The effects of direct solar gain should be carefully considered. The surface temperature of exposed copper can be significantly higher, by 70 to 80 degrees or more, than the surrounding ambient temperature. The effects of this additional gain, commonly called "superheat", must be anticipated, as increased thermal movement will occur.

- **Building Orientation** Consideration should be given to the relationships between roof components, such as the ridge, eave, parapet, and the direction of prevailing wind, rain, and sun. The intensity of many issues discussed above will depend on the exposure of each roof component. For example, ice build-up on a gutter is more likely to occur on the North side of a building or a partially shaded area of an eave. Wind can exert extreme positive pressure on a coping in one area and negative in another.

- **Staining** With good design, staining from run-off can be minimized or eliminated. In brief, staining occurs when moisture that has been in contact with copper, drips off onto adjacent porous or reactive materials. The primary methods of preventing staining include the use of gutters, architectural overhangs, drip edges, careful material selection and sealers. In addition, the designer can try to divert water away from places where it may cause stains. Where parapet covers or copings are used, for example, the top surface should be sloped toward the roof side, to minimize the amount of water that drips off the outside face.

- **Patination** The natural weathering process that leads to the patination of exposed copper surfaces usually takes many years to complete. A number of processes have been developed to quickly produce a patina. Although the industry has continued its development efforts in this area, and occasionally new methods and products are introduced. Please contact **CDA Project Managers & Architectural Applications Specialists** for current information.

7. BASIC DETAILS

Introduction

Copper has been used as a construction material for centuries. During this time, it has achieved an excellent record for low maintenance and durability. Proper design and construction are essential to ensure high quality, long-lasting installations.

This section contains details and descriptions of the basic components commonly used in sheet copper construction. These include various seams, expansion joints, edges, hold-downs, and cleats.

Attachments

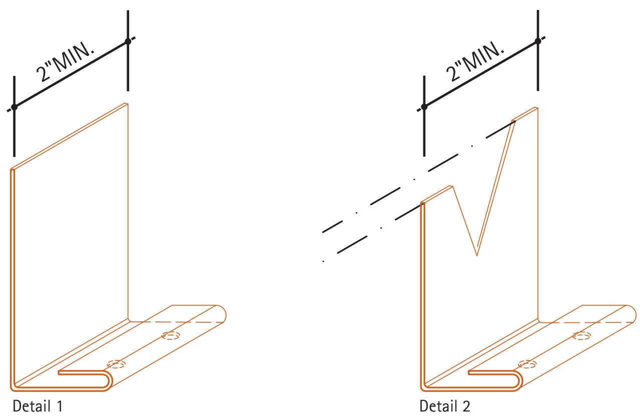
All fasteners should be of galvanically compatible metals, such as copper, copper alloys, like brass or bronze or neutral stainless steel alloy. Washers or Expansion shields, when necessary, must also be of galvanically compatible or neutral materials. Copper, copper alloy, lead, rubber and plastics are all common.

- **Cleating:** This is the most commonly used method, because it allows the copper to move, minimizing the potential for buckling. Cleats are usually made of 16 oz. copper, although they need not be heavier than the material being secured. Cleats made of compatible stainless steel are also acceptable. Two types of cleats are used. Fixed cleats allow a small amount of movement, while expansion cleats typically allow up to 3/4" total movement. Fixed cleats are usually suitable for short pan construction. Long pans require the use of expansion cleats, see 8.8. Long Pan Systems. Cleats are typically spaced at a minimum of 12" on center.
- **Nailing:** This method is predominantly used where movement is not desired, such as at a base flashing at built-up roofs, gravel stops, and eave strips. Nailing is used only on cleats and copper strips up to 12" wide. Only one edge of a strip should be nailed, to allow movement perpendicular to the line of nailing. Nails should be spaced no more than 3" O.C. to provide continuous resistance to thermal stresses. All nails should be flathead, wire slating nails, at least 1" long, of not less than 12 gauge hard copper, brass, or bronze. Those used in wood should be barbed; nails used in concrete or gypsum should not. Surfaces with poorer nail-holding qualities require longer, stronger nails. For the right nail to use with such material, contact the manufacturer.
- **Screwing**: This method is used where the copper must be held rigidly in place, such as at a ridge cap subject to the severe vibrations caused by wind, or as a hold-down for large, flat copper areas. It is also used to secure copper to masonry when expansion shields are required. Screws should be made of stainless steel, bronze, or brass. They should have round heads, and flat seats which will not puncture the copper. Galvanically compatible metal washers may be used for additional protection. Where watertightness is required, a small copper cap is soldered over the screw head, see Detail 7.1B.

7.1. Attachments

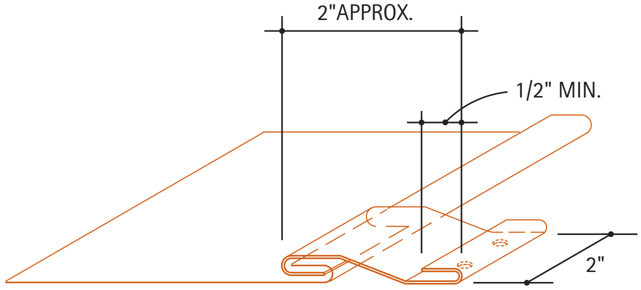
7.1A. Typical Copper Cleats

The typical copper cleats shown are usually 16 oz. copper, at least 2" wide. They are attached to the deck or nailable inserts with two copper, brass, bronze, or compatible stainless steel nails or screws. When cleats are used on flat or nearly flat surfaces, the end of each cleat should be folded back over the nail heads to prevent possible damage to the covering sheet by expansion and contraction, traffic or other forces. When fixed cleats are used on vertical surfaces or not exposed to traffic, this is not necessary.



TYPICAL FIXED CLEATS, STANDING SEAM

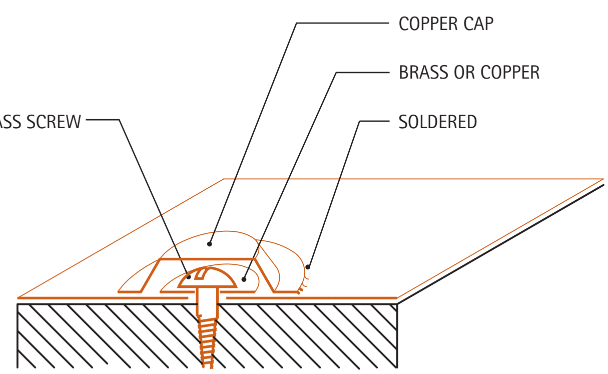
Detail 1: is used to form a hook over the upstanding flange of the lower pan only, allowing some differential movement between pans in a standing seam roofing system. **Detail 2** is used to form hooks over both upstanding flanges of the pans in a standing seam roofing system, locking them both together to minimize differential movement.



TYPICAL COPPER CLEAT INSTALLED, HEMMED EDGE

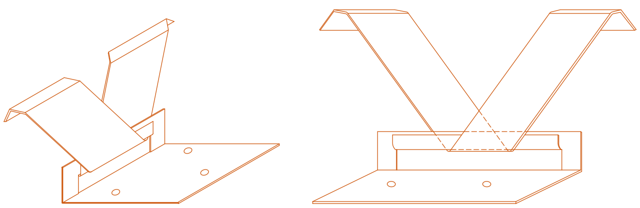
7.1B. Typical Copper Hold-Downs

Copper hold-downs are used to prevent the lifting of large, flat portions of copper from the substrate, while allowing thermal movement. They are typically used on wide gutters, extended gutter apron pieces, and wide apron flashings. For the through fastener hold-down, the maximum recommended spacing is 4 feet longitudinally, and 18" transversely. The screw should be brass No. 12 x 3/4" round head, with an expansion shield if used in masonry. A large brass or copper washer, 1-1/4" diameter, should be placed under the screw head. The screw should be tightened sufficiently to keep the metal flat, but not restrict its movement. After the hold-down is in place, a 16 oz. copper cap should be soldered over the assembly to provide watertightness.

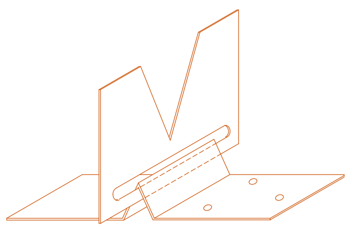


7.1C. Expansion Cleats

Expansion cleats are typically used on long runs of standing seam roofing. Movement caused by thermal expansion and contraction is transmitted towards the ridge and eaves. Expansion cleats relieve the stresses that weaken the holding power of fixed cleats on long runs.



TYPICAL EXPANSION CLEAT

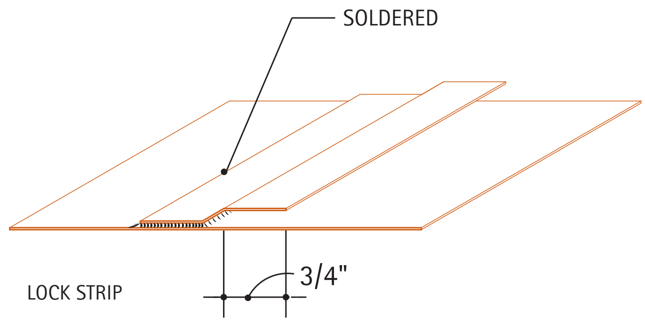


ALTERNATE EXPANSION CLEAT

Two types of expansion cleats are shown. One utilizes a full-width sliding tab. The other is formed into a in "V", so that the cleat legs do not fold over onto each other. This reduces the build-up of copper material in the finished joint. Various other types of expansion cleats are available throughout the industry.

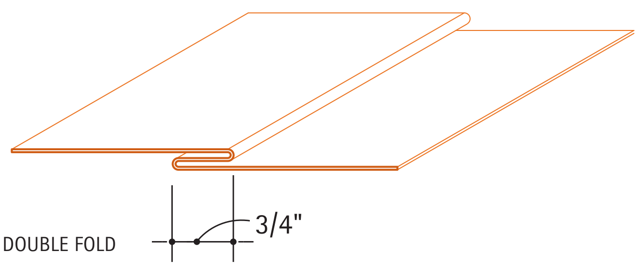
7.1D. Lock Strips

Two restraining methods are illustrated. Both are designed to prevent vertical wind uplift of roof pan edges, but allow horizontal expansion and contraction. The lock strip is a continuous strip usually of 20 oz. copper, soldered or fastened to a substrate. Its leading edge is raised to allow the end of a copper sheet to be locked over into a 3/4 inch lock.



LOCK STRIP

The double-fold is utilized in areas where conditions are limited in space. The copper base sheet is folded into a raised lip to allow the end of a "top sheet" to be locked over into a 3/4 inch lock.



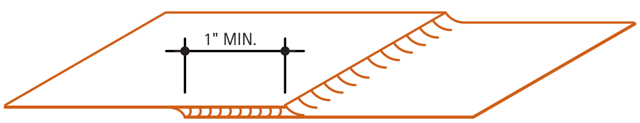
DOUBLE FOLD

7.2. Joints and Seams

Rigid Seams

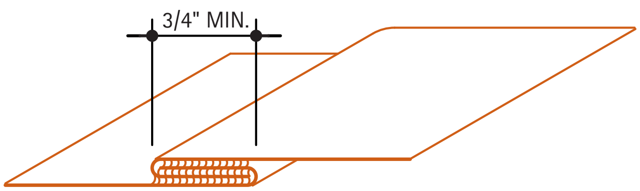
7.2A. Lap Seam, Soldered

This seam should only be used on copper sheets with weights up to 20 ounces.



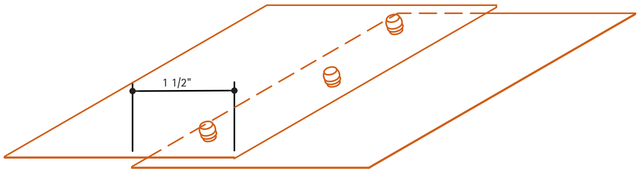
7.2B. Flat Lock Seam, Soldered

This seam provides a positive mechanical connection between adjacent sheets. It should not be used for copper sheets weighing more than 20 ounces per square foot. It should be used where watertightness is required.



7.2C. Lap Seam, Riveted

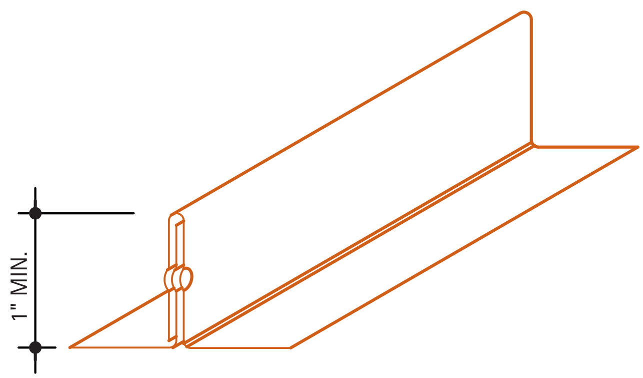
This seam provides a strong mechanical connection for copper sheets. It should only be used where watertightness is not required.



Where strength of seam is a major consideration, solid rivets should be copper or copper alloy, 1/8" to 3/16" in diameter and spaced 3" O.C. in two rows in a staggered pattern. The use of 1/8" pop rivets of either copper or copper alloy should be restricted to applications where strength of seam is not a major consideration.

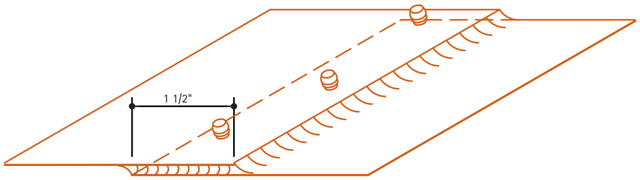
7.2D. Single Lock Standing Seam, Button Punched

This is one type of standing seam. Both copper sheets are bent up where they meet. One is longer than the other. The longer one is folded over the shorter one. They are then button punched to provide a more rigid, mechanical connection. Only suitable for small, noncritical areas—not a roofing system.



7.2E. Lap Seam Riveted and Soldered

This seam offers a strong, watertight joint. The rivets provide strength, while the solder provides a watertight seal.

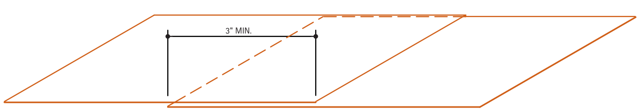


Loose Seams

This type of seam allows thermal expansion and contraction by sliding or flexing. It can be made watertight by the use of high quality flexible sealants, such as butyl, polysulfide, silicone, or urethane, which do not restrict movement.

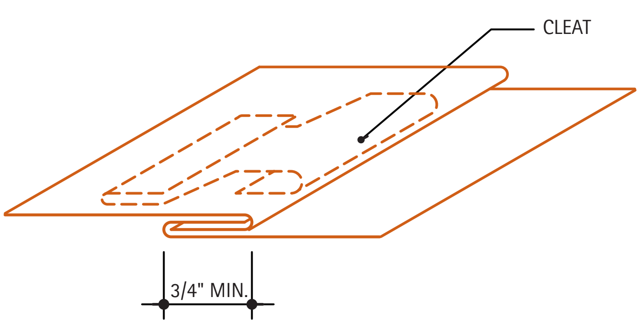
7.2F. Lap Seam

This seam is not used where water-tightness is required. It allows free movement of the copper sheets.



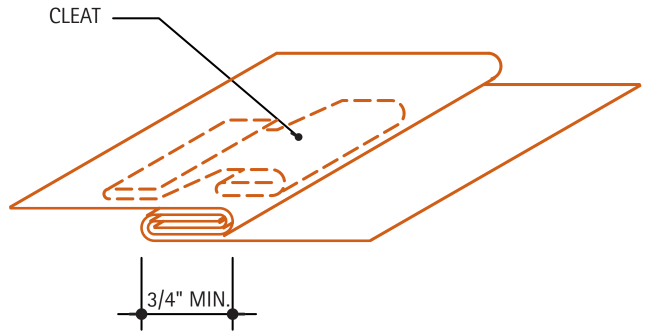
7.2G. Flat Lock Seam, Cleated

The cleats are used to secure the sheets to the understructure. Cleats should (in general) be spaced a maximum of 12" O.C.



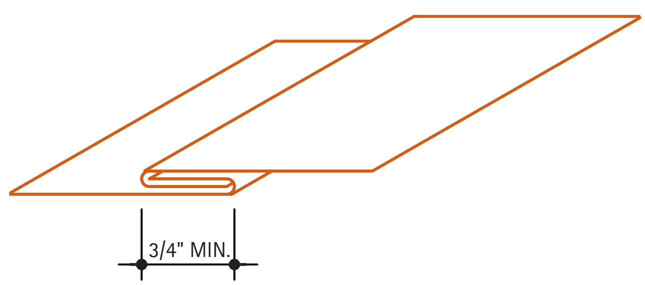
7.2H. Double Lock Seam, Cleated

This seam is essentially a single lock seam with an additional fold. It develops increased mechanical strength and watertightness.



7.2I. Common Lock

(also referred to as a hook seam or single lock seam) This seam provides for a mechanical connection between the copper sheets. The hook in the lower sheet provides a degree of security against water penetration as long as it is not submerged. It also provides a good place for sealant when used.



