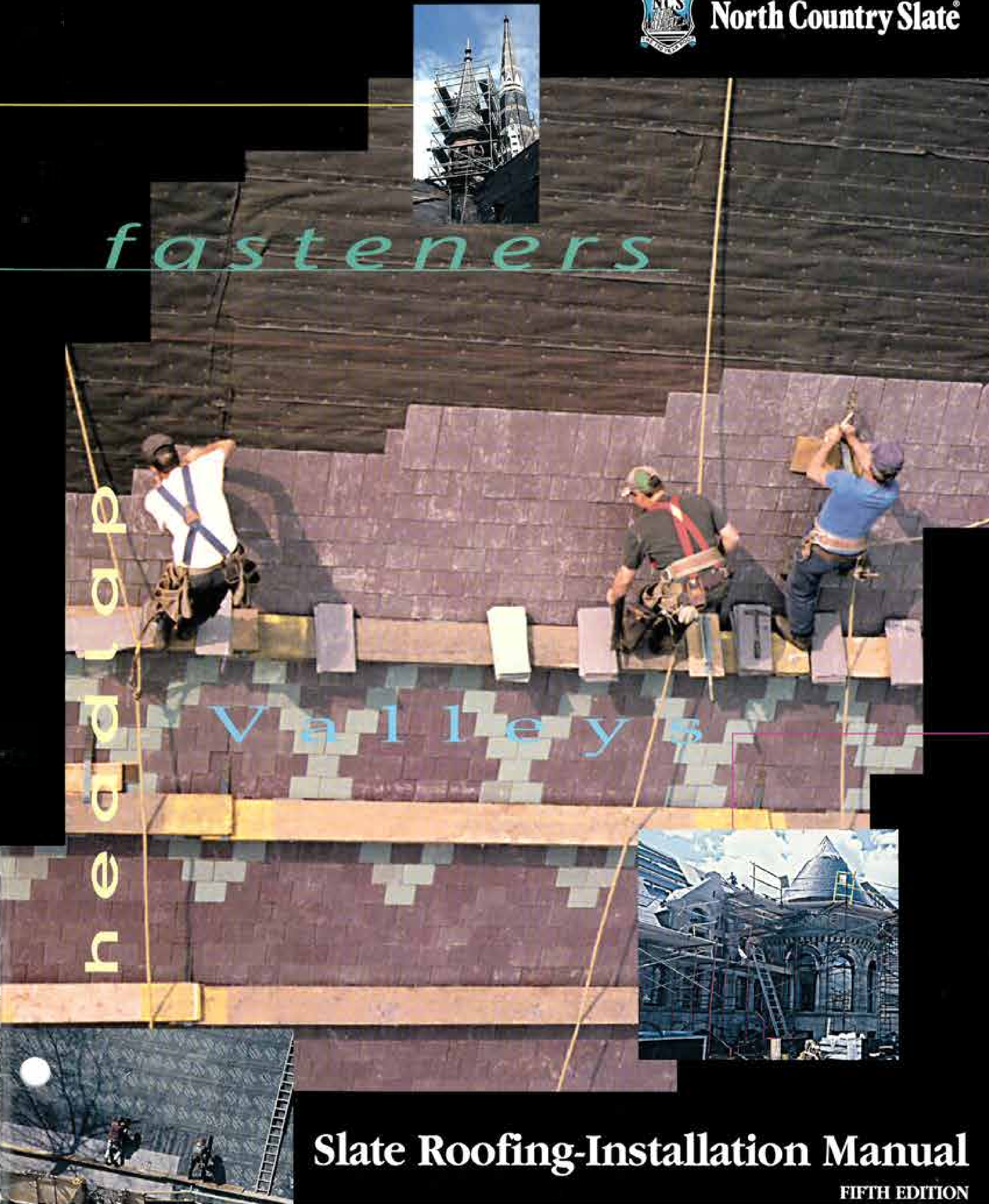
North Country Slate®



Slate Roofing-Installation Manual

FIFTH EDITION

timeless

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excellence

North Country Slate®

SLATE ROOFING

1. GENERAL INFORMATION

1.1 Slate Roof Systems

Slate roof systems may be classified into three general categories:

- standard
- graduated
- textural

1.1.1 Types of Slate Roof Systems

Standard Slate Roof Systems

Standard slate roof systems are those roof systems composed of standard commercial slate that is approximately ³⁄₁₆ inch to ¼ inch (4 mm to 6 mm) thick . The most common have uniform lengths and widths, with square tails or butts. Standard commercial slate may be used to form a variety of designs on a roof, and are suitable for many buildings where a long servicelife steep-slope roof covering is desired.

If desired, butts or corners of each slate may be trimmed to a diamond, hexagonal, or other pattern for specific portions or for all the roof system. Variety in the pattern of standard slate roof systems is sometimes attained by using random widths. A staggered butt line can be achieved by using longer length slates randomly.

Graduated Slate Roof Systems

Graduated slate roof systems feature variations in thickness, size and exposure. In graduated slate roof systems, the thickest, widest and longest slates are placed along eaves. As slate courses progress upslope to ridges, slates of gradually diminishing size and/or thickness are used, creating a "graduated" effect. This effect is intended to make the eave-to-ridge distance look longer and give the roof a more massive appearance. Slate for roofs of this type can be obtained in any combination of thicknesses from ³⁄₁₆ inch (4 mm) to 1 ½ inches (38 mm). Thicker slates are sometimes specified. Graduated slate roof systems may be installed in a wide variety of patterns.

Textural Slate Roof Systems

Because slate shingles come in a wide variety of sizes, thicknesses, textures and colors, a wide range of appearance can be created. When a range of thicknesses are mixed throughout a roof system, the roof system is sometimes referred to as a textured or textual roof system. Textural slate roof systems are composed of slate that has a rougher texture than standard slate. This slate type also has uneven tails or butts.

1.1.2 Active Slate Quarries

Active roofing slate quarries in North America exist in New York, Pennsylvania, Vermont, Virginia, and the Canadian provinces of Quebec and Newfoundland. The main area of slate production in Pennsylvania is the Lehigh district. The active Vermont quarry district lies in Bennington and Rutland counties and extends into Washington County in New York. Virginia slate operations are now conducted only in Buckingham County at Arvonia.

Imported slate is available from Spain, Wales, China, Brazil and South Africa.

There is concern with the durability of roofing slate from some quarries. Slate can be tested to recognized standards if the source of a slate at a quarry provides a consistent quality. Tests include those in ASTM C 406, "Standard Specification for Roofing Slate," especially the modulus of rupture test. British Standard 680 has an acid-resistance test for carbonate impurities especially calcite. A new European Standard for petrogrpahic examinations can describe the mineralogy and fabric of the stone and identify most problematic features of building stones.

1.1.3 Slate Tools

Specialized tools for slate roofing include the slate hammer, stake, ripper, roof scaffold bracket, and roof ridge or hook ladder. A slate hammer has many uses. The hammer head is used for driving nails, the claw for pulling nails, the point for punching slate and the knife edge on the shaft for cutting slate.

A slate stake is used with a slate hammer to cut slate in the field. It is a T-shaped tool that can be stuck into a roof deck or scaffold plank and provides a solid support at the underside of slate along the line where a cut or hole punch is to be made. It is also used as a straight edge to mark slate before cutting or trimming slate at valleys and other flashing areas.

A slate ripper is used to take out broken slate by cutting or pulling the concealed nails. The upper portion of a ripper is designed to hook around nails and loosen or cut them by force. The handle is designed to be struck with a hammer to assist in cutting or loosening a slate nail after the ripper has been positioned around or against the nail.

A roof scaffold bracket is used to secure toe boards. Roof scaffold brackets are adjustable and hold wood plank toe boards parallel to the ground. A toe board is a wood plank that provides a platform for a worker and holds material and tools.

A roof ridge or hook ladder is lightweight and has a hook that goes over a roof ridge. It enables a worker to climb on slate roof system without putting full weight on individual pieces of slate. Weight is transferred along the length of a ladder.

2. COMPONENTS

2.1 Slate

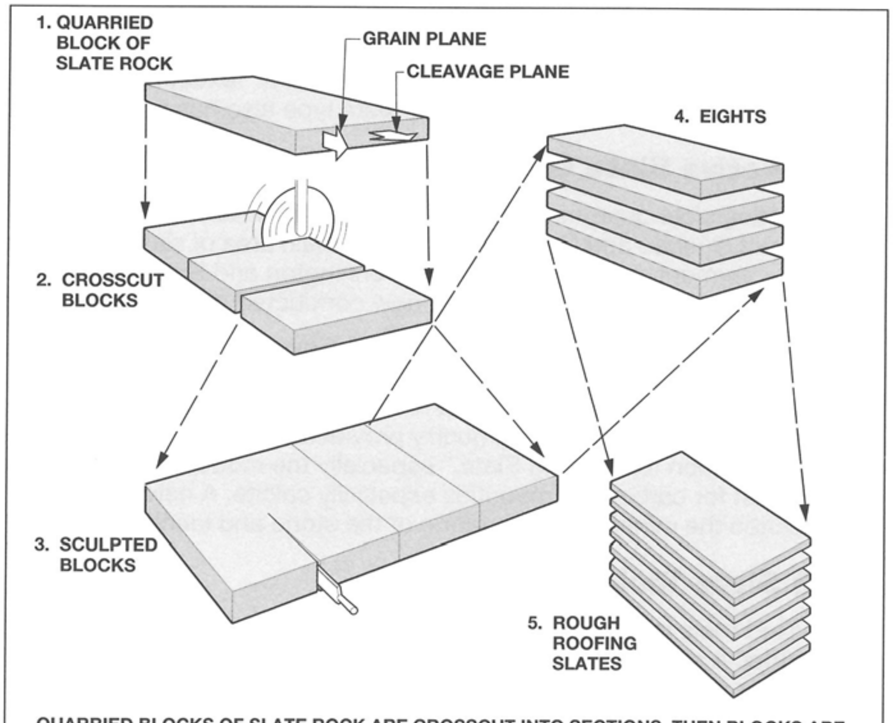
2.1.1 Material Description

Slate rock originates from sedimentary particles of clay and silt. Silt and other particles were originally washed down into streams, which transported the particles into ancient seas. As quantities of these particles were deposited over time, successive parallel layers of the material accumulated. These accumulations of sediment, built-up over thousands of years to varying thicknesses, and are called beds.

The pressure of successive overlying layers compressed and consolidated the lower underlying sedimentary layers, which formed shale. Years of these geological forces caused great pressure on the underlying shale layers and, as pressures rose, heat and force loads combined to chemically change original clay materials into harder materials such as chlorite, mica and quartz. Many years of these combined geological forces transformed relatively weak shale rock into hard slate.

The original layering of materials gives slate natural cleavage planes. These natural cleavage planes are what allows slate to be easily split into relatively thin layers. Slate also possesses a natural grain that usually occurs at right angles to cleavage. Roofing slates are commonly split so that the length of the slate runs in the direction of the natural grain. See Figure 1.

Figure 1: Example of quarried slates to roofing slates



QUARRIED BLOCKS OF SLATE ROCK ARE CROSSCUT INTO SECTIONS, THEN BLOCKS ARE SPLIT (SCULPTED) ALONG THE GRAIN. BLOCKS ARE THEN SPLIT ALONG THE CLEAVAGE PLANE INTO THINNER BLOCKS OFTEN REFERRED TO AS "EIGHTS." THE EIGHTS ARE SPLIT ALONG CLEAVAGE PLANE TO YIELD 8 INDIVIDUAL ROUGH SLATES. THESE ROUGH SLATES ARE THEN TRIMMED AND THE NAIL HOLES PUNCHED TO PRODUCE THE FINISHED ROOFING SLATE.

The surface texture of slate, after it is split for commercial use, depends on the quality and characteristics of the rock from which it was quarried. Many slates split to a smooth, practically even, uniform surface, and others split to a surface that is rough and uneven. As a result, a wide range of surface textures are available.

Some slate contains narrow "ribbons of rock" that are different in chemical composition and color from the principal slate. Slate that has been trimmed so that the ribbons are eliminated is known as clear slate. Slate that contains acceptable ribbons is sold as ribbon stock.

2.1.1.1 Colors

The color of slate is determined by its chemical and mineral composition. Because these factors differ in various regions, it is possible to obtain roofing slate in a variety of colors and shades. Various shades of the same slate may be used to provide interesting color mottling or shaded patterns when applied across a roof, or when interspersed randomly. The diversity of color makes slate a sought-after material for the creation of certain architectural or aesthetic conditions. When multiple colors are used, a roof system is sometimes called polychromatic.

Exposure to weather causes all slate to change slightly in color and composition. The degree of color change varies. Slate that exhibits minimal color change is classified as unfading. Slate that exhibits a more obvious color change is known as weathering. Weathering slate offers the designer another variation in roof aesthetics. Weathering and semi-weathering gray and green slates contain some slates that can weather to buff or tan as the mineral particles in the slate oxidize, providing a varied color pattern throughout a roof system.

When texture and color are essential considerations in roof design, architects and owners should consider the source of the slate, its potential for color change and the effect of weathering on the slate to be used. Slate producers know from experience the probable degree of color change for various slate materials obtained from their quarries. Producers may be consulted on selection of particular slate for a specific project.

For the purpose of classifying the basic natural colors of roofing slate currently available in large quantities for general use, the following color nomenclature may be used:

- black
- green
- gray
- gray green
- mottled purple
- mottled green
- purple
- red

In addition, slate distributors use the following names and nomenclature for certain roofing slate:

- blue-black
- blue-gray
- mottled gray-black
- mottled gray-green
- mottled purple-green
- mottled green-purple
- purple variegated
- sea green

When selecting a slate color from a distributor, the color should be preceded by the word "unfading" or "weathering" to designate the color stability or change that may be expected for a particular type of slate. In addition to the colors previously mentioned, slate distributors use different combinations of names to identify the colors of a particular slate.

2.1.1.2 Weight

Slate of commercial standard thickness weighs approximately 850 pounds per square (41 kg/m^2).

A square of slate on a roof system set at the standard 3 inch (75mm) headlap will vary in weight from 650 pounds to 8,000 pounds (295 kg to 3,629 kg) depending on the thickness of each slate.

Slate varies significantly in weight because of the numerous thicknesses, and types available from the different quarries. Table 1 shows the approximate weights of roofing slates of different thicknesses. The actual weight of slate products may be from 10 percent above to 15 percent below the weights shown.

Approximate Weight of Roofing Slate at Various Thicknesses (Based upon 3 inch [75 mm] exposure)	
Slate thickness	**Weight**
3/16" to ¼" (4 mm to 6 mm)	700 lbs/sq to 1,000 lbs/sq (3,400 kg/m^2 to 4,900 kg/m^2)
⅜" (9 mm)	1,500 lbs/sq (7,300 kg/m^2)
½" (13 mm)	2,000 lbs/sq (9,800 kg/m^2)
¾" (19 mm)	3,000 lbs/sq (14,600 kg/m^2)
1" (25 mm)	4,000 lbs/sq (19,500 kg/m^2)
1¼" (32 mm)	5,000 lbs/sq (24,400 kg/m^2)
1½" (38 mm)	6,000 lbs/sq (29,300 kg/m^2)
1¾" (44 mm)	7,000 lbs/sq (34,200 kg/m^2)
2" (50 mm)	8,000 lbs/sq (39,000 kg/m^2)

Table 1: Weights of Slate Weight at Various Thicknesses

A quarry or supplier should be consulted for specific slate weight(s), length, width dimensions and thickness. Slate is also available with sawn or chamfered edge, depending on the slate producer.

2.1.1.3 Quantities Per Square

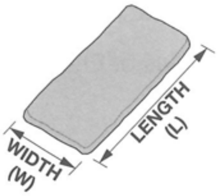
In the United States, slate is sold by the square. A square of roofing slate is defined by the U.S. Department of Commerce, National Bureau of Standards in Simplified Practice Recommendation No. 14 as:

> "a sufficient number of slate shingles of any size to cover 100 square feet of plain roofing surface, when laid with the approved or customary standard headlap of 3 inches (75 mm)." Slates for surfacing flat roofs are usually laid tile-fashion, without lap, in which case a square of slate would cover an area greater than 100 square feet."

The quantity of slate per square varies from 89 pieces of 26 by 14 inch (660 by 360 mm) slate, to 686 pieces of 10 inch by 6 inch (250 mm by 150 mm) slate. These quantities include an allowance for the 3 inch (75 mm) headlap.

It should also be noted that for roofs of lower slope, where a 4 inch (100 mm) headlap is used, an additional quantity of slate is required to cover 1 square of roof. For very steep roofs or vertical siding/cladding applications, where a 2 inch (50 mm) overlap is sufficient, fewer slates will be needed.

Table 2 shows length and width dimensions for standard slate, the minimum number of slates required per square and respective exposures for the slates listed.



