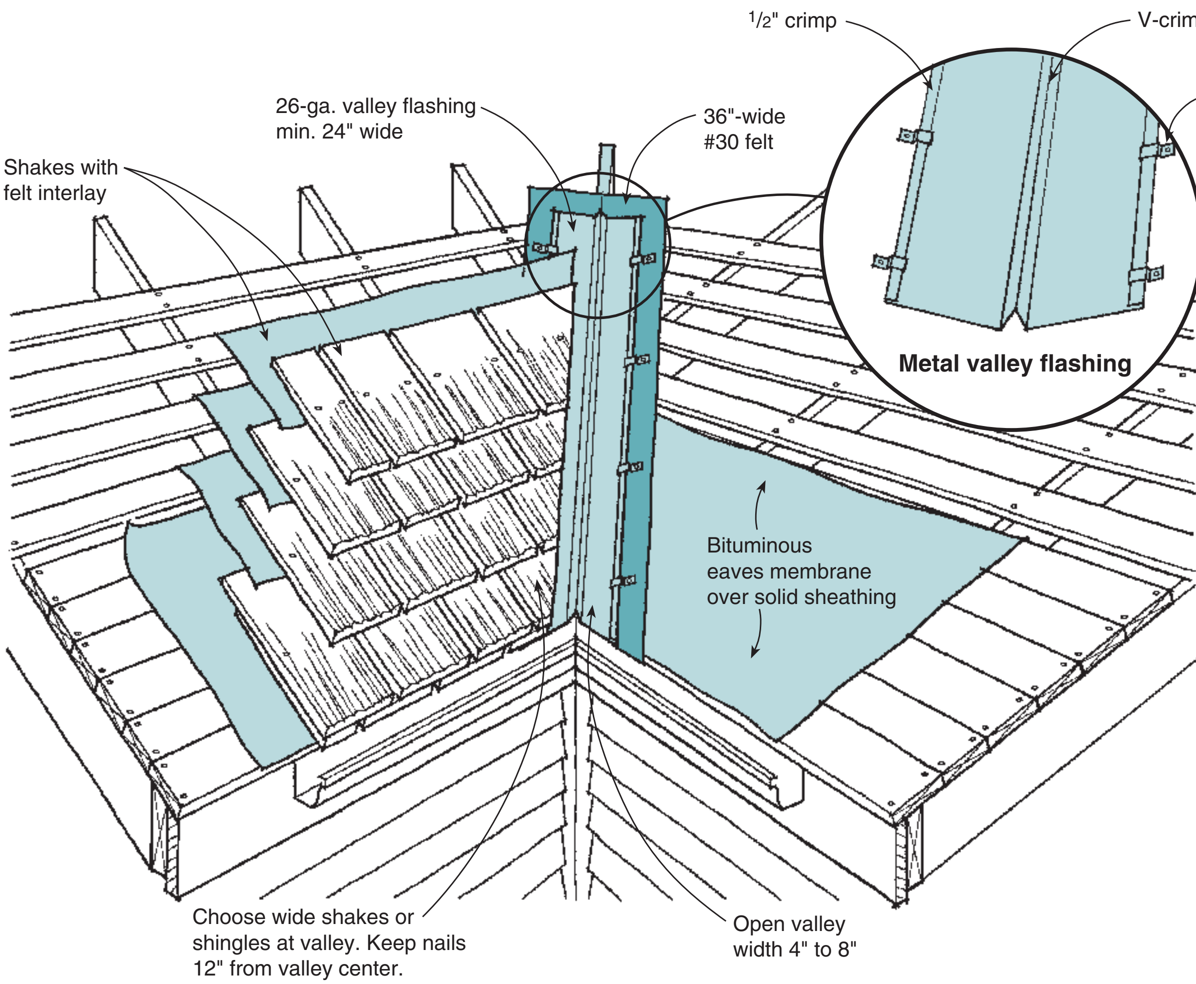
Roof flashings should be at least 26-gauge, corrosion-resistant sheet metal, preferably painted galvanized steel or painted aluminum.

Copper and Cedar. Copper is a popular flashing material with wood roofs, although some experts caution against using copper in direct contact with red cedar or its runoff, since the soluble tannins in cedar can etch copper and, in extreme cases, lead to perforation of the flashing within 10 to 20 years (see also “Copper,” pages 7, 83). Premature failures have been documented in areas of the eastern United States that are subject to acid rain, leading the Cedar Shake and Shingle Bureau to advise against using copper flashing in areas east of the Great Lakes that are exposed to acid rain. Another approach endorsed by the Copper Development Association is to design flashing joints with a cant or hem that holds the edge of the cedar shingle slightly away from the flashing. The gap prevents water from being wicked into the joint, bathing the copper in the acidic solution.

Valleys. Wood roofs typically use open valley designs. While the International Residential Code (IRC) only requires the valley flashing to extend a minimum of 10 inches up each side of the valley for shingles and 11 inches for shakes, most contractors install 24- to 36-inch-wide valley flashing based on the area and pitch of the roof planes being drained. The valley metal should be protected by an extra layer of 36-inch-wide No. 30 felt installed directly under the metal or a layer of self-adhesive bituminous membrane applied directly to the sheathing. It is best to set aside the widest shingles or shakes for use in the valley to keep nails at least 12 inches from the valley centerline (Figure 2-52).

Chimneys and Skylights. These are flashed conventionally, using step flashing on the sides in accordance with Table 2-16. Use a soldered apron flashing below the

FIGURE 2-52 Valley Flashing for Shakes and Shingles.



Use a minimum 24-inch-wide crimped metal valley protected by an extra layer of No. 30 felt installed directly under the metal. Choose the widest shingles for use in the valley and keep nails at least 12 inches from the valley centerline.