Expansion Seams

This type of seam is used wherever significant movement of the copper sheets is expected. Expansion and contraction are a function of temperature change, material properties, and the dimensions of the material. The amount of movement can be calculated with the following general formula:

$dL = L \times E \times dT$

Where:

dL = change in length (expansion or contraction)

L = Length of copper material

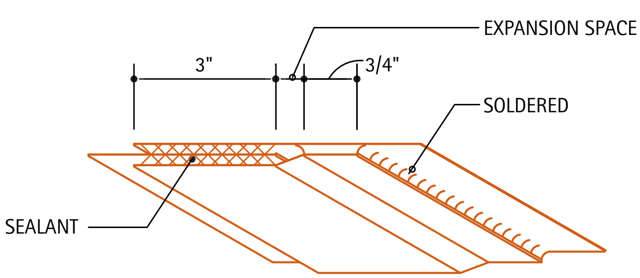
E = coefficient of linear expansion of copper = 0.0000098 per degree Fahrenheit

dT = temperature change in degrees Fahrenheit

Calculation of movement is rarely required in short roof pan construction, since the details shown here can accommodate thermal movement of short pans.

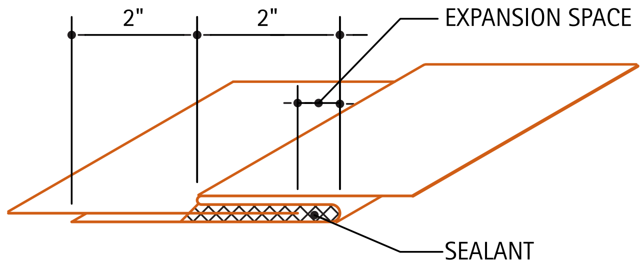
7.2J. Clevis Seam

This seam is similar to the slip expansion seam. The difference is in forming the lock. Where as the slip expansion lock is formed by braking a sheet of copper, the lock on this seam is formed by soldering a small strip of copper below the sheet.



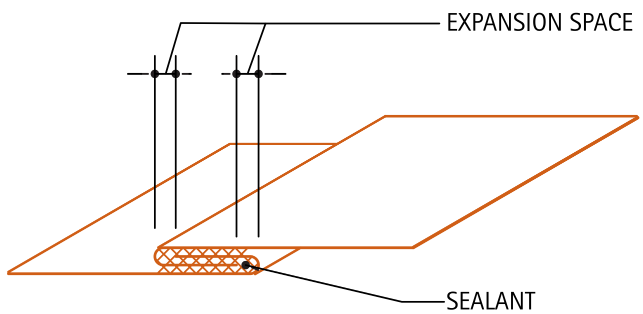
7.2K. Slip Expansion Seam

The tail piece of the formed lock section may be nailed to secure it more firmly to the substrate. The joint is filled with sealant for watertightness.



7.2L. Loose Lock With Sealant

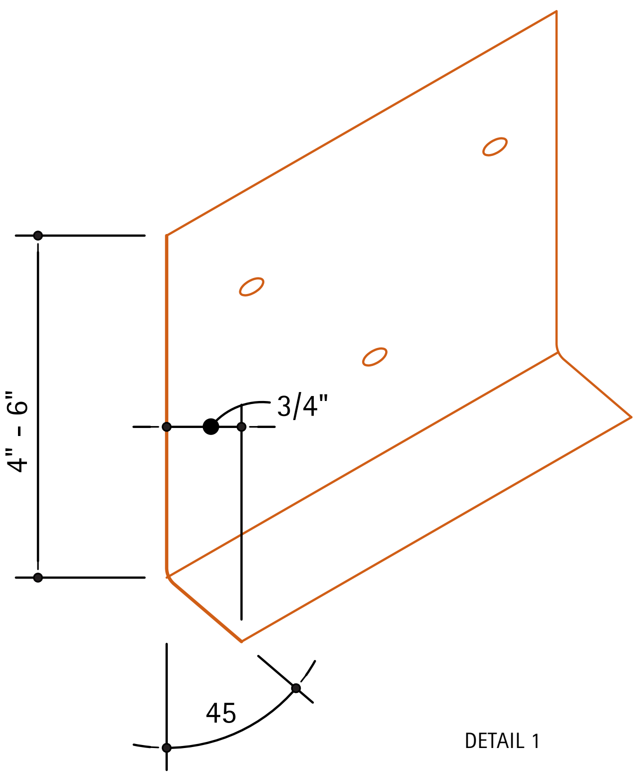
This expansion seam is formed by filling a loose lock seam with a non-hardening, elastic sealant. The space between locks is required to allow for expansion and contraction.



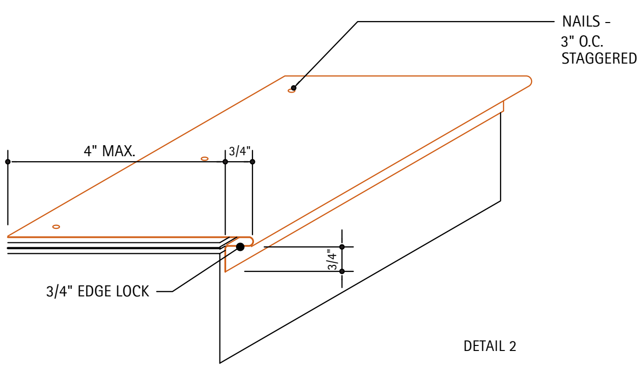
Corner Seams & Edges

7.2M. Edge Strip

Two edge strips are shown. Edge strips are used for securing copper roofing at eaves, gable ends, etc. The edge strip shown in **Detail 1** is attached to the fascia board with nails at 3" O.C. The locking strip is turned out 45 degrees a minimum of 3/4".



DETAIL 1

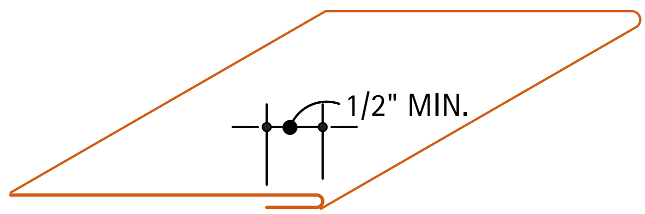


DETAIL 2

The horizontal flange in **Detail 2** projects back onto the roof a maximum of 4". It is secured with copper or copper alloy nails spaced 3" apart. The locking member is hemmed for at least 3/4".

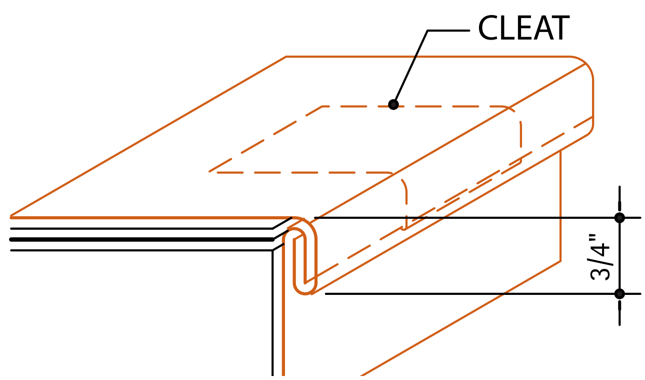
7.2N. Hemmed and Brake Formed Edge

These are used as edge stifferes at free edge.



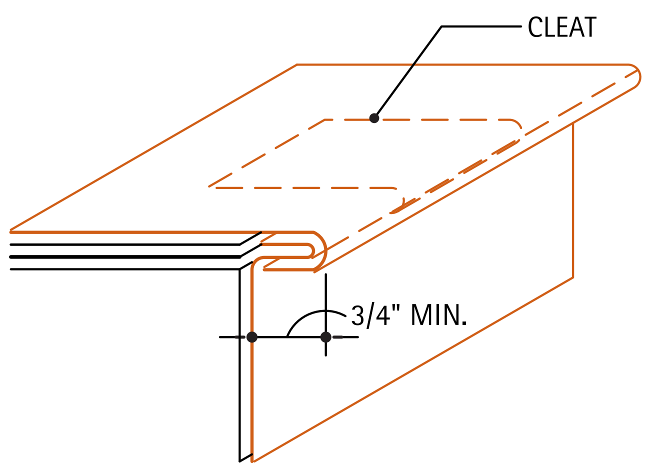
7.2O. Double Seam Corner Lock

This detail is preferred over the single seam corner lock because the folds provide a more secure edge. It should be used if the copper fascia is part of an overhang detail.



7.2P. Single Seam Corner Lock

The end of the copper sheet is locked over the edge strip in a 3/4" lock.

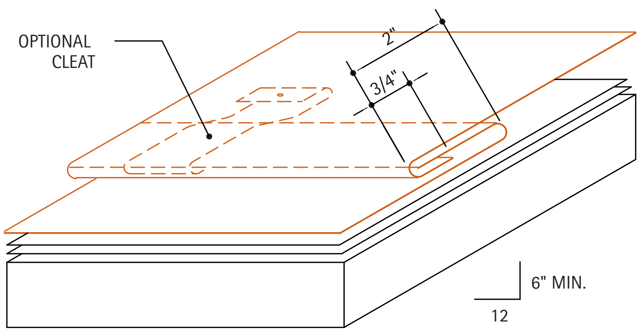


7.3. Additional Loose Lock Seams

Transverse Seams: Transverse seams are often used on copper standing seam and batten seam roofs. See specific roof type for requirements.

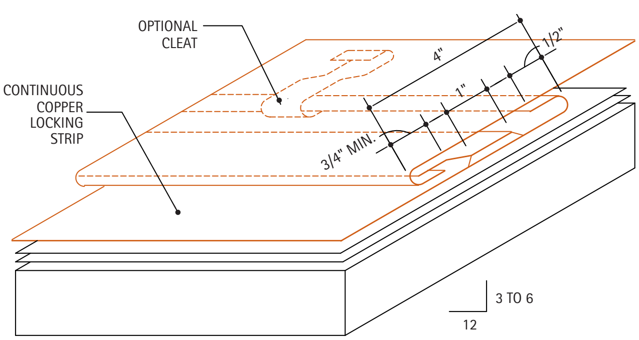
7.3A. Narrow Loose Lock – Transverse Seam, Steep Pitch

This variation is limited to roof slopes of at least 6" per foot. The upper edge of the lower sheet is folded over 2". Cleats may be used at transverse seams to facilitate installation and limit movement. The lower edge of the upper sheet is then folded under ¾" and locked into the lower sheet.



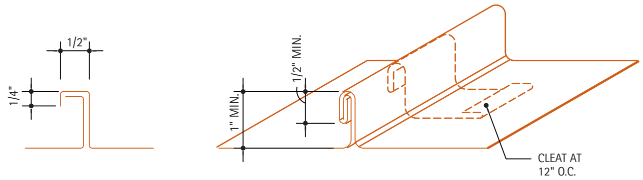
7.3B. Wide Loose – Lock – Transverse Seam, Low Pinch

This seam reduces the chance of water penetration through wind action and is recommended for slopes 3" to 6" per foot. Here, the lower sheet is folded over and lapped at least 4" by the upper sheet. Cleats may be used at transverse seams to facilitate installation and limit movement. An additional copper locking strip is soldered onto the lower sheet, into which the upper sheet is locked.



7.3C. Standing Seam

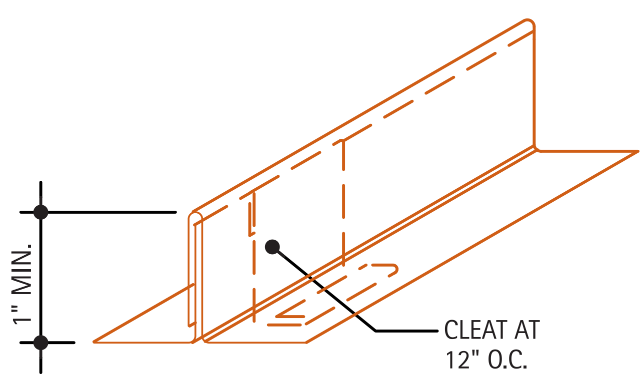
This is the typical standing seam. The copper sheets are bent up where they meet. One sheet extends 1/8" higher than the other. This extension is folded over the end of the shorter sheet. The two sheets are then folded over together. Cleats, 12" O.C. along the seam, are folded in together with the copper sheets.



On flat surfaces the finished seam may be almost any height, but should be at least 1" with a ½" lock. Seam heights of 2" or more suffer in appearance and are not recommended. On curved surfaces, such as domes and barrel arches, seams may be ½" to ¾" high, in order to facilitate installation. Transverse seams should be avoided in areas where the curved surface results in slopes less than 3" per foot.

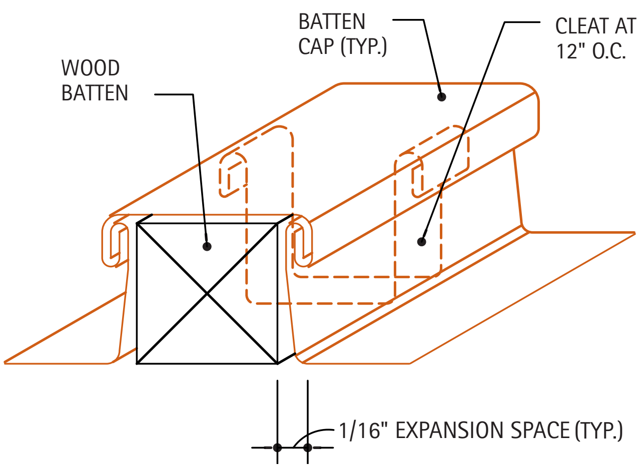
7.3D. Single Lock Standing Seam

This is the simplest form of a standing seam. The copper sheets are bent up where they meet. One sheet extends up 1" beyond the other. This longer upstand is then folded down over the other. This seam is not recommended in high wind areas, roofing or wall cladding of any significant size, strength or water tightness.



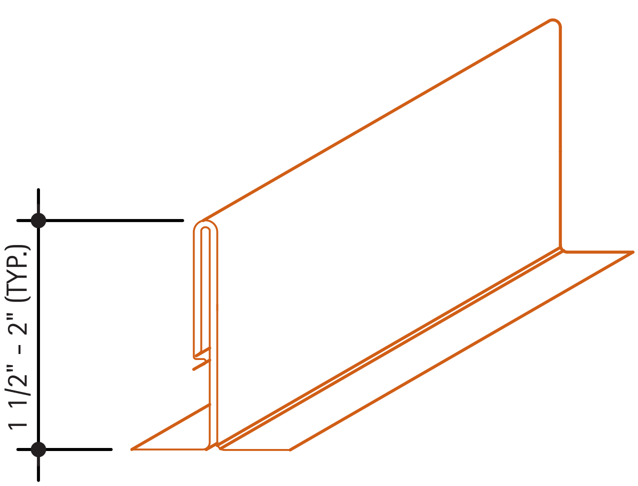
7.3E. Batten Seam

This typical batten seam shows a square batten. The expansion space is provided by folding the copper sheets up 1/16" short of the batten. An alternative method is to use tapered battens, that are 1/16" narrower on each side at the bottom than at the top. This second approach allows the upstanding legs of the copper pans to be vertical. Transverse seams should be avoided in areas with slopes less than 3" per foot.



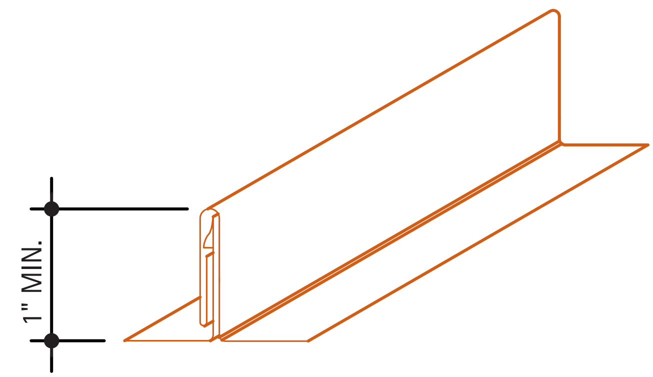
7.3F. Pre-fabricated Standing Seam

This detail shows a typical standing seam that is part of a pre-fabricated roofing system. Its properties are similar to the Snap Lock Standing Seam discussed below. These systems vary with manufacturer and are proprietary. For additional information and specific system performance consult the respective manufacturer's literature.



7.3G. Standing Seam with Snap Lock

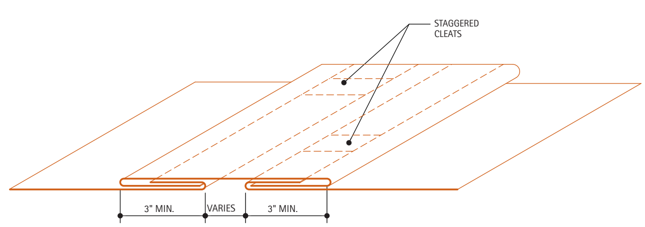
This is another variation of the typical standing seam, most often used in prefabricated standing seam roofing systems.



