General Requirements

- **Support Requirements:** Copper wall flashing in new masonry is typically held in place by setting the upper edge into the mortar joint between the courses in the backing material. In a retrofit condition, the upper edge of the copper flashing can usually be inserted into a reglet or an existing joint that has been raked. If the backing is not masonry it must be a nailable material.

  Wood blocking must be provided for the attachment and support of copper copings, gravel stops, edge strips, roof sumps, scuppers, and other copper roof accessories. These are shown in the accompanying details.

- **Materials:** Flashings and copings are fabricated from cold rolled copper in weights ranging between 16 and 20 ounces per square foot. The required weight depends on the application and is outlined in the discussion related to each detail.

  Wherever sealant is used that comes into contact with copper a rubber or synthetic-base sealant that is compatible with copper must be specified.

- **Description:** The wide variety of uses for copper as a flashing material makes it impossible to discuss installations for all specific conditions. However, the principles behind good applications can be summarized.

  Copper movement must always be anticipated. It should be accommodated with proper details, but in circumstances where movement cannot be tolerated, it should be limited. The latter condition is often encountered with edge strips, gravel stops, and continuous cleats.

  The flow of water must be planned for and not impeded. Flashing should, typically, have at least an 8" vertical drop from its upper to its lower edge. The ends of discontinuous flashings, such as at window sills, must be dammed to prevent moisture from flowing into the wall cavity. Pea gravel should be used on throughwall flashing to help prevent construction debris from blocking flow. Where a sealant is used in conjunction with flashing, as at a shelf angle for example, it should be installed below the flashing so that moisture diverted by the flashing will not be trapped by the sealant.

  Contact between copper and non compatible metals should be avoided. Where this is not possible, such as at a steel shelf angle, some method of material separation is required. This condition is most often solved with the use of a bituminous coating applied to the metals to prevent direct contact.

The details shown in this section illustrate these and other important points.

9.1. Through-Wall Flashing

Description: Through-wall flashing is used to divert moisture, which has entered the wall, to the outside, before it can cause damage. This flashing method is considered the most satisfactory method of preventing leaks except in areas exposed to earthquakes.

Through-wall flashing is used at all points where moisture may enter the wall, and in selected places particularly susceptible to water damage.

The flashing must typically rise at least 8" from the low point at the exterior face of the building to the high point inside the wall. Weeps spaced a maximum of 24" O.C. must be included. Use of pea gravel is recommended behind brick veneer. The ends of the flashing must be dammed to prevent water that has been caught from draining back into the wall.

Through-wall flashing is commonly fabricated by deforming the metal in such a way as to provide bond strength in mortar joints. All through-wall flashing should be set with a bed of mortar above and below the flashing in strict compliance with the flashing manufacturer's specifications.

On nailable sheathing, the flashing should be fastened with wide head nails or cleats. Nailing through flashing prohibits movement and should be avoided when movement is expected. The nail should be driven just above the upper edge of the flashing, allowing its wide head to hold the copper sheet. Nails or cleats should be spaced no more than 12" O.C.

The minimum recommended weight for copper through-wall flashing is 12 oz. using "High Yield", or 16 oz. using standard cold rolled copper.

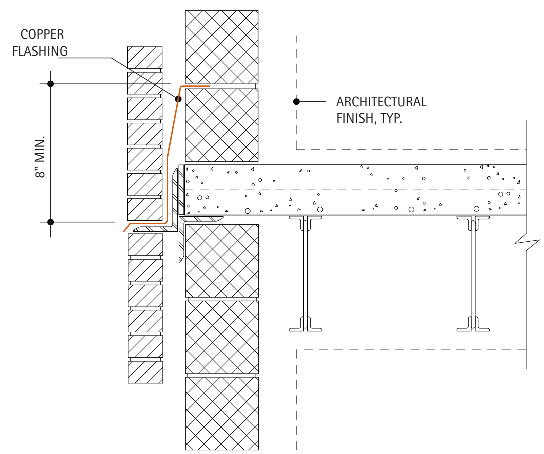
Special Conditions: If copper flashing is used adjacent to other metals, proper care should be taken to account for separation of the materials. These conditions often arise at brick shelf angles, and under metal window and door frames. They are typically handled with the use of bituminous paint, zinc chromate or red lead primers on the contact surfaces.

Although copper flashing is not adversely affected by the corrosive alkalies present in masonry mortar, it's long term performance can be compromised by excessive chlorides. Therefore, chloride based additives in the mortar should be avoided.

See **Detail 9.1I** for more information on flashing special brick veneer conditions.

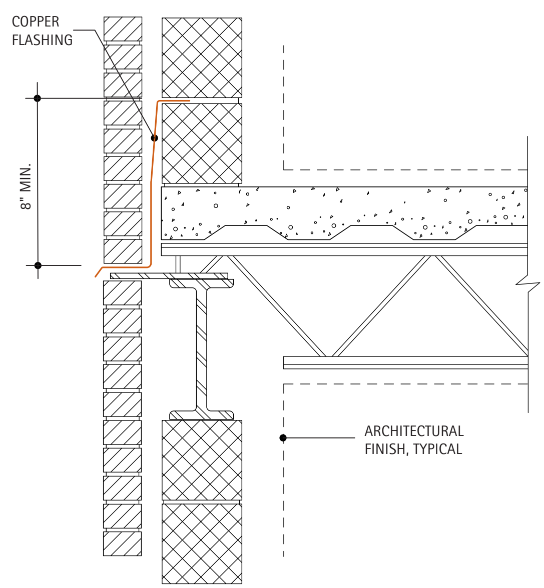
9.1A. Brick Veneer on CMU at Decking

This detail illustrates a condition where the top edge of the flashing is held by the CMU backup. This is the typical method of holding the flashing in a cavity wall.



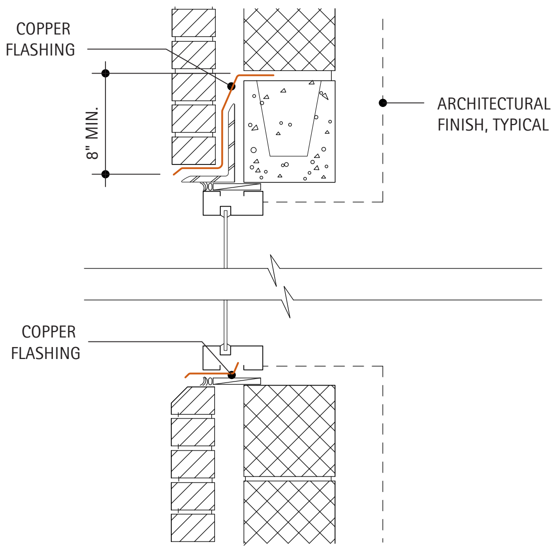
9.1B. Brick Veneer on CMU at Steel Spandrel

This condition is similar to **Detail 9.1A**, except that the brick veneer is supported by a steel plate. The flashing detail is essentially identical.



9.1C. Brick Veneer on CMU at Window Head & Sill

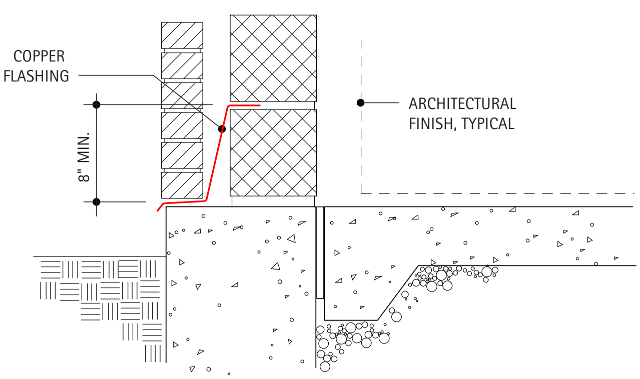
It is particularly important to provide flashing at the head and sill of a window or door. Moisture can promote corrosion in the steel lintel, and may stain or damage the window.



At the sill, the risk of moisture entering the wall is especially high. Here, a backer rod and sealant are applied below the flashing to prevent moisture penetration. The ends of the flashing are dammed to prevent water penetration behind the sealant below.

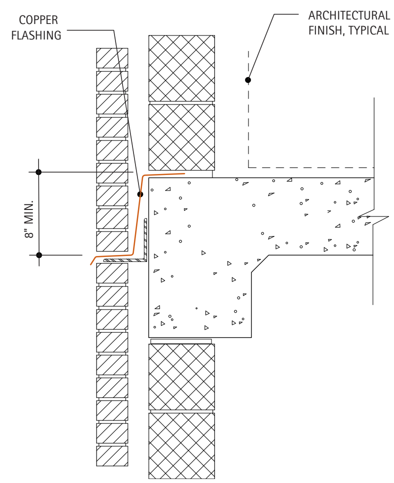
9.1D. Brick Veneer on CMU at Grade

This detail shows the typical method for flashing a cavity wall at grade.



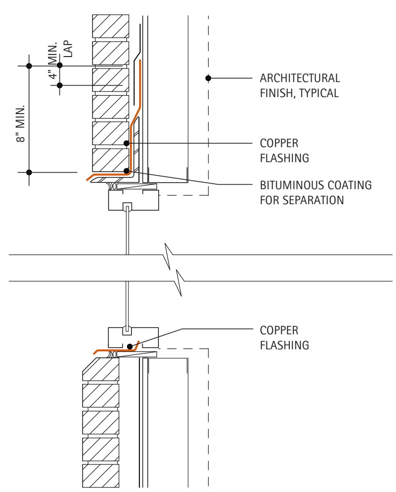
9.1E. Brick Veneer on CMU at Concrete Spandrel

Shown is one way of flashing over the shelf angle at a concrete spandrel. This detail can be used where the distance from the top of the concrete to the shelf angle is at least 8". If the distance is less than this, then a detail similar to **Detail 9.1A** should be used. If the distance is large, then a detail similar to **Detail 9.1H** should be used.



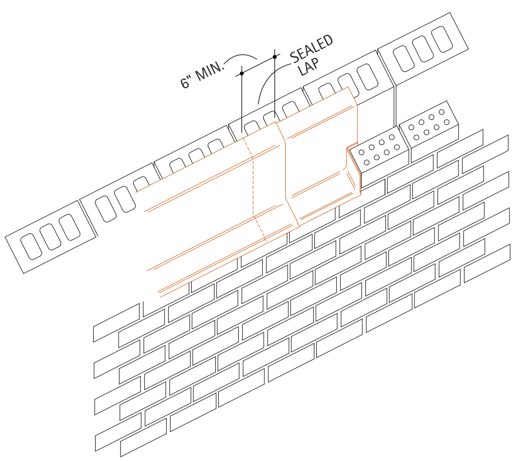
9.1F. Brick Veneer on Metal Studs

As with brick on CMU, proper flashing at window and door heads and sills is very important. With brick veneer on studs, the flashing at the head must be extended up along the sheathing and lapped by the building paper at least 4". The sill flashing detail requires that a backer rod and sealant be applied below the flashing. The flashing must be dammed at the ends. A bituminous coating or a strip of asphalt saturated felt should be applied to prevent contact between dissimilar metals.



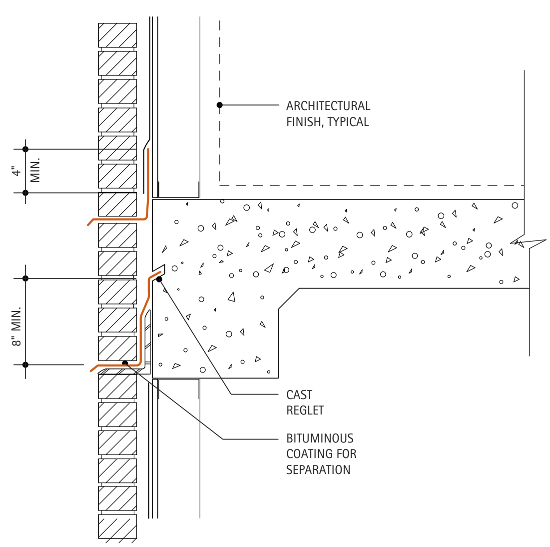
9.1G. Typical Flashing Joint and End Dam

Wherever long runs of copper flashing are required, multiple sheets of copper flashing are used. Adjacent pieces are lapped at least 6" and sealed (see **Solder and Sealants (page 15)** section for sealant recommendations). At the ends, the flashing is detailed as shown to provide an effective dam, preventing moisture from draining back into the wall.



9.1H. Brick Veneer on Metal Studs at Concrete Spandrel

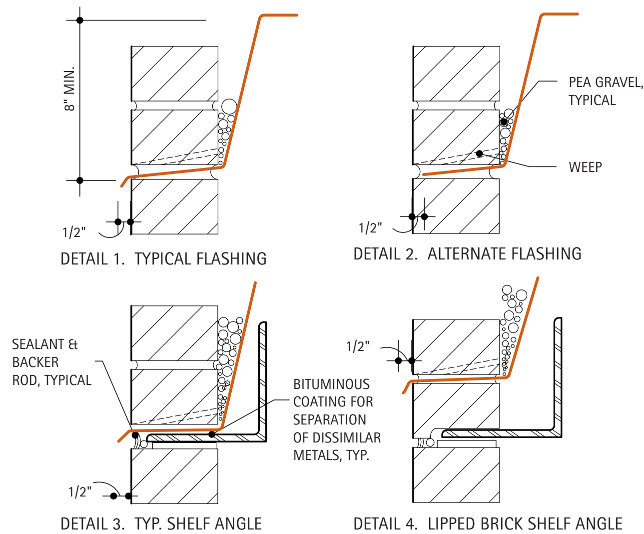
This concrete spandrel condition can be used if there is a large distance from the top of the concrete to the shelf angle. The flashing at the shelf angle is inserted into a reglet cast into the concrete and held with lead wedges.



Dissimilar metals should not be in contact. A bituminous coating or a strip of asphalt saturated felt can be used to achieve this separation.

9.1I. Brick Veneer Flashing

The first detail shows the typical method of flashing a brick wythe. The flashing must extend up at least 8", weeps spaced a maximum of 24" O.C., and pea gravel are rec-ommended. The lower edge of the flashing should extend about 1/2" beyond the face of the brick, and have a downward bend to provide a drip.



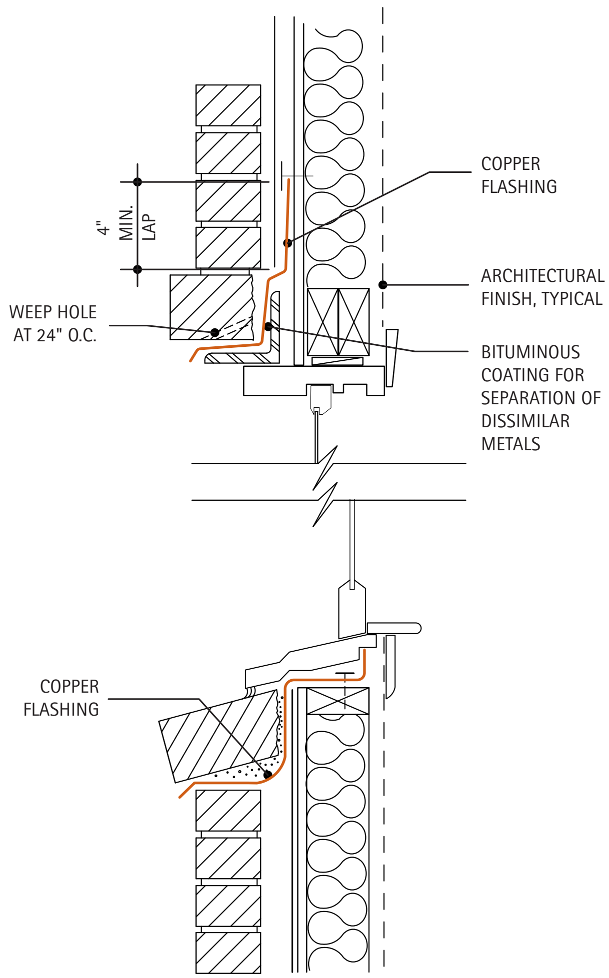
The alternate flashing method shown is primarily for use with asphalt coated copper flashing. Because the coating exposed to the weather is likely to flow and stain the surfaces below, this flashing is held back from the face of the brick. With hollow brick, the flashing must fully cover the internal holes. The coating may also not be compatible with most currently available sealants. If this flashing material is used at a shelf angle, a proper seal below it may not be possible. For this reason it is recommended that the flashing be installed a brick course above the shelf angle.

The last two details show typical shelf angle flashing. These follow the same principles outlined in the first detail.

The detail on the left shows the copper flashing resting on the shelf angle. Direct contact of dissimilar metals must be avoided. This can be achieved by the application of a bituminous coating on the shelf angle or the insertion of a strip of asphalt saturated felt.

9.1J. Brick Veneer on Wood Studs at Window Head and Sill

The head condition shows a row lock course of brick. This detail is essentially the same as that for brick veneer on metal studs. The flashing is extended up the sheathing and lapped 4" minimum by the building paper. Weeps at 24" O.C. maximum must be included. The copper flashing must not be in direct contact with the shelf angle. A bituminous coating or a strip of asphalt saturated felt can be applied to the angle to provide a separation.

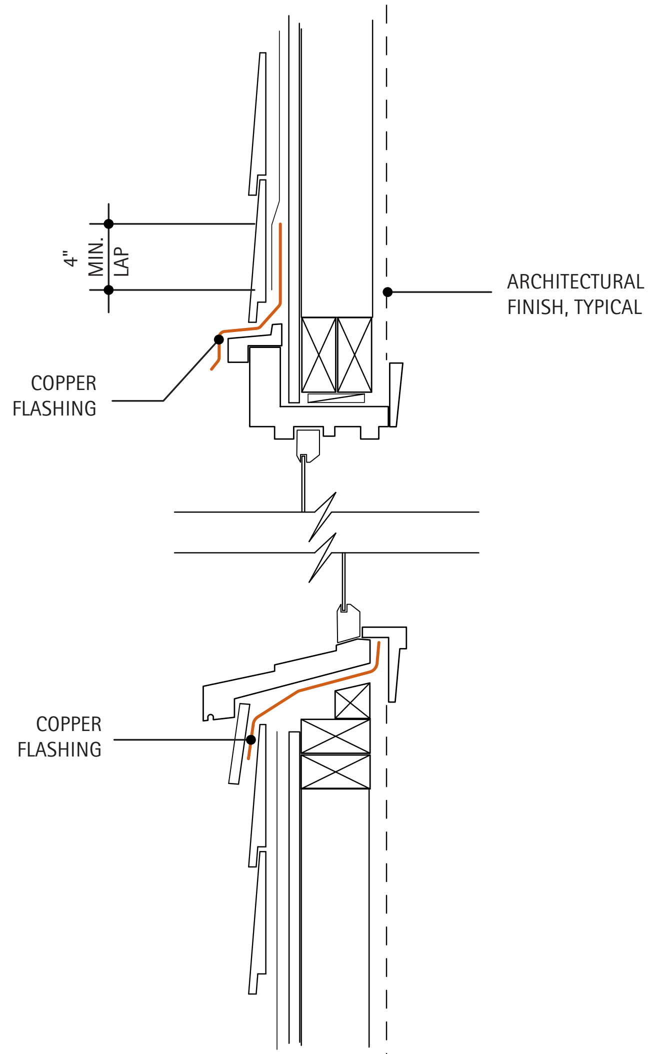


The sill condition for a wood framed window is considerably different to that of a metal window. The flashing extends from the inside face of the sill piece, under the sill, then down and under the brick sill. It should project out about 1/2" beyond the face of the brick below and be bent to form a drip.

The ends of both head and sill flashings should be dammed to prevent moisture penetration.

9.1K. Wood Siding at Window Head and Sill

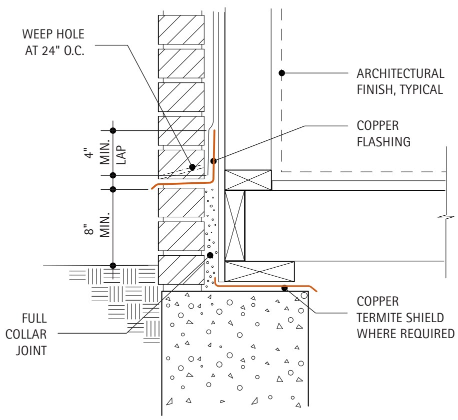
The top edge of the flashing at the head is attached to the sheathing and is lapped a minimum of 4" by the building paper. The lower edge of the flashing is bent over the wood trim and turned down to form a drip.



At the sill, the flashing is turned up against and is attached to the inside face of the sill piece. Then it runs under the sill and laps over the siding below. A wood trim piece covers the copper flashing.

9.1L. Brick Veneer on Wood Studs at Grade

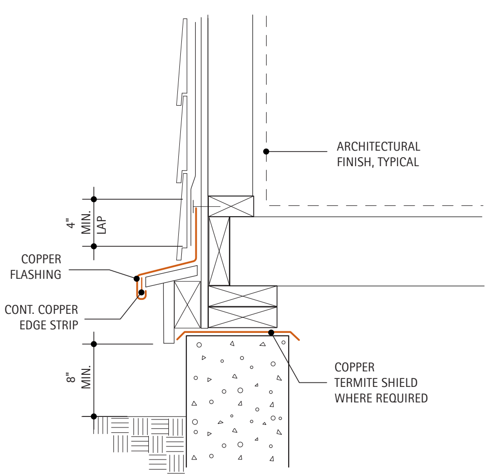
The bottom edge of the copper flashing is held at least 8" above grade to reduce the risk of moisture penetration from capillary action. The top edge is attached to the sheathing and lapped by the building paper a minimum of 4". Weeps at 24" O.C. maximum are required. The cavity below the flashing is filled with mortar.



A copper termite shield may also be required between the wood structure and the concrete or masonry.

9.1M. Wood Siding at Grade

This detail illustrates one method of flashing wood siding at grade. The top edge of the flashing is lapped by the building paper at least 4". The bottom edge is locked into a continuous 20 oz. copper edge strip which is attached to a wood watertable.



A copper termite shield may be required between the wood structure and the concrete or masonry.

For Additional Information:

- 9.8. Stepped and Chimney Flashings

9.2. Counterflashing

Description: Copper flashing is used wherever a wall intersects a roof. Such a system usually consists of copper counterflashing and base flashing in conjunction with roof composition flashing or coping. The counterflashing diverts water to the base flashing, which, in turn, diverts it to the composition flashing. The base flashing is designed to accommodate building movement. It laps the composition flashing at least 4". The composition flashing is extended up a cant strip then up the wall at least 10".

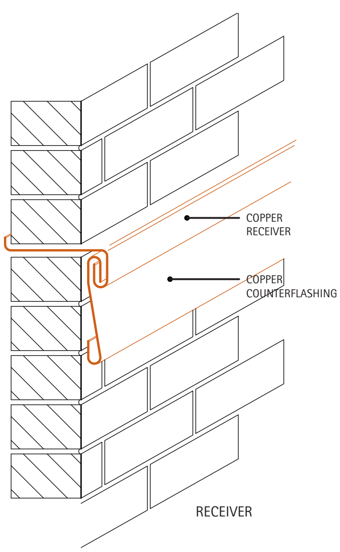
The minimum recommended weight for copper coping and counterflashing is 16 oz.

Special Conditions: Copper counterflashing may be used in conjunction with copper base flashing and composition base flashing for built-up roofing. The copper flashing is used over the base flashing to prevent water penetration behind the composition base flashing.

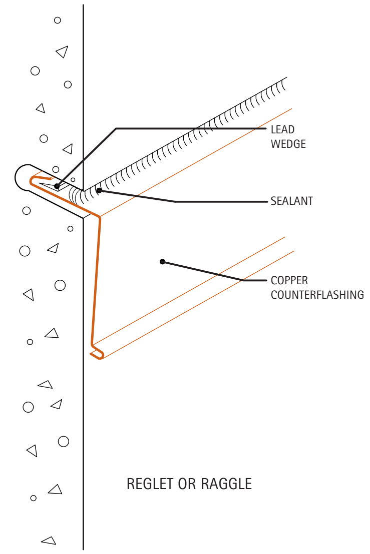
9.2A. Typical Counterflashing Methods

There are many ways to attach and seal copper counter-flashing. Three typical methods are shown.

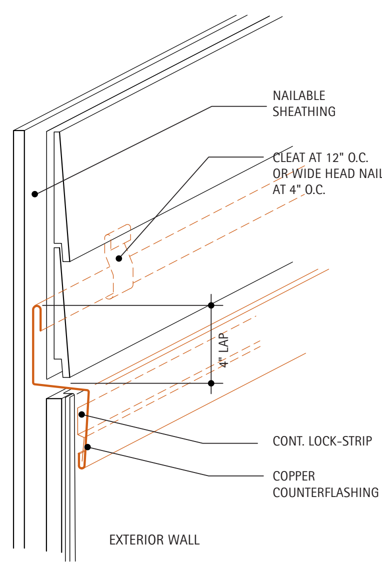
The first shows a copper receiver which is laid in the mortar joint between two masonry courses. The counterflashing is locked into the exposed edge of the receiver.



The second detail shows a reglet (or raggle) cut or cast into concrete. The flashing is inserted into this reglet and held by lead wedges. The reglet is then filled with sealant.

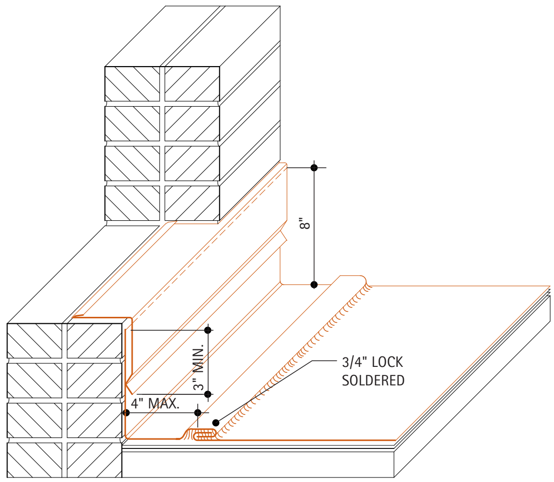


The third type of counterflashing is used for exterior wall coverings of several types. The top edge of the flashing is lapped a minimum of 4" by building paper. It is held to the sheathing by cleats spaced 12" O.C. Wide head nails, spaced 3" O.C., may be used instead of cleats. These nails should not penetrate the flashing. The flashing is simply held by the bottom edge of the wide head.



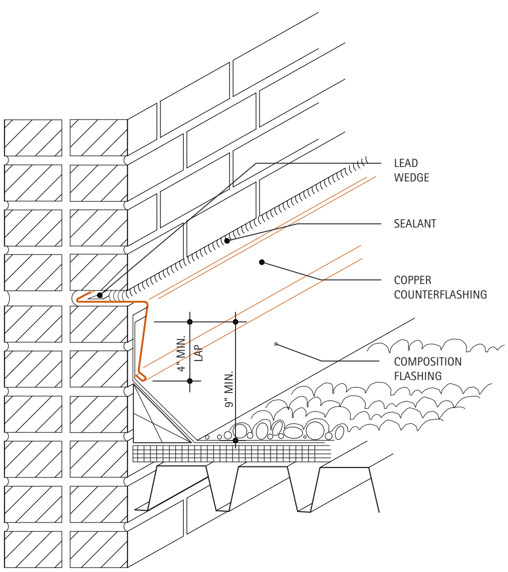
9.2B. Vertical Wall Flashing

This detail shows a flashing condition at a vertical wall or parapet. The roofing squares are locked into a 20 oz. copper base flashing, which extends at least 8" up the wall. The counterflashing laps the base flashing a minimum of 3".



9.2C. New Flashing in Existing Brick Wall

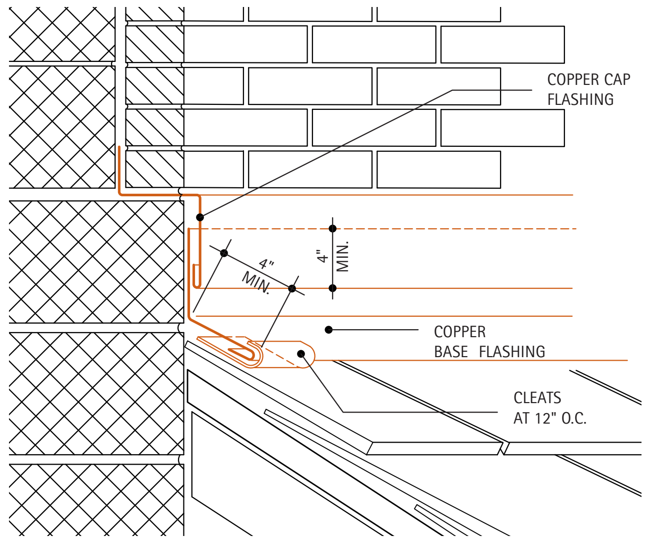
This detail shows how new copper flashing is installed in an existing brick wall. The mortar joint between brick courses is raked at least 2" deep. This forms a reglet similar to **Detail 9.2A**. The copper counterflashing is inserted into the reglet and held by lead wedges. The reglet is then filled with sealant.



For Additional Information see: **9.3. Coping Covers**, for similar conditions at parapets and copings.

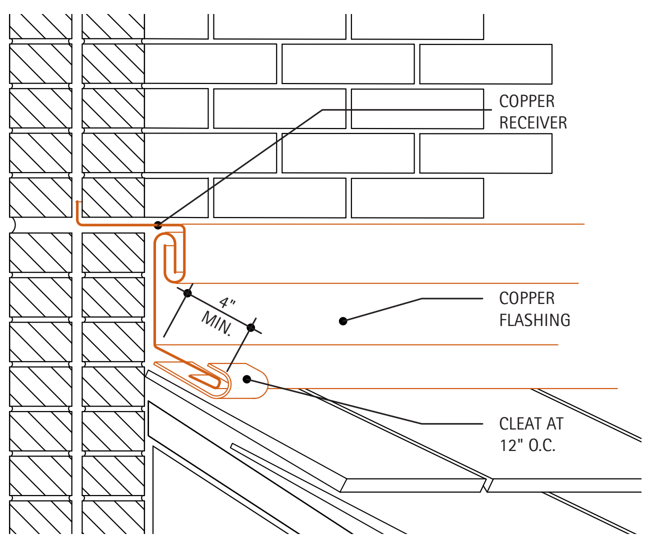
9.2D. Wall Intersection at Shed Roof

This detail shows the use of copper cap flashing extending over copper base flashing at the intersection of a shed roof with a masonry wall. The cap flashing is set in the mortar joint between bricks. The lower edge is hemmed and laps the base flashing and is formed to be a snug fit against the base flashing. The base flashing is fastened to the roof with cleats spaced a maximum of 12" apart. The base flashing laps the roof a minimum of 4".



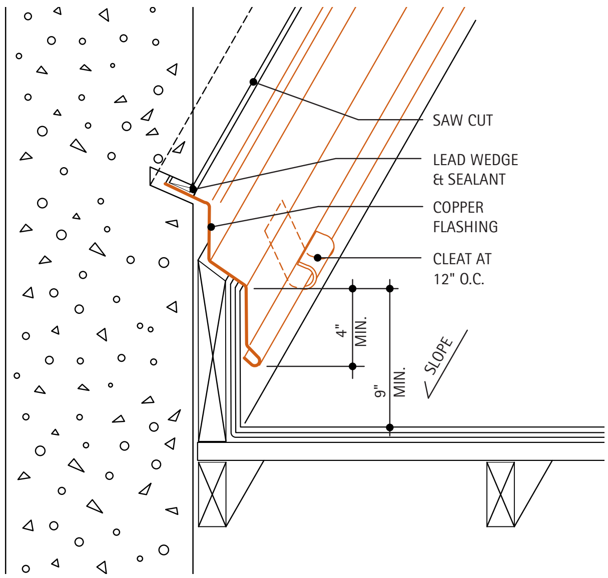
9.2E. Shed Roof - Alternate

This detail shows an alternate flashing method for the condition in **Detail 9.2A**. The difference is that a copper receiver holds the top edge of the flashing.



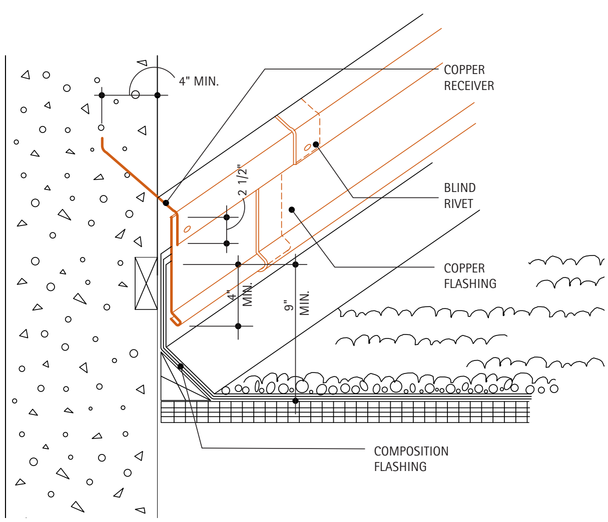
9.2F. Wall Intersection Along Sloped Roof

This detail illustrates the use of a saw cut to hold the flashing with the aid of lead wedges. The cut is filled with sealant. One of the difficulties using this method is dealing with end conditions, such as inside corners. The lower end of the flashing is hemmed and held by cleats at 12" O.C. max.



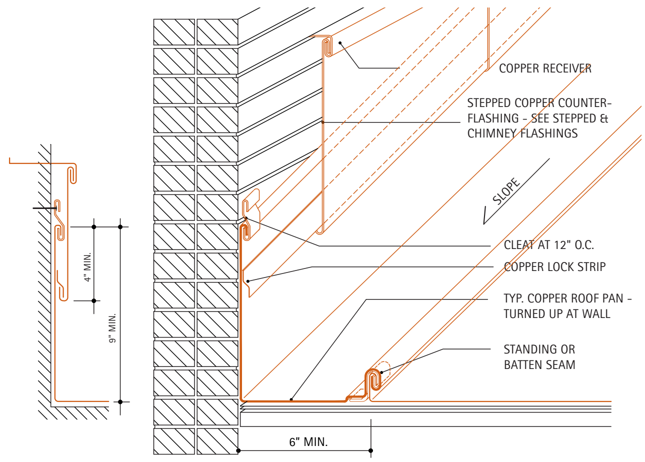
9.2G. Copper Receiver Cast in Concrete Wall

Another method of flashing a concrete wall is to cast the cap flashing into the wall. The cap flashing is attached to the base flashing by blind riveting. An alternate base flashing fastening method is to use cleats spaced at 12" O.C. This detail can be used on either a sloped or a flat roof.



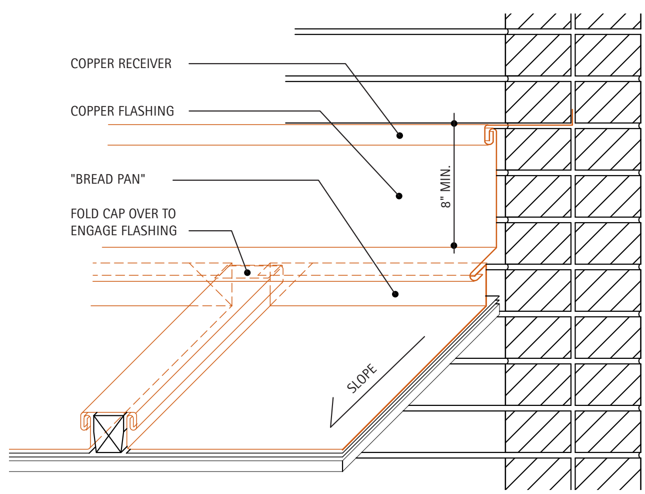
9.2H. Pitched Copper Roof Parallel to Wall

This detail can be used for both standing and batten seam roofs. The copper roofing pans are turned up on the vertical wall to form a base flashing extending at least 9" up the wall where they are cleated. Copper flashing, held by a receiver at the top, is locked into a locking strip soldered to the base flashing. The counterflashing overlaps the base flashing by at least 4".



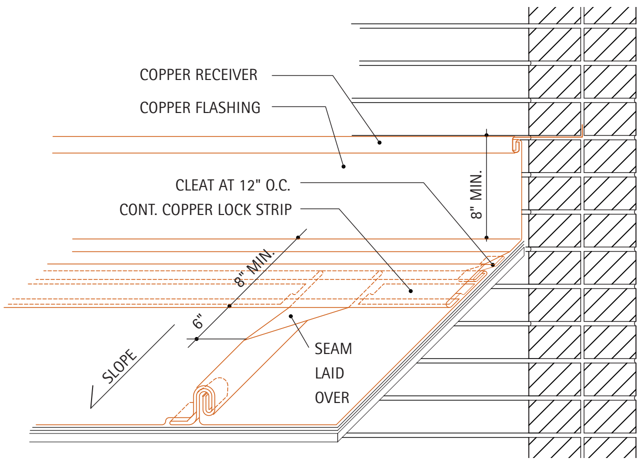
9.2I. Batten Seam Roof at Wall

The flashing of the head of a **8.3. Batten Seam Roofing** at a wall is shown in this detail. The top of the roof pan is formed into a "bread pan" whose upper edge is just above the finished batten. Copper flashing is locked into this edge, and extends at least 8" up the wall. A copper receiver holds the counterflashing at its top edge.



9.2J.Standing Seam Roof at Wall

The detail shows the method of flashing the head of a **8.2. Standing Seam Roofing**. The standing seams are laid flat 8" from the vertical wall, 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 wall and engage the base flashing in a 3/4" lock. Copper base flashing extends at least 8" up the wall to a copper receiver.



"Bread-Pan" construction details similar to **Detail 9.2I** can also be used.

For Additional Information:

- **9.8. Stepped and Chimney Flashings**, for information on stepped flashing methods.
- **8.2. Standing Seam Roofing** or **8.3. Batten Seam Roofing**, for information on the respective roofing types.
- **8.8. Long Pan Systems**, for details and requirements on pans over 10 feet in length.

9.3. Coping Covers

Description: The horizontal top surfaces of walls are the most vulnerable point for water to enter the wall. There are a number of ways of protecting this surface with copper flashing alone, or in combination with stone or precast concrete.

In general, copper flashing for copings comes in lengths of 8 or 10 feet. Adjacent sheets are joined with standing seams or transverse seams that are locked and soldered. The width of the coping, the weight and the location of expansion joints can all be determined by utilizing **Table 10B**.

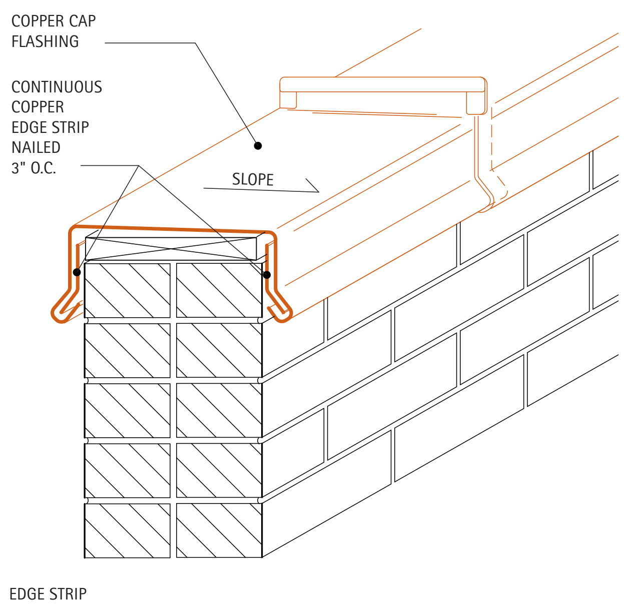
For example, assume 20 oz. cold rolled copper is specified as a flat coping cover on an 8" thick parapet wall. The copper coping is bent down 4" on both sides of the wall at an angle of 90 degrees. The lower edges of the copper coping are hooked over an edge strip and are free to move. Referring to **Table 10B** for 20 oz. copper: first, find 8" in the column "width of gutter bottom"; then, travel horizontally to the right and in the column "90° MAX 90° MIN" find the dimension 24'-6"; the maximum allowable distance between expansion joints is 2 x 24'-6" or 49'-0".

Special Conditions: For areas where ice and snow conditions occur see the **8.1. Special Roofing Design and Installation Considerations**.

On roofs with short parapet walls, positive roof drainage must be provided. The water level on the roof must not reach any point where the the roofing membrane terminates or has been punctured, such as at cleats.

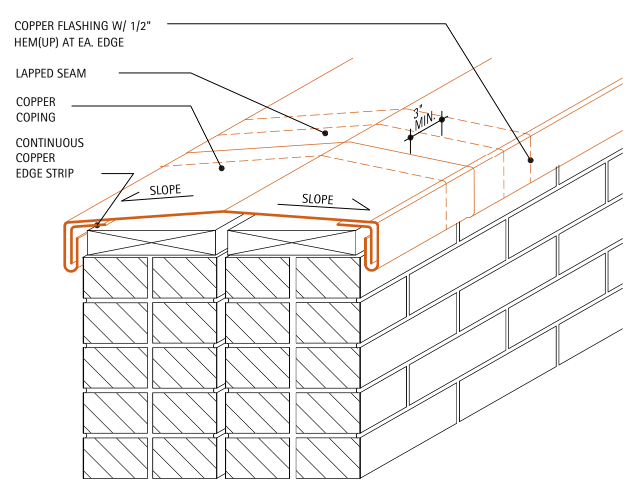
9.3A. Typical Copper Coping

The detail illustrates a copper cap flashing installed over a masonry wall. Continuous wood blocking is first securely anchored to the top of the masonry and covered by a layer of building paper. Continuous copper edge strips are then fastened to the wood blocking. The cap flashing is then locked over the edge strips.