TABLE 2-16 Step Flashing Dimensions

	Horizontal Leg	Vertical Leg
Shakes	4 in.	3 in.
Shingles	$2\frac{1}{5}$ in.	$2\frac{1}{5}$ in.

chimney and a soldered head flashing at the top. Larger chimneys with significant water flow behind them should have a cricket above.

Maintenance

A number of factors affect the longevity of a wood roof. Key factors include the durability of the wood, local humidity and precipitation levels, and whether the roofing was installed with adequate ventilation. Other factors include the slope of the roof (steeper slopes shed water faster) and the presence of overhanging trees that shade the roof and drop organic debris onto the roof, trapping moisture on the surface. Some of these factors can be controlled by the contractor; some managed by the homeowner. Others, like the weather or the reduced durability of second-growth cedar, are beyond our control.

Some simple steps that a homeowner can take to prolong the life of a wood roof include:

- Trim overhanging branches that drop pine needles or leaves on the roof.
- Clean debris out of gutters and off the roof, both the surface areas and the keyways between shakes or shingles. A garden hose can do an adequate job.
- Ensure adequate year-round ventilation of the attic or roof assembly.
- Install strips of zinc or copper at the ridge (can serve also as a ridge cap) and midway across the roof on long slopes. Runoff from these strips forms a mild solution that reduces the growth of moss, mold, and mildew. This is effective for up to 15 feet downslope from the metal.
- If moss or lichen begin to grow, scrape it away and scrub the area with a solution of 1 quart household bleach, 1 ounce detergent, and 3 quarts warm water.

Over time, the natural extractives in cedar and other decay-resistant species will leach out, making the wood vulnerable to decay. Also, as the shingles dry out, they are prone to cupping, checking, and splitting. At some point, it may make sense to wash and treat the entire roof.

Washing. Cleaning wood roofs with high-pressure equipment is controversial and, in untrained hands, can cause significant damage. It is best to use normal garden hose pressure along with a brush or pump sprayer. To remove dirt, mildew, and weathered gray residue, a consortium of wood technology and coatings experts, including the U.S. Forest Products Laboratory (FPL), recommend a solution of sodium percarbonate (disodium peroxydicabonate) and water. With redwood and cedar, a second wash with a solution of oxalic acid may be needed to remove brown and black discoloration caused by tannins that leached out of the wood. Concentrated oxalic acid is toxic and should be handled with care.

Preservative Treatment. There are a number of commercial treatments available to restore decay-resistance to an aging wood roof. One effective and relatively benign (to plants) treatment consists of a copper-naphthenate compound called Cunapsol 5, which is diluted 1:4 with water and can be applied with a garden sprayer. The treatment needs to be repeated approximately every five years.

Oil-Borne Preservatives. Although Cunapsol 5 and similar waterborne treatments offer good protection against mold, mildew, and decay fungi, they will not do anything to slow down the cupping and splitting caused by weathering. For that, an oil-borne treatment is required. Effective treatments include copper naphthenate with a 3 to 4% metal content and copper octoate with a 1 to 2% metal content. These can be brushed on or dipped (before installation) or professionally applied with spray equipment.

Semitransparent Oil-Based Preservative Stains. Semitransparent oil-based preservative stains work well on rough-textured wood, such as shakes and shingles. They provide some pigmentation and protect the roof from decay for several years. Look for a product with both a wood preservative and a water repellent. Stains with a high percentage of pigment provide the best protection against UV degradation. While preservative stains are best applied before installing the shingles, a surface application can significantly extend the life of a wood roof.

Treatments to Use and to Avoid. According to the Shingle and Shake Bureau, one should use only products that are marketed and labeled as a cedar roof treatment, that have an MSDS available, and that contain one or more of the following: a water repellent, UV inhibitor, or U.S. EPA-registered wood preservative.

The following treatments should never be used:

- Film-forming finishes, including paints, solid stains, waterproofers, sealants, and plasticizers
- Any product with more than 40% solvents
- Any products that contains unfortified linseed oil or diesel fuel
- Any topical treatment marketed with fire-retardant claims

LOW-SLOPE ROOFING

Most roof coverings can be applied on roofs as shallow as 2:12 as long as a fully waterproof membrane is installed over the decking. In this case, the finish roofing material, whether asphalt shingles, wood, or tile, functions mainly as a decorative element but also helps protect the underlying membrane from UV radiation and physical damage.

At slopes lower than 2:12 on residential structures, the primary roofing options are built-up roofing (BUR), often called "tar and gravel," modified bitumen, and EPDM (see Table 2-17). In addition, a handful of proprietary single-ply membranes designed for easy application to small jobs have entered the market and offer a few new choices. While some of these products look promising, how long a new product will perform over 20-plus years is uncertain.

Minimum Slope. With any roofing material, a slope of at least $\frac{1}{4}$ inch per foot is recommended to promote drainage and minimize ponding. Where deflection from snow or other live loads is a concern, a greater slope will be needed to prevent any ponding. Most manufacturers of low-slope roofing products specify a minimum slope of between $\frac{1}{4}$ and $\frac{1}{2}$ inch per foot in their warranties.

While membranes, such as vinyl or EPDM, are unaffected by standing water, it will shorten the life of asphalt-based materials, such as BUR and modified bitumen. With any roofing material, ponding of water increases the likelihood of leakage, increases deflection in the roof framing, and contributes to rooftop growth of mosses, algae, and other plant life. Also, the freezing and thawing of ponded water can harm most roof surfaces.

Roll Roofing

The simplest product to install on a small section of low-slope roof is 90-pound roll roofing. This consists of a heavy, asphalt-saturated organic or fiberglass felt with a granular surface. Rolls are 36 inches wide and weigh 90 pounds. Single-coverage roll roofing typically has a 2-inch lap with exposed nails and is used mainly on utility structures.