The edge with the lock is cleated to the deck. The adjacent pan is pressed over the lock until it snaps securely. Sealant may be applied, either at the shop or in the field, for low pitch conditions, consult manufacturer. This type of system does not usually require additional finishing such as button punching or field seaming.

7.3H. Drive Cleat or Lock

This method of joining separate sheets of copper is similar to the common lock, except that it uses an intermediate copper strip. This seam can act as an expansion relief, such as in parapet caps.



8. ROOFING SYSTEMS

Introduction

Copper offers a character and durability that no other metal roof can match. Its appearance can complement any style of building, from the traditional to the modern. Its warmth and beauty make it a preferred material for many architects.

The use of copper is based upon traditional practices proven over many years. There are numerous examples of copper roofs which have been in place one or more centuries. Copper's resistance to the elements ranks among the highest of modern roofing materials.

When properly designed and installed, a copper roof provides an economical, long-term roofing solution. Its low life cycle costs are attributable to the low maintenance, long life and salvage value of copper. Unlike many other metal roofing materials, copper requires no painting or finishing.

Through its natural weathering process, the warm bronze tones can be expected to lead to the elegant green patina finish. There are also a number of methods available to retard or accelerate the weathering process. These methods are currently under study, with results to be issued in subsequent updates. See **3. Finishes** for current information, or contact CDA.

The ductility and malleability of copper make it an easy material to form over irregular roof structures. Domes and other curved roof shapes are readily handled with copper.

In recent years, new tools and installation methods have been introduced that aid in the quick, proper, and economical installation of copper roofs.

Typical Requirements

- **Decking Requirements:** Different roofing systems have different fastening requirements. In general, they can be divided into two categories: those systems that use cleats secured to battens and those whose cleats are fastened directly to the roof deck.

  Batten systems may be applied over any type of decking. On concrete, gypsum, or steel decks, the wood battens may be secured by thru-bolts, expansion inserts or similar anchoring devices.

  For systems that use cleats secured directly to the deck, it is imperative that the holding power of the deck is adequate to sustain design wind conditions. If the surface to receive the roofing is other than wood or a nailable deck, nailing strips or inserts must be provided to secure the cleats. Nailers should, in general, be installed transverse (perpendicular) to the seams rather than parallel to them since variations in the widths of finished pans make it impossible to assure proper alignment of seams over parallel nailers for an entire roof.

- **Materials:** Copper roofing is typically constructed using 16 oz. or 20 oz. cold rolled copper sheets. Sheets can be either preformed or formed in the field into pans. Pans up to 10 feet long are considered short pans. Roofs using pans longer than 10 feet should be designed to accommodate additional movement at the ends of the pans. For additional information, see 8.8. Long Pan Systems.

The copper pans rest on 4 lb., minimum, rosin-sized smooth building paper. The underlayment is typically 30 lb., minimum, saturated roofing felts. Other materials may be substituted in specific applications. See the specifications and manufacturers' recommendations.

- **Surface Preparation:** The surface preparation for copper roofing systems is similar. The deck should be thoroughly dry, smooth, and free from projecting screws, nail heads or other imperfections. The entire surface should be covered with an approved underlayment secured with copper nails and washers. The underlayment, which is often saturated roofing felt, acts as a cushion, as well as providing temporary weather protection for the roof deck.

  A sheet of building paper must be applied over the felt. Because copper has a tendency to conduct heat, elevated temperatures can cause asphalt in the underlayment to bond the copper to the roof deck. This inhibits the movement of the copper roof and can result in premature fatigue. The building paper acts as a slip sheet to prevent such bonding.

- **Equipment:** A variety of power pan formers and power seamers are available to assist in the construction of copper roofs. Power pan formers can take flat or coiled, sheet or strip copper and produce roofing pans on site. They result in high quality, uniform pans whose length is limited only by the contractor's ability to transport and handle the material (pan lengths should not exceed the recommendations in the 8.8. Long Pan Systems). Pan formers typically have the ability to produce pans of varying width with 1" high standing seams.

  Power seamers are used to produce finished standing or batten seams. The seamers are engaged onto an unfinished seam and propel themselves under electrical power the length of the seam. They can form seams of virtually any length.

8.1. Special Roofing Design and Installation Considerations

One of the most important issues in the use of copper is the relative movement of components. Movement can occur as a result of internal stresses due to temperature changes, or from external sources such as wind, ice, or movement in the substrate. Since copper is most often used as a water barrier, installations must account for the anticipated movement as well as prevent the infiltration of water.

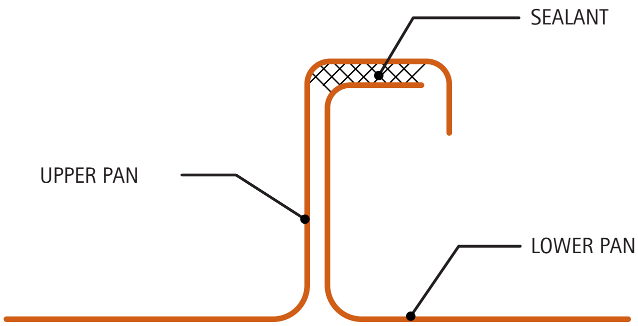
This section presents key information on practical limits and Special Conditions. For additional information on thermal stresses see **1.4. Structural Considerations**.

Providing an effective path for water to flow in a controlled direction is one of the most important principles in design and construction. **Table 8.1A** shows the recommended minimum slopes for various copper roofing systems using the details shown throughout this Handbook. Lower slopes are possible under certain conditions, using modified details. **Table 8.1B** shows the minimum recommended slopes using these special details. The modified details are discussed below. Only flat seam roofing is constructed to be completely watertight, and therefore can sustain standing water. **Table 8.1C** outlines the recommendations regarding flat seam construction.

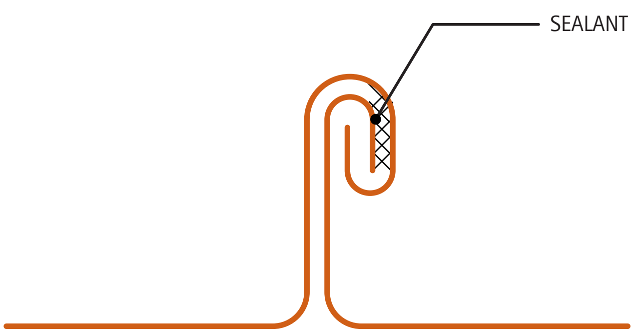
Mansard roofs are usually steep, but they often have changes in their slope. They are based on either standing or batten seam roofing. The minimum recommendations, are therefore, the same as the "base" standing or batten seam roof.

8.1A. Standing Seams

Before the two pans are locked, a compatible quality rubber or synthetic based sealant should be applied to the top of the flange of the lower pan. Transverse seams should be based on the "low pitch" option. **See Detail 8.2C**.



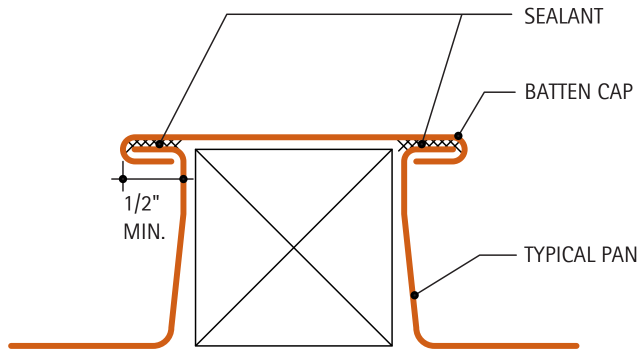
DURING CONSTRUCTION



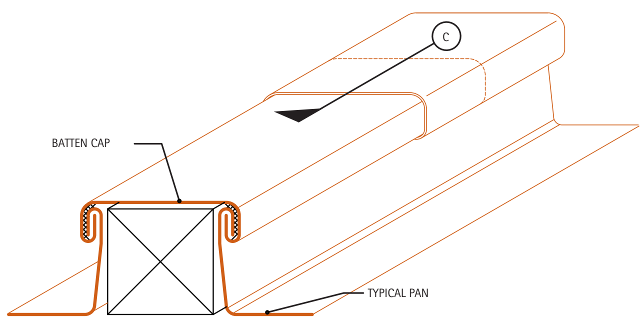
COMPLETED SEAM

8.1B. Batten Seams

A compatible quality rubber or synthetic based sealant should be applied to the top flange of each pan prior to installation of the batten cap.



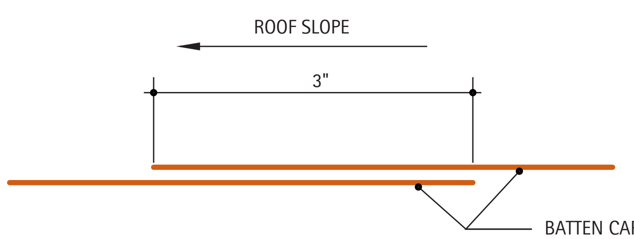
DURING CONSTRUCTION



COMPLETED SEAM

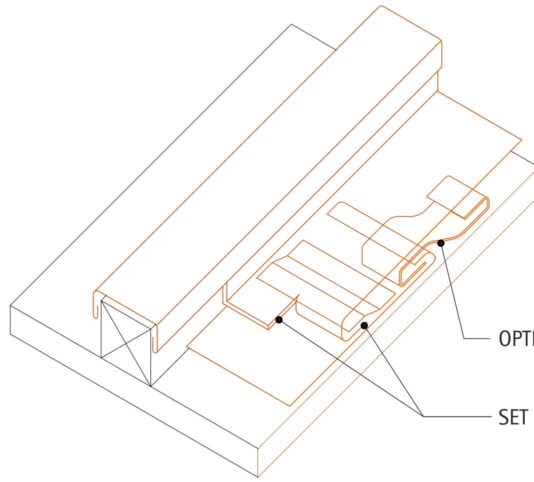
8.1C. Batten Cap

Where batten caps join, a 3" lapped seam is required



8.1D. Transverse Seam for Batten Roof

A continuous compatible sealant must be applied in the lock formed by the soldered locking strip immediately before placing the upper pan on the roof. After engaging the ends of the pans, seams should be dressed down to a thickness of not less than 1/8”, and a continuous bead of sealant should be visible the entire width of the pan. The lap of the upstanding legs of the pans should also be set in sealant.



The optional cleat shown can be used to hold the roofing pans during installation. This is particularly helpful on a steep roof.

Table 8.1A. Minimum Recommended Roof Slopes Using Standard Details

Conditions	*Standing Seam*	*Batten Seam*	*Chevron*	*Horiz. Seam*	*Mansard*
Where ice, snow, and heavy rain do not occur	3	3	3	3	See Batten or Standing Seam
Ice and snow conditions	4	4	4	4	See Batten or Standing Seam
Heavy rain conditions	4	4	4	4	See Batten or Standing Seam

Slopes are in inches per foot.

Table 8.1B. Minimum Recommended Roof Slopes Using Special Details – See Details 8.1A, 8.1B, 8.1C, or 8.1D above

Conditions	*Standing Seam*	*Batten Seam*	*Chevron*	*Horiz. Seam*	*Mansard*
Where ice, snow, and heavy rain do not occur	1	2	2	N/R	See Batten or Standing Seam
Ice and snow conditions	3	3	3	N/R	See Batten or Standing Seam
Heavy rain conditions	3	3	3	N/R	See Batten or Standing Seam

Slopes are in inches per foot. N/R = Not Recommended

Table 8.1C. Recommendations for Flat Seam Construction

Slope	*Remarks*
0-3	Seams fully soldered
3-6	Seams may be fully sealed
>6	Neither sealant nor solder is required in seams

Slopes are in inches per foot.

8.2. Standing Seam Roofing

Description: Standing seam roofing is composed of preformed or field formed pans, usually between 14 to 18 inches wide when finished. The recommended dimensions should be specified from the table below. These pans run parallel to the slope of the roof, and are joined to adjacent pans with double locked standing seams. Fixed copper cleats, spaced 12" apart and locked into these seams, secure the roofing to the deck. This method limits slippage between pans, and is recommended for use with pans up to 10' long.

When preformed pans are used, they are joined at their upper and lower ends by transverse seams. These seams should be staggered for adjacent pans to avoid excessive thickness of copper at the standing seam.

Field forming involves the use of copper in flat sheets or rolls which are formed into pans by power panformers. Long rafter-length pans can be made, eliminating the need for transverse seams, however eave and ridge details must allow for copper expansion and contraction characteristics. See **8.8. Long Pan Systems**, for additional information.

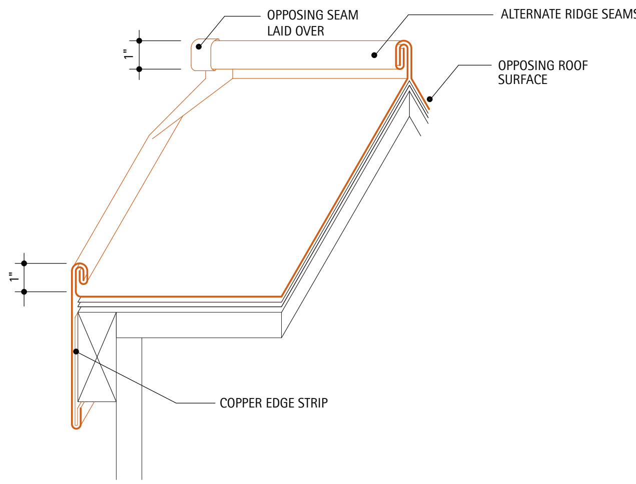
Special Conditions: The details shown are for roof slopes of at least 4" per foot. For roof slopes less than 4" per foot, and areas where ice, snow or heavy rain conditions occur, see **8.1. Special Roofing Design and Installation Considerations** section.

For standing seam roofing using pan lengths greater than 10 feet in length see **8.8. Long Pan Systems**, for discussion.

Decking Requirements: Nailable deck or nailing strips.

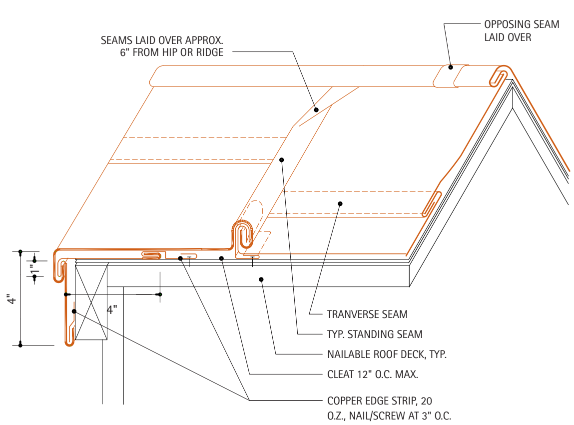
8.2A. Gable Rake

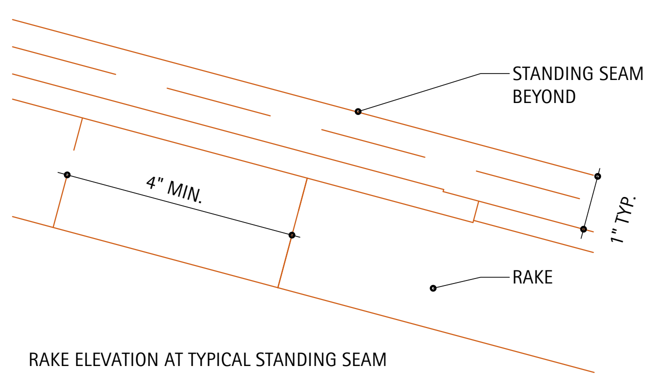
This detail shows a typical gable rake and ridge seam. Adjacent lengths of rake strips should be lapped at least 3" in the direction of flow. Opposing standing seams are staggering to avoid excessive thickness of copper at the ridge.



8.2B. Typical Standing Seam

A typical standing seam with cleats. Alternative gable rake and ridge seam are also shown in this detail. The gable detail shown in **Detail A** is generally preferred since it minimizes water washing down the gable end. All ridges should be cleated at 12" O.C.

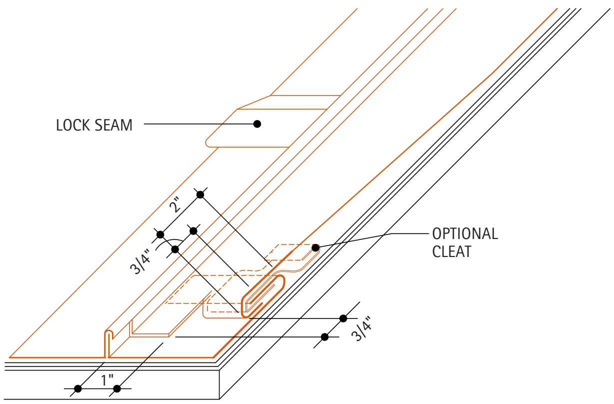




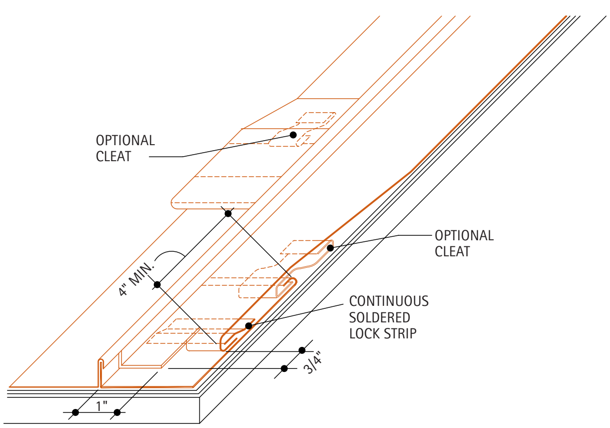
RAKE ELEVATION AT TYPICAL STANDING SEAM

8.2C. Transverse Seams

Two types of transverse seams are shown. The detail on the first example above is recommended only for steep pitch roofs, 6 or more inches per foot. The detail on the second can be used for roof slopes as low as 3 inches per foot. For roof slopes less than 3 inches per foot, and areas where ice, snow or heavy rain conditions occur, see **8.1. Special Roofing Design and Installation Considerations**.