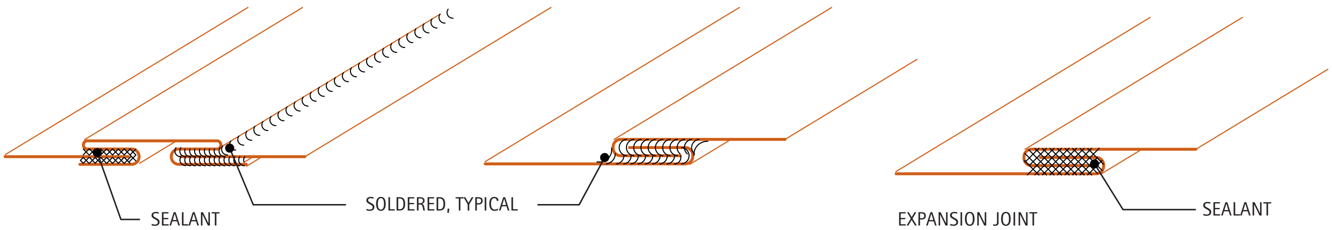
9.3B. Two Walls of Same Height

This detail can be used when a new wall is constructed adjacent to an existing wall of the same height. The principle is the same as that for **Detail 9.3A**.



9.3C. Alternate Coping Seams – Section

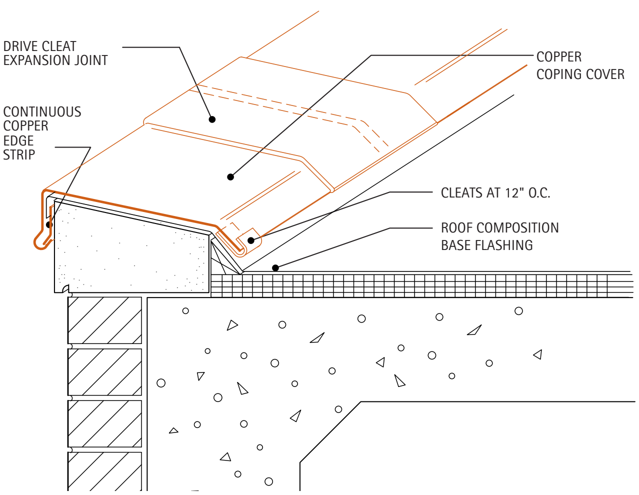
The first two depictions are alternative transverse seams for joining adjacent sheets of copper cap flashing. These seams are typically locked and soldered. Expansion joints must be used if the coping is more than 30 feet long.



The third is an expansion joint composed of a flat lock seam filled with sealant.

9.3D. Complete Cover at Short Parapet

This coping is fully covered by a copper cap flashing. The roof composition flashing extends up the cant strip, over the coping, and part-way down its face, under the copper flashing. The roof side of the copper is cleated to the nailable cant strip. On the opposite side, a continuous copper edge strip is attached to the coping, and the lower edge is bent to form a drip. The cap flashing is then locked to the edge strip.

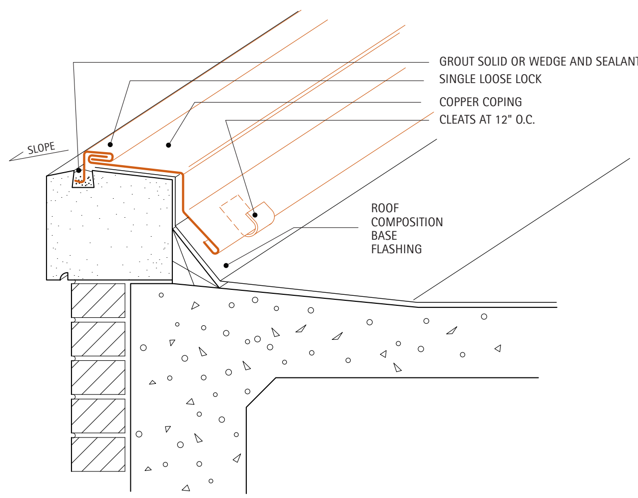


Expansion joints typically use a drive cleat (see **7. Basic Details**) set in 2 beads of sealant, 1/4" to 3/8" wide on each side of the joint.

See note under **Special Conditions** regarding short parapet walls.

9.3E. Partial Cover at Short Parapet

This detail is used where the copper cap flashing should not be visible on the building facade. The cap flashing, therefore, does not fully cover the coping. The roof side of the coping is detailed similar to **Detail 9.3D**.

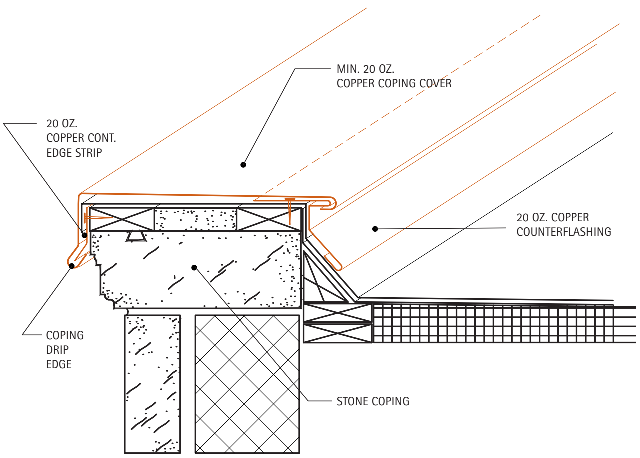


The upper edge of the copper flashing is locked into a continuous copper lock strip. This strip is inserted into a reglet cut or cast into the top of the coping. The strip can be grouted in, or held by lead wedges and sealed.

See note under **Special Conditions** regarding short parapet walls.

9.3F. Coping Cover

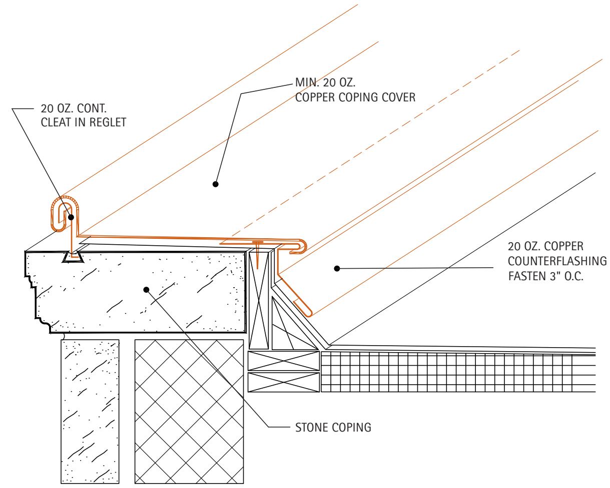
This detail illustrates a copper cap flashing installed over a masonry wall. Continuous wood blocking is securely anchored to the top of the stone coping, along both edges, and covered with building paper. A continuous copper cleat, of 20 oz. cold rolled copper, is nailed to the blocking on the outside face. The copper coping cover is locked over the cleat to form a drip. On the roof side, 20 oz copper counterflashing is nailed to the blocking. The coping cover is locked onto the upper edge of the counterflashing.



See note under **Special Conditions**, regarding short parapet walls.

9.3G. Coping Cover

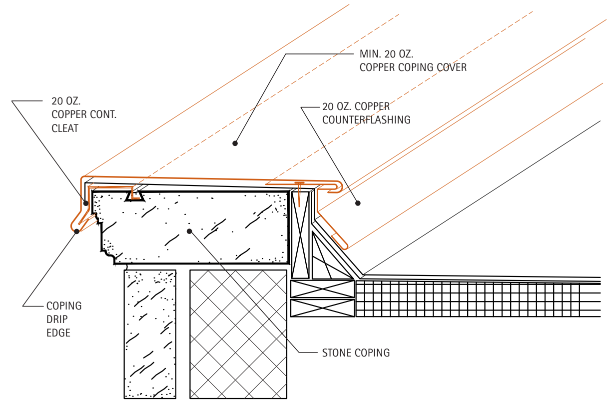
In this detail, a reglet is formed in the stone or precast coping. This provides a suitable means by which to anchor (grout solid or wedge and seal) the continuous copper cleat. The counterflashing at the roof side of the coping is nailed to the wood blocking. The coping cover is locked into place.



See note under **Special Conditions**, regarding short parapet walls.

9.3H. Coping Cover

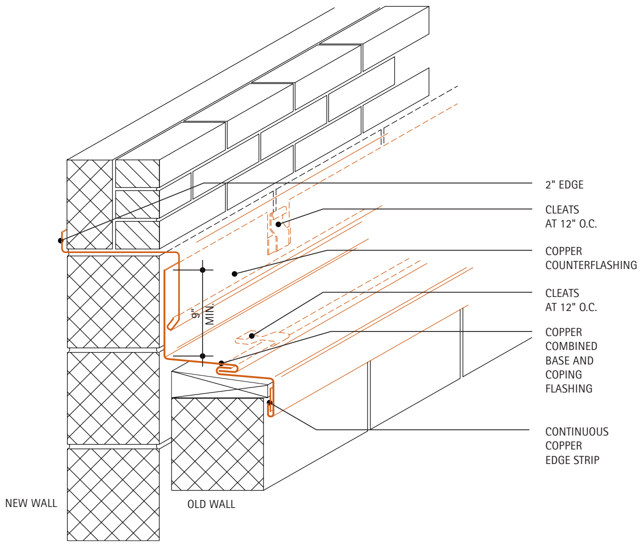
This cap flashing detail combines elements of **Detail 9.3F** and **Detail 9.3G**. A reglet is used to hold the continuous cleat in place, thus eliminating the need for wood blocking. This cleat is bent down over front face of the coping. The coping cover is locked onto the cleat.



See note under **Special Conditions**, regarding short parapet walls.

9.3I. Cover – Where New Wall is Higher Than Old

Shown is a condition where a new wall is constructed adjacent to an existing lower wall. A combination coping with a base and counterflashing is used.

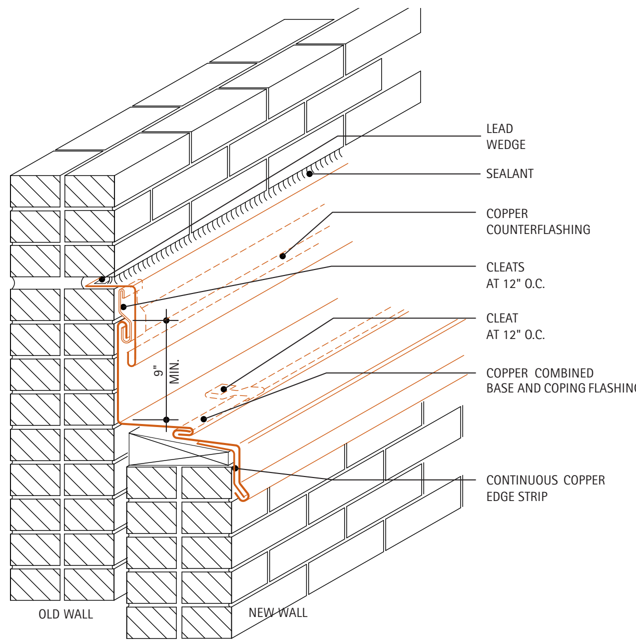


A continuous copper edge strip is fastened to wood blocking which has been anchored to the top of the old wall. The coping flashing locks into this strip then runs over the old wall. A common lock seam joins it to the base flashing which runs up the face of the new wall at least 9". The top edge of the base flashing is cleated to the new wall.

Through-wall flashing is installed in the new wall, then bent down to lap the base flashing and cleats. The combined base and coping flashing must be installed to provide positive drainage away from the new wall. Its lower edge should be formed into a drip, either by projecting out over the wall as shown here or by introducing a bent drip edge as shown in **See Detail 9.3J**.

9.3J. Cover – Where Old Wall is Higher Than New

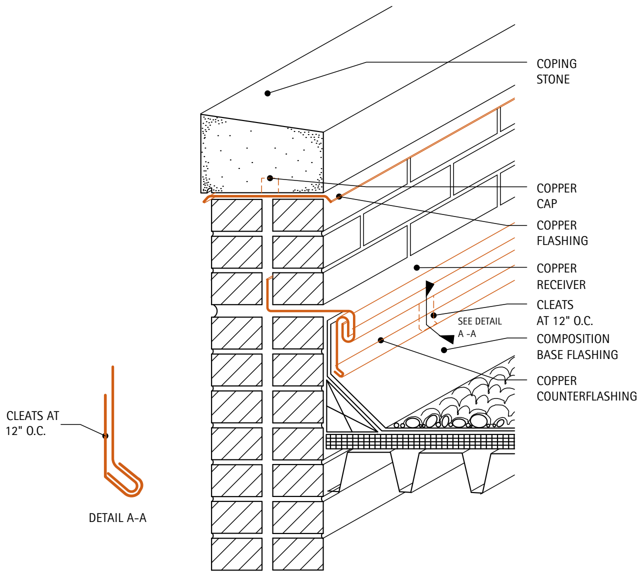
This condition is similar to **See Detail 9.3I**, except it is not possible to install through-wall flashing in the old wall. A reglet is formed by raking the mortar joint between brick courses. Counterflashing is inserted into the reglet and held by lead wedges. The reglet is then filled with sealant.



The base and coping flashing are installed similar to **See Detail 9.3I**.

9.3K. Masonry or Precast Coping

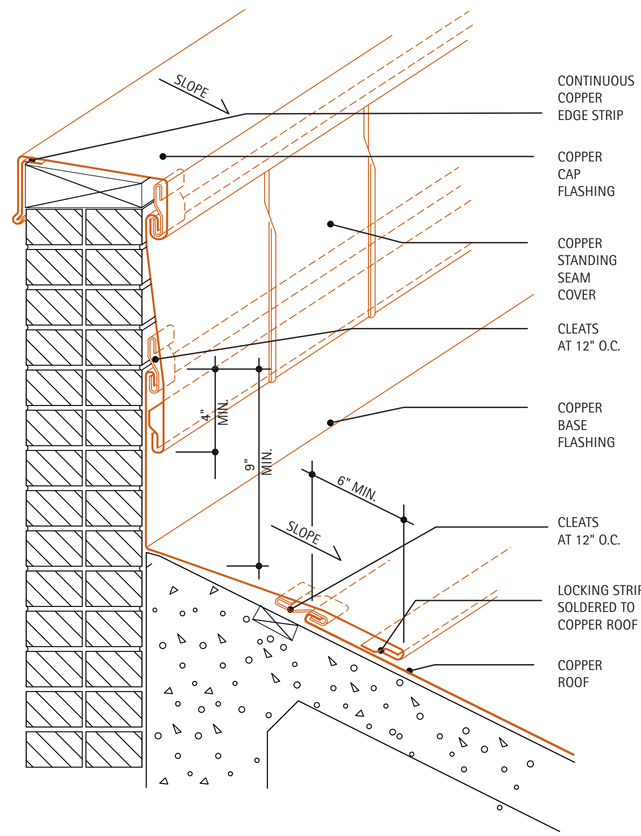
This detail illustrates the use of copper through-wall flashing to protect the wall under a stone or precast concrete coping. The flashing is continuous and projects beyond the face on both sides of the wall. The projections provide drips.



The dowel securing the masonry coping is fully covered by a copper cap soldered to the flashing. If this is not possible, the penetrations through the flashing should be properly sealed.

9.3L. High Parapet – Copper Roof

A combination of elements are used in this detail. The top of the wall is covered by a copper coping cover, similar to **Detail 9.3A**. On the roof side, the cover is locked into a standing seam parapet cover. This cover, in turn, laps over base flashing which is cleated to the roof deck or a nailing strip.



The lower edge of the parapet cover is joined to the upper edge of the copper roof with a transverse seam.

For Additional Information:

- **7. Basic Details** for information on expansion joints, and transverse seams.
- **9.2. Counterflashing**, for additional information on flashing methods.

9.4. Ridges and Hips

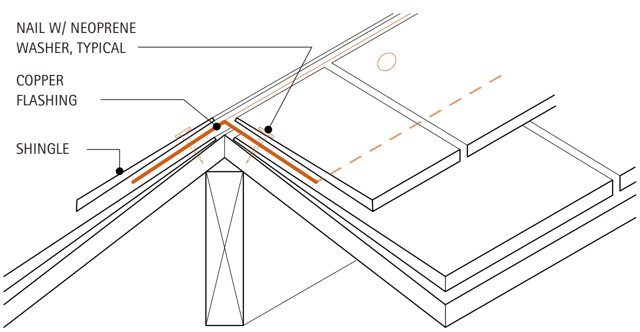
Description: There are many ways to construct copper ridge and hip flashings. The ridge flashings form a cover over the roofing material. The anchoring methods vary.

Most hip installations involve the weaving of copper flashing sheets between roofing shingles.

The minimum recommended weight for ridge and hip flashing is 16 oz.

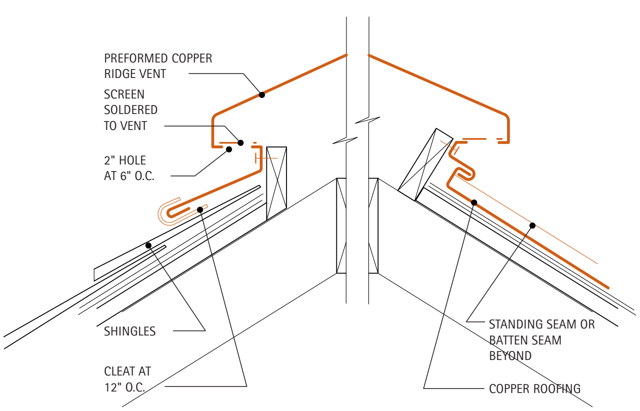
9.4A. Ridge at Shingle Roof

The flashing is nailed to the sheathing after the shingles are installed. Then the flashing is covered by shingles applied end to end across the ridge. These shingles are nailed with neoprene washers.



9.4B. Ridge Vents

Two conditions are shown, a shingle roof on the left and a copper roof on the right. In each case, wood blocking frames the perimeter of the roof opening. The preformed copper ridge vent is nailed to the blocking at 3" O.C. and is formed from a minimum of 20 oz. copper.



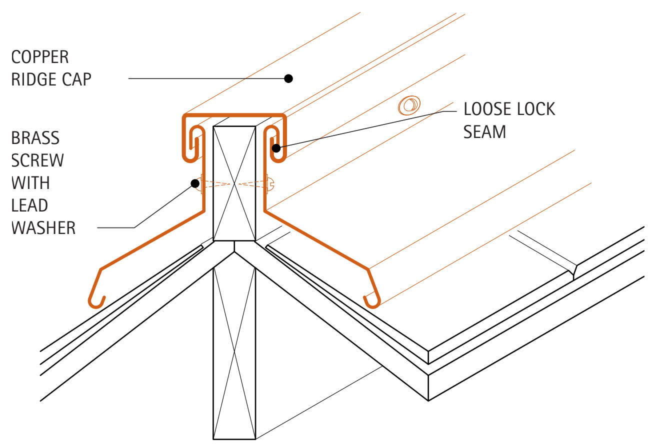
For the shingle roof, the lower edge of the vent is hemmed and held by cleats at 12" O.C.

For the copper roofing, the lower vent edge is locked into the upturned edge of the roofing pans.

A bronze screen is soldered to 2" diameter holes in the vent frame punched at 6" O.C.

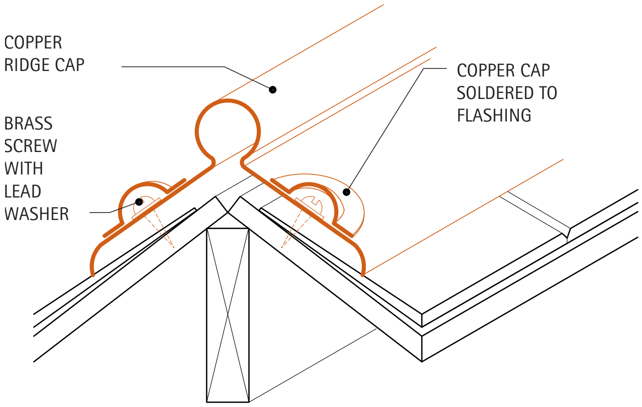
9.4C. Spring and Batten Ridge

This detail involves the use of a ridge batten anchored to the ridge pole. Copper base flashing is installed on both sides of the batten with brass screws and lead washers. The copper ridge cap is locked into the base flashings. The base flashings maintain contact with the shingles by spring action.



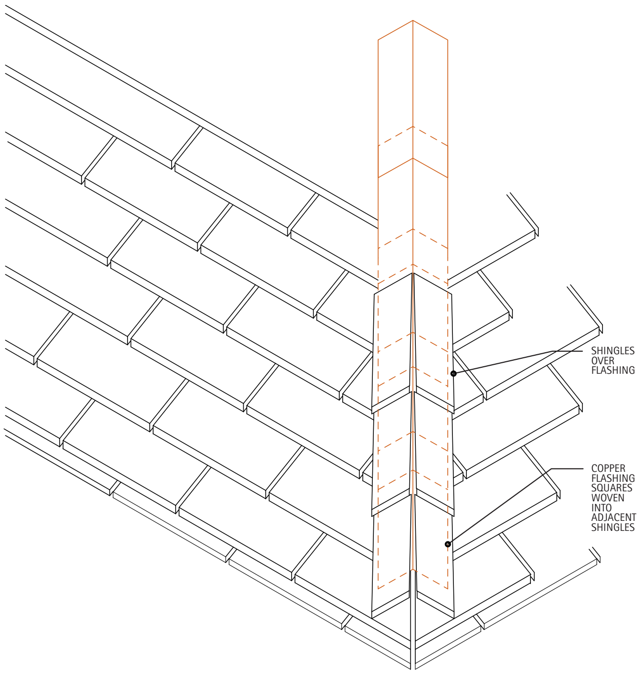
9.4D. Screwed Down Ridge

This ridge cap is made from a one piece copper flashing. It is fastened to the roof sheathing by brass screws after the shingles have been installed.



9.4E. Concealed Hip Flashing

In this detail the hip flashing is concealed. Small copper flashing squares are inserted between successive layers of shingles during installation. They are then covered by shingles applied end to end along both sides of the hip.



For Additional Information:

- **8. Roofing Systems** for additional information on copper roofing ridge details.
- **7. Basic Details** for details on hold-downs.

9.5. Valleys

Description: Valley flashings are usually categorized as open or closed. The former is visible when completed, the latter is not. The main difference is that for open valleys, long sheets of 16 oz. (minimum) copper are **cleated** to the sheathing and underlayment before the shingles are applied. Adjacent sheets of copper are lapped a minimum of 8". The sheets are nailed at the top only with copper or bronze nails.

Closed valleys are constructed during shingle installation by inserting copper flashing squares between successive layers of shingles. These flashing squares are folded on the diagonal. The recommended square dimensions for slate and shingle roofs are shown in **Table 9.5A**.

Table 9.5A. Recommended Copper Square Dimension Sizes for Slate and Shingle Roofing

	Square Size, Inches Roof Slope	
Slate Size, Inches	***6" or greater per foot***	***less than 6" per foot***
12	9 x 18	9 x 24
14	10 x 18	10 x 24
16	11 x 18	11 x 24
18	12 x 18	12 x 24
20	13 x 18	13 x 24

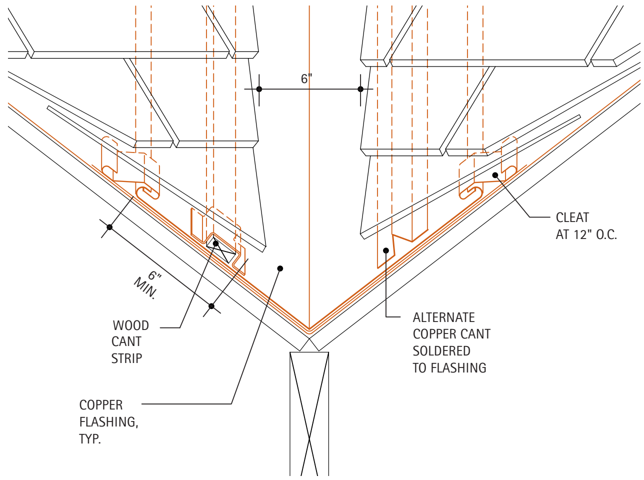
Cant strips are used to raise the shingles, thus breaking contact with the copper surface which minimizes line corrosion.

If slate or tile is used for the roof covering, 20 oz. copper is recommended for valley flashing.

Special Conditions: The details shown are for roof intersections resulting in valley slopes of at least 4-1/2" per foot.

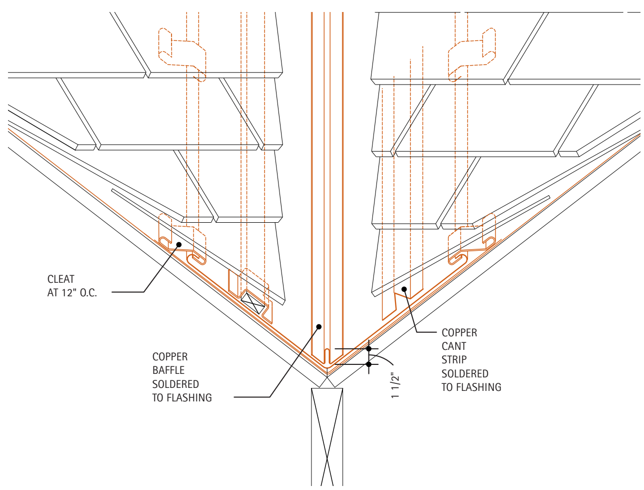
9.5A. Open Valley

The detail shows a typical open valley flashing for a shingle or slate roof. Two different cants are illustrated. The cant strip can also be constructed as shown in **Detail 9.5D**. The shingles or slate must lap the flashing at least 6".



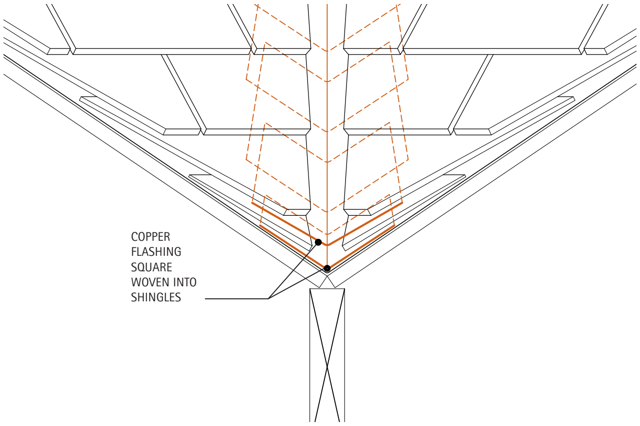
9.5B. Equal Slopes – Unequal Water Flow

Where unequal water flow is expected, a baffle, 1-1/2" high, should be installed as shown to prevent water of higher velocity from forcing its way past the opposite edge of the valley flashing. The baffle can also be constructed as shown in **Detail 9.5D**.



9.5C. Closed Valley

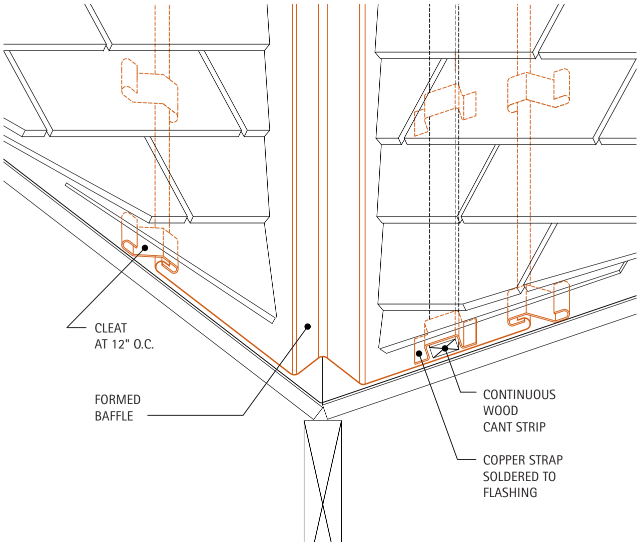
Intersecting roofs using a closed valley must have the same slopes so that the shingle butts line up at the valley intersection. For roof pitches of 6" or more per foot the flashing extends at least 9" under the roof covering on each side. For roof pitches less then 6" per foot the flashing extends at least 12".



The lower edge of the flashing should be held 1/2" short of the butt line of the slate, tile or shingle in the succeeding course. The upper edge is fastened to the sheathing with copper or bronze nails.

9.5D. Unequal Slopes

This condition requires a baffle for the same reason as **Detail 9.5B**. It can be constructed as shown in either detail. This detail also shows a different cant strip. Other methods of raising the shingles away from the copper are shown in **Detail 9.5A** and **Detail 9.5B**.



For additional information on copper roofing valley details see: **8. Roofing Systems**.

9.6. Changes in Roof Slopes

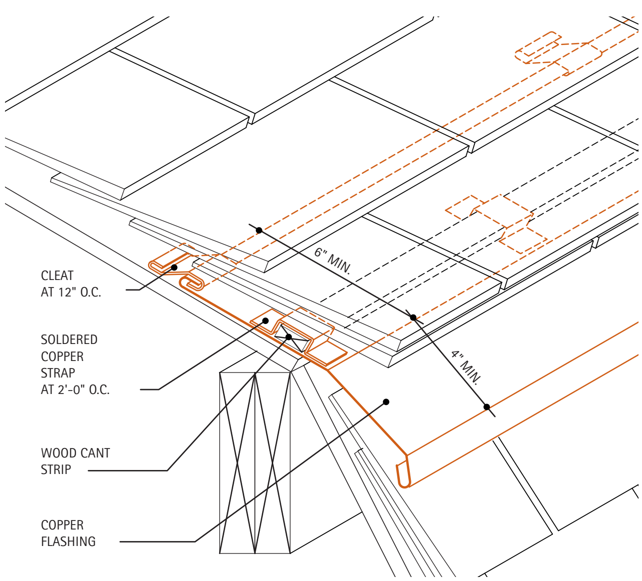
Description: Flashing a change in roof slope usually involves copper sheets 8 or 10 feet in length. They lap over the lower roof and are lapped by the upper roof. A cant of some kind is used to raise the roofing material and keep it from direct contact with the copper surface, to minimize line corrosion.

There are many combinations of roofing materials and corresponding numbers of appropriate details for each condition. The details shown are valid for shingle, tile, and slate roofing. The conditions are representative of typical installations.

The recommended minimum thickness of copper is 16 oz. unless slate or tile roofing is used in which case 20 oz. copper is used.

9.6A. Change of Roof Slope – Wood Cant

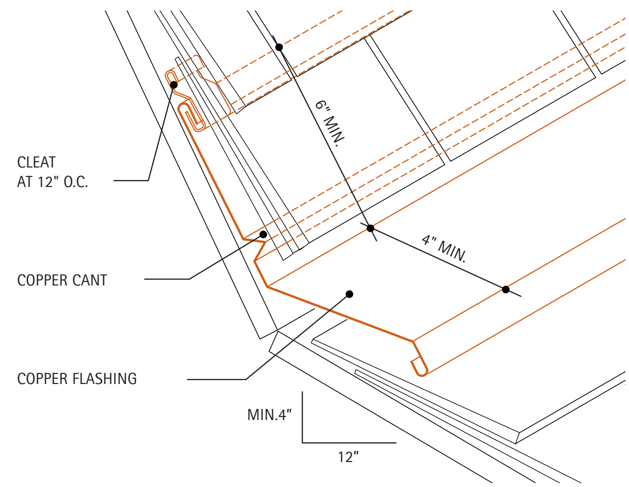
This detail shows a shallower pitched roof joining a steeper pitched roof below. The copper flashing extends under the upper roofing at least 6". It laps the lower roofing a minimum of 4". The ends of each sheet should lap over the preceding one at least 4". The lower edge of the flashing is hemmed for stiffness.



The cant strip shown is wood fastened by copper straps, spaced 2'-0" apart, soldered to the copper flashing. A copper cant can be used instead, as shown in **Detail 9.6B**.

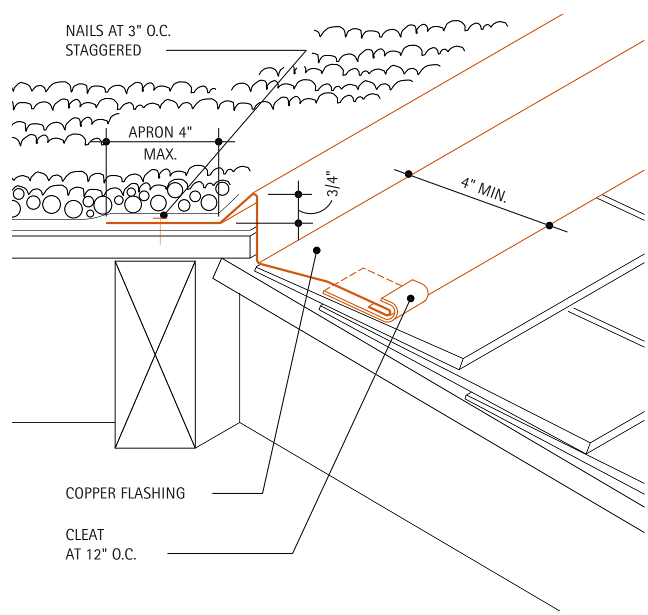
9.6B. Change of Roof Slope – Copper Cant

In this detail the steeper pitched roof is above the one of lower pitch. The flashing method is similar to the one shown in **Detail 9.6A**.



9.6C. Flat to Sloped Roof with Gravel Stop

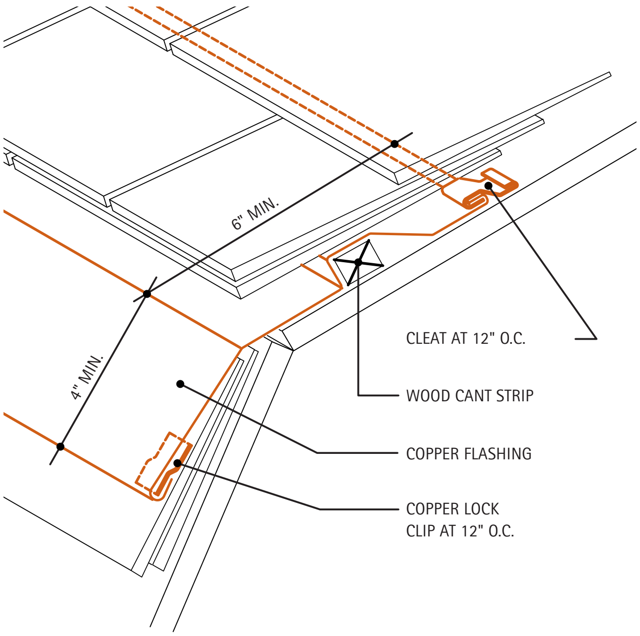
This detail shows a flat built-up roof joining a lower pitched roof. Here the flashing extends a maximum 4" under the built-up roofing. It also has a built-in, formed gravel stop.



The lower edge of the flashing is hemmed and cleated to the sheathing at 12" O.C. As an alternate, a lock clip can be used as shown in **Detail 9.6D**.

9.6D. Change of Roof Slope – Alternate Wood Cant

This detail shows an alternate cant. The wood cant is nailed to the sheathing. It is then covered by the copper flashing. The lower edge of the flashing is hemmed and held by a lock clip. Alternately, cleats at 12" O.C. can be used as shown in **Detail 9.6C**.



For Additional Information:

- **9.7. Gravel Stops and Fascias**, for additional information on gravel stops.
- **9.4. Ridges and Hips**, for related conditions.
- **9.5. Valleys**, for additional information on valley conditions.

9.7. Gravel Stops and Fascias

Description: Gravel stops and fascias are used where flat roofs end to provide a weathertight transition between roof and wall. Fascias may have a wide variety of decorative patterns. The details shown concentrate on combined gravel stops and fascias.

Where possible, gravel stops are installed over cant strips or raised curbs. When installed on a concrete or a steel deck, a wood nailer is required. Gravel stops are, in general, about 3/4" high and formed from copper sheet 8 to 10 feet long. The copper apron extends 4" onto the roof deck. The sheets are fastened to the roof deck by nails spaced 3" O.C. The ends are lapped 3" minimum. The lapped joint on the horizontal flange is set in mastic or elastic sealant. On vertical surfaces, the lapped sheets are held together by a clevis seam, as shown in **Detail 7.2J**. On sloped surfaces, the clevis seam is filled with sealant before assembly.

To minimize roof membrane cracking at gravel stop apron due to differential material expansion and contraction, the maximum apron dimension is 4", whenever additional sealing stripping is required.

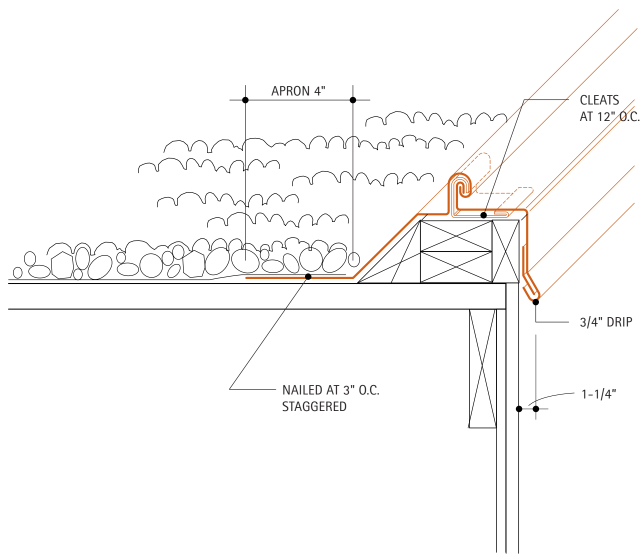
The maximum recommended fascia dimension is dependent on local wind conditions. **Table 9.7A** lists these recommendations as a function of the gauge of copper material used. The fascia dimension is the vertical dimension of the outside face of the fascia.

Table 9.7A. Maximum Recommended Fascia Dimensions

Weight of Fascia Sheet (Ounces)	*Velocity Pressure*			*Weight of Edge Strip (Ounces)*
	10-20 PSF (Inches)	*21-30 PSF (Inches)*	*31-45 PSF (Inches)*	
16	8	6	4	20
20	10	8	6	24
24		10	8	32
32			10	48

9.7A. Set-Back Gravel Stop

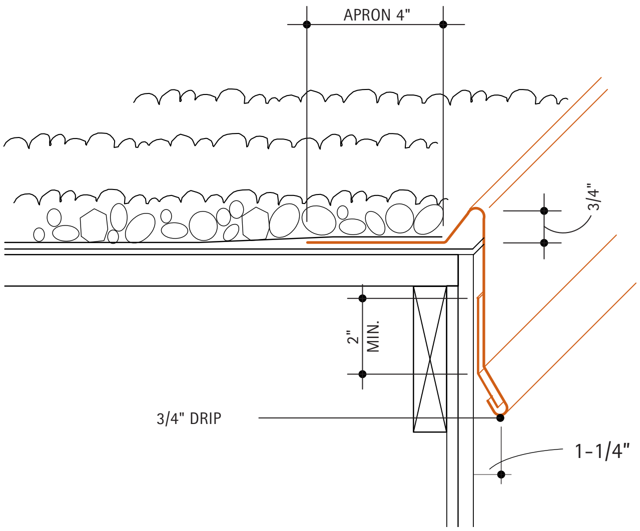
This detail shows a gravel stop installed on a wood curb, but set back from the fascia face. There are two sheets, a gravel stop and a fascia, joined on the curb by a standing seam. The lower edge of the fascia locks into a continuous edge strip, and is formed into a drip with a 3/4" lock. On a flat wall surface with no overhang, the drip should be formed at a 1-1/4" as shown, to minimize staining of wall surface below.



A nailable roof deck is required, otherwise wood blocking inserts must be provided.

9.7B. Gravel Stop at Fascia Board

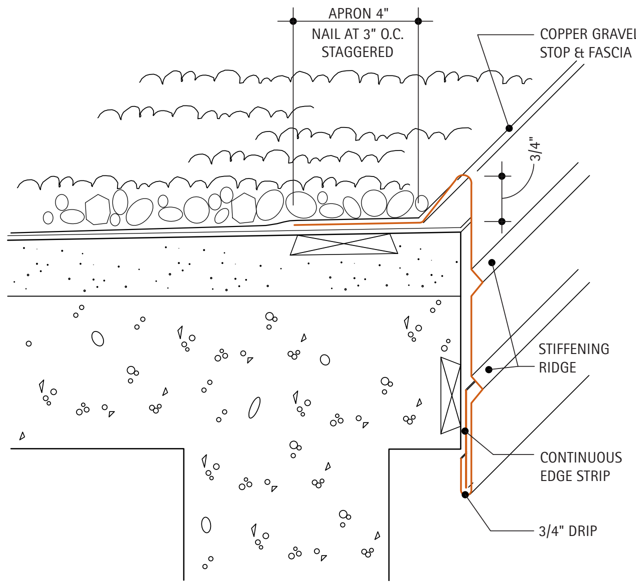
This is a single piece gravel stop and fascia. The sheet is installed directly on the roof deck, with a 3/4" vertical projection that acts as the gravel stop. The lower edge is locked into a continuous edge strip forming a drip.