**SCHEDULE FOR STANDARD 3/16" (5 mm)
THICK SLATE**

SIZE OF SLATE (L x W)	SLATES PER SQUARE	EXPOSURE WITH 3" (76 mm) Lap	SIZE OF SLATE (L x W)	SLATES PER SQUARE	EXPOSURE WITH 3" (76 mm) Lap
26 in. x 14 in. (660 mm x 360 mm)	89	11½ in. (290 mm)	16 in. x 14 in. (410 mm x 360 mm)	160	6½ in. (170 mm)
			16 in. x 12 in. (410 mm x 310 mm)	184	6½ in. (170 mm)
24 in. x 16 in. (610 mm x 410 mm)	86	10½ in. (270 mm)	16 in. x 11 in. (410 mm x 280 mm)	201	6½ in. (170 mm)
24 in. x 14 in. (610 mm x 360 mm)	98	10½ in. (270 mm)	16 in. x 10 in. (410 mm x 250 mm)	222	6½ in. (170 mm)
24 in. x 13 in. (610 mm x 330 mm)	106	10½ in. (270 mm)	16 in. x 9 in. (410 mm x 230 mm)	246	6½ in. (170 mm)
24 in. x 12 in. (610 mm x 310 mm)	114	10½ in. (270 mm)	16 in. x 8 in. (410 mm x 200 mm)	277	6½ in. (170 mm)
24 in. x 11 in. (610 mm x 280 mm)	138	10½ in. (270 mm)			
			14 in. x 12 in. (360 mm x 310 mm)	218	5½ in. (140 mm)
22 in. x 14 in. (560 mm x 360 mm)	108	9½ in. (240 mm)	14 in. x 11 in. (360 mm x 280 mm)	238	5½ in. (140 mm)
22 in. x 13 in. (560 mm x 330 mm)	117	9½ in. (240 mm)	14 in. x 10 in. (360 mm x 250 mm)	261	5½ in. (140 mm)
22 in. x 12 in. (560 mm x 310 mm)	126	9½ in. (240 mm)	14 in. x 9 in. (360 mm x 230 mm)	291	5½ in. (140 mm)
22 in. x 11 in. (560 mm x 280 mm)	138	9½ in. (240 mm)	14 in. x 8 in. (360 mm x 200 mm)	327	5½ in. (140 mm)
22 in. x 10 in. (560 mm x 250 mm)	152	9½ in. (240 mm)	14 in. x 7 in. (360 mm x 180 mm)	374	5½ in. (140 mm)
20 in. x 14 in. (510 mm x 360 mm)	121	8½ in. (220 mm)	12 in. x 10 in. (300 mm x 250 mm)	320	4½ in. (110 mm)
20 in. x 13 in. (510 mm x 330 mm)	132	8½ in. (220 mm)	12 in. x 9 in. (300 mm x 230 mm)	355	4½ in. (110 mm)
20 in. x 12 in. (510 mm x 310 mm)	141	8½ in. (220 mm)	12 in. x 8 in. (300 mm x 200 mm)	400	4½ in. (110 mm)
20 in. x 11 in. (510 mm x 280 mm)	154	8½ in. (220 mm)	12 in. x 7 in. (300 mm x 180 mm)	457	4½ in. (110 mm)
20 in. x 10 in. (510 mm x 250 mm)	170	8½ in. (220 mm)	12 in. x 6 in. (300 mm x 150 mm)	533	4½ in. (110 mm)
20 in. x 9 in. (510 mm x 230 mm)	189	8½ in. (220 mm)			
			11 in. x 8 in. (280 mm x 200 mm)	450	4 (100 mm)
18 in. x 14 in. (460 mm x 360 mm)	137	7½ in. (190 mm)	11 in. x 7 in. (280 mm x 180 mm)	515	4 (100 mm)
18 in. x 13 in. (460 mm x 330 mm)	148	7½ in. (190 mm)			
18 in. x 12 in. (460 mm x 310 mm)	160	7½ in. (190 mm)	10 in. x 8 in. (250 mm x 200 mm)	515	3½ in. (90 mm)
18 in. x 11 in. (460 mm x 280 mm)	175	7½ in. (190 mm)	10 in. x 7 in. (250 mm x 180 mm)	588	3½ in. (90 mm)
18 in. x 10 in. (460 mm x 250 mm)	192	7½ in. (190 mm)	10 in. x 6 in. (250 mm x 150 mm)	686	3½ in. (90 mm)
18 in. x 9 in. (460 mm x 230 mm)	213	7½ in. (190 mm)			

Table 2: Schedule for standard slate

2.1.2 Standards

To satisfy the need for slate classification, the National Slate Association established various standards for commercial slate during the 1800's. The primary standard was based on visual grading of slate by color, surface texture, straightness, thickness and weight. Even though grading was visual and varied from region to region, the standard helped ensure that slate products (that met the standard) would contain certain physical characteristics essential for quality slate roofing. For many years, roofing slates were specified according to the National Slate Association's standard.

Since 1957, the American Society for Testing and Materials (ASTM) has established a consensus material standard for slate used for roofing shingles. This material standard is designated as ASTM C 406, "Standard Specification for Roofing Slate." ASTM C 406 addresses material characteristics, physical properties and sampling procedures appropriate to the selection of slate for use as roofing shingles.

ASTM C 406 lists three grades of roofing slate depending on geographic location and environmental exposure: Grade S_1 slates are to have specific properties that are said to provide for an expected service life of more than 75 years; Grade S_2 slates are to have an expected service life of 40 to 75 years; and Grade S_3 slates are to have an expected service life of 20 to 40 years. Actual service lives for quality S_1 slate roofs range from 75 to more than 300 years.

There are three ASTM standard test methods that apply to roof slate and provide the basis of ASTM C 406. These are:

- ASTM C 120, "Standard Test Methods of Flexure Testing of Slate (Modulus of Rupture, Modulus of Elasticity)"
- ASTM C 121, "Standard Test Method for Water Absorption of Slate"
- ASTM C 217, "Standard Test Method for Weather Resistance of Slate"

These test method standards provide the basis for the grade classifications in ASTM C 406 which establishes the physical requirements shown in Table 3.

Physical requirements for roofing slate

Classification	Modulus of Rupture Across the Grain, minimum (ASTM C 120)	Absorption, maximum (ASTM C 121)	Depth of Softening, maximum (ASTM C 217)
Grade S_1	9,000 psi (62 kPa)	0.25%	0.002 in. (0.05 mm)
Grade S_2	9,000 psi (62 kPa)	0.36%	0.008 in. (0.20 mm)
Grade S_3	9,000 psi (62 kPa)	0.45%	0.014 in. (0.36 mm)

Table 3: Physical requirements for roofing slate

The grade of slate used should be commensurate with the expected design life of the building. NRCA recommends designers specify slate that meets the requirements of ASTM C 406, Grade S_1, for all geographic regions and environmental exposure conditions in North America.

2.2 Underlayment

NRCA recommends the use of underlayments with slate roof systems. Underlayment is applied over a roof deck before the application of roofing slate. Underlayment performs two primary functions: It provides temporary weather protection until a roof covering is installed, and it provides a secondary weatherproofing barrier should moisture migrate below the slate roof covering.

In addition, underlayments are generally necessary for the following reasons:

- to comply with local building codes
- to help prevent dust, dirt and insects from entering buildings

There are different underlayment configurations that can be used for slate roof systems. Generally, these configurations can be categorized as follows:

- single layer of underlayment
- single layer of self-adhered membrane
- double layer underlayment system

A single layer of underlayment is the most common underlayment configuration for slate roof systems.

2.2.1 Asphalt-saturated Felt

Asphalt-saturated felt underlayments are the most common underlayments used in steep-slope roof systems and typically use organic reinforcing mats.

The weatherproofing material used to manufacture roof underlayment felt is asphalt flux. Asphalt flux is obtained from the fractional distillation of petroleum that occurs toward the end of the petroleum refining process. Asphalt flux is sometimes further refined by air blowing to produce roofing-grade asphalt at the refinery or at the product manufacturer's facility.

Depending on the type of underlayment, asphalt may be used in two processes: first as a saturant and second as a coating.

Saturant-grade asphalt — Asphalt used in the saturation process is a "soft," less viscous asphalt than a coating asphalt and is used to impregnate organic reinforcing mats. Saturant-grade asphalt has a lower melting point than coating-grade asphalt. Common underlayments such as No. 15 and No. 30 are asphalt-saturated felts.

Coating-grade asphalt — If the felt underlayment is a coated felt, a coating-grade asphalt is applied to the felt after the saturation process. Coating-grade asphalt is more viscous than saturant-grade asphalt. Mineral additives, or "fillers," are added to the coating-grade asphalt to stabilize the bitumen and reduce its natural flow characteristics, and increase fire resistance and weatherability, making it more suitable as a coating material.

Underlayments are reinforced with mats that are designed to "carry" or support the asphalt. Reinforcing mats of different thicknesses are used to produce underlayments of different weights. These reinforcements, sometimes referred to as carriers, are most commonly made out of organic fibers. However, some underlayments are produced that use reinforcing mats made of glass fibers.

- Organic Mat

Over the years, organic mat has been produced from various combinations of cotton rag, wood fiber and other cellulose fibers. Currently, wood and other cellulose fibers are the types of reinforcements most widely used in organic mats. Organic mats are then saturated with a soft, saturant grade asphalt intended to fill voids between fibers.

- Glass Fiber Mats

Glass fiber mats are composed of inorganic, glass fibers. The fibers may be continuous or random and are bonded together with plastic binders or resin. Additionally, these glass fiber mats may be further reinforced with chopped glass fiber strands or with continuous random or parallel glass fiber strands. The mats are then coated with asphalt.

The following American Society for Testing and Materials (ASTM) standards apply to asphalt saturated organic felt underlayments for slates:

- ASTM D 224, "Standard Specification for Smooth-Surfaced Asphalt Roll Roofing (Organic Felt)." This standard addresses material characteristics and physical properties and provides four classifications: Type I–minimum net mass per unit area of roofing 39.8 lb/100 ft^2 (1943 g/m^2); Type II–minimum net mass per unit area of roofing 54.6 lb/100 ft^2 (2666 g/m^2); Type III–minimum net mass per unit area of roofing 51.1 lb/100 ft^2 (2495 g/m^2); and Type IV–minimum net mass per unit area of roofing 39.8 lb/100 ft^2 (1943 g/m^2).
- ASTM D 226, "Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing." This standard addresses material characteristics and physical properties and provides two classifications: Type I, commonly called No. 15 asphalt felt, and Type II, commonly called No. 30 asphalt felt.

NRCA recommends that asphalt organic felt underlayments meet or exceed the minimum physical property values listed in ASTM D 224 or D 226, Type II. ASTM D 226 covers asphalt-saturated organic felts with or without perforations. When used as underlayment, only non perforated asphalt felts should be used.

2.2.2 Polymer-modified Bitumen Sheet Underlayments

Polymer-modified bitumen sheet membrane products are now being used as underlayments in some steep-slope roof systems. Some of these materials are marketed for use specifically as underlayments for steep-slope roof systems. Others are heavy, non-porous sheets commonly used in low-slope roof systems.

Bitumen used in this type of underlayment is asphalt that has been modified with polymers. The common polymers currently used are atactic polypropylene (APP) and styrene butadiene styrene (SBS). These polymers alter the basic physical characteristics of the asphalt and provide enhanced weathering, aging and sealing characteristics. Polymer-modified bitumen base sheets are generally reinforced with either a glass fiber or polyester mat. Polymer-modified bitumen products specifically marketed for use as underlayments range in weight from 35 mils to 90 mils (0.7 mm to 2.3 mm) thick. In some cases, self-adhering polymer-modified bitumen membranes most often used as ice dam protection membranes, are installed over roof decks as underlayments. Self-adhered polymer-modified underlayments range from 20 mils to 60 mils (0.5 mm to 1.5 mm) thick. However NRCA recommends the use of a minimum thickness of 40 mils (1.0 mm).

Some of these materials are more resistant to wrinkling and distortion upon exposure or after installation and exhibit better watershedding properties than traditional asphalt-saturated organic felts. As a result, more of these types of underlayments are being used for projects where higher degrees of underlayment performance are desired.

2.3 Ice Dam Protection Membrane

A specialized type of underlayment is an "ice dam protection membrane." This underlayment provides additional protection from moisture intrusion along eaves where ice dams can occur during winter.

An ice dam protection membrane may consist of:

- a single layer of self-adhering polymer bitumen membrane
- two plies of No. 30 asphalt-saturated, non perforated felt where the first ply sheet is fastened to a deck and the second ply sheet is adhered to the first with roof cement or cold adhesive
- a combination of one heavyweight coated base sheet and one ply of No. 30 asphalt-saturated non perforated felt where the heavyweight, coated base sheet is fastened to a deck and the ply sheet is set in roof cement or cold adhesive.

The most common product used for ice dam protection membranes is a self-adhering, polymer-modified bitumen membrane. The bitumen used in this type of membrane is an asphalt that has been modified with polymers, typically SBS. These polymers alter the basic physical characteristics of asphalt and provide enhanced weathering and sealing characteristics.

Self-adhering polymer-modified bitumen membranes are generally reinforced with either glass fiber or a thin layer of polyethylene on the top side. These membranes should not be exposed for extended periods of time before the application of the slate. Some polymer-modified bitumen membrane products incorporate granule surfacings to provide more slip-resistant surfaces for workers.

The product is manufactured with an adhesive on the back side of the membrane to create a self-adhering material. A release paper covers the adhesive layer to prevent the membrane from sticking to itself after it is wound into a roll.

The following ASTM standard is applies to modified bitumen ice dam protection membranes:

- ASTM D 1970, "Standard Specification for Self-Adhering Polymer Modified Bituminous Sheet Materials Used as Steep Roofing Underlayment for Ice Dam Protection." This standard addresses thickness, tear resistance, adhesion properties, low-temperature flexibility and thermal stability, as well as other physical properties.

NRCA recommends that self-adhering polymer-modified bitumen sheet membranes used as ice dam protection membranes in slate roof systems be a minimum of 40 mils (1.1 mm) thick and comply with ASTM D 1970.

2.4 Asphalt Roof Cements

Roof cements are commonly used in the application of slate roof systems. The base material used in the manufacture of roofing cement is an air-blown asphalt. The asphalt is thinned, or "cut-back," with a petroleum-based solvent to create a softened, workable mixture. Some roofing cements contain mineral fibers as stabilizers. Some manufacturers are now offering modified bitumen roofing cements.

There are two common types of asphalt roofing cement: "flashing cement" and "lap cement." Flashing cements are commonly used on vertical surfaces and are of a trowelable consistency. Lap cements are used more specifically for bonding asphaltic materials together, and their consistency is characterized as either trowelable or brushable.

Asphalt roof cements are also available in different grades. The two most common grades are referred to as winter or summer. The primary difference between the winter and summer grades is their softening point temperature; winter grades have a lower softening point temperature than summer grades.

Common uses for asphalt roof cement in slate roof systems are:

- to bond two layers of felt underlayment together to form an ice dam protection membrane along the eaves in lieu of a self-adhering modified bitumen membrane
- as a bedding cement for the purpose of sealing the base or flange of a metal accessory to a roof
- to provide a temporary seal around roof penetrations or at walls before installing flashing components
- as a bedding cement to secure and seal hip/ridge units

The following ASTM standards apply to asphalt roof cement used as a utility cement or flashing cement:

- ASTM D 2822, "Standard Specification for Asphalt Roof Cement." This standard addresses composition, pliability, high-heat behavior and adhesion properties, as well other physical requirements. Type I is a cement composed of a low-softening point asphalt, and Type II is composed of a high-softening point asphalt. These classifications are further categorized by the intended application: Class I for dry surfaces or Class II for damp, wet surfaces.
- ASTM D 4586, "Standard Specification for Asphalt Roof Cement, Asbestos Free." This standard addresses composition, pliability and high-heat behavior, as well other physical requirements. The Type I and Type II classifications are the same as those in ASTM D 2822; however, this standard does not differentiate between wet or dry surface usage.

The following ASTM standard applies to asphalt roof cement used as a lap cement:

- ASTM D 3019, "Standard Specification for Lap Cement Used with Asphalt Roll Roofing, Non Fibered, Asbestos Fibered, and Non Asbestos Fibered." Three types of lap cement are described in this standard: Type I, brushing consistency with no stabilizers: Type II, heavy brushing or light troweling consistency with a quantity of short-fibered asbestos stabilizers: Type III, heavy brushing or light troweling consistency with nonasbestos stabilizers.

3. DESIGN CONSIDERATIONS

3.1 Roof Deck

A roof deck provides the structural substrate over which a roof system is applied. It also must be able to provide adequate withdrawal resistance for fasteners used to attach the roof system. Because of the typical longevity of slate roof systems, a roof deck material of comparable long-term expected service life is important. Slate roof systems require a structure capable of supporting heavier loads than most other steep-slope roof systems. The thickness and structural characteristics of wood sheathing/decking should be increased with thicker layers or heavier slates.

Slate may be applied over the following substrates:

- wood plank
- wood board
- structural wood panels

For new construction, NRCA recommends designers specify roof deck slopes intended for the application of steep-slope materials at 4:12 (18 degrees) or greater. Slate should be applied only over continuous or closely spaced wood plank or board decking and not over a spaced, or "skipped," application of wood plank or board decking.

The proper thickness and species of wood decking required for a specific roof is determined by design loads, including uplift, anticipated for the roof assembly and the distance between the supporting members. End joints of each piece of decking should be staggered. The end joints, except for matched ends (e.g., tongue-and-groove) should also be centered over supporting members.

3.1.1 Wood Plank and Board Decking

Slate may be applied over wood plank or board decking that is not warped, cupped or bowed. The terms "plank" and "board" are generally differentiated by thickness. The Western Wood Products Association (WWPA) defines the term "plank" as " A piece of lumber, from 2 but not including 5 inches thick, generally used with wide face horizontal." The term "board" is defined by the WWPA as ".a term generally applied to lumber when the nominal size is 1 inch thick and 2 or more inches wide." Wood boards used for decks should be a minimum of 6 inches (150 mm) nominal width.

A wood plank or board roof deck is composed of solid-sawn dimensional lumber. It is normally supported by wood beams — often glue-laminated timber or glulams — and/or solid lumber joists, purlins or rafters. Wood planks or boards may be single or double tongue-and-groove, straight-edged, ship-lapped, or grooved for splines or longitudinal edges.

3.1.2 Structural Wood Panel Decking

Structural wood panel decking consists of either plywood or oriented strand board (OSB).

- Plywood Roof Decks

A plywood roof deck is composed of panels made of thin wood layers called veneers that are peeled from logs. The veneers are laid at right angles to each other then glued together under heat and pressure. This cross-lamination adds strength and stability to all-veneer panels. Panels consist of a number of cross-laminated layers that vary in number according to a panel's thickness.

- Oriented Strand Board (OSB) Roof Decks

An OSB roof deck is composed of panels made from layers of compressed, glued wood strands. These strand layers are oriented at right angles to one another before being glued and formed into panels.

NRCA is concerned with potential fastener-holding problems and dimensional stability because of the effects of moisture where OSB and other nonveneer products are used as roof decking.

All plywood and wood-based panel roof decks suitable for application should be made from plywood or wood-based panels rated for structural use as roof sheathing. Most building codes require a label on plywood or wood-based panels ensuring that the plywood or wood-based panel complies with the criteria set forth in U.S. Product Standards (PS) PS 1-95, "Construction and Industrial Plywood", for all-veneer plywood or PS 2-92, "Performance Standard for Wood-Based Structural-Use Panels;" or APA—The Engineered Wood Association (APA) standard PRP-108, "Performance Standards and Policies for Structural-Use Panels," for structural-use panels (e.g., oriented strand board, all-veneer plywood).

Performance standards PS 1-95 and PS 2-92, which were initiated by APA — The Engineered Wood Association, formerly the American Plywood Association, have been developed under the "Procedures for the Development of Voluntary Product Standards" of the U.S. Department of Commerce. Performance standard PRP-108 was developed by APA — The Engineered Wood Association.

NRCA recommends that plywood or wood-based panels intended for use as roof sheathing meet or exceed the requirements set forth by PS 1-95, PS 2-92 or PRP-108. Some roofing materials manufacturers will allow application of roof products over other wood substrates.

When installing slate roof systems, if plywood is used as the roof deck material, ⅝ inch (15 mm) CDX nominal thickness is the minimum recommended by NRCA.

All wood panel roof decks should consist of panels rated for structural use as roof sheathing. For particularly demanding applications, such as prefabricated panelized roof deck systems where cross-panel strength and stiffness or shear properties are critical, designers are recommended to use panels meeting the standard's requirements for "Structural I Rated Sheathing."