DETAIL 1. STEEP PITCH

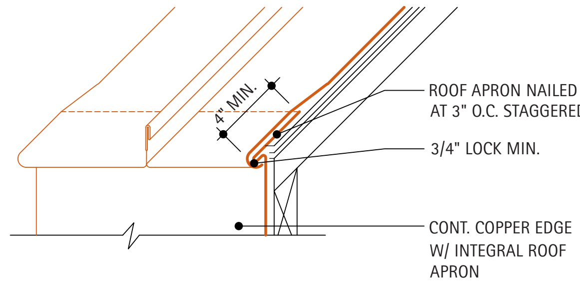


DETAIL 2. LOW PITCH

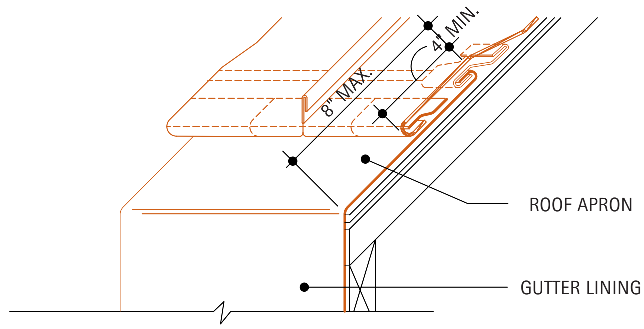
Cleats may be used at transverse seams to facilitate installation for sheets 10' or less in length.

8.2D. Eave Details

Two types of eaves, one with a gutter and one with a copper edge strip are shown.



DETAIL 1. TYPICAL EAVE WITHOUT GUTTER - STEEP PITCH



DETAIL 2. EAVE WITH GUTTER LINING - LOW PITCH

The eave ends of the standing seam are formed and folded vertically. Under the roofing, a continuous integral apron is installed and nailed at 3" O.C. in a staggered pattern.

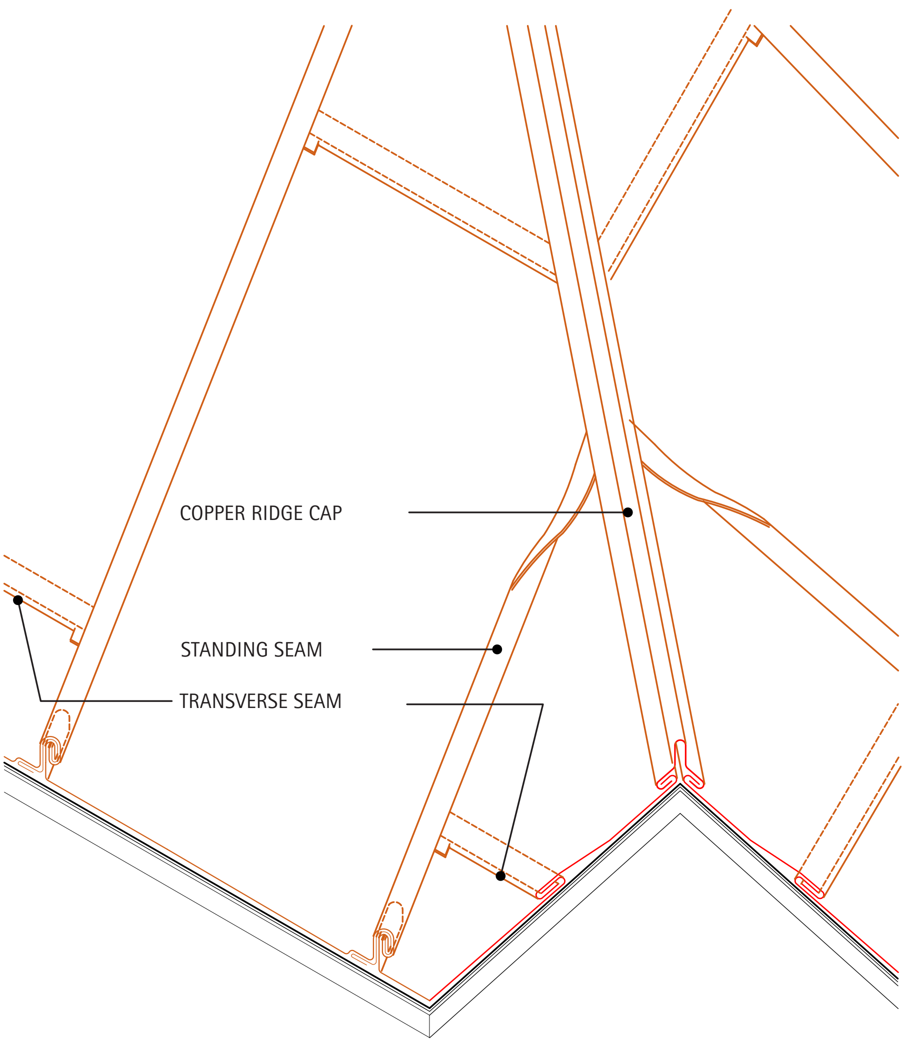
The integral gutter lining apron in **Detail 2** should be a maximum of 8" in width, along the roof.

Table 8.2A. Typical Seam Spacing for ½" Locks

Width of Sheets	Seam Spacing (Inches)			Recommended Copper Wt. (Ounces)
	Seam Ht. ⅞"	Seam Ht. 1"	Seam Ht. 1¼"	
18	15	14¾	14¼	16
20	17	16¾	16¼	16
22	19	18¾	18¼	16
24	21	20¾	20¼	20
26	23	22¾	22¼	20
28	25	24¾	24¼	20

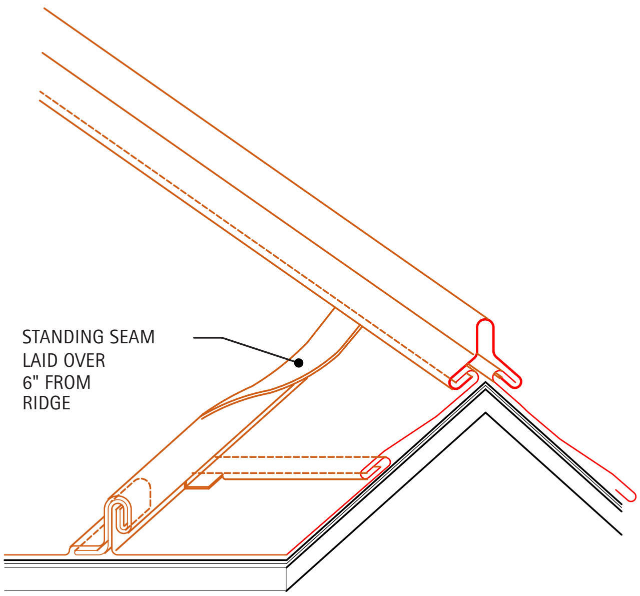
8.2E. Standing Seam at Hip

This detail shows a method of finishing the standing seams of a copper hip roof along the sloping ridges. This method allows standing seams to be concealed by a ridge cap which affords both a clean appearance and weather tight seal.



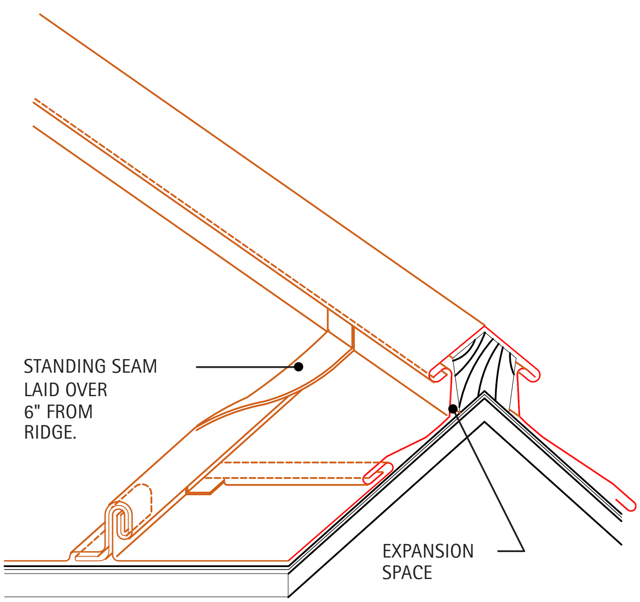
8.2F. Alternative Ridge Caps

Two alternative methods of detailing a ridge are shown. Both can be used at a gable ridge and/or a sloping hip ridge. The standing seams are laid over a minimum of 6" from the ridge.



ALTERNATIVE 1

In **Alternative 1**, a continuous copper cap is used to secure standing seams along the ridge. The ridge cap is loose locked into the upper edges of the roofing pans allowing for expansion and contraction. See **Detail 8.2D** for similar termination at eave.

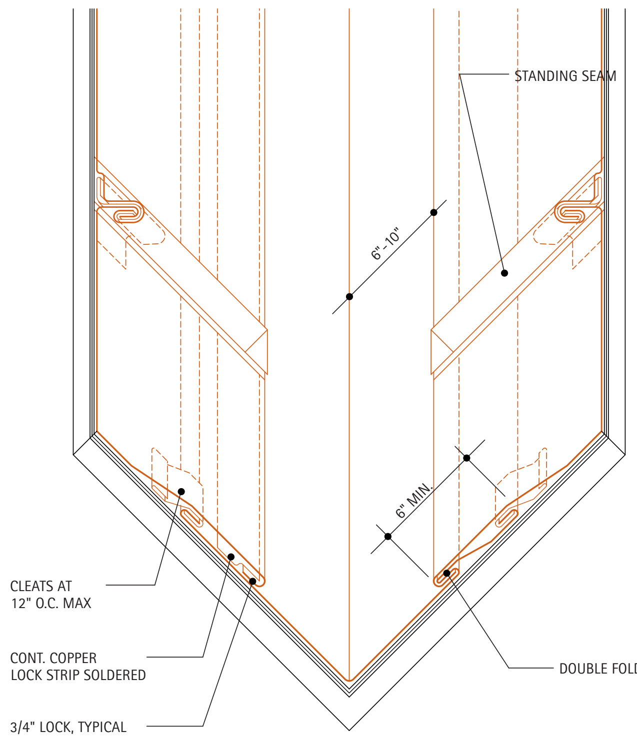


ALTERNATIVE 2

In **Alternative 2**, the ridge is formed by a wood batten clad with a copper cap. The standing seams fold and lock into the batten cap along the vertical batten face. See **Detail 8.2C** for similar termination at eave.

8.2G. Detail at Valley

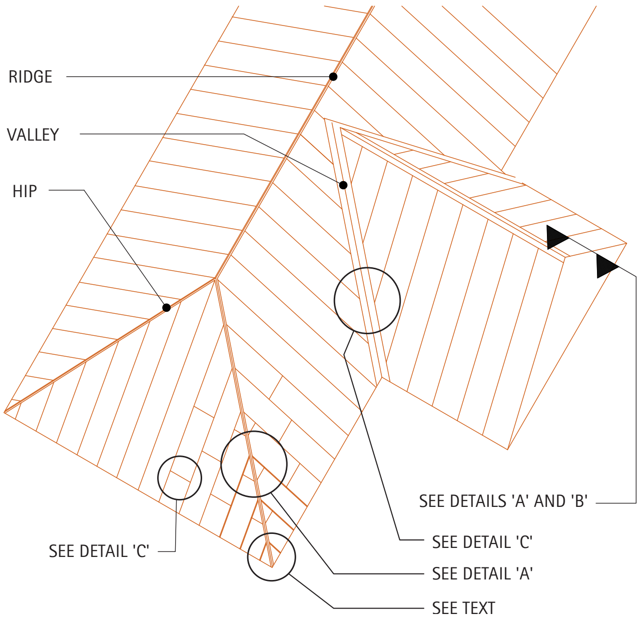
This detail shows a method of detailing a valley condition on a standing seam roof. The copper roofing laps the **9.5. Valleys** a minimum of 6" and is folded and locked into a continuous copper locking strip. The continuous locking strip is soldered to the valley flashing.



An Alternate method is to use a double fold in the valley flashing, instead of a locking strip. Both methods are shown in the detail.

8.2H. Overall View of Standing Seam Roof

This overall view of a standing seam roof shows the basic concept.



For Additional Information:

- **9. Flashings and Copings**, under the appropriate sections for flashing details.
- **7. Basic Details**, for information on seams, fixed and expansion cleats, hold-downs, edge strips and transverse seams.
- **8.8. Long Pan Systems**, for requirements when using pans greater than 10' in length.

8.3. Batten Seam Roofing

Description: Batten seam roofing consists of copper pans running parallel to the roof slope, separated by wood battens. The battens are covered with copper caps that are loose locked into adjacent pans. The width of these preformed or field formed pans may vary. The recommended maximum depends on the weight of copper, see below.

The battens, which can have a wide variety of shapes and sizes, provide not only a means of securing the roofing, but also permit a wide variety of design expressions. Transverse seams are required to join the ends of preformed pans (see **Detail 8.3D**).

There are two methods of accommodating expansion movement of the pans. Both rely on a space of 1/16" between the upstanding leg of a pan and batten. Both use battens that are nominally 2" x 2". In the preferred method, the battens are tapered so their base is 1/16" narrower on each side than at the top. The upstanding leg of the pan is then formed vertically. The alternative method uses square battens. The pans are formed 1/16" narrower on each side, with their upstanding legs bent at an angle greater than 90 degrees to meet the batten cap.

Copper Weight Requirements for Batten Seam

Roofing:

1. 16 oz. sheets for pans not exceeding 20" wide
2. 20 oz. sheets for pans exceeding 24" wide

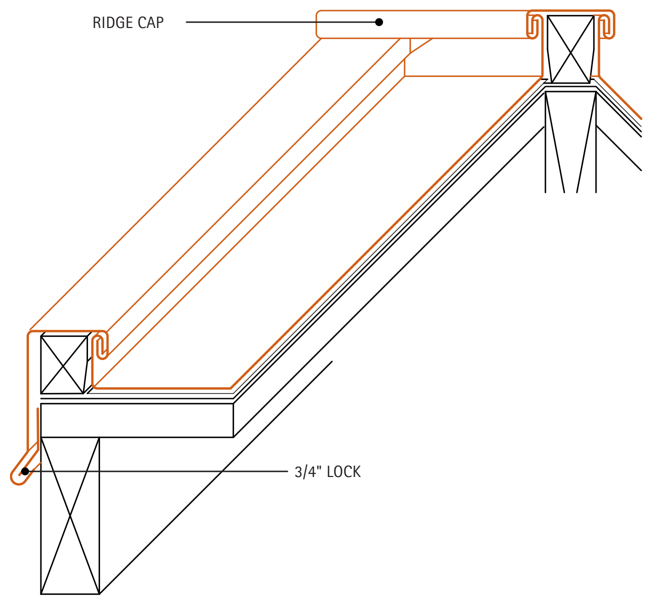
Batten caps are joined at their ends with 1/2" locks or lapped at least 3" in the direction of flow. Batten caps should be formed of the same weight as the underlying pan.

Special Conditions: For roof slopes less than 4" per foot, or areas where ice, snow or heavy rain conditions occur see **8.1. Special Roofing Design and Installation Considerations**.

Decking Requirements: Any type of smooth, flat roof deck.

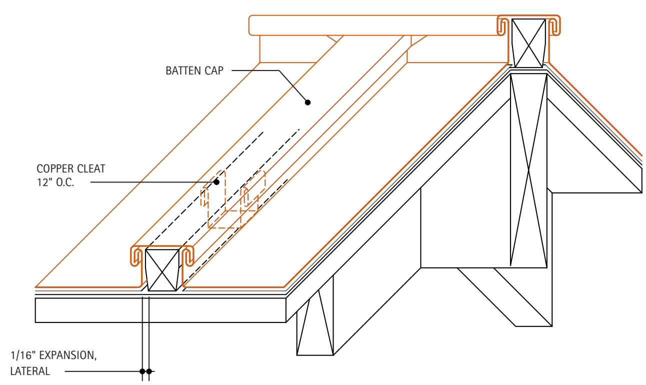
8.3A. Gable Rake

A typical gable rake is shown. This detail shows the preferred method where a batten is set flush with the edge of the roof. In this case the cap is extended, effectively becoming a rake strip, and locked into the edge strip. An alternative method is shown in **Detail 8.2B**.



