BC CARPENTER APPRENTICESHIP PROGRAM

LEVEL 2

2018 (Harmonized)

Line I: Finishing Materials

Competency I-1: Describe Roofing Materials

Version 2, New, November 2017

ISBN 978-0-7726-7150-9

Permissions

I1 LT1 Figures 7 and 14 licensed from Thinkstock
I1 LT1 Figure 15 from Certainteed; copyright pending
Every effort has been made to secure copyright permission for the images used in this document.

Acknowledgments

The Industry Training Authority of British Columbia would like to acknowledge the Carpentry Articulation Committee and Open School BC, a division of the BC Ministry of Education, as well as the following individuals and organizations for their contributions in updating the BC Carpenter Apprenticeship Learning Guides:

Carpentry Articulation Curriculum Committee members
Dennis Carlson, Tom Haag, Erik Hardin, Alf Leimert, Geoff Murray, Don Naidesh, Stephen Pelley, Al van Akker
Writers: Gary Backlund, Gary Henderson
Reviewers: Trevor Feddersen, Roy Mironuck, Geoff Murray, Don Naidesh, Stephen Pelley

Open School BC
Christina Teskey, project management
Dennis Evans, photography, illustration
Sharon Barker, print layout
Beverly Hooks, print layout
Shannon Sangster, copyright management, art coordination
Max Licht, illustration
Greg Aleknevicus, editing
Keith Learmonth, editing

Ordering

Crown Publications, Queen's Printer
PO Box 9452 Stn Prov Govt
Victoria, BC V8W 9V7

Phone: 1 800 663-6105
Fax: 250 387-1120
Email: crownpub@gov.bc.ca
Web: www.crownpub.bc.ca

Contents

Disclaimer

The materials in these Learning Guides are for use by students and instructional staff, and have been compiled from sources believed to be reliable and to represent best current opinions on these subjects. These manuals are intended to serve as a starting point for good practices and may not specify all minimum legal standards. No warranty, guarantee or representation is made by the Carpentry Articulation Committee, the British Columbia Industry Training Authority or the Queen's Printer of British Columbia as to the accuracy or sufficiency of the information contained in these publications. These manuals are intended to provide basic guidelines for carpentry practices. Do not assume, therefore, that all necessary warnings and safety precautionary measures are contained in this Competency and that other or additional measures may not be required.

These materials contain information that has been derived from information originally made available by the Province of British Columbia at: http://www.bclaws.ca/, and this information is being used in accordance with the Queen's Printer License – British Columbia available at: http://www.bclaws.ca/standards/2014/QP-License_1.0.html. They have not, however, been produced in affiliation with, or with the endorsement of, the Province of British Columbia, and THESE MATERIALS ARE NOT AN OFFICIAL VERSION.

Safety Advisory

Please note that it is always the responsibility of any person using these materials to inform him or herself about the Occupational Health and Safety Regulation pertaining to his or her work. The references to WorkSafeBC safety regulations contained within these materials may not reflect the most recent Occupational Health and Safety Regulation (the current standards and regulation in BC can be obtained on the following website: http://www.worksafebc.com).

Symbol Legend

Electric shock: This icon is a reminder for potential electric shock.

Explosive: This icon is a reminder for a possibly explosive situation.

Flammable: This icon is a reminder for a potentially flammable situation.

Important: This icon highlights important information.

Poisonous: This icon is a reminder for a potentially toxic/poisonous situation.

Resources: The resource icon highlights any required or optional resources.

Safety gear: The safety gear icon is an important reminder to use protective equipment.

Self-Test: This icon reminds you to complete a self-test.

We want your feedback! Please go to the BC Trades Modules website (www.bctradesmodules.gov.bc.ca) to enter comments about specific sections that require correction or modification. All submissions will be reviewed and considered for inclusion in the next revision.

Program Outline

Line B – Documentation and Organizational Skills
B-1 Use Construction Drawings and Specifications
B-2 Interpret Building Codes and Bylaws

Line C – Tools and Equipment
C-2 Use Portable Power Tools
C-3 Use Stationary Power Tools
C-4 Use Oxy-Fuel Equipment

Line D – Survey Instruments and Equipment
D-2 Use Site-Layout Equipment

Line F – Site Layout
F-1 Lay Out Building Locations

Line G – Concrete Formwork
G-4 Build Slab-On-Grade Forms and Suspended Slab Forms
G-7 Place and Finish Concrete

Line H – Wood Frame Construction
H-2 Select Framing Materials
H-4 Build Wall Systems
H-5 Build Stair Systems
H-6 Build Roof Systems

Line I – Finishing Materials
I-1 Describe Roofing Materials
I-2 Install Doors and Hardware
I-3 Install Windows and Hardware
I-4 Install Exterior Finishes

Line J – Building Science
J-1 Control the Forces Acting on a Building
J-2 Control Heat and Sound Transmission
J-3 Control Air and Moisture Movement in Buildings

Competency I-1: Describe Roofing Materials

Carpenters install roofing materials as part of house construction and residential renovations. The roofing materials must be suitable for the slope and design of the building. Selecting the appropriate roofing material for a specific roof requires the carpenter to have a thorough knowledge of roofing materials and accessories.

The roof must provide a weathertight cover for the building. This Competency describes the procedures used for applying roofing materials for residential and commercial buildings.

Learning Objectives

When you have completed the Learning Tasks in this Competency, you will be able to:

- identify types of roof coverings
- identify types of flashing, roof vents and accessories
- describe the preparation of the roof surface
- describe the installation of flashing and roofing accessories
- describe the application of roofing materials
- calculate roofing material quantities

Competencies

Written: “Describe Roofing Materials”

- You will be tested on your knowledge of roofing materials, flashing, roof vents and roofing accessories.
- You will be tested on your ability to calculate quantities of roofing materials.

LEARNING TASK 1

Describe Roofing Materials

The *BC Building Code* states the following: Roofs shall be protected with roofing, including flashing, installed to shed rain effectively and prevent water due to ice damming from entering the roof."

The Code states that "roofs shall include platforms that effectively serve as roofs with respect to the accumulation or drainage of precipitation." Platforms include decks, balconies, exterior walkways and similar exterior surfaces that serve as roofs where the platforms do not allow free drainage through spaced deck boards. Because the *Building Code* definition of a platform includes decks, then even decks over open areas need to be treated as roofs.

In addition to needing to be able to shed water, roofing also needs to be able to stand up to high winds, UV degradation from sunlight, thermal shock, damage from hail, intense heat and being walked upon. Some roofing must also be able to resist moss and algae growth.

As roofing has a lifespan as short as 20 years, disposal and recycling are also becoming a consideration when choosing a roofing product.

Roofing is normally installed in large sheets or in shingle form. *Shingles* are defined as small, thin, partially overlapping layers of roofing. Shingle types include asphalt, wood, metal, slate and tile.

The most common types of roofing are asphalt shingles, wood shakes and wood shingles, built-up (torch-on membrane), metal sheets and metal shingles. Other roofing types include clay tile, concrete tile, slate, tar and gravel, selvage (roll roofing), glass-reinforced polyester panels, rubberized asphalt and polyvinyl chloride sheet roofing.

Slope

The slope of the roof is the main factor when choosing roofing materials. Roof slopes are described as rise:run.

- Flat roofs normally have a small amount of slope, from 1/2:12 up to 2:12.
- Low-slope roofs range from 2:12 up to 4:12.
- Conventional-slope roofs range from 4:12 to 9:12.
- Steep-sloped roofs are those steeper than 9:12.

Asphalt shingle and wood roofing materials are suitable for steep and conventional sloped roofs. Torch-on roofing can be used on all roof slopes. Metal roofing can be used on 3:12 and steeper roofs. Slate, clay tile and concrete tile are generally restricted to roof slopes of 6:12 and steeper.

Fire Rating Classes

The *BC Building Code*, Fire Code, municipal bylaws and insurance companies may require certain fire rating classes for some roofs.

Class A – This is the most fire-resistant class and should be used in areas prone to wildfires. It includes some fibreglass asphalt shingle types, metal, clay and concrete roofing. Treated wood shakes can have a Class A rating if installed over a fire-barrier material.

Class B – Includes fire-retardant treated wood shakes that are not installed over a fire-barrier material, and some asphalt shingles.

Class C – This is the least fire-resistant type of roofing and includes some asphalt shingles that have an organic felt base, and non-treated wood shakes and shingles. It must be able to withstand very light exposure to fire sources.

Asphalt Shingles

Asphalt shingles are one of the most common residential roofing materials used in North America due to their low cost and long life expectancy. Available in many sizes, types and finishes, they can be installed as a low-slope application for slopes as low as 2:12, and a normal application for slopes 4:12 and steeper. Sometimes known as *square butt*, the two common styles of asphalt shingles are *three-tab* and *laminated*.

Typically asphalt shingles are made 1 m (39") long and are installed with an exposure of approximately 140 mm (5½"). Each course is glued to the previous course with a factory-applied strip of asphalt adhesive. The heat of the sun activates the adhesive.

Three-tab Shingles

Three-tab square butt shingle (Figure 1) roofs were common for many years. They gave a traditional asphalt shingle look.

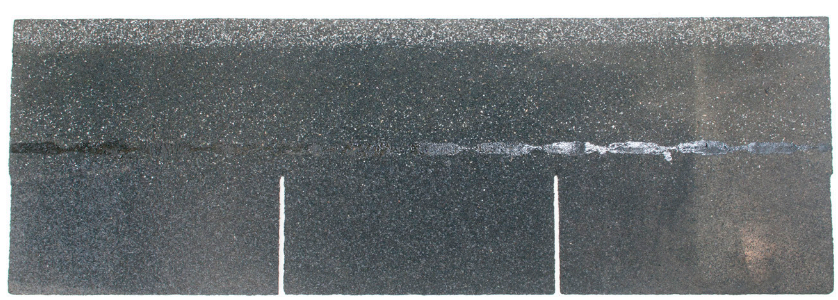

Figure 1—Three-tab asphalt shingle

Three-tab shingles have lost popularity compared to laminated shingles, but they are still commonly used for ridge caps and starter strips.

Laminated Shingles

Today, most asphalt shingles are made with multiple laminations (Figure 2). These shingles give a rough appearance that looks similar to a cedar shingle roof. Laminated shingles are also known as *architectural shingles*.

Figure 2—Partial bundle of laminated asphalt shingles

Both types of asphalt shingle use a base mat material. This can be organic or fibreglass. Asphalt is applied to one or both sides to saturate the mat. The surface is then covered with a mineral or ceramic material to block UV, provide physical protection and give the shingles colour.

Asphalt shingles are prone to wind damage and need to have adhesive applied at roof edges (gables and eaves). They are also prone to moss growth (Figure 3).

Figure 3—Moss growth on laminated asphalt shingle roof

Three-tab and laminated asphalt shingles come in bundles. A "square" of asphalt shingles consists of three bundles. A square of any roofing materials will cover approximately 9.3 m^2 (100 $ft.^2$).

Asphalt Shingle Warranties

Most asphalt shingles come with a manufacturer's leak and wind warranty, and some are warranted against discolouring and for algae growth resistance. For leaks to be covered by warranty, they must have been caused by defective shingles, not poor workmanship by the roofer. Most warranties are prorated after a period of time, so at 15 years into a 20-year warranty, the coverage may only pay for 25% of the original purchase cost. Many companies will only warranty the product if it is installed by a roofer certified by the roofing manufacturer. For some warranties, the roof will have to be inspected by the manufacturer's representative.

Asphalt shingles are often sold as a 20-, 25- or 30-year roof (reflecting the warranty period), although some manufacturers offer a lifetime warranty (until the house is sold). Some manufacturers reduce the warranty period if the shingles are used in a low-slope application or under decking boards.

Wood Roof Coverings

Western red cedar is the most common wood species used for roofing. It is naturally weather resistant. Cedar from the heartwood of first-growth trees produces clear stock that is dark in colour and is relatively free of knots. Sapwood is not resistant to the weather and should not be used for roofing.

Wood roofing was quite common in Canada in the past, as were log homes, but technology has given builders more efficient and effective roofing materials. The popularity of wood roofing has decreased substantially due to its expense and because it performs poorly in fire situations. Also, harvesting old-growth cedar is not considered sustainable.

Wood Shakes and Shingles

Split or sawn, cedar shakes and shingles can last for 20 to over 100 years depending on climate and the quality of the product. Cedar shakes and shingles can be treated with a fire retardant or a preservative. If treated, then the *BC Building Code* requires special fasteners to be used that are compatible with the treatment.

Cedar Shakes

The difference between shakes and shingles is that shingles are sawn on both surfaces while shakes are split on one or both surfaces. Taper-sawn shakes are a special case; they are sawn on both surfaces like a shingle except that they are thicker. Shakes are required to have a butt thickness of between 9 mm and 32 mm (0.354–1.26").