Wood sheathing panels should be spaced approximately ⅛ inch (3 mm) to allow for expansion. End joints of wood sheathing panels that do not occur over supporting members should be blocked to provide adequate support for the sheathing panel ends.

NRCA does not recommend the direct attachment of slate to gypsum; concrete plank; cementitious wood fiber; or similar, nonwood materials.

3.1.3 Preservative-treated and Fire-retardant-treated Wood

Caution should be exercised when roof decks are constructed of wood that has been treated with an oil-borne preservative. Many roofing materials manufacturers recommend that wood roof decks be constructed with wood that has been treated with a nonoil preservative pressure treatment, or with nontreated air- or kiln-dried lumber. For additional information regarding preservative wood treatment, consult the American Wood Preservers Association (AWPA).

Because of the deterioration of some fire-retardant-treated wood panels caused by chemical reaction, special care should be given to investigate the use of fire-retardant-treated wood panel decks in the design of a steep-slope roof system.

3.1.4 Other Deck Types

NRCA recognizes that other types of structural decking are becoming more common in steep-slope roof construction, specifically in the commercial sector; however, NRCA recommends that slates be attached only to structural wood panel decks or to wood plank or board decks or batten systems unless a wire tie attachment system is used. NRCA does not recommend the direct attachment of slate to gypsum; concrete plank; cementitious wood fiber; or similar nonwood materials. If deck types or attachment methods other than these are used, NRCA suggests that a nailing substrate consisting of structural wood panels, such as plywood, is installed over the structural deck.

Examples of deck types over which NRCA suggests a layer of plywood are:

- steel roof decks
- poured and precast, structural concrete decks

For ventilation purposes, if necessary, and to allow acceptable clearance for proper fastener penetration of a plywood nailing substrate, NRCA suggests the use of wood battens or metal channels attached over a structural deck to raise and separate the plywood panels from the deck surface below. The design, placement, spacing, height and attachment of wood battens or metal channels is the responsibility of the designer. A complete roof assembly, including the structural deck, plywood nailing substrate and roof covering should be designed to meet local building code requirements. Key factors to consider during the design phase are fire resistance, structural loading and wind-resistance requirements of the applicable building code.

When installing slate roof systems, NRCA does not recommend the installation of a nailing substrate over cementitious wood fiber deck panels, poured and precast lightweight insulating concrete, or poured and precast gypsum roof decks.

3.2 Underlayment and Roof Slope

The possibility of water migration through a slate roof covering should be carefully considered. The watershedding capabilities of a primary roof covering are closely related to the slope of a roof, dimension of the overlap and headlap, distance between side joints in neighboring courses location of fastener holes, surface conditions of the slate and severity of weather conditions anticipated.

Slate roof coverings are designed for use as multilayered, watershedding roof systems. Slate roof coverings rely on slope to shed water off a roof system's surface.

Many slate roof systems have outlived the underlayment felts over which they were installed. Therefore, where the long-term watershedding characteristics of the underlayment are necessary to provide the weatherproof integrity of finished roof systems, designers should carefully consider the type and quality of underlayments to be specified.

An underlayment should be comparable to the design service life of a primary steep-slope roof covering and components. Consideration should be given to good local practices, which draw upon experience with various underlayment products and methods that have been developed to address special conditions.

3.2.1 Underlayment Configurations

There are different underlayment configurations that can be used for slate roof systems. Generally, these configurations can be categorized as follows:

- single-layer underlayment
- single-layer of self-adhered underlayment
- double-layer underlayment

A "single-layer underlayment" is one layer of underlayment fastened to a deck before the application of the slate. In single-layer applications, all underlayment felts or sheets should be lapped a minimum of 2 inches (50 mm) over the preceding sheet. End laps should be a minimum of 4 inches (100 mm). The underlayment should be fastened approximately for the slope of the roof, sufficient to hold the felts in place until the installation of primary roof covering materials.

A "single layer of self-adhered underlayment" is one layer of self-adhering polymer-modified bitumen membrane applied over the roof deck. Typically, this type of membrane is designed for use as an ice dam protection membrane. Designers should note that these types of membranes, when installed over an entire roof area, tend to act as vapor retarders. Potential problems with ventilation, moisture control and vapor-retarder placement should be considered during the design phase.

A "double-layer underlayment system" is two layers of underlayment fastened to a roof deck before application of slate. When a double-layer underlayment is required, felt should be applied horizontally at a 19 inch (480 mm) overlap and an 17 inch (430 mm) exposure. An underlayment should be fastened approximately for the slope of the roof, sufficient to hold the felts in place until primary roof covering material is applied.

When a double-layer underlayment configuration is used and where the underlayment layers are identical materials, they are commonly installed in a shingled fashion with a 19 inch (480 mm) overlap and a 17 inch (430 mm) exposure. However, if one layer is used to "dry-in" the building temporarily or underlayments of two differing compositions are used, each layer may be applied in a single layer configuration.

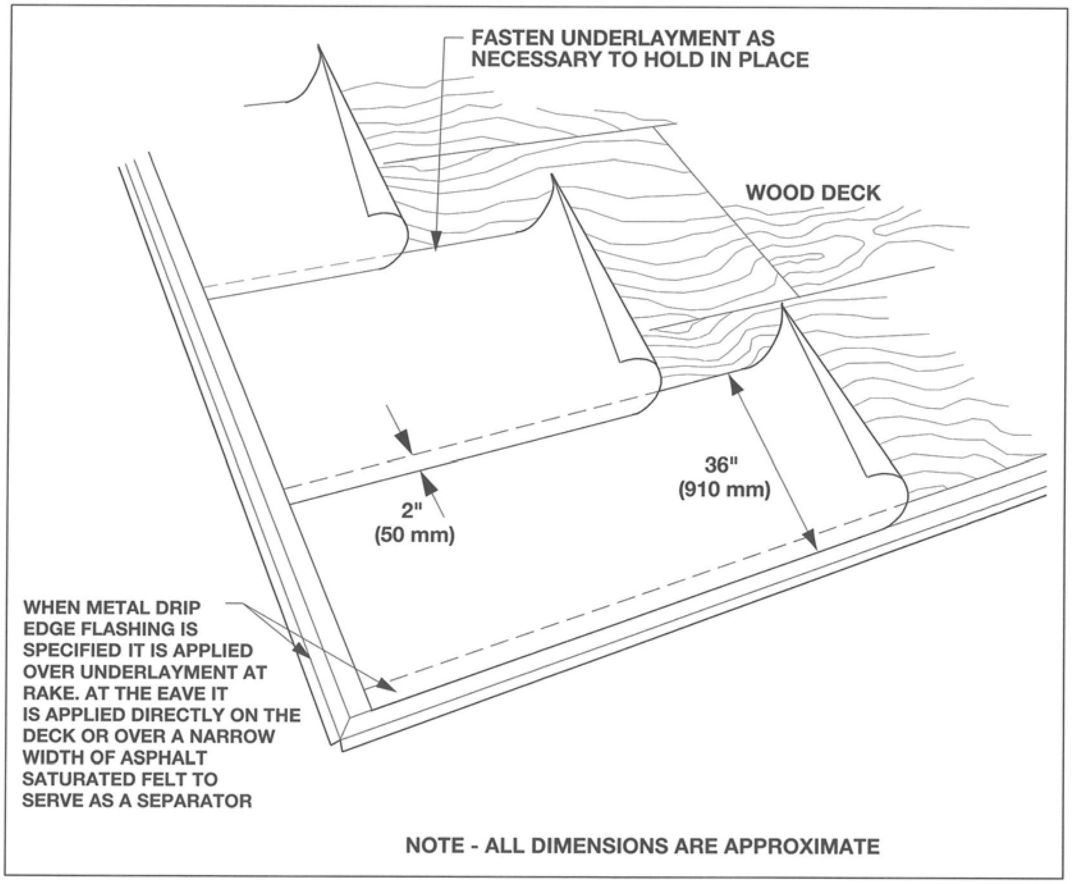
3.2.2 Roof Slope

The following are recommendations for underlayment and slate headlap with respect to roof slope:

- for roof slopes of 8:12 (34 degrees) and above, a minimum of one layer of No. 30 underlayment felt or one layer of polymer-modified bitumen underlayment is recommended. See Figures 2 and 3.

Where weather conditions are severe and hard wind-driven rains are common, NRCA recommends specifying a minimum of two layers of No. 30 asphalt-saturated felt or one layer of a polymer-modified bitumen underlayment with 40 mil (1.0 mm) minimum thickness for use as underlayment with a slate roof.

Figure 2: Example of single-layer underlayment



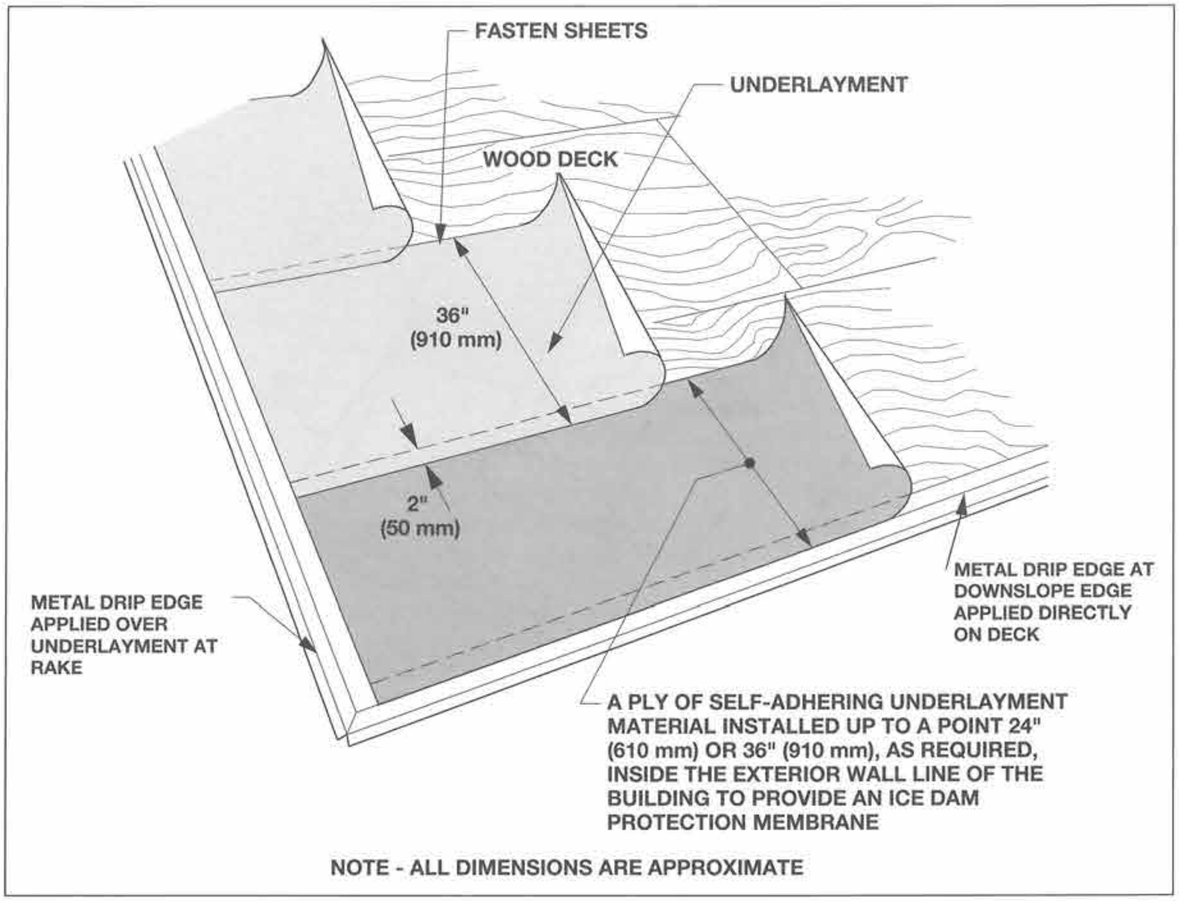
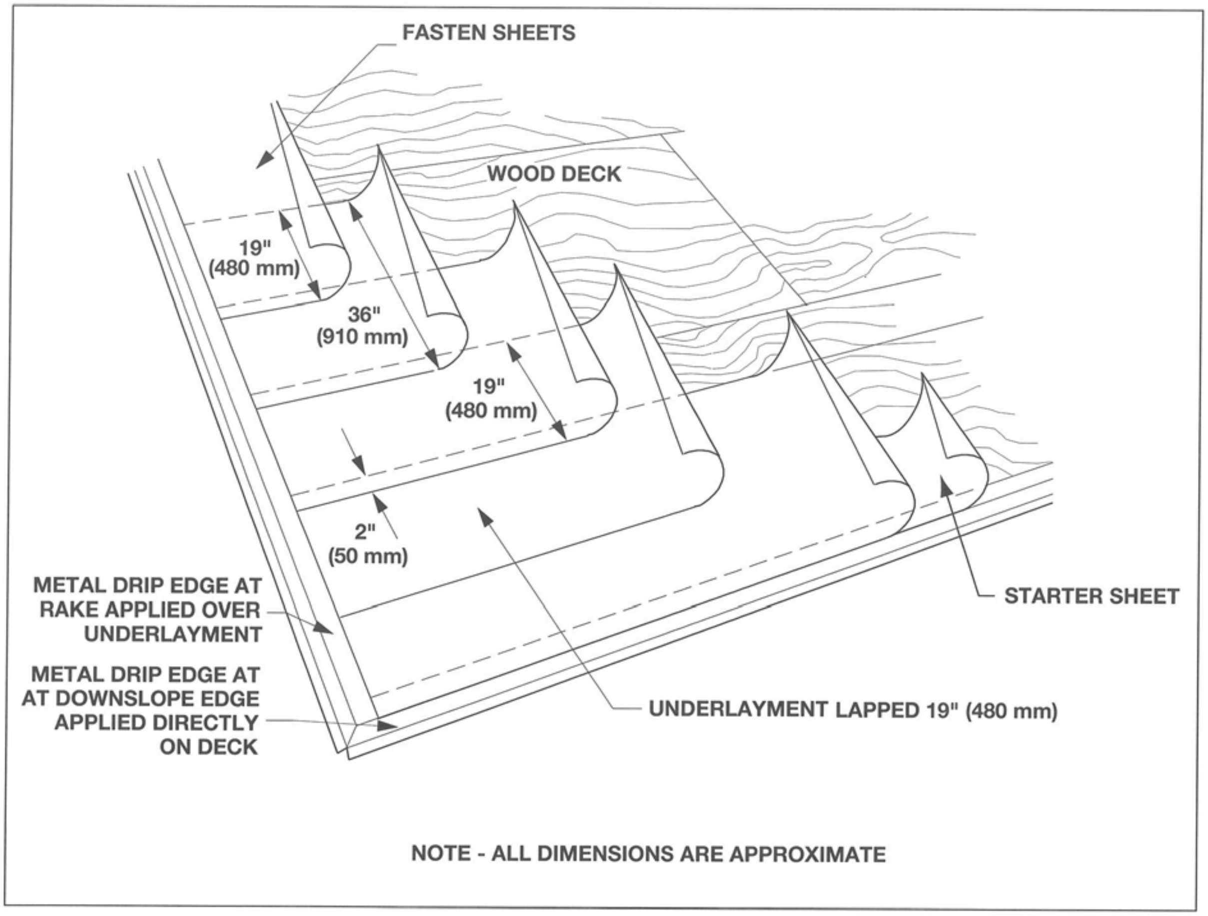


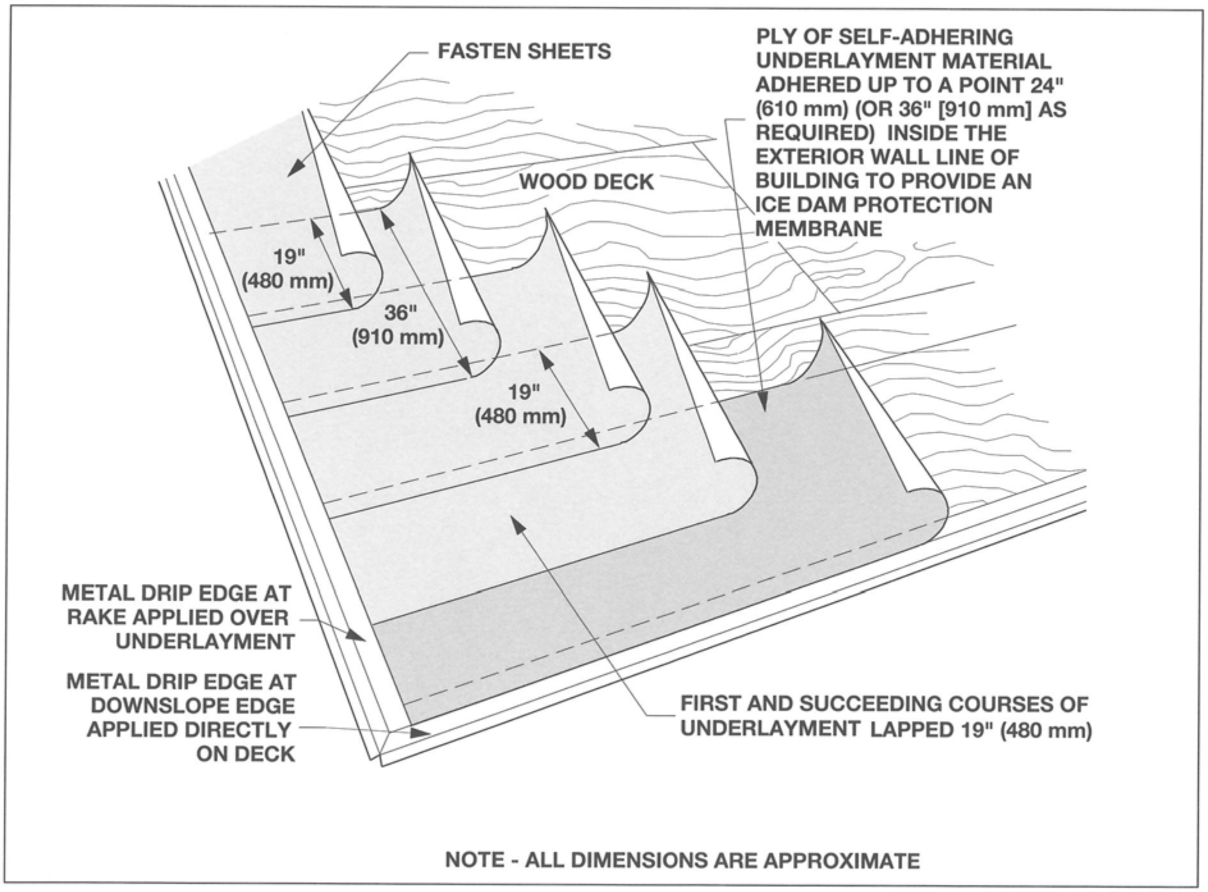
Figure 3: Example of a single layer of underlayment with an ice dam protection membrane

- for roof slopes of 4:12 (18 degrees) to 8:12 (34 degrees), a minimum of two layers of No. 30 underlayment or one layer of a polymer- modified bitumen underlayment are recommended for use as underlayment with standard-size slate as long as the slate is installed with a 3 inch (75 mm) minimum headlap. See Figures 4 and 5.