A nailable roof deck is required, otherwise wood blocking inserts must be provided. The horizontal base is fastened with copper nails staggered at 3" O.C.

9.7C. Gravel Stop at Deep Fascia Board

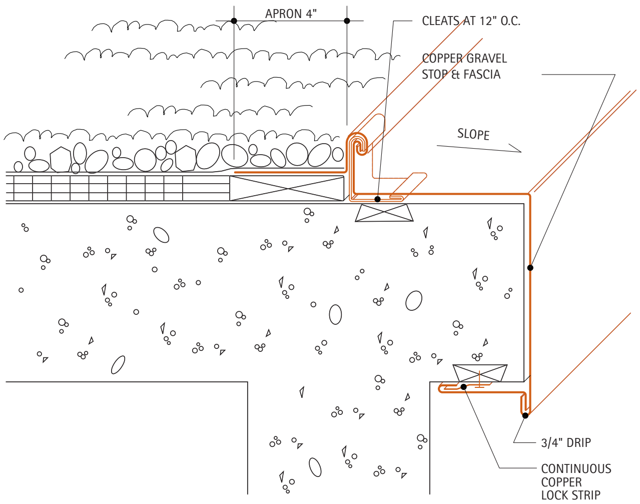
This is another example of a one-piece gravel stop-fascia. The lower edge of the fascia is held by a continuous edge strip attached to a wood nailer. The edge forms a natural drip because of the soffit provided by the overhang. The horizontal portion is fastened as described in **Detail 9.7B**.



When the fascia is 8” or more in height, waviness may be countered by forming one or more horizontal raised “V” ridges or steps not less than 1/2” high in the fascia. These ridges stiffen the flat section and should be spaced proportionally across the height of the fascia. As an alternative, consider **Detail 9.7H**.

9.7D. Set-Back Gravel Stop on Concrete

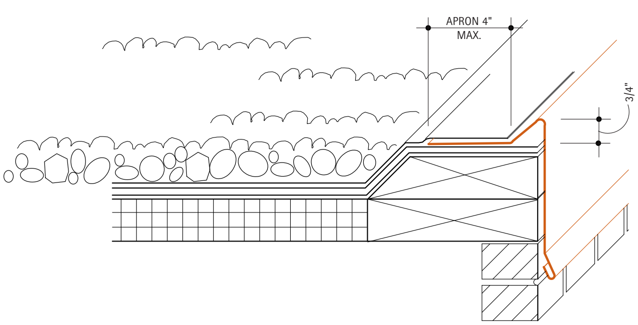
A separate gravel stop and fascia are illustrated. As in **Detail 9.7A**, the two copper sheets are joined by a standing seam cleated at 12" O.C. Since the roof deck is concrete, wood nailer is provided for securing the various elements.



The lower edge of the fascia is held by a continuous edge strip, which also serves as the soffit for the underside of the concrete deck and is fastened with a continuous lock strip. The horizontal portion of the gravel stop is fastened as described in **Detail 9.7B**.

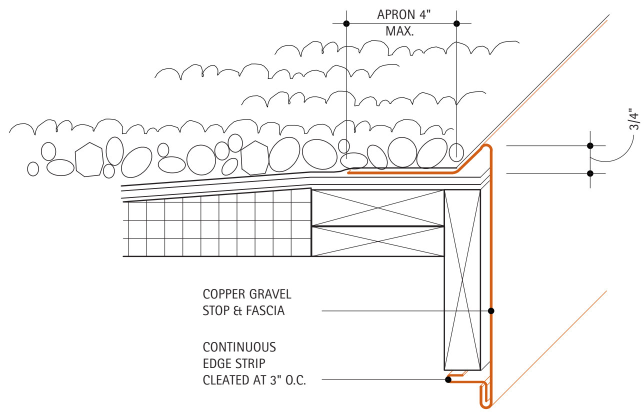
9.7E. Gravel Stop on Raised Curb

This detail shows the typical one piece gravel stop-fascia. It is installed on a raised, canted wood curb. Its lower edge is formed into a drip. A continuous edge strip is not required if the fascia dimension is less than the recommendations in **Table 9.7A**. The horizontal apron portion of the gravel stop is fastened with copper nails staggered at 3" O.C.



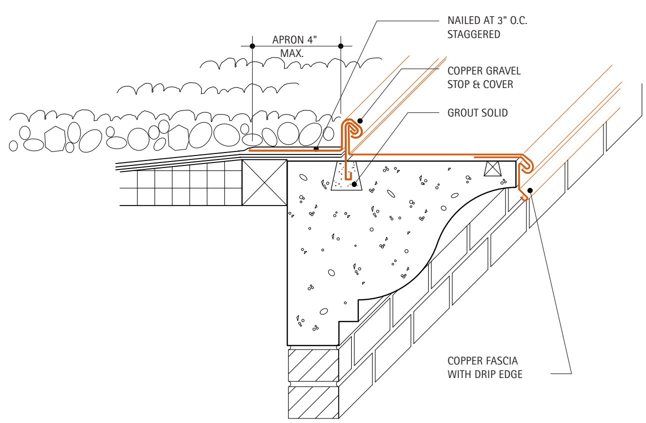
9.7F. Gravel Stop at Tapered Insulation

This combined gravel stop and fascia is shown on a curb with preformed tapered insulation. The continuous edge strip at the lower edge is formed into a small soffit covering the wood blocking and nailed at 3" O.C. The horizontal apron portion of the gravel stop is fastened with copper nails staggered at 3" O.C.



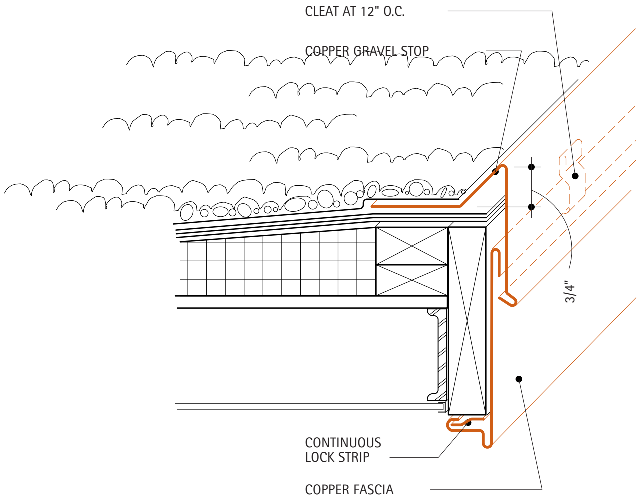
9.7G. Gravel Stop at Concrete Cornice

This gravel stop is installed over a precast concrete cornice and joined to a copper cover. The roof side apron of the cover is locked into the gravel stop using a standing seam, cleated and anchored to a raggle in the cornice. The outer edge of the cornice cover is hooked over a one-piece continuous combination edge strip and drip edge.



9.7H. Two Piece Gravel Stop and Fascia

Illustrated is a two-piece gravel stop and fascia installed on a raised curb. The lower edge of the fascia is formed into a soffit and drip edge. It is held by a continuous copper lock strip which is nailed at 3" O.C., staggered.



The upper piece is nailed to the curb through its horizontal flange. Its lower edge is also formed into a drip.

For Additional Information:

- **7. Basic Details**, for information on seams, exp ansion seams, and cleats.
- **9.6. Changes in Roof Slopes**, for additional information on gravel stops at changes in roof slopes.
- **9.3. Coping Covers**, for more information on parapet and coping conditions.
- **Table 9.7A**, for recommended fascia dimensions and thicknesses.

9.8. Stepped and Chimney Flashings

Description: Stepped flashing is used where a sloped roof meets a masonry wall. A typical occurrence is where a brick chimney rises above a roof. The details shown concentrate on such chimney flashings, but apply to other wall conditions.

There are two approaches to stepped flashings. One type uses pieces of copper base flashing installed with each course of shingles. The upper edge of each flashing piece extends 2" above each course of shingles. The lower edge is held 1/2" above the butts of the succeeding course. The base flashing extends a minimum of 4" up the wall and onto the roof. The one piece cap flashing is inserted into a reglet and held by lead wedges. The reglet is filled with sealant. The length of each piece of cap flashing varies with the pitch of the roof; no step should be more than 3 bricks high. The width also varies but should always be wide enough to cover 4" of the base flashing.

The second type uses a single copper runner under the shingles, tile or slate. This type is attached before the roofing material is installed. The roof portion of this runner flashing has a hooked edge and is cleated at 12" O.C. The base flashing is extended up the wall a minimum of 8". This requires the cap flashing to be in two pieces, a receiver and a counterflashing.

If the chimney straddles the ridge of the roof, this stepped flashing is used on the two sloped sides. The lower sides are flashed with a copper apron that covers the next course of shingles.

If the chimney is entirely on one side of the ridge, a copper cricket must be used on the high side to divert the water to either sloped side.

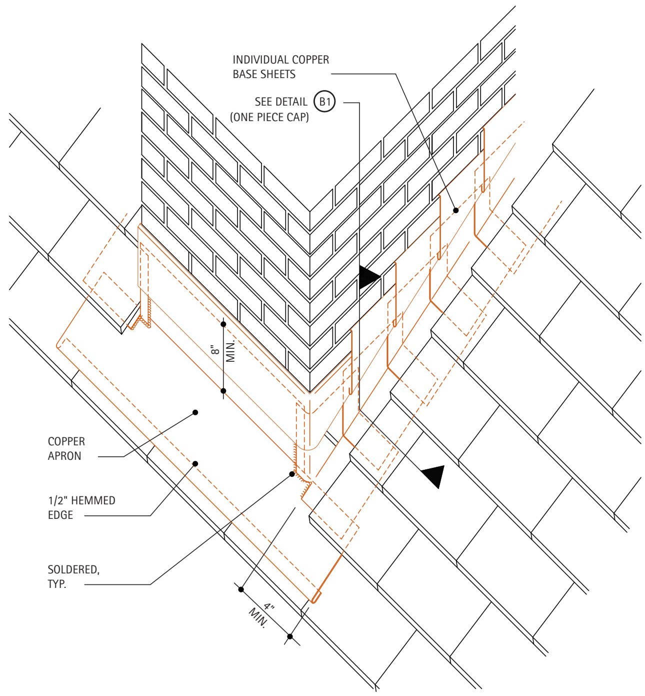
Apron and cap flashing should be of at least 16 oz. Base flashing for shingles can also be 16 oz., but for slate or tile roofs 20 oz. is recommended.

The apron joint with the base sheets is soldered horizontally and vertically.

The minimum weight for the cap and base flashing used at chimneys and other stepped flashing conditions is 16 oz. Crickets should also be formed from 16 oz. copper.

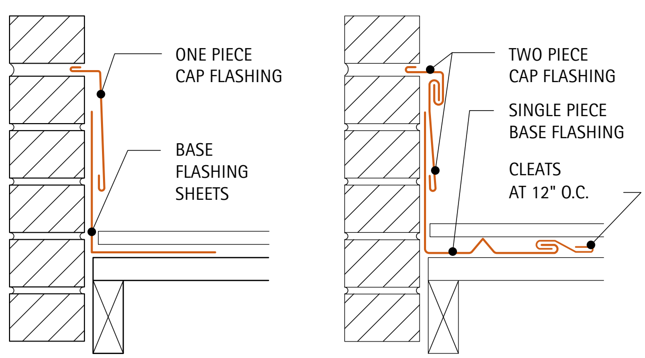
9.8A. Flashing at Base of Chimney

This detail shows a typical installation using individual copper base sheets, as described above.



9.8B. Alternate Step Flashing Methods

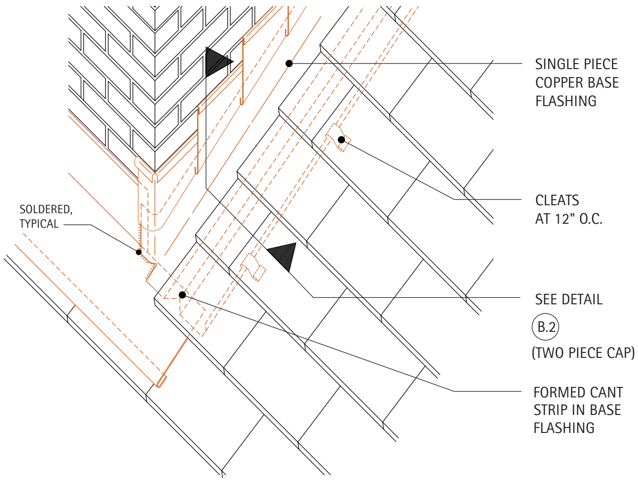
These sections illustrate two methods of stepped flashing. The one on the left uses individual copper base flashing sheets, and a one-piece cap. The other one uses the single piece base flashing with a two-piece cap flashing. Note the hooked edge on the base flashing to prevent water from running under the roofing material. The water is conducted instead to the end of the base flashing, over the apron, and onto the roof below.



1. ONE PIECE CAP
2. TWO PIECE CAP

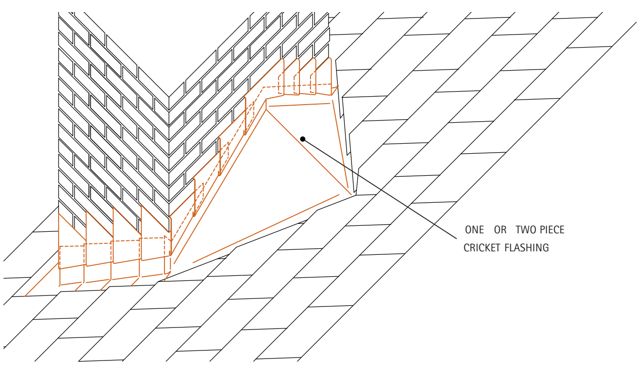
9.8C. Chimney Flashing – Alternate

This detail shows a second method of stepped flashing as described above.



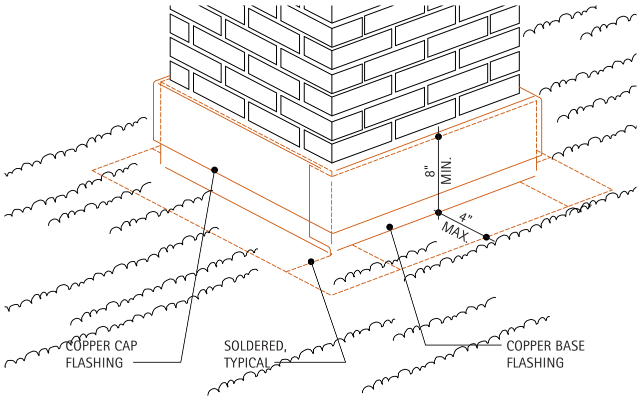
9.8D. Chimney Cricket Flashing

This detail illustrates the use of a cricket to divert water above the chimney to either side. The cricket can be a one piece design or a two piece, joined by a standing seam at its ridge.



9.8E. Chimney Flashing – Flat Roof

Copper base flashing is attached to the roof deck before installation of the roofing. It extends at least 8" up the wall and at least 4" onto the roof, on all sides of the chimney. Copper cap flashing then covers the upper edge.



All joints between base flashing sheets are soldered.

For Additional Information:

- 9.2. Counterflashing

9.9. Roof Penetrations

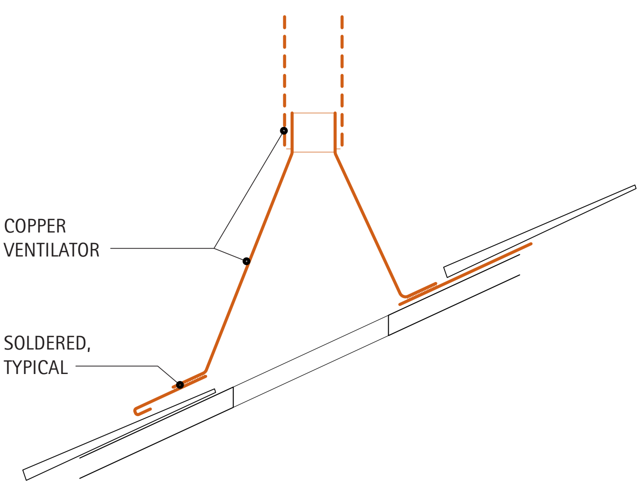
Description: Roof penetrations can be categorized by whether the roof is sloped or flat. The preferred method of flashing penetrations through flat roofs involves the construction of a curb around the opening. Small penetrations often do not require curbs.

With sloped roofs, the general approach is to attach the flashing before the roofing is installed. The shingles, slate or tile are placed over the flashing on the upper and two sides and slipped under the lower edge of the flashing. This approach is similar to the chimney flashing in **Detail 9.9C**. A concern with penetrations in sloped roofs is ensuring that no pockets are created where water can collect. If the shape of the flashing is such that water does not flow freely, a cricket is constructed on the high side of the flashing, similar to the one in **Detail 9.9D**.

The minimum weight for copper sheets used in flashing roof penetrations is 16 oz.

9.9A. Ventilator Flashing

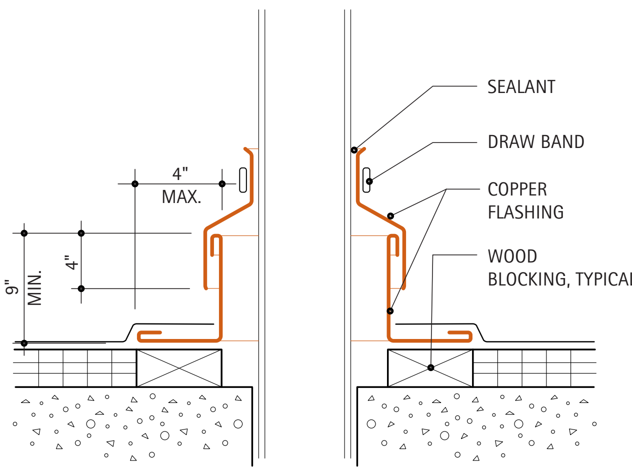
This detail illustrates a method of flashing a ventilator on a sloped roof. The base flashing extends onto the roof a minimum of 4" and is soldered to the ventilator. The lower edge is hemmed for stiffness. Large flashings are formed with a hook edge on the top and sides and cleated to the sheathing at 12" O.C. maximum.



Straps may be attached inside the stack section of the ventilator and to the structural framing for additional support.

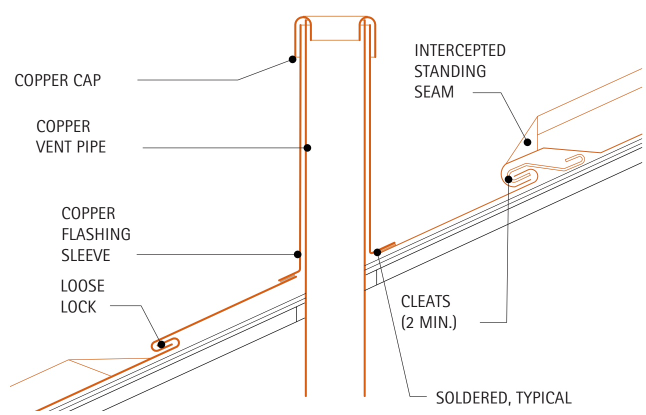
9.9B. Long Pipe Flashing

This detail is used for pipes that continue above the roof, and cannot be flashed as shown in **Detail 9.9D**. The copper base flashing extends a maximum of 4" onto the roof. The horizontal portion is nailed to wood blocking or to a nailable deck. It extends up at least 9", and is lapped at least 4" by the counterflashing. The cap flashing is attached to the pipe with a draw band. The cap flashing is sealed at its top edge where it meets the pipe.



9.9C. Vent Pipe Flashing – Copper Roof

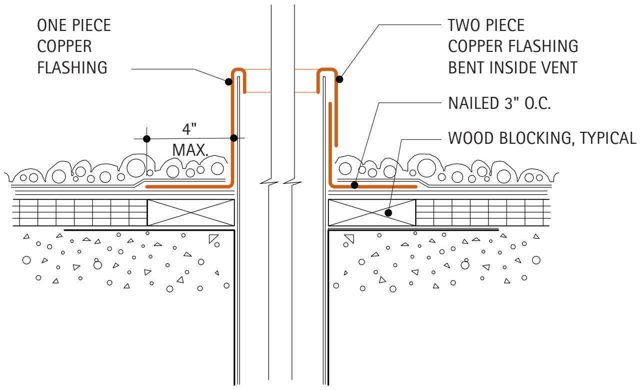
The copper base flashing extends a minimum of 6" onto the roof in all directions. The upper edge is held by at least 2 cleats and is locked into the roof pans. Any batten or standing seams that are interrupted at the upper joint, are to be continued below the lower joint.



A copper sleeve is soldered to the base flashing. This sleeve runs up to the top of the vent pipe. A copper cap is placed over the exposed edges and is soldered to the sleeve.

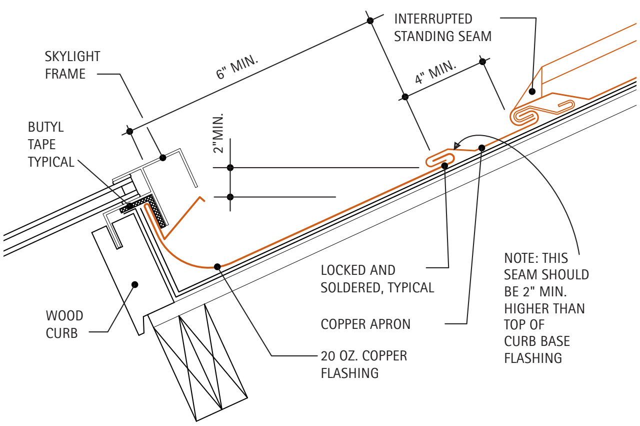
9.9D. Vent Pipe Flashing Methods – Flat Roof

Two methods of dealing with this condition are shown. The one on the right uses a separate copper cap flashing, the one on the left uses a single sheet of copper for the base and cap flashing.



9.9E. Skylight Head Flashing Detail

This detail shows the head of an aluminum skylight with a wood curb installed in a standing seam copper roof. The 20 oz., minimum, copper flashing is formed into a water diverter as shown. Effective separation of the aluminum and the copper is provided with the use of butyl tape. This tape is formed into an "L" shape, and applied over the flashing on all four sides of the curb, to fully cover any copper.

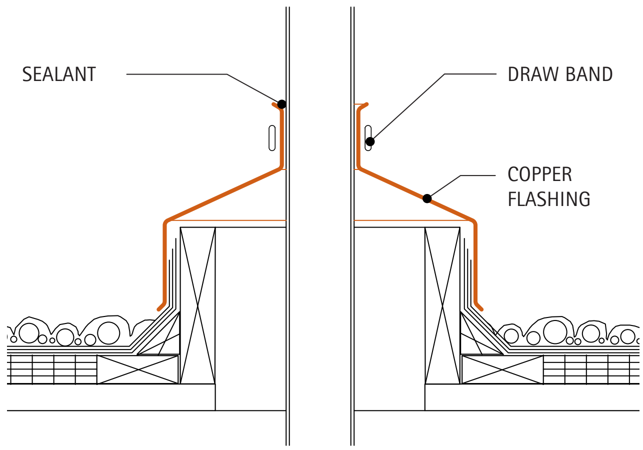


The roof edge of the flashing is locked and soldered into a copper apron. The apron is cleated at its upper edge and is joined to the copper roof pans with a transverse seam. Any standing seams that are interrupted at the upper joint, are to be continued below the skylight.

The sides of the skylight are flashed similarly, except that a water diverter is not used. The edge of the copper flashing is brought over the top of the curb.

9.9F. Pipe Penetration with Wood Curb

This detail shows a penetration with a wood curb. The composition flashing is brought up the cant strip and blocking, at least 8". Copper flashing laps over the composition flashing a minimum of 4". The top edge of the copper is held by a draw band tightened around the pipe. The exposed copper edge is then sealed.



For Additional Information:

- **10.6. Roof Sumps and Drains**

9.10. Dormers

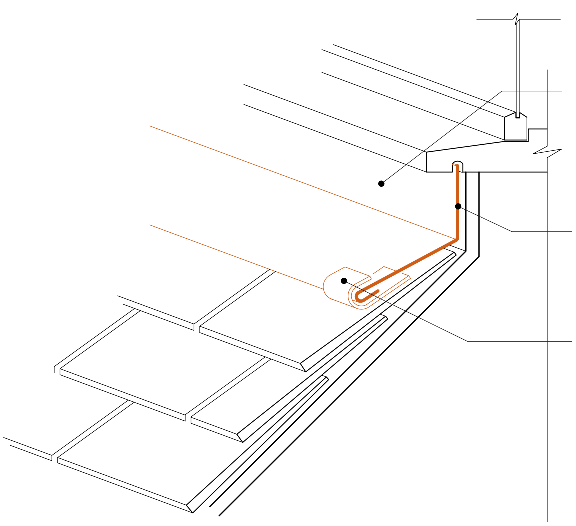
Description: The conditions for flashing the junction of a dormer and roof are similar to those for chimney flashing. The two methods described for **9.8. Stepped and Chimney Flashings** can be applied. The first is based on using copper flashing squares as base flashing inserted between successive courses of roofing. The second uses a single copper runner flashing under the roofing material. In both cases the dormer cap flashing is simpler than chimney flashing because the wall is of light weight construction. The upper edges of the base flashing are installed under the siding or shingles.

Dormer sill conditions vary from typical window sills in that the flashing is extended into an apron which laps over the roofing.

Copper flashing used at dormers should weigh a minimum of 12 oz. Aprons must be at least 16 oz. copper.

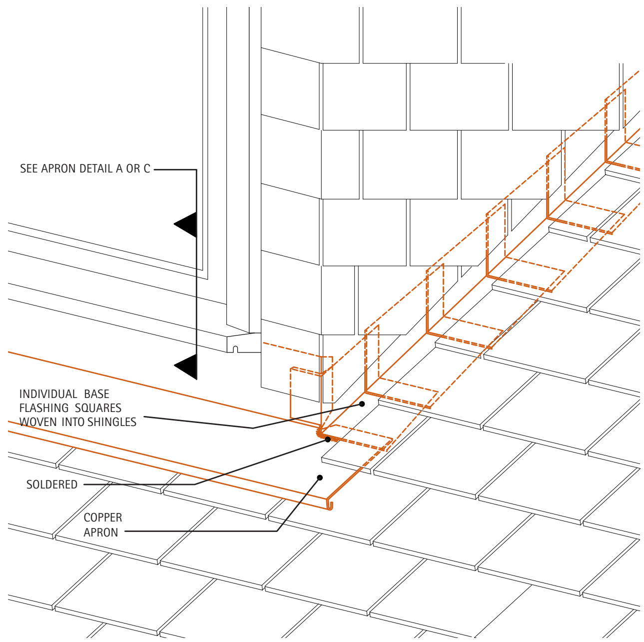
9.10A. Section at Apron Flashing

This section shows a typical sill condition where the flashing remains visible. It extends over the roofing material to provide positive drainage. The lower edge is then **cleated** at 12" O.C. maximum, and the upper edge is inserted into the sill drip and nailed to the sheathing at 3" O.C.



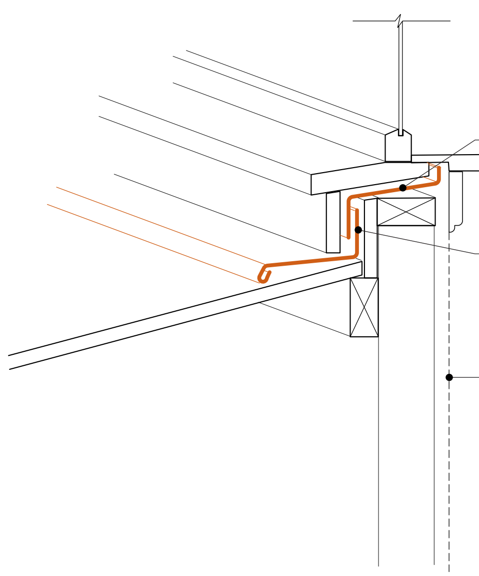
9.10B. Dormer to Roof Junction

This detail illustrates the first method described above, using individual copper flashing squares woven between the shingles, tile, or slate. The flashing extends at least 4" onto the roof and 8" up the wall. The joint between the copper apron and base flashing is soldered.



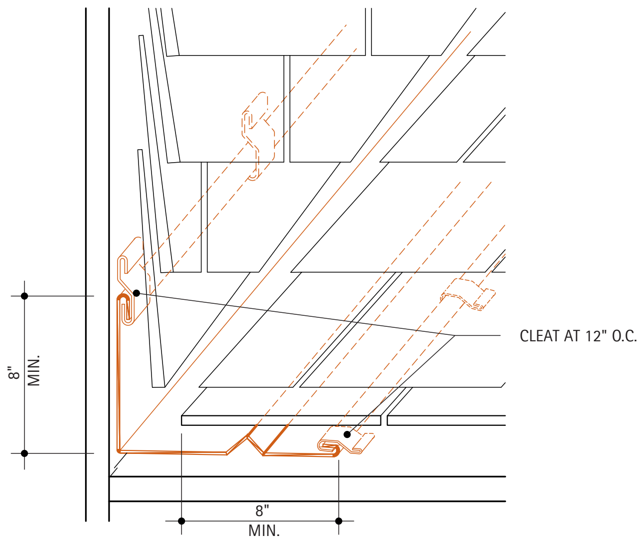
9.10C. Apron Flashing – Alternate

This section shows the use of separate sill and apron flashing covered by trim. The vertical portion of the flashing is hidden. The vertical piece is nailed to wood blocking or nailable sheathing at 3" O.C.



9.10D. Dormer Flashing - Alternate

A second method is illustrated here. The flashing is attached to the roof deck before the roofing material is installed. The roof portion of the flashing is formed with a hooked edge and **cleated** to the sheathing at 12" O.C. maximum. Joints in the flashing are lapped 6" in the direction of flow. A cant strip is formed in the roof flashing, as shown.



For Additional Information:

- **7. Basic Details**, for information on cleats.
- **9.8. Stepped and Chimney Flashings**, for similar flashing conditions.

9.11. Eave Snow Flashing

Description: In areas where snow remains on the roof for extended periods, the snow over heated spaces thaws first. When the run-off reaches the exposed eave overhang, it freezes and forms an ice dam. As this ice dam collects more melting snow, the water backs up under the roofing material causing a leak.

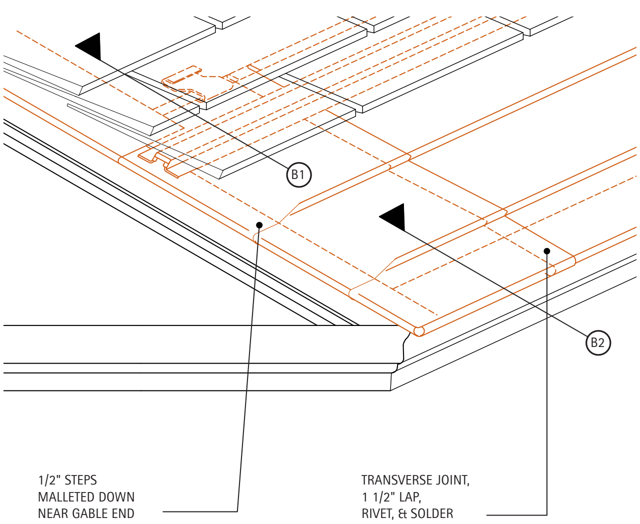
Eave snow flashing is designed to prevent roof leaks under these conditions. It does this by providing a waterproof layer around the perimeter of the roof. The flashing extends at least 18" beyond the face of the exterior wall, and is lapped by the roofing a minimum of 6".

The flashing described in the details is formed with 1/2" steps running horizontally, spaced no more than 8" apart, for rigidity. 8.2. Standing Seam Roofing is also suitable.

The minimum weight of copper used for eave snow flashing is 16 oz.

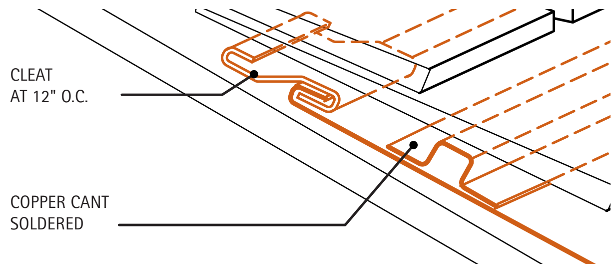
9.11A. Gable Detail

Vertical steps, 1/2" high, are formed and installed approximately 8" apart. These steps provide sheet rigidity as well as creating the horizontal lines simulating the shingle butt line. This detail shows that the 1/2" steps are malleted down within 2" of the gable end. The flashing is hooked over a continuous edge strip into a loose lock, 3/4" wide.

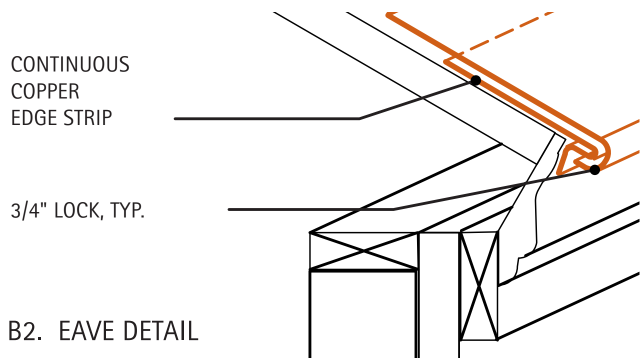


9.11B. Typical Sections

These sections show that the upper edge of the flashing is folded over and cleated at 12" O.C. A cant strip is used to elevate slate or wood shingles at the edge. The eave detail shows how the flashing is hooked over the continuous edge strip to form a drip.



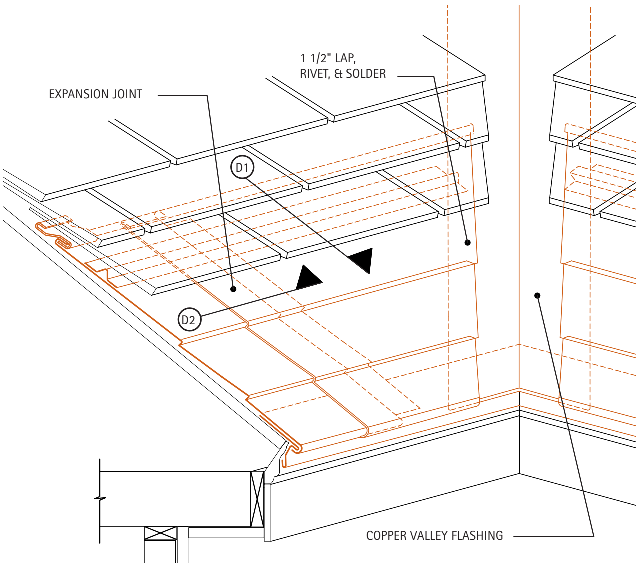
B1. CANT DETAIL



B2. EAVE DETAIL

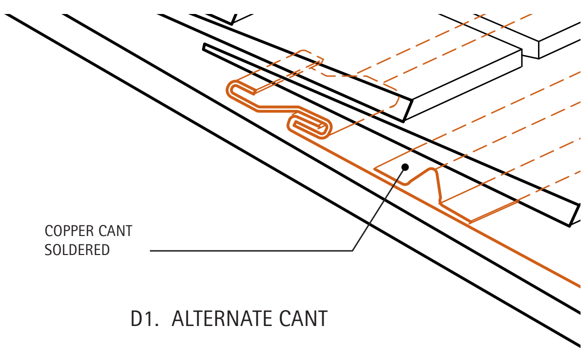
9.11C. Valley Detail

At the valley, the valley sheet is installed first. The flashing is cut to lap 1-1/2" over the valley sheet. After the 1/2" steps are flattened, the valley and flashing sheets are joined together by a lapped, riveted and soldered seam.

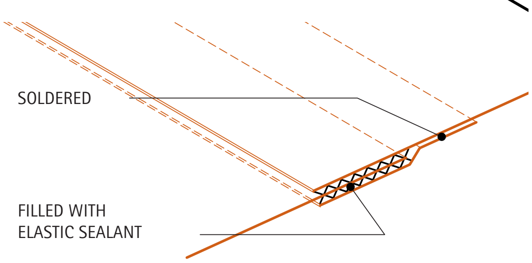


9.11D. Sections

The alternate cant detail shows a different copper shape that can be used for elevating slate and wood shingles. The expansion joint uses a clevis seam filled with sealant to make it waterproof.



D1. ALTERNATE CANT



D2. EXPANSION JOINT

For Additional Information:

- **7. Basic Details**, for information on seams, transverse joints, and cleats.
- **8. Roofing Systems** for similar conditions.

9.12. Eave Conditions

Description: The details contained in this section are intended to show a variety of eave conditions and roofing materials. One key concern that is common to all eaves is the ability to withstand wind forces. This is a very vulnerable part of the exterior of a building. In many cases, it is the ability of this and other roof edges to withstand suction forces that keeps the entire roofing from being peeled off during high wind conditions.

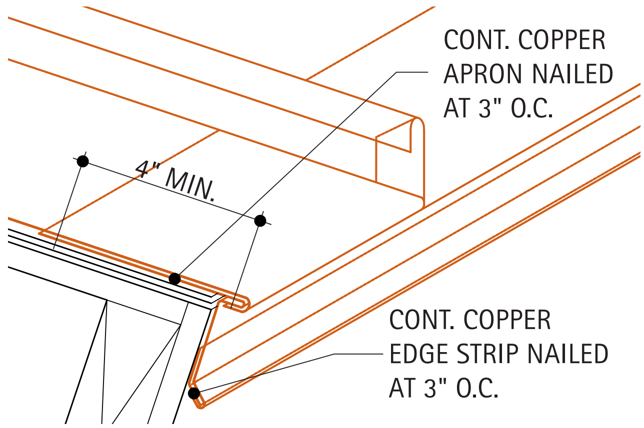
For this reason, it is recommended that a continuous edge strip be used to secure the lower edge of eave flashing. The strip should be nailed to a secure part of the roof, fascia, or eave with nails spaced no more than 3" apart, in a staggered pattern.

The upper edge of the eave flashing, the apron, may be similarly nailed, as shown in **Detail 9.12A**, or cleated at 12" O.C., as shown in **Detail 9.12B**. In general the apron should extend a minimum of 4" onto the roof.

When designing the eave, consideration should be given to the drip line provided for water draining off the roof. This is particularly important if porous material, which is liable to stain, is used below. See **Detail 9.12A**, for drip design discussion. See **Table 9.7A** for fascia design considerations.

9.12A. Eave at Standing Seam Roofing Without Gutter

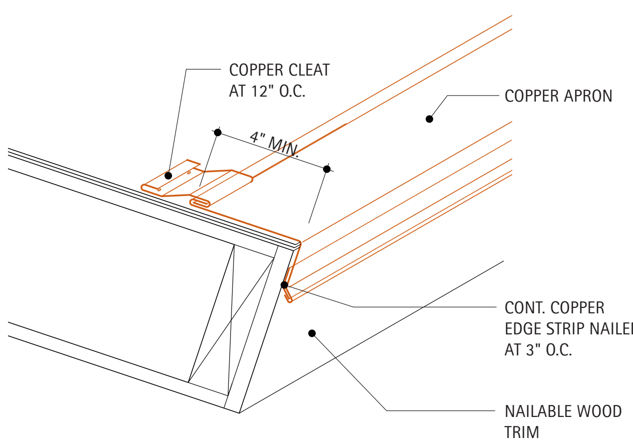
This detail shows a typical copper apron that is nailed to the roof. The apron may also be **cleated** as shown in **Detail 9.12B**. The lower end of the standing seam may also be folded down as in **Detail 9.12C**.



This detail should be avoided where gutters are used, as it does not offer much protection if the gutter gets clogged, or if ice and snow prevent proper drainage.

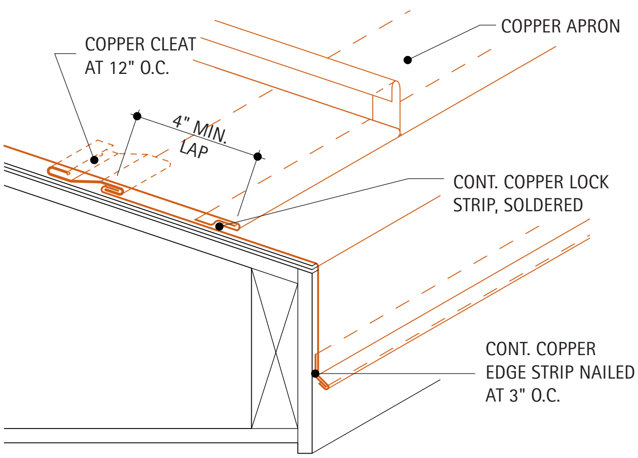
9.12B. Typical Eave Flashing

This detail is typically used for flashing eaves of non-copper roofs. The copper flashing is extended a minimum of 4" onto the roof to form an apron. The upper edge of the apron is cleated at 12" O.C. max., or it may be nailed as shown in **Detail 9.12A**. The apron width should take into account local conditions such as wind, rain, snow, and ice build-up.