Split shakes generally last longer than shingles because the split surface resists the weather better and allows for a small amount of breathing between layers of shakes.

Wood shakes can be installed on slopes of 3:12 and steeper. Exposure amount (Figure 4) is based on the length of the shingle: 190 mm (7.5") for shakes 450 mm (17.7") long, and 250 mm (9.8") for shakes 600 mm (24") long.

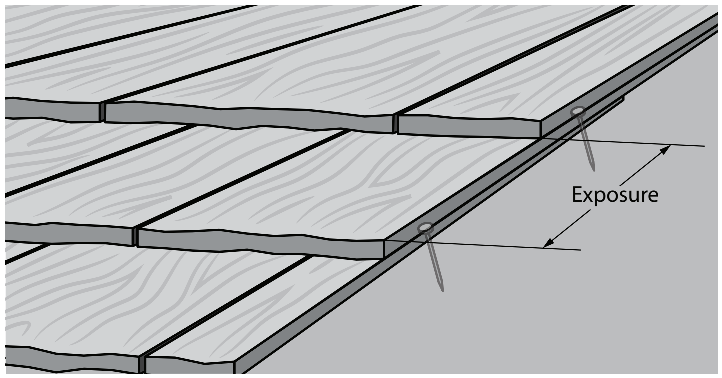

Figure 4—Exposure amount

Cedar Shingles

Wood shingles can be installed on slopes of 3:12 and steeper. Exposure length is based on roof slope, shingle length and shingle grade. Figure 5 shows cedar shingles installed on a roof.

Figure 5—Cedar shingle roofing

Cedar Shingle Grades and Uses

No. 1 shingles are the top grade of shingles that can be used for roofs and sidewalls. These shingles are 100% heartwood, 100% clear and 100% edge-grain. A blue label identifies them.

No. 2 shingles meet the *Building Code* for use as a roofing and sidewall shingle. Due to the flat grain, these shingles tend to warp and twist, giving the roof an unlevel surface. The No. 2 grading requires that the shingles have no knots for the bottom 250 mm on 400-mm-long shingles, 280 mm on 450-mm shingles, and 400 mm on 600-mm shingles. Flat grain and limited sapwood are permitted in this grade. A red label identifies the No. 2 shingles.

No. 3 shingles are only allowed to be used as an under-course for sidewall applications and not for roofing. A black label identifies the No. 3 shingles.

Shakes and shingles are sold by the bundle. Normally four bundles will cover one square (9.3 m^2 / 100 $ft.^2$).

Built-up and Membrane Roofing

Built-up and membrane roofing is commonly used for low slopes and flat roofs. The minimum allowable slope is 1:50 (1/4:12).

Built-up Roofing

Known as a *hot tar and gravel roof*, built-up roofing consists of three or more layers of roofing felt, mopped with hot tar (bitumen) between layers and covered with a layer of hot tar (Figure 6). In many cases, a layer of pea gravel is applied over the top of the roof to provide protection from UV. This type of roofing has been mostly replaced by torch-on membrane roofing.

Figure 6— Tar and gravel roofing

Membrane Roofing

Membrane roofing comes in rolled sheets and is the most common flat and low-slope roofing product today. It is rolled out and the overlapping seams are fused together using heat or solvents (Figure 7). The advantages of this type of roofing include being flexible and easily repairable. There are three main types:

- Thermoset (synthetic rubber)—seams are chemically cross linked or vulcanized.
- Thermoplastic (PVC sheet vinyl and other plastics)—seams are bonded together with heat or solvents. Most Code-approved sundeck coatings are of this type of product.

- Modified bitumen (torch-on or torch-down)—a large flame-throwing torch is used to melt the seams together and to adhere the product to the roof sheathing.

Membrane roofing may be applied as a one-, two- or three-layer roof. A three-layer roof will have a base layer of roofing felt, a smooth layer of torch-on roofing and a cap layer of torch-on with a granulated surface.

Membrane roofing is often used to form the weatherproof layer of hidden gutters. Its ability to be cut and moulded to irregular shapes makes it suitable for many waterproofing applications.

Figure 7—Torch-down membrane roofing

Roll Roofing

Roll roofing is an inexpensive roofing product that is normally only used for sheds and temporary buildings. The product has a comparatively short lifespan and tends to form wrinkles over time.

Its composition is the same as asphalt shingles. The rolls are 1 m wide and 10 m long (39" × 32'9"). There are two types of roll roofing: single coverage and double coverage. The single coverage has a 100 mm (4") selvage. The selvage area is not mineral coated and is the portion that gets lapped by the sheet of roofing above. Double coverage, also called 19" (480 mm) selvage roofing, has asphalt granules on only half of its width.

Single coverage roofing can be applied to roof slopes of 3:12 or steeper. 19" selvage roofing can be applied to roof surfaces as flat as 2:12. There is a cold application felt version approved for as low as 1:50.

Metal Roof Coverings

Coated steel is a very common roofing material. Metal roofing materials are lightweight, non-flammable and resist the buildup of moss. Disadvantages include scratching and denting if improperly walked on or from falling tree branches.

There are many manufacturers of metal roofing, and each has its own line of colours and styles. There are two basic types of metal roof coverings: sheet metal and shingles.

Sheet Metal

Sheet metal roofing materials come in various widths and profiles and can be ordered to specific lengths. The finishes are baked enamel or vinyl plastic. Aluminum, copper and stainless steel are available, but they are not often used.

The sheets are usually bent into a profile. The profile gives the material strength to span between supports. The sheets can be very long, up to 12 m (40'). The supplier cuts them to length. In some cases, the sheets are both shaped into the profile and cut to length on-site using a special machine.

There are two main types of sheet application. One uses exposed screws with neoprene washers. This creates a finished product with hundreds or even thousands of holes in the roof. Metal expands and contracts with temperature changes and this can "work" the screws, eventually causing leaks.

For this type of application each sheet is overlapped and screwed together (Figure 8).

Figure 8—Sheet metal roofing with exposed fasteners

The other, more common type of sheet metal application is the hidden fastener type, known as a *standing seam roof* (Figure 9). Standing seam metal roofs consist of flat sheets that are less than 600 mm (24") wide. These sheets are overlapped and interlocked at their edges. The fasteners for standing seam roofs are built into the overlap and are hidden.

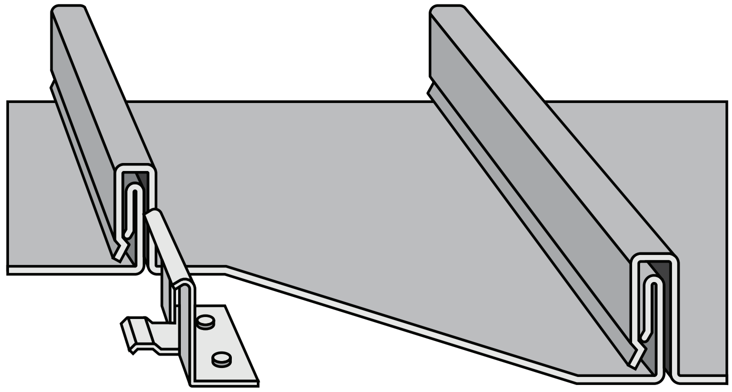

Figure 9—Standing seam sheet metal roofing

Metal Shingles

Metal shingles (Figure 10) are made in many profiles and colours. They are manufactured in strips of shingles similar in size to three-tab asphalt shingles, and as single shingles similar in size to a wood shingle or tile. They are a lightweight roofing material that will last twice as long as standard asphalt shingles.

Some metal shingles are mineral coated to give a clay tile appearance; others have a wood shake profile or a slate look. There are many colours and textures available.

Figure 10—Metal shingle roofing

Tile and Slate

Other long-lasting types of roofing are made from clay, concrete or slate. Due to the weight of these types of roofing, the building must be structurally designed for this extra load. The *BC Building Code* requires a minimum slope of 6:2 for these products.

Clay Tile

Clay tile is a long-lasting roofing material that is often specified for architectural reasons. They are available as flat tiles or in the traditional overlapping barrel shape (Figure 11). Clay tiles are formed with nail holes at the top of the tile. Special "rake" tiles are made to finish the gable ends of the roof. Leaks can be difficult to find and hard to repair.

Figure 11— Barrel-shaped clay tile roofing

Concrete Tile

Like clay tile, concrete tiles (Figure 12) are long lasting and fireproof. The finish on the surface of the tile is usually made from baked enamel. The tiles are usually flat or barrel-shaped and are installed as shingles in an overlapping fashion.

Cutting concrete or clay tile is done with a diamond blade on a portable circular saw.

Figure 12—Concrete tile roofing

Slate

Slate is a natural stone that can be split into flat sheets. The sheets are made into shingles and are drilled for nailing. With long-lasting fasteners, a slate roof can last 80–100 years. Due to the amount of labour needed to make and install the shingles, slate is a very expensive roofing product (Figure 13).

Figure 13— Slate tile roofing

Green Roofs

With so many streets, sidewalks and buildings in urban areas, there are concerns that there isn't enough green space. Green space (plants and trees) is considered desirable because it helps modulate temperatures and reduces airborne pollutants.

A green roof (Figure 14) is constructed with membrane-type roofing covered with a root barrier. This is covered by a drainage layer mat of gravel and topped with a growing medium (soil). Low-maintenance grass or foliage is then planted. Guardrails or fall protection anchors are usually required, as the plants will need occasional tending. Leaks in green roofs can be very difficult to find and fix.

Figure 14— A green roof

Solar Photovoltaic Shingle Roofing

One of the more recent types of roofing now being developed is the solar photovoltaic shingle. (Photovoltaic is commonly abbreviated PV.) These shingles act as both roofing and a solar electricity producer.

Although more expensive than most types of roofing, these panels take the place of conventional roofing shingles, and they generate electricity to sell back to the power grid or to use in the home.

Most manufacturers make a thin, flexible product that can be integrated with asphalt shingles (Figure 15).

Figure 15—Solar shingles integrated with asphalt shingles

Roofing Accessories

There are many roofing accessories needed to install roofing. They include underlay (roofing felt), fasteners, eave protection, flashing and vents.

Roofing Felt

Most roofing types are required to have an underlay paper. Underlay (roofing felt) comes in rolls that are about 900 mm (36") wide and typically are either a #15 or #30 asphalt-impregnated paper (Figure 16). A square (100 ft.^{2}) of #15 paper weighs 6.8 kg (15 lb.). Non-perforated paper can be used under most types of roofing.

Decay on wood shingles begins on the underside. Wood shakes and shingles require a perforated paper underlay. This breathing type of underlay gives the shingle an ability to dissipate moisture.

Figure 16—#15 roofing underlay paper

When the project needs to be weathertight and the roofing can't be installed immediately, there are products available, such as RhinoRoof® Paper U20, that can be left exposed to weather and UV for up to 60 days. Products like this have many other advantages compared to standard roofing felt underlay.

Eave Protection

The eave of a roof can be the coldest portion of the roof during freezing weather. In certain weather conditions snow can remain frozen on the exposed eave, but the snow over the living space will melt due to heat loss from the building. This creates an ice dam at the eave that can back up water and cause leaks (Figure 17).

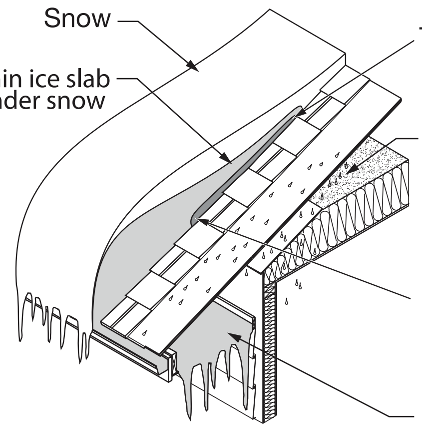

Figure 17— Ice damming causing a leak

To counteract this, the *BC Building Code* requires that shingle, shake and tile roofing have eave protection that extends at least 900 mm (3') up the roof slope to a line not less than 300 mm (1') beyond the inside face of the exterior wall (measured horizontally) (Figure 18).