NOTE - ALL DIMENSIONS ARE APPROXIMATE

Figure 4: Example of a double-layer underlayment



NOTE - ALL DIMENSIONS ARE APPROXIMATE

Figure 5: Example of a double layer of underlayment with an ice dam protection membrane

NRCA does not recommend the design of slate roofing on slopes less than 4:12 (18 degrees). At slopes less than 4:12 (18 degrees), slate is a decorative roof covering only, and a weatherproof membrane installed under the slate is necessary.

3.3 Ice Dam Protection Membranes

Regardless of the type of underlayment required or roof slope, in locations where the average temperature for January is 30° F (-1° C) or less, NRCA suggests installation of an ice dam protection membrane. See Figure 6.

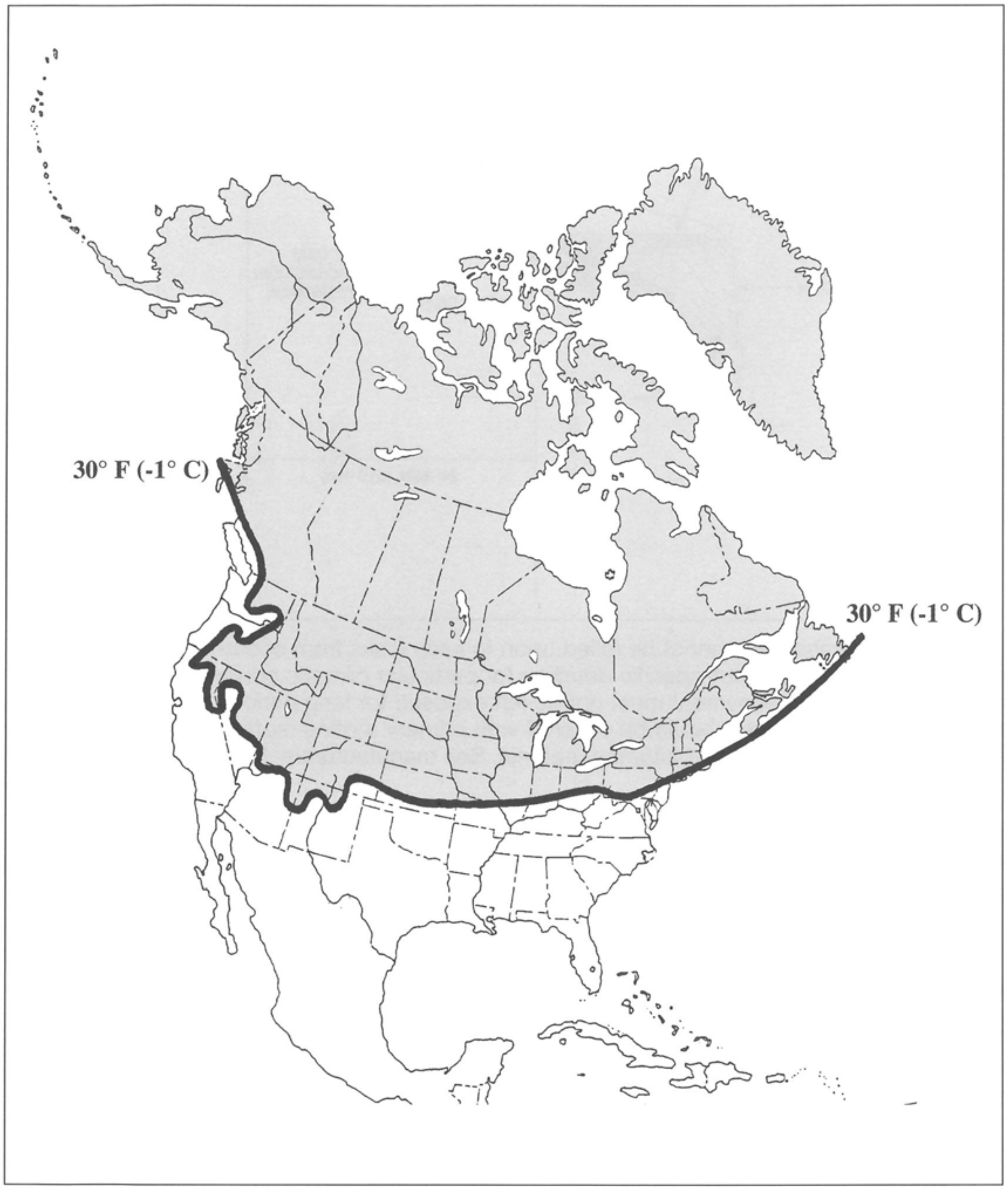


Figure 6: Approximate area of North America that has an average January temperature below 30° F (-1° C). Map courtesy of Coastal Weather Research Centery, University of Alabama.

An ice dam protection membrane generally is a self-adhering polymer-modified bitumen membrane. NRCA recommends that these types self adhering membranes be a minimum of 40 mils (1.0 mm) thick and comply with ASTM D 1970. Underlayment felts, as well as polymer-modified bitumen base sheets, cemented together with asphalt roof cement or a cold adhesive can also be used as ice dam protection membranes.

An ice dam protection membrane should be applied starting at the eaves and extending upslope a minimum of 24 inches (610 mm) from the inside of the exterior wall line of a building. See Figure 7.

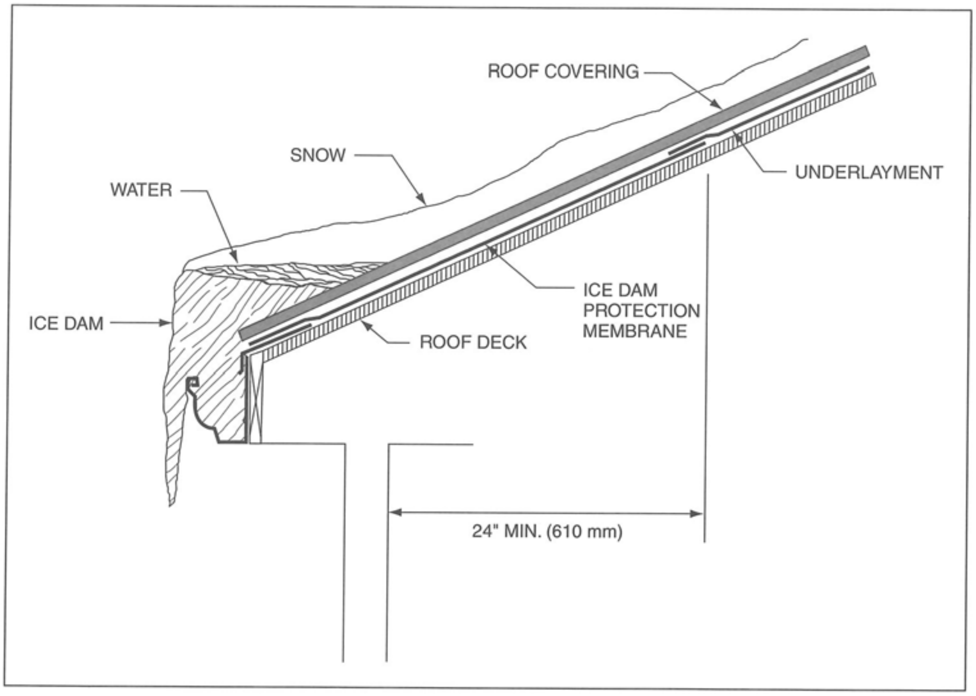


Figure 7: Example of ice damming

Ice dam protection membranes, by themselves, cannot be relied upon to keep leaks from occurring. Careful consideration of roof ventilation, insulation and project-specific detailing for particular climatic conditions is vital. Also, self-adhering polymer-modified bitumen underlayment must not be left exposed for long periods of time. Self-adhering polymer-modified bitumen underlayments should be covered with primary roofing material as soon as practical to prevent premature degradation of the modified bitumen material. See manufacturers' individual product requirements.

Designers should note that these types of membranes, when used as underlayments over an entire roof area, tend to act as vapor retarders. Potential problems with ventilation, moisture control and vapor-retarder placement should be considered during the design phase.

3.4 Fasteners

Because of the long-term service life of slate, serious consideration should be given to the type of fasteners to be specified. Several fastener types apply to certain projects, such as copper slating nails, stainless steel, bronze or cut-brass roofing nails. NRCA suggests the use of copper slating nails for slate roofs. Unprotected black-iron and electroplated nails are not recommended. An additional benefit or consideration for the use of copper is that copper slating nails can be easily cut with a slate ripper when repair work is needed.

Nail shank should not be of larger diameter than the fastener holes in the particular slate being used. Nails recommended for most standard-sized slate roof systems are sharp-point, ⅜ inch (9 mm) large flat head, copper-wire slating nails with a smooth, round, barbed or otherwise deformed shank. Generally, thicker slates require the use of larger diameter, longer nails. Consideration should also be given to the slope of a roof, weight of slate, wind loads anticipated, and roof sheathing specified all these items relate to slate fastener selection for a specific project.

Fasteners should be long enough to penetrate through all layers of roofing material and achieve secure anchorage into a roof deck. Fasteners should extend through the underside of plywood and penetrate at least ¾ inch (19 mm) into wood board or plank decks. The required length of slate fasteners varies according to the thickness and exposure of the slate being used. For most 3⁄16 inch (5 mm) to ¼ inch (6 mm) thick slate, laid with a 3 inch (75 mm) head lap over an underlayment, a 1½ inches (38 mm) or 1¾ inches (44 mm) nail length is adequate.

Standard-sized slate is fastened with two nails. All roofing slate should have a minimum of two nails. However, slate that is subject to high-wind conditions and/or ¾ inch (19 mm) and thicker should be fastened with four nails.

Holes are punched from ¼ to ⅓ the way down from the upper end, and 1¼ inches to 2 inches (32mm to 50mm) in from the edges. Where four holes are used, it is typical to punch two additional holes approximately 2 inches (50mm) above the two regular holes.

When attaching slates, nails should not be driven tight against the slate as if to draw the slate tight to the deck. Slating nails should be driven so that a nail's head just touches the surface of the slate so the slate hangs on the nail. See Figure 8.

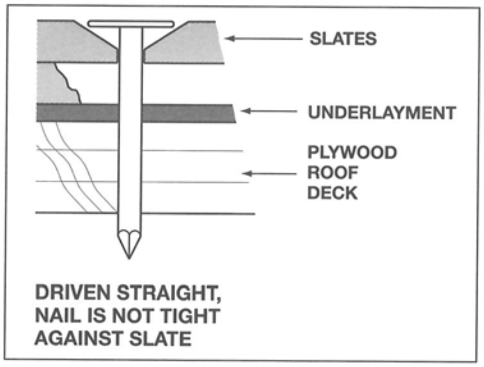


Figure 8: Example of proper nailing of slates

In high-wind areas, a 1 inch (25 mm) dab of flashing-grade roof cement, roofer's cement or polyurethane sealant placed under the exposed part of the slate near the leading edge can help secure it.

Other methods of attaching/affixing slate in certain situations are with slating hooks and wire tie systems.

3.5 Exposure and Appearance

The exposure of slate is the portion of the slate shingle that is not covered by the course above and is, therefore, the length of the slate roofing unit exposed to the weather. The proper exposure for a particular length of slate is obtained by deducting the 3 inch (76 mm) headlap from the total length of the slate then dividing that number by two. For instance, the proper exposure for a 24 inch (610 mm) slate is:

24 inches - 3 inches = 21 inches; 21 inches ÷ 2 = 10½ inches
(600 mm - 75 mm = 525 mm ÷ 2 mm = 263 mm)

Table 4 shows the proper exposures for various lengths of slate if all are to be set with a 3 inch (76 mm) headlap.

Length of Slate	Slate Exposure
24" (610 mm)	10½" (265 mm)
22" (560 mm)	9½" (240 mm)
20" (510 mm)	8½" (215 mm)
18" (460 mm)	7½" (190 mm)
16" (410 mm)	6½" (165 mm)
14" (360 mm)	5½" (140 mm)
12" (300 mm)	4½" (115 mm)
10" (250 mm)	3½" (90 mm)

Table 4: Slate exposures with a 3 inch (75 mm) headlap.

Slate can be installed to graduate by thickness and/or size. Thicker and/or longer slates are laid at eaves graduating to the thinner or smallest size at ridges. A typical graduation by thickness is ½ inch (13 mm) to ⅜ inch (10 mm) to ¼ inch (6 mm). A typical graduation by size is 20 inches (500 mm) to 18 inches (450 mm) to 16 inches (400 mm) to 14 inches (350 mm).

When multiple colors are used, the percentage of each color to be used throughout the roof system should be specified. An example is 40 percent unfading green, 40 percent weathering green and 20 percent purple. With regard to weathering slates, some quarries can reasonably predict the percent and intensity of color change from the base color to weathered color.

3.6 Starter Course

Before the first course of slate is installed, a row of starter slates is applied along the eave of a roof system to serve as the starter course. The starter course's primary purpose is to shed water that may migrate through the joints of the slates in the overlying first course.

The lower edge of the starter course should extend beyond the downslope perimeter (eave) approximately 2 inches (50 mm) to assist in directing runoff away from the fascia board and other underlying building components. When gutters or eave troughs are used, the overhang may be reduced to approximately 1 inch (25 mm) or less. Slates should be installed to extend approximately 1 inch to 2 inches (25 mm to 50 mm) beyond the rake edge.

Starter slates may be applied face down. This allows the smooth backs of the starter course and first course of slate contact each other.

3.6.1 Eave Cant

An eave cant is necessary to raise the butt edge of a starter and first course of slate the same way the headlap or third layer of slate raises the butt edge of all succeeding courses. The thickness of the eave cant should be about the thickness of the eave slates. A traditional eave cant is a wood lath ¼ inch (6 mm) thick and 2 inches (50 mm) wide. It is nailed to a deck and covered with eave flashing metal and underlayments. Beveled boards and raised metal eave flashings are also used.

3.7 Flashings

Because steep-slope roof systems are frequently interrupted by the intersection of adjoining roof sections; adjacent walls; or penetrations, such as chimneys and plumbing soil-pipe stacks, all of which create opportunities for leakage, special provisions for weather protection must be made at these locations. These components used to control water entry are commonly called flashings. Careful attention to flashing details is essential to successful long-term roof performance regardless of the type of roof construction.

Flashings in this section are divided into the following categories:

- perimeter/edge metal
- penetrations
- valleys
- vertical surfaces

Flashing metals should be made from a material of thick enough gauge to achieve at least the expected design life of the steep-slope roof covering used with it.

3.7.1 Perimeter Edge Metal

Depending on the severity of the climate, anticipated rainfall and freeze-thaw cycling, the use of perimeter edge metal should be considered.

Where climate or roof edge construction dictates the need for perimeter edge metal, the type and minimum thickness of the metal should be commensurate with the anticipated service life for the slate roof system. NRCA suggests metal penetration flashings for slate roof systems be fabricated from one of the following metal types and minimum thicknesses.

- 24 gauge (0.025 inch [0.64 mm] thick) prefinished galvanized steel
- 24 gauge (0.024 inch [0.61 mm] thick) stainless steel
- 16 ounce (0.022 inch [0.56 mm] thick) copper
- 16 ounce (0.026 inch [0.66 mm] thick) lead-coated copper

In some regions, particularly those with mild climates, other types of metal and/or metals of lesser thickness than are shown above may be used successfully. NRCA considers these applications to be area practices. Refer to the Introduction for additional information about area practices.

3.7.2 Penetration Flashings

There are many other smaller penetrations that need to be flashed into slate roof systems, such as plumbing soil stacks, vents, exhaust fans, furnace of water heater flue pipes, electrical standpipes and others. This is typically accomplished with the use of some type of flat flange that extends around the penetration and is installed under the slate and underlayment on the upslope side of the flange and extends down on top of the slate at the downslope side of the flange. Attached and sealed to the flange is a cylinder, rectangular box or neoprene gasket that is used to seal around the penetration. The flange can be set into mastic for additional protection. These flashing components are often supplied by other trades but may be installed by a roofing contractor. See Figure 9.

The type and minimum thickness of the metal used for penetration flashings should be commensurate with the anticipated service life for the slate roof system. NRCA suggests metal penetration flashings for slate roof systems be fabricated from one of the following metal types and minimum thicknesses.

- 24 gauge (0.024 inch [0.64 mm] thick) prefinished galvanized steel
- 0.032 inch (0.81 mm) thick aluminum
- 0.032 inch (0.81 mm) thick prefinished aluminum
- 24 gauge (0.024 inch [0.61 mm] thick) stainless steel
- 16 ounce (0.022 inch [0.56 mm] thick) copper
- 16 ounce (0.026 inch [0.66 mm] thick) lead-coated copper
- 4 pound (0.062 inch [1.57 mm] thick) lead.

In some regions, particularly those with mild climates, other types of metal and/or metals of lesser thickness than are shown above may be used successfully. NRCA considers these applications to be area practices. Refer to the Introduction for additional information about area practices.

3.7.3 Valley Construction

A valley is created at the downslope intersection of two sloping roof planes. Water runoff from the portions of the roof areas sloping into the valley flows toward and along the valley. Because of the volume of water and lower slope along a valley line, this area is especially vulnerable to leakage. A clear, unobstructed drainage way is desired in valleys, so the valley may carry water away quickly and perform successfully for the life of the roof system.