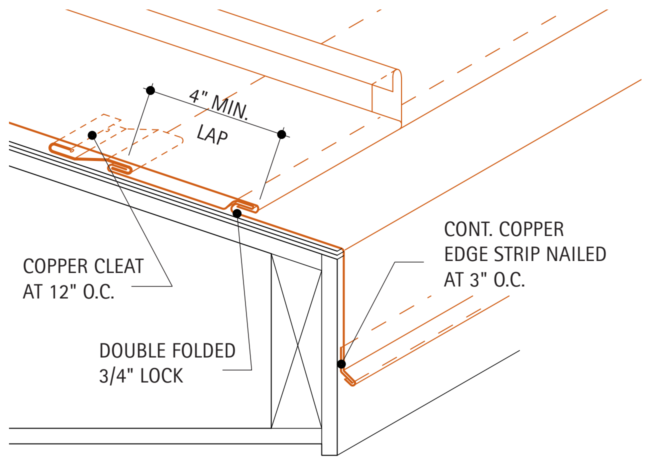
9.12C. Eave at Standing Seam Roofing With or Without Gutter

This detail may be used with or without a gutter. The upper edge of the continuous apron is cleated at 12" O.C. A continuous lock strip is soldered a minimum of 4" away from this upper edge. The copper roofing is locked into the strip. The distance from the lock strip to the edge of the roof depends on the roof pitch, whether or not a gutter is used, the likelihood of water damming from ice or snow, and architectural design considerations. The lower end of the **8.2. Standing Seam Roofing** may be terminated vertically, as shown in **Detail 9.12D**.



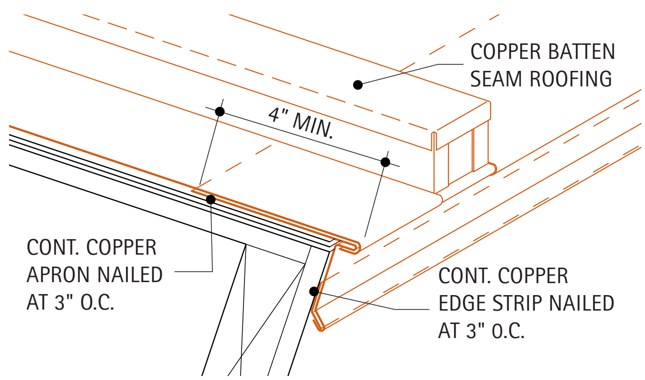
9.12D. Eave at Standing Seam Roofing With or Without Gutter

This detail is similar to **Detail 9.12C**, except that the standing seam roof is locked into a double fold in the apron, instead of a soldered lock strip. The lower end of the standing seam may be folded over, as shown in **Detail 9.12C**.



9.12E. Eave at Batten Seam Roofing

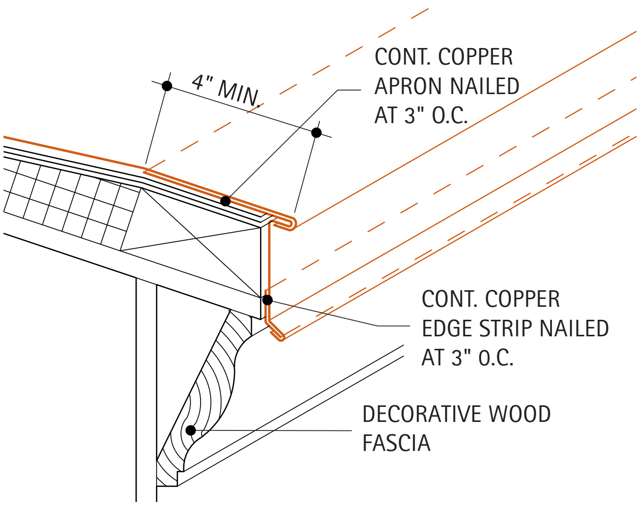
This is a typical detail for flashing the eave of a **8.3. Batten Seam Roofing**. This detail is not recommended for eaves with gutters, see **Detail 9.12H**.



The copper apron extends a minimum of 4" onto the roof. Its upper edge is nailed at 3" O.C., in a staggered pattern, or may be cleated at 12" O.C. max. At the edge of the roof, the apron is formed into a 3/4" lock. The pans of the batten seam roof are folded over this lock. The process is shown in **Detail 8.3C**. The lower edge of the flashing is held by a continuous copper edge strip.

9.12F. Eave at Horizontal Seam Roofing

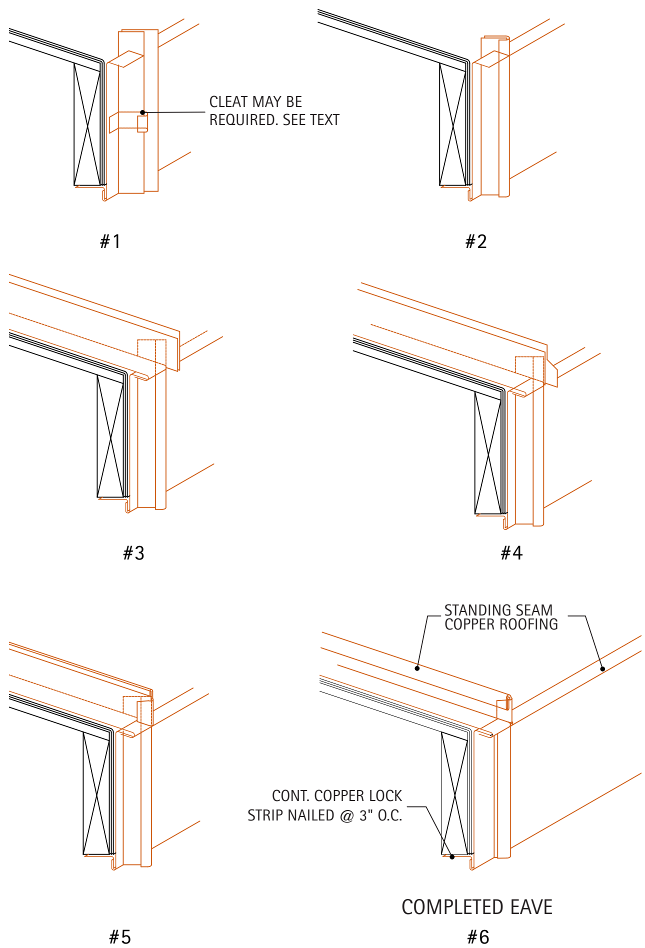
The technique for flashing the eave of a horizontal seam roof is similar to that of a batten seam. The copper apron extends a minimum of 4" onto the roof. The upper edge of the apron is nailed or cleated to the wood nailer at the eave. The nailer must be wide enough to provide nailable surface under the apron or cleats. The lower edge of the roofing is locked into a 3/4" lock formed by the copper apron. The lower edge of the flashing is locked into a continuous edge strip.



This detail also shows a decorative wood trim.

9.12G. Standing Seam Roofing and Fascia

This detail shows the eave condition where standing seam copper is used for the roof and fascia. The construction process is shown, with the completed eave on the right. This detail is not intended for use with gutters.



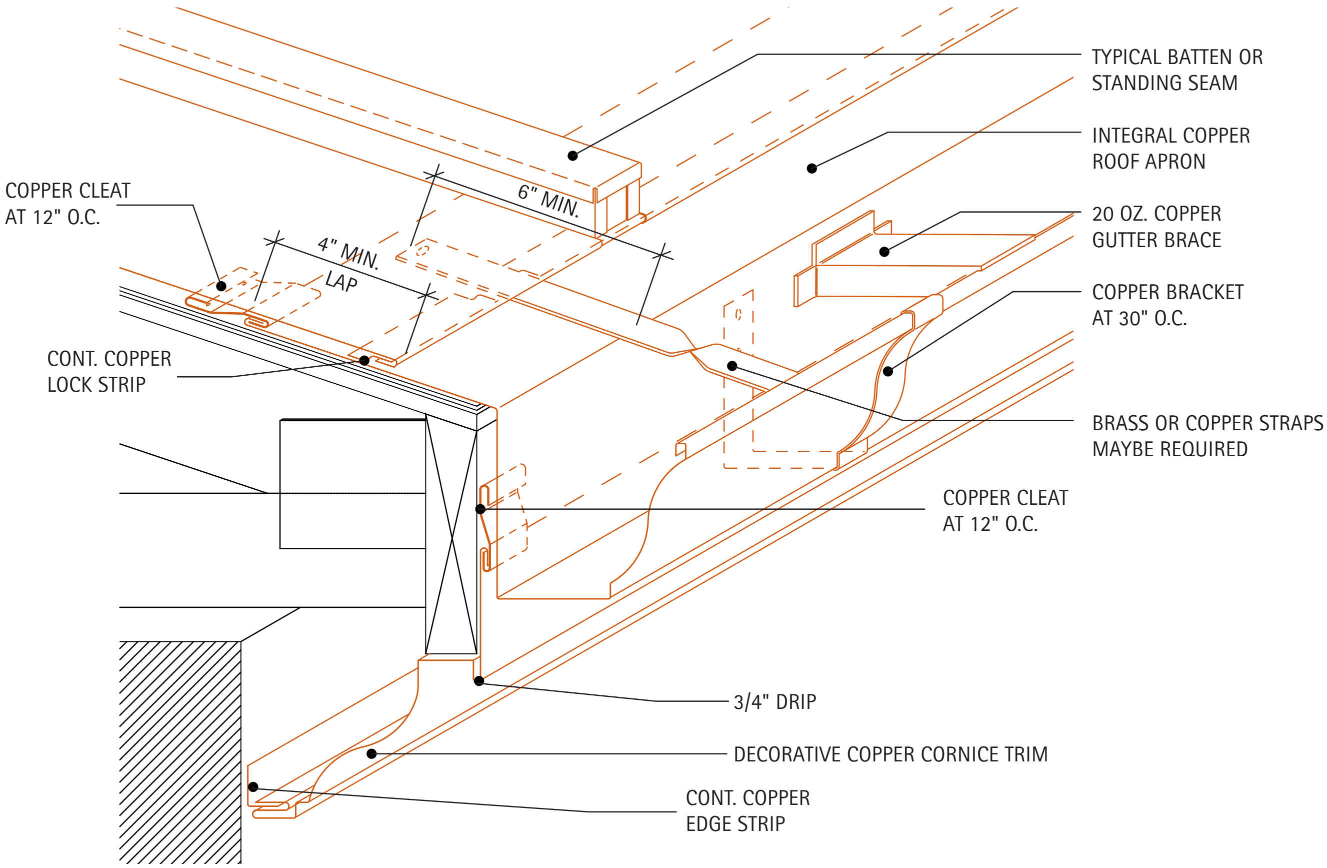
This detail may also be used to construct a standing seam mansard. If the vertical dimension of the fascia exceeds 12", cleats spaced no more than 12" O.C. are required, as shown in step 1.

The bottom of the fascia pans are locked onto a continuous copper lock strip. The top of the fascia pans are bent out to form a lock. The roof pans are folded over this lock.

The two following details are intended to show how to flash the same eave with and without a gutter.

9.12H. Decorative Eave With Gutter

A decorative copper cornice is attached to the wood fascia board with cleats spaced no more than 12" O.C. The upper edge of the cornice should be positioned high enough so that it will be concealed by the gutter. Its lower edge is held by a continuous copper edge, secured to the building wall. A 3/4" drip is formed into the shape of the cornice, to ensure that water is kept away from the building facade and reduce the chance of staining. This is particularly important if the building exterior is a light color porous material.

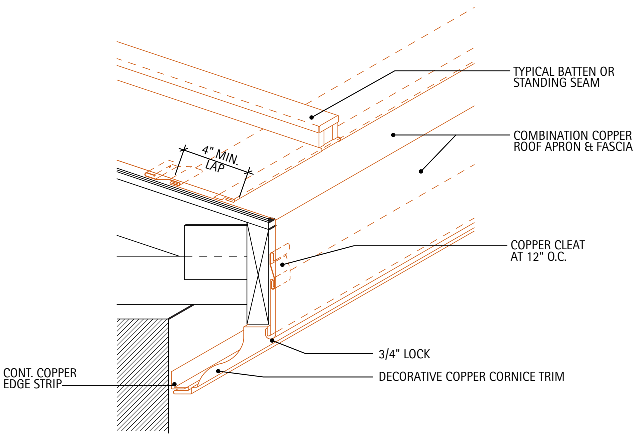


The apron, which is an integral part of the gutter, extends onto the roof a minimum of 6". It is attached to the roof with **cleats** spaced a maximum of 12" O.C. A continuous copper lock strip is soldered a minimum of 4" below the upper edge. The batten or standing seams are terminated at this lock strip, and the roofing pans are locked onto it.

The gutter is supported by brass brackets spaced a maximum of 30" O.C. in snow areas, and 36" O.C. in non-snow areas. Brass or copper straps may be required, see **10. Gutters and Downspouts** section for additional gutter information.

9.12I. Decorative Eave Without Gutter

This detail is very similar to Detail 9.12H, except that the copper apron extends down along the fascia, and locks onto the decorative cornice. This 3/4" lock forms a drip for water shedding from the roof.



Special Conditions: For areas prone to ice and potential gutter damage, refer to a two piece gutter-apron design as noted in Section **10.2. Hung Gutters**.

For Additional Information:

- **7. Basic Details**, for additional seams, transverse joints, and clests
- **8. Roofing Systems** for similar conditions.

9.13. Roof Area Divider

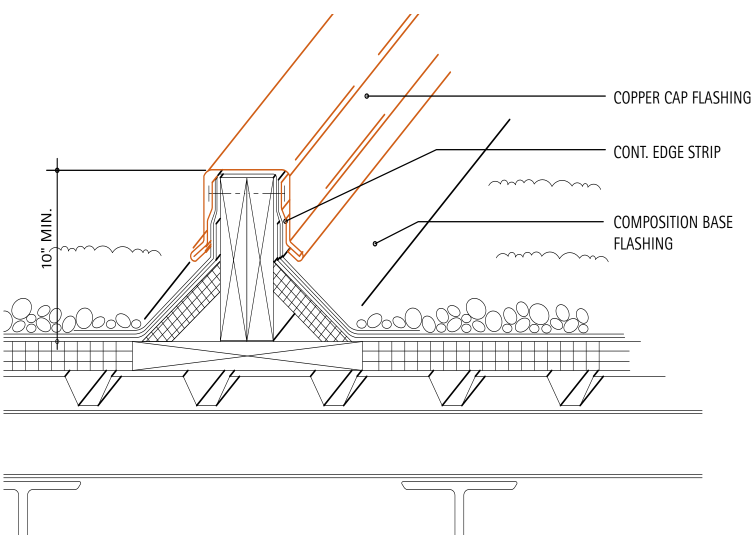
Description: Roofing material on flat roofs is subjected to extreme temperature changes. As a result, the material experiences significant thermal expansion and contraction. All roofing types are designed to accomodate a certain amount of movement. This adjustment occurs at the roof perimeter. However, with large flat roofs, it may be necessary to divide the area into smaller parts, in order to keep the total movement within acceptable limits. Roof area dividers perform this task. The roofing manufacturer's recommendations should be followed in determining the need for and placement of roof area dividers.

Roof area dividers rely on wood curbs to effectively frame areas of the roof. The roofing material extends up the curb, much the same as it does at the roof perimeter. Copper cap flashing is used to cover the curbs and the ends of the roofing.

The minimum recommended weight for the copper caps is 16 oz.

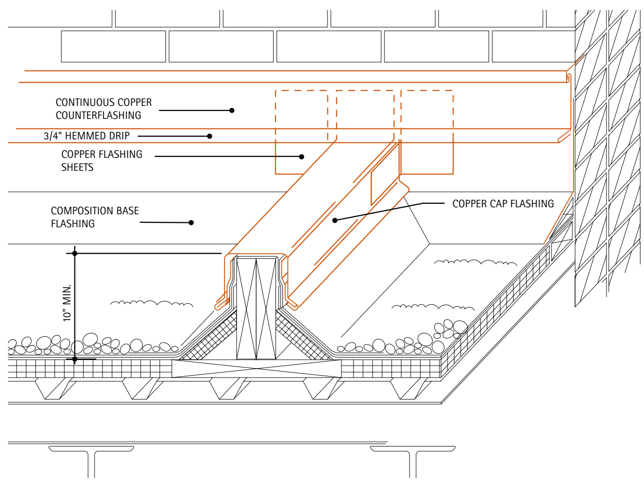
9.13A. Typical Roof Area Divider

The copper cap flashing is held on each side of the wood curb by continuous copper lock strips. Adjacent caps are joined with drive cleats or single flat lock seams.



9.13B. Roof Area Divider at Perimeter Wall

This detail shows how an area divider is terminated at a wall. The top surface of the copper cap is extended and bent up under the continuous counterflashing of the roof perimeter. Small copper flashing sheets are formed and inserted under the adjacent flashing to complete the corners.



For sections greater than 10 feet, cap seams must be designed to accomodate expansion and contraction, see **8.8. Long Pan Systems** for additional information.

10. GUTTERS AND DOWNSPOUTS

Introduction

The design of gutter and downspout assemblies is an area of building design which demands special attention. Leaking gutters and downspouts can cause serious damage to a building's interior as well as exterior, and repairs can be expensive.

Maintenance, durability and longevity are important factors to consider when designing gutters and downspouts. Copper is an intelligent choice of materials because of its low maintenance, high resistance to corrosion and long life. Even in severe climates such as marine atmospheres, a well designed copper gutter and downspout assembly will provide many years of low maintenance service.

Other metals used in gutter and downspout assemblies require frequent repainting or recoating to maintain their durability. Copper is an inherently corrosion resistant material which does not require special coatings to maintain its durability or its appearance.

The ease with which a material can be joined to form a continuous, leak-free water conductor is also important. Copper's inherent properties make it an easy material to form and solder. Thus, strong leakproof joints are readily achievable with copper.

Design Principles for Roof Drainage Systems

The building type, its appearance and location have a direct influence on the design of the roof drainage system. They determine the roof area, slope and rainfall intensity. They also influence the use of gutters and downspouts, roof drains and scuppers.

The process of calculating the required size of gutters and downspouts involves:

1. Obtaining rainfall intensity for the building location.
2. Determining the spacing and locations of downspouts.
3. Calculating design roof areas.
4. Sizing the downspouts.
5. Sizing the gutters.

Rainfall Intensity

Rainfall intensity is measured over a 5-minute period. It is recorded, in inches per hour, as the resulting accumulation as if the intensity remained constant for a full hour. **Table 10A** shows the rainfall intensity for major U.S. cities. The table is divided into two sections, A and B. These sections represent the intensities which are likely to be exceeded once in 10 years, and once in 100 years, respectively.

The table also shows the calculated roof area which can be drained per square inch of downspout. It is based on the assumption that during a rainfall with an intensity of 1 inch per hour, each square inch of downspout can drain 1200 square feet of roof. If the intensity is doubled the downspout capacity is halved, or 600 sq. ft.; if it is tripled the capacity is one third, and so on.

Table 10A. Rainfall Data and Drainage Factors

AREA		A Storms which should be exceeded only once in 10 years		B Storms which should be exceeded only once in 100 years	
		1 5 Minute intensity (in/hr)	2 Area drained per sq. inch of downspout (sq. ft.)	1 5 Minute intensity (in/hr)	2 Area drained per sq. inch of downspout (sq. ft.)
Alabama	Birmingham	7.5	160	10.1	120
	Mobile	8.2	150	10.8	110
Alaska	Fairbanks	2.1	570	3.8	320
	Juneau	1.7	710	2.3	520
Arizona	Phoenix	5.6	210	8.8	140
	Tucson	6.1	200	19.1	130
Arkansas	Bentonville	7.4	160	10.2	120
	Little Rock	7.4	160	10.0	120
California	Los Angeles	4.9	240	6.7	180
	Sacramento	2.5	480	3.9	310
	San Diego	2.2	550	3.1	390
	San Francisco	2.7	440	3.7	320
Colorado	Denver	5.7	210	9.1	130
	Boulder	6.4	190	9.4	130
Connecticut	Hartford	6.2	190	8.7	140
District of Columbia		7.1	170	9.7	120
Florida	Jacksonville	7.9	150	10.1	120
	Miami	7.7	160	9.8	120
	Tampa	8.3	140	10.8	110
Georgia	Atlanta	7.3	160	9.9	120
Hawaii	Honolulu	8.7	140	12.0	100
	Kahului	7.0	170	12.0	100
	Hilo	17.4	70	19.2	60
	Lihue	10.4	120	14.4	80
Idaho	Boise	1.8	670	3.3	360
Illinois	Chicago	6.8	180	9.3	130
Indiana	Indianapolis	6.8	180	9.4	130
Iowa	Des Moines	7.3	160	10.3	120
Kansas	Wichita	7.5	160	10.5	110
Kentucky	Louisville	6.9	170	9.4	130
Louisiana	New Orleans	8.3	140	10.9	110
Maine	Portland	5.4	220	7.6	160
Maryland	Baltimore	7.1	170	9.7	120

AREA		A Storms which should be exceeded only once in 10 years		B Storms which should be exceeded only once in 100 years	
		1 5 Minute intensity (in/hr)	2 Area drained per sq. inch of downspout (sq. ft.)	1 5 Minute intensity (in/hr)	2 Area drained per sq. inch of downspout (sq. ft.)
Massachusetts	Boston	5.3	230	7.2	170
Michigan	Detroit	6.4	190	8.9	130
Minnesota	Minneapolis	7.0	170	10.0	120
Missouri	Kansas City	7.4	160	14.4	80
	St. Louis	7.1	170	9.9	120
Montana	Helena	1.8	670	3.1	390
	Missoula	1.8	670	2.4	500
Nebraska	Omaha	7.4	160	10.5	110
Nevada	Reno	2.3	520	4.5	270
	Las Vegas	2.1	570	5.2	230
New Jersey	Trenton	6.7	180	9.3	130
New Mexico	Albuquerque	4.0	300	6.7	180
	Santa Fe	4.5	270	6.4	190
New York	Albany	6.5	180	9.1	130
	Buffalo	6.0	200	8.4	140
	New York City	6.7	180	9.2	130
North Carolina	Raleigh	7.3	160	9.8	120
North Dakota	Bismarck	6.6	180	9.8	120
Ohio	Cincinnati	6.8	180	9.3	130
	Cleveland	6.3	190	8.8	140
Oklahoma	Oklahoma City	7.6	160	10.5	110
Oregon	Baker	2.2	550	3.8	320
	Portland	2.1	570	3.0	400
Pennsylvania	Philadelphia	6.8	180	9.4	130
	Pittsburgh	6.4	190	8.8	140
Rhode Island	Providence	5.6	210	7.8	150
South Carolina	Charleston	7.2	170	9.4	130
Tennessee	Memphis	7.4	160	10.0	120
	Knoxville	6.7	180	9.0	130
Texas	Fort Worth	7.6	160	10.5	110
	Dallas	7.6	160	10.5	110
	Houston	8.2	150	10.8	110
	San Antonio	7.6	160	10.5	110
Utah	Provo	3.0	400	5.2	230

AREA		A Storms which should be exceeded only once in 10 years		B Storms which should be exceeded only once in 100 years	
		1 5 Minute intensity (in/hr)	2 Area drained per sq. inch of downspout (sq. ft.)	1 5 Minute intensity (in/hr)	2 Area drained per sq. inch of downspout (sq. ft.)
	Salt Lake City	2.8	430	4.3	280
Virginia	Norfolk	7.1	170	9.5	130
Washington	Seattle	2.1	570	3.3	360
	Spokane	2.1	570	3.5	340
West Virginia	Parkersburg	6.6	180	9.1	130
Wisconsin	Madison	6.8	180	9.5	130
	Milwaukee	6.6	180	9.1	130
Wyoming	Cheyenne	5.7	210	9.9	120

Downspout Locations

The locations of down-spouts depends on the configuration, architectural features and appearance of the building. The technical considerations include:

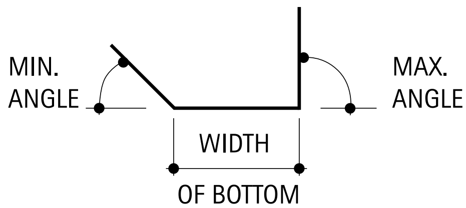
1. Each downspout should drain a maximum of 50 feet of gutter. Gutter expansion characteristics may further limit the distances, since water cannot flow past an expansion joint.
2. Avoid locations where water must flow around a corner to reach a downspout.
3. In locations where icing occurs, downspouts on the north side of the building should be avoided, if possible.

Expansion Joint Spacing

Expansion joints in copper gutters must be provided to allow for the natural expansion and contraction of copper caused by thermal changes. In general, long straight runs should have joints spaced a maximum of 48 feet apart. Expansion joints may also be required at changes in gutter width or depth, at corners and at end conditions. Based upon the desired joint spacing, designers should consult **Table 10B** to determine the required gauge of copper gutter, width of gutter bottom and angle of gutter sides.

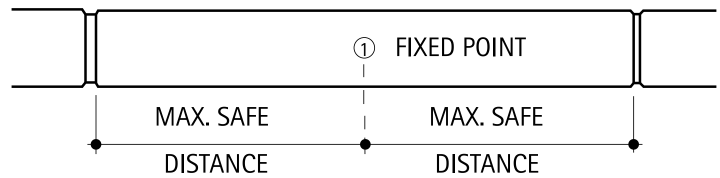
Expansion Joint Table

Determination of gauge and expansion joint location for various sizes and shapes of copper "U" sections



SECTION

EXPANSION JOINT



PLAN

Table 10B. Critical Load Table – Expansion Joint Table

Maximum Distance Between Fixed Point and Expansion Joint in Feet

Weight of Cold Rolled Copper in Ounces	*Width of Gutter Bottom in Inches*	*Angle of Gutter Sides*														
		90° Max.- 25° Min.	*90° Max.- 35° Min.*	*90° Max.- 45° Min.*	*90° Max.- 60° Min.*	*90° Max.- 90° Min.*	*60° Max.- 25° Min.*	*60° Max.- 35° Min.*	*60° Max.- 45° Min.*	*60° Max.- 60° Min.*	*45° Max.- 25° Min.*	*45° Max.- 35° Min.*	*45° Max.- 45° Min.*	*35° Max.- 25° Min.*	*35° Max.- 35° Min.*	*25° Max.- 25° Min.*
16	4	19'-6"	20'-6"	21'-6"	23'-0"	26'-0"	17'-0"	18'-0"	19'-6"	20'-6"	16'-6"	17'-0"	18'-0"	13'-6"	15'-0"	12'-0"
	6	16'-6"	17'-6"	18'-6"	19'-6"	21'-6"	14'-0"	15'-0"	16'-6"	17'-6"	13'-0"	14'-0"	15'-0"	11'-6"	12'-6"	10'-6"
	8	14'-0"	15'-0"	16'-0"	17'-6"	19'-0"	12'-0"	13'-0"	14'-0"	15'-0"	10'-6"	12'-0"	13'-0"	9'-6"	10'-0"	8'-6"
	10	12'-0"	13'-0"	14'-0"	15'-0"	16'-6"	10'-0"	11'-0"	12'-0"	13'-0"	9'-0"	10'-0"	11'-0"	7'-6"	8'-0"	6'-0"
	12	10'-6"	11'-6"	12'-0"	13'-6"	14'-6"	9'-0"	9'-6"	10'-6"	11'-6"	8'-0"	9'-0"	10'-0"	6'-0"	7'-0"	5'-0"
	14	9'-6"	10'-0"	11'-0"	12'-0"	13'-0"	7'-6"	8'-6"	9'-6"	10'-6"	6'-6"	7'-6"	8'-6"			
	16	8'-6"	9'-0"	10'-0"	11'-0"	12'-0"	7'-0"	7'-6"	8'-6"	9'-0"	6'-0"	7'-0"	7'-6"			

Con't

Maximum Distance Between Fixed Point and Expansion Joint in Feet

Weight of Cold Rolled Copper in Ounces	*Width of Gutter Bottom in Inches*	*Angle of Gutter Sides*														
		90° Max.- 25° Min.	*90° Max.- 35° Min.*	*90° Max.- 45° Min.*	*90° Max.- 60° Min.*	*90° Max.- 90° Min.*	*60° Max.- 25° Min.*	*60° Max.- 35° Min.*	*60° Max.- 45° Min.*	*60° Max.- 60° Min.*	*45° Max.- 25° Min.*	*45° Max.- 35° Min.*	*45° Max.- 45° Min.*	*35° Max.- 25° Min.*	*35° Max.- 35° Min.*	*25° Max.- 25° Min.*
20	4	25'-0"	27'-0"	28'-0"	30'-6"	34'-0"	22'-0"	24'-0"	25'-0"	27'-0"	20'-0"	22'-0"	24'-0"	17'-6"	19'-6"	16'-0"
	6	21'-6"	23'-0"	24'-0"	26'-0"	29'-0"	18'-6"	20'-0"	21'-6"	23'-0"	17'-0"	18'-6"	20'-0"	15'-6"	17'-6"	14'-0"
	8	18'-0"	19'-6"	20'-6"	22'-0"	24'-6"	15'-6"	17'-0"	18'-0"	19'-6"	14'-0"	15'-6"	17'-0"	13'-0"	14'-6"	11'-6"
	10	15'-6"	17'-0"	18'-0"	19'-6"	21'-6"	13'-6"	15'-0"	15'-6"	17'-0"	12'-6"	13'-6"	15'-0"	11'-0"	12'-6"	10'-0"
	12	14'-0"	15'-0"	16'-6"	17'-6"	19'-6"	12'-0"	13'-6"	14'-0"	15'-0"	11'-0"	12'-0"	13'-6"	10'-0"	11'-0"	8'-6"
	14	12'-6"	13'-6"	14'-6"	15'-6"	17'-6"	11'-0"	12'-0"	12'-6"	13'-6"	9'-6"	11'-0"	12'-0"	9'-0"	10'-0"	8'-0"
	16	11'-6"	12'-6"	13'-6"	14'-6"	16'-0"	10'-0"	11'-0"	11'-6"	12'-6"	9'-0"	10'-0"	11'-0"	8'-0"	9'-0"	7'-0"
	18	10'-6"	11'-6"	12'-6"	13'-6"	14'-6"	9'-0"	10'-0"	10'-6"	11'-6"	8'-0"	9'-0"	10'-0"			
	20	10'-0"	10'-6"	11'-6"	12'-6"	14'-0"	8'-6"	9'-0"	10'-0"	10'-6"	7'-6"	8'-6"	9'-0"			
24	4	32'-0"	34'-0"	36'-0"	38'-6"	41'-6"	28'-0"	30'-0"	32'-0"	34'-0"	25'-6"	28'-0"	30'-0"	23'-6"	26'-0"	21'-0"
	6	27'-0"	29'-0"	30'-6"	33'-0"	36'-0"	24'-0"	26'-0"	27'-0"	29'-0"	22'-0"	24'-0"	26'-0"	20'-0"	22'-0"	18'-6"
	8	23'-6"	25'-0"	26'-0"	28'-0"	31'-0"	20'-0"	22'-0"	23'-6"	25'-0"	18'-6"	20'-0"	22'-0"	17'-0"	19'-0"	15'-6"
	10	20'-6"	22'-0"	23'-0"	25'-0"	27'-0"	18'-0"	19'-6"	20'-6"	22'-0"	16'-6"	18'-0"	19'-6"	15'-0"	16'-6"	13'-6"
	12	18'-6"	20'-0"	21'-0"	22'-6"	24'-6"	16'-0"	17'-6"	18'-6"	20'-0"	14'-6"	16'-0"	17'-6"	13'-6"	15'-0"	12'-0"
	14	17'-0"	18'-6"	19'-6"	20'-6"	22'-6"	14'-6"	16'-0"	17'-0"	18'-6"	13'-6"	14'-6"	16'-0"	12'-0"	13'-6"	11'-0"
	16	15'-6"	16'-6"	17'-6"	19'-0"	21'-0"	13'-6"	14'-6"	15'-6"	17'-0"	12'-6"	13'-6"	14'-6"	11'-0"	12'-6"	10'-0"
	18	14'-6"	15'-6"	16'-6"	18'-0"	19'-6"	12'-6"	13'-6"	14'-6"	15'-6"	11'-6"	12'-6"	13'-6"	10'-6"	11'-6"	9'-6"
	20	13'-6"	14'-6"	15'-6"	16'-6"	18'-0"	11'-6"	12'-6"	13'-6"	14'-6"	10'-6"	11'-6"	12'-6"	10'-0"	10'-6"	8'-6"
	22	12'-6"	13'-6"	14'-6"	15'-6"	17'-0"	11'-0"	12'-0"	12'-6"	13'-6"	10'-0"	11'-0"	12'-0"			
	24	12'-0"	13'-0"	14'-0"	15'-0"	16'-6"	10'-6"	11'-6"	12'-0"	13'-0"	9'-6"	10'-6"	11'-6"			

Con't

Maximum Distance Between Fixed Point and Expansion Joint in Feet

Weight of Cold Rolled Copper in Ounces	*Width of Gutter Bottom in Inches*	*Angle of Gutter Sides*														
		90° Max.- 25° Min.	*90° Max.- 35° Min.*	*90° Max.- 45° Min.*	*90° Max.- 60° Min.*	*90° Max.- 90° Min.*	*60° Max.- 25° Min.*	*60° Max.- 35° Min.*	*60° Max.- 45° Min.*	*60° Max.- 60° Min.*	*45° Max.- 25° Min.*	*45° Max.- 35° Min.*	*45° Max.- 45° Min.*	*35° Max.- 25° Min.*	*35° Max.- 35° Min.*	*25° Max.- 25° Min.*
32	6	46'-0"	48'-6"	51'-0"	54'-6"	59'-6"	40'-6"	43'-0"	46'-0"	48'-6"	37'-0"	40'-6"	43'-0"	36'-0"	39'-6"	33'-6"
	8	41'-0"	44'-0"	46'-0"	49'-0"	53'-6"	36'-6"	39'-0"	41'-0"	44'-0"	33'-6"	36'-6"	39'-0"	31'-0"	34'-0"	28'-6"
	10	36'-6"	39'-0"	40'-6"	43'-6"	47'-6"	32'-6"	34'-6"	36'-6"	39'-0"	30'-0"	32'-6"	34'-6"	27'-6"	30'-0"	25'-0"
	12	33'-6"	35'-6"	37'-6"	39'-6"	43'-0"	29'-6"	31'-6"	33'-6"	35'-6"	27'-0"	29'-6"	31'-6"	25'-6"	27'-0"	23'-0"
	14	30'-6"	32'-6"	34'-6"	36'-6"	40'-0"	27'-0"	29'-0"	30'-6"	32'-6"	25'-0"	27'-0"	29'-0"	23'-0"	25'-0"	21'-0"
	16	28'-6"	30'-6"	32'-0"	34'-0"	37'-0"	25'-0"	27'-0"	28'-6"	30'-6"	23'-0"	25'-0"	27'-0"	21'-0"	23'-0"	19'-6"
	18	27'-0"	28'-6"	30'-0"	32'-0"	35'-0"	23'-6"	25'-6"	27'-0"	28'-6"	21'-6"	23'-6"	25'-6"	20'-0"	22'-0"	18'-0"
	20	25'-6"	27'-0"	28'-0"	30'-0"	33'-0"	22'-0"	24'-0"	25'-6"	27'-0"	20'-6"	22'-0"	23'-6"	19'-0"	20'-6"	17'-6"
	22	24'-0"	25'-6"	27'-0"	28'-6"	31'-6"	21'-0"	22'-6"	24'-0"	25'-6"	19'-6"	21'-0"	22'-6"	18'-0"	19'-6"	16'-6"
	24	23'-0"	24'-6"	25'-6"	27'-6"	30'-0"	20'-0"	21'-6"	23'-0"	24'-6"	18'-6"	20'-0"	21'-6"	17'-0"	18'-6"	15'-6"
	26	22'-0"	23'-6"	24'-6"	26'-0"	28'-6"	19'-0"	20'-6"	22'-0"	23'-6"	17'-6"	19'-0"	20'-6"	16'-6"	18'-0"	15'-0"
	28	21'-0"	22'-6"	23'-6"	25'-0"	27'-6"	18'-6"	20'-0"	21'-0"	22'-6"	17'-0"	18'-6"	20'-0"	16'-0"	17'-6"	14'-6"

Design Area for Pitched Roofs

The roof area to be drained is a key factor in designing gutters and downspouts. The area of roof contributing runoff to each gutter and downspout should be determined. The maximum accumulation of rainfall occurs when it falls perpendicular to the roof plane. With flat roofs, it is a simple matter of calculating area, since the true roof area is equal to plan area.

When a roof is pitched, its plan area is less than its true area. However, using the true area in the calculations has typically resulted in oversized gutters, downspouts and drains. **Table 10C** shows the factors that should be used to determine the design area for pitched roofs. The plan roof area should be multiplied by this factor. The result is the design roof area that is used to calculate the required sizes of downspouts.

Table 10C. Area Factor for Pitched Roofs

Pitch, in/ft	*B Area Factor*
Level to 3	1.00
4 to 5	1.05
6 to 8	1.10
9 to 11	1.20
12	1.30

Downspout Sizing

Downspouts should have a cross-sectional area of at least 7 square inches, except for small areas such as porches and canopies. Their size should be constant throughout their length.

The design roof area is divided by the area of roof shown in **Table 10A**, column A2 or B2 (see discussion above), to give the minimum required area for each downspout. See **Table 10.7A** for standard downspout sizes.

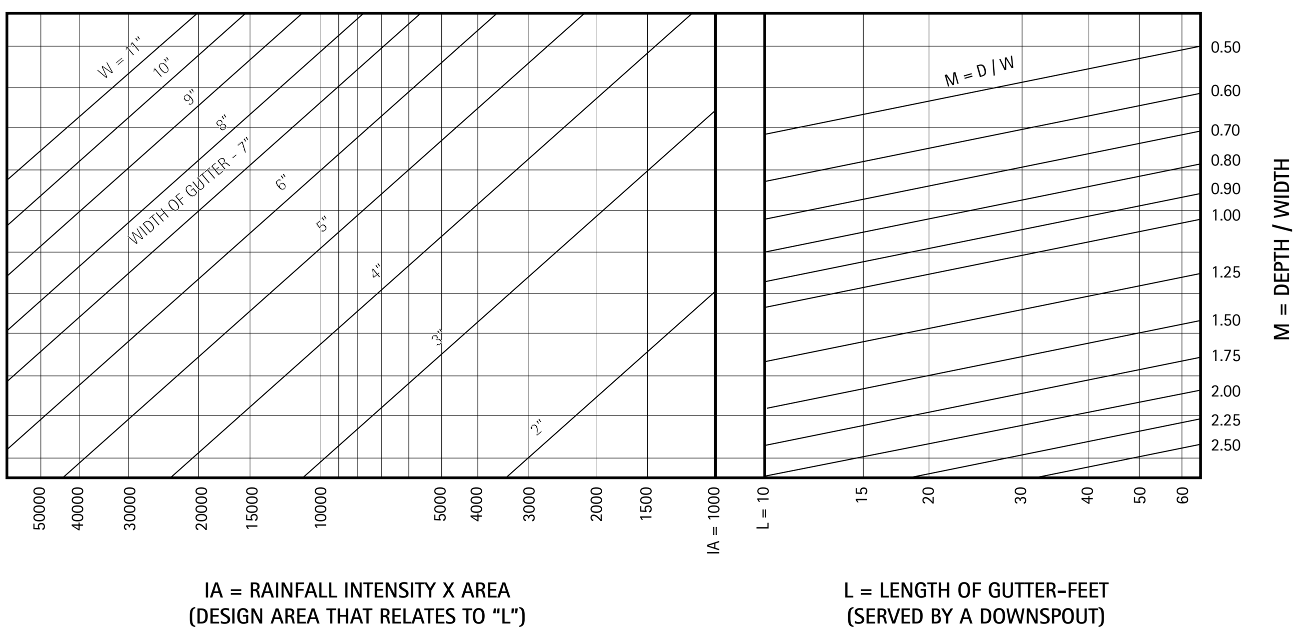
Gutter Sizing

The minimum required size of a gutter is related to the intensity of rainfall and the area of roof that drains into the gutter. The latter depends on the length of the gutter, which is related to locations of downspouts, expansion joints, and gutter ends.

Other factors considered in the design of gutters, include the size and spacing of outlets, the shape of the gutter, and the pitch of the roof. The gutter size must be capable of handling even fast moving water from a steep roof.

Table 10D is used to determine the required width and depth of a gutter. To do this, a ratio, M which equals the depth divided by the width, is initially assumed. Starting with the length of the gutter, L, follow a vertical line until the ratio, M, is reached. At this point follow a horizontal line to the left until the vertical line of rainfall intensity x design area, IA, is crossed. The required gutter width can be read from the diagonal lines. If the intersection lies between two lines, use the higher value. Finally, the width is multiplied by the ratio, M, to determine the depth.

Table 10D. Gutter Sizes for Given Roof Area and Rainfall Intensity



The size of gutters with an irregular shape can be determined by calculating the required size of a rectangular gutter which closely matches in profile and cross-sectional area, the irregularly shaped gutter.

Table 10E shows an example of the complete process.

Table 10E. Example Calculation

Select round downspouts and size rectangular gutters for a building in Chicago, Illinois. The building is 120' x 80' with a gable roof having a pitch of 5 in. per foot. The slope is toward the long side. Maximum rainfall conditions will be used to determine downspout size.