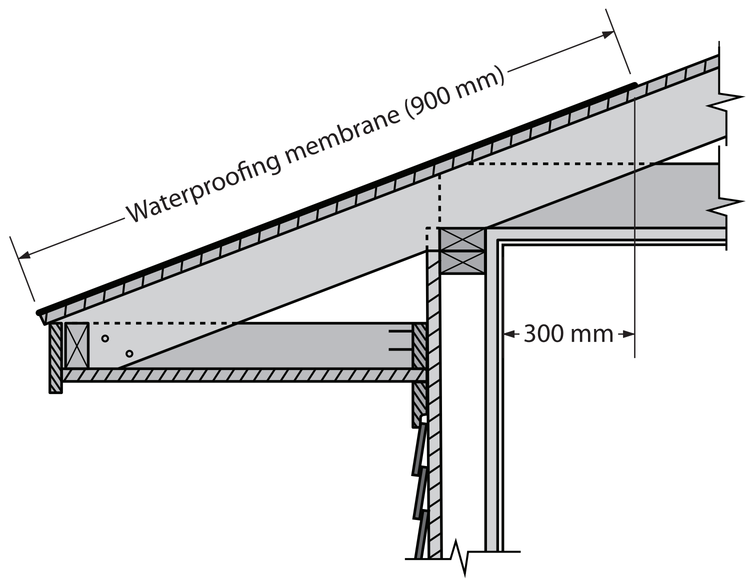

Figure 18— Eave protection location

Eave protection is not required in the following situations:

- over unheated garages, carports and porches
- when the roof overhang measures more than 900 mm (3') along the slope to the inner face of the exterior wall
- with asphalt shingle applications on slopes of less than 4:12 where shingles are cemented together with a continuous band of cement that is the width of exposure plus 50 mm (2")
- on roofs with a slope of 8:12 or steeper
- in regions with 3500 or fewer degree days (most of Vancouver Island and Lower Mainland)

Eave protection must be self-sealing. The nail holes made by the fasteners must not allow entry of the backed-up water. Common products used for eave protection include roll roofing and membrane roofing.

Flashing

Roofing requires flashing at intersections and in some cases for drip edges in order to help protect the lowest edge of the roof. Intersections include valleys, where roofs meet walls that rise above the roof, and around skylights and chimneys.

Materials

Flashing is usually made from metal. The metals used must be able to be bent and must resist weather.

Lead and Copper

Lead and copper are very flexible metals and resist the weather very well. Both of these metals are expensive to use. They are usually only used when the flashing must last indefinitely or where the design requires their use. Lead flashing is very flexible and can be moulded by hand to almost any shape. Copper requires machine bending and soldering. Copper flashing will change to a light blue-green colour after it has been exposed to the weather for a few months.

Aluminum

Aluminum flashing is not recommended. It is too light and is easily eroded by salt air.

Steel

Steel flashings are the most cost effective and will last as long as most common roofing materials. They are usually galvanized or enamel coated. Enamel-coated surfaces last for years and are available in many colours.

Flashing Roof Openings

When a skylight penetrates the roof surface, the four sides of the opening must be flashed (Figure 19). The downslope side of the opening is flashed with a base flashing, the sides of the opening are flashed with step flashing and the top of the opening is flashed with a back pan or chimney saddle.

Figure 19—Typical skylight flashing

Chimneys are flashed in the same manner as skylights except that if the chimney is made from masonry, a counter flashing is used to overlap the step flashing. Woodframed zero clearance chimneys do not require the counter flashing because the wall finish will overlap the flashing.

Counter flashing is also used when a roof butts into a masonry or concrete wall. A groove (reglet) for the flashing is needed if the counter flashing is placed into a concrete wall. Forming a reglet into the wall before the concrete is placed makes this groove. Chimneys normally have the counter flashing installed as the bricks are laid. In this case the top of the counter flashing is embedded well into the mortar joint and extends down the brick at least 150 mm (6") and must lap the lower base flashing by at least 100 mm (4") (Figure 20).

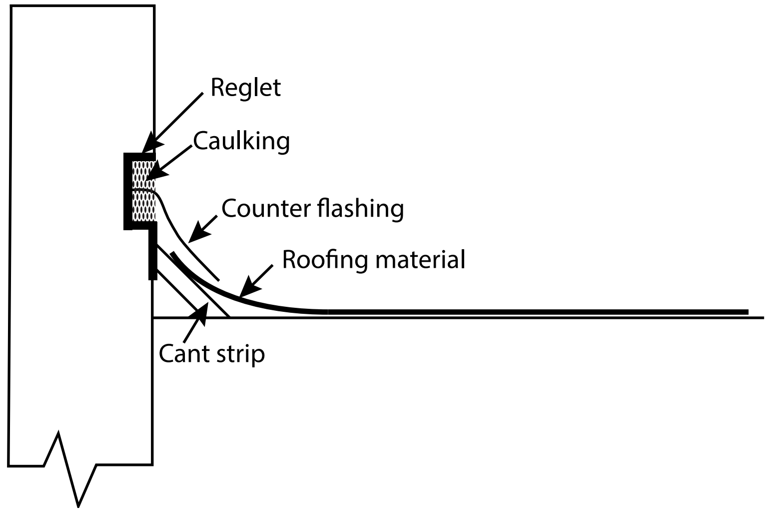

Figure 20—Reglet used to install counter flashing

Valley Flashing

Valley flashing is used when an open valley is built. The minimum width of valley flashing is 600 mm (24"). Often the centre of the valley flashing is bent into an up-stand to help keep rainwater from running up the other side of the valley (Figure 21).

Figure 21—Open valley

Some types of closed asphalt shingle valleys do not require flashing since the roofing acts as a valley protection as shown in Figure 22. Membrane or roll roofing is run up the valley and the roofing on one side of the valley is run across the valley and at least 300 mm (12") onto the roof on the second side of the valley. The roofing on the second side is then run over this roofing and trimmed using a chalk line running down the valley.

Figure 22—Closed valley

Roof Vents

Attic spaces must be ventilated to prevent moisture damage and to reduce heat buildup in the summer months. This may be done with soffit, gable-end or roof vents (Figure 23). Roof vents should be installed near the ridge of the roof. The soffit vents must be open into the attic to allow convection current to help to move the air from the soffit to the ridge.

Roof vents are made from metal or plastic. They are screened to prevent the entry of insects. An electrically powered fan assists some vents. Wind turbine vents have a vane on the top that is spun by the force of the wind. The spinning vane drives a fan blade that moves the air out of the attic. Roof vents can also be in the form of a vented ridge cap.

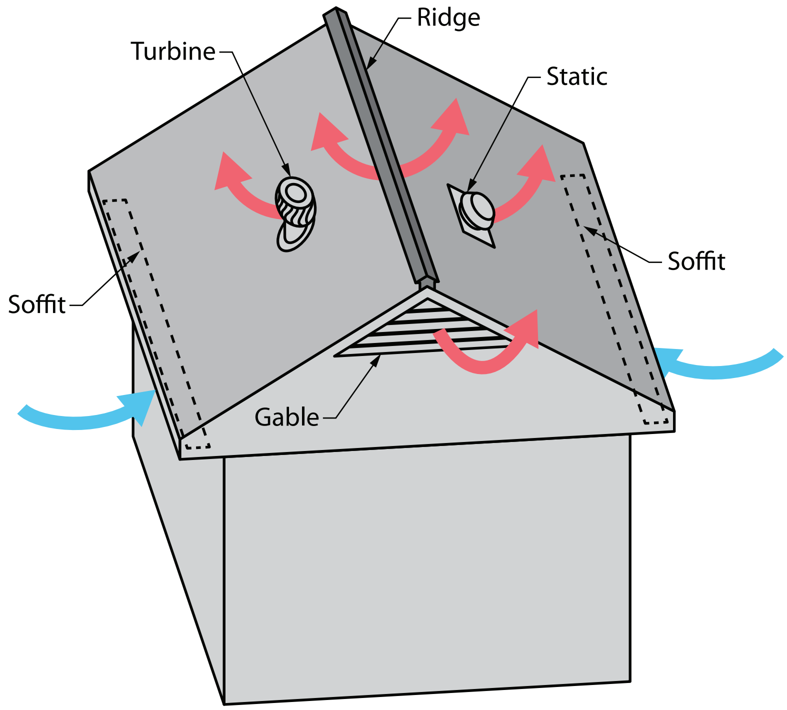

Figure 23—Types of roof vents

Plumbing Vents

The building's waste plumbing is required to be vented, and this stack pipe will normally pass through the roof. At least one vent is required to be at least 75 mm (3") diameter. Rubber boots are normally used as flashing and are installed similar to a shingle (Figure 24).

Figure 24—A plumbing stack

Hidden Gutters

Modern roof styles may include hidden gutters (Figure 25).

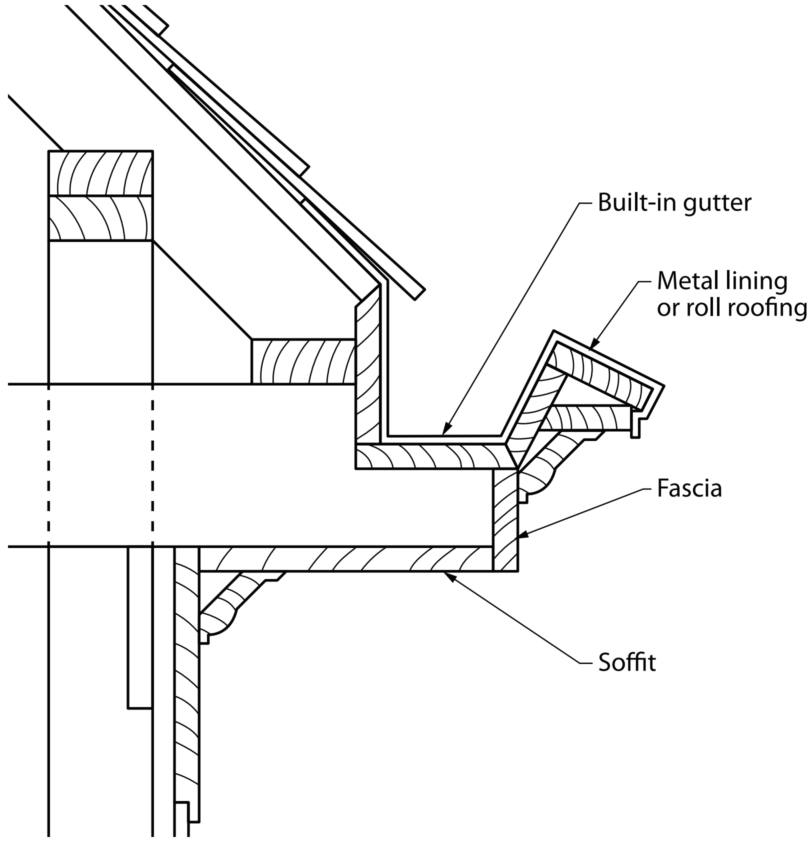

Figure 25—Hidden gutter form made from plywood

The insides of the gutters are finished with a torch-on roofing membrane. The gutter space must be large enough to collect all of the rainwater. The gutter should be sloped toward the drain locations.

Scuppers

Flat roofs often use scuppers instead of eavestroughs (gutters) (Figure 26). A curb wall is formed around the edge of the roof using a cant strip. A cant strip is a 45-degree bevelled strip of wood such as a 4x4 cut on the diagonal. Openings in this curb wall drain into a box connected to a downspout (roof leader).

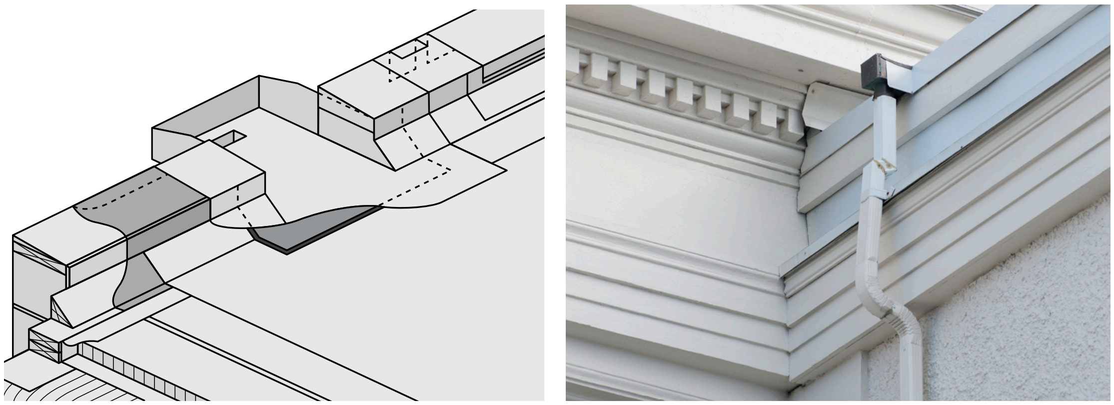

Figure 26—Scupper drain for a flat roof

Sloped Insulation Package

As mentioned at the beginning, flat roofs are not completely flat. They must have a slope of 1:50 or more. One easy way of achieving this is to frame a flat roof and then install a sloped insulation package.

A sloped insulation package is made up of tapered rigid insulation panels attached to the roof sheathing.