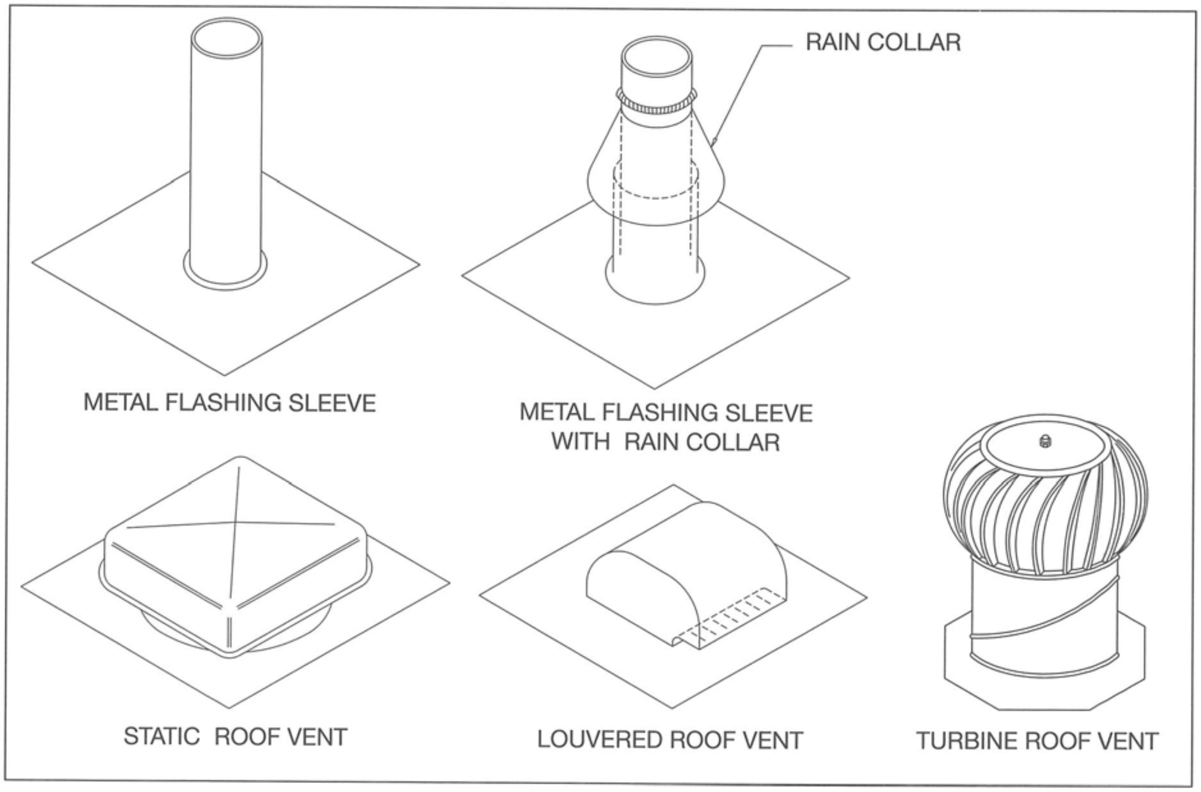


Figure 9: Examples of common roof penetrations

Where roofs of two equal slopes join to form a valley, the slope of the valley is less than that of the two adjacent fields of the roof. For example, where two sloped roofs with slopes of 4:12 (18 degrees) intersect at a valley, the actual valley slope is only about 3:12 (14 degrees).

With slate roof systems, there are three basic types of valleys:

- open valleys
- closed or mitered valleys
- rounded valleys

These three general types of valleys are constructed only after the necessary layer(s) of underlayment and any valley lining material specified have been applied to a deck.

Valley underlayment construction consists of a full-width, 36 inch (900 mm) sheet of No. 30 underlayment felt or a polymer-modified bitumen underlayment, base sheet or ice dam protection membrane. This valley underlayment is centered in the valley. Valley underlayment sheets should be secured with only enough fasteners to hold them in place until the balance of valley materials are applied. The courses of underlayment from the fields of two adjoining roof areas are extended so that each course overlaps the valley underlayment by at least 12 inches (300 mm). The valley is then lined with the balance of the valley flashing and slate. Another recognized installation method is weaving the intersecting underlayment courses through the valley extending the underlayment a minimum of 18 inches (460 mm) beyond the center line of the valley on each side.

To prevent leakage it is important with all types of valley construction to avoid placing fasteners near the center of a valley to prevent leakage. Generally, slate fasteners should be kept back from the center of a valley by a minimum of 8 inches (200 mm).

To avoid fastening too close to the center of valley metal, slate may be secured by wire-tie attachment. Wire-tie methods of attachment may be used with closed and open types of valleys. Using wider slate may provide an alternative to wire-tie attachment of slates, because all wider slates allow fasteners to be installed without penetrating valley flashing metal.

3.7.3.1 Open Valleys

Open valleys are typically lined with sheet metal. A metal valley is constructed by installing lengths, typically 8 feet or 10 feet (2.4 m or 3 m) of corrosion-resistant metal through the valley.

The slate and, with some area practices, the underlayment is lapped onto the flange on either side of the valley metal, leaving a clear space between the roofing material to channel runoff water down the valley. See Figure 10.

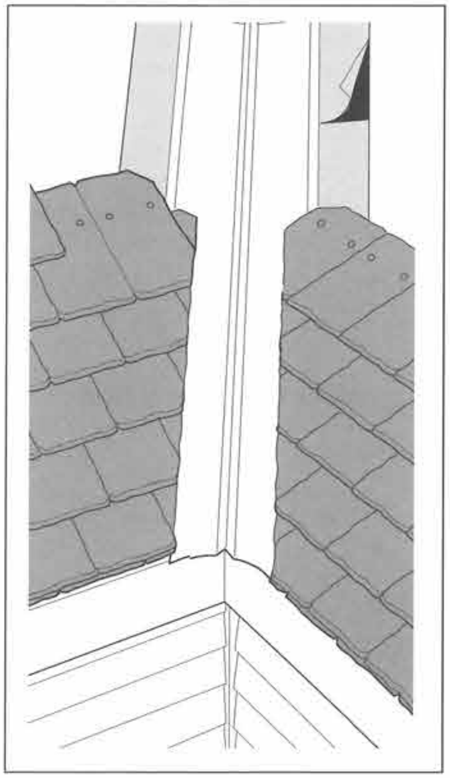


Figure 10: Example of open valley flashing

The type and minimum thickness of the metal used in an open valley should be commensurate with the anticipated service life for the slate roof system. NRCA suggests valley metal for slate roof systems be fabricated from one of the following metal types and minimum thicknesses.

- 24 gauge (0.025 inch [0.64 mm] thick) prefinished galvanized steel
- 24 gauge (0.024 inch [0.61 mm] thick) stainless steel
- 16 ounce (0.022 inch [0.56 mm] thick) copper
- 16 ounce (0.026 inch [0.66 mm] thick) lead-coated copper
- 4 pound (0.062 inch [1.57 mm] thick) lead.

In some regions, particularly those with mild climates, other types of metal and/or metals of lesser thickness than are shown above may be used successfully. NRCA considers these applications to be area practices. Refer to the Introduction for additional information about area practices.

NRCA also suggests that valley metal be formed with a "W"-shaped splash diverter or rib in the center. A center rib can be especially beneficial in valleys where adjoining roof areas are of unequal slope because the rib helps prevent "wash over" of runoff. A center rib should not be less than 1 inch (25 mm) high. For easier installation and controlling thermal expansion and contraction, NRCA suggests valley metal pieces used with slate roofing be no longer than 10 feet (3 m). NRCA recognizes that "V-"shaped valley metal performs satisfactorily in certain environments but not when a valley is formed by two different roof slopes.

NRCA recommends that valley metal used with slate be a minimum of 18 inches (450 mm) wide. This means flanges on either side of the metal valley center line are approximately 8 inches (200 mm) wide. Having a flange width of approximately 8 inches (200 mm) allows the slate to lap onto the flange at least 4 inches (100 mm).

Open valleys permit clear, unobstructed drainage and are advantageous in locations where fallout from surrounding foliage settles on the roof system and tends to accumulate in the valley. Valley metal should be made from a material thick enough to achieve at least the expected design life of the steep-slope roof covering.

3.7.3.1.1 Enhanced Open Valleys

In some climates, particularly those in areas prone to accumulations of snow and ice or with regular freeze-thaw cycling open valley construction can be enhanced by one of the following procedures:

- lining the valley with a self-adhering polymer-modified bitumen underlayment material before application of the metal valley
- stripping in flanges on either side of the metal valley with a 9 inch to 12 inch (230 mm to 300 mm) strip of self-adhering polymer-modified bitumen underlayment material. The self-adhering material is adhered onto the valley metal flange and onto an underlying width of similar self-adhering membrane material
- attaching valley flashing metal with cleats rather than through-fastening
- tapering the valley so that it is wider at the low point than it is at the high point.

Tapering the valley has the following advantages:

- allows for increase in runoff water volume to be received at the downslope end
- allows any ice that may form within the valley to free itself when melting and slide down and exit the valley rather than lodging somewhere along the length of the valley.

3.7.3.2 Closed Valleys

In a closed valley, slate on both sides are cut at an angle parallel to the center line of the valley and are butted together, forming a mitered joint. In areas of the United States where heavy accumulations of foliage fallout are anticipated or if moss can be expected to grow between the slate roofing joints, a closed valley can hamper runoff. Therefore, specifying a closed valley should be carefully considered to be sure it is appropriate for the particular project. See Figure 11.

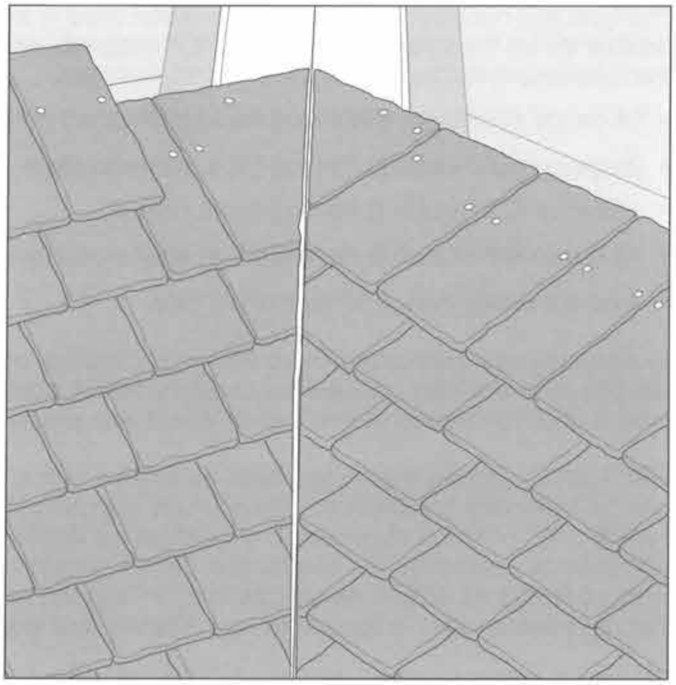
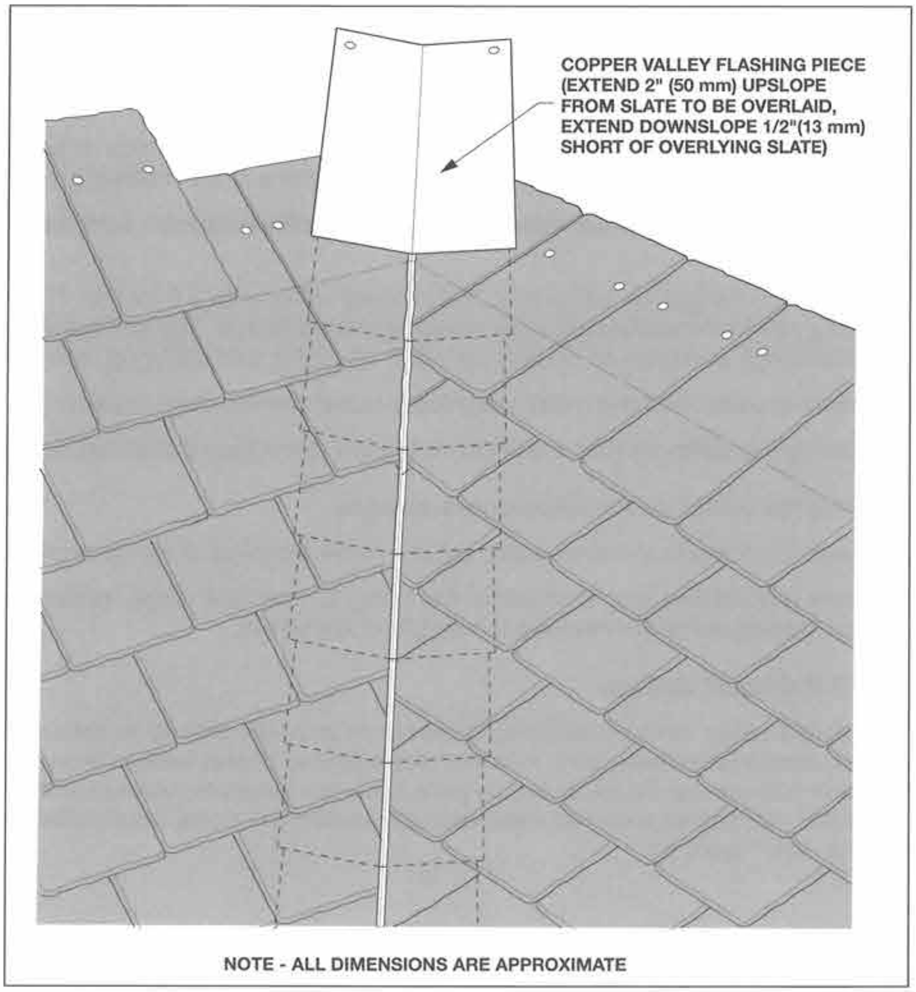


Figure 11: Example of a closed mitered valley using interwoven pieces of valley

Closed valleys for slate may also be formed by installing the slate tight to the valley line and placing individual pieces of metal flashing under each course of slate along the valley centerline. See Figure 12.



NOTE - ALL DIMENSIONS ARE APPROXIMATE

Figure 12: Example of a closed mitered valley

3.7.3.3 Rounded Valleys (Closed)

To form a rounded valley, field slates are taper-cut and fanned or swept through the valley and slates are used to create the valley surface. Individual metal valley flashings are installed with each course of slate.

Note: Rounded valleys are the least common of the three slate valley types. Of the three common slate valley types, closed rounded valleys are the most labor-intensive and intricate to construct.

3.7.4 Vertical Surfaces

There are four types of metal flashings that are commonly used at locations where a roof intersects a vertical wall:

- apron flashing — a metal used at a head-wall transition, such as the downslope side of chimney.
- step flashing — used at a side-wall transition, such as the side of a dormer.
- cricket or backer flashing — used at the upslope side of a roof penetration, such as a chimney.
- counterflashing — secured to a vertical wall and used to cover and protect the top edge of an apron, step, and cricket or backer flashing.

Figure 13 shows a chimney penetration and the use of all four flashing types.

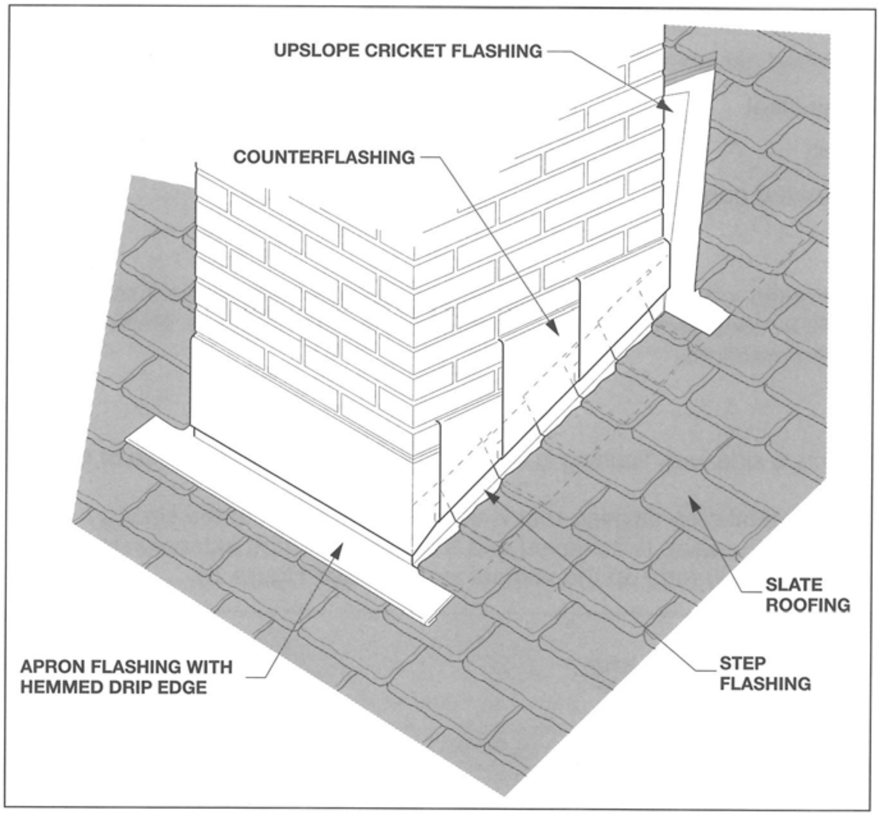


Figure 13: Example of a basic sheet-metal flashing components used at chimneys

Generally, before flashings are applied, an asphalt-saturated felt underlayment should be applied to a roof deck around roof penetrations. However, in moderate and severe climates, an ice dam protection membrane can be installed around the bases of chimneys or curbs. If appropriately specified and constructed, an ice dam protection membrane can assist in keeping water from migrating into a roof system at roof-to-wall intersections during times of severe winter freeze-thaw cycling.

3.7.4.1 Apron Flashings

Apron flashings provide a weatherproofing transition Material where a roof area intersects a head wall. Common locations for apron flashings are the front, downslope, side of a dormer or chimney; curbed roof penetrations; and clerestory transitions. See Figure 14.

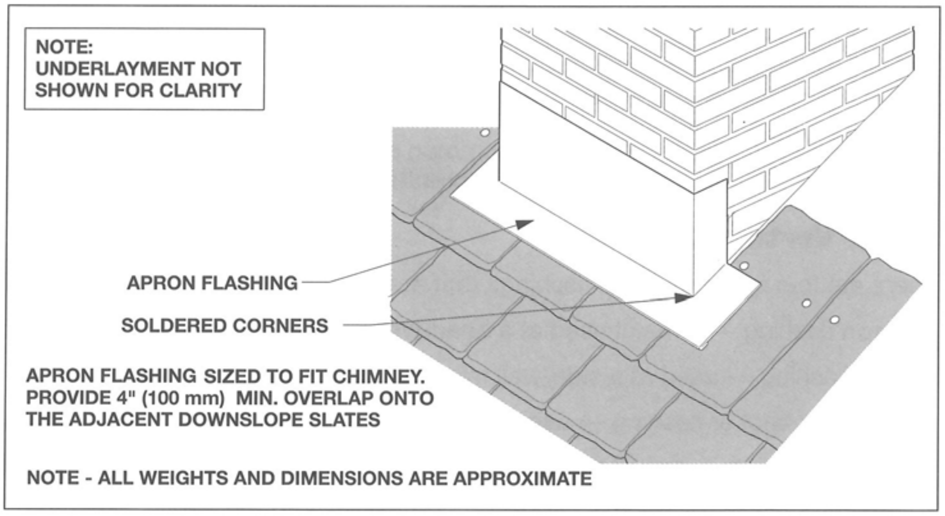


Figure 14: Example of an apron flashing at a masonry chimney

The type and minimum thickness of the metal used for apron flashing should be commensurate with the anticipated service life for the slate roof system. NRCA suggests metal apron flashings for slate roof systems be fabricated from one of the following metal types and minimum thicknesses.