Downspout spacing is restricted by two factors: each downspout should drain no more than 50 feet of gutter; and gutter expansion joints should be spaced no more than 48 feet (see **10.2. Hung Gutters**). Three downspouts will be used on each side, with expansion joints in the gutters 40 feet from the ends. Each downspout therefore, will drain 40 feet of gutter.

Downspout Selection:

The roof plan area that is drained by each downspout is,

PLAN AREA = 40' x 40' = 1600 SF

Given the Area Factor, B, in Table 10C, the design area is,

DESIGN AREA = PLAN AREA x B = 1600 x 1.05 = 1680 SF

From Table 10A, column B2, the area drained per square inch of downspout is 130 SF. The minimum downspout size is,

MIN. DOWNSPOUT AREA = 1680 / 130 = 12.9 SQ. IN.

From Table 10.7A, plain round 5" downspouts, with an area of 19.63 square inches, will be used.

Gutter Sizing:

The roof area that is drained by each gutter is,

AREA = 40' x 40' = 1600 SF

From Table 10A, column B1, the rainfall intensity is,

I = 9.3 in/hr.

Therefore,

IA = 9.3 X 1600 = 14880

On Table 10D, draw a vertical line representing IA = 14880.

Initially assume the gutter width ratio, M, is 0.75. On Table 10D, find the vertical line representing L = 40'. Follow the vertical line to its intersection with the oblique line representing M = 0.75. Follow a horizontal line to the left to the intersection with the vertical line drawn previously representing IA = 14880.

This intersection occurs on the oblique line representing a gutter width of 7".

The gutter depth should be at least,

MIN. GUTTER DEPTH = WIDTH x M = 7 x .75 = 5.25"

10.1. Hung Gutters and Downspouts Basics

Description: Hung copper gutters are typically supported by brass or copper brackets or hangers, spaced a maximum of 30” O.C. in snow areas, or 36” O.C. in non-snow areas. Brass or copper straps, used in conjunction with a gutter bead stiffening brass bar, are recommended for gutter widths greater than 6” or where severe ice or snow conditions exist. Braces, to stiffen the gutter, are made of 20 oz. copper.

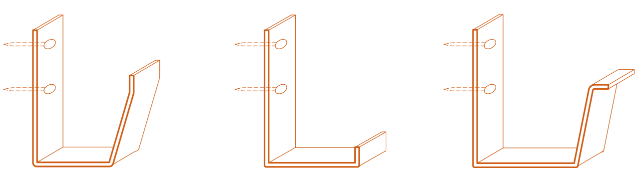
An alternate support method uses brass straps, fastened to 32 oz. copper braces, spaced a maximum of 30" O.C. A brass stiffening bar is required in the gutter bead. This method does not require the use of brackets.

Regardless of the support method, gutters must be hung to intercept the flow of water off the roof. This usually means that the surface to which the gutter is attached is vertical.

Special Conditions: The details shown are based on gutters with rectangular shapes. Half round gutters are also available but are usually supported by straps with spring clips or by special brackets.

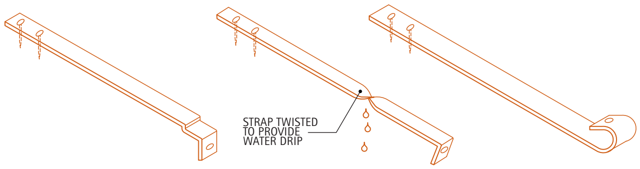
10.1A. Gutter Brackets

Brackets are attached to the exterior wall at intervals of 30” to provide the support needed for the gutter. They are fastened by two brass screws in lead sleeves or two brass wood screws if a wood fascia exists. Brackets are formed into various shapes to fit the profile of the gutter. In high wind areas, brackets should be fastened to the face of the gutter.



10.1B. Gutter Straps

Where gutter width exceeds 6” or in areas with severe ice or snow conditions, straps are used in conjunction with brackets to provide additional support.



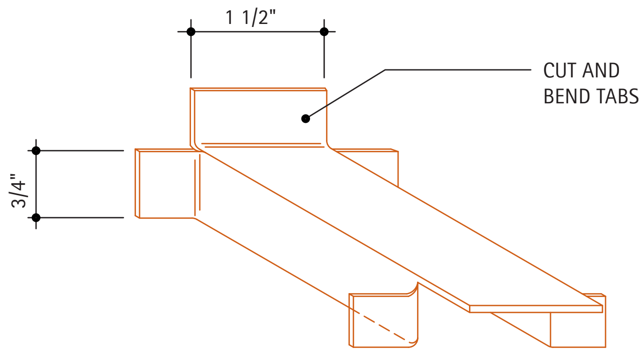
Gutter straps should be spaced 30" apart and extend 6" up onto the roof. Brass screws are used to secure the straps onto the roof sheathing. The end of the strap is fastened to the gutter at the bead. A continuous 3/4" x 3/16" brass stiffening bar is inserted into gutter beads to stiffen the gutter edge and allow better fastening of the strap.

When copper roofing is used, areas around screws and straps should be soldered for watertightness.

Brass gutter straps can also be used in conjunction with heavy (32 oz.) copper braces to support the gutter. (see typical description above)

10.1C. Gutter Brace

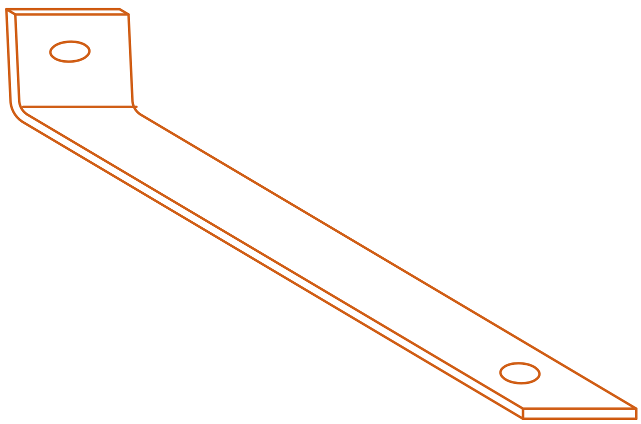
Gutter braces are made of 20 oz. cold rolled copper. Gutter braces are soldered, riveted or bolted to the top edge of the gutter to prevent spreading.



Where the braces are used as hangers to support the gutter, they should be made of 32 oz. cold rolled copper.

10.1D. Gutter Spacer

Gutter spacers made of 1" x 1/16" (minimum) flat-stock copper are installed in gutters to provide additional strength. Gutter spacers are fastened to the back of the gutter at the top edge and to the front of gutter at the bead.



For Additional Information:

- **10.2. Hung Gutters**, for information on expansion joints and seams.

10.2. Hung Gutters

Description: Hung gutters are formed from 8'-0" to 10'-0" long sheets of 20 oz. cold rolled copper. Adjacent sheets are joined by 1" lapped, riveted, and soldered seams.

Expansion joint spacing depends on gutter configuration and material thickness, see **Table 10B**. At inside or outside corners, expansion joints should be provided not more than 24' from the corner.

As shown in the details, there are many configurations for gutter assemblies. A few basic principles generally apply. For most climates, the supporting brackets or straps should not be spaced more than 30" O.C. The roof (upper) edge of the gutter is folded over. A continuous copper apron, edge strip or cleat, that extends onto the roof sheathing a minimum of 4", is locked into this fold to form a drip.

If straps are used, a reinforcing bar in the gutter bead is required. The straps are fastened through this reinforcing bar. The reinforcing bars or support brackets are made of copper, brass or bronze stock.

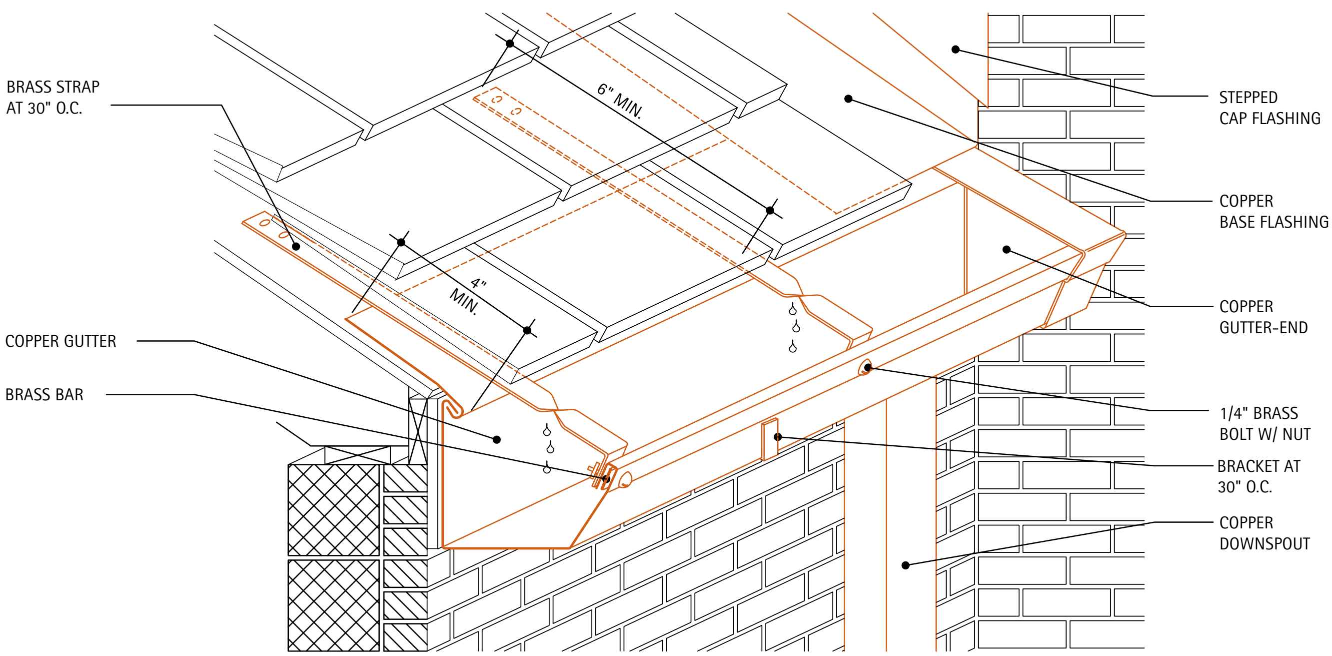
Special Conditions: In areas where severe ice or snow conditions exist, special steps must be taken to account for the effects of water back-up, and the weight of the ice or snow. A one-piece gutter and apron design, as shown in **Detail 10.2B**, helps reduce the chance of a leak from capillary action when ice and snow prevent positive drainage. The additional support, also described in **Detail 10.2B**, is required for these climates.

10.2A. Strap Hung Molded Gutter

This is a typical detail of a gutter hung by straps. Straps are riveted or bolted to the outer edge at the gutter bead and attached to the roof with two brass screws. The straps should extend a minimum of 6" onto the roof.

The gutter is supported by brackets spaced 30" O.C. The upper edge of the gutter is folded over 3/4" to engage the apron flashing. The separate apron flashing extends at least 4" onto the roof. Its upper edge is nailed, at 3" O.C., while its lower end hooks over the lock of the gutter.

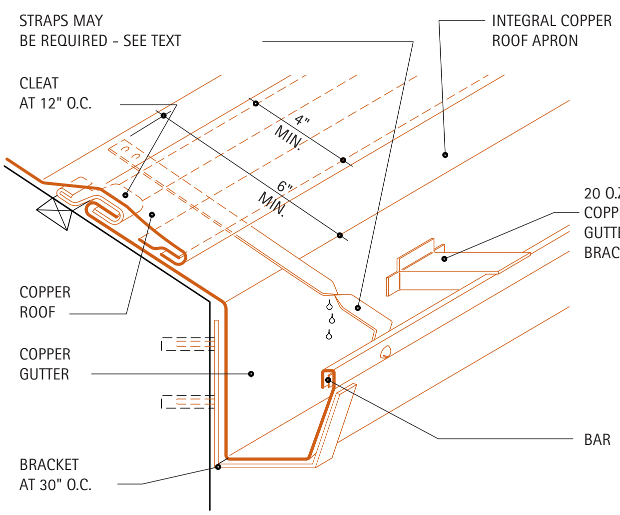
A two-piece copper gutter and apron is not suitable for areas with severe ice and snow conditions or high winds. In such conditions, refer to the integral apron and gutter in **Detail 10.2B**.



NOTE: STRAPS AND BRACKETS TO BE COMPATIBLE WITH COPPER GUTTER.

10.2B. Bracket Hung Gutter with Copper Roof

The detail shows the recommended method for use in areas with severe ice and snow as well as other conditions. In this example, use with a copper roof is illustrated.



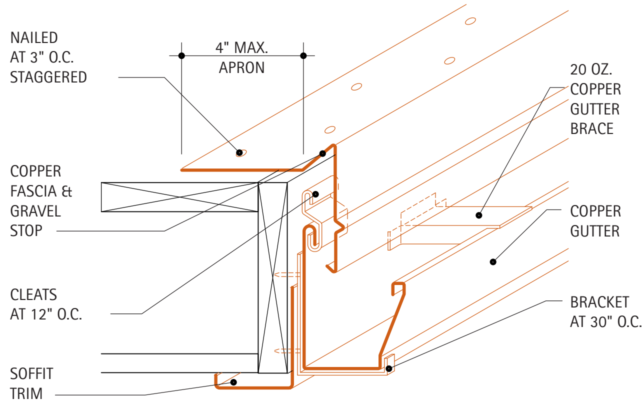
A one-piece copper gutter and apron is supported by brass brackets at 30" O.C. The upper edge of the gutter extends at least 6" onto the roof and is folded over and held by cleats at 12" O.C. A continuous locking strip is soldered to the apron at least 4" below its upper edge. The lower edge of the copper roof is hooked over the locking strip.

20 oz. copper braces at 30" O.C. are placed at the mid-points between brackets.

If the gutter width is more than 6", or in areas with ice and snow, straps should also be used. These must extend at least 6" onto the roof. If a copper roof is used, the area around screws and the strap must be soldered to ensure watertightness. Brackets, straps and braces are spaced alternately.

10.2C. Hung Gutter with Copper Fascia

This detail illustrates a method of using a hung copper gutter in conjunction with built-up roofing with a copper fascia and gravel stop.



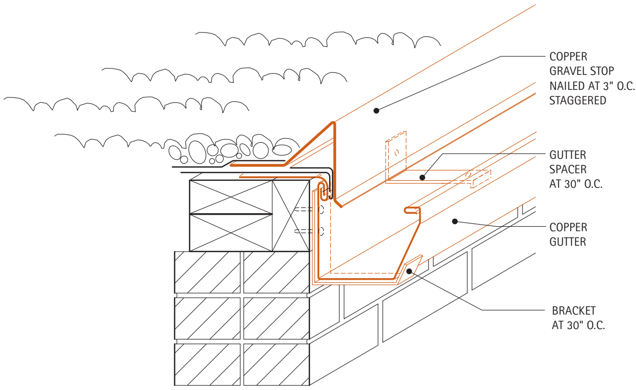
The gutter is secured to the wood fascia with cleats at the top edge and is supported by brackets spaced at 30". The brackets are fastened to the wood fascia by two brass screws. Install 20 oz. copper braces at the midpoints between the brackets.

A continuous copper apron strip extends onto the roof a maximum of 4". The copper gravel stop is fastened to the roof by nails spaced 3" in a staggered pattern, through the edge strip.

An optional copper soffit trim piece is also shown. It is attached to the wood fascia under the gutter brackets.

10.2D. Bracket Hung Molded Gutter

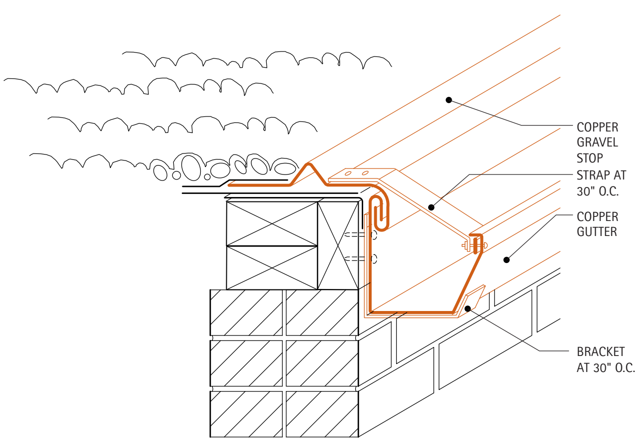
This detail illustrates a gutter supported by brackets on an asphalt built-up roof with a gravel stop. Brackets and spacers, alternately spaced, are used to support and stiffen the gutter.



To divert any asphalt drippage, the top ply of roofing felt is extended over the back edge of the gutter.

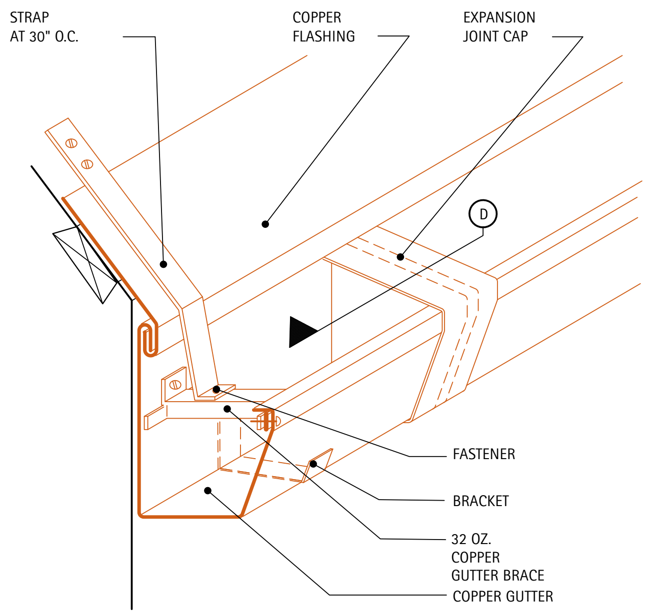
10.2E. Strap Hung Molded Gutter

This detail shows a copper gravel stop and a copper gutter supported by straps and brackets. They are loose locked together to allow the gutter to expand and contract independently of the gravel stop. The gravel stop is fastened to the roof at its back edge with nails 3" O.C. This detail is not recommended for areas with severe snow and ice conditions. In such areas use an integral gutter and apron detail. See **Detail 10.2B**.



10.2F. Strap Hung Gutter on Sloping Roof

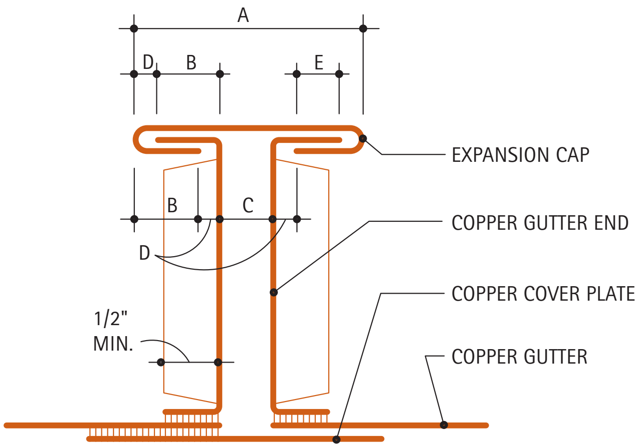
This detail illustrates an alternate method of attaching copper gutters on sloped roofs. The continuous copper apron strip is fastened to the gutter with a single lock seam and is nailed to the roof with copper nails 12" O.C. Copper braces of 32 oz. copper are alternately spaced with copper brackets at 30" O.C. Straps, extending at least 6" onto the roof, are fastened to these braces and screwed to the roof with two brass screws. Sealant should be applied between the straps and copper apron at fastenings. A bar is required in the outer edge of the gutter for stiffness.



This detail is not recommended for areas with ice and snow conditions.

10.2G. Expansion Joint Sections

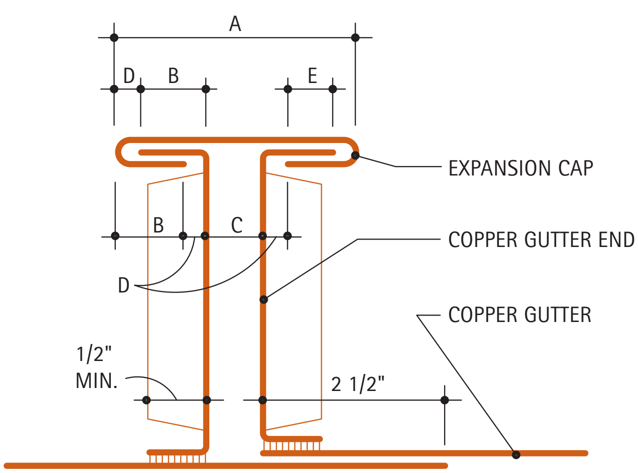
Expansion joints should be provided on gutters to allow movement caused by thermal changes. Long straight runs should have joints spaced a maximum of 48' apart. They should also be provided no more than 24' from any corner. See the expansion calculation example in **Table 10.2A**.



BUTT TYPE EXPANSION JOINT

This detail illustrates two types of expansion joints. For the butt type gutter expansion joint, gutter ends are flanged, then riveted and soldered into the ends of gutter sections to be joined. A cover plate is then placed over the expansion joint to improve the appearance of the gutter. Installation of the cover plate should not restrict the movement of gutter sections.

An expansion joint cap is placed on top, over the gutter-end flanges and the cover plate.



LAP TYPE EXPANSION JOINT

For the lap type gutter expansion joint, a gutter-end is recessed 2-1/2" minimum into the gutter on one gutter section and fitted flush on the other. Gutter-ends are flanged, then riveted and soldered into the gutter sections. The flush end of the gutter section is then slipped into the recessed end of the next section. The expansion joint cap is then placed on top, in a manner similar to the fabrication of butt type gutter expansion joints.

Table 10.2A. Example Gutter Expansion Calculation

A 60 foot copper hung gutter is being installed in 65 degree weather in a locality where the maximum temperature range is from 0 degrees to 100 degrees Fahrenheit. The ends are fixed because they contain downspouts. One end is at a corner the other is at another wall.

Expansion joints must be spaced a maximum of 48' on a straight run, but not more than 24' from a corner. Conforming to these limits results in two sections of gutter, 36' and 24'. The calculations should be based on the dimensions of the longer section.

Min. design temperature = 0 degrees Fahrenheit
Max. design temperature = 100 + 50 (superheat) degrees F.

Contraction temperature difference = dTc = 65 - 0 = 65
Expansion temperature difference = dTe = 150 - 65 = 85

The general formula for calculating the change in Length is (see Plate 4.1.3 for more information):

dL = Length x Expansion coef. x Temperature change
dL = L x 0.0000098 x dT

For the longer section:

Amount of contraction,
dLc = 36 x .0000098 x 65 = .0229' = .28" say 1/4"

Amount of expansion,
dLe = 36 x .0000098 x 85 = .0300' = .36" say 3/8"

For both sections combined:
Total contraction = dLc x 2 = 1/4" x 2 = 1/2"
Total expansion = dLe x 2 = 3/8" x 2 = 3/4"
Total relative movement = dLc + dLe = 1/2" + 3/4" = 1 1/4"

Allowing 1/4" clearance with heads expanded
Min. C = 1/4",

Clearance of heads at installation,
C = Min. Clearance + Total Expansion C = 1/4" + 3/4"= 1"

Clearance when contracted,
Max. C = C at installation + Total Contraction
Max. C = 1" + 1/2" = 1 1/2"

Amount of movement in long section,
dL = dLe + dLc = 1/4 + 3/8 = 5/8"

Allowing 1/4" laps (dimension E) with cap at top angles when expanded, and 1/8" clearances (dimension D) when contracted,

Leg of each top angle,
B = D + E + dL = 1/4" + 1/8" + 5/8" = 1"
Fold-back of cap, also = 1"

Total width of cap,
A = Max. C + 2 x B + 2 x D = 1 1/2" + 2 x 1" + 2 x 1/8" = 3 3/4"

10.3. Built-in Gutter Linings

Description: Copper gutter linings are most often built into wood framed supporting structures. Although the copper lining conforms closely to the gutter frame profile, it should not fit tightly. The lining must be free to move. The bottom of the frame may be pitched to provide positive drainage to the downspout. The inner edge of the lining should finish not less than 2” above the outside edge.

Copper linings should be constructed of sheets 10' maximum in length without longitudinal seams. The ends of the sheets must be pre-tinned 1-1/2". Adjacent sheets are joined by 1-1/2" lapped, riveted and soldered seams. If the girth of the gutter is more than a sheet of copper (typically 36" in some cases 48"), the cross seams should not be more than the sheet width apart (36" or 48").

Expansion joints are placed at intervals to accommodate thermal movement of the gutter lining. See **Table 10C** for spacing of expansion joints and downspouts. Expansion joints should also be provided within a short distance of the downspout if the gutter lining forms the leg of an inside or outside corner. If an expansion joint must be accommodated at the corner itself, it should be constructed as shown in **Detail 10.3B**.

Clearance for downspouts through the wood framing, is a minimum 1/2" all around.

Special Conditions: The details shown are for the lining of a wood box gutter frame. When lining a masonry cornice, the edge strip can be secured to the masonry cornice with brass screws and lead shields 12" apart. If a reglet is used, the edge strip is secured into the reglet with lead wedges and sealant.

Note: For ease of soldering, whenever possible, built-in gutters should be fabricated outside of the gutter framing to allow soldered seams inspection and watertightness testing of the gutter, prior to final gutter system installation.

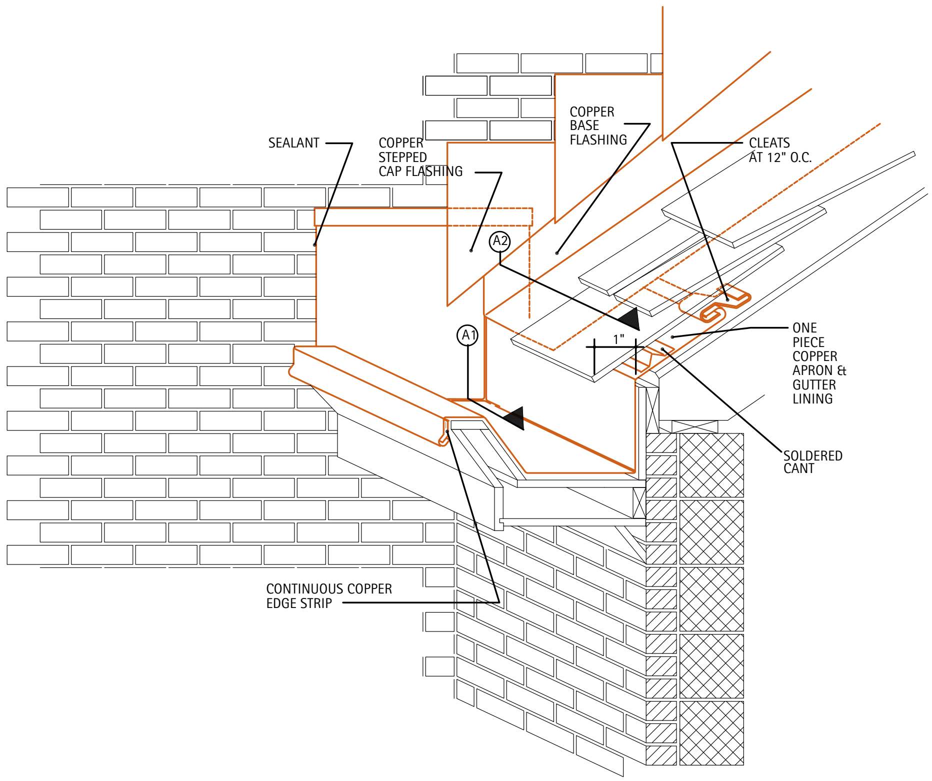
10.3A. Built-In Gutter at Inside Corner

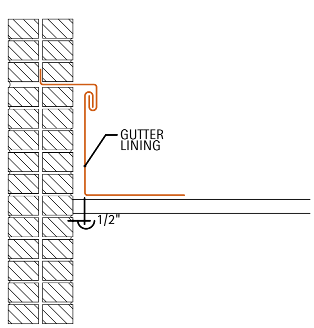
This detail shows a one piece copper gutter lining and apron design that is suitable for use in areas with ice or snow conditions. The apron extends a minimum of 6" onto the roof.

Where the lining meets the vertical wall, provide at least 1/2" for expansion. **Section 1 of Detail 10.3A** shows this dimension, along with two methods of flashing. Method A shows a typical end condition with an expansion joint cap, recommended in areas with ice and snow conditions. Method B is used in areas with no ice and snow conditions.

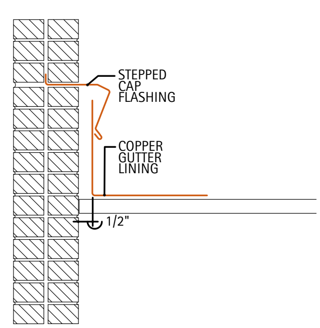
Section 2 of Detail 10.3A illustrates a flashing method for the portion of the apron that rests on the roof.

A continuous edge strip of 20 oz. cold rolled copper is formed and attached along the outer edge of the gutter frame with copper nails or brass screws. The copper gutter lining hooks over the edge strip forming a 3/4" loose lock.

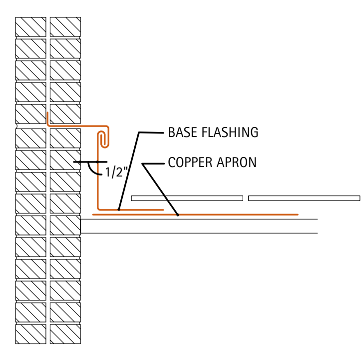




METHOD A
A1. SECTION AT GUTTER



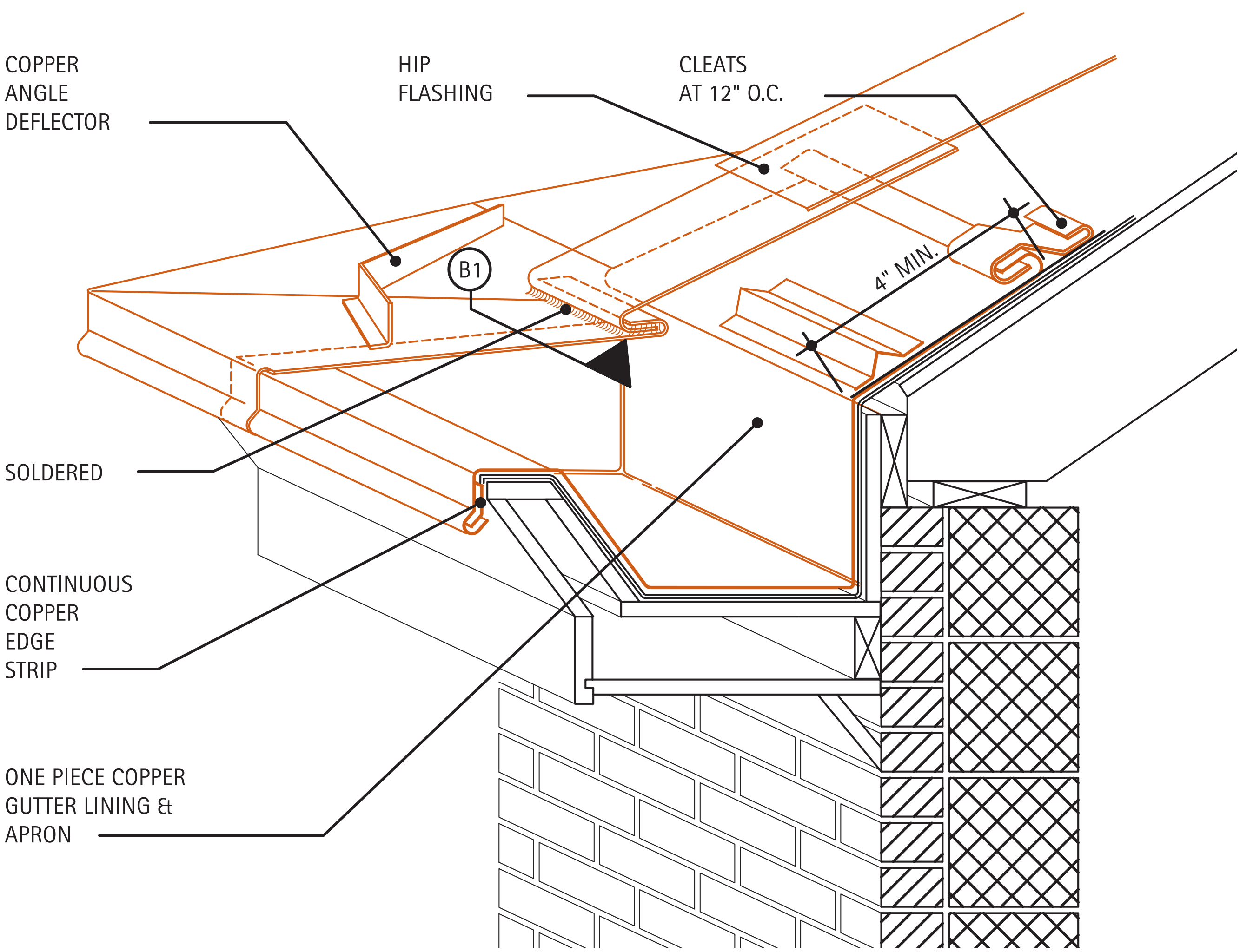
METHOD B
A1. SECTION AT GUTTER

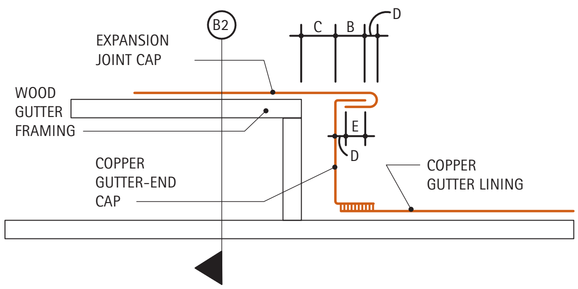


A2. SECTION AT ROOF

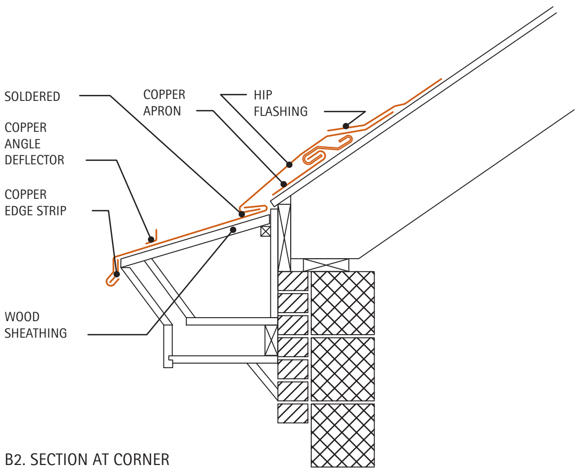
10.3B. Built-In Gutter at Outside Corner

This detail shows an outside corner condition where expansion must be accommodated at the corner. Only the copper gutter, apron and flashing are shown. The roofing extends beyond the edge of the apron as shown in **Detail 10.3A**. The corner must allow movement in both copper linings. It is framed in wood then covered with a corner expansion joint cap. A copper angle deflector is soldered onto this cap to direct water into the gutter.





B1. SECTION ACROSS EXPANSION JOINT



B2. SECTION AT CORNER

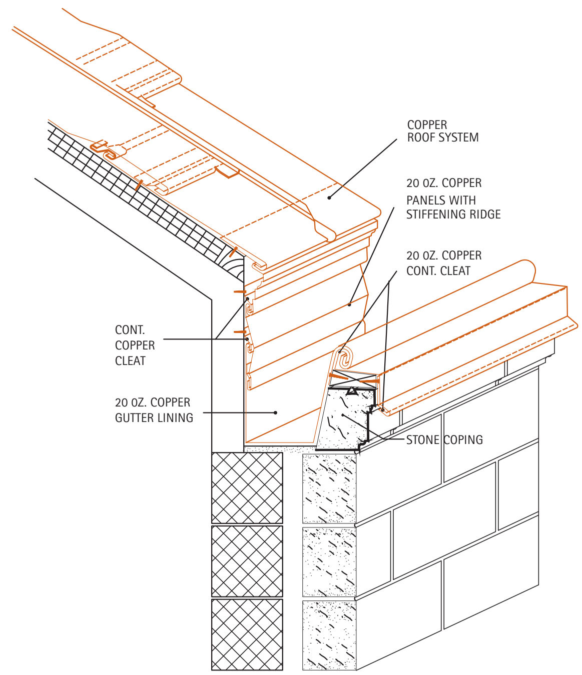
This detail shows a one piece copper lining and apron. The apron is secured to the sheathing with copper cleats. It is suitable for areas where ice and snow conditions exist.

See discussion on expansion in **10.2. Hung Gutters** page and **Table 10B** for more information on required dimensions.

Section 2 of Detail 10.3B illustrates the various components at the outside corner. The expansion joint cap is placed on wood sheathing and folded over the top gutter-end flange. Its upper edge is locked and soldered into the hip flashing.

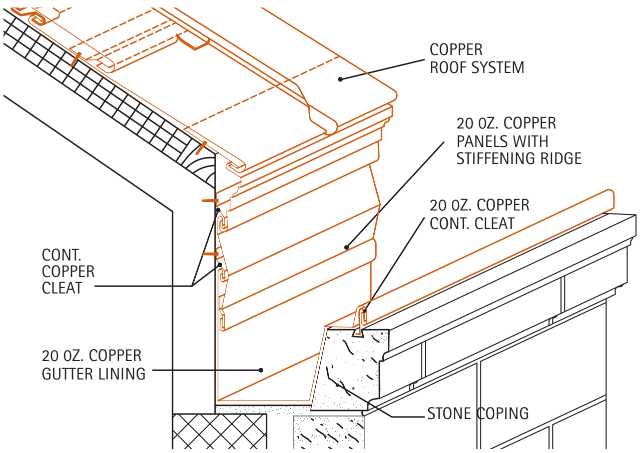
10.3C. Built-in Gutter

In this built-in gutter detail, continuous copper cleats are used to secure the gutter lining in place. At the coping, a continuous cleat is anchored to wood blocking with nails at 3" O.C. Just below the eave of the roof, another continuous cleat is attached to the fascia. A copper panel with stiffening ridge is used as counterflashing to complete the closure between the copper roofing system, and the gutter lining. The panel is secured with the cleat at its upper end, and with a lock-strip soldered to the gutter lining at its lower end. The top of the rear edge of the gutter lining must be higher than the front edge to prevent potential leaks into the building.



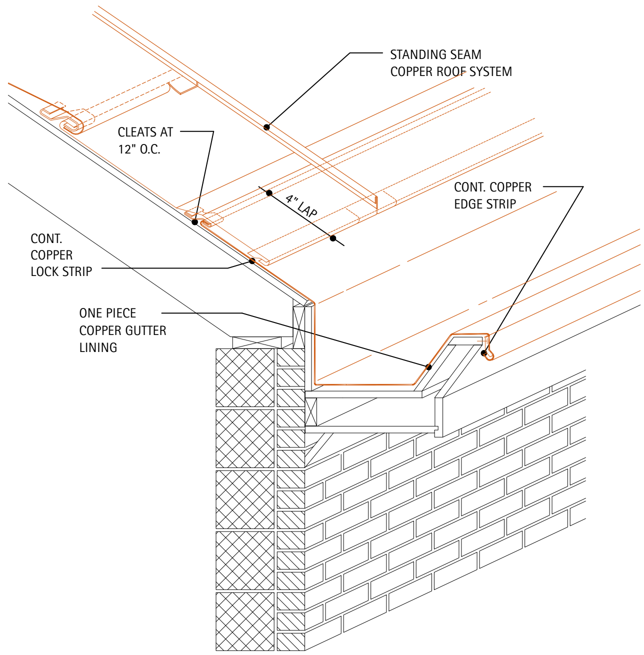
10.3D. Built-in Gutter

This detail is similar to **Detail 10.3C** except that a continuous reglet in the stone coping is used to anchor a continuous cleat. This eliminates the need for wood blocking, and in some cases may simplify the installation of the gutter lining. The cleat is inserted into the reglet, grouted in, held by lead wedges and sealed, or fastened with bronze screws and expansion shields and sealed.



10.3E. Built-in Gutter

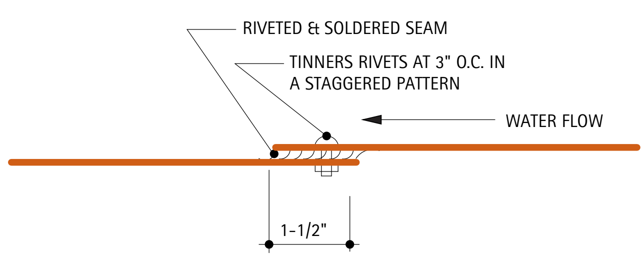
In this detail, a one-piece copper gutter lining and apron is used in conjunction with a standing seam roof. The upper edge of the gutter apron extends at least 6" onto the roof and is folded over and held by cleats at 12" O.C. A continuous lock strip is soldered to the apron at least 4" below its upper edge. The lower edge of the copper roof is hooked over the locking strip.



This detail is recommended for roofs with a pitch of at least 6 inches per foot. For roofs with lower pitches, see **Detail 10.3D**.