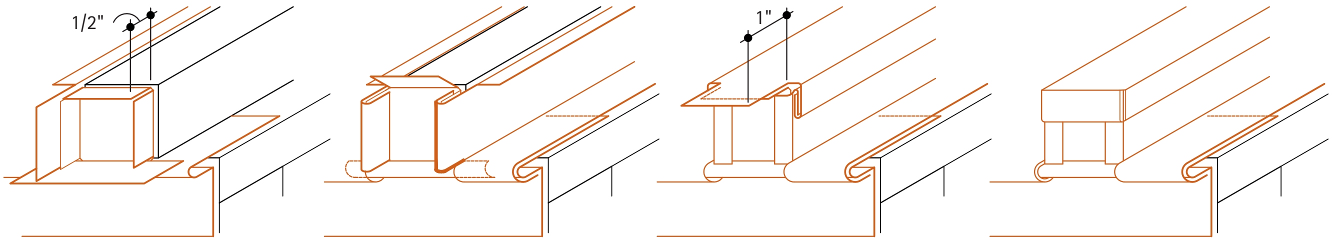
8.3B. Ridge and Typical Batten Seam

This detail shows typical ridge and batten seams.



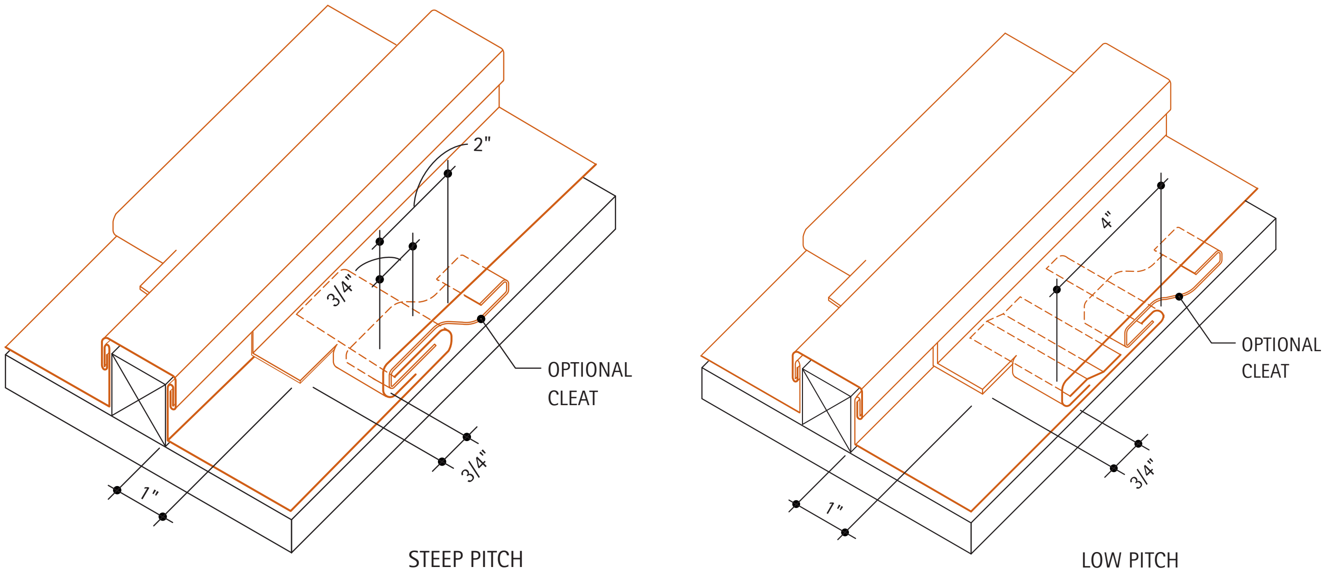
8.3C. Finished Batten End — Process

The finishing process of the ends of battens is shown. The eave details for batten seams are otherwise similar to those for standing seam, as shown in **Detail 8.2D**.



8.3D. Transverse Seams

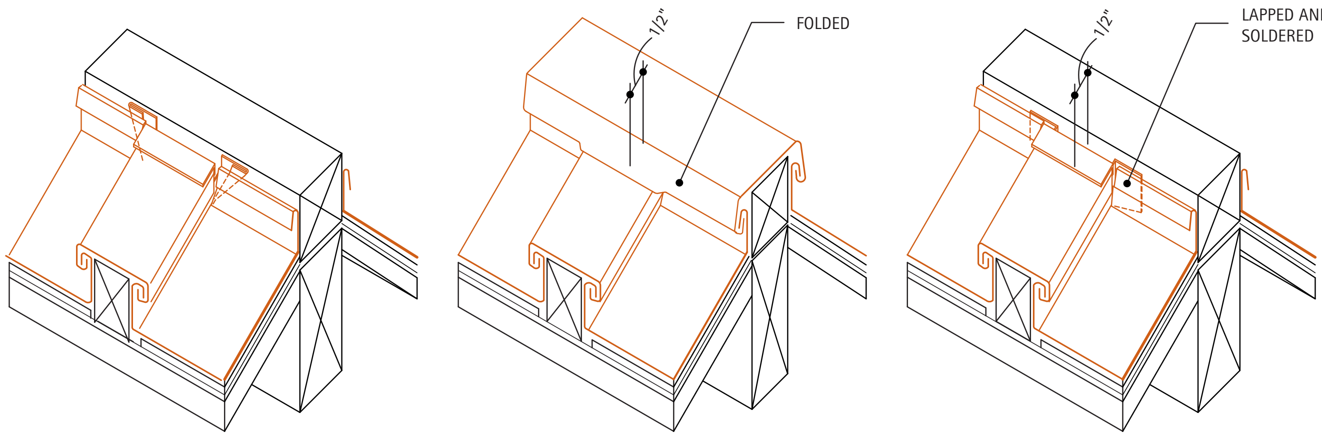
The steep slope transverse seam shown is for roof slopes of at least 6" per foot. The low slope detail is for slopes less than 6" and greater than 3" or where additional protection desired.



Cleats may be used at transverse seams to facilitate installation and restrict movement for pans 10' or less in length.

8.3E. Detail at Ridge and Batten

This detail shows two alternative methods of finishing the joint between a vertical batten and a ridge batten. Both details achieve the proper seal with extensions to the upstanding legs of the pans.



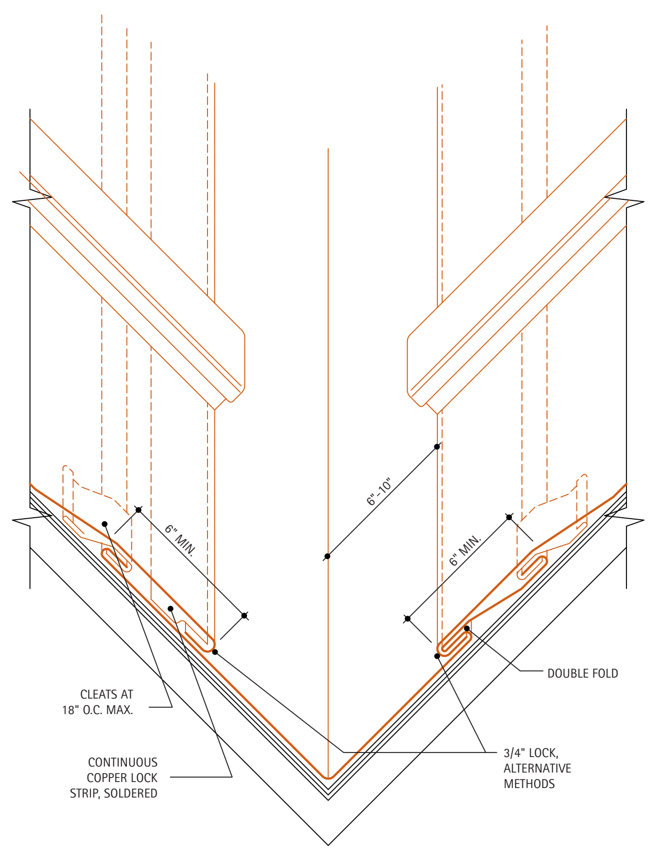
COMPLETED JOINT | ALTERNATIVE 1 | ALTERNATIVE 2

In **Alternative 1**, shown in the middle, this extension is folded. This fold diverts water that has penetrated the vertical joint out onto the roof. **Alternative 2** shows this extension lapped and soldered. The solder provides a watertight seal.

8.3F. Detail at Valley

Two alternative methods of detailing a valley condition are shown. Both require a 6" minimum lap of the roofing over the valley flashing. The one shown on the left uses a continuous locking strip soldered to the valley flashing. The other uses a double fold in the flashing to receive the ends of the roofing.

The ends of the wood battens terminating at the valley are undercut to allow the folded edges of the valley flashing to pass underneath. The ends of the battens are covered with copper as described in **Detail 8.2C**.



8.3G. Alternate Cleat Types

These types of cleats may be used with batten seam roofs. The type shown on the left must be placed during batten installation. The type on the right is attached to the installed battens with copper nails before or after batten installation.

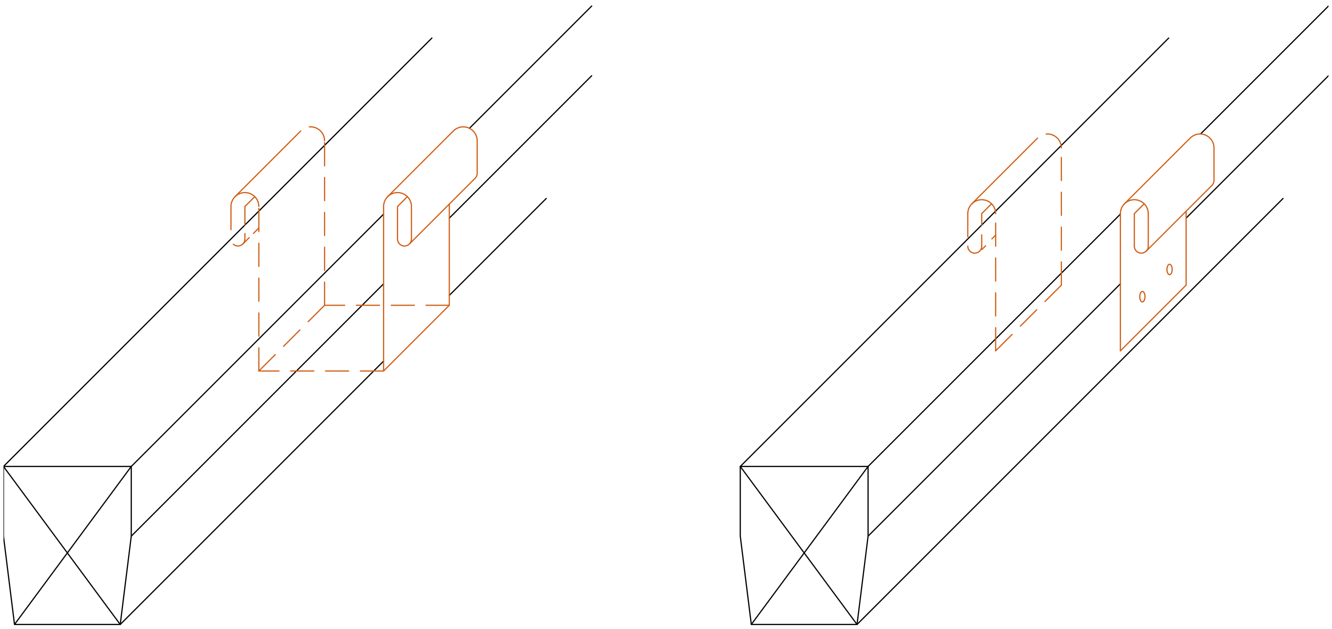


Table 8.3A. Typical Batten Spacing for 1/2" Locks

Width of Sheets	*Batten Spacing (Inches)*		*Recommended Copper Wt. (Ounces)*
	Square Battens	*Tapered Battens*	
18	14-1/8	14	16
20	16-1/8	16	16
24	20-1/8	20	20
30	26-1/8	26	20
36	32-1/8	32	20

Assuming 1-1/2" high battens

For Additional Information:

- **8. Roofing Systems**, for general roofing system descriptions and requirements.
- **9. Flashings and Copings**, under the appropriate sections for flashing details.
- **7. Basic Details** for information on seams, fixed and expansion cleats, hold-downs, edge strips and transverse seams.
- **8.2. Standing Seam Roofing** for similar gable rake, and additional eave details.

8.4. Chevron Roofing

Description: Chevron roofs come in a wide variety of configurations. A common design is based on typical batten seam construction, to which auxiliary battens are attached.

These additional battens are decorative and do not contribute to the functionality of the roof. They are usually formed as inverted copper channels that are attached to the roof with copper U-clips.

With proper design, decorative battens can have almost any shape or size and run in any direction. The unobstructed flow of water, expansion and contraction of the copper, and the effects of **Ice and Snow** and **High Winds** must all be considered.

Special Conditions: Other chevron roof designs can have fully functional wood battens, which are arranged in a chevron pattern. These rely on specially shaped preformed pans that fit between the battens. However, these designs must be carefully detailed to maintain weathertight performance.

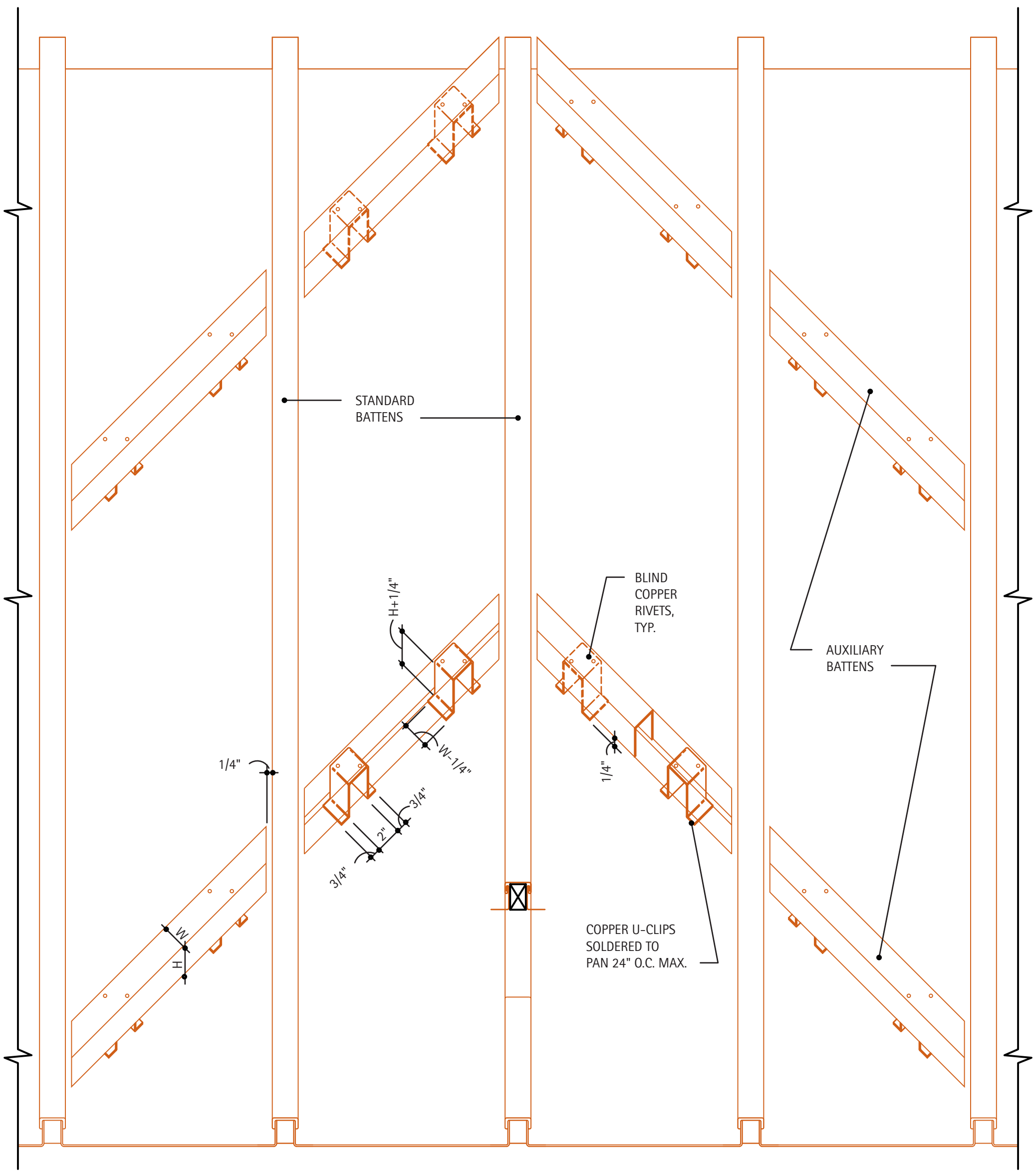
Decking Requirements: Any type of smooth, flat roof deck.