Re-roofing

When re-roofing, the existing roofing is removed (called a *tear-off*) and the condition of the roof sheathing is checked. If the roof had been leaking, some repair or replacement of the roof sheathing/boards may be required. Old flashings should be inspected and may need to be replaced.

In some cases the existing roofing is left and new roofing is applied over the old roofing. Although this method saves money, it adds weight to the roof and doesn't allow inspection of the roof sheathing for water or other damage.

Roofing is designed to be installed on flat surfaces. Roofing on top of existing roofing can also result in a lumpy appearance. When roofing with asphalt shingles, no more than one layer of old roofing should be roofed over due to the excessive weight that would result.

When roofing on top of existing roofing, always check the roofing warranty, as some roofing is not warranted if installed over existing roofing.

☑ Now complete Self-Test 1 and check your answers.

Self-Test 1

1. Name five materials that shingles are made from.

2. What is the minimum slope for a flat roof?

3. What can wood shakes be treated against?

4. What is the difference between wood shakes and wood shingles?

5. What governs the amount of exposure allowed for wood shingles?

6. What types of roofing can be used on slopes of 1:50 (1/4:12)?

7. What are the advantages of a metal shingle roof?

8. Besides expense and leak repair problems, what is the main disadvantage of clay, concrete and tile roofs?

9. What is the purpose of eave protection?

10. What type of roofing material is used for hidden gutters?

11. List two reasons for ventilating attic spaces.

12. What is the minimum width of valley flashing? (Use the current *Building Code*.)

13. What is the purpose of a reglet?

14. Why are sloped insulation packages used?

LEARNING TASK 2

Plan for the Installation of Roofing Materials

Roofer is a Red Seal trade in Canada, and most roofing is installed by professional roofers working as a subcontractor to the carpenter. When the carpenter is the prime contractor, the carpenter becomes responsible for safety and many other aspects of the roofer's work.

Even though roofers perform most of the roofing work in Canada, carpenters are often called upon to do small amounts of roofing, especially when building sheds and additions. A properly installed roof should protect the building from the elements for many years. For a long life, the condition of the roof sheathing, the underlay and the eave protection is vital.

Safety

The main safety concern regarding roofing is working at heights where falls can cause serious injury or even death. Other safety considerations include burns and health hazards from working with chemicals and from cuts when trimming shingles or working with sheet metal. The following are good safety practices:

- Proper personal protective equipment (PPE) must be worn. This may include hardhats, gloves, safety footwear with good traction, eye protection, hearing protection, respirators and fall arrest/restraint equipment.
- Getting workers and materials on and off the roof is a major cause of accidents and access needs to be carefully planned.
- Working on roofs often requires working near electrical connections, and this presents an electrocution hazard. Maintain a safe distance from electrical wires when working on the roof and when setting up and taking down ladders.
- Heat stroke is a serious concern for roofers due to lack of shade, the use of torches and the colour of the roofing. Acclimatize workers, take cool-down breaks and drink liquids.
- Falls through skylights and other types of roof openings must be guarded against.
- Rooftop vents and chimneys may expose workers to hazardous fumes, gases or vapours. Be aware of these and move away from the gases or work upwind.
- In many cases workers need to plan for fire protection when working with torches or solvents and adhesive. Have fire-suppression equipment and a plan to deal with fire readily on hand.

WorkSafeBC Regulations

WorkSafeBC has regulations relating to all the safety concerns listed above. They publish booklets and guides on roofing safety in addition to the OHS Regulation.

MSDS

WorkSafeBC requires that the information in the roofing product's Material Safety Data Sheet (MSDS) be read and followed by those installing the product. Solvents and adhesives can enter the bloodstream through lungs, skin or eyes. Prolonged exposure may have long-term adverse health effects.

Roof Access

Typically roof access is by use of a ladder. However, if using a ladder is not safe, scaffolding must be used.

Using Ladders

Stepladders should not be used to access a roof; use a single or extension ladder instead. Both these types of ladders have the same basic requirements for safe use:

- Rest the feet of the ladder on a firm, level base.
- Choose a ladder of sufficient length to project at least 900 mm (3') above the level of the landing to which it provides access.
- Do not stand on the top two rungs or cleats.
- Use a 4 vertical to 1 horizontal slope. In Figure 1, if A is 4 m (12'), then B should be approximately 1 m (3') (4:1 ratio).

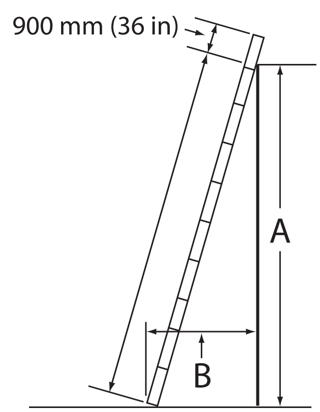

Figure 1—Safe slope

- Ladders must have slip-resistant safety feet or they must be secured to prevent slipping during use (Figure 2).

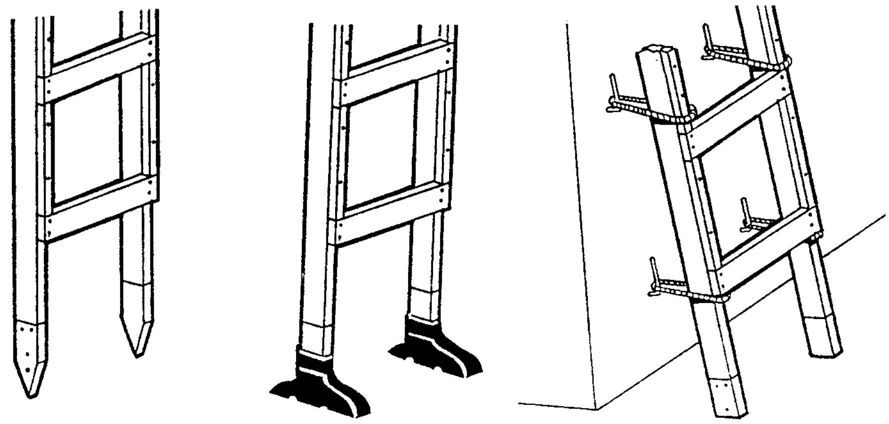

Figure 2—Securing the base of single or extension ladders

- Use only CSA or ANSI standard approved heavy-duty ladders and do not exceed the ladder's load ratings.
- Inspect the ladder before use.
- Do not climb a ladder carrying materials or tools. Use a hoist or rope to lift them onto the roof.
- Always face the ladder and use a three-point contact when climbing up or down.

Do not use metal ladders or wire-reinforced ladders near energized electrical equipment.

Use fibreglass or un-reinforced wood ladders where there are electrical hazards. Equipment that might be dangerous if contacted by a metal ladder includes junction boxes, fuse panels, overhead lines and cable trays. Always watch for overhead power lines when setting up or taking down a ladder.

Working at Heights

A fall protection system is used where there is risk of a fall of 3 m (10') or more, or where a fall from a lower height has the added risk of injury from jagged or rough surfaces.

Heights are calculated differently for roofs steeper than 4:12 (v:h), and requirements increase for roofs steeper than 8:12 (v:h). The requirements are covered in OHS Guideline G20.75. Figure 3 depicts the categories of roofs based on slope.

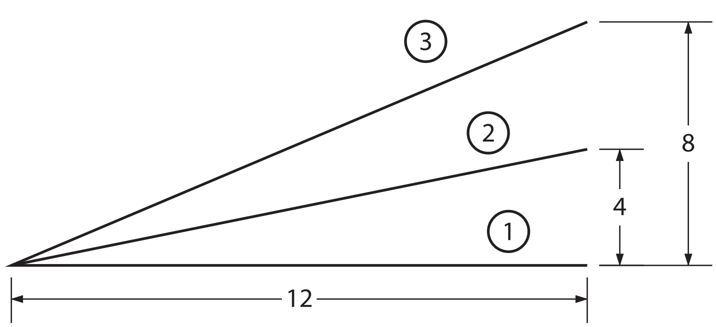

Figure 3—Categories of roofs based on slope

When a roof is steeper than 4:12, the height is normally calculated from the bottom edge of the roof to the next safe lower surface or to the ground below. The vertical distance from the worker's position to the unguarded roof edge should be added to this distance.

Acceptable fall protection for flat roofs and roofs no greater than 4 vertical to 12 horizontal include the following:

- guardrails
- personal fall protection systems
- safety nets
- control zone
- safety monitor system with control zone

Acceptable fall protection for roofs with a slope ratio greater than 4 vertical to 12 horizontal but less than 8 vertical to 12 horizontal include the following:

- guardrails
- personal fall protection systems
- safety nets

The control zone and safety monitor systems are not to be employed on roofs steeper than 4 vertical to 12 horizontal.

With fall protection for roofs where the slope ratio is 8 vertical to 12 horizontal or greater:

- If the roofing material allows for the nailing of toe boards, they must be used in conjunction with personal fall protection systems or personnel safety nets.
- If the roofing material precludes the use of toe boards, such as on steel cladding or concrete tile, workers should use roof ladders or acceptable work platforms in conjunction with a personal fall protection system.

Fall Protection Systems

Different work environments and locations require different fall protection systems. The priority is to remove the hazard, but if that cannot be achieved, other methods of protection must be provided.

Fall protection systems use different methods to protect workers. The following is a list of fall protection methods in order of preference:

1. guardrails
2. fall restraint system
3. fall arrest system (full body harness)
4. safety monitor and control zone

Guardrails

Installing guardrails (Figure 4) around exposed edges and floor openings is the preferred method of fall protection. Guardrails must:

- Be 1.0–1.1 m (40–44") above the work surface.
- Consist of a top rail, mid rail and toe board.
- Be able to resist a 57 kg (125 lb.) horizontal load.
- Be supported by uprights at a maximum spacing of 2.4–3.0 m (8–10') (Uprights may be spaced up to 3.0 m (10') o.c. when they form the posts for scaffolds.)
- Use a minimum of a 2×4 top rail for uprights spaced at 2.4 m (8') o.c.
- Use a minimum of a 2×6 top rail for uprights spaced up to 3.0 m (10') o.c.
- Use mid rails of 1×6 or 2×4.

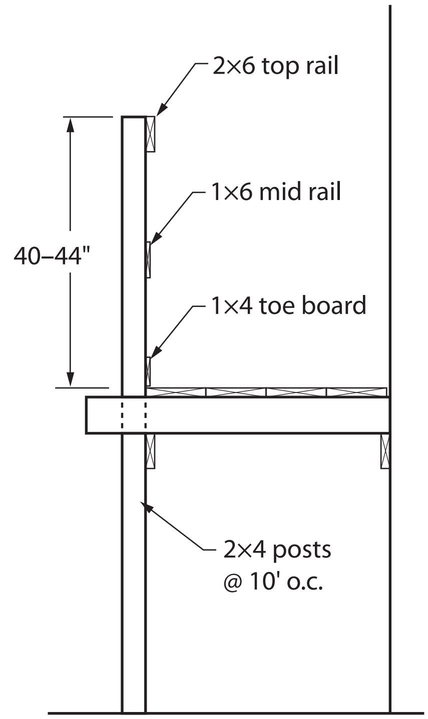

Figure 4—Guardrail

Fall Restraint System

A fall restraint system allows a worker to travel far enough to reach an unprotected edge or drop-off without going over it. A basic fall restraint system consists of a WorkSafeBC-approved harness or safety belt combined with suitable and compatible components (D-ring, lifeline and/or lanyard, rope grab and anchor).

Fall restraint arrangements must be thoroughly planned. The choice of components, the location of anchor points and the identified fall hazards in the work area must be carefully considered. The system must be set up so that the lifeline and/or lanyard, when fully extended, prevent the worker from reaching any point where he/she could fall.

All components must be strong enough to withstand the force required to stop a fall, and the entire system must have an anchor capable of supporting either 350 kg (800 lb.) or four times the body weight of the person using it (whichever is greater). An anchor point should be located as close as possible to the centre of the work area and at a 90° angle from the unprotected edge.

Special attention should be given to work areas located near corners and areas with floor openings or irregularly shaped perimeters. The fall restraint system will need to be adjusted as the worker moves through the work area. A lifeline and/or lanyard that adequately restrains a worker in one section might be too long in another section.

It's preferable to restrain workers from falling in the first place as opposed to arresting their fall.

Fall Arrest System

A basic fall arrest system must include a WorkSafeBC-approved harness combined with suitable and compatible components (D-ring, lifeline, lanyard, shock absorbers, rope grab and anchor). The anchor must provide adequate fixed support, and the harness must be connected to the anchor via a lifeline, or via a lanyard and a lifeline.

The fall arrest system must prevent a falling worker from hitting any object and from hitting the ground at any level below the work area. The fall arrest system must not subject a falling worker to peak fall arrest force. That is, the system should not cause injury to the worker in the course of stopping the fall.