Double-coverage roll roofing is installed with a full 19-inch lap joint, leaving a 17-inch exposure, with a 2-inch head-lap. Nails are concealed under the lap joints that are sealed with asphalt lap cement. With two layers of protection, double-coverage roll roofing is acceptable for small roof areas and can be used on roofs as shallow as 1:12.

TABLE 2-17 Low-Slope Roofing Options

Material Type	Pros	Cons	Avg. Longevity
Roll roofing (double-coverage)	Inexpensive. Easily installed by carpenters. Concealed fasteners.	Short life span. Not suitable for cold weather installation.	Approx. 10 years
BUR	Long track record. Forgiving of installation errors due to multiple plies.	Expensive for small jobs. Heavy equipment, odors, potential spills during installation. Ponding water can cause deterioration. Leaks are hard to detect and repair.	15 to 20 years
Modified bitumen (torch-applied)	Durable heat-fused seams do not rely on adhesives. Self-flashing at openings. Easy to inspect and repair. Compatible with asphalt materials. Low temperature installations possible. Self-adhesive and cold-process versions available.	Requires careful installation for proper seaming. Fire risk during installation. Ponding water can reduce longevity. Different chemical formulations difficult to evaluate.	20+ years
EPDM	Relatively easy to install. Proven track record. Lightweight and UV-resistant. Self-flashing. Tolerates building movement and extreme heat and cold. Easy to inspect and repair. Self-adhesive version available for small jobs.	Requires careful installation for proper seaming. Can be damaged by petroleum products, solvents, and grease.	20+ years

BUR

Built-up roofing (BUR) systems dominated the commercial and residential low-slope roofing markets until the 1980s, when single-ply membranes became widely accepted. BUR roofs consist of layers of asphalt-impregnated felt bonded with hot asphalt, or in some parts of the country, hot coal tar. The average life span of a hot-mopped BUR roof is 15 to 20 years, although this can be extended by applying an aluminum coating every three to five years to reduce UV degradation and alligatoring.

BUR roofs can have either a smooth coated surface or a stone surface created by spreading crushed stone or gravel into a thick flood coat of hot asphalt or tar. Aggregate-faced roofs are typically more durable due to the heavier flood coat and the protection offered by the stone from UV radiation, hail, and other environmental wear and tear. However, the stone coating makes leaks harder to find and repair.

Proper detailing of metal flashings at openings, parapet walls, and roof edges is critical, and these areas need regular inspection and maintenance. The most likely place for leaks is flashings, particularly metal edge flashings due to their thermal movement. Asphaltic or rubber flashings may also become brittle and crack.

Pros and Cons. BUR roofs are reliable if properly installed, and their multiple layers provide some protection against small installation errors. However, the long set-up time makes BUR expensive for small residential jobs. Also the heavy equipment, odors, and potential spills associated with a hot-mop job are not welcome on many residential job sites.

Modified Bitumen

Most modified-bitumen roofs are torch-applied, although there are also self-adhesive and cold-process systems. The waterproofing membrane, sometimes called "single-ply modified," consists of asphalt bitumen reinforced with a polyester or fiberglass fabric and modified with polymers to give it greater strength, flexibility, resistance to UV degradation, and resistance to heat and cold. A variety of different chemical formulations have been tried over the years. It is best to stick to a product with an established track record. In general, modified-bitumen roofs can be applied to slopes as shallow as $\frac{1}{4}$ inch per foot.

Installation. A torch-applied, or *torchdown,* roof starts with a nonflammable base sheet made of asphalt-saturated felt or fiberglass that is mechanically attached to the roofing deck. In residential construction, the base sheet is usually attached with roofing nails driven through metal caps. The second layer is the waterproofing membrane, or *cap sheet.* This is heated with a torch as it unrolls, fusing it to the base sheet, to itself at seams, and to penetrations such as skylights. Installers must learn to heat the membrane so it is hot enough to fuse but not so hot as to burn through. Membranes may be either smooth or have a granular surface like roll roofing. Smooth-faced membranes need a third coating, which has colored or reflective pigments to protect against UV radiation. The smooth type is preferable where foot traffic is expected or where decking is going over the roofing.

Torchdown roofing is self-flashing and uses no adhesives or solvents to seal around openings. The material can be run up parapets and abutting wall, and patches are used to seal around metal skylight curbs and similar openings. A special patching compound is used to seal to PVC stacks. If applied correctly, the torchdown membrane is essentially seamless.

Pros and Cons. Modified bitumen is easily repaired without solvents or adhesives. It is compatible with asphalt shingles and asphalt compounds, although patching with roofing cement is not recommended. The reinforced fabric layer isolates the membrane above from building movement and gives the material enough strength to support occasional foot traffic.

The main drawback is the risk of fire during installation. While the risk of fire is low in the hands of trained installers, care must be taken when using torchdown on a wood-frame structure. A number of fires have started with sawdust that has accumulated in empty cavities, such as crickets and parapets. Inspection of the roof for sawdust pockets while it is being framed is advised.

EPDM

While a variety of single-ply roofing membranes are used on commercial jobs, only EPDM has become widely used on residential sites. EPDM, a form of synthetic rubber, owes its popularity to its relative ease of installation combined with exceptional durability. If installed correctly, roofs often exceed 20 years of service and callbacks are exceedingly rare.

While some commercial EPDM systems are loose-laid or ballasted, residential applications are typically fully adhered. Rolls typically vary from 10 to 50 feet in width and from 50 to 200 feet in length, but many distributors will cut a piece to size for smaller jobs. If possible, use a single piece with no seams for the field of the roof. EPDM membranes are available in two thicknesses: .045 inch and .060 inch. For fully adhered applications or any application where foot traffic or decking is planned, the thicker membrane is recommended.

Substrates. EPDM can be bonded to a wide variety of substrates, including plywood, OSB, fiberboard, and urethane insulation board. The substrate should be smooth, even, and free of debris. Fasteners should be driven flush except in the case of insulation fastening caps, which project their shape though the membrane. If the surface is uneven or deteriorated, a layer of fiberboard or thin plywood should be installed first.