8.4A. Typical Chevron Roof

This drawing illustrates a typical application of decorative battens on a batten seam roof. The auxiliary battens are dimensioned to maintain 1/4" clearance above and to each side of the functional roof. Copper U-clips are soldered onto the copper roofing at 24" O.C., maximum, then the inverted channels are secured to them with blind rivets.

For Additional Information:

- **8. Roofing Systems**, for general roofing system descriptions and requirements.
- **9. Flashings and Copings**, under the appropriate sections for flashing details.
- **7. Basic Details** for information on seams, fixed and expansion cleats, hold-downs, edge strips and transverse seams.
- **8.3. Batten Seam Roofing** for information on the underlying batten seam roofing.



8.5. Flat Seam Roofing

Description: Flat seam roofing systems are typically used on roofs that are flat or have a low pitch or alternatively on very steep slopes. They are also used on curved surfaces such as **13.3. Circular Dome with Flat Seam System** and **13.7. Barrel Vault With Flat Seam**.

Flat seam roofing is constructed of 18" by 24", 20 oz. rectangular cold rolled copper sheets. Two adjacent sides of the sheets are folded over and two are folded under to form 3/4" locks. Copper **7.1. Attachments** of 16 or 20 oz. cold rolled copper are installed in each of the longitudinal and transverse seams. The finished pans are interlocked longitudinally and transversely, with staggered transverse seams. For applications of this system to **12. Wall Cladding**, see **Section 12.7. Horizontal Flat Lock Systems**.

Where slopes are 3:12 or less, seams are soldered, see **Section 8.1. Special Roofing Design and Installation Considerations**. The edges of the sheets should be cleaned, wire brushed, fluxed and pretinned to a width of 1-1/2" before folding. After locked seams are engaged they should be malleted or dressed down and thoroughly sweated full with solder. The soldering coppers should weigh at least 5 pounds per pair, unless torch-heated soldering copper is used, in which case the soldering coppers should weigh at least 3 pounds per pair.

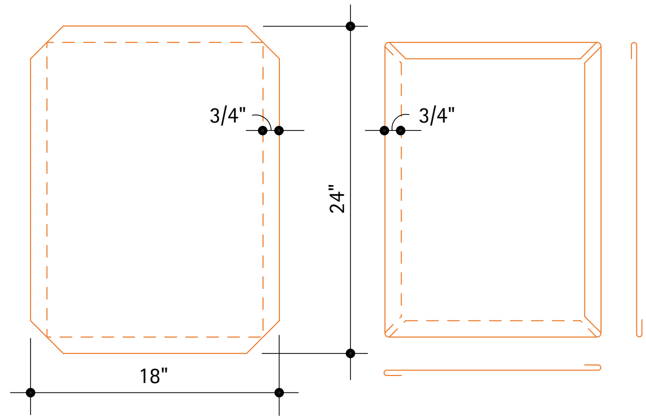
To accommodate the accumulation of expansion, roofs over 30 feet in the direction of continuous, longitudinal seams should be divided by expansion battens. These tapered battens should be spaced no more than 30 feet apart. They are covered with 20 oz. copper sheets in 8 to 10 feet lengths, locked and soldered together. See **Detail 8.5E** for additional information.

Special Conditions: Where roof slopes are greater than 4" per foot, seams may be filled with a rubber or synthetic based sealant instead of solder. See **Section 8.1. Special Roofing Design and Installation Considerations**.

Decking Requirements: Nailable deck or nailing strips.

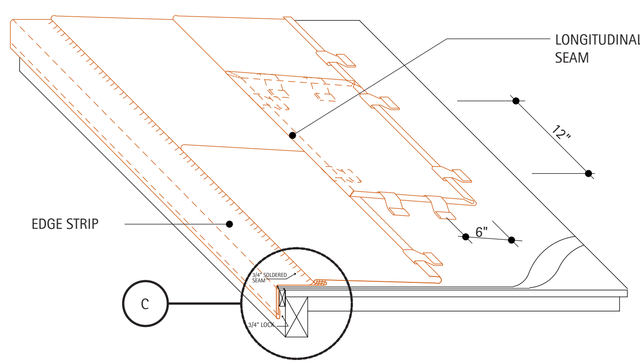
8.5A. Standard Roofing Square

Shown are the typical roofing square and the formed pans. The corners of the sheet are clipped before the edges are folded.



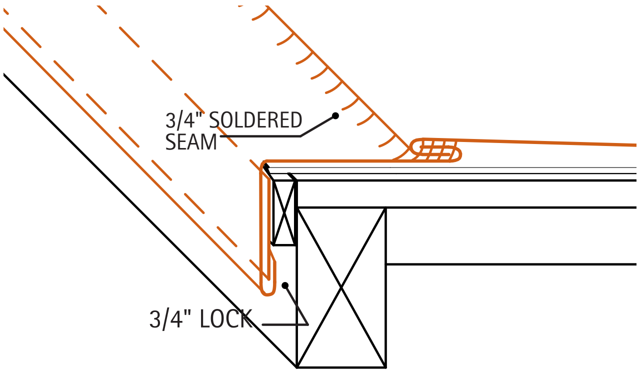
8.5B. Typical Flat Seam Roof

This drawing illustrates the overall concept of flat seam roofing. The longitudinal seams are typically continuous, whereas the transverse seams are staggered. Each pan is cleated to the roof deck. The pans should be installed so that water always sheds from one pan to the underlying pan.



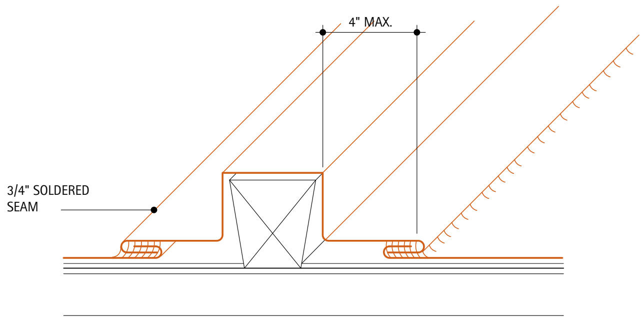
8.5C. Edge Detail

A typical edge detail is shown. This design allows water to shed from the roof at this edge. Other methods, preventing this flow, use battens similar to the gable rake detail for batten seam roofs (**Detail 8.3A**).



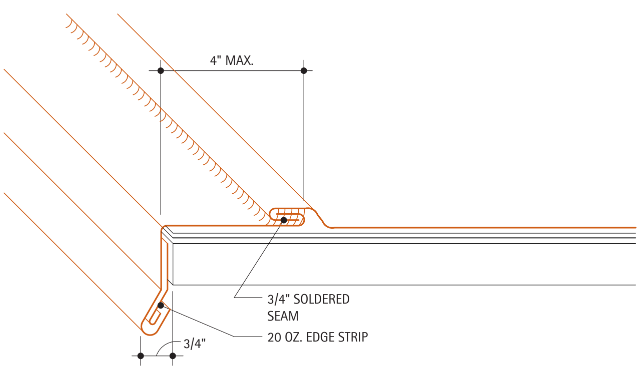
8.5E. Expansion Batten

The tapered expansion batten shown is typically 3" wide at the top and 2-1/4" at the bottom. The height should be at least 1-1/2". The 20 oz. copper cover sheets are continuous from 4" on one side of the batten to 4" on the other. They are bent at right angles where they meet the tapered batten, leaving some room for movement. These sheets are locked and soldered into the flat seam roofing.



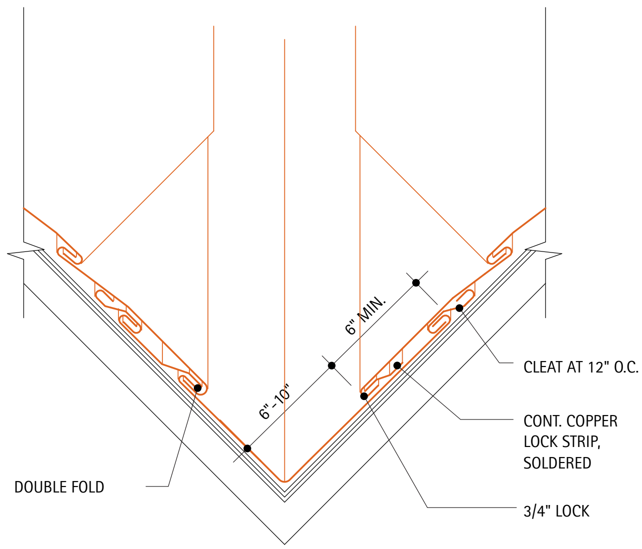
8.5D. Eave and Gable End

This detail shows the 20 oz. copper rake or eave sheet. The lower edge of this sheet hooks over the edge strip. The upper edge is locked and soldered into the typical roof sheets.



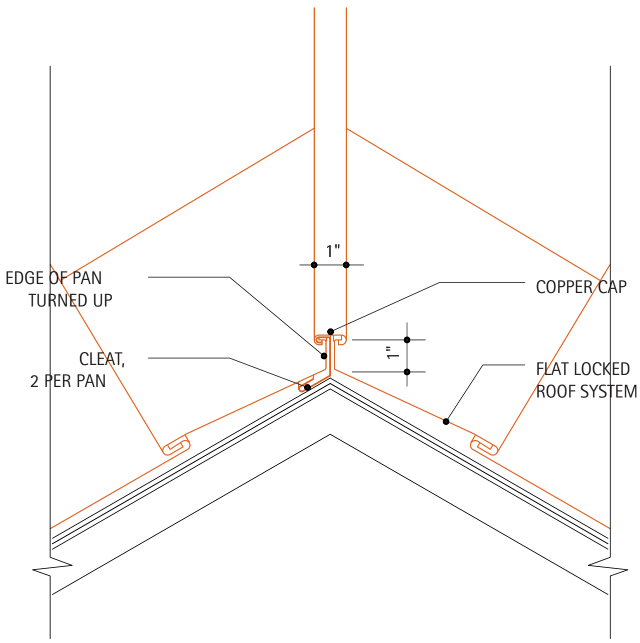
8.5F. Detail at Valley

The copper flashing is laid into **the valley** and its upper edges held by cleats spaced no more than 12" O.C. The flat seam roofing laps the flashing at least 6". Two methods are shown for engaging the lower edge of the roofing. The one on the right uses a continuous lock strip soldered to the **valley flashing**. The one on the left uses a double fold in the valley flashing.



8.5G. Hip Detail

The upper ends of the copper roofing sheets are turned up to form a 1" high standing seam. Two cleats are used, at the top, to secure each pan. A 20 oz. copper cap covers the hip joint.



For Additional Information:

- **8. Roofing Systems**, for general roofing system descriptions and requirements.
- **9. Flashings and Copings**, under the appropriate sections for flashing details.
- **7. Basic Details** for information on seams, fixed and expansion cleats, hold-downs, edge strips and transverse seams.

8.6. Horizontal Seam Roofing

Description: Horizontal seam roofs consist of copper pans, whose long dimension runs horizontally across a roof, attached to horizontal wood nailers. At each nailer a step is used to allow adjacent pans to lock effectively. The height and spacing of the steps may be varied or additional steps may be included between locks to achieve different appearances.

The copper pans may be supported by rigid insulation, inserted between nailers, or by wood sheathing applied over the nailers. The table below shows the recommended dimensions for copper pans based on their width (dimension D in **Detail 8.6B** and **Detail 8.6C**).

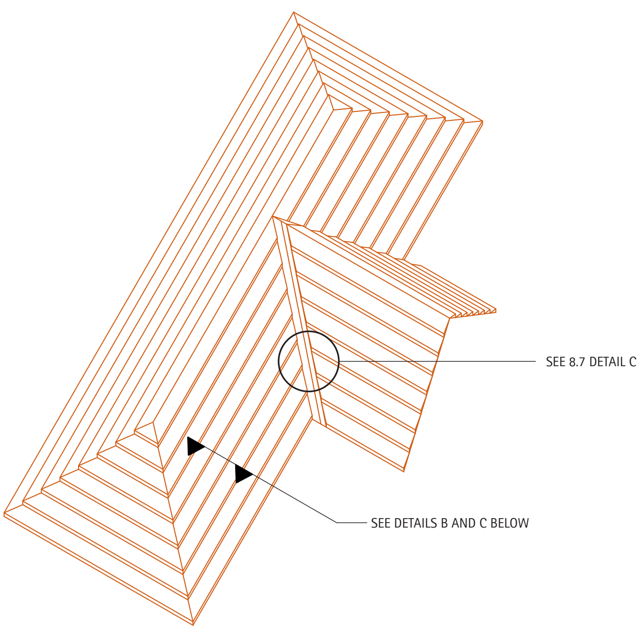
Expansion in the vertical (transverse) direction is accommodated by the steps and locks between pans. In the horizontal (longitudinal) direction expansion joints or vertical battens are required for runs 30' to 40'. Expansion seams must be staggered on adjacent pans to avoid excessive thickness of copper at the locks.

Special Conditions: For roof slopes less than 4" per foot, and areas where **Ice and Snow** or **Heavy Rain** conditions occur, see **8.1. Special Roofing Design and Installation Considerations**.

Decking Requirements: Any type of smooth flat roof deck.

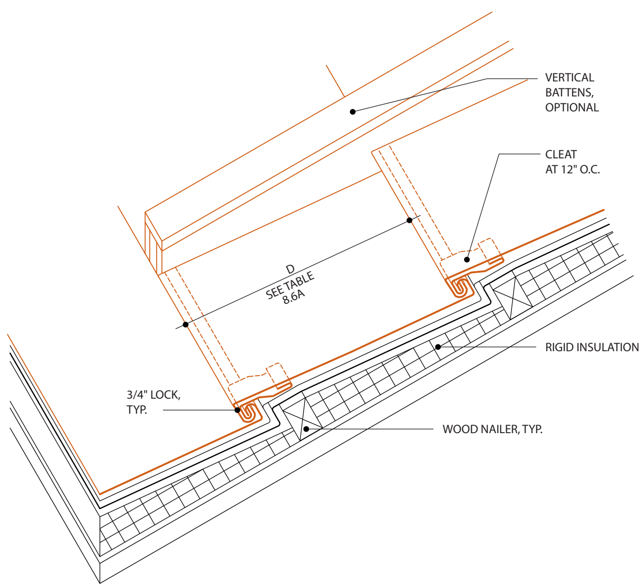
8.6A. Typical Horizontal Seam Roof

This overall view of a horizontal seam roof shows the basic concept.



8.6B. Steep Pitch Detail

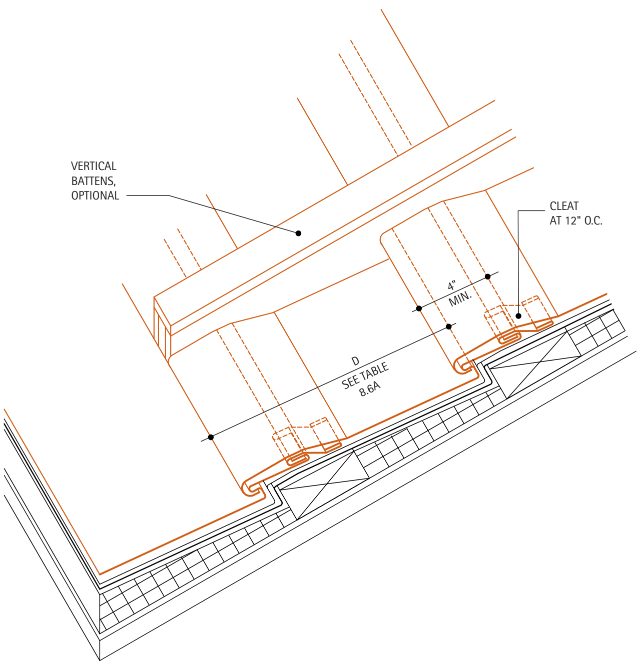
This detail shows typical copper pans for roof slopes of at least 6" per foot. The pans are joined with 3/4" locks with **cleats** secured to the wood nailers. The locks should be laid down against the vertical face of the nailers.



Dimension D, the width of the pans, is used to determine the recommended thickness of copper sheet.

8.6C. Low Pitch Detail

The detail shown is for low pitch conditions. See **Special Conditions** for recommendations.



Under these conditions the lower pans are formed with a 3/4" lock and extended at least 4" onto the next higher step, where they are secured by cleats. The lower edge of the upper pan is folded under 3/4" and hooked over the locking edge of the lower pan. The lock should be laid down against the vertical face of the nailers.

Dimension D, the width of the pans, is used to determine the recommended gage of copper sheet.