A qualified worker must inspect all fall arrest equipment for damage, wear and obvious defects before each use. If any component is defective, it must be replaced by one that meets or exceeds the manufacturer's minimum performance standards for that particular system.

When receiving fall arrest instruction, every worker must also carefully review the manufacturer's instructions, especially warnings and limitations for each piece of equipment. Any fall arrest system that has been involved in a fall must be removed from service until the manufacturer certifies all components are safe for reuse.

Whereas safety belts may be used in fall restraint systems, they must not be used in a fall arrest system. An approved fall arrest system uses a full body harness, lanyard and lifeline and will limit free fall to 120 cm (4').

Safety Monitor and Control Zone

In certain situations, the use of other fall protection systems may be impractical or may cause additional hazards. In these situations, a control zone (which may also include a safety monitor) may be used.

A *control zone* is the area between an unguarded edge of a building or structure and a line that is set back a specific distance. The minimum width of the control zone is 2 m (6.5'). The work surface must be sloped no steeper than 4:12 (v:h) and be non-slippery. No workers are permitted in the control zone (unless a safety monitor is used).

If a safety monitor is not used, the control zone must be clearly marked with a raised line. A *safety monitor* is a trained worker designated to monitor activities in a control zone to minimize the potential for a worker to fall. A safety monitor is required if workers must be in the control zone. Only workers directly required for the work at hand may be inside the control zone.

A safety monitor must:

- Be experienced in the work overseen and trained in the role of safety monitor.
- Be present at all times when a worker is in the control zone.
- Have complete authority over the work as it relates to the prevention of falls.

- Engage in no other duties while acting as the safety monitor.
- Be located so as to have a clear and continuous view of the work.

Also, a safety monitor should:

- Be able to have normal voice communication with the workers being protected.
- Monitor no more than eight workers.
- Be instantly distinguishable from other workers.

The written fall protection plan for the workplace should specify the name of each safety monitor.

Example
A safety monitor and a control zone can be used during the installation of a torch-on roof on an existing building. Installing a guardrail that meets WorkSafeBC regulations is impractical given the finished surfaces of the building. Using a safety harness and lifeline introduces a tripping hazard that may cause a worker to fall into the hot roofing material.

The workers inside the control zone work without wearing any fall arrest or fall restraint equipment. The safety monitor's job is to constantly watch the workers and warn them if they get too close to the unprotected edge.

Harnesses, Lanyards and Lifelines

Full Body Safety Harnesses

Safety harnesses (Figure 5) must meet CSA standards and must bear the CSA label. In order for a fall restraint or fall arrest system to function properly, it's vital that the harness be worn correctly, as follows:

1. Adjust the chest strap so that it's snug and located near the middle of the chest. In a headfirst fall, a properly adjusted chest strap will prevent you from coming out of the harness.
2. Adjust the leg straps so that your fist can fit snugly between strap and leg.
3. Adjust the harness straps to put the D-ring between your shoulder blades. A properly positioned D-ring will keep you upright after fall arrest.

Once a safety harness has been involved in a fall arrest, it must be inspected and re-approved by the manufacturer before being used again.

Figure 5—Safety harness

Take the time to adjust the harness to fit your body. A poorly fitting harness is uncomfortable and may not protect you.

Lanyards

Safety lanyards must meet CSA standards and bear the CSA label. Lanyards connect the D-ring on the back side of a safety harness to a lifeline or anchor point. A rope grab is used for a vertical lifeline connection. The rope grab should be positioned on the lifeline to allow a maximum free fall of 120 cm (4') unless the lanyard is equipped with a shock absorber.

Follow these basic guidelines for selecting and using lanyards:

- Use manufactured lanyards only. They can be made of wire rope, synthetic fibre rope or synthetic webbing.
- Never try to shorten a lanyard by tying knots in it. Lanyards are manufactured to specific lengths. Knots can seriously reduce their rated strength.
- Never store lanyards around chemicals or sharp objects, or in wet places.
- Never leave lanyards exposed to direct sunlight for long periods.
- Inspect lanyards for burns, cuts, signs of chemical damage, loose or broken stitching and frayed web material before each use.

Wire rope lanyards must be used when using cutting tools or where abrasion can cause damage to the lanyard. Wire rope lanyards must not be used if there is a danger of electrical shock. If using cutting tools and there is an electrical hazard, use two non-conductive lanyards.

Rope Grabs and Shock-limiting Devices

A rope grab is used to connect the lanyard to a lifeline. These devices can be moved up and down the lifeline if pushed steadily, but they will lock when pulled or tugged sharply. They'll remain locked on the lifeline until the applied force is released.

Each rope grab is designed and manufactured for use with a specific diameter and type of lifeline—rope grab and lifeline must be compatible. Specifications are usually listed on the housing.

The rope grab must be attached to the lifeline in the correct direction—not upside down. On most rope grabs an arrow indicates the direction in which to orient the device. In addition, each rope grab is designed for use with a specific length of lanyard, normally 60–90 cm (2–3') maximum.

Check all connecting devices for:

- rust
- bends
- dents
- cracking

- deformation
- signs of wear or metal fatigue

Ensure that connecting rings are centred (not bent to one side or otherwise deformed) and that all moving parts are working smoothly.

Shock-absorbing Devices

Shock-absorbing devices reduce the impact of a lifeline stopping a fall. These shock-absorbing devices are required if a wire rope lanyard is used. If a shock-absorbing device is used, the free-fall limit can be increased to 2 m (6.5').

Lifelines

Lifelines are used to extend the connection of a harness to an anchor point. There are three basic types of lifelines:

- vertical
- horizontal
- retractable

Vertical lifelines used as part of a personal fall arrest system must:

- Be CSA-approved.
- Have a breaking strength of at least 26.7 kN (6000 lb.).
- Be made from synthetic fibre or wire rope.
- Be free of knots and splices, except at the termination points.
- Have a positive stop to prevent the rope grab from running off the end of the lifeline.
- Be secured to an anchor capable of supporting at least 22 kN (5000 lb.).
- Have only one worker attached to it.
- Extend to within 1.2 m (4') of the ground or a safe lower landing.
- Not exceed a suspended length of 91 m (300') without prior approval from WorkSafeBC.

Horizontal lifelines used as part of a personal fall arrest system must:

- Provide a minimum 360 kg (800 lb.) of support for each worker attached to the line.
- Have a breaking strength of at least 89 kN (20 000 lb.).
- Be made from ½" diameter wire rope or larger.
- Be free of knots and splices, except at the termination points.
- Be secured to an anchor capable of supporting at least 71 kN (16 000 lb.).
- Have a span over 6 m (20') but less than 18 m (60').
- Have an unloaded sag of 1/60th of the span.
- Be at least 1 m (3') above the working surface.

- Limit free fall to 1.2 m (4').
- Be positioned to not impede other workers.
- Have a minimum of 3.6 m (12') of clear space below the working surface.
- Have a maximum of three workers attached to it.

Retractable lifelines consist of a lifeline spooled on a retracting device attached to adequate anchorage. Retractable lifelines:

- Are usually designed to be anchored above the worker.
- Employ a locking mechanism that lets the line unwind off the drum under the slight tension caused by a worker's normal movements.
- Automatically retract when tension is removed, thereby preventing slack in the line.
- Lock up when a quick movement, such as that caused by a fall, is applied.
- Are designed to minimize fall distance and the forces exerted on a worker's body by fall arrest.

Always refer to the manufacturer's instructions regarding use, including whether a shock absorber is recommended with the system. Any retractable lifeline that has been involved in a fall arrest must be removed from service until the manufacturer or a qualified testing company has certified it for reuse.

All lifelines must be inspected daily to ensure that they are free of:

- cuts
- burns
- frayed strands
- abrasions
- discoloration
- brittleness
- other defects, damage or signs of heat or chemical exposure

Connecting Devices

There are two types of connecting devices:

- snap hooks
- carabiners

A **snap hook** connects a lanyard to the rope grab and to the harness. Snap hooks are also used to connect a lanyard to a horizontal lifeline. The snap hook must be self-locking. A locking snap hook has a spring-loaded keeper across the opening of the hook that cannot be opened unless the locking mechanism is depressed.

A **carabiner** (or D-clip) is designed to remain closed under twist loads. A carabiner can be used instead of a snap hook. It must be rated for at least 22 kN (5000 lb.). Opening the gate or keeper of this clip requires two separate actions:

- twisting the locking mechanism
- pulling the locking mechanism back

When released, the spring-loaded locking mechanism flicks back into the locked position.

Anchor Systems

There are three basic types of anchor systems for fall protection:

- designed fixed support
- temporary fixed support
- existing structural features

Designed fixed supports are load-rated anchors specifically designed for fall protection purposes. They are permanently installed as an integral part of the building or structure. An example is roof anchors on high-rise buildings.

Designed fixed supports can be used to anchor a fall arrest system, fall restricting system or travel restraint system if the support has been installed according to *Part 4* of the *Building Code* and is safe and practical to use.

Permanent anchors should be made of stainless steel, hot-dipped galvanized steel or other corrosion-resistant material. They are required to have an ultimate load capacity in any direction able to resist a fall of at least 22 kN (5000 lb.).

Temporary fixed supports are designed to be connected to the structure following specific installation instructions. An example is the nail-on anchors that shinglers use. Temporary fixed supports can be used under the following conditions:

- to anchor a fall restraint system if it has an ultimate load capacity in any direction of 350 kg (800 lb.) or four times the weight of the person using it
- to anchor a fall arrest system if it has an ultimate load capacity in any direction of 2200 kg (5000 lb.) or twice the maximum arrest force

Existing structural features are those that were not designed as anchor points but that a professional engineer or competent person has verified as adequate for that purpose. Examples include rooftop mechanical rooms, structural steel and reinforced concrete columns.

When using existing structural features or equipment as anchor points, avoid corners or edges that can cut, chafe or abrade fall protection components. Where necessary, use softeners such as wood blocking to protect connecting devices, lifelines and lanyards from damage. Never anchor to:

- roof vents
- roof hatches
- small pipes and ducts
- metal chimneys
- antennas
- stair or balcony railings

Pendulum Effect

The farther sideways you move from your anchor point, the greater the chance of swinging during a fall. This is known as the *pendulum effect*. The more you swing, the greater the force with which you'll strike columns, walls, frames or other objects. Swinging can also cause a taut lanyard or lifeline to break if it runs over rough or sharp edges.

To minimize the pendulum effect, keep your lanyard or lifeline perpendicular from edge to anchor. Where work extends along an open edge, change the anchor point to keep the lanyard or lifeline perpendicular as work progresses.

Another solution is to run a horizontal lifeline parallel to the edge. Attach the lanyard to the lifeline. As you move along the edge, the lanyard travels at the same pace, remaining close to perpendicular at all times.

Bottoming Out

Bottoming out occurs when a falling worker hits a lower level, the ground or some other hazard before the fall is fully arrested. This happens when the total fall distance allowed by the system is greater than the distance from the work surface to the next level, the ground or other hazard. Fall arrest systems must be planned, designed and installed to prevent bottoming out.

Inspection and Maintenance

All fall protection equipment, including safety belts, harnesses, lanyards, lifelines and connecting hardware, must be:

- inspected by a qualified person before use on each work shift
- kept dry and away from substances that can cause deterioration
- maintained in good working order

If any part of the fall protection equipment is damaged or worn, it must be repaired and re-certified by the manufacturer prior to use.

Emergency Rescue Plans

Before using any fall arrest system at heights greater than 7.6 m (25'), the employer must establish written rescue procedures. It's important that a worker involved in a fall arrest be brought to a safe area as quickly as possible without causing injury or putting rescuers at risk.

It's very likely that a worker left dangling for more than four minutes will lose circulation in their legs, resulting in injury. In many cases, the rescue plan can be simple. A ladder or elevating work platform can be used to reach a suspended worker and get him or her down safely. Alternatively, the worker could be hauled back up to the level from which he or she fell or pulled in through a nearby window or other opening.

In other cases, rescue procedures can be more complicated. For instance, a worker trapped on or hanging from a failed swing stage might need to be rescued by specially trained and equipped personnel from the local fire department. Aerial ladder trucks or other high-reach equipment might be necessary. In extreme cases, the fire department might use rappelling techniques to reach a trapped worker and lift or lower him or her to a safe level.

Rescue plans should cover the on-site equipment, personnel and procedures for different types of rescue. Any off-site rescue services that might be required should be contacted and arranged in advance to familiarize them with the project. The nearest hospital and the phone numbers of fire, ambulance and police services should be noted in the plan.

The employer must ensure that everyone on-site is aware of the rescue plan, that equipment and other resources are available and that designated personnel are properly trained.