Installation. After cutting the material to fit, installers use a roller to apply a proprietary contact cement to both the membrane and the substrate. Typically, a length of roofing is set in place and folded in half lengthwise so one-half can be glued at a time. The adhesive should be fully dry on both surfaces before bonding, or bubbles may develop. Also, care must be taken to smooth out wrinkles and air pockets as the two surfaces are mated. Where seams are required, the material is lapped 4 to 6 inches and sealed with either double-faced seam tape or a special adhesive used for bonding rubber to rubber.

At openings, inside corners, outside corners, and other irregular shapes where the membrane has been cut, patches of *uncured* EPDM are applied using the rubber-to-rubber adhesive. The uncured form of EPDM is highly elastic and can be stretched to conform to irregular shapes.

The material is lapped up abutting walls and serves as its own flashing. Other terminations are usually sealed with an aluminum termination bar or an aluminum flashing covered with a strip of EPDM. Finally all exposed edges of EPDM at laps, patches, and terminations are sealed with a bead of proprietary caulking that protects the edge and acts as an extra water stop.

Self-Adhesive. For small jobs, a few manufacturers offer a peel-and-stick version of EPDM. Installation is similar to standard EPDM but may require a primer on plywood and OSB substrates. Seams generally require a proprietary adhesive with special caulking on exposed edges. Although the square foot cost is greater than with site-glued EPDM, on small jobs labor savings offset the higher material costs.

Pros and Cons. While not intended as a walkway, EPDM works well as a substrate under rooftop decks. Leftover strips of membrane should be used to cushion the roofing from wood sleepers. Leaks are rare and usually can be traced to sloppy sealing of joints. Leaks are also relatively easy to identify and fix. One caution is that EPDM can be damaged by grease and petroleum-based products, a potential problem with outdoor grills and spillage of oil-base finishes used on siding or wood decking.

WALKABLE ROOFING MEMBRANES

For rooftops that will also serve as decks (see "Rooftop Decks," page 150), one option is to use a roofing material designed for foot traffic. Duradek (Duradek U.S. Inc.) is a sheet vinyl membrane similar to Hypalon but with a non-skid wear surface. It was developed over 25 years ago for waterproofing decks, balconies, and outdoor living spaces. For use over a living space, the manufacturer recommends its 60-mil Ultra series, which is warranted against leakage for 10 years.

Duradek is made of reinforced PVC sheet with heat stabilizers and additives for resistance to fire, UV degradation, and mildew. The wear surface is textured for slip resistance and available in a variety of colors.

Installation. Installation is similar to other single plies and must be done by factory-certified contractors. The membrane glues to almost any clean substrate with either a proprietary contact cement or a special water-based adhesive applied with a notched trowel. Seams are heat welded with a heat gun, the most critical step. Like other single-ply membranes, the material is self-flashing at abutting walls and penetrations.

Pros and Cons. Duradek creates an attractive and durable no-skid deck surface that can withstand normal wear and tear, direct sun exposure, high winds, and freeze-thaw cycles. However, because the membrane is also the wear surface, it can be damaged by cigarette burns, punctures, and heavy abrasion.

ROOF VENTILATION

All residential building codes require some form of roof ventilation. These rules were first developed in the 1940s, when attic spaces first started to develop problems with mold and mildew due to excess moisture. With the growing use of plywood, asphalt shingles, insulation, and better doors and windows, houses were being built tighter. The tighter spaces retained more of the normal household moisture generated by cooking, bathing, household plants, crawlspaces, and exposed basement slabs. As the stack effect drove this moisture up into attic spaces, problems ensued.

Code Requirements

The rules of ventilation developed by researchers in the 1940s were adopted first by the Federal Housing Administration (FHA) and later by all the major residential building codes, including the 2003 IRC, with few changes. Most asphalt shingle manufacturers will void their warranties if these rules are not followed. They require:

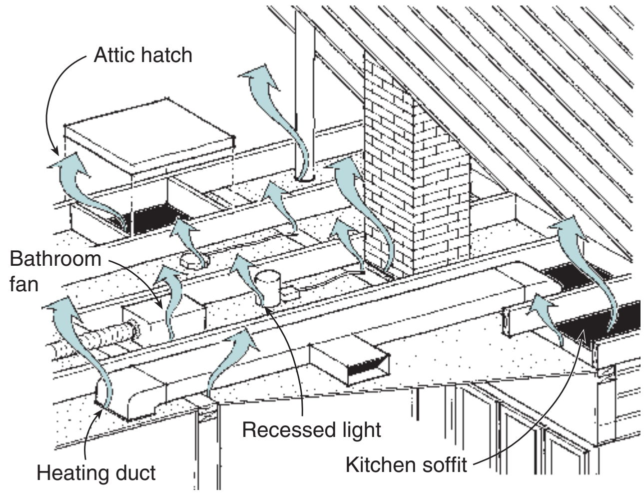
- 1 square foot of *net free vent area* (NFVA) per 150 feet of attic floor.
- 1 square foot of NFVA per 300 square feet of attic floor if a vapor barrier is installed on the ceiling below.
- The IRC adds that the NFVA ratio can also be reduced to 1:300 if 50% to 80% of the required ventilation is located in the upper portion of the attic (or cathedral ceiling) and the rest is located at the eaves, with the upper vents at least 3 feet above the lower.

Tight Ceiling

Although the code-mandated ventilation rate has proven adequate under normal conditions, homes with high-moisture levels and air leaks in ceilings may still experience problems such as moldy sheathing. Cathedral ceilings are at the greatest risk due to the limited ventilation path. The best defense against problems is to create a continuous air and vapor barrier between the living space and attic or roof cavity by carefully sealing all air leaks. The ceiling air barrier may consist of foam insulation with taped seams, taped polyethylene sheeting, or finished drywall that is sealed at corners and top plates with gaskets or sealants.