10.3F. Transverse Seams in Gutter Lining

Where seams occur in the copper gutter lining, a locked and soldered or riveted and soldered are required to maintain a watertight gutter condition. The seam should be oriented to allow the water to flow away from the joint. Rivets are installed in a staggered pattern at 3” O.C.



10.4. Water Diverters

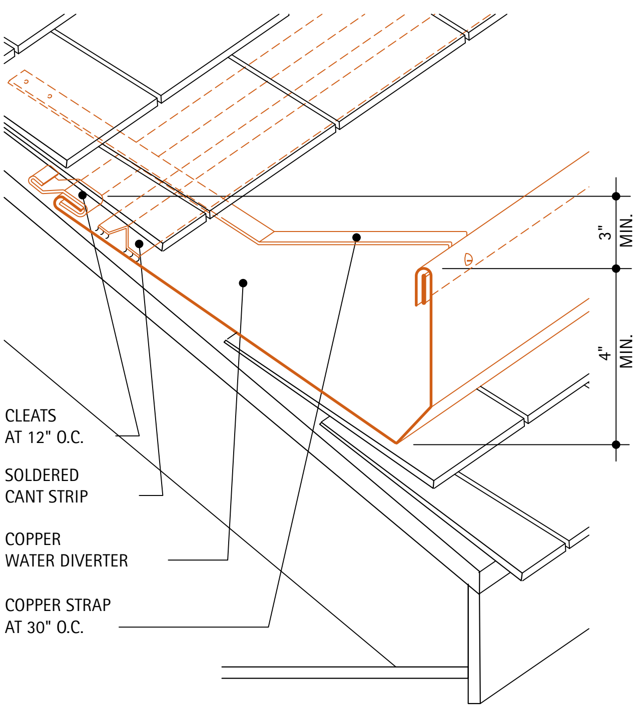
Description: At entranceways or on sloping canopies, where the appearance of a gutter is not desired or the installation of the gutter is difficult, drainage can be handled by installing water diverters.

The minimum suitable gauge for the fabrication of water diverters is 16 oz. cold rolled copper.

The height of the front face of the water diverter, which extends vertically, varies with the roof pitch and the area of roof to be drained; a 4" minimum is suggested. The back edge of the water diverter extends up the roof far enough so it is at least 3" higher in elevation than the front edge.

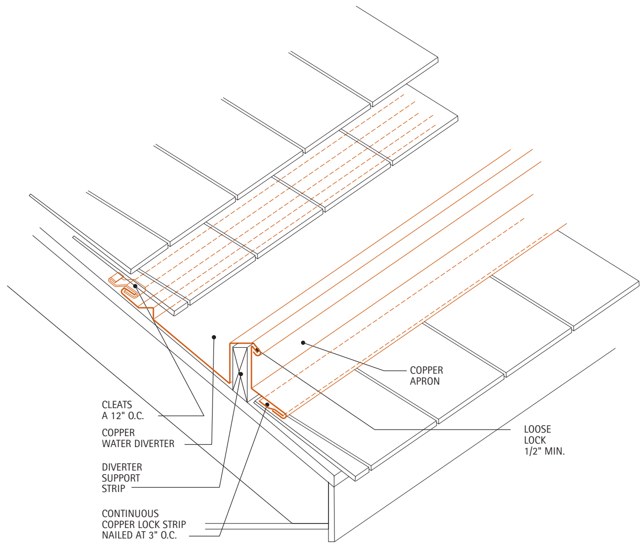
10.4A. Strap Hung Water Diverter

This detail illustrates a method of installing a water diverter using straps. The diverter is held in place by cleats spaced 12" O.C., maximum. Straps, attached to the roof and fastened to the diverter at the bead, provide additional support. The spacing of these straps should not exceed 2'-6" O.C.



10.4B. Strip Supported Water Diverter

Water diverters can also be constructed with wood strips placed on the roof.

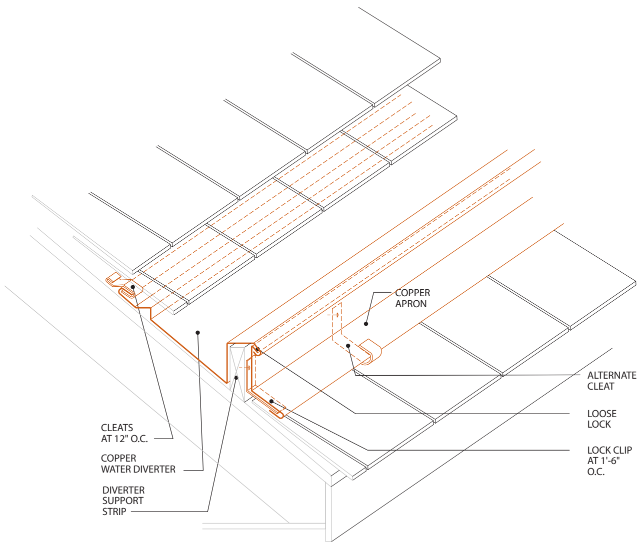


A continuous copper lock strip is attached to the roof, below the diverter support strip. Apron flashing is then hooked onto this strip. The copper water diverter is held in place by cleats at the top back edge and loose locked to the apron flashing.

The inverted V cant should be formed into the diverter when used in conjunction with rigid roofing material.

10.4C. Strip Supported Water Diverter - Alternate

This detail is similar to **Detail 10.4C**, except that the copper apron is held by lock clips or cleats which are nailed to the wood supporting strip. Both are shown for illustration purposes.



10.5. Scuppers

Description: Scuppers are used to provide an outlet through parapet walls or gravel stops on flat and built-up roofs to allow drainage of excess water. They can be used in conjunction with gutters and downspouts to divert the flow to the desired location.

Scuppers can be installed to carry water into gutters or directly into downspouts through conductor heads. When a conductor head is used, it should be at least 2" wider than the scupper. When neither conductor heads nor gutters are used to catch the water, scupper spouts should extend past the exterior surface of the building to avoid wetting the building surface.

The minimum recommended weight for the construction of scuppers is 16 oz. copper. Scuppers are fabricated with flanges on the roof side which extend 4" onto the roof. Wood blocking is required under scuppers to provide a nailable surface. Scuppers should be spaced no greater than 10 feet apart depending on the roof area drained.

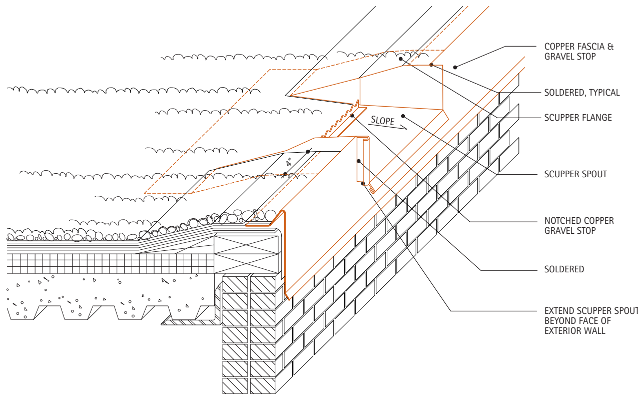
Special Conditions: In areas with severe ice and snow conditions and/or excessive debris, conductor heads with overflow openings should be used.

Where a roof is completely surrounded by parapet walls and drainage is provided by scuppers or internal drains, overflow scuppers should be provided.

The roof-side flange of the gravel stop is nailed at 3" O.C. to the perimeter blocking.

10.5A. Scupper at Raised Roof Curb

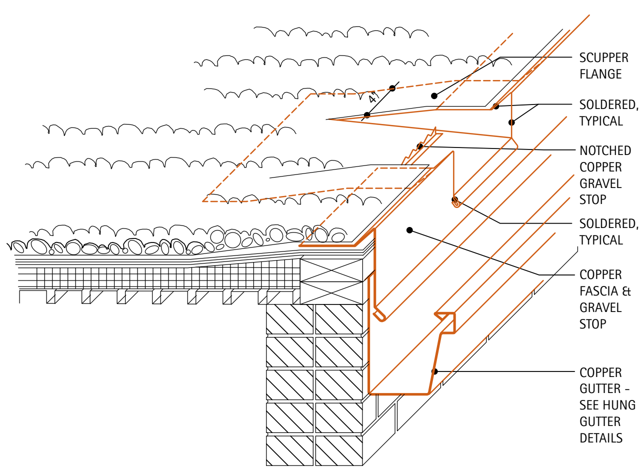
This detail illustrates the installation of a scupper through a raised roof curb with a gravel stop. Since no gutters or conductor heads are provided, the scupper spout should extend beyond the exterior face of the building.



All joints of the scupper should be soldered. The edge of the copper fascia and gravel stop at the scupper should also be soldered.

10.5B. Scupper at Gutter

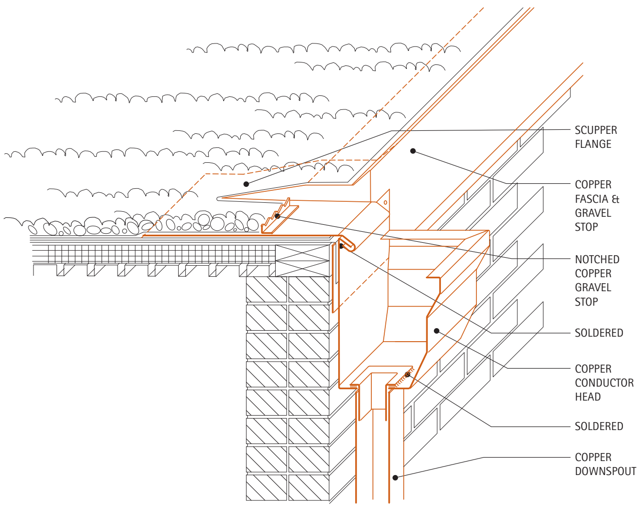
This detail shows a scupper used in conjunction with a gutter. The scupper spout is soldered into the copper fascia and gravel stop.



The drip edge of the fascia should extend over the back edge of the gutter by 1" minimum. The scupper and gravel stop flanges are nailed to the blocking. The gutter should be allowed to move independently of the fascia/gravel stop.

10.5C. Scupper at Conductor Head

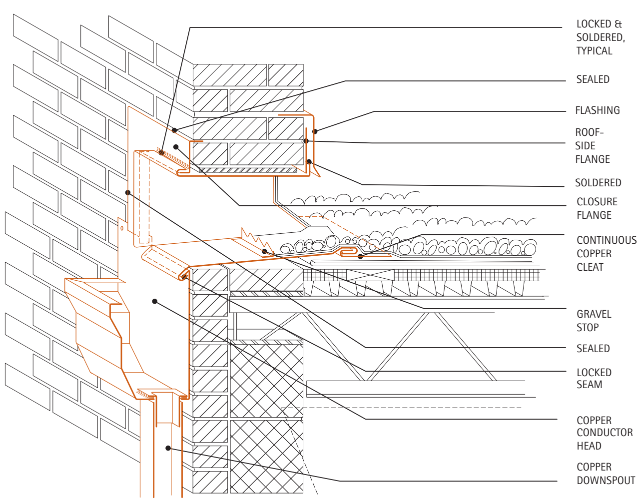
The conductor head must be at least 2" wider than the scupper. It is attached to the wood nailer through the fascia. The scupper spout is locked and soldered to the conductor head. All joints between scupper, conductor head, downspout, fascia and gravel stop are soldered.



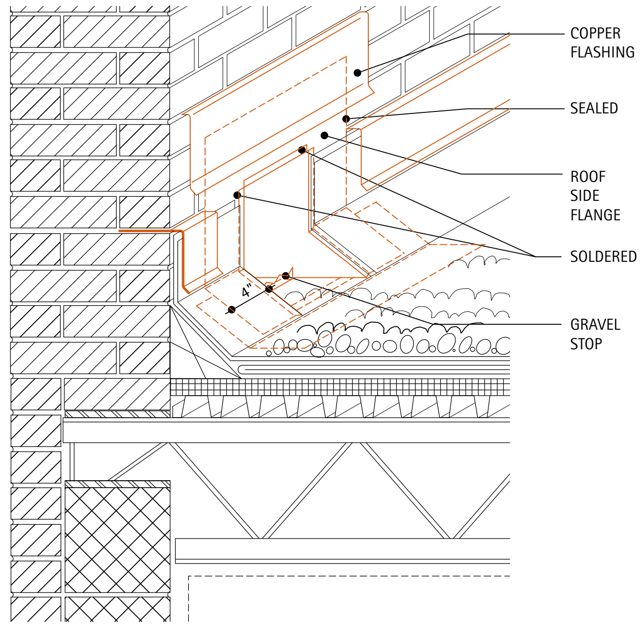
The minimum weight of copper suitable for conductor heads is 16 oz.

10.5D. Scupper at Parapet Wall

Shown is the installation of a copper scupper through a parapet wall in conjunction with conductor head and downspout.



SECTION AT SCUPPER



VIEW FROM ROOF SIDE

The conductor head is attached to the exterior wall using masonry fasteners. The scupper spout is locked and soldered onto the back edge of the conductor head. If conductor heads without overflow are used, the rim of the head should be set 1" below the scupper.

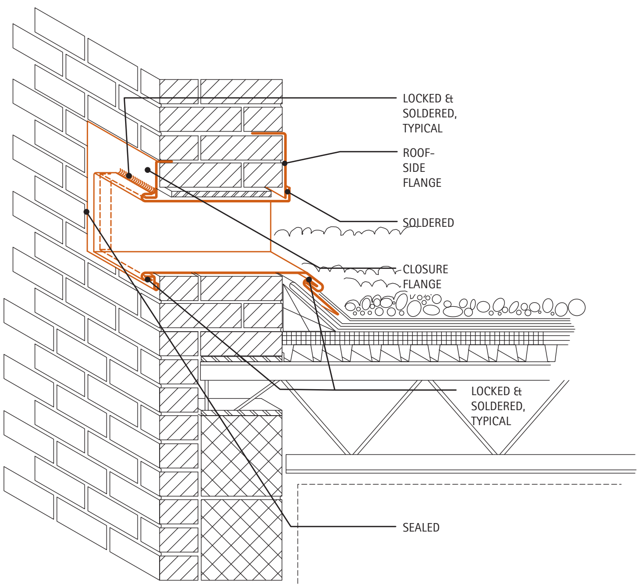
A closure flange is inserted and sealed into a masonry joint above the scupper. The sides are also sealed against the masonry. The scupper is locked and soldered onto the flange at the top and two sides.

On the roof side, the flange is covered by copper flashing. The flange is formed and soldered to the roof side of the scupper, leaving at least 4" of material around the opening. A continuous sheet of copper counterflashing is inserted into a masonry joint above this flange. This flashing extends at least 2" beyond the ends of the flange and laps the soldered joint between the flange and the scupper.

The bottom edge of the scupper on the roof side is locked and soldered into a continuous copper cleat. A copper gravel stop is soldered in the scupper.

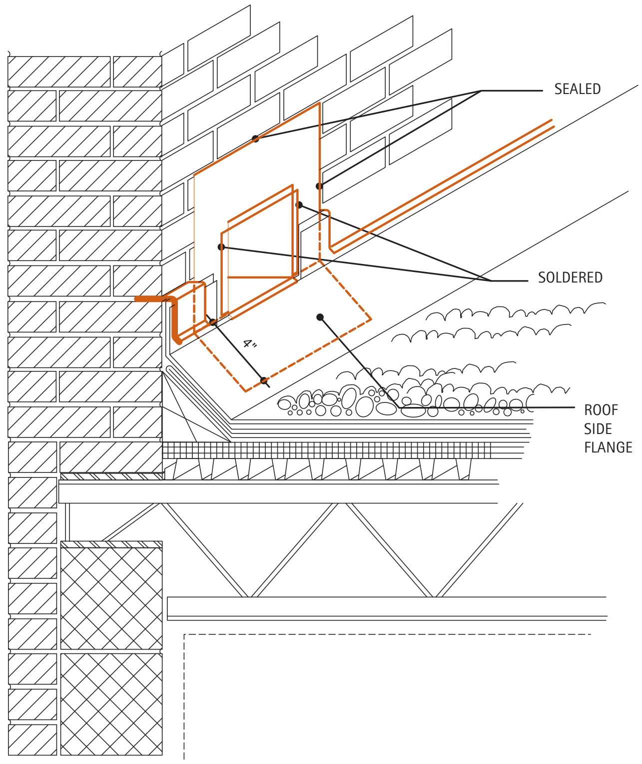
10.5E. Overflow Scupper

This detail illustrates the installation of an overflow scupper. Overflow scuppers should be carefully positioned to prevent excess water from remaining on the roof if the regular scuppers become clogged. They should, therefore, be placed at an elevation higher than the regular scuppers.



SECTION AT SCUPPER

The outside detail is similar to **Detail 10.5D**, except that conductor heads and downspouts are not required. The scupper is locked and soldered to the closure flange on all sides.



VIEW FROM ROOF SIDE

On the roof side, overflow scuppers can be detailed similar to **Detail 10.5D**. The detail shows an alternate method of constructing either type of scupper. The top of the roof side flange is extended into a masonry joint. The sides of the flange are sealed against the masonry.

10.6. Roof Sumps and Drains

Description: Copper roof sumps are generally used for draining small roof areas such as canopies. Their size depends on the roof area, the numbers of roof sumps used on the roof, the drainage outlet size, and the location of the sump on the roof.

The form of the roof sump should conform to the form of the roof. On a roof composed of a series of arches, for example, roof sumps should be placed in the valleys between the arches. The flange should conform to the shape of the arches.

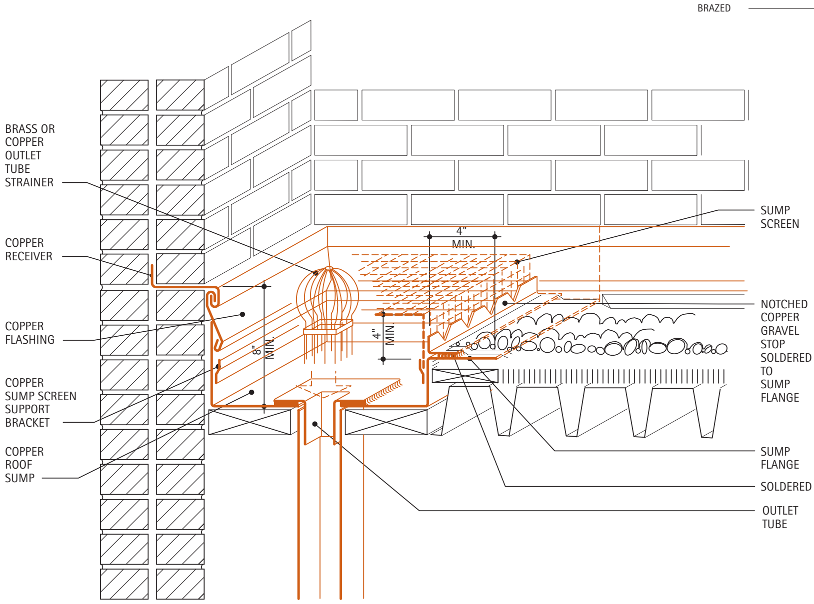
Roof sump drains are not recommended for use as a general roof drainage system.

Special Conditions: Formed copper roof sumps may also be used on flat roofs with copper flat seam construction. The details differ in that gravel stops are not required, and the horizontal flanges of the sump are joined to the copper roofing with soldered flat seams.

10.6A. Formed Roof Sump at Parapet Wall

This detail illustrates the installation of a roof sump at the corner formed by parapet walls.

Wood framing for the curb around the sump is provided as required. The horizontal flanges should be a maximum 4" wide and should be fastened to the roof through the roofing felts.



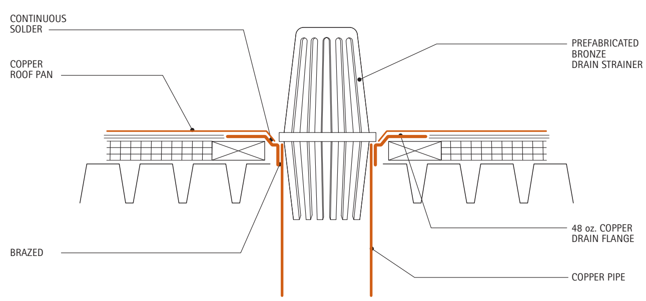
Vertical flanges of 8" minimum are provided on the sides of the roof sump and fastened to the wall with brass screws and lead shields. The top edges of the vertical flanges are lapped by counterflashing. The brass screws should be overlapped by the flashing.

Water collected in the sump is drained through an outlet tube into the downspout or other drainage stack. An outlet tube strainer is installed to minimize clogging. The use of a 1/2", minimum, copper or copper alloy mesh removable screen is also suggested. The top of the screen should be a minimum of 4" above the roof level.

Gravel stop angles are notched and soldered onto the horizontal sump flange to prevent gravel and tar from entering the drain.

10.6B. Prefabricated Roof Drain

This detail shows a prefabricated copper roof drain installed in a steel deck. Wood blocking is required for support of the 48 oz. copper drain flange. The copper roof pan is fastened to the flange with a continuous soldered joint. A prefabricated bronze strainer is shown.



10.7. Downspouts

Description: Copper downspouts are usually shop fabricated using 16 or 20 oz. cold rolled copper. Plain and corrugated, round and rectangular downspouts are typical. Other decorative downspout designs can also be fabricated.

Special Conditions: Downspouts should be installed vertically wherever possible. All horizontal offsets should be sloped in the direction of flow.

10.7A. Typical Downspout Sections

This drawing shows typical downspout cross-sections. Downspouts can be fabricated in any size. **Table 10.7A** shows the dimensions of standard sizes.

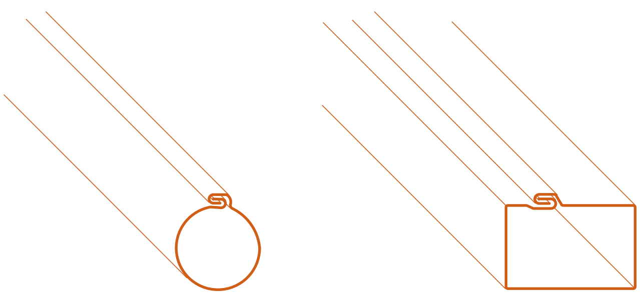
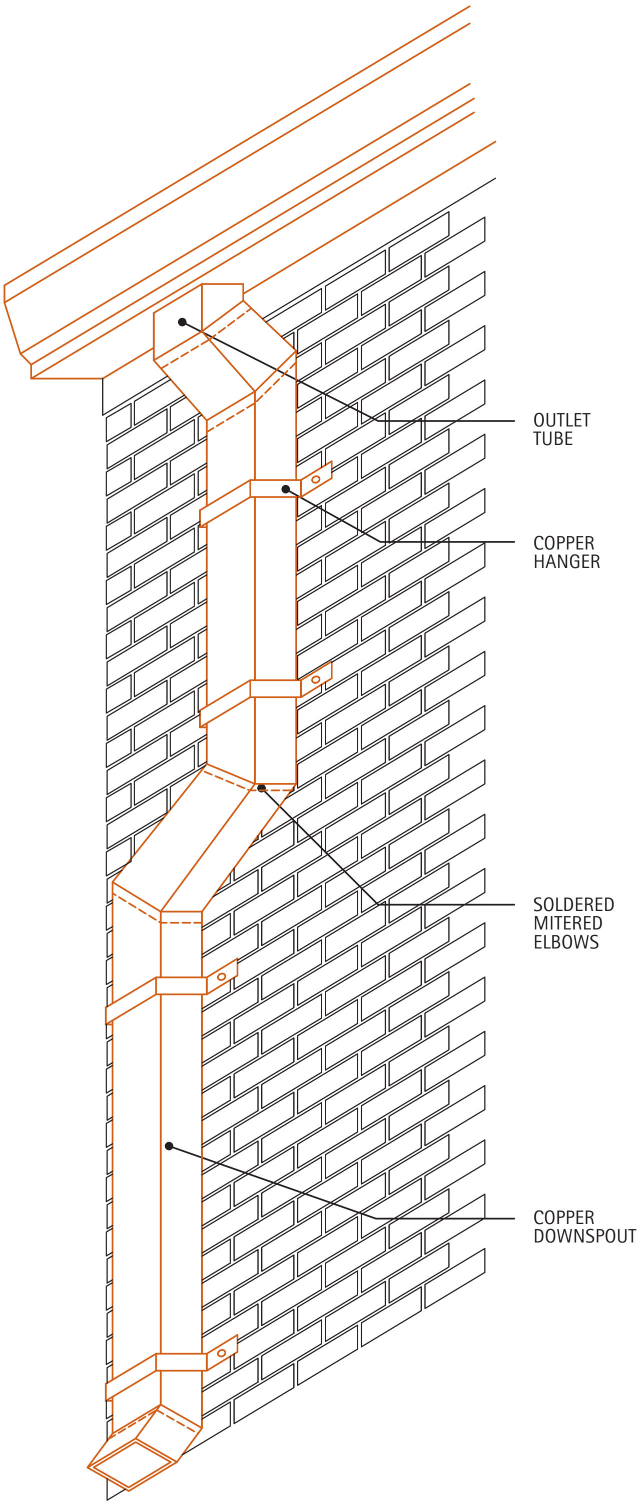


Table 10.7A. Recommended Sizes for Downspouts

Type	*Area (Sq. In.)*	*Nominal Size (Inches)*	*Actual Size (Inches)*
Plain Round	7.07	3 Dia.	3 Dia.
	12.57	4 Dia.	4 Dia.
	19.63	5 Dia.	5 Dia.
	28.27	6 Dia.	6 Dia.
Corrugated Round	5.91	3 Dia.	3 Dia.
	11.01	4 Dia.	4 Dia.
	17.72	5 Dia.	5 Dia.
	25.97	6 Dia.	6 Dia.
Corrugated Rectangular	3.8	2	1 3/4 x 2 1/4
	7.73	3	2 3/8 x 3 1/4
	11.70	4	2 3/4 x 4 1/4
	18.75	5	3 3/4 x 5
Plain Rectangular	3.94	2	1 3/4 x 2 1/4
	6.00	3	2 x 3
	12.00	4	3 x 4
	20.00	5	3 3/4 x 4 3/4
	24.00	6	4 x 6

10.7B. Downspout Assembly

This detail illustrates the various components of an installed downspout assembly.

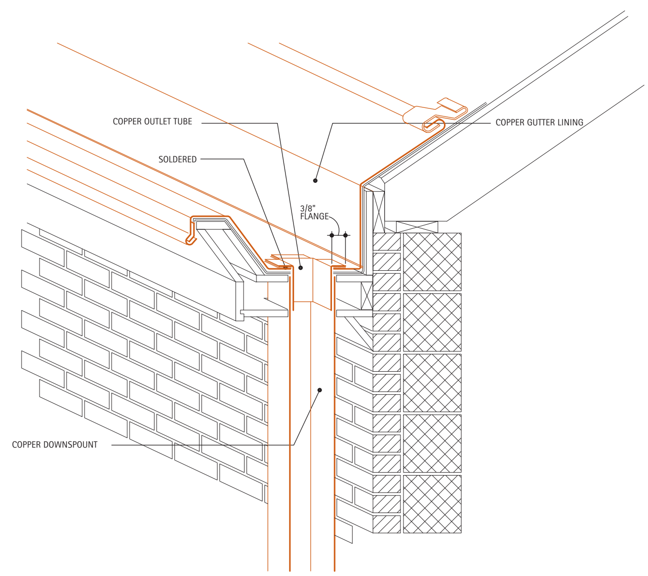


The downspout is joined to the gutter with an outlet tube, see **Detail 10.7C**. The flanges of the outlet tube are soldered to the gutter. Downspout sections are joined together by soldering. The bottom end of the upper section is inserted into the top of the section below it. Copper straps are used to hold the downspout against the building or structure.

Note: Copper drainage tubes can be substituted for the downspouts in all indicated details.

10.7C. Outlet Tube in Gutter Lining

The length of the outlet tube is a minimum of 4" from the flange edge to the bottom edge. The flange is 3/8" wide. The outside dimension of the outlet tube is 1/8" less than the inside dimension of the downspout.



The outlet tube is inserted through a hole at the gutter bottom. The hole size equals the outside dimension of the tube. The flange of the tube is soldered to the gutter.

For Additional Information:

- **10.2. Hung Gutters**, for information on downspout hangers.
- **10.8. Downspout Hangers**, for additional information on hung copper gutters.

10.8. Downspout Hangers

Description: Hangers are used to hold downspouts in position. Copper used for the fabrication of hangers should be 2 gauges heavier than the copper used for downspouts.

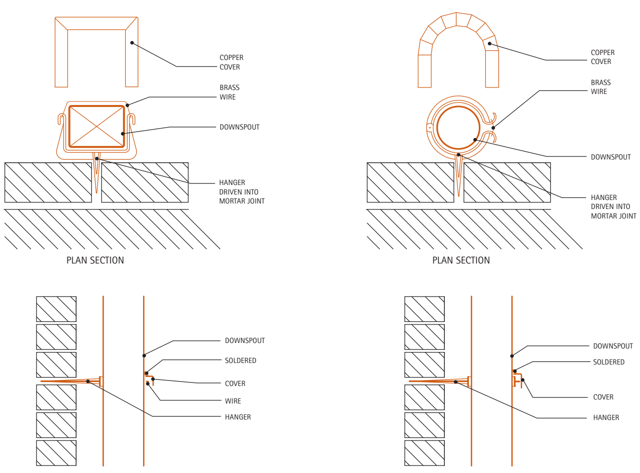
The form of the hanger should conform to the shape of the downspout. Selection of the proper hanger includes the following considerations: the size and type of downspout, the construction type of the building, appearance, and ease of removal for painting and repair.

Fasteners used for the attachment of downspouts to hangers vary; the most typical are screws, bolts, and blind rivets. Fasteners with minimal penetration length are used to reduce clogging.

When light colored porous wall materials are used, gaskets may be placed between the downspout straps and the wall to minize potential wall staining.

10.8A. Downspout Hangers

Two typical factory-made downspout hangers are illustrated.



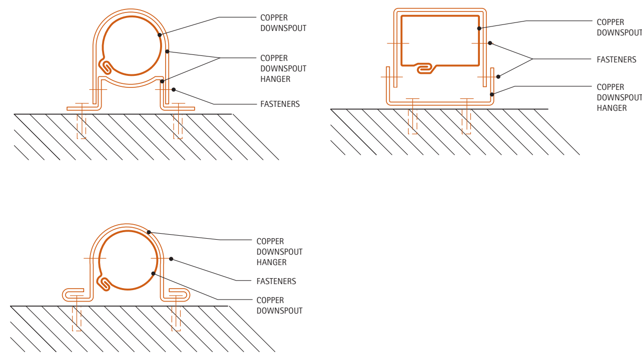
The downspout is inserted in the hanger after the hanger has been driven into the mortar joint. A wire is used to hold the downspout in place.

A shop-fabricated copper cover may be used to protect the hanger. The cover is placed over the hanger and soldered onto the downspout.

A variation uses a hinged hanger which is wired shut after the downspout is inserted.

10.8B. Downspout Hangers

This detail illustrates some typical strap hangers. The minimum dimensions for these copper straps are 1/16" x 1". The straps are attached to the building with copper or bronze fasteners appropriate to the wall material.



The bottom left figure illustrates a light gauge hanger for a round downspout. This type of hanger is installed after the downspout is in place.

For Additional Information:

- 10.7. Downspouts

11. BUILDING EXPANSION JOINTS

Introduction

Designing for the movement of building components is an important part of architectural detailing. The movement can be the result of temperature changes, imposed loads, settlement, or other causes. Building expansion joints are used to cover the space between components, and provide a barrier to the exterior.

Expansion joints can follow complicated paths along varying materials. Copper is an excellent material for such joints, since it is easy to form and lasts a long time.

When detailing an expansion joint for a specific application, it is important to consider the magnitude and direction of movement. Some dimensions of details presented in this section are based on the expected maximum amount of expansion (labeled "E" in the details). Most expansion joints are optimized to accommodate movement in only one direction. Their ability to accommodate movement in other directions varies with their design. The designer should review the details and select the appropriate design based on particular requirements.

One issue that must be addressed in the proper design of expansion joints, is the height of curbs. This dimension depends largely on whether or not a cant strip is used at these locations. Normally, the minimum recommended curb height, measured above adjacent roofing, is 8 inches. However, if a cant strip is used, this dimension must be increased. If a typical 4" cant is used, the height of the curb should be a minimum of 10 inches above the adjacent roof. This leaves room for a minimum counterflashing lap of 4" and 1" to 2" space between the cant and the counterflashing.

11.1. Roof Conditions

Description: Expansion joints in roofs require wood curbs around each roof area. The curbs should extend at least 8", or 10" if a cant is used, above the adjacent roof. In general, the top surface of the curbs should be sloped away from the joint, to shed condensation and moisture onto the roof. Insulation is often used in the expansion space, but is left out of the details for clarity.

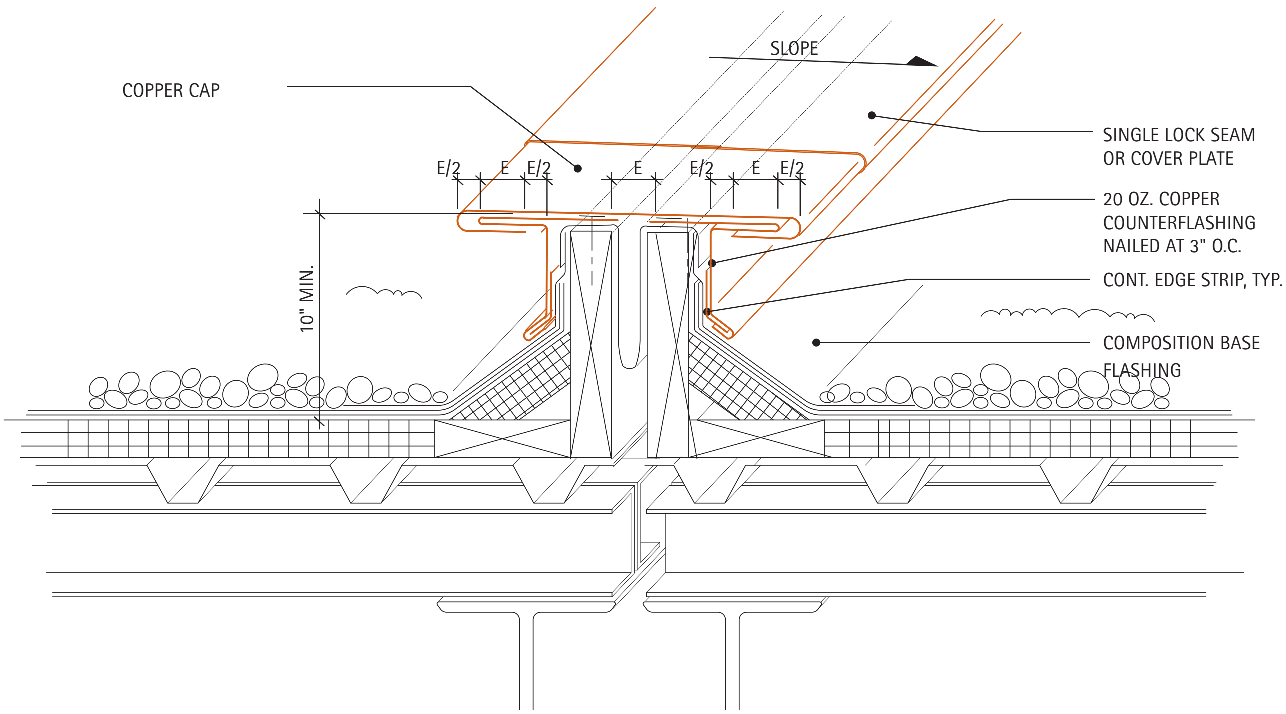
The minimum recommended gauge for copper used on roof expansion joints is 16 ounces.

The following plates outline some common building expansion joint details. The noted dimension "E" is the total expected movement within the joint.

Special Conditions: When comparing details for roof expansion joints, it is important to consider the risk of physical damage to the joint. For example, if a catwalk is adjacent to or crosses a joint, the joint is more likely to be exposed to damage from people kicking or stepping on the joint, or from equipment being dropped or dragged over it. Some joint designs are inherently better at resisting these impacts, while others can be modified to improve their performance.

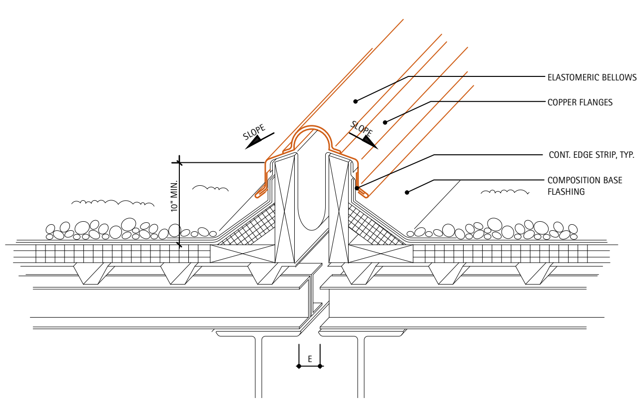
11.1A. Building Expansion Joint at Roof

This detail shows a typical symmetrical copper roof expansion joint. It uses a copper cap to span the expansion space. Copper counterflashing is attached to the top surface of each curb with nails spaced no more than 3" O.C. A continuous copper lock strip holds the bottom of the counterflashing. The copper cap is loose locked onto the counterflashing, as shown to accommodate expansion and contraction movement.



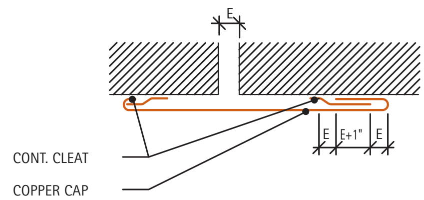
11.1B. Building Expansion Joint at Roof – Alternate

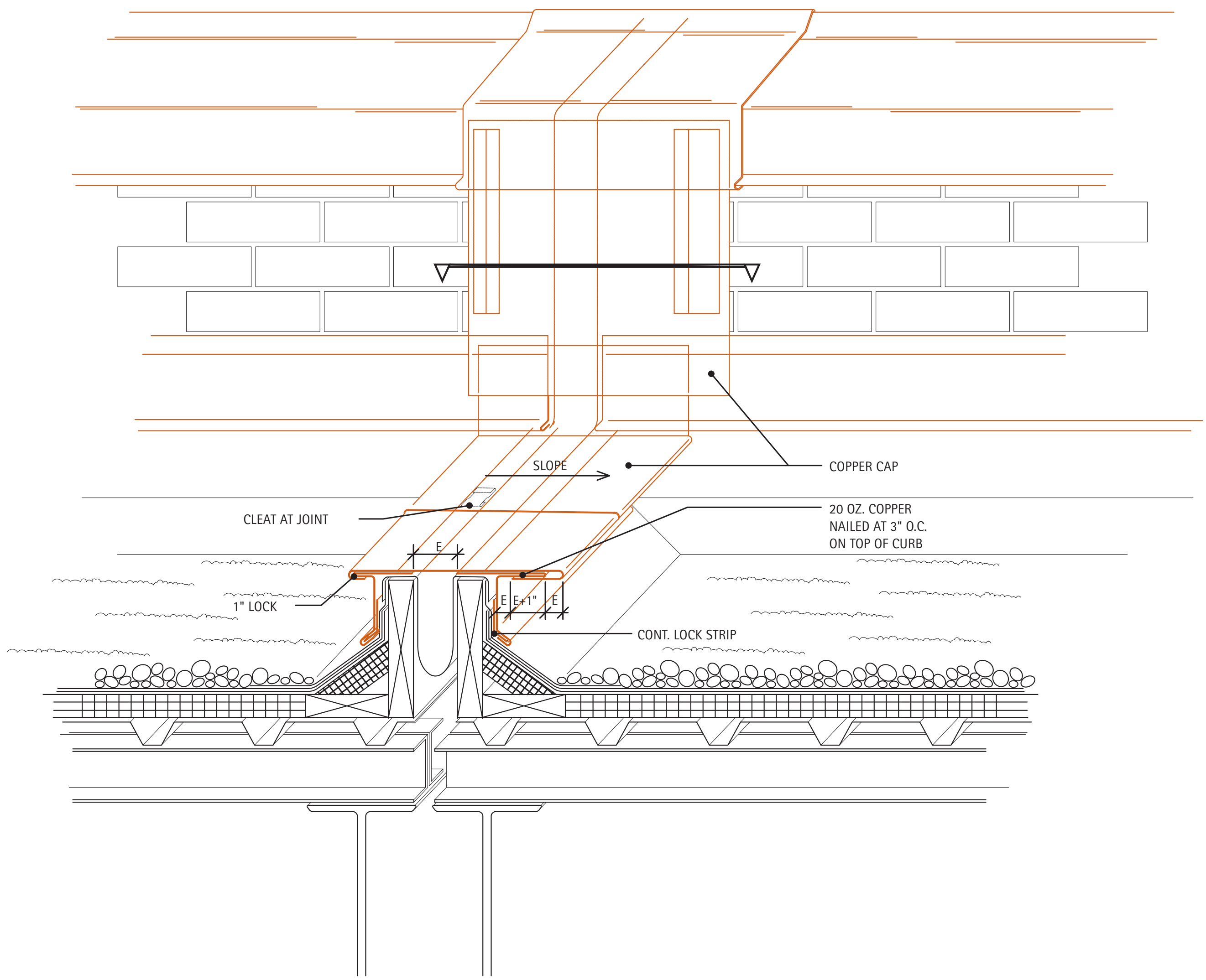
This design relies on manufactured elastomeric bellows secured to copper flanges. The bottom of the flanges are secured to each curb with a continuous copper edge strip. The size of the bellows depends on the maximum expansion movement and must be selected from the manufacturer's literature.