- 24 gauge (0.025 inch [0.64 mm] thick) prefinished galvanized steel
- 24 gauge (0.24 inch [0.61 mm] thick) stainless steel
- 16 ounce (0.022 inch [0.56 mm] thick) copper
- 16 ounce (0.026 inch [0.66 mm] thick) lead-coated copper
- 4 pound (0.062 inch [1.57 mm] thick) lead.

In some regions, particularly those with mild climates, other types of metal and/or metals of lesser thickness than are shown above may be used successfully. NRCA considers these applications to be area practices. Refer to the Introduction for additional information about area practices.

3.7.4.2 Step Flashings

For slate roof systems, when a roof area intersects a side wall, flashing is installed at the end of each course of slate.

For most climatic regions, NRCA suggests using metal step flashing that is equal to the length of the slate by 8 inches (200 mm) wide so a minimum step flashing headlap is achieved and a 4 inch (100 mm) extension is obtained onto each underlying shingle and 4 inches (100 mm) up the vertical surface. See Figure 15.

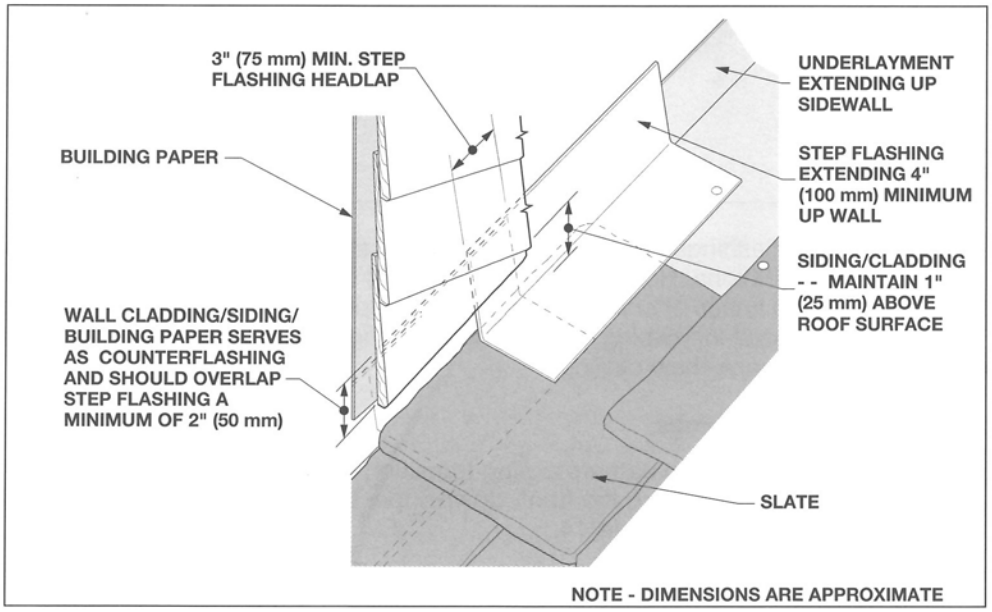


Figure 15: Step flashing at the intersection of a sloping roof and vertical wall

The type and minimum thickness of the metal used for step flashing should be commensurate with the anticipated service life for the slate roof system. NRCA suggests metal step flashing for slate roof systems be fabricated from one of the following metal types and minimum thicknesses.

- 24 gauge (0.025 inch [0.64 mm] thick) prefinished galvanized steel
- 24 gauge (0.024 inch [0.61 mm] thick) stainless steel
- 16 ounce (0.022 inch [0.56 mm] thick) copper
- 16 ounce (0.026 inch [0.66 mm] thick) lead-coated copper
- 4 pound (0.062 inch [1.57 mm] thick) lead.

In some regions, particularly those with mild climates, other types of metal and/or metals of lesser thickness than are shown above may be used successfully. NRCA considers these applications to be area practices. Refer to the Introduction for additional information about area practices.

The length of step flashing is generally the length of slate.

Special attention needs to be paid at the first (bottom) step flashing where an eave intersects a continuous vertical surface to ensure water is diverted to the outside of the wall covering. See Figures 16 and 17.

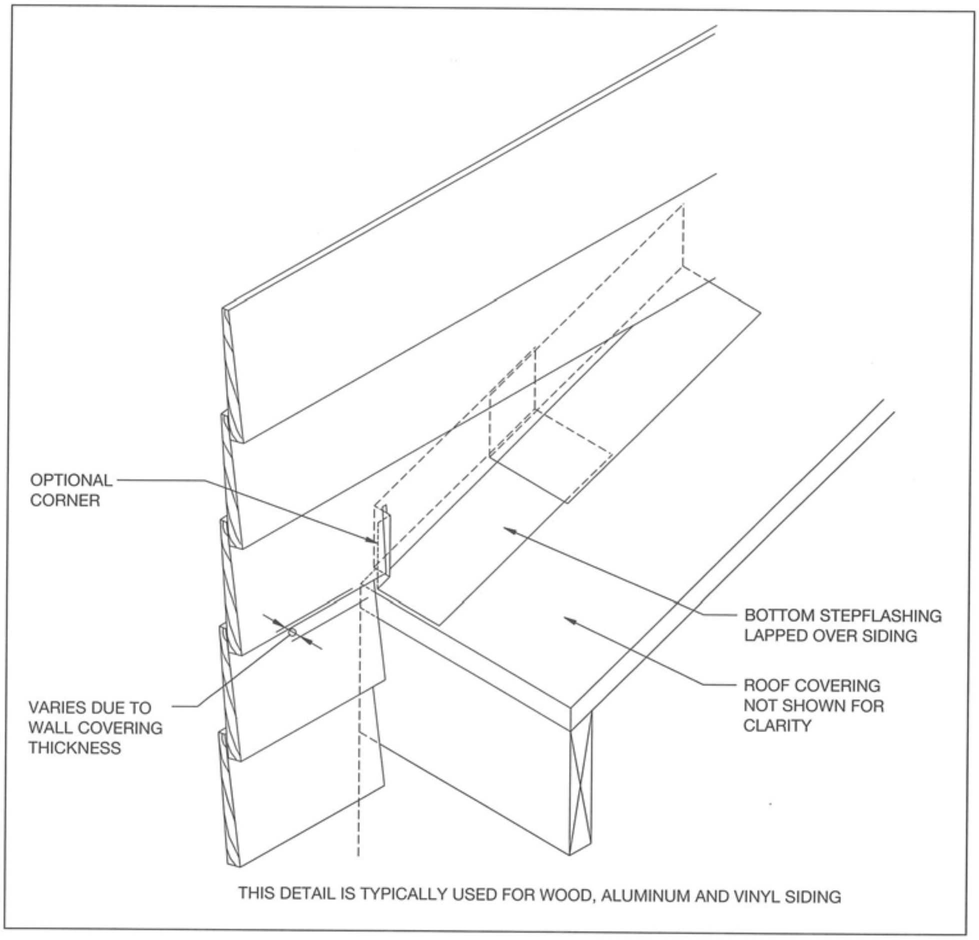
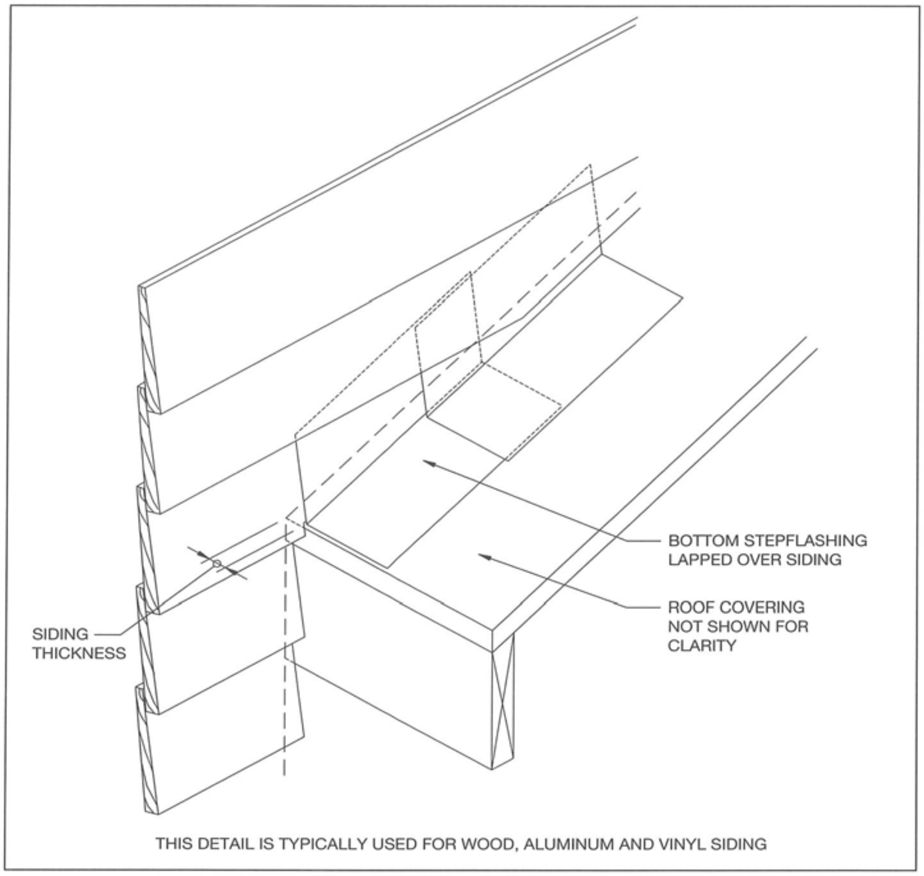


Figure 16: Example of soldered one-piece flashing at an eave-to-wall interface

Figure 17: Example of a step flashing at an eave-to-wall interface



3.7.4.3 Cricket or Backer Flashings

When a roof area intersects the upslope side of a chimney or curbed roof penetration, either a cricket or backer flashing should be installed at this location. A cricket diverts water around the penetration, and a backer flashing simply provides a weatherproofing transition material where the roof intersects the back side of the penetration.

NRCA recommends that designers specify crickets at the upslope sides of chimneys or curbed roof penetrations when:

- large volume of water, snow, ice or debris is expected.
- the chimney or curb is more than 24 inches (610 mm) wide.
- the roof slope is 6:12 (27 degrees) or greater.
- the average January temperature is 30° F (-1° C) or lower and significant accumulations of snow and ice are anticipated on the upslope side of the chimney or curb.

The type and minimum thickness of the metal used for cricket or backer flashings should be commensurate with the anticipated service life for the slate roof system. NRCA suggests metal cricket and backer flashings for slate roof systems be fabricated from one of the following metal types and minimum thicknesses.

- 24 gauge (0.025 inch [0.64 mm] thick) prefinished galvanized steel
- 24 gauge (0.024 inch [0.61 mm] thick) stainless steel
- 16 ounce (0.022 inch [0.56 mm] thick) copper
- 16 ounce (0.026 inch [0.66 mm] thick) lead-coated copper
- 4 pound (0.062 inch [1.57 mm] thick) lead.

In some regions, particularly those with mild climates, other types of metal and/or metals of lesser thickness than are shown above may be used successfully. NRCA considers these applications to be area practices. Refer to the Introduction for additional information about area practices.

In some instances, the roof deck at the upslope side of a chimney forms a cricket. When this condition occurs, it is generally treated in the same way as a dormer where similar valley and ridge detailing conditions occur, and slates are used to cover the main surface area of the cricket. Figures 18, 19 and 20 illustrate examples of crickets used behind chimneys.

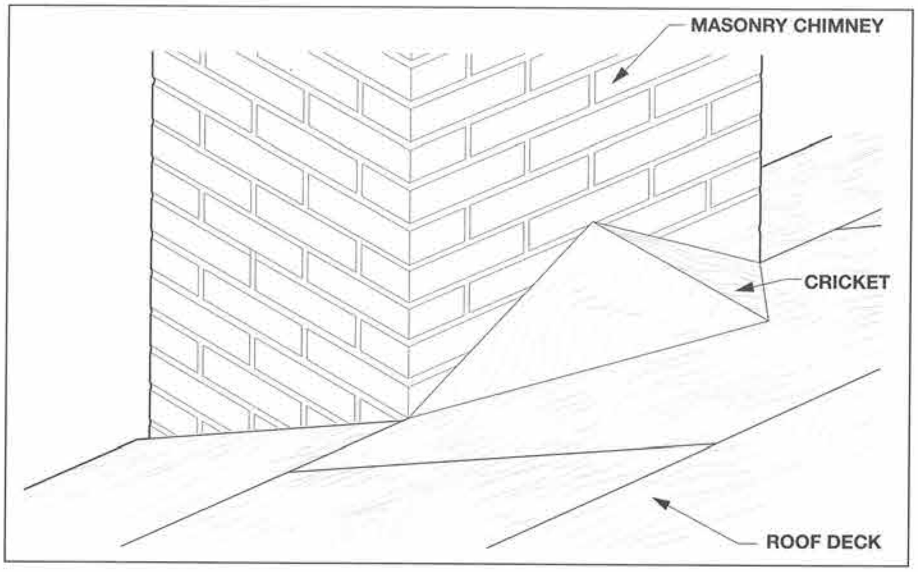


Figure 18: Example of a wood cricket built on the upslope side of a chimney

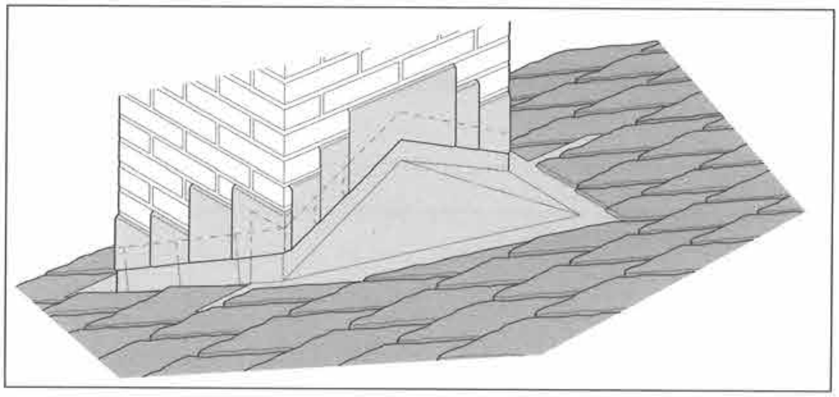


Figure 19: Example of a cricket flashing for the upslope portion of a masonry chimney

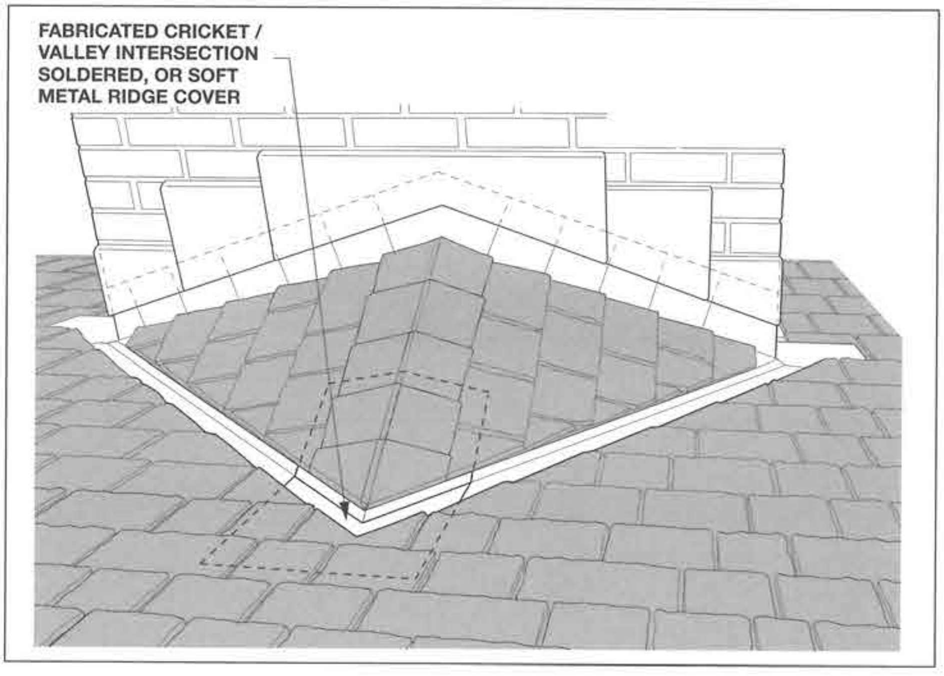


Figure 20: Example of a wood cricket roofed-in with slates

Generally, before any valley metal (when used) is applied, an asphalt-saturated felt underlayment should be applied to a roof deck around a chimney. However, in moderate and severe climates, before the underlayment is applied, an ice dam protection membrane should be installed around the base of a chimney. If appropriately specified and constructed, an ice dam protection membrane can assist in keeping water from migrating into a roof system at the intersection with the chimney during times of severe winter freeze-thaw cycling.

3.7.4.4 Counterflashings

Apron, step, cricket and backer flashings require some form of counterflashing to cover and protect the top edge of these flashings from water intrusion. In many instances, the wall covering or cladding material performs the counterflashing function. Where this does not occur, a metal counterflashing mounted to the vertical wall should be installed along the top edge of the flashing metal. See Figures 21, 22 and 23.