Penetrations. Pay special attention to penetrations in the ceiling plane, particularly in cathedral ceilings. Chimneys, recessed lights, plumbing chases, and holes drilled through top plates for plumbing or wiring should all be sealed (Figure 2-53).

FIGURE 2-53 Typical Ceiling Air Leaks.



Standard attic ventilation will prevent moisture problems and ice dams as long as the ceiling plane is properly sealed, controlling air and heat leakage from the living space below. Common leakage paths are shown above.

Plug holes with durable materials, such as expandable urethane foam, foam backer rod, EPDM, or sheet metal, and use long-lasting sealants such as high-quality urethanes, silicones, and butyls.

With a tightly sealed ceiling, attic moisture is no longer a significant problem. Attic ventilation is still recommended for three other reasons:

- Preventing ice dams in cold climates
- Reducing cooling loads in hot climates
- Extending shingle life
- Allowing roof components to dry out in the event of a leak

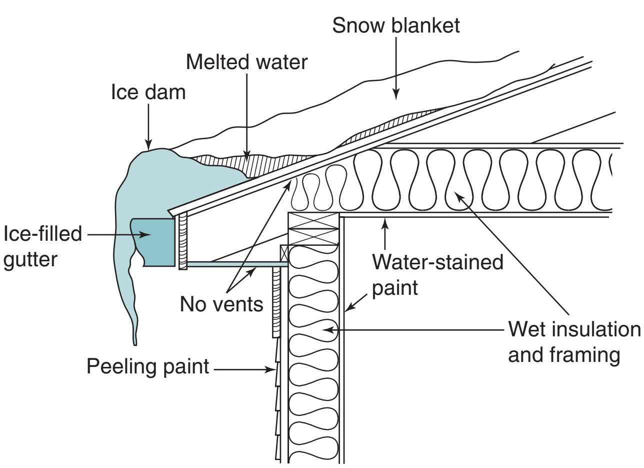
Preventing Ice Dams

Ice dams form when heat leaking into attics or roof cavities from the building below, or from attic ductwork, melts the bottom layer of snow on the roof. The melt water runs down the length of the roof to the eaves, where it refreezes, forming a dam and icicles. In the worst cases, liquid water pools behind the dam and flows under the shingles and into the building (Figure 2-54).

Research has indicated that the ice-dam risk is greatest when temperatures range between 15°F and 20°F—when it is warm enough for snow to melt but cold enough for it to refreeze at the eaves. Also, the greater the depth of snow on the roof, the greater the risk of ice dams due to the insulating value of the snow itself.

Cold Roofs. Ventilation helps prevent ice dams by keeping the roof surface cold enough to limit uneven melting. Tests conducted in 1996 at the U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory (CRREL), showed that the traditional 1:150 ventilation

FIGURE 2-54 Ice-Dam Formation.



Ice dams form when melted snow, caused by excessive heat loss through the roof, runs down and refreezes at the eaves. Pooled water behind the dam can flow into ceiling and wall cavities causing extensive damage. The best protection is a well-ventilated "cold roof."

rule was sufficient to prevent ice dams on roofs with R-25 or greater ceiling insulation. The 1:300 rule proved adequate for roofs with R-38 or greater insulation. Since most standard eave and ridge vents sold today meet the higher ventilation rates, most new homes are protected as long as there are no large heat leaks into the attic, or tricky sections of the roof with inadequate ventilation.

Reducing Cooling Loads

Experts recommend using attic ventilation in hot climates as part of an overall strategy to reduce cooling loads. Ventilation helps even more when used in combination with radiant barriers.

Ventilation Alone. Researchers at the Florida Solar Energy Center (FSEC) have found that adequate attic ventilation can modestly lower sheathing and shingle temperatures, and reduce an average home's cooling load by about 5%.

Ventilation and Radiant Barriers. For greater savings on cooling, consider adding a radiant barrier to the underside of the roof sheathing or draped between the rafters. This can reduce peak cooling loads by 14 to 15% and seasonal loads by an average of 9%. By doubling the roof ventilation from 1/300 to 1/150, the annual savings from radiant barriers rises to 12%. These numbers assume R-19 ceiling insulation and cooling ducts located in the attic, which are typical in Florida. With R-30 ceiling insulation, the cooling benefits of radiant barriers are less dramatic.

Roofing Color. Tests at FSEC also indicate that simply switching from dark to white asphalt shingles in a cooling climate can reduce peak cooling loads by 17% and seasonal loads by 4%. The greatest savings resulted from using white metal roofing (see Table 2-18.)

TABLE 2-18 Roofing Color and Cooling Loads*

Roofing Type	Reduction in Peak Load	Annual Savings
Dark gray asphalt shingle (control)	—	—
White asphalt shingle	4%	17%
Terra-cotta tile	3%	13%
White S-tile	20%	32%
White flat tile	17%	34%
White galvanized steel	23%	28%

*Based on an average-sized south Florida home with R-19 ceiling insulation and cooling ducts located in the attic.

SOURCE: Adapted from the FSEC report *Comparative Evaluation of the Impact on Roofing Systems on Residential Cooling Energy Demand in Florida,* 2000, by Danny Parker, Jeffrey Sonne, John Sherwin, and Neil Moyer. Courtesy of Florida Solar Energy Center.