Building Code Requirements

Roofing materials are manufactured to CSA or CGSB standards. As most of these are engineered products, they must be installed as per manufacturer's instructions provided in their technical literature. The exceptions to this are wood shingles and shakes, and slate roofing.

Section 9.26 of the *Building Code* covers roofing. Included in *9.26* are subsections on fasteners, allowable slopes, flashing requirements, eave protection, underlay and requirements for the application of the different types of roofing.

As the manufacturer's installation literature may be generic for all of North America, it is important to read both the literature and the appropriate portions of the *Building Code*.

Tools

Other than ladders, most tools used for roofing will be specific to the type of roofing being applied.

Tools for Asphalt Shingles and Roll Roofing

Tools needed for applying asphalt shingles or roll roofing may include:

- hammer or roofer's hatchet (Figure 6a)
- chalk line
- roofing knife with hooked blade (Figure 6b)
- framing square
- caulking gun and putty knife or pointed trowel
- metal snips for cutting flashing
- tool apron and knee pads
- circular saw and nail puller, if re-roofing, for replacing damaged sheathing
- pry bar for lifting shingles and flashing and for correcting mistakes
- compressor and air nailers or staplers (for larger projects)

Figure 6— Roofer's hatchet and a roofer's knife

Tools for Flat and Low-slope Roofing

Tools needed for flat and low-slope roofing types may include those used for asphalt roofing and may also include heavy rollers and propane torches. When using propane:

- Check all connections using a 50/50 liquid soap and water mixture. If bubbles expand, adjust the connection and test again.
- A regulator must be used.
- Propane cylinders must be secured in an upright position during use, transportation and storage.
- Adequate size and type of fire extinguishers are needed in case the roofing or structure catches fire.
- A first aid kit suitable for treating serious burns is needed.

Tools for Wood Roofing

A roofer's hatchet is needed for wood roofing to split and trim shingles or shakes. A small saw will be needed to cut shingles and shakes for valleys. A hand plane may be needed if making ridge caps.

Tools for Metal Roofing

Tools for metal roofing may include electric or pneumatic shears, and bending tools and brakes. Most metal roofing is done by sheet metal workers; like roofer, this is a Red Seal trade.

Protect Existing Surfaces and the Public

It is important to do proper housekeeping to protect the building, landscaping, other workers and the public. Some of these activities include:

- Removing waste and tripping hazards from the work area before starting the work.
- Stacking roofing materials near the work area.
- Storing tools and equipment at least 2 m (6.5') from the roof edge.
- Providing chutes for waste material when the roof is more than 6 m (20') from the ground level.
- Using barricades and/or warning signs to protect the public and other workers from hazards.
- Planning for the securing of material, tools and equipment in the event of high winds.
- Disposing of waste in a timely manner into a disposal bin or truck.

Ladders leaning against eavestroughs (gutters) can exert enough pressure to damage the eavestrough. Blocking can sometimes be used to prevent damage, or ladder standoffs can be used (Figure 7).

Figure 7—Ladder standoff stopping the ladder from bearing against the eavestrough

Gardens below the roofing project may need protection. Vegetable gardens may need to be tarped over to prevent contamination from bits of roofing and nails. Shrubs and trees may need pruning, bundling or tying back.

Tips for Installing Roofing

The following are some tips for installing roofing. As mentioned previously, always follow the *Building Code* and manufacturer's instructions.

Roof Sheathing

Pay extra attention to the manufacturer's warranty requirements for the roofing material being installed. Some manufacturers require specific types of roof sheathing or strapping and that underlay materials are to be used.

The choice of roof sheathing may also be determined by *Building Code* seismic requirements.

Installation of Underlay Materials

There are many situations in which the *Building Code* does not require underlay. Using underlay will prolong the life of the roof and may be required to meet the warranty requirements of the roofing materials.

Different types of roofing materials require different types of underlay material. Underlay has two functions: it provides a second level of protection from the weather, and it cushions soft or thin roofing materials from the heads of the sheathing fasteners.

15 lb. asphalt impregnated felt paper is the most common underlay. Non-perforated paper may be used under asphalt shingles or tiles. Perforated paper is used between each course of cedar shakes.

Install the paper in a shingle-like fashion, overlapping the upper sheets over the lower sheets. The *Building Code* requires a minimum 50 mm (2") overlap and end lap of the sheets. Half-lapping the sheets will provide extra protection and is an inexpensive method of adding protection to the roof sheathing. The underlay paper must overlap the eave protection by at least 100 mm (4").

Drip Edge

The eave of a roof is exposed to the most rainwater and requires special protection. Roofing is required to be installed with a small drip edge of at least 12 mm (½").

For shingle-type roofs, a metal drip edge can be used to help protect the lowest edge of the roof (Figure 8).

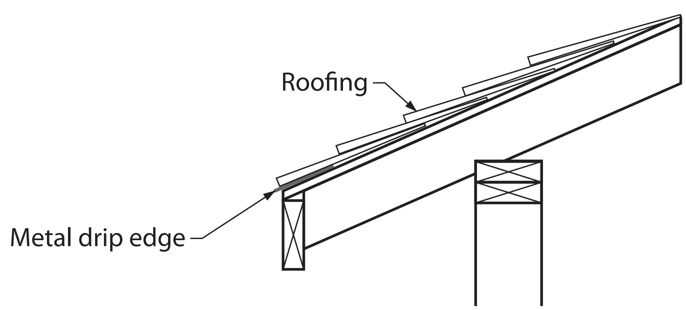

Figure 8—Metal drip edge and eave protection

Installing Asphalt Shingles

There are several types of asphalt shingles. The following information gives a few basics for installation.

Under-course Shingles

Asphalt shingles require a special under-course at the eave. The under-course consists of an upside-down layer of shingles that is fully covered by the first course of exposed shingles (Figure 9).

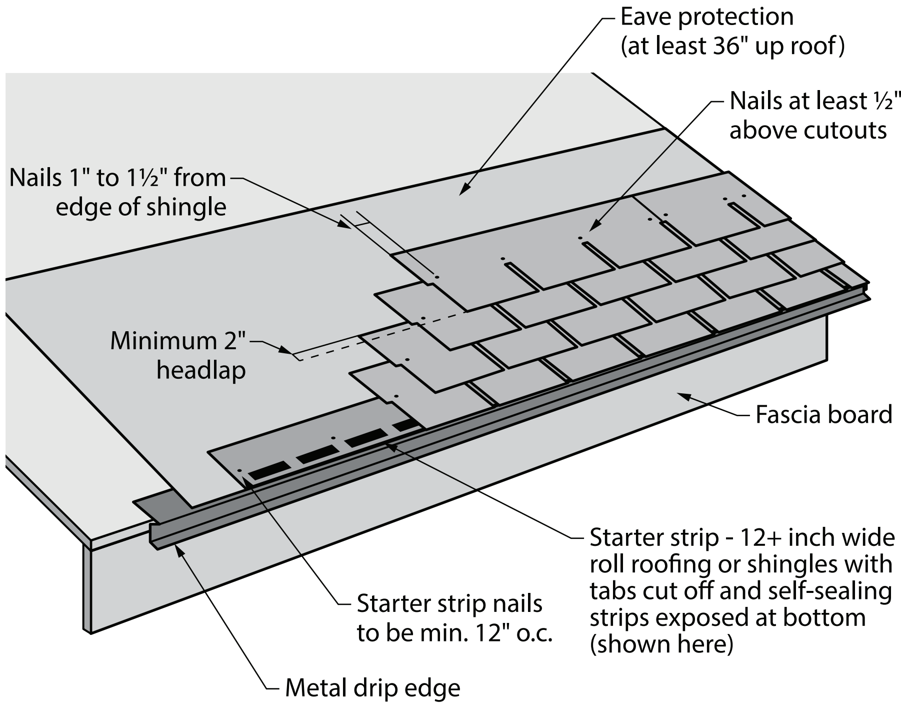

Figure 9—Under-course at the eave

Capping Hips and Ridges

The hip and ridges of an asphalt roof are capped with single tabs of three-tab shingles. Cut the shingles into three pieces at the cutout. Then cut an angle away from the cutout. This angle is used to ensure that the back edge of the cap shingles does not stick out from under the capping (Figure 10).

Figure 10—Cap shingle and cutting a cap shingle

Do not use a hook knife when the shingles are too soft. Attempting to cut warm shingles will just tear them. Take extra care installing the cap shingles. Irregularities in these shingles can be easily seen from the ground.

Installing Wood Shingles

Use a layer of wood shingles under the first course for wood shakes or shingles. The taper of this double layer will kick the first course up to match the angle of following courses.

Wood continually expands and contracts due to changes in moisture content. Seasonal changes in relative humidity can cause a dimensional change of up to 6 mm (¼") in the width of a roof shingle or shake. Wood roofing must be installed to allow for this movement.

Wood shingles are sawn from a cedar block, while shakes are split. Because shingles are sawn, they lie flat on the surface of the roof. Wood shingles are usually installed over panel-type sheathing with an underlay of #15 felt paper.

Exposure

Check the *Building Code* to determine the appropriate exposure for the size and type of roofing. Cedar shingles are often applied in a pattern for architectural effect. Patterns vary the exposure of the shingles. Keep the maximum exposure under the Code allowance.

Fastening

Cedar shingles are fastened with hot dipped galvanized box nails, two nails per shingle. Locate the nails just above the exposure line of the next course of shingles (Figure 11).

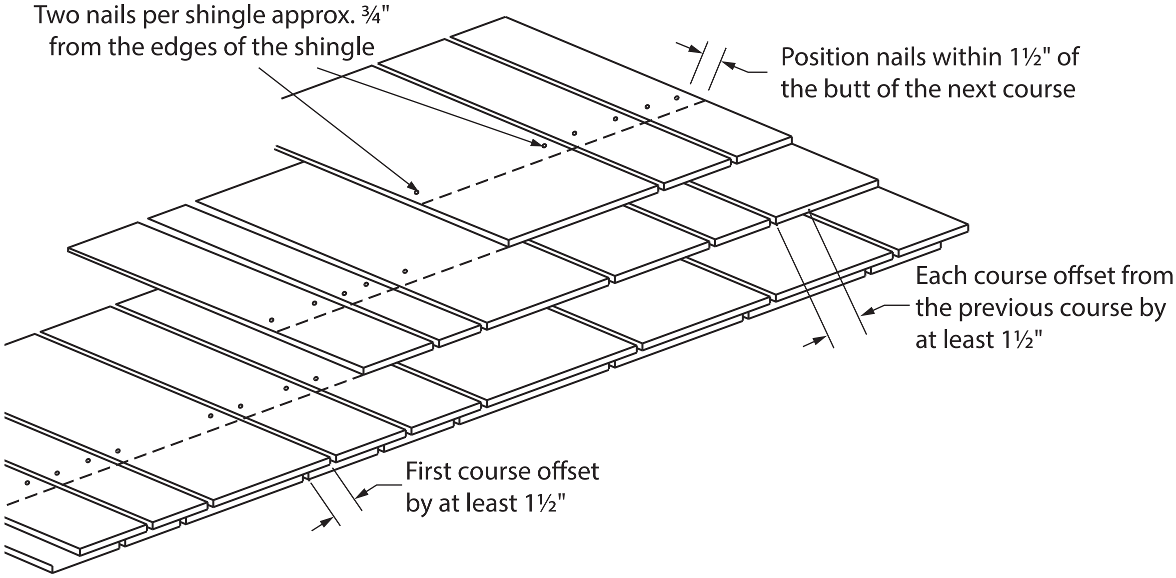

Figure 11— Nailing of cedar shingles

Spacing

Wood shingles should be spaced slightly apart, approximately 6 mm to 9 mm (¼–⅜"). This space is to allow for expansion of the shingles when they get wet.

Trimming

Wood shingles are graded and packed very carefully. There is little waste when using No. 1 shingles. Any sapwood left on the shingles by the manufacturer should be removed. Sapwood is lighter in colour, less dense and tends to rot much faster than heartwood. Do not use flat grain shingles as they will cup and bow.

Grading rules allow for some off-size shingles in each bundle. The *Building Code* requires wood shakes to be between 100 mm and 350 mm wide (4–13¾"). Wood shingles are allowed to range from 75 mm to 350 mm wide (3–13¾").

Hips and Ridge Capping

The hip and ridge capping is done with pre-made caps or by fitting individual shingles together. If making the caps, the overlap of the shingles should alternate left and then right (Figure 12).