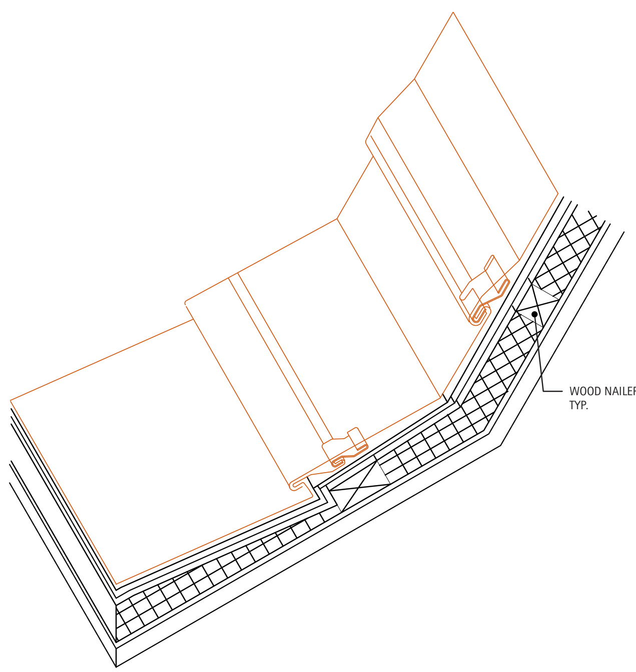
Table 8.6A Typical Horizontal Seam Roofing Pan Dimensions

Width of Sheet (inches)	*Width of Pan, "D"*		*Copper (Ounces)*
	Steep Pitch (Inches)	*Low Pitch (Inches)*	
18	14-1/2	10-1/4	16
20	16-1/2	12-1/4	16
22	18-1/2	14-1/4	16
24	20-1/2	16-1/4	20
26	22-1/2	18-1/4	20
28	24-1/2	20-1/4	20

Note: Assuming step height of 1-1/2"

8.6D. Change of Slope Without Step

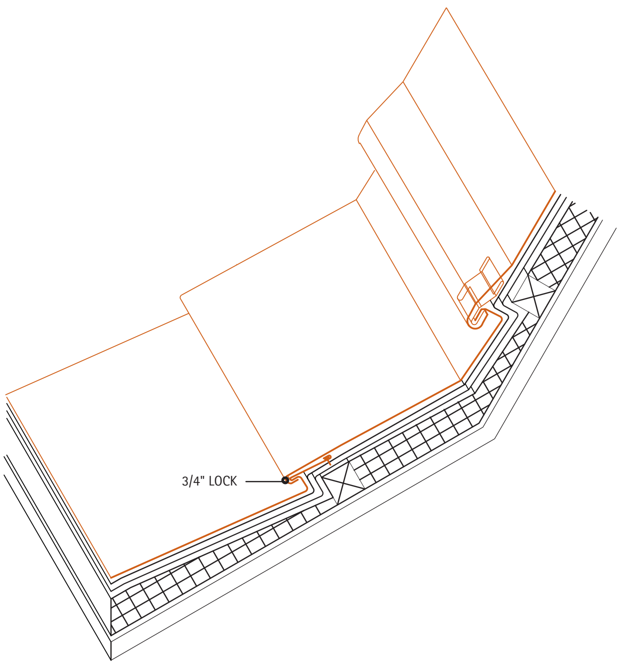
The detail shown is one method of handling a change in roof slope. The adjacent pans are joined with a seam similar to a typical transverse seam for low slope conditions. The cleats securing the pans are attached to wood nailers at 12" O.C.



8. ROOFING SYSTEMS

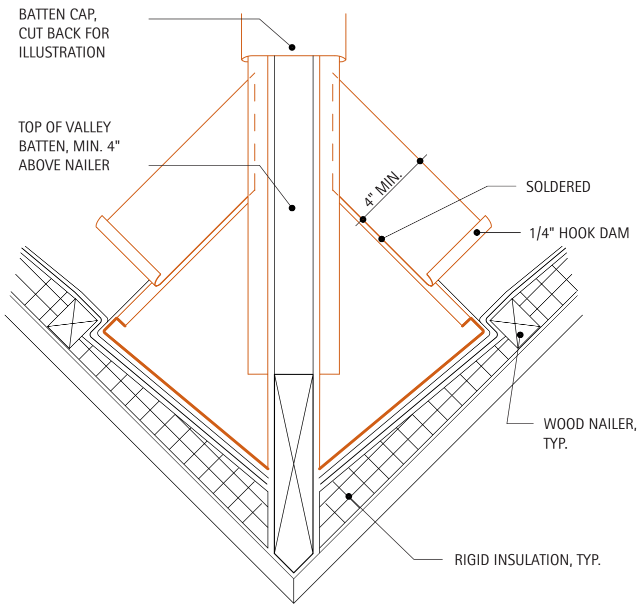
8.6E. Change of Slope With Step

This detail is for conditions similar to **Detail 8.6A**, except that a step exists below the upper nailer. This detail shows a lock similar to that used on typical steep pitch horizontal roofs.



8.6F. Valley Detail - Steep Pitch

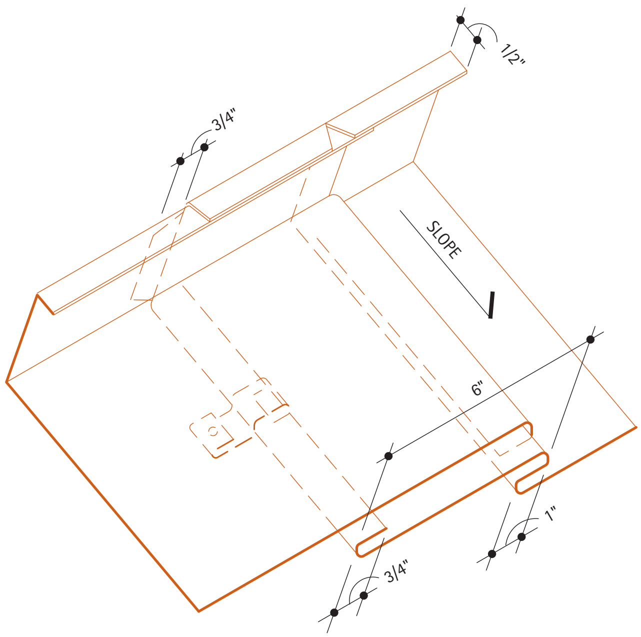
The valley detail shown is for roofs with a slope of least 6" per foot. The low slope detail is similar.



A valley batten, with a height at least 4" higher than adjacent wood nailers, runs the full length of the valley. A small sheet of copper, 4" wide, is used for additional protection. This piece extends at least 6" onto the nailers, rigid insulation, or wood sheathing and is terminated with a 1/4" dam. The lower edge must be soldered to the copper pans below.

8.6G. Expansion Seam Detail

This detail shows a typical transverse seam. Transverse seams are used instead of vertical battens to allow for expansion on roofs that run more than 25 feet horizontally.



One pan has a 1" lock double-folded 6" from the end and a 3/4" fold at the edge, into which a cleat is locked. The adjacent pan is folded under 1" at the end, and hooked into the matching lock of the lower pan.

Transverse seams should be staggered to avoid excessive thickness of material at the horizontal locks.

For Additional Information:

- **8. Roofing Systems**, for general roofing system descriptions and requirements.
- **9. Flashings and Copings**, under the appropriate sections for flashing details.
- **7. Basic Details** for information on seams, fixed and expansion cleats, hold-downs, edge strips and transverse seams.
- **8.3. Batten Seam Roofing**, for information on battens, and similar eave, hip, and ridge conditions.
- **8.1. Special Roofing Design and Installation Considerations** - Tables 8.1A, and 8.1B.

8.7. Mansard Roofing

Description: Mansard roofs are, for the most part, based on 8.2. Standing Seam Roofing or 8.3. Batten Seam Roofing construction.

The lower ends of the pans are typically hooked over an edge strip to form a drip. The ends may alternately attach to the base flashing where a change in roof slope occurs.

The recommended detail for the upper edges of the pans is to fold them out the height of the batten or standing seam and terminate them with a 3/4" fold. The lower edge of the gravel stop or coping flashing is then hooked over this fold (see Detail 8.7A and Detail 8.7B).

Special Conditions: Since mansards are inherently used on vertical or nearly vertical surfaces, most of the special provisions for low slope standing and batten seams are not necessary.

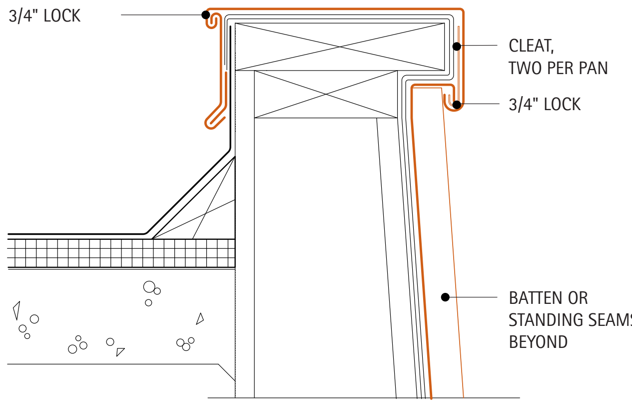
Decorative battens may be added in the same manner as for 8.4. Chevron Roofing.

If the standing seams or battens are to continue over the top edge of the mansard, special steps must be taken. The pans should be continuous over the top edge. The upstanding legs of the standing or batten seams must be slit where they are bent. After bending, small pieces of copper must be soldered over the legs to restore continuity. The seams are then finished in the conventional manner.

Decking Requirements: A continuous sheathing substrate is required, compatible with the roofing system used.

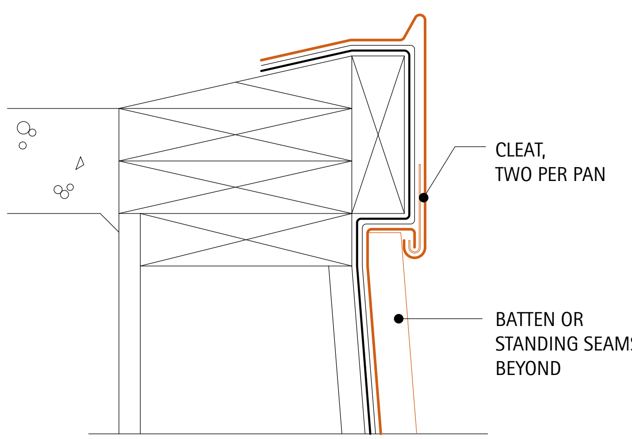
8.7A. Top of Mansard – Coping Cover

This detail shows a condition where the top of the mansard meets a coping cover. The top edge of the pans are folded out to the height of the standing or batten seam, then bent down 3/4". The coping cover is hooked over this edge, effectively forming a drip.



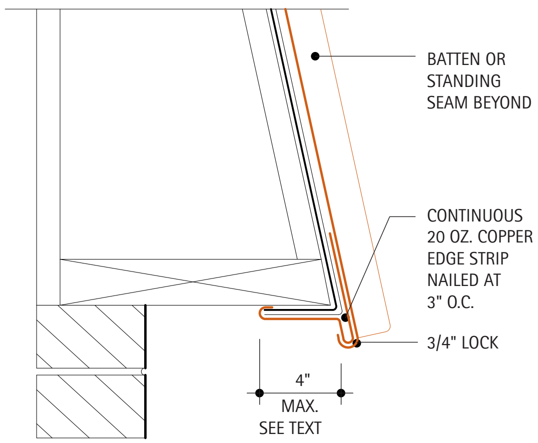
8.7B. Top of Mansard – Gravel Stop

The top of a mansard at a gravel stop is illustrated. The top edge of the pans are treated similar to Detail 8.7A, with the gravel stop engaging the folded pan edge.



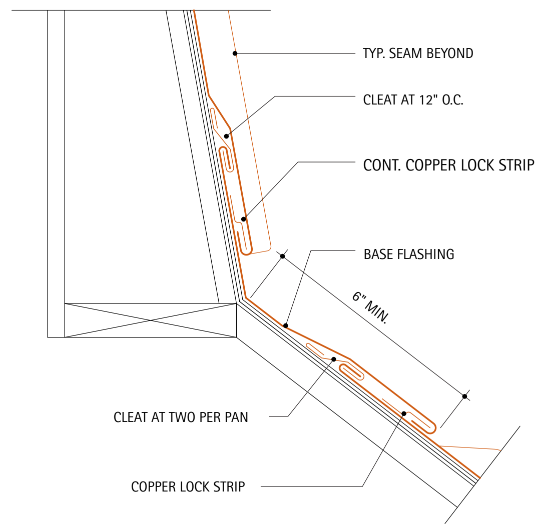
8.7C. Bottom of Mansard

This is a typical condition for the lower edge of a mansard. The bottom edge of the pans are hooked over the edge strip to form a drip. The horizontal dimension of the edge strip should not exceed 4" if it is not fastened to the soffit.



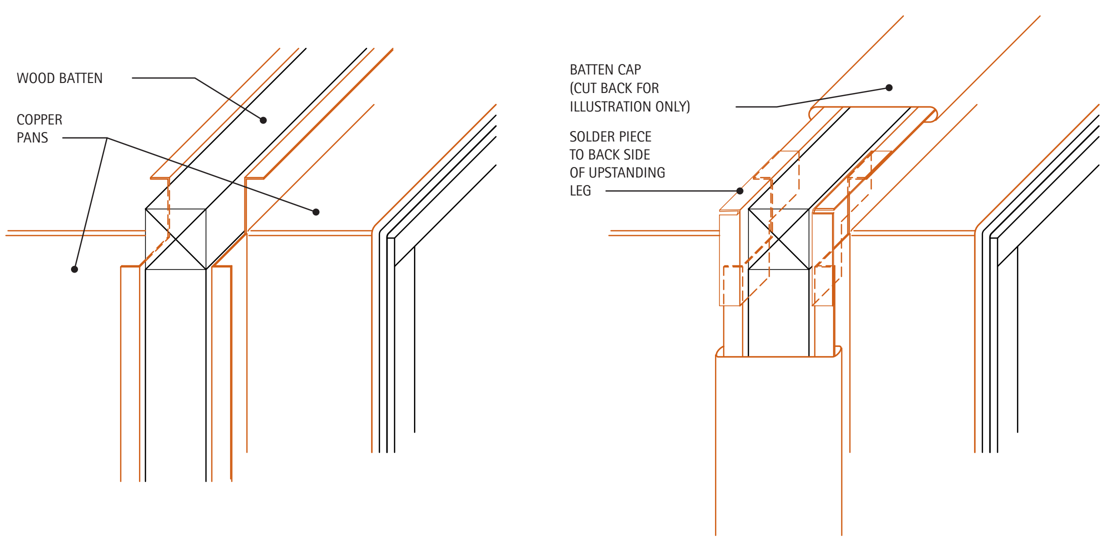
8.7D. Change in Mansard Slope

This detail shows the condition where the bottom of the mansard meets another roof. At the lower roof, the standing seams are laid flat 8" from the roof break, folded 3/4" and secured with copper cleats spaced 12" O.C. Copper locking strips of the same weight as the flashing are soldered to the pans between seams at least 6" from the roof break and engage the base flashing in a 3/4" lock. At the upper roof, the upper edge of the base flashing is folded 3/4" and secured with copper cleats spaced 12" O.C. A continuous locking strip is soldered to the base flashing and secures the mansard roof edge.



8.7E. Continuous Over Roof Batten Detail

The detail illustrates the installation for batten seams which are continuous over the roof. Standing seams under the same conditions are detailed in a similar method.



The pans shown are continuous from the face of the mansard over the edge onto the roof. The upstanding legs of the seams must be slit where they are bent. After bending, small pieces of copper must be soldered to the back side of these legs. Batten caps are then added in the conventional manner, except that their legs must also be slit and soldered where they are bent.

For Additional Information:

- **Roofing Systems - Introduction**, for general roofing system descriptions and requirements.
- **Flashing and Copings**, under the appropriate sections for flashing details.
- **Basic Details** for information on seams, fixed and expansion cleats, hold-downs, edge strips and transverse seams.
- **Roofing Systems - Standing Seams** or **Roofing Systems - Batten Seams** for information on the respective roof types.
- **Roofing Systems - Chevron** for additional information on decorative battens.

8.8. Long Pan Systems

Description: Potential problems with standing seam roofs due to expansion and contraction stem from three conditions:

1. Racking of cleats due to cyclical expansion/contraction
2. Structural strength of the formed pans
3. Seam lock-up

Typically, racking of cleats and subsequent loosening of fasteners is a greater problem, and can result from inappropriate installation of **fixed cleats** for long runs of copper roofing utilizing a double locked standing seam system. As this system expands and contracts, fixed cleats, locked tightly into the seam, are flexed and can loosen their deck fasteners.

Some of this movement can be accommodated by the copper pans as indicated by the "oil-canning" of the pans. If aesthetically objectionable, "oil-canning" may be minimized by the use of **expansion cleats**, and by limiting the use of fixed cleats to pans 10 feet maximum in length. Fixed cleats should be installed at the midpoint of the respective pan in the patternindicated. The dimension "E" in the respective details denotes the total amount of expected relative movement of the components in the details.

Historical details and installation procedures have recommended the installation of continuous roof seam lengths up to 30' utilizing fixed cleats. For seam lengths exceeding 30', the recommendation has been to utilize expansion cleats. Although such recommended techniques have proven effective with satisfactory historical roof performance, contemporary building design and construction practices require a more careful approach. Insulated roof systems potentially leading to higher roof temperatures, and light weight roof decks leading to higher differential movement all require careful design.