Unvented "Hot" Roofs

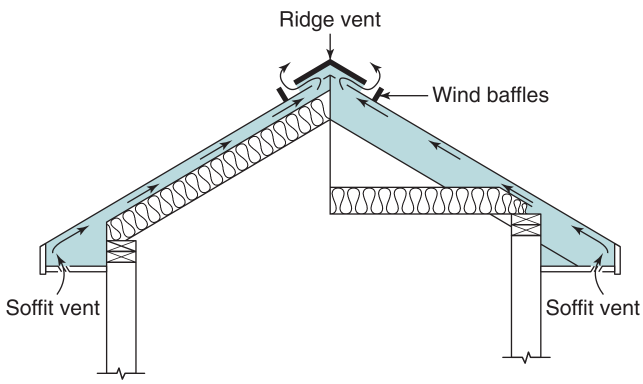
In cathedral ceiling configurations where it is difficult to provide ventilation, some builders have eliminated the vent space, relying instead on careful sealing of the ceiling plane to prevent moisture problems. While experts concede that this should work in theory, most caution that it is difficult to build a truly airtight ceiling assembly. Also, cathedral ceilings are slow to dry out if moisture problems do occur, whether from condensation or roofing leaks. If a hot roof is the only option for a section of roof, take the following precautions:

- Install a continuous air and vapor retarder, such as 6-mil poly, carefully sealed at all junctures.
- Do not use recessed lights or other details that penetrate the ceiling plane.
- Carefully seal all penetrations in the ceiling assembly, including top plates of partitions, with durable materials.
- Use a nonfibrous insulation, such as plastic foam, and install it without voids where moisture could collect.
- In regions prone to ice dams, use enough insulation to maintain a cold roof—preferably R-38 or greater.
- Eliminate all sources of excess moisture in the home (wet basements, uncovered crawlspaces, unvented bathrooms).

Attic Ventilation Details

Soffit and Ridge Vents. For both attics and cathedral ceilings, roof ventilation works best when it is balanced

FIGURE 2-55 **Balanced Roof Ventilation.**



The soffit vent area should be equal to or a bit larger than the ridge vent area, so there is always sufficient makeup air. Also, ridge vents should have either external or internal baffles to limit the infiltration of windblown rain and snow.

between high and low to take advantage of natural convection (Figure 2-55).

This configuration also tends to evenly wash the underside of the roof with ventilation air. The soffit-vent area should be equal to or slightly larger than the ridge-vent area. Ridge vents should either have external or internal baffles to minimize infiltration of windblown rain and snow. Use insulation baffles or modified framing to make sure that the ceiling insulation does not block airflow at the eaves (Figure 2-56.)

Alternatives. Where ridge vents are not an option, combine any type of upper vent such as gable-end vents, roof vents, or turbines, with soffit vents. Where soffit vents are not possible, use gable-end vents on both ends of the roof, which will ventilate adequately under wind pressure.

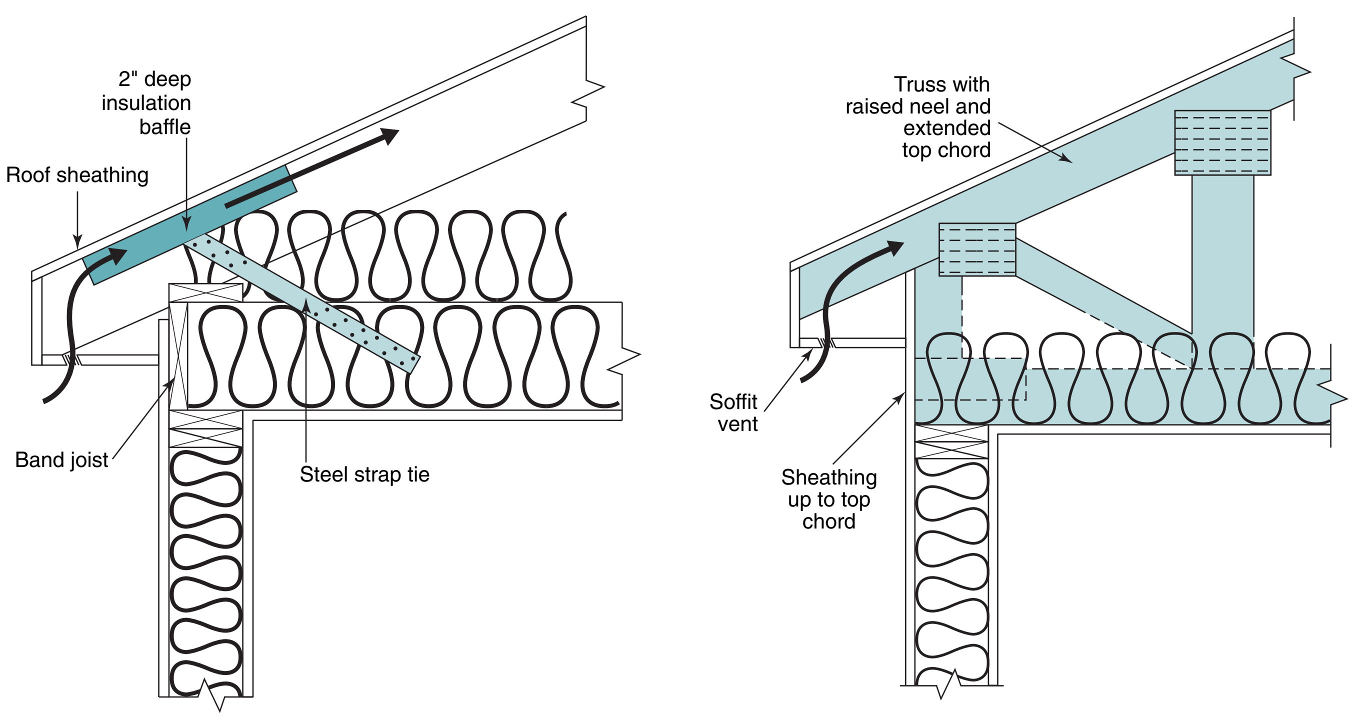
Avoid High Vents Alone. Do not use ridge vents or other rooftop vents without low vents to provide makeup air. The suction created could help pull moist household air into the attic.