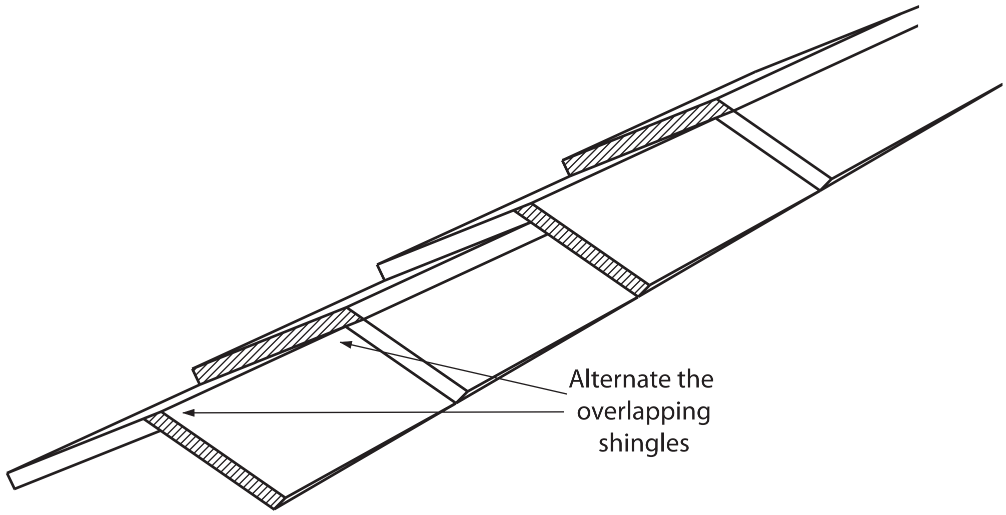

Figure 12— Hip and ridge caps

The bevel on the edge of the overlapping shingles is made with a hatchet and a hand plane. The approximate width of the shingle is trimmed with the hatchet and the angle is made with the hand plane.

The capping of the hips and the ridge is the finish of the roof and must be done carefully. Align the cap shingles to a chalk line to ensure that they are straight. The quality of the capping will often define the quality of the roofing.

Installing Wood Shakes

Installing wood shakes is very similar to installing shingles. The main difference in installation is due to the fact that shakes are split and not sawn. This gives them a rough surface, which will not lie flat against the previous course of shakes.

To prevent windblown snow from entering the attic, the underlay for shakes is installed in strips that are 457 mm (18") wide. A strip of perforated #15 felt underlay is placed between each course of shakes. The location of these strips is important; they must be positioned just above the exposure line of the next course of shakes.

Stripping Existing Roofing

When stripping an existing roof, a safety zone on the ground should be established using barricades or flagging and signage to keep people from entering the danger zone below the roof edges. Stripping is done using flat-bladed shovels or special stripping tools (Figure 13). Normally the work is done from the top down.

Figure 13— Tool for stripping shingle-type roofs

The roof decking should be carefully inspected and repaired, if needed, before applying new roofing.

Re-roofing normally requires a roll-off disposal bin. The bin should have a locking cover so neighbours do not contaminate the load with household garbage or yard trimmings. Bins can damage driveways or landscaping and may require mud sills under the rollers.

Now complete Self-Test 2 and check your answers.

Self-Test 2

1. What is the primary safety concern when working on roofs, and how is safety improved to reduce the danger?

2. What is a proper slope for an extension ladder and how high must it project above the upper landing (roof)?

3. Is it considered safe to carry a bundle of shingles up a ladder?

4. The roof slope is 5:12, the height from the ground to the eave is 8'0", and the worker is 4'0" up the roof (measured on the slope). How high is the roofer above the ground, and is fall protection required?

5. Define the following terms:
   a. Fall protection

b. Fall restraint

c. Fall arrest

6. Using *Section 9.26* of the *Building Code*, look up the requirements for nailing asphalt shingles and for using staples instead of nails.

7. How far above the eave should tools and equipment be stored?

8. How can eavestroughs be protected from ladder damage?

9. Use the *Building Code* to determine the allowable exposure for 18" long #1 wood shingles on a slope of 5:12.

10. What is the minimum joint offset between courses for wood shingles or shakes?

____

11. What is the narrowest shingle allowed for roofing?

____

12. What should be established on the ground for safety when stripping a roof for re-roofing?

____

____

LEARNING TASK 3

Calculate Roofing Materials

Calculating roofing materials is a relatively simple task. The area of each roof section (plane) is calculated, along with the lengths of ridges, hips, valleys and eaves. Although this can all be done on the ground using the building's footprint dimension, plus roof overhang and roof slope, it is often easier and more foolproof to either go on the roof to measure, or to work from a ladder and take measurements.

Calculating Roof Area

The first step in calculating the roof area is to draw a plan view sketch of the roof and divide it into rectangles and right triangles. This is fairly simple with a gable roof like the one shown in Figure 1.

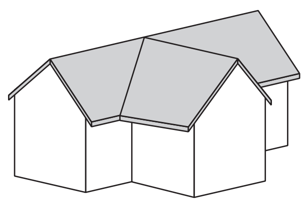

Figure 1—Building with an intersecting gable roof

As shown in Figure 2, this roof can be divided into five rectangles (1–5) and four right triangles (6–9).

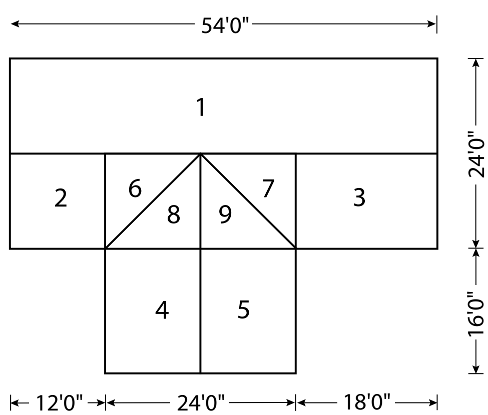

Figure 2—Roof divided into rectangles and right triangles

The measurements shown in Figure 2 can be taken on the ground. These measurements are to the outside of the eave projection.

The roof slope then needs to be determined to calculate the nine roof areas. It can be found on the plans if available; measured using a ladder, level and tape; determined from the ground using a simple handheld device designed for measuring roof slopes; or determined using a roof slope app on a smart phone or tablet.

The next step would be to climb up on the roof and take rafter length measurements. If going on the roof isn't practical due to weather, roofing type or any other reason, the rafter total length is done by calculation.

For the example shown in Figure 2, the roof slope is 6:12 and the run (including projection) is 12 feet for all the rectangles. This will give a total rafter length of 13'5".

Note: Instead of the method shown in Figure 3, the LCPUR (length of common per unit run) can be used to find the 13'5" distance.

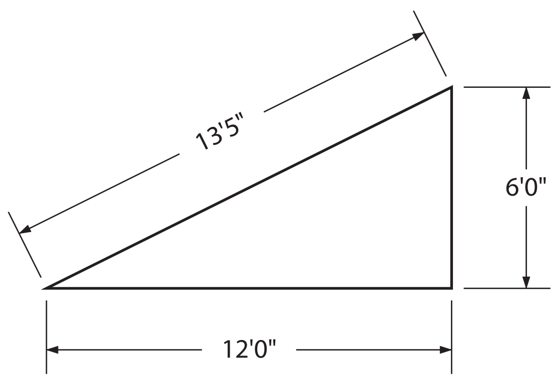

Figure 3—Rafter length

13'5" is converted to 13.42'. The roof area is then calculated as follows:

Area 1 = 13.42 × 54 = 724.68 ft.^{2}

Area 2 = 13.42 × 12 = 161.04 ft.^{2}

Area 3 = 13.42 × 18 = 241.56 ft.^{2}

Area 4 = 13.42 × 16 = 214.72 ft.^{2}

Area 5 = 13.42 × 16 = 214.72 ft.^{2}

Area 6 = (13.42 × 12)/2 = 80.52 ft.^{2}

Area 7 = (13.42 × 12)/2 = 80.52 ft.^{2}

Area 8 = (13.42 × 12)/2 = 80.52 ft.^{2}

Area 9 = (13.42 × 12)/2 = 80.52 ft.^{2}

Total = 1878.8 ft.^{2}

Some rounding up is usually done when measuring roofing. Instead of using 13.42', it would be better to round up to 13.5' and simplify the equation to (13.5 × 116) + (13.5 × 12 × 2) = 1890 ft.^{2}

This process becomes much more complicated for complex roof designs such as is shown in Figure 4. For roofs like this one, if new construction, the sheets of plywood roof sheathing can be counted, using 32 ft.^{2} per full sheet and estimating the area of the partial and angle-cut sheets.

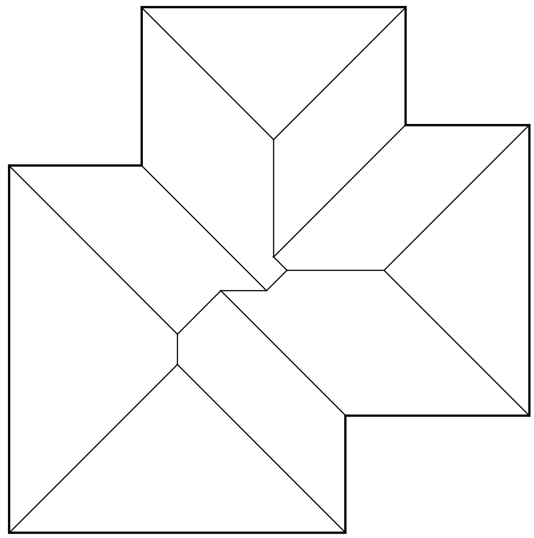

Figure 4—Complicated hip roof

Alternate Method for Calculating Roof Area

Another method to estimate roofing materials is similar to that for roof sheathing: multiply the flat area of the roof (building dimension plus the roof projection) by the slope gain ratio.

Using Figure 5, the flat area of the roof consists of two rectangles:

The major roof including projection is 40' + 1'8' + 1'8"= 43'4"= 43.333' by

25' + 1'8' + 1'8"= 28.333'

The flat area of the major roof is 43.333' × 28.333' = 1228 ft.^{2}

The flat area of the minor roof is 12' × 21.333' = 256 ft.^{2}

The total flat area of the roof is 1484 ft.^{2}

If this roof has a slope of 8 in 12, the slope gain ratio is 14.42/12, where 14.42 is the length of the common rafter per unit of run. This is simply how much larger the roof is on the slope than on the flat.

Total area of the roof is 1484 × 14.42/12 = 1784 ft.^{2}

This would be 17.84 squares or 18 squares.

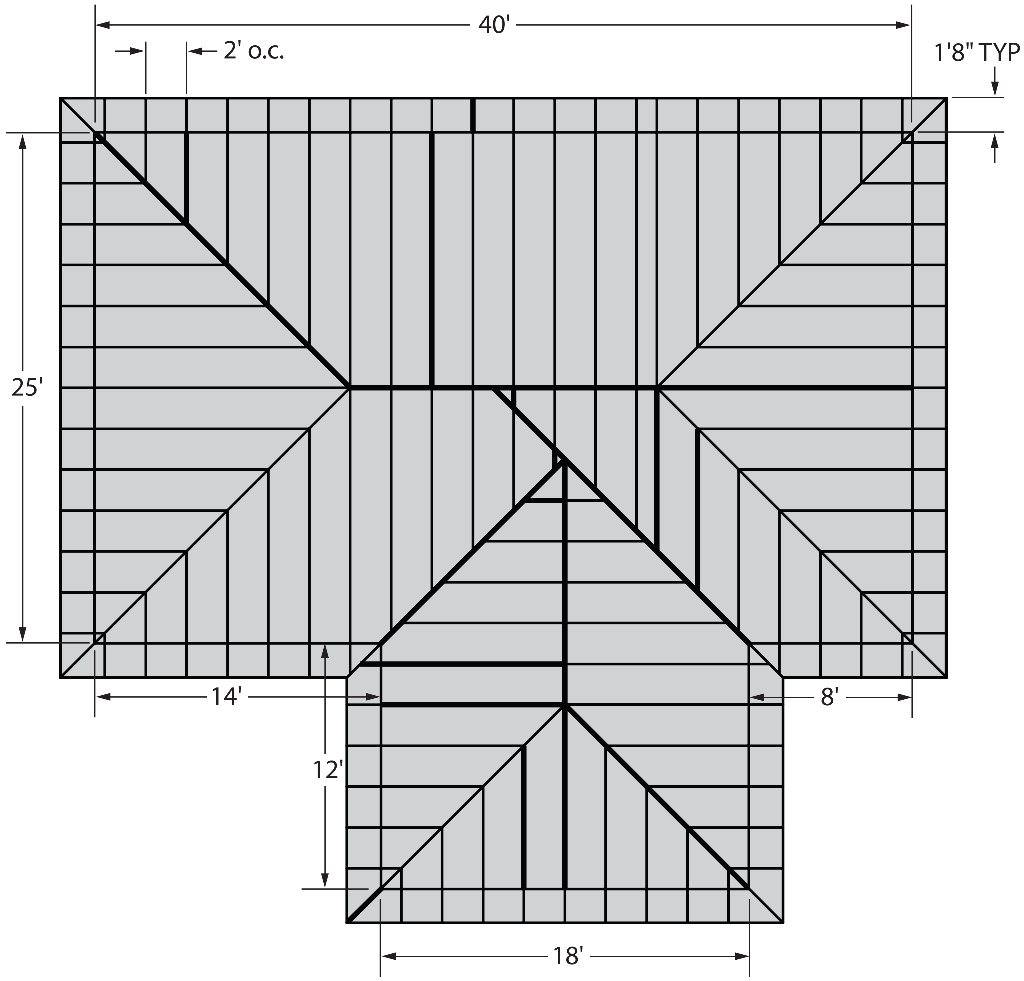

Figure 5— Intersecting equal slope roof

The actual roofing material required is also dependent on the quality of shingles. Typically, it takes three or four bundles of shingle to cover one square. For example, at four bundles per square, this roof would require 18 × 4 = 72 bundles of shingles.