11.1C. Building Expansion Joint at Parapet

This detail illustrates an expansion joint designed to accomodate the unequal movement of two portions in a building. The basic principle is that copper cap is attached to one curb while the other side is designed to accomodate movement. The end of the expansion joint cap is bent up where it meets the wall. A continuous lock strip is attached to the wall on each side of the expansion space. A vertical copper cap is folded into each lock strip. The lock strip on one side is designed to accommodate the maximum movement, while the cap is locked onto the other side (see section).

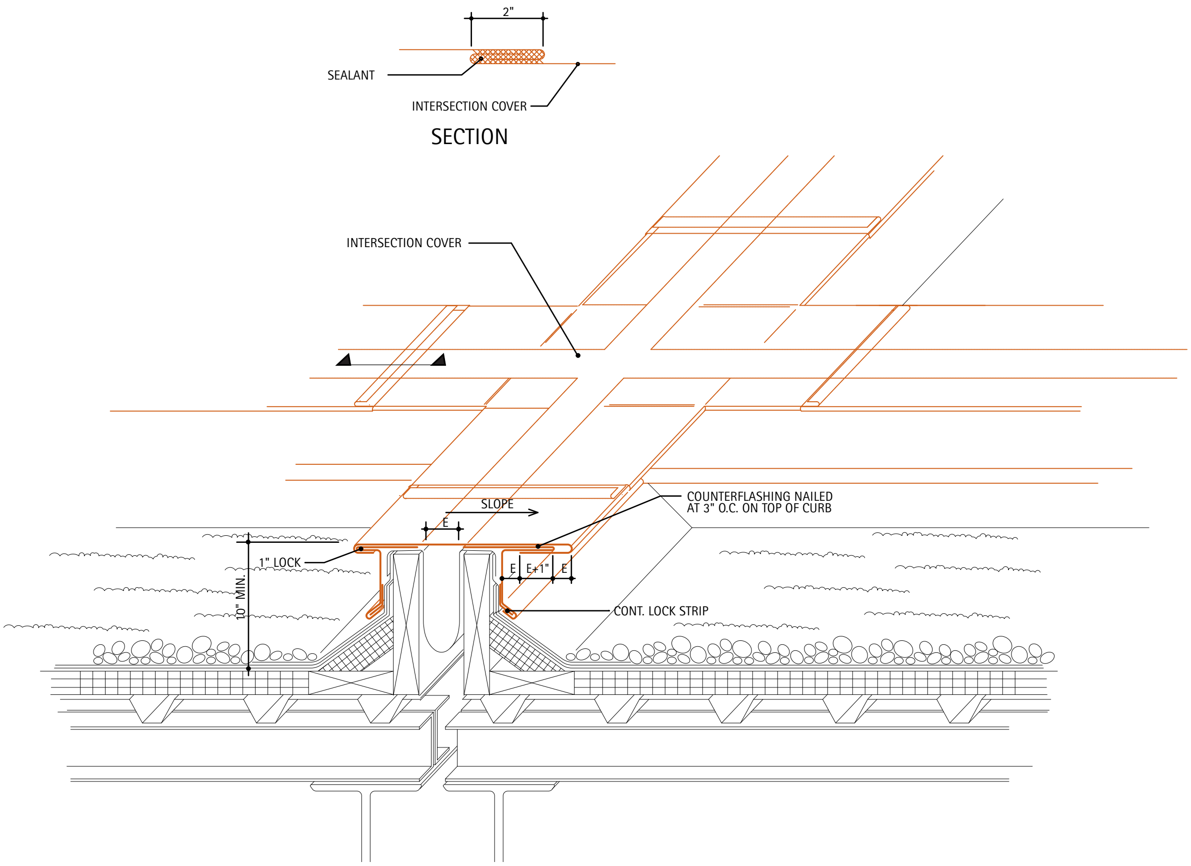




A copper cap is also formed to match the contours of the coping cover, and locked over the cover drip edge.

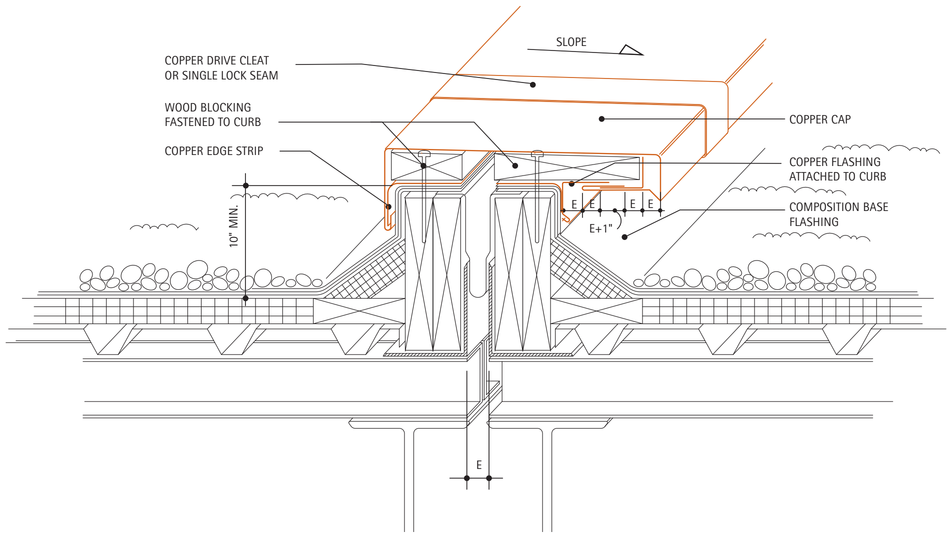
11.1D. Building Expansion Joint Intersection

This detail shows an expansion joint intersection. The cover for the intersection is made of a single piece of copper. It is joined to the other caps with a 2" loose lock filled with elastic sealant.



11.1E. Building Expansion Joint at Roof

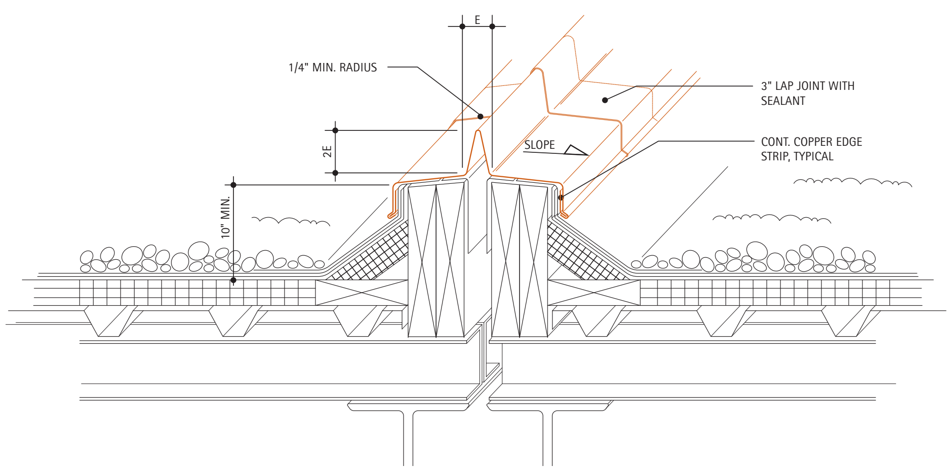
This detail illustrates an asymmetrical design which uses wood blocking to help support the copper cap flashing. The blocking on each side is fastened to the curbs.



The copper cap is locked onto a continuous edge strip on one side. It extends over the expansion space, then down and underneath the other blocking. It is loose locked into a continuous edge strip. The dimensions should be calculated as shown to accomodate the expected movement.

11.1F. Building Expansion Joint at Roof

This design for an expansion joint relies on flexing of the copper material to accomodate movement. This approach is acceptable as long as the radii of all bends that flex are at least 1/4".



The copper cap is formed into an inverted "V". Its height should be twice its width, as shown. The lower edges of the flashing are hooked onto continuous edge strips. Adjacent caps are joined with 3" sealant filled lap joints.

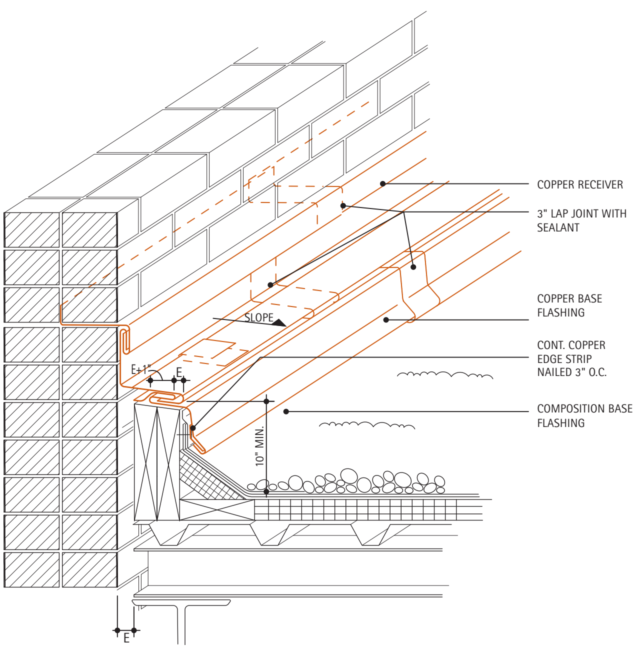
11.2. Roof Edges

Description: Expansion joints at roof edges usually occur where an independently supported roof meets a wall. This condition is often the result of a new structure adjacent to an existing one.

A continuous wood curb is required along the roof perimeter. It should extend at least 10" above the adjacent roof. The top surface of the curbs should be sloped away from the joint, to shed condensation and moisture onto the roof. Insulation is often used in the expansion space, but is left out of the details for clarity.

11.2A. Expansion Joint Between Flat Roof and Wall

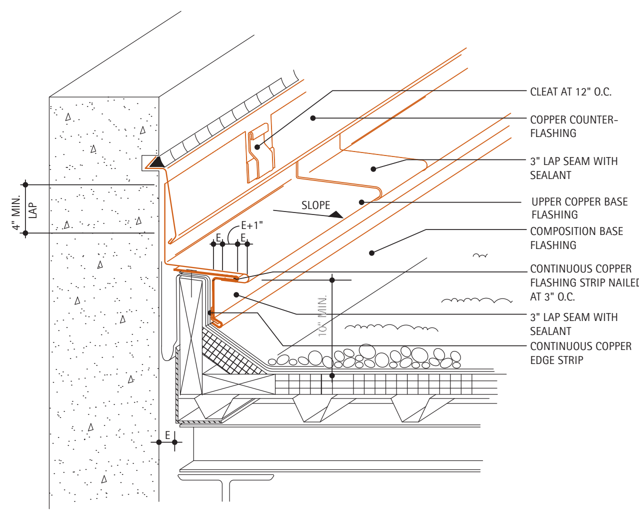
Copper base flashing is double-folded and nailed to the top surface of the curb which is cut to a slope of 3" per foot. Its lower edge is held by a continuous edge strip. Its upper edge is folded over, and long enough to accommodate maximum movement. Copper counterflashing is folded into this edge. The upper edge of the counterflashing is held by a copper receiver, which is set in the brick joints. If the wall is an existing one, the mortar joint is raked to a depth of 1" and the copper receiver is inserted, wedged, and sealed.



The curb shown is double width to provide a broad enough surface for the expansion and contraction in the copper joint and to allow for the nailing of the base. Depending on the width of the expansion joint, it may be necessary to widen the curb further.

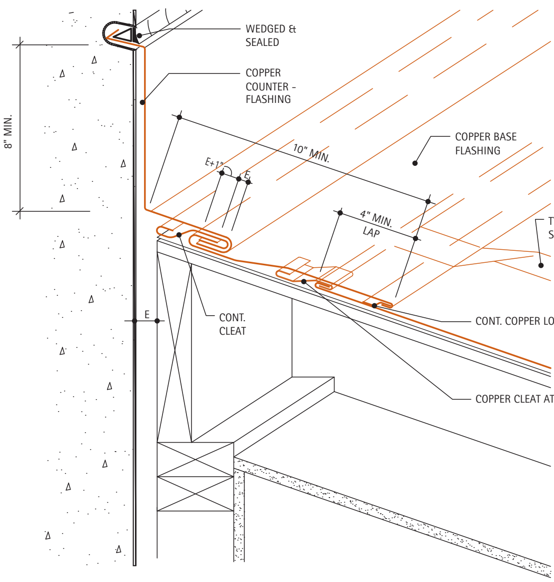
11.2B. Expansion Joint Between Flat Roof and Wall

A continuous lower copper base flashing is nailed to the top surface of the wood curb. Its lower edge is locked onto a continuous edge strip. The lower base flashing is formed into a lock large enough to accommodate the maximum expansion, as shown. the upper copper base flashing is loose locked onto the edge strip. Its upper edge is held to the wall by cleats, spaced no more than 12" O.C. Copper counterflashing laps the upper base flashing a minimum of 4". It is secured to the wall in a reglet or in a joint in masonry, and sealed.



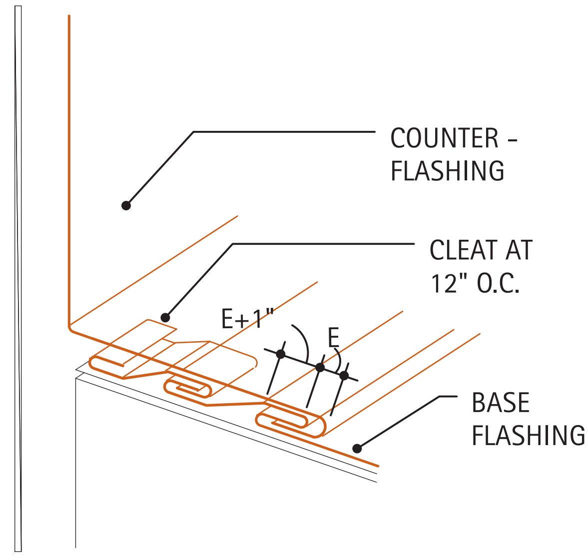
11.2C. Expansion Joint at Standing Seam Shed Roof

This condition shows the expansion joint between the head of an independently supported shed roof and a wall. Three alternate details are shown.

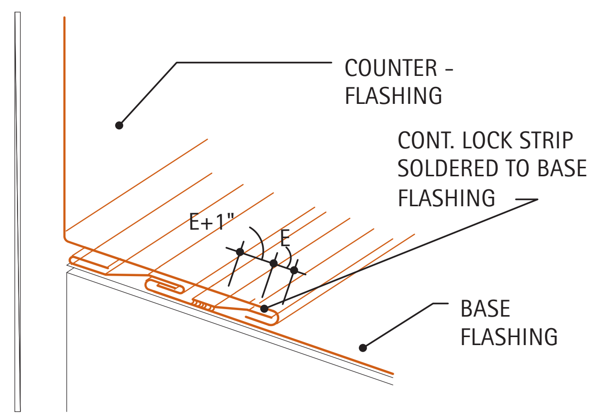


The roofing pans are terminated several inches below the top of the roof. Each pan is secured to the roof substrate with 2 cleats. A continuous copper lock strip is soldered to the pans at least 4" below the pan's upper edge. The standing seams are laid flat to this point. Copper base flashing is locked into the lock strip. The upper edge of the base flashing is formed into a loose lock large enough to accommodate the maximum movement and fastened with cleats at 12" O.C. Copper counterflashing is folded into the loose lock.

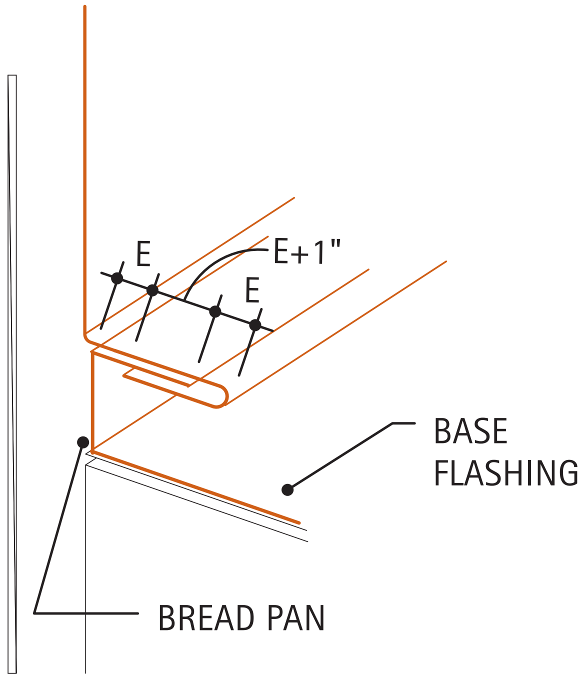
- **Alternate 1** The copper base flashing's upper edge is formed into a double fold large enough to accommodate the maximum movement. It is fastened with cleats spaced a maximum of 12" O.C. The copper counterflashing is folded and loose locked into the double fold. It extends at least 8" up the wall, where it is inserted into a reglet or in the joint between masonry courses.



- **Alternate 2** The copper base flashing's upper edge is formed into a lock and fastened with cleats spaced a maximum of 12" O.C. A continuous copper lock strip is soldered to the base flashing and receives the end of the counterflashing.



- **Alternate 3** The copper base flashing's upper edge is formed into a "bread pan". Its upper edge is large enough to accommodate the maximum movement. The copper counterflashing is loose locked into this edge.



Special Conditions:

If the design is for long pan, then expansion of the roof pan relative to the base flashing must also be accommodated at the lock strip and cleat. See **8.8. Long Pan Systems**.

11.3. Floor Conditions

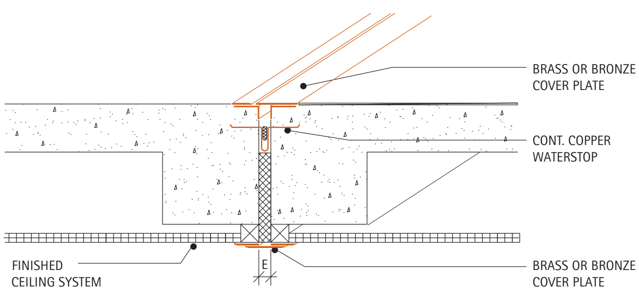
Description: Since building expansion joints are designed to isolate sections of a building, they inevitably cut through floors. Copper and copper alloys can be used in floor expansion joints in two ways: as trim and cover plates, or to prevent the flow of water through the expansion space.

Copper waterstops are used to prevent the flow of water. They run continuously from one end of the building to the other. Adjacent waterstops are joined with 3/4" soldered lap joints. Water stops are designed to accommodate movement by flexing. The recommended minimum weight for copper waterstops is 16 oz.

As cover plates are not required to stop the flow of water, their technical requirements are not as strict. The main criteria is that the material used must be strong enough to bridge the expansion space under given loads. Brass and bronze are used to provide the required strength.

11.3A. Building Expansion Joint at Concrete Floor

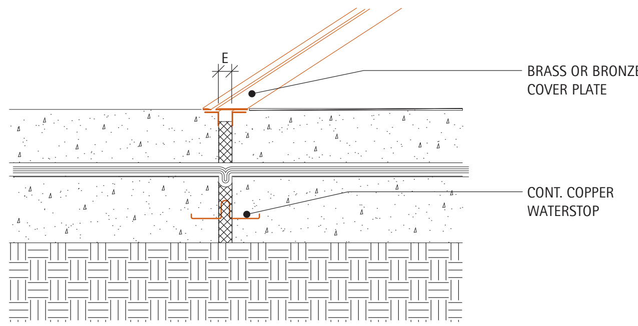
This detail shows a continuous cast-in-place copper waterstop bridging the space between concrete floor slabs.



The detail also shows the use of brass or bronze cover plates. An insert is cast into the edge of each floor. The actual cover plates are then attached to one side of the insert and allowed to slide freely over the other side. This is also true for cover plates in the ceiling, as shown.

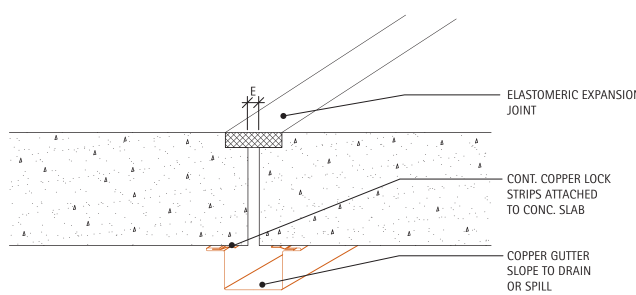
11.3B. Building Expansion Joint at Slab on Grade

In this detail, the grade slab is exposed to moisture from below. A continuous cast-in-place copper waterstop is used in the expansion joint to prevent water infiltration. A brass or bronze cover plate is shown in the floor slab, as described above.



11.3C. Building Expansion Joint at Concrete Garage Floor Slab

Exterior concrete structures, such as garages, are exposed to a much greater volume of water. It is often impossible or impractical to completely prevent water from getting through an expansion joint. Under these circumstances, a copper gutter can be used to catch the water and direct it to a drain or spill. The gutter is supported by copper or bronze lock strips that allow it to accommodate expansion and contraction movement.



11.4. Wall Conditions

Description: Expansion joints in walls are typically handled with copper waterstops. Waterstops are designed to accommodate movement by flexing. Waterstops run from the footing continuously to the top of the wall, where they are covered by a coping or other flashing.

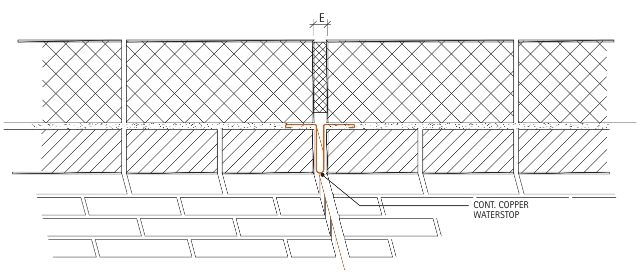
Above grade waterstops are lapped at least 4" in the direction of flow. Those below grade must be soldered.

Brass or bronze cover plates can be used to cover expansion joints in interior walls. These are similar to the cover plates shown in **11.3. Floor Conditions**.

The recommended minimum weight for copper waterstops is 16 oz.

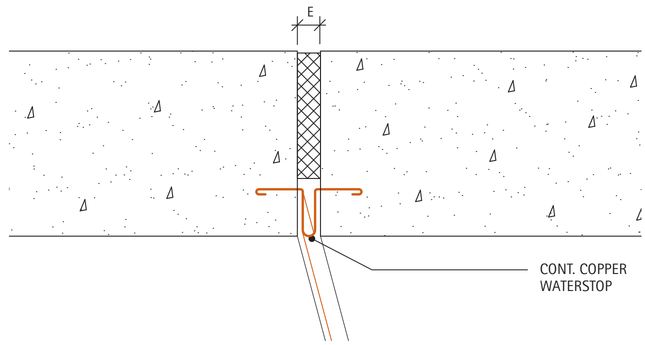
11.4A. Building Expansion Joint in Solid Masonry Wall

A continuous copper waterstop is set in the mortar joint between the brick and the CMU back-up.



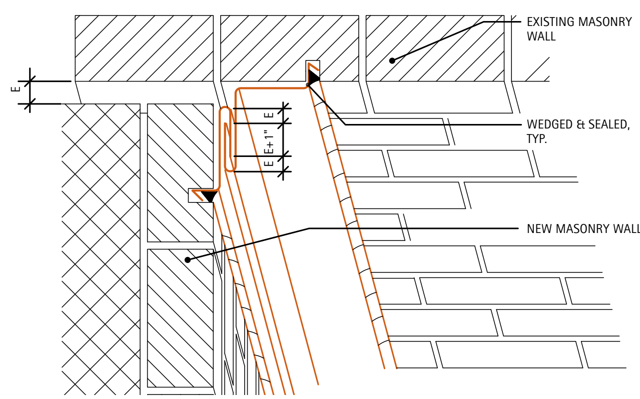
11.4B. Building Expansion Joint in Concrete Wall Below Grade

This detail shows a continuous cast-in-place copper waterstop bridging the space in the wall.



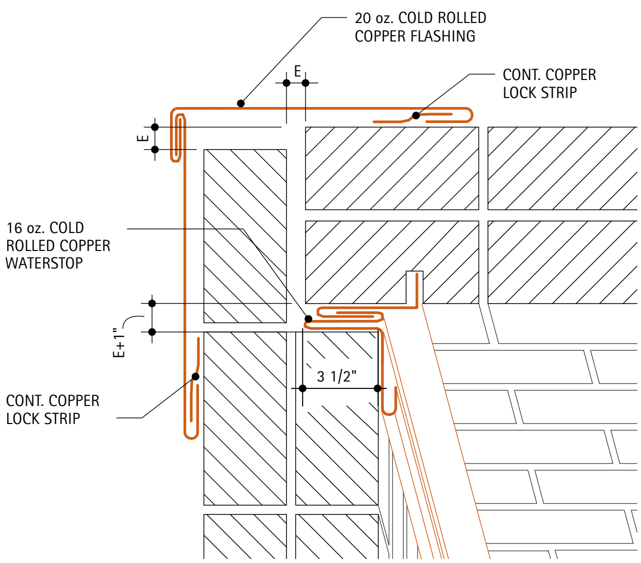
11.4C. Building Expansion Joint – New Wall at Existing Wall

This detail shows a condition where a new masonry wall is constructed perpendicular to an existing wall. A vertical reglet is cut into each wall. Separate copper flashings are inserted, wedged, and sealed into each reglet. A loose lock is used to join the flashings. It must be designed to accommodate the maximum expansion movement, as indicated by "E".



11.4D. Building Expansion Joint at Corner

This detail illustrates how to accommodate expansion in both directions at a building corner. A copper two-piece waterstop that allows movement in two directions is required. The dimensions of each piece should be designed to accommodate the total amount of movement expected.



One side of the waterstop is held in place by brass bolts through a copper bar, while the other side is built into the masonry. The top of the waterstop is lapped by a coping cover. Each 8 to 10 foot length of the waterstop is lapped 4".

The exterior side of the walls is covered by 20 oz. copper flashing, which is held by continuous lock strips. The lock strips should also be designed to accommodate movement.

12. WALL CLADDING

Introduction

Copper, brass, bronze are uniquely suited for wall cladding applications. These materials are strong, light weight highly corrosion resistant and are available in numerous factory applied and alloy finishes and colors.

In addition to the systems outlined in this section, many of the 8. Roofing Systems detailed in Section 8 can be adapted for use as wall claddings.

Most copper wall cladding systems are in many ways similar to copper roofing systems. They are generally installed over a continuous nailable substrate which is covered with 30 pound asphalt saturated felt. Rosin-sized building paper is laid over the felt to keep the copper siding or panels from bonding to the felt. Flat, circular, and other shaped walls can easily be covered with copper cladding systems.

The majority of the copper cladding systems can be field formed from sheet material. Many can also be pre-manufactured and transported to the site. In addition, there are a number of engineered systems from a variety of US and foreign manufacturers. These systems include insulated panels, non-insulated honeycomb panels, and copper screen panels.

Structural wall claddings have also been developed. Such systems become an integral part of a wall and must be properly engineered to satisfy all structural and building code requirements.

The following pages contain descriptive information and copper wall cladding system details. The described systems are generic in scope and are meant to convey basic design concepts. Other systems may vary to some degree.

The terms "siding" and "panel" have been used throughout this section as a convenient way to refer to components in the details. Their use may not reflect established regional definitions.

12.1. Profiled Panels

Description: Profiled copper panels can have a variety of shapes and sizes. The shapes can be formed on site with a brake or powered forming equipment. They can also be pre-manufactured and specified with embossed patterns or other designs.

The minimum recommended weight for copper used on profiled panels is 16 ounces, but some panel profiles may require heavier material.

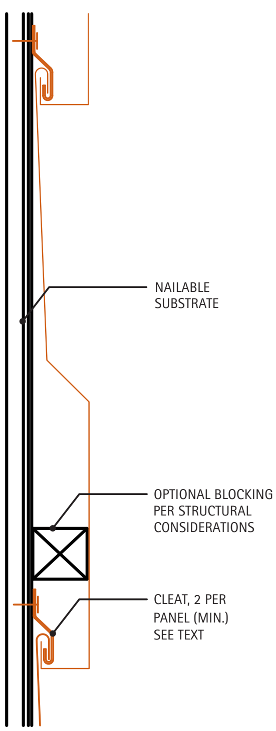
Note: Support blocking behind the panels may be required depending on panel thickness and dimensions, along with wall configuration, i.e., straight or curved.

Substrate: Continuous nailable substrate.

Fastening Method: Cleats screwed or nailed to substrate.

12.1A. Typical Section

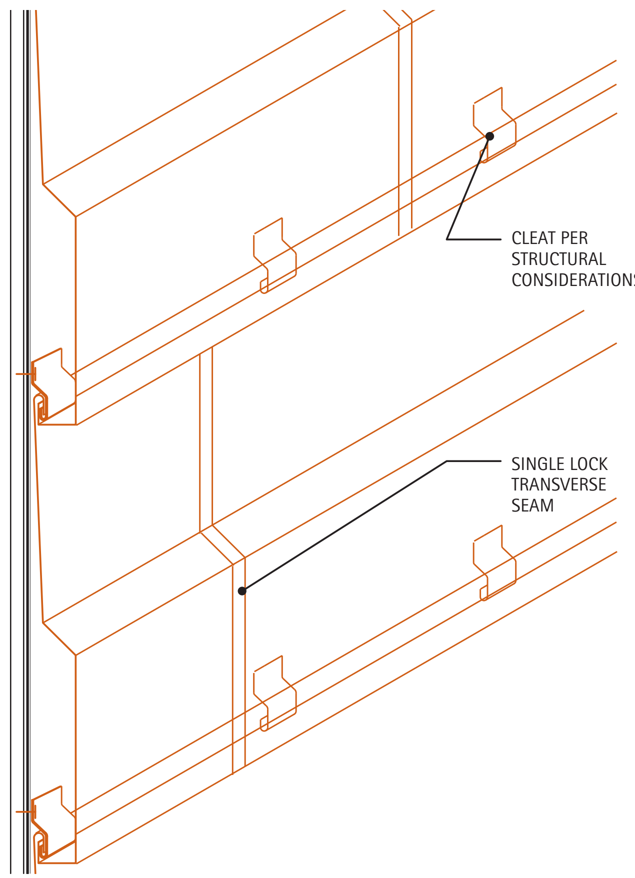
This section shows a common seaming method used in the horizontal joint between runs. Cleats are used to fasten the panels to the substrate. The panel must not be shaped so that it holds water.



A minimum of two cleats per panel are required. The actual number and spacing needed should be determined by a structural engineer, to ensure wind and other loads will not lift or distort the panels. A minimum of two copper, brass, bronze, or stainless steel screws per cleat are required for fastening to the substrate.

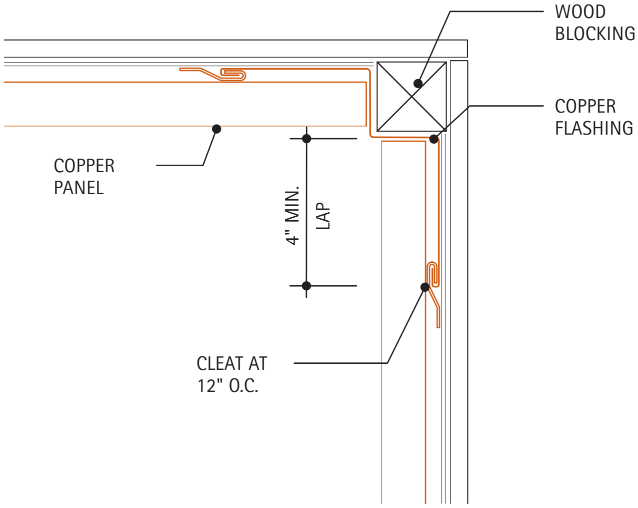
12.1B. Typical Axonometric

This detail shows the single lock used at transverse seams. A lapped seam (6” minimum) may also be used. The transverse seams should be staggered as shown.



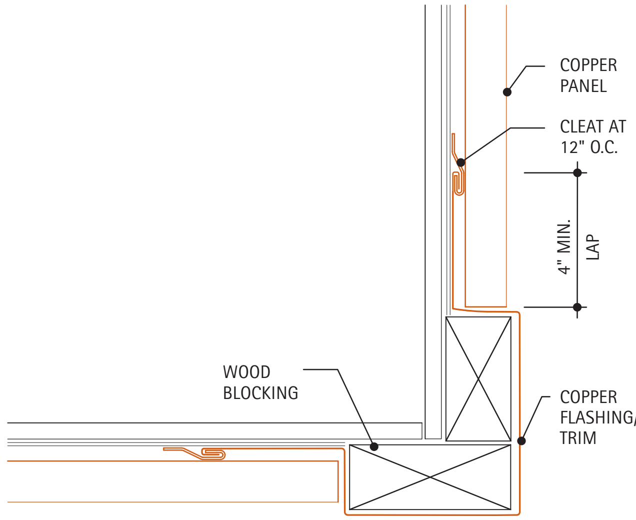
12.1C. Inside Corner

Wood blocking is used to fill the gap left between the copper panels at the corner. Copper flashing is installed over the blocking, and extends a minimum of 4" under the panels. The flashing is held by cleats at 12" on center.



12.1D. Outside Corner

The ends of the panels are closed by **9. Flashings and Copings** over wood blocking. The blocking must be thick enough to completely close the end void. The flashing covers the blocking and extends under the panels a minimum of 4". The flashing is held by cleats at 12" on center.



An alternate detail is shown in **Detail D** in **12.3. Beveled Systems**.

12.2. Horizontal Siding

Description: This type of copper siding provides a relatively flat appearance with fine horizontal lines. The length of each piece of siding is usually limited to 10 feet. The height varies but is typically 12" to 18". Transverse seams are 6" minimum, lap joints. The joints are staggered on successive runs to improve water resistance. This also helps reduce the stacking of multiple layers of copper at one place, which can make it difficult to fold the horizontal joints. Panels are installed shingle fashion, from the bottom up.

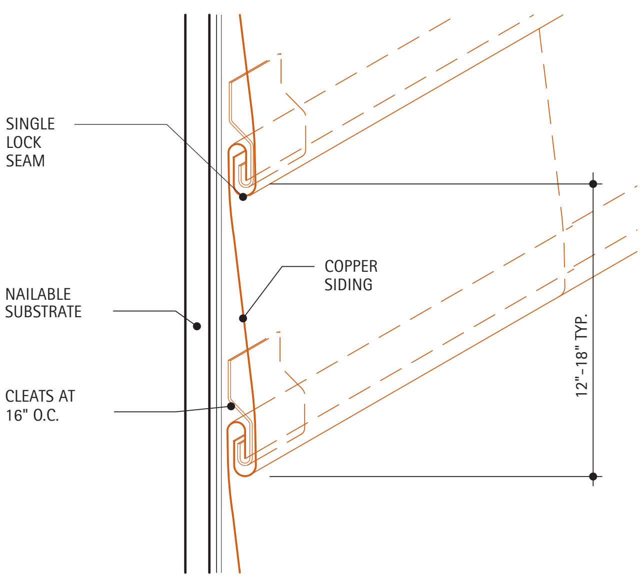
The minimum recommended gauge for copper used on flat siding is 16 ounces.

Substrate: Continuous nailable substrate.

Fastening Method: Cleats screwed to substrate.

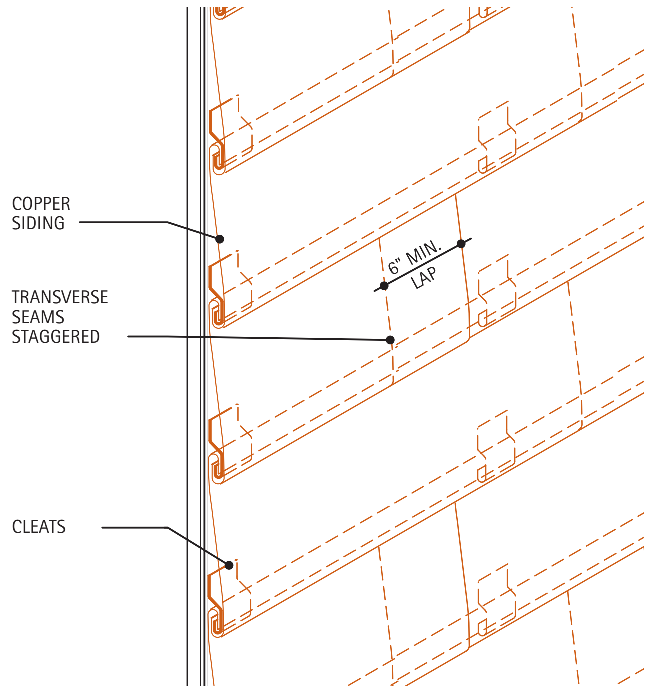
12.2A. Typical Section

This section shows the 7.2. Joints and Seams used in the horizontal joint between runs. Cleats are used to fasten the siding to the substrate. The cleats are spaced at 12" on center.



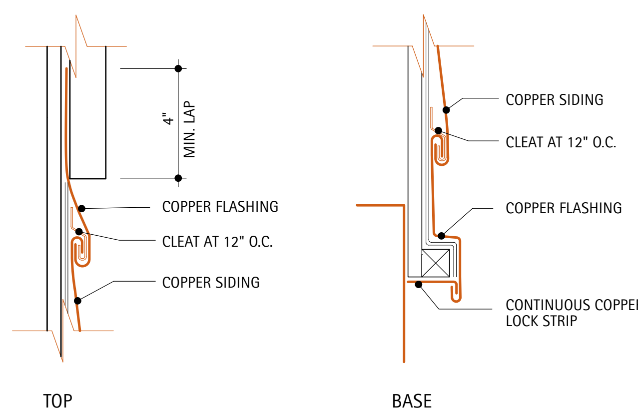
12.2B. Typical Axonometric

The 6" minimum, lap is shown at the transverse seams. The transverse seams should be staggered, as shown.



12.2C. Top and Base Details

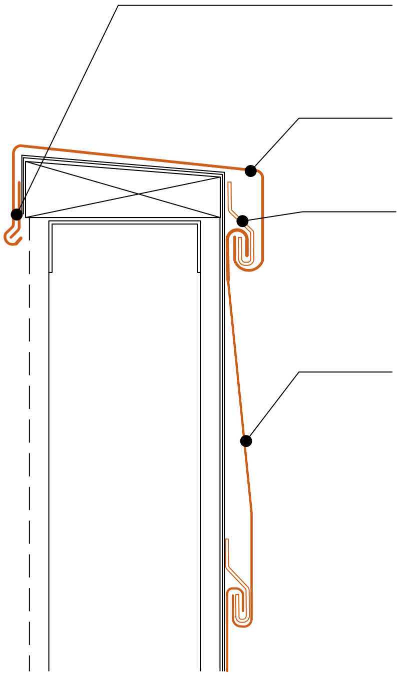
The top condition can be handled in many ways, depending on the material above the copper siding. The copper flashing is typically lapped a minimum of 4" by the material above.



In the bottom detail, wood blocking is used to provide a drip and a protected place for fastening the continuous copper lock strip.

12.2D. Parapet Detail

Cleats are fastened into the blocking at the top of the parapet framing. A copper coping cover is attached to the upper most run of copper siding using a single lock seam. The cover extends over the parapet and is locked into a continuous lock strip on the back side of the parapet.



12.3. Beveled Systems

Description: Beveled copper panels typically have a significant depth for bold heavy-shadowed effects. In order to provide the rigidity required, the minimum recommended thickness for copper is 20 ounce **half-hard temper** alloy.

Panels are typically limited to 10 foot lengths. Transverse seams are 6", minimum, lap joints. The joints must be staggered on successive runs to reduce the build-up of multiple layers of copper at one point, which would make it difficult to fold the horizontal joints. This is particularly important since beveled panels use fairly rigid copper material.

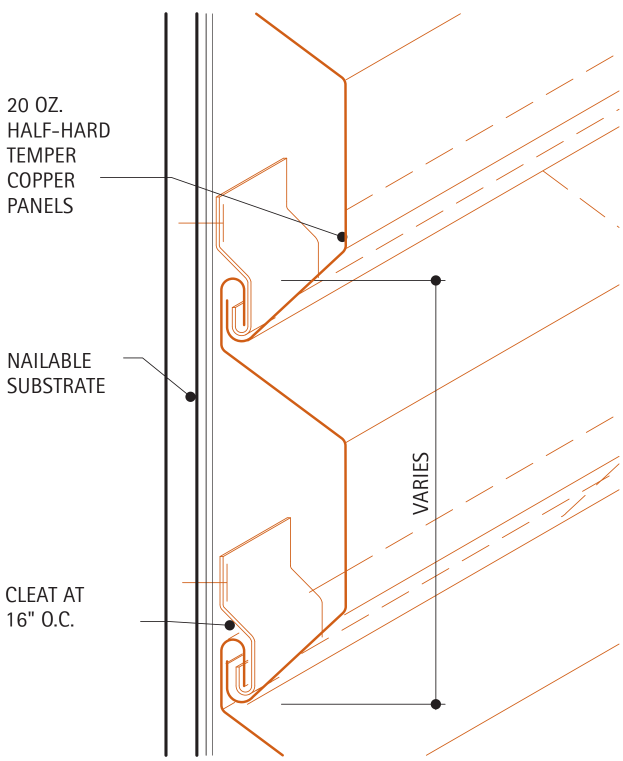
Note: Panel profile, thickness and lengths must be reviewed per structural considerations.