Cathedral Ceiling Ventilation Details

Cathedral ceilings require the same continuous air barriers, and balanced soffit and ridge vents, as attics. Both air sealing and ventilation are more critical, however, since any trapped moisture in the roof cavity will remain longer and potentially cause greater damage than in an open attic. Also, since there is little or no communication from bay to bay, an effective ventilation system must reach every bay (Figure 2-57).

Hips and Valleys. Ventilating hips and valleys can be challenging with a cathedral ceiling. One approach is to use a double or triple hip or valley rafter one size smaller than the common or jack rafters. This will create a vent space along the top of the hip or valley rafter that can be used to supply ventilation air to the jack rafters (Figure 2-58).

FIGURE 2-56 **Soffit Vents.**

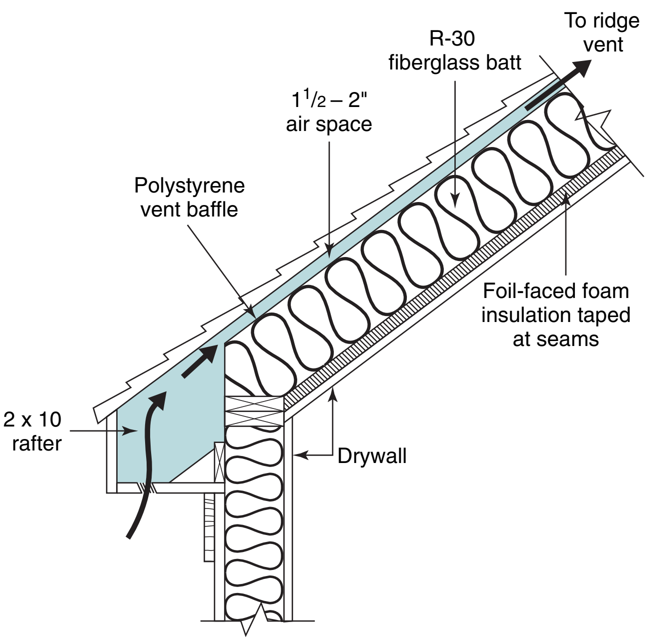


Place soffit vents close to the fascia for best performance. With high levels of insulation, a raised-top plate (left) or raised-heel truss (right) are recommended to allow full insulation at the plate area. With a raised top plate, use steel strap ties or similar connectors to securely anchor the rafters to the joists.

Skylights. Localized hot spots such as skylights can also lead to ice dams below, due to blocked ventilation as well as melt water from skylight heat loss. Notching the rafters on either side of the skylight will help maintain airflow above the skylight (Figure 2-59).

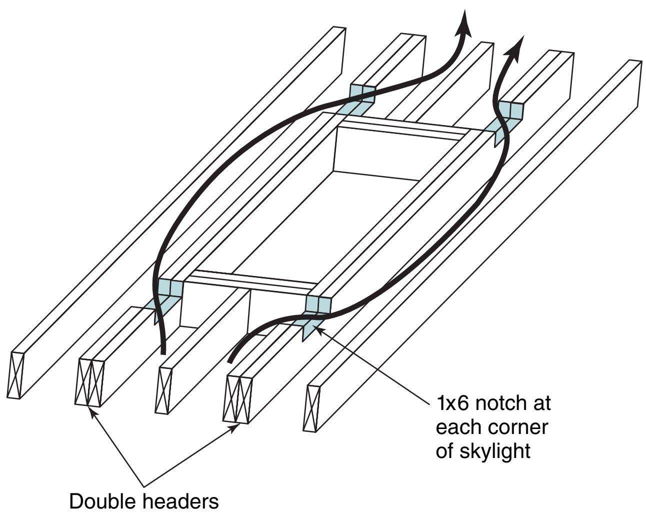
If icing is still a problem, add an interior storm window to reduce heat loss through the glass in cold weather. As a backup, it is always a good idea to seal the skylight curb and surrounding roof area with a bituminous membrane (see Figure 2-5, page 57).

FIGURE 2-57 Cathedral Ceiling Ventilation.



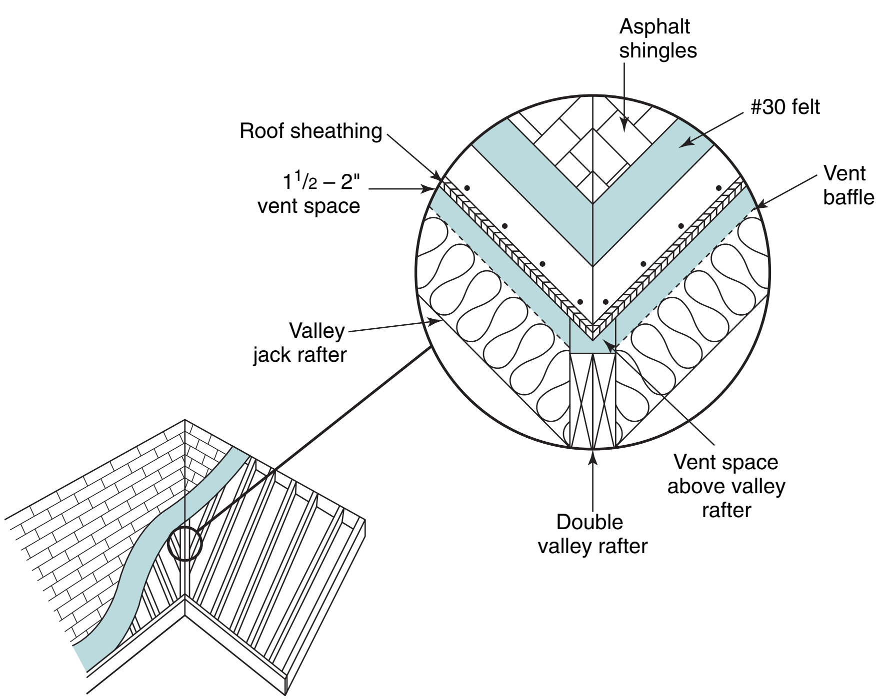
Builders have devised many methods to effectively ventilate cathedral ceilings. The key elements for success are an airtight ceiling plane and a minimum $1\frac{1}{2}$ inch free vent space from soffit to ridge.