On reviewing historical and contemporary design and installation conditions, this Handbook has adopted a conservative approach and is referencing all pans and seam lengths greater than 10' as Long Pan construction.

The second issue, structural strength of the formed shape, relates to the ability of roof pans to transfer accumulated expansion stresses to a pre-determined point of release. This ability becomes limited as the roof pan becomes longer and a 45 foot limit should be set for individual roof pans.

The third issue deals with short lengths of pans, under 10 feet, in standing seam installations, locked together so tightly as to prevent free expansion and contraction movement between pans. This "locking" together may result from multiple thicknesses of metal in the seam (seven at the transverse seam) and deformation through malleting and in particular through the use of mechanical seamers.

The end result may lead to expansion being transferred from pan to pan resulting in a long-pan installation in spite of short pan utilization.

This condition can be mitigated by requiring the following:

- Omit any cleats in the transverse seam.
- Review all transverse seam locations carefully to ensure sufficient off-set.
- Use expansion release points for very long seam runs
- Correct use and location of fixed and expansion type cleats.

Note: Expansion release points can be **loose locked seams** that allow expansion and contraction of adjacent pans relative to each other.

Long Pan construction details are designed to accommodate the cumulative expansion stress which develops over long spans of copper sheets. The points of stress relief are typically accommodated at eaves, transverse joints, and ridge and base conditions by ensuring that the copper sheet is provided with proper clearances and is secured by expansion fastening devices that will not hinder thermal movement.

Long Pan construction requires the use of expansion cleats and installation details substantially different than short pan construction where pans are less than 10 feet in length.

The proper alignment of pans is critical for both appearance and function as is the proper placement of expansion cleats and the design of all associated seams.

Adjacent pans should be layed out symmetrically to a common centerline, to allow for ease of installation of the fixed cleats. See **Long Pan Layout** on **Table 8.8A**.

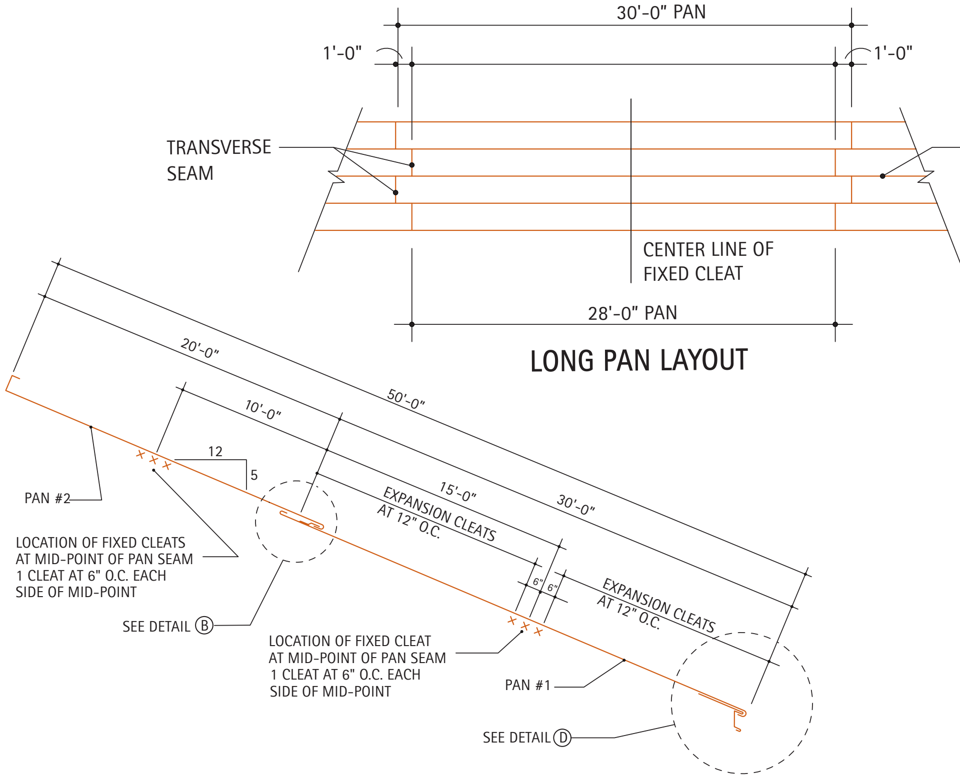
Particular building dynamics should be considered before specific copper details are established. Building expansion joints must be accommodated and properly detailed. Similarly, **Building Orientation** should be taken into consideration. A south sloping roof will incur greater heat gain differentials than a north sloping roof.

Under certain conditions, for a southerly sloping roof with clear skies and no wind, it is possible for the copper roof temperature to exceed the ambient air temperature by 75° to 85°F. Ultimate temperature may also be influenced by reflection from adjacent materials and other factors. Seam design should take into consideration the maximum temperature extremes. Under most conditions, the minimum (lowest) temperature will occur approximately 1 hour before sunrise under clear skies and no wind. Depending upon building construction and heat loss, the lowest roof temperature may be somewhat higher than air temperature. Prudent design suggests designing for minimum rather than roof air temperatures.

All roof penetrations should allow for expansion in the same amounts as the roof panels, voids or spaces should be filled with loose insulation or compressible joint filler.

8.8A. Typical Long Pan Roof Section

This detail indicates the proper cleat locations for a long pan copper roofing sheet. Expansion cleats are positioned according to the temperature of the panel during the installation and the anticipated temperature extremes. Substantial tolerances should be designed into the installation since over 100°F change in roof temperature in a single day is possible. Most commercially available expansion cleats permit a maximum 3/4" movement in either direction. Therefore, when set at mid-point a total expansion of 3/8" can be accommodated in either direction.



8.8B. Transverse Seam – Low Pitch

For a long span roof utilizing multiple seamed pan lengths, transverse seams are required. For roof slopes less than 6" on 12", the upper roof pan is attached to a locking strip soldered to the lower pan. The lower pan is cleated to the roof deck with the indicated clearances determined by expansion calculations. See Example **Table 8.8A**.

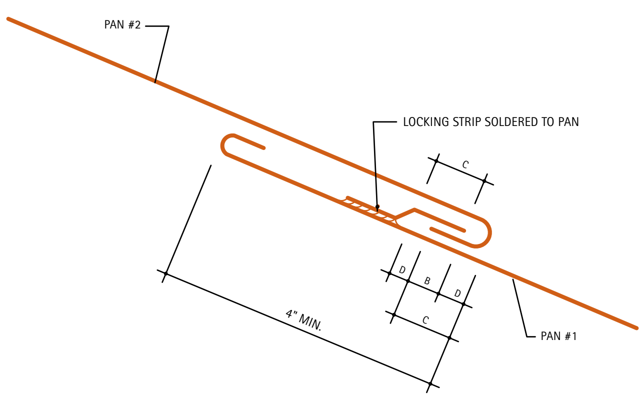


Table 8.8A. Example Expansion Joint Calculation

A long pan standing seam roof is being installed in 80 degree weather, in an area where the maximum temperature range is from -20° to 100° Farenheit. The roof pitch is 5" per foot. The ridge and eave details are designed for movement. The total run of the roof is 50 feet. This exceeds the maximum recommended length (30 feet) for each long pan. Locate and design the expansion joint between pans.

The expansion joint could be located in the middle of the roof run, with the length of each pan at 25 feet. For the purposes of this example, unequal length pans are used, to demonstrate how to accommodate such differences. The lower pan is 30 feet long, the upper pan is 20 feet long.

Since the ridge and eave conditions are detailed for expansion and contraction, fixed cleats are used at the mid-point of each pan, see Detail A.

Min. design temperature = -20°F
Max. design temperature = 100°F + 75°F (superheat) = 175°F

Contraction temperature difference = 80 - (-20) = 100 degrees
Expansion temperature difference = 175 - 80 = 95 degrees

Dimension A is based on expansion and contraction of the lower pan (#1) only, see Detail A, Plate 4.2.11.

Amount of contraction,
dLc = 15' x .0000098 x 100 = 0.0147' = 0.18", say 3/16"

Amount of expansion,
dLe = 15' x .0000098 x 95 = 0.00140' = 0.17", say 3/16"

Allowing 1/8" clearance with pan #1 contracted,
Min. A = 1/8"

Clearance at installation,
A = 1/8" + 3/16" = 5/16"

Clearance when pan #1 is expanded,
Max. A = 5/16" + 3/16" = 1/2"

Dimensions B, C, and D are based on the total expansion and contraction of both the lower (#1) and the upper pan (#2).

Amount of contraction,
dLc = contraction of pan #1 + contraction of pan #2
= (15' + 10') x .0000098 x 100
= 0.0245' + 0.29", say 5/16"

Amount of expansion,
dLe = expansion of pan #1 + expansion of pan #2
= (15' + 10') x .0000098 x 95
= 0.0233' = 0.28", say 5/16"

Allowing 1/8" clearance with pans contracted,
Min. D = 1/8"

Clearance at installation,
D = 1/8" + 5/16" = 7/16"

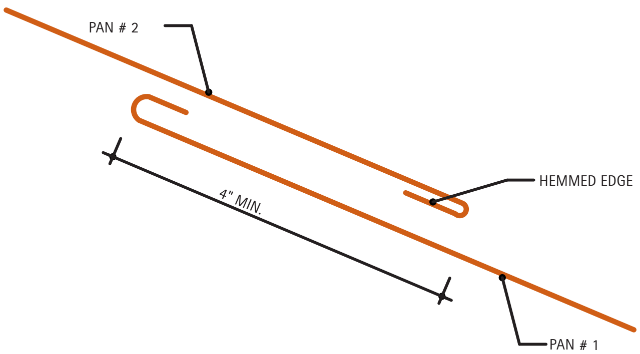
Clearance when pans are expanded,
Max. D = 7/16" + 5/16" = 3/4"

Total relative movement of pans = dLc + dLe
= 5/16" + 5/16" = 5/8"

Allowing 1/4" overlap (B) between pans #1 and #2, dimension D (pan #2 fold and locking strip leg),
C = Min. B + Max. D = 1/4" + 3/4" = 1"

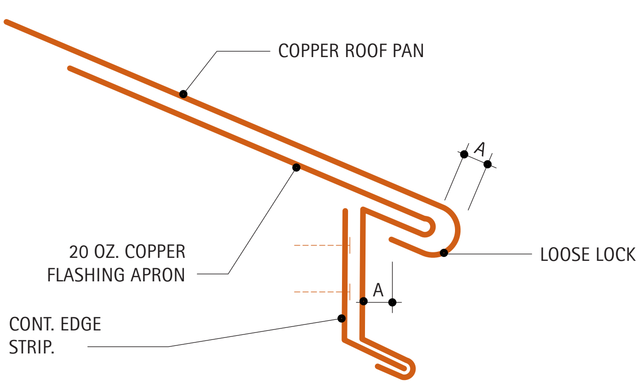
8.8C. Transverse Seam – High Pitch

For slopes greater than 4" per foot, the lower pan is folded under the upper pan. The lower pan is installed, before the second pan is installed. The detail shows the completed seam.



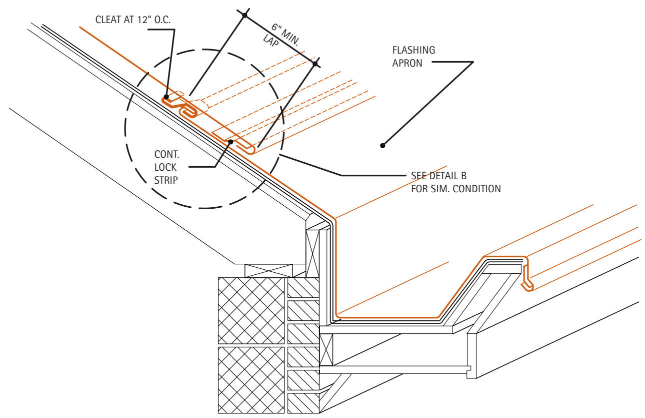
8.8D. Eave Detail

This detail indicates a method for terminating a copper roof at the eave. The fascia trim is bent to extend onto the roof deck to become an integral flashing apron nailed to the roof. The copper pan is secured to the apron lip in order to achieve vertical restraint. Horizontal movement of the copper roof sheet is accommodated by the loose-lock fold of the pan over the fascia lip.



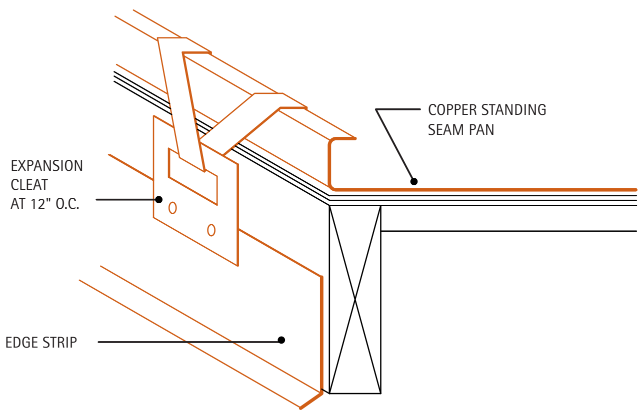
8.8E. Eave with Gutter

This is an alternate eave detail and is recommended in snow areas when using a gutter. The gutter is extended to the roof to form a flashing apron fastened to the roof with cleats at 12" O.C. A 20 oz. copper locking strip is soldered to the apron and engages the end of the copper roof pan. The locking strip prevents vertical wind up-lift of the roof pan, but allows horizontal expansion and contraction. Proper clearances must be maintained as outlined in the above example.

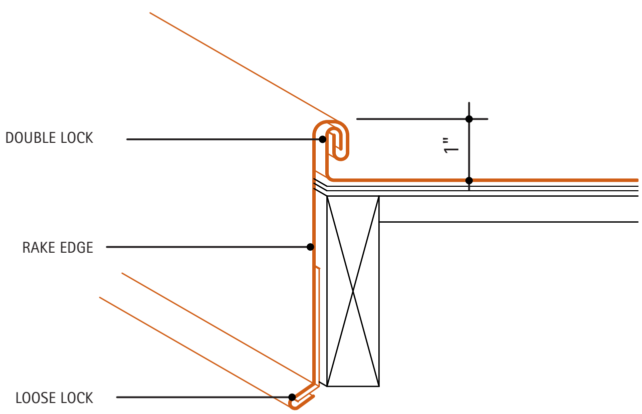


8.8F. Gable Rake Edge

Compensation for expansion and contraction at a rake edge is shown using a double lock seam detail. A continuous edge strip is fastened to the fascia board followed by the installation of an expansion cleat.. The moveable tabs of the cleat hook onto the edge of the roof pan, as shown in the detail.



BEFORE RAKE INSTALLATION

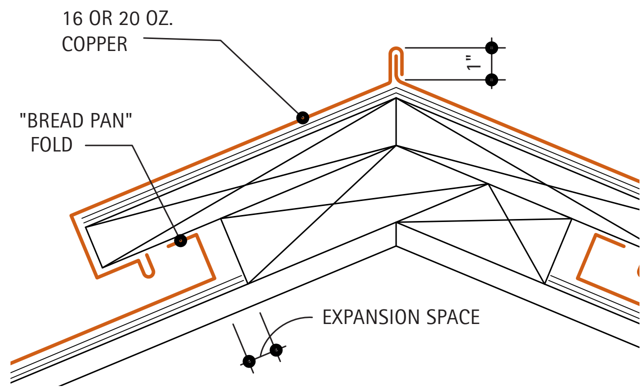


FINISHED EDGE

The *Finished Edge* detail shows the completed joint. The fascia rake edge is engaged into the edge strip and all 3 components are formed into a double lock seam. The lower end of the rake edge is formed into a loose lock around the edge strip to accommodate unrestrained movement.

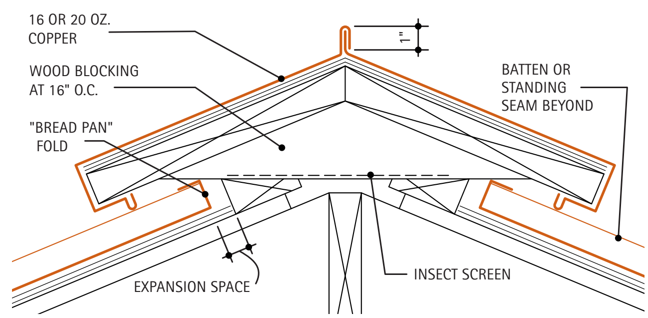
8.8G. Non-Venting Ridge

For the installation of a non-vented ridge, a blocking framework is formed as indicated. The copper roofing is formed into a "bread pan" with the required expansion space as indicated.



8.8H. Venting Ridge

This detail shows the installation of a ridge cap where venting is a requirement. A sub-frame of plywood and blocking is formed to follow the slope of the roof. This frame is covered with copper which is allowed to float freely from the copper roof pan. The pan is terminated in a folded "bread-pan" with the required expansion space as indicated.



For Additional Information:

- **8. Roofing Systems**, for general roofing systems descriptions and requirements.
- **9. Flashings and Copings**, under the appropriate sections for flashing details.
- **8.2. Standing Seam Roofing** or **8.3. Batten Seam Roofing**, for additional information on the respective roofing types.