Also required are the starter course, hip and ridge cap, and valley flashing.

The starter course is the linear measurement around the building at the bottom of the roof, equal to the length of the sub fascia. Hip and ridge cap is the total theory lengths of the hips including overhangs, and ridges. Valley flashing is the total length of the valleys including overhangs.

For an unequal-slope roof, the total roof area is slightly more complicated in that each roof area needs to be calculated separately, using a separate slope gain ratio for each.

Using another method that works well for a gable roof, the total roof area is calculated by multiplying the length of the common rafter including the overhang times the length of the ridge (a rectangle) times two sides.

Underlay

If using a single layer of #15 roofing felt for the underlay, a roll will cover 400 ft.^{2} The roof shown in Figure 2 is 1890 ft.^{2}, so 1890 / 400 = 4.7. Thus five rolls of #15 roofing felt are needed for underlay. If the equation had shown 5.0 instead of 4.7, six rolls would be required, as there are two valleys that would each require a full-length piece of #15.

Eave Protection

Eave protection is typically done with type M or S roll roofing (mineral or smooth). The rolls are usually 36" (900 mm) wide, which is the required width for eave protection. The length of a roll, depending on manufacturer, is typically 35.9'.

Assuming the roof planes #4 and #5 in Figure 2 are over heated areas (not over an unheated garage), the lengths needed for eave protection will be:

54' + 12' + 18' + 16' + 16' = 116'

Because of the valleys, a minimum of 6' extra is needed, and preferably 12'.

Calculating the number of rolls needed:

(116 + 12) / 35.9 = 3.6, so four rolls are needed.

If asphalt shingles with closed valleys are being used, two additional lengths of roll roofing would be required, one for each valley. These lengths could be measured on the roof or calculated as shown in Figure 6 using a total rise of 6' and a total run of 17'. The lengths are the same as the total length for the valley rafter (including facia).

Note: Instead of the method shown in Figure 5, the LVPUR (length of hip or valley per unit run) can be used to find the 18' 0 5⁄16" distance.

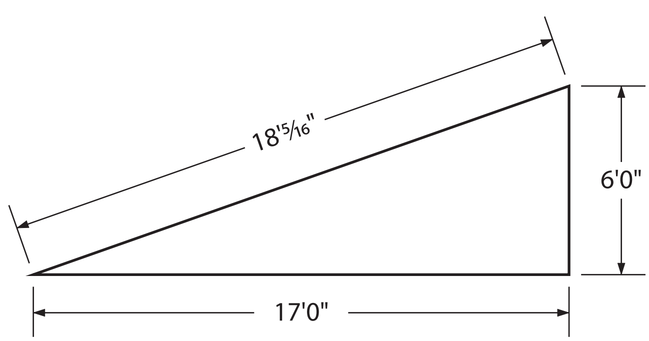

Figure 6—Valley length calculation

Roof Flashing

Assume that the building shown in Figure 2 will have open valleys and a metal drip edge on all eaves. The amount of valley flashing will be 18' × 2 = 36'. The amount of drip edge will be:

54' + 12' + 18' + 16' + 16' = 116'

The flashing can be purchased in 10-foot lengths or be custom ordered full length. If in 10-foot lengths, four valley lengths and 12 lengths of drip edge will be needed.

If the roof has skylights, a flashing set for each skylight would be required. These sets are packaged to supply all the flashing for one skylight based on the skylight size, roof slope and roofing type.

Flashing may also be desired under the ridge caps for added protection and to help control moss growth on the roofing. This product comes in rolls of thin, easily bendable metal. The rolls come in various widths and are 10 feet long.

Flashing will be required where a roof intersects a wall. This flashing will be at least 3" by 3". The *Building Code* specifies the size of flashing at intersections based on several factors, including roof and wall types.

Roofing Accessories

Roofing accessories include plumbing boots, chimney roof jacks for factory-built chimneys, vent hoods for exhaust fans, and roof vents. Also needed will be adhesive to seal the shingles at gable ends for wind resistance and to cover any exposed nail heads.

Metal roofs may require snow stops (also known as *avalanche control*) where people pass under eaves. In winter months throughout much of BC large amounts of snow accumulate on roofs. Vibration as minor as closing an exterior door can be enough to cause an avalanche of snow from a metal roof. Snow stops should always be considered and can be in the form of metal curbs or a pattern of knobs.

Roofing Amounts

Once roof area has been measured or calculated, the amount of roofing to order is based on coverage.

Typically with asphalt shingle roofing, coverage is three bundles per square (100 ft.^{2}). For very heavy asphalt shingles there might be four or even five bundles per square. Wood shingles and shakes are usually four bundles per square.

A three-bundle square of asphalt shingles typically has 21 shingles that are 39⅜" by 13¼" and are designed for a 5⅝" exposure. Actual coverage is 98.4 ft.^{2} per three bundles.

Assuming three bundles per square for the roof area of 1890 ft.^{2} shown in Figure 2:

(1890 / 98.4) × 3 = 57.6 bundles are required.

This amount does not include starter courses, ridge and hip caps, or wastage.

The sample roof has 116' of eave, and if the shingles are 3.28' long, 116 / 3.28 = 35.4 extra shingles are needed for the starter course.

Ridge caps can be purchased or made from shingles. A bundle of shingles (three to a square) will cover 30 linear feet of ridge or hip. The sample roof has 54 + 16 + 12 = 82' of ridge.

Two extra shingles for every foot of valley need to be added. In the example roof, there are 36 feet of valley, so 72 extra shingles are needed.

Total amount of shingles needed for the example house is:

57.6 bundles (based on area)
1.7 bundles (for starter)
2.7 bundles (for ridge)
3.4 bundles (for valleys)
65.4 bundles total

Calculating the amount of bundles for wood shingles or shakes is done using similar methods.

Waste

The simplicity or complexity of the roof design will heavily influence the amount of waste to plan for. Normally 5% is enough, but complex roofs may require as much as 10%. Since our example roof is relatively simple, 5% would be appropriate:

65.4 × 1.05 = 68.7 or 69 bundles.

Normally unopened undamaged shingles can be returned, and many roofers order two extra bundles in addition to the waste factor to make sure they will have enough.

Fasteners

Always check the *Building Code* for the correct type and size of fastener that is required. Asphalt shingles use either four or six fasteners per shingle. Assuming the example house is using the four-fastener method, the number of nails or staples needed would be:

69 × 21 × 4 = 5796 (bundles) × (shingles per bundle) × (fasteners per shingle).

Now complete Self-Test 3 and check your answers.

Self-Test 3

Use Figure 1 below to answer the following questions. Assume a roof slope of 5:12, asphalt shingle roofing (three bundles per square), all roofing is over heated areas (except for overhangs), open valleys and metal drip edge flashing. Measurements are to roof edges.

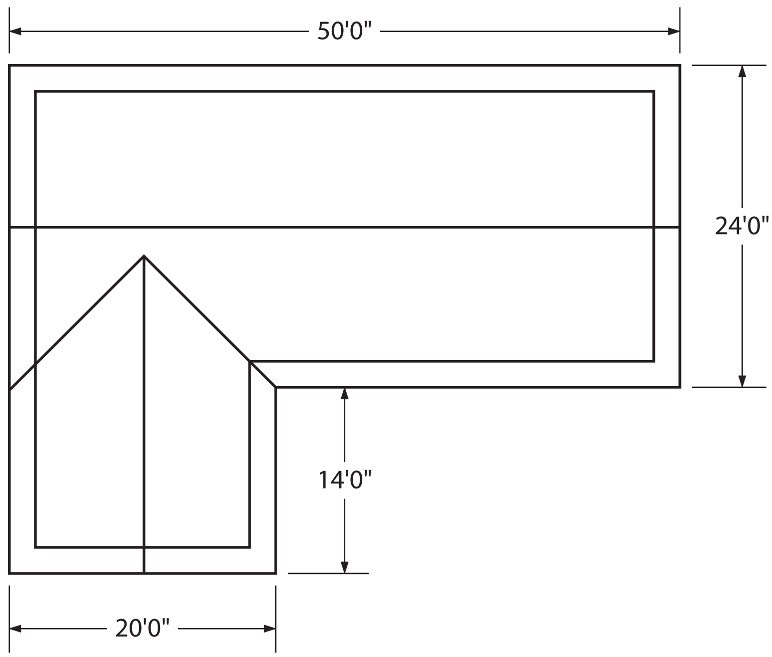

Figure 1

1. Divide the roof into the minimum number of rectangles and right triangles. What is the area of each of these and what is the total area? (Round numbers up to one decimal place.)

2. How many rolls of #15 roofing felt are needed for a single layer of underlay coverage?

3. How many rolls of type S roll roofing are required for eave protection?

4. How long is each valley?

5. How many bundles are needed for:
   a. Roof area:

   b. Starters:

   c. Ridge capping:

   d. Valleys

6. Including 5% for waste, how many bundles are needed for this roof?

Answer Key

Self-Test 1

1. asphalt, wood, metal, slate and tile
2. ½" in 12" (1:50)
3. Fire or rot
4. Shakes are thicker (butt thickness of between 9 mm and 32 mm) and are split on one or two faces (except taper-sawn shakes).
5. roof slope, shingle length and shingle grade
6. built-up, membrane, cold application felt roll roofing
7. fire and algae resistant, lightweight and long lasting
8. The roofing's weight requires the building's structural design to be increased to support the additional load.
9. to prevent leaks due to ice damming
10. membrane
11. to remove excess moisture and to prevent overheating
12. 600 mm
13. to create a groove in a concrete wall for counter flashing
14. to make framing easier by providing the required slope using insulation

Self-Test 2

1. falls when working at heights; the use of fall protection equipment
2. 4:1 (v:h) and 36" above
3. No
4. 9'8" above the ground. Fall protection is only required if the ground surface is jagged or rough.
5. a. Can include guardrails, personal fall protection systems (restraint and arrest), safety nets, control zone and safety monitor system with control zone.
   b. Restricts travel using harness or belt with suitable and compatible components (D-ring, lifeline and/or lanyard, rope grab and anchor).
   c. Prevents a falling worker from hitting any object and from hitting the ground at any level below the work area. Uses a harness and compatible components (D-ring, lifeline, lanyard, shock absorbers, rope grab and anchor).

6. Must penetrate at least 12 mm into or through the sheathing, head diameter of at least 9.5 mm and a shank thickness of not less than 2.95 mm. Staples must have the crown parallel to the eaves, be not less than 19 mm long, 1.6 mm diameter or thickness, with not less than a 25 mm crown (11 mm crown allowed if 6 staples are used per shingle).
7. at least 2 m (6½')
8. by using blocking or ladder standoffs
9. 140 mm (5½")
10. 40 mm (1½")
11. 75 mm (3")
12. a safety zone using barricades, or flagging and signage

Self-Test 3

1. Area 1 50 × 13 = 650
   Area 2 20 × 2.2 = 44
   Area 3 30 × 13 = 390
   Area 4 14 × 10.9 = 152.6
   Area 5 14 × 10.9 = 152.6
   Areas 6–9 (10 × 10.9) × 2 = 218
   Total roof area = 1607.2 ft.^{2}
2. 1607.2 / 400 = 4.018, therefore 5 rolls
3. 50 + 30 + 14 + 14 = 108' of eave
   (108 + 12) / 35.9 = 3.34, therefore 4 rolls
4. LVPUR = 17.72", so
   10 × (17.72 / 12) = 14.8 feet
5. a. (1607.2 / 100) × 3 = 48.3 bundles
   b. (108 / 3.28) / 21 = 1.6 bundles
   c. 74 / 30 = 2.5 bundles
   d. (30 × 2) / 21 = 2.9 bundles
6. (48.3 + 1.6 + 2.5 + 2.9) × 1.05 = 58.07, therefore 59 bundles

7960003837

ISBN 978-0-7726-7150-9

9 780772 671509