Figure 21: Example of a through-wall metal counterflashing embedded in masonry

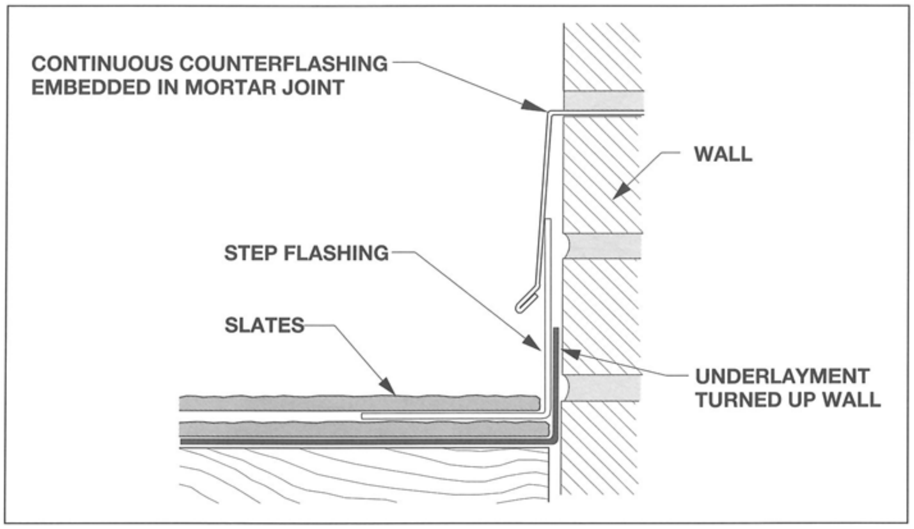
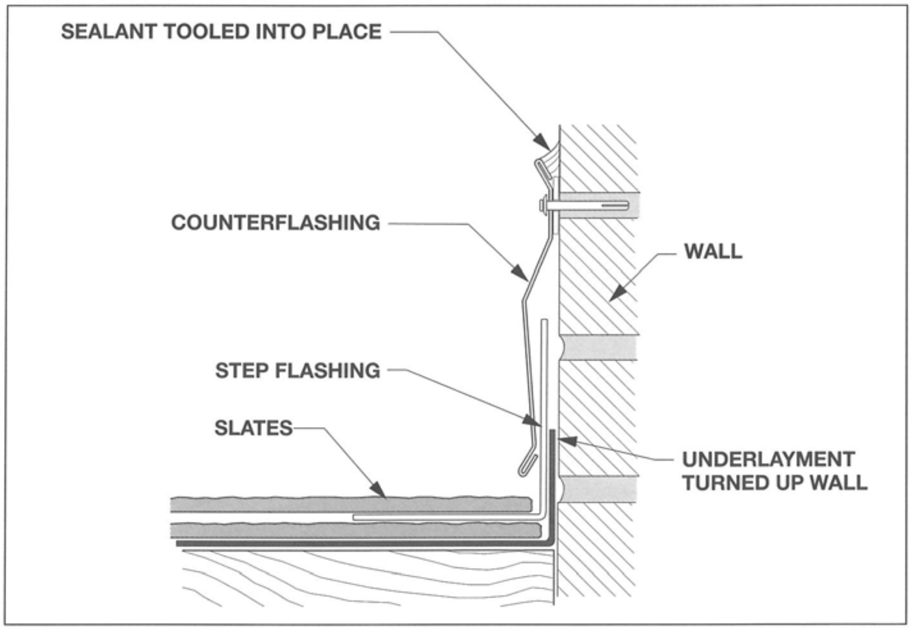


Figure 22: Example of a surface-mounted metal counterflashing attached to masonry



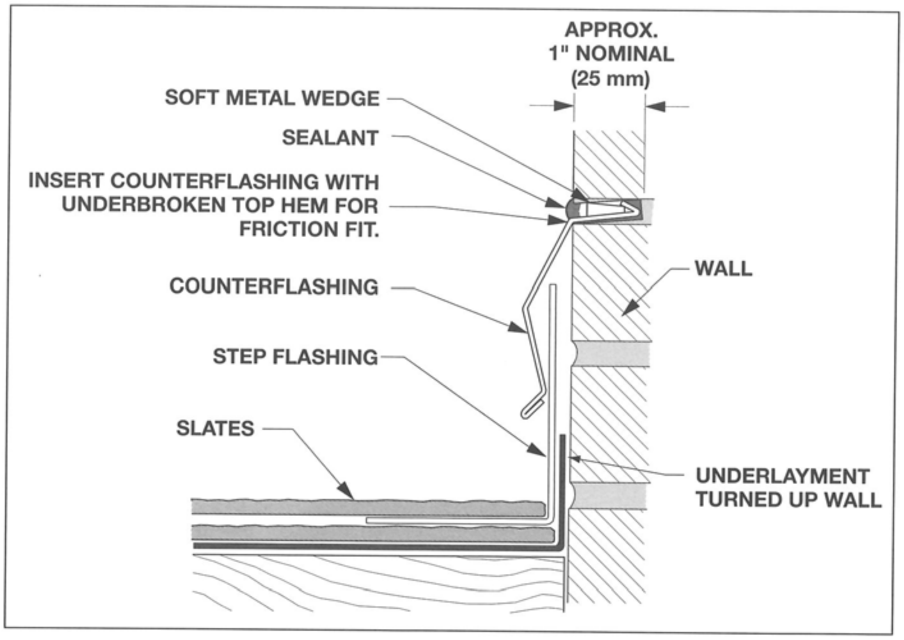


Figure 23: Example of a metal counterflashing inset in masonry mortar joint

The type and minimum thickness of the metal used for counterflashings should be commensurate with the anticipated service life for the slate roof system. NRCA suggests metal counter flashings for slate roof systems be fabricated from one of the following metal types and minimum thicknesses.

- 24 gauge (0.025 inch [0.64 mm] thick) prefinished galvanized steel
- 24 gauge (0.024 inch [0.61 mm] thick) stainless steel
- 16 ounce (0.022 inch [0.56 mm] thick) copper
- 16 ounce (0.026 inch [0.66 mm] thick) lead-coated copper

In some regions, particularly those with mild climates, other types of metal and/or metals of lesser thickness than are shown above may be used successfully. NRCA considers these applications to be area practices. Refer to the Introduction for additional information about area practices.

Where the wall cladding counterflashes the wall flashing metal (e.g., step flashing), NRCA recommends that the cladding material and underlayment extend past and cover the top edge of the flashing metal a minimum of 2 inches (50 mm).

3.8 Ridges

There are a variety of standard methods with regional variations that can be used to finish the ridge of a slate roof. Two common materials used to finish the ridges on slate roofs are slate and metal.

3.8.1 Slate Ridge

Common methods of finishing a ridge with slate are:

- Slate saddle ridge
- Strip saddle ridge
- Combing slate ridge
- Metal ridge

In all slate ridge applications, the ridge slate can be set in sealant or asphalt roof cement and a secondary method of sealing the joint at the apex of the ridge slate is needed.

3.8.1.1 Slate Saddle Ridge

With a slate saddle ridge, wood nailers are installed at the peak of the roof along the ridge. The first nailer is installed at the thicknesses of the slate to accommodate the last field slate, and the second nailer is installed at about twice the thickness of the slate to accommodate the ridge slate. The field slates are installed up the roof to the ridge nailers on both sides of the roof. A soft metal or membrane ridge flashing may be installed over the ridge nailer, and, then, ridge slate is installed perpendicular to the field slate on each side of the ridge. As the ridge slate is run across the ridge and nailed, they overlap and cover the nails. See Figure 24.

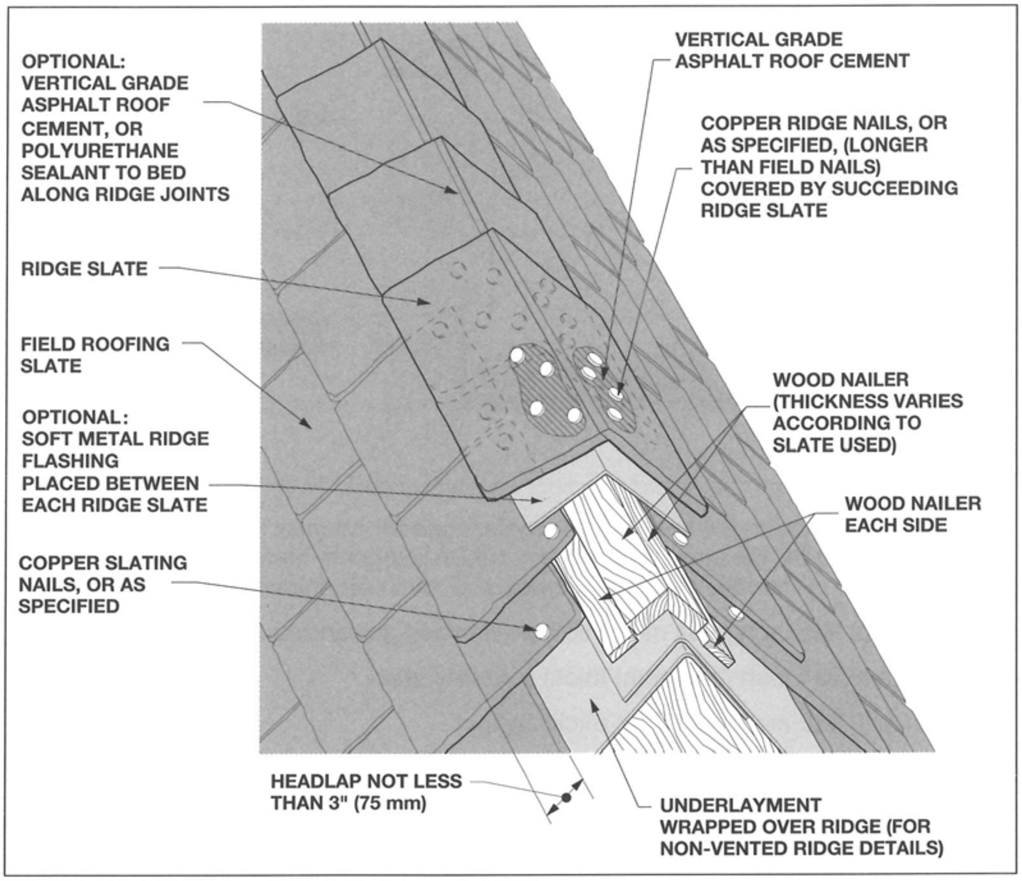


Figure 24: Example of a slate saddle ridge

3.8.1.2 Strip Saddle Ridge

The strip saddle ridge is a variation of the slate saddle ridge. It is installed in the same manner as the slate saddle ridge except the ridge slates do not overlap. Instead they butt against each other. See Figure 25.

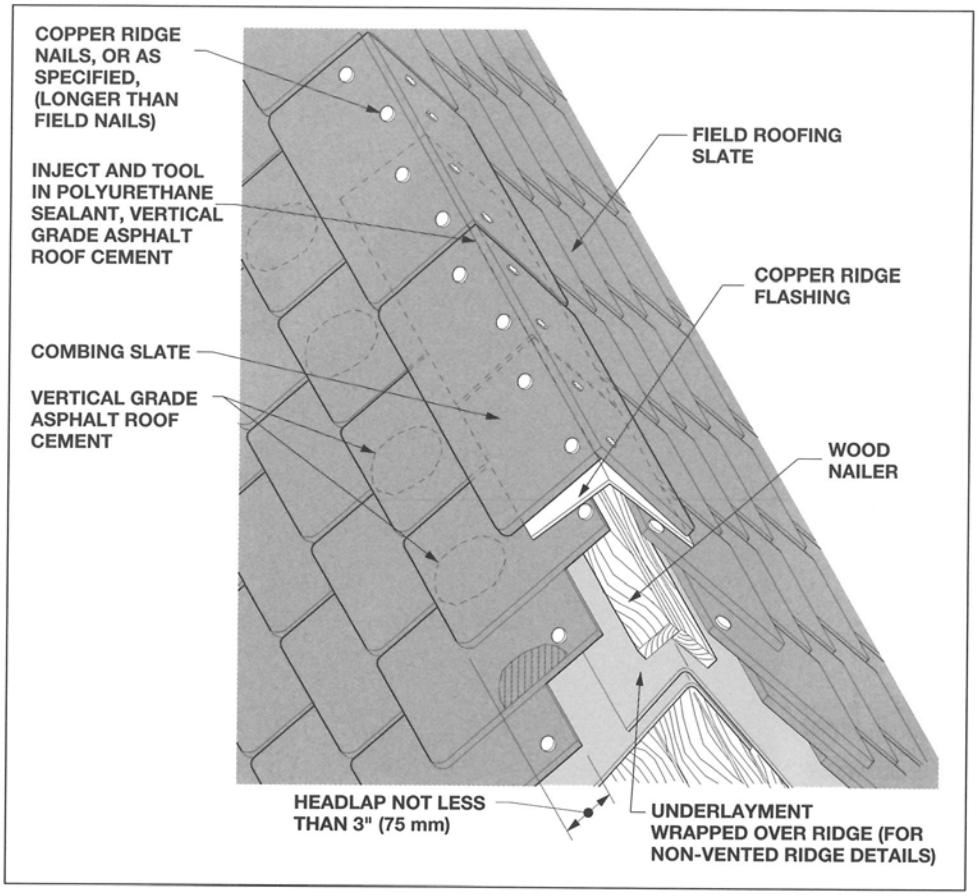


Figure 25: Example of a strip saddle ridge

3.8.1.3 Combing Slate Ridge

With the combing slate ridge, a nailer about the thickness of the slate is installed at the ridge to accommodate the field slate that is run up the roof to the ridge on both sides of the roof. The ridge slate is installed in same manner as the strip saddle ridge except the ridge slate facing the prevailing weather side is extended beyond the ridge line. See Figure 26.

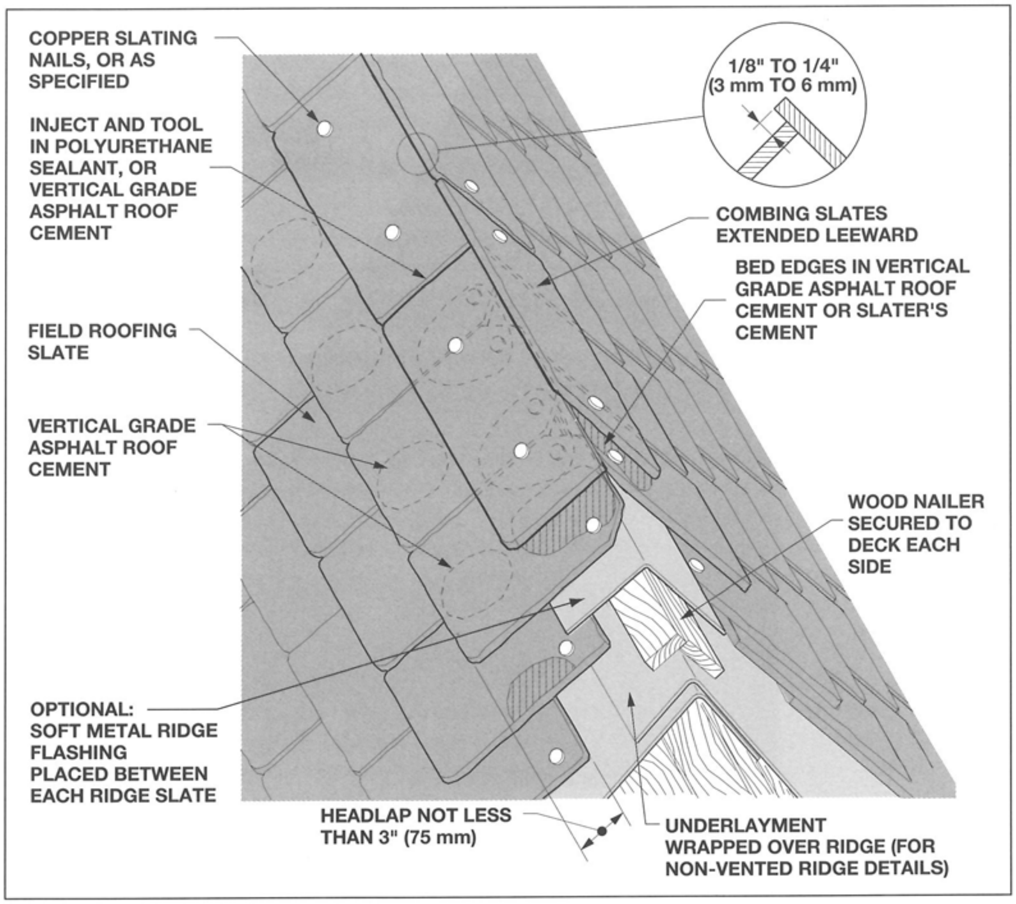


Figure 26: Example of a combing ridge

3.8.2 Metal Ridge

With a metal ridge, the nailers and field slate are run up to the ridge in the same manner as the slate saddle ridge. The metal ridge is fabricated to extend down over the field slate on both sides of the ridge. There are many variations of the profile of metal ridges. See Figure 27.

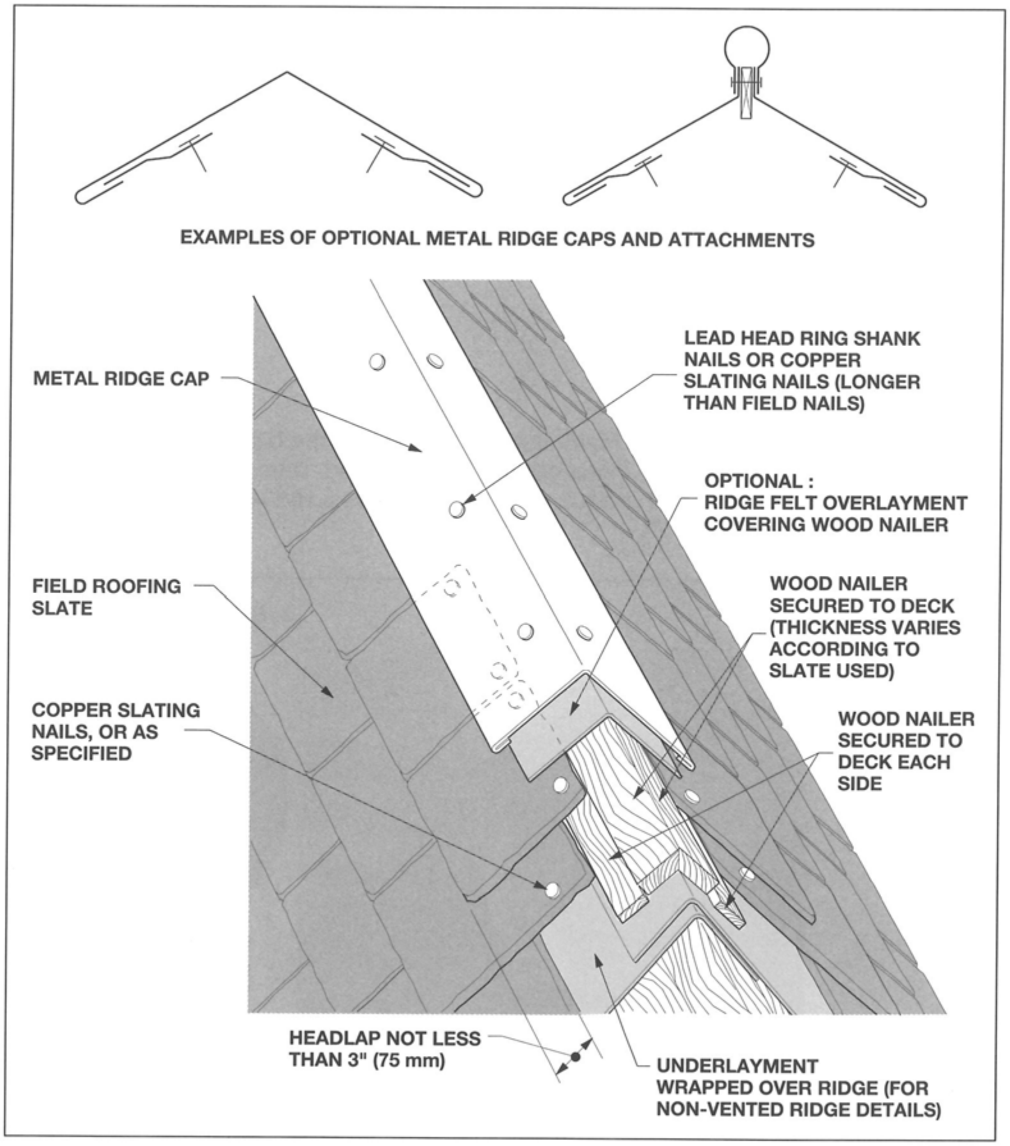


Figure 27: Example of a metal saddle ridge

The type and minimum thickness of the metal used for metal ridges should be commensurate with the anticipated service life for the slate roof system. NRCA suggests metal metal ridges for slate roof systems be fabricated from one of the following metal types and minimum thicknesses.