FIGURE 2-59 Venting Around Skylights in Cathedral Ceilings.



Notching the tops of the rafters on either side of a skylight will help maintain airflow to the roof area above the skylight.

FIGURE 2-58 Ventilating Cathedral Ceiling Hips and Valleys.



To ventilate the rafter bays between hip or valley jacks, use a double or triple hip or valley rafter one size smaller than the common or jack rafters. The space left above the hip or valley rafter provides an air inlet for hips or an air inlet for valleys.

RESOURCES

Manufacturers

Asphalt Shingles

Atlas Roofing Corp.
www.atlasroofing.com
Fiberglass and organic felt shingles

Certainteed Roofing
www.certainteed.com
Fiberglass shingles

Elk Premium Building Products
www.elkcorp.com
Fiberglass shingles

GAF Materials Corp.
www.gaf.com
Fiberglass shingles

Georgia-Pacific Corp.
www.gp.com/build
Fiberglass and organic felt shingles

IKO
www.iko.com
Fiberglass and organic felt shingles

Owens Corning
www.owenscorning.com
Fiberglass shingles

Tamko Roofing Products
www.tamko.com
Fiberglass and organic felt shingles

Concrete Roof Tiles

Bartile Roofs
www.bartile.com

Eagle Roofing Products
www.eagleroofing.com

Entegra Roof Tile
www.entegra.com

MonierLifetile
www.monierlifetile.com

Vande Hey-Raleigh
www.vhr-roof-tile.com

Westile
www.westile.com

Clay Roof Tiles

Altusa, Clay Forever LLC
www.altusa.com

Ludowici Roof Tile
www.ludowici.com

MCA Clay Tile
www.mca-tile.com

U.S. Tile Co.
www.ustile.com

Tile Fasteners and Adhesives

Dow Building Products
www.dow.com/buildingproducts
Tile Bond polyurethane foam tile adhesive

Fomo Products
www.fomo.com
Handi-Stick polyurethane foam tile adhesive

Newport Fastener
www.newportfastener.com
Twisted wire systems, hurricane clips, nose clips, and the Tyle-Tye TileNail

OSI Sealants
www.osisealants.com
RT 600 synthetic rubber tile adhesive

Polyfoam Products
www.polyfoam.cc
Polyset and Polyset One polyurethane foam tile adhesives

Wire works, Inc.
www.wireworks-inc.com
Tile hooks, hook nails, copper and stainless-steel nails

Metal Roofing

Classic Products
www.classicroof.com
Modular metal shingle panels and standing seam panels

Decra Roofing Systems
www.decra.com
Modular metal shingle, tile, and shake panels

Dura-Lok Roofing Systems
www.duraloc.com
Modular metal roofing shingles with granular coating

Fabral
www.fabral.com
Exposed fastener and concealed clip metal roofing panels

Gerard Roofing Technologies
www.gerardusa.com
Modular metal shake and tile panels with granular coating

Met-Tile
www.met-tile.com
Modular metal roof-tile panels

Atas International
www.atas.com
Modular metal shingle, tile, and standing-seam panels

Custom-Bilt Metals
www.custombiltmetals.com
Modular metal shakes and standing seam panels

Low-Slope Roofing Membranes

Duradek
www.duradek.com
Vinyl roofing and walkable deck membrane

Firestone
www.firestonebpe.com
RubberGard EPDM residential roofing system

GenFlex Roofing Systems
www.genflex.com
Peel-and-stick TPO membrane

Hyload, Inc.
www.hyload.com
Kwik-Ply self-adhering polyester and coal-tar roofing membrane

Ridge Vents

Air Vent/A Gibraltar Company
www.airvent.com
A complete line of roof ventilation products, including shingle-over and exposed-ridge vents with exterior wind baffles and internal weather filters. Also soffit and drip edge vents and passive and powered attic turbine-type vents.

Benjamin Obdyke
www.benjaminobdyke.com
Shingle-over ridge vents. Low-profile Roll Vent uses nylon-matrix. Extractor vent is molded polypropylene with internal and external baffles.

Cor-A-Vent
www.cor-a-vent.com
Shingle-over low-profile ridge vents, including Cor-a-vent, Fold-a-vent, and X-5 ridge vent, designed for extreme weather. Corrugated core.

GAF Materials Corp.
www.gaf.com
Cobra vent: roll-out shingle-over ridge vent with a polyester-matrix core

Mid-America Building Products
www.midamericabuilding.com
Ridge Master and Hip Master shingle-over molded plastic ridge vents with internal baffles and foam filter

Owens Corning
www.owenscorning.com
VentSure corrugated polypropylene ridge vents; also passive roof vents and soffit vents

Trimline Building Products
www.trimline-products.com
Shingle-over low-profile ridge vents, Flow-Thru battens for tile roofs

Elk Premium Building Products
www.elkcorp.com
Highpoint polypropylene shingle-over ridge vents

Tamko Roofing Products
www.tamko.com
Shingle-over ridge matrix–type Roll Vent and Rapid Ridge (nail gun version) and Coolridge, which is molded polypropylene with external and internal baffles

Venting Underlayments

Benjamin Obdyke
www.benjaminobdyke.com
Cedar Breather, a $\frac{3}{8}$-in.-thick matrix-type underlayment designed to provide ventilation and drainage space under wood roofing

For More Information

Asphalt Roofing Manufacturers Association (ARMA)
www.asphaltroofing.org

Cedar Shake and Shingle Bureau
www.cedarbureau.org

Metal Roofing Alliance
www.metalroofing.com

Tile Roofing Institute
www.tileroofing.org