- 24 gauge (0.025 inch [0.64 mm] thick) prefinished galvanized steel
- 24 gauge (0.024 inch [0.61 mm] thick) stainless steel
- 16 ounce (0.022 inch [0.56 mm] thick) copper
- 16 ounce (0.026 inch [0.66 mm] thick) lead-coated copper

In some regions, particularly those with mild climates, other types of metal and/or metals of lesser thickness than are shown above may be used successfully. NRCA considers these applications to be area practices. Refer to the Introduction for additional information about area practices.

There are additional methods to seal the ridge of the slate roof by using various profiles of tile. These tiles are typically set in a bed or mortar to seal and bond the tile ridge cap.

3.9 Hips

There are a variety of standard methods with regional variations that can be used to finish the hip of a slate roof system. Two common materials used to finish the hips on slate roofs are slate and metal.

3.9.1. Slate Hip

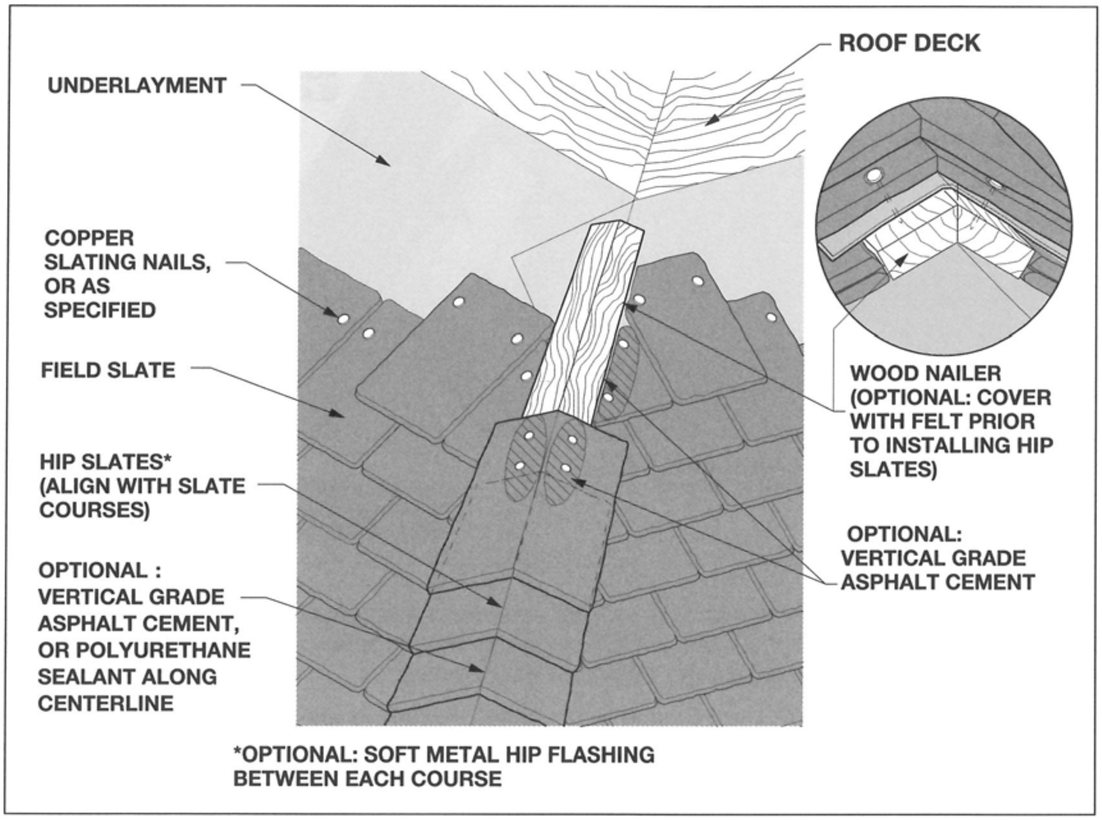
Common methods of finishing a hip with slate are:

- saddle hip
- mitered hip
- fantail hip

3.9.1.1 Saddle Hip

With a slate saddle hip, wood nailers are installed along the hip. Field slate is installed to the hip nailers on both sides of the hip. A soft metal or membrane hip flashing may be installed over the hip, and, then, the hip slate is installed parallel to the hip on each side of the hip. The hip slate are run up the hip and secured with nails. They overlap the proceeding hip slate and cover the nails. See Figure 28.

Figure 28: Example of a saddle hip



3.9.1.2 Mitered Hip

With a mitered hip, field slate is installed to the hip line and fit together. Hip slate is the same slate as the field slate and is in the same plane as the field slate. Wider slates are often used at the hip. The joint at the hip is sealed with a metal or membrane installed course for course with the hip slate or with a sealant. See Figure 29.

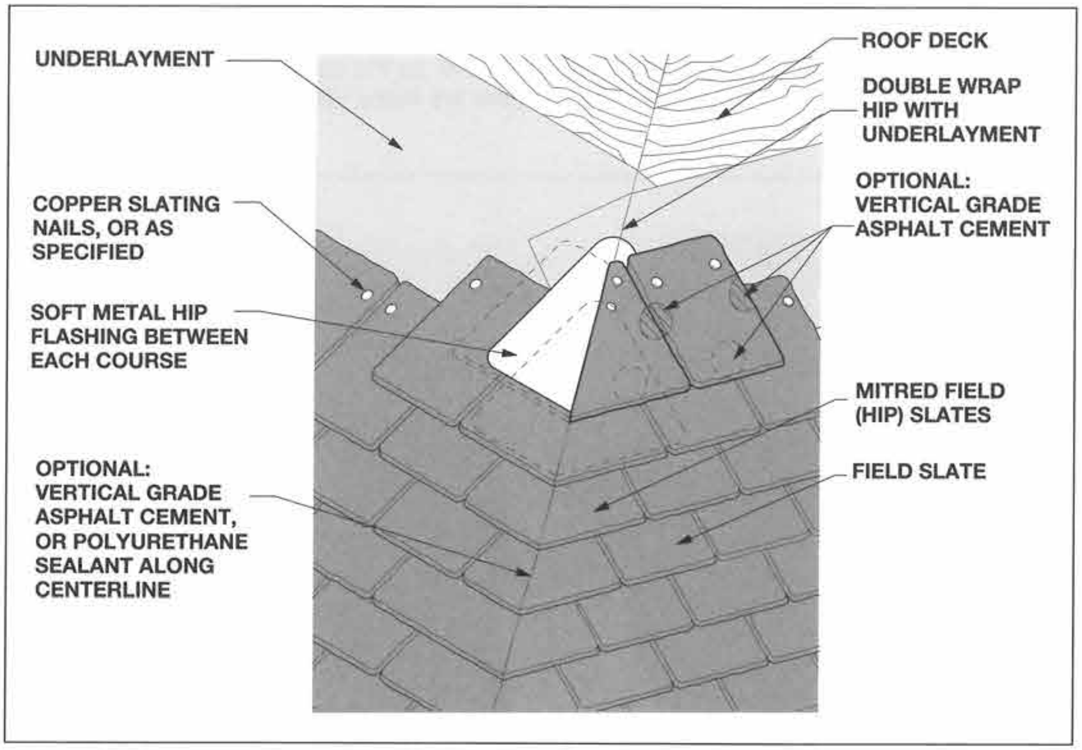


Figure 29: Example of a mitered hip

3.9.1.3 Fantail Hip

A fantail hip is a variation of the mitered hip. The mitered corner at the butt is cut or rounded to direct the water away from the hip joint and reduce breakage of the corner point. See Figure 30.

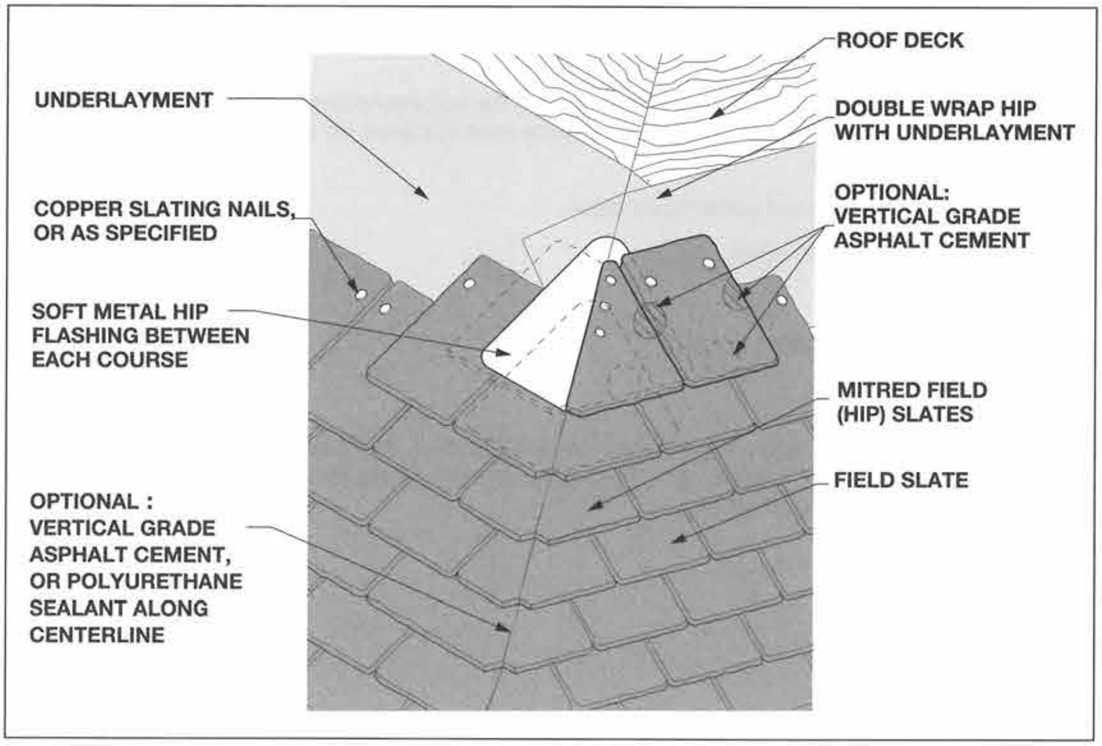


Figure 30: Example of a fantail hip

3.9.2 Metal Hip

With a metal hip, nailers and field slate are run up to the hip in the same manner as the saddle hip. The metal hip is fabricated to extend down over the field slate on both sides of the hip. There are many variations of the profile of metal hips. See Figure 31.

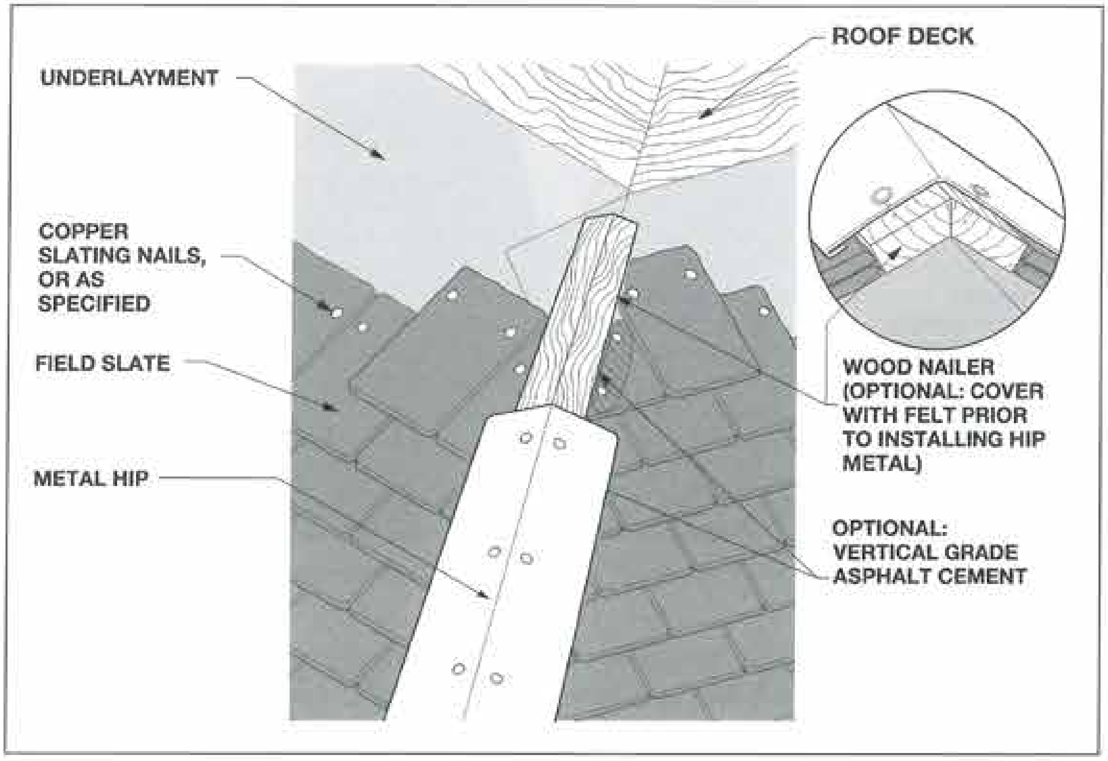
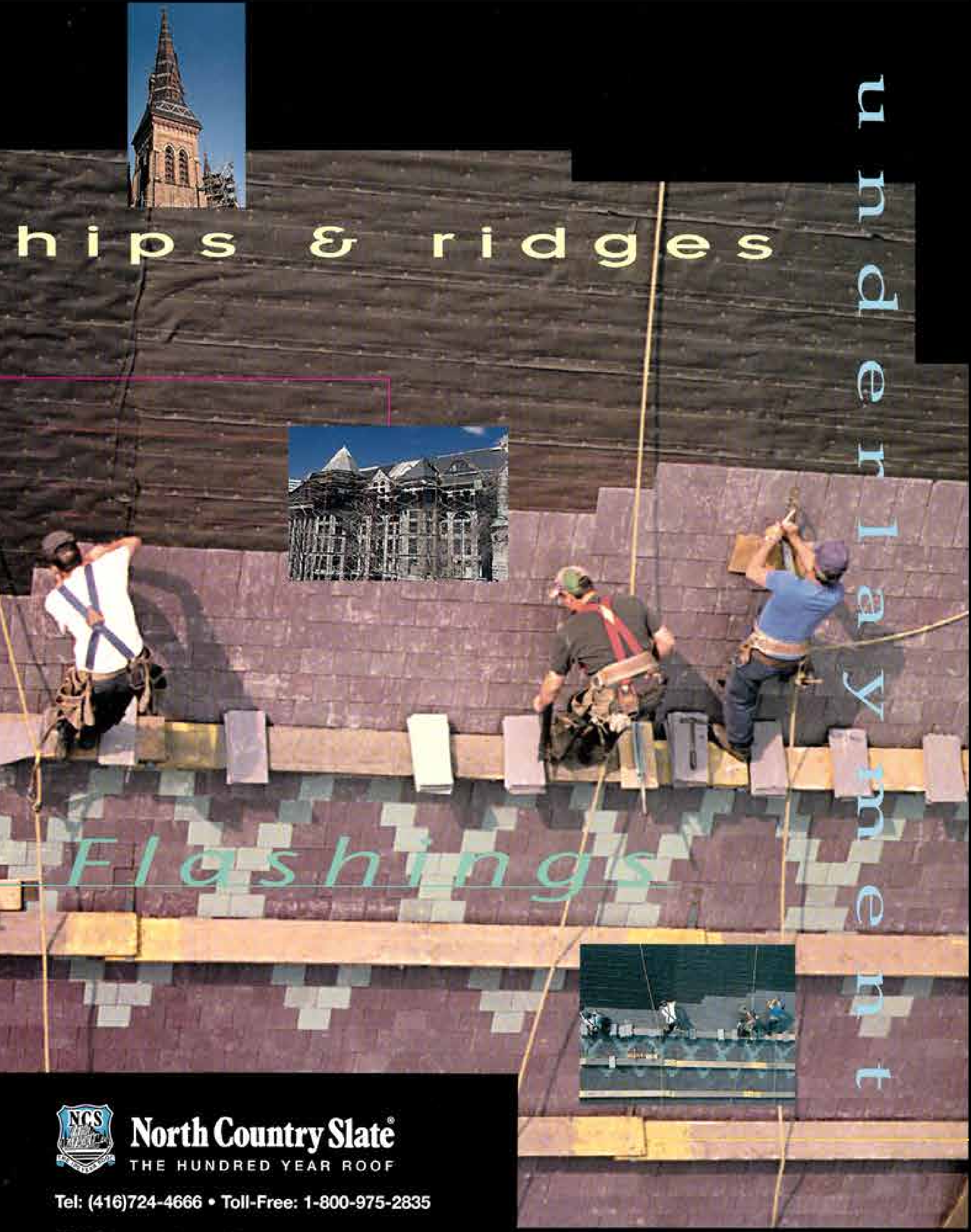


Figure 31: Example of a metal hip

The type and minimum thickness of the metal used for metal hips should be commensurate with the anticipated service life for the slate roof system. NRCA suggests metal hips for slate roof systems be fabricated from one of the following metal types and minimum thicknesses.

- 24 gauge (0.025 inch [0.64 mm] thick) prefinished galvanized steel
- 24 gauge (0.024 inch [0.61 mm] thick) stainless steel
- 16 ounce (0.022 inch [0.56 mm] thick) copper
- 16 ounce (0.026 inch [0.66 mm] thick) lead-coated copper
- 4 pounds (0.062 inch [1.51 mm] thick) lead

In some regions, particularly those with mild climates, other types of metal and/or metals of lesser thickness than are shown above may be used successfully. NRCA considers these applications to be area practices. Refer to the Introduction for additional information about area practices.



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