Substrate: Continuous nailable substrate.

Fastening Method: **Cleats** screwed to substrate.

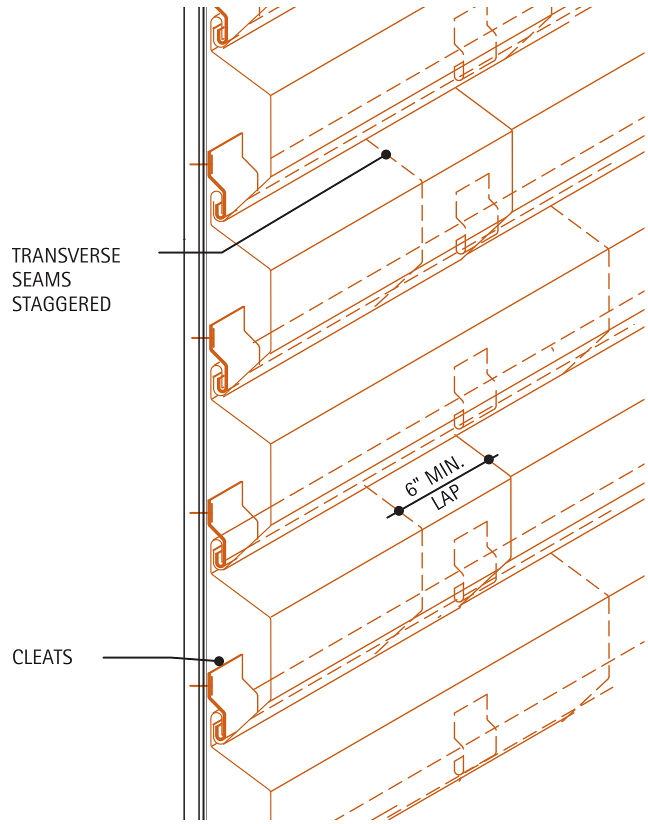
12.3A. Typical Section

A **single lock seam** is used in the horizontal joint between runs. Cleats, spaced at 16" on center, are used to fasten the panels to the substrate.



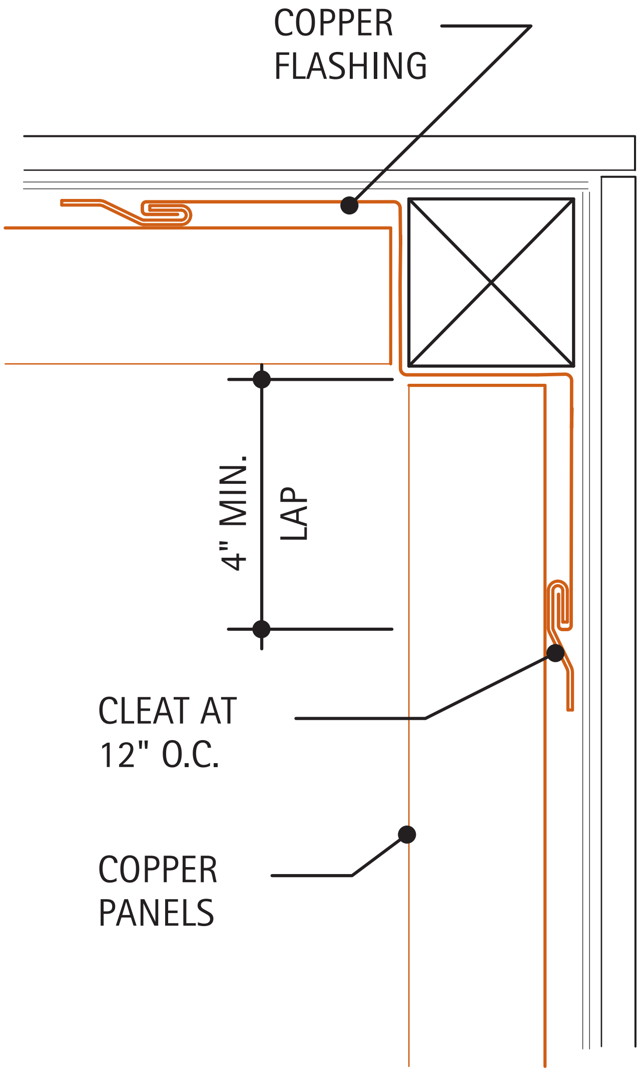
12.3B. Typical Axonometric

This detail shows an overall view of a beveled panel wall system. The deep panels provide strong horizontal shadow lines. The transverse seams should be staggered, as shown.



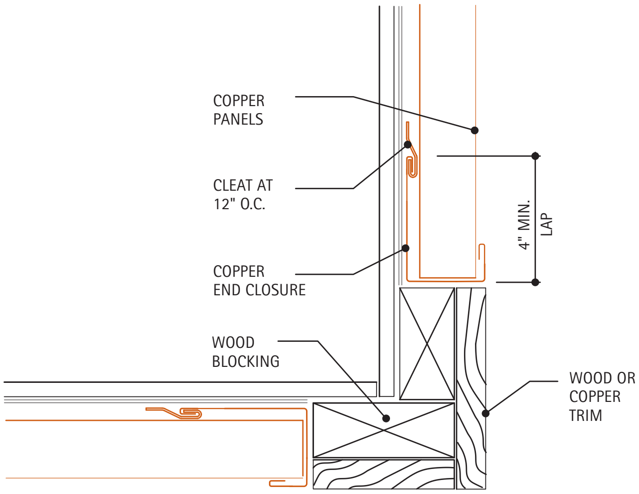
12.3C. Inside Corner

9. Flashings and Copings is laid over wood blocking in the corner to close the gaps at the ends of the panels. The flashing extends a minimum of 4" under the panels, and is held by cleats at 12" on center.



12.3D. Outside Corner

The ends of the panels in this condition are closed by copper flashing. The flashing extends a minimum of 4" under the siding and a minimum of 1" over it. Wood blocking and trim is used to finish the corner. An alternate detail is shown in **Detail D** in **12.1. Profiled Panels.**



12.4. Flat Siding

Description: This type of siding is fabricated from 24-ounce copper. Its profile is designed to provide very tight joints between panels, and very flat wall appearance with minimal shadows. Panel depth is approximately 1/4". This system is self-flashed at horizontal seams, using a double-fold detail.

The panels are installed from the top down. The bottoms of the panels are fastened to the substrate with screws through slotted holes in the siding. The screws are not fully tightened to allow the siding to expand and contract.

Transverse seams are lap joints with a minimum of 6 inch lap. The seams should be staggered on successive runs to prevent build-up of copper material.

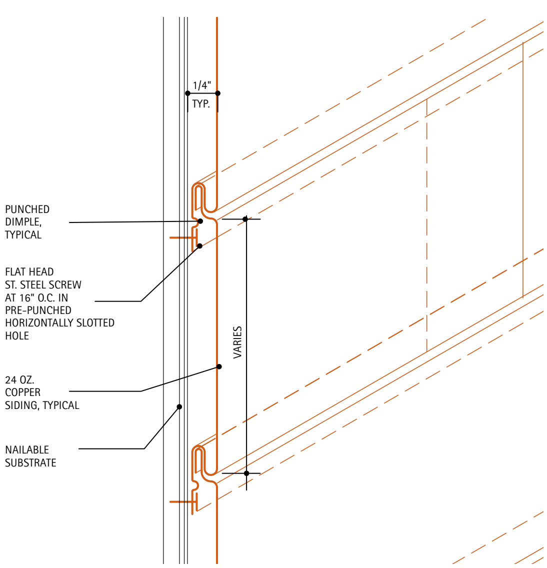
Lock strips and flashing are of the same weight as the siding.

Substrate: Continuous nailable substrate.

Fastening Method: Screwed to substrate through slotted holes in panels.

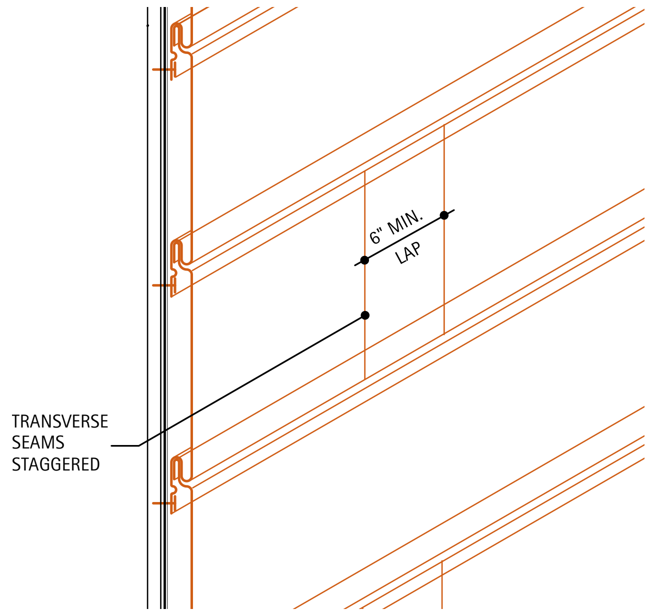
12.4A. Typical Section

This section shows how the top edge of successive runs of copper siding are held by the double-fold and punched dimple of the run above. The bottom edge is screwed with stainless steel screws through slotted holes in the siding.



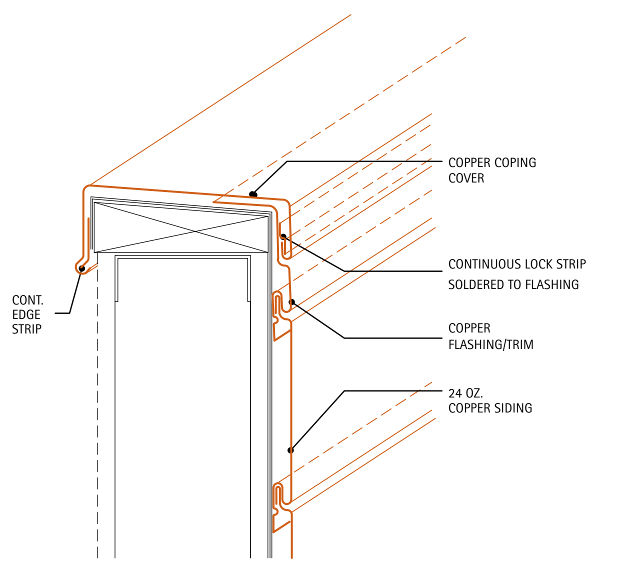
12.4B. Typical Axonometric

The seams should be staggered as shown.



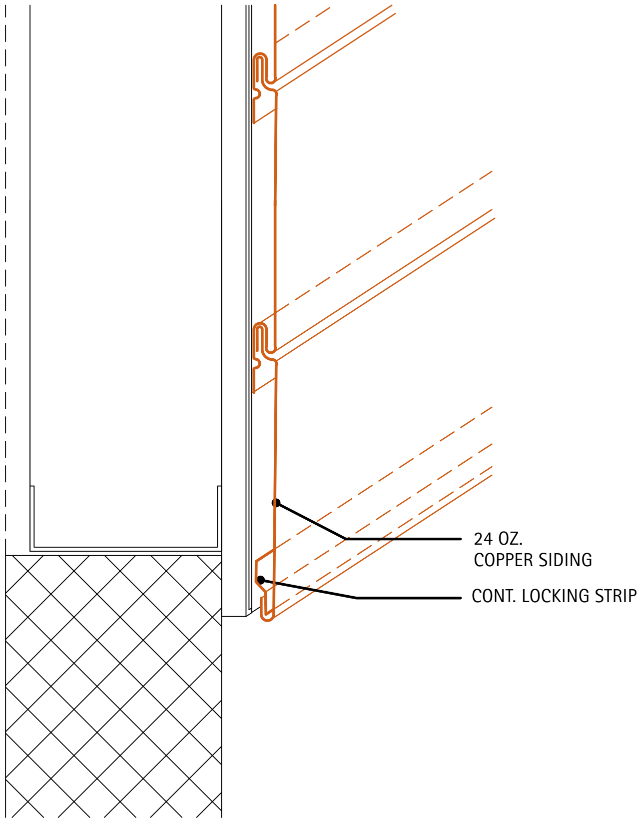
12.4C. Parapet Detail

The installation of this siding begins at the top and work progresses down the wall. The top of the upper run of siding is held by a 24-ounce copper flashing and trim piece. This trim extends up and over the wood blocking, where it is nailed. A continuous copper lock strip is soldered to it. The coping cover then locks into this strip, extends over the coping and is locked into an edge strip on the opposite side of the wall.



12.4D. Base Transition Detail

A continuous copper lock strip is nailed at the bottom of the substrate. The copper siding is then locked into this strip.



12.5. Structural Systems

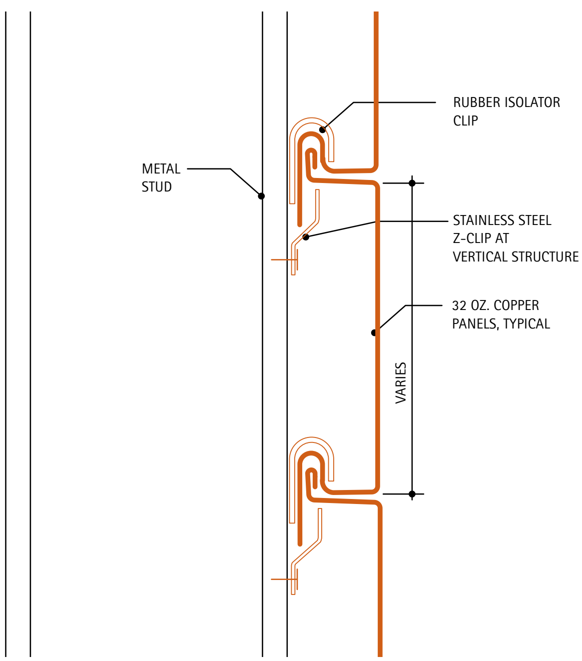
Description: These panels are designed to be attached directly to the wall structure, without the use of a continuous substrate. The panels must withstand all forces and transfer those forces to the structure. Therefore, the panel dimensions and thicknesses, z-clip and structure designs must be reviewed by a structural engineer to ensure that all codes and structural requirements are satisfied.

Substrate: Structural system. A continuous substrate is not required.

Fastening Method: Stainless steel z-clips and rubber isolators.

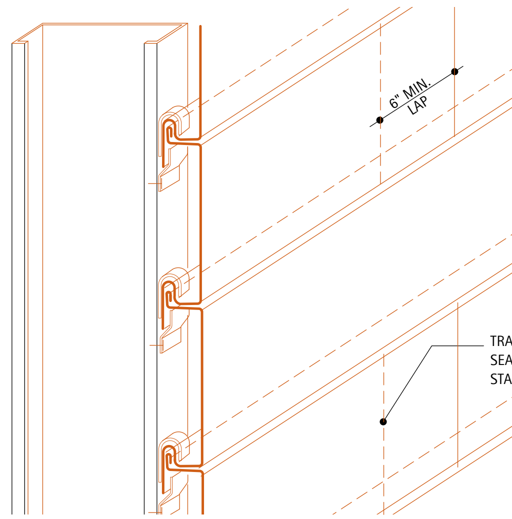
12.5A. Typical Section

This section shows the rubber isolator clips and the stainless steel z-clip required to hold the copper panels and prevent direct contact with the structural system.



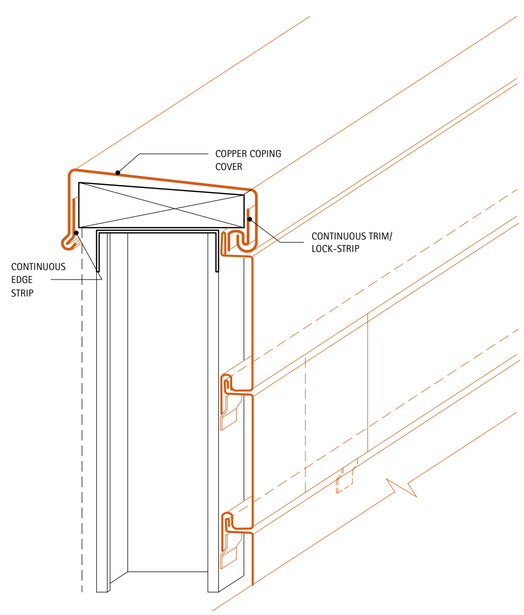
12.5B. Typical Axonometric

Staggering the transverse seams, as shown, is required to avoid having many layers of the copper panels at one point. It also helps improve weather resistance.



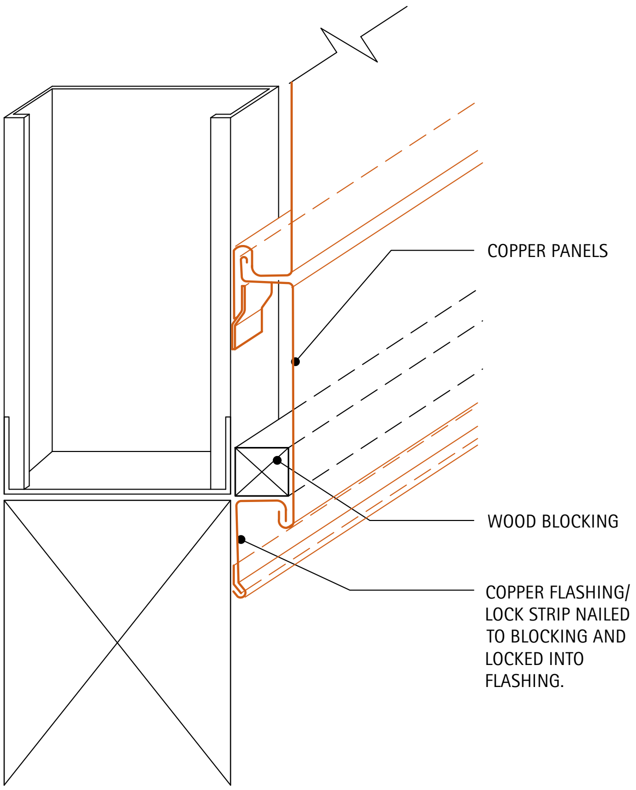
12.5C. Parapet Detail

A continuous copper trim/lock strip is nailed to the wood blocking. This strip holds the top edge of the copper panels. The coping cover locks into this strip, extends over the wood blocking and is locked into a continuous edge strip on the opposite side of the wall.



12.5D. Base Detail

Wood blocking is attached to the structure at the base of the wall. A continuous copper flashing/lock strip is nailed to the bottom of the blocking. The bottom edge of the copper panel is locked into the strip.



12.6. Diagonal Flat Lock Systems

Description: Diagonal flat lock panels are usually constructed of relatively small, 8 to 12 inch, square copper pieces. They are very often used on curved surfaces, such as domes, spires and vaults.

There are two slightly different patterns of panels. Their differences are presented below. All panels can be attached to the substrate with cleats or they can be nailed at their upper vertex with a single copper, brass, bronze, or stainless steel nail.

Corner and base conditions use transition and termination strips, respectively.

The minimum recommended thickness for these panels is 16 ounce copper.

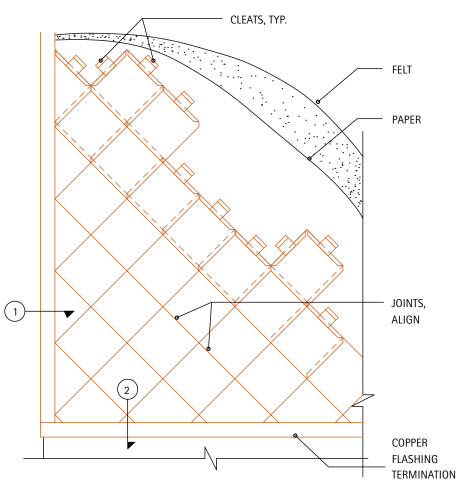
The number of cleats per panel is determined by panel size.

Substrate: Continuous nailable substrate.

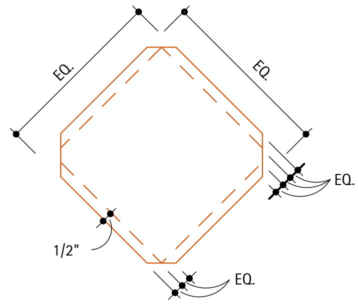
Fastening Method: Cleats or nails.

12.6A. Flat Seam – Diagonal Lock

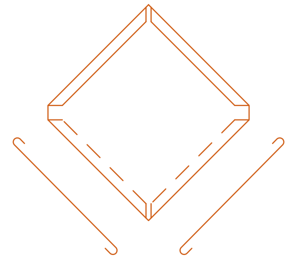
The corners of the square panels are trimmed as shown. Notice the corners on the right and left are cut deeper than the top and bottom. This small difference results in the joints aligning as shown in the elevation. Sections 1 and 2 show that copper flashing is used at transitions, such as corners and base conditions.



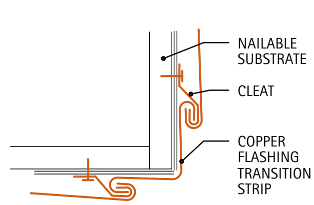
ELEVATION



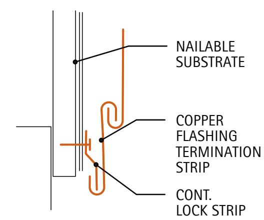
TYP. PANEL - UNFOLDED



TYP. PANEL - FOLDED



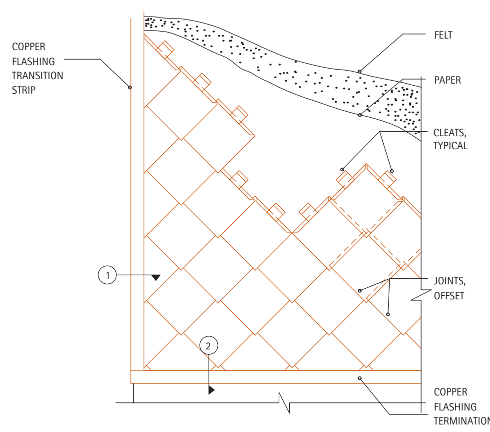
SECTION 1 - CORNER



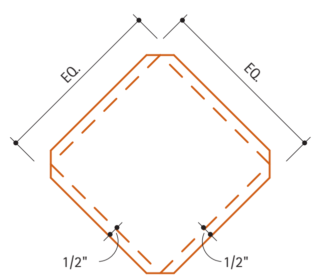
SECTION 2 - BASE

12.6B. Flat Seam – Diagonal Lock – Alternate

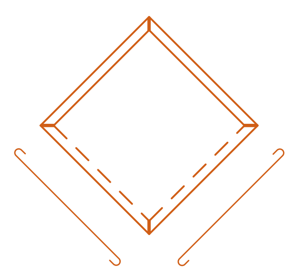
These panels are trimmed equally at all four corners. The result is joints that are offset, as shown in the elevation. Sections 1 and 2 from Detail A, also apply to this panel pattern.



ELEVATION



TYP. PANEL - UNFOLDED



TYP. PANEL - FOLDED

12.7. Horizontal Flat Lock Systems

Description: This type of wall panel is basically identical to 8.5. Flat Seam Roofing applied on a vertical surface. However, neither solder nor sealant is required in the joints, since the vertical surface provides positive drainage.

The panels are typically 18 x 24 inches, with 3/4 inch folds on all four sides. Two sides are folded over and two folded under. All corners are trimmed at a 45 degree angle.

The single lock seams are typically hammered flat. The minimum recommended gauge is 16 ounce copper.

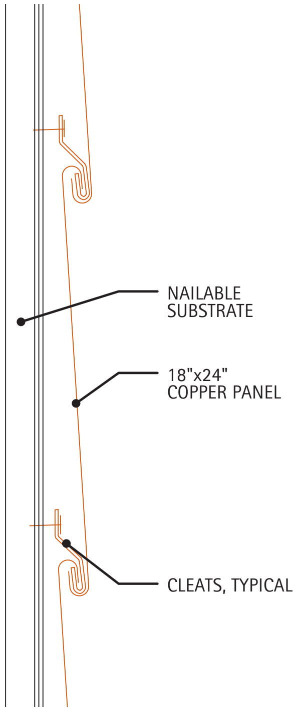
Cleats are fastened with two stainless steel screws per cleat.

Substrate: Continuous nailable substrate.

Fastening Method: Cleats screwed to substrate.

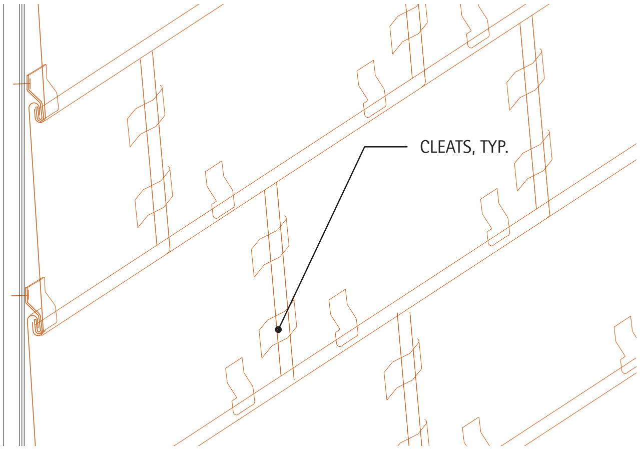
12.7A. Typical Section

This section shows the single lock seam and cleats used for both horizontal and vertical joints.



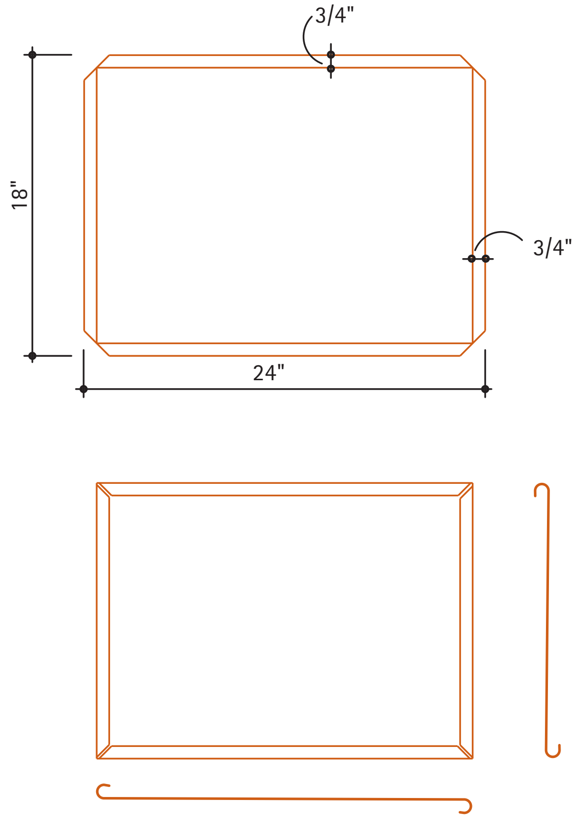
12.7B. Typical Axonometric

This detail shows that one side and the lower edge of each panel lock into adjacent panels. The other side and upper edge are held by two cleats each. Vertical joints are always staggered for weather resistance.



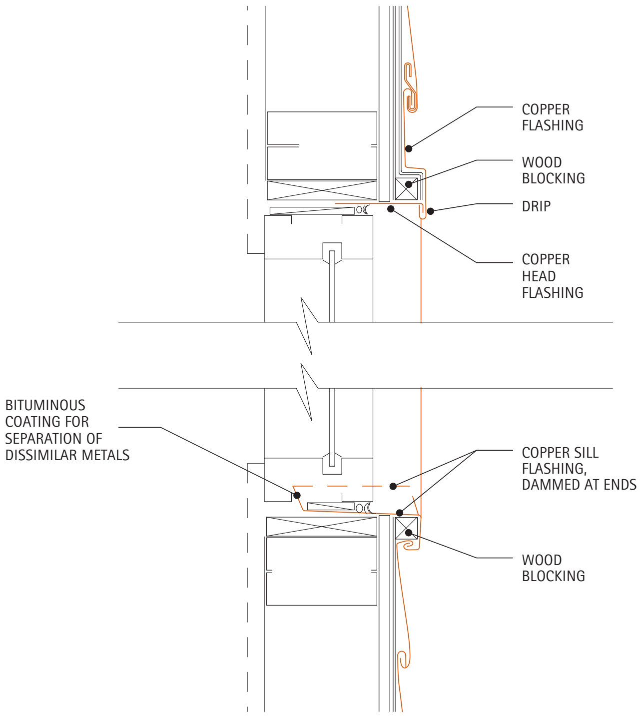
12.7C. Typical Copper Panel

These elevations show the typical panel, before and after the edges are folded.



12.7D. Typical Window Head and Sill

Wood blocking can be used at the head as shown. It provides a solid surface for attaching the copper head flashing and continuity around the window opening. The lower edge of the copper wall panels is locked into the head flashing to provide a drip.



At the sill, the wood blocking is covered with copper sill flashing which is locked into the upper edge of the copper wall panels. The ends of the sill flashing must be dammed to prevent water leaks into the wall cavity. If aluminum or other metal window frames are used, a bituminous coating or other isolating material must be applied to the sill flashing to prevent direct metal-to-metal contact.

For corner and base details, refer to **12.6. Diagonal Flat Lock Systems.**

12.8. Copper Clad Honeycomb Systems

Description: Copper clad honeycomb panels are engineered and fabricated by a variety of manufacturers. They are light weight, strong, and offer a very flat copper panel appearance. Total panel thickness is variable to suit project requirements.

The honeycomb material varies depending on manufacturer and whether it is an interior or exterior application. Copper is bonded to the front side of the honeycomb and a backer panel is bonded to the back side. The backer panel is required, to ensure the rigidity of the assembly, thereby minimizing warping. The backer panel is usually of a material compatible with the structural system.

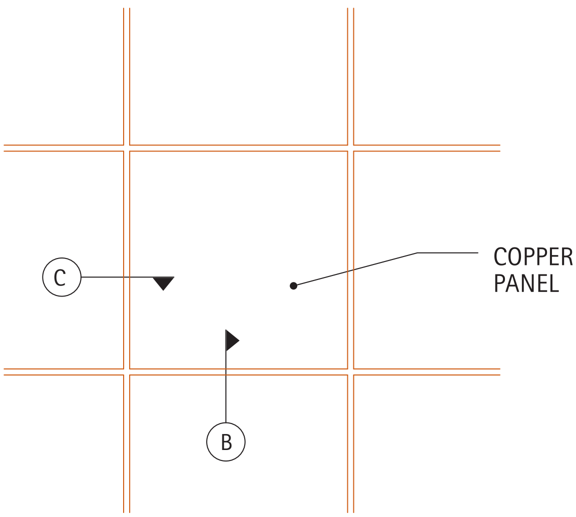
The details shown are generic, and do not represent a particular system. The details illustrate a system attached to a steel structure. With proper detailing, copper clad honeycomb panels can be installed on virtually any kind of structure or wall. For information on specific systems, contact the manufacturer.

Substrate: Any substrate or structure as required by the specific system manufacturer.

Fastening Method: Typically screws or bolts, as required by the specific system manufacturer.

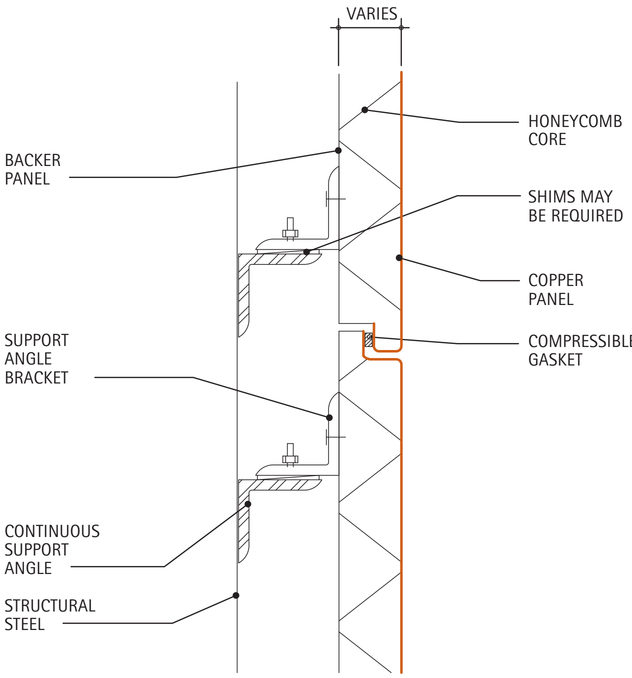
12.8A. Typical Elevation

This diagrammatic elevation indicates the locations of Sections B and C.



12.8B. Horizontal Joint Section

These panels are shaped to provide hidden surfaces for the compressible gaskets. The joint shape is designed to prevent water penetration.

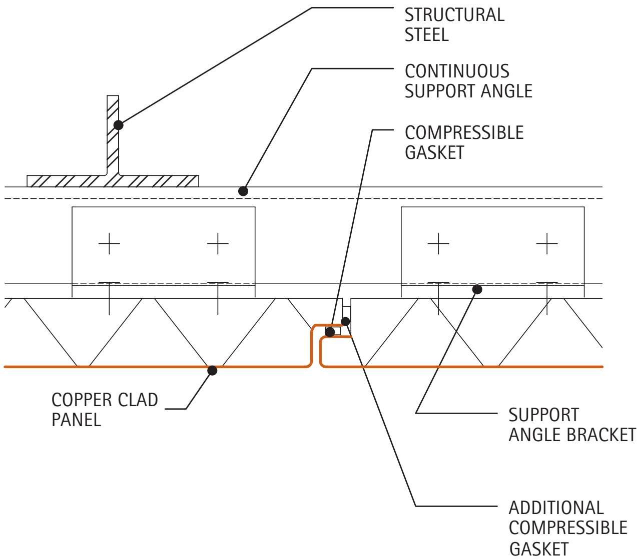


Separation of dissimilar metals is an important consideration in the design of copper clad honeycomb panels. Manufacturers have engineered a variety of solutions, depending on the honeycomb and backer panel material, and the method of attachment to the structure.

In the system shown, the backer panel is not copper. Separation is maintained between the copper cladding and the backer panel. Steel or aluminum support angle brackets are bolted to the backer panel. The support brackets are bolted to continuous support angles which are welded or bolted to the steel structure. Shims or other leveling devices may be required for proper panel alignment.

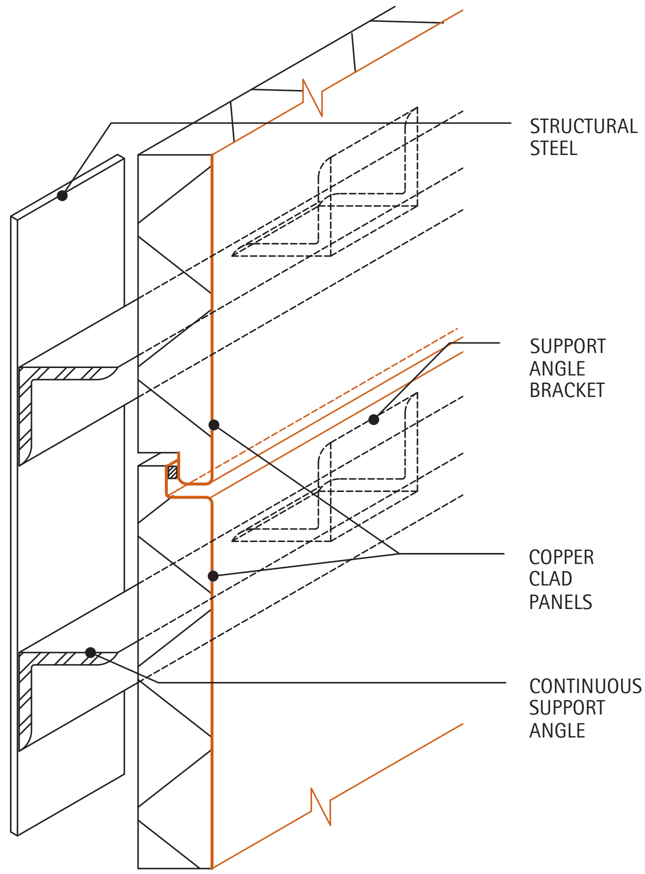
12.8C. Vertical Joint Section

The vertical joint is detailed the same as the horizontal joint, with an additional compressible gasket to reduce water penetration.



12.8D. Axonometric View

This view shows the relationship of the various parts. Note the use of structural support angles and alignment support angle brackets.



12.9. Copper Screen Panels

Description: Copper screen panels are part of a manufacturer's engineered system. The details shown here illustrate the main concepts in the design of copper screen panels. The system shown uses metal support brackets and channel tracks to carry the copper panels. The support brackets can be attached to virtually any kind of building structure.

The copper screen panels act as a lightweight, finish screen. The system shown is designed to be a water shedding rain screen. Alternatively, the panels can be perforated or have shaped openings acting as sun or decorative screens. The backup wall system should always be designed to be watertight.

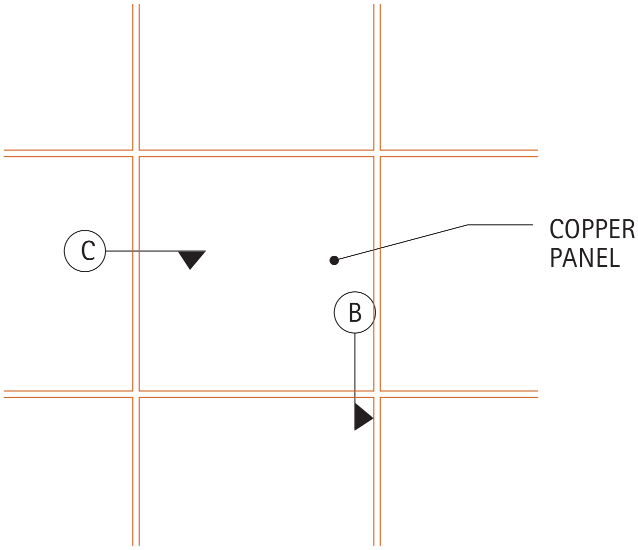
Isolator clips are used between the metal support system and the copper panels to separate dissimilar metals. The minimum gauge of the copper panels is dependent on the size of the panels and the design of the specific system used. Manufacturer's recommendations should be followed.

Substrate: Any substrate or structure as required by the specific system manufacturer.

Fastening Method: Typically screws or bolts, as required by the specific system manufacturer.

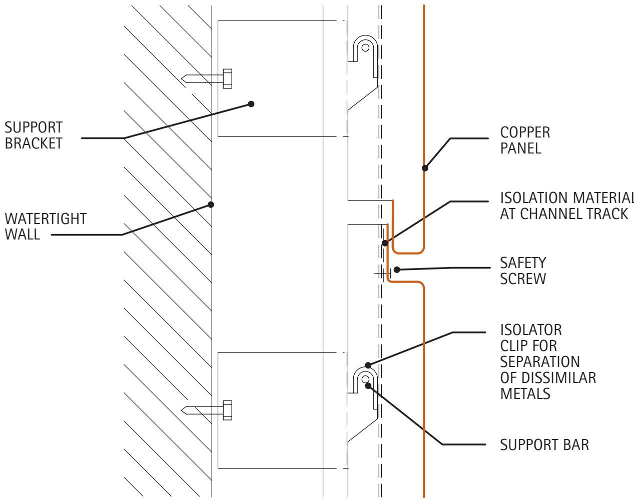
12.9A. Typical Elevation

This diagrammatic elevation indicates the locations of Sections B and C.



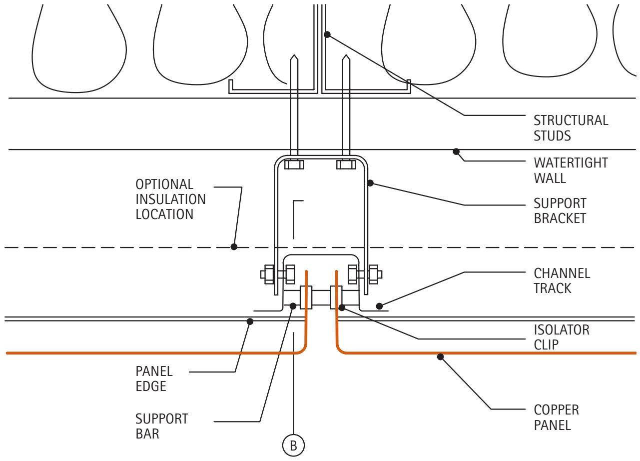
12.9B. Vertical Section - Horizontal Joint

This section is cut through the vertical channel track to show the support bar that carries the copper panels. This system uses one stainless steel screw per panel to ensure panels are not lifted by wind. Isolation tape or a bituminous coating must be applied where the back of the copper panel contacts the channel track, to separate dissimilar metals. In addition, isolation clips are used between the support bars and the copper panels.



12.9C. Horizontal Section - Vertical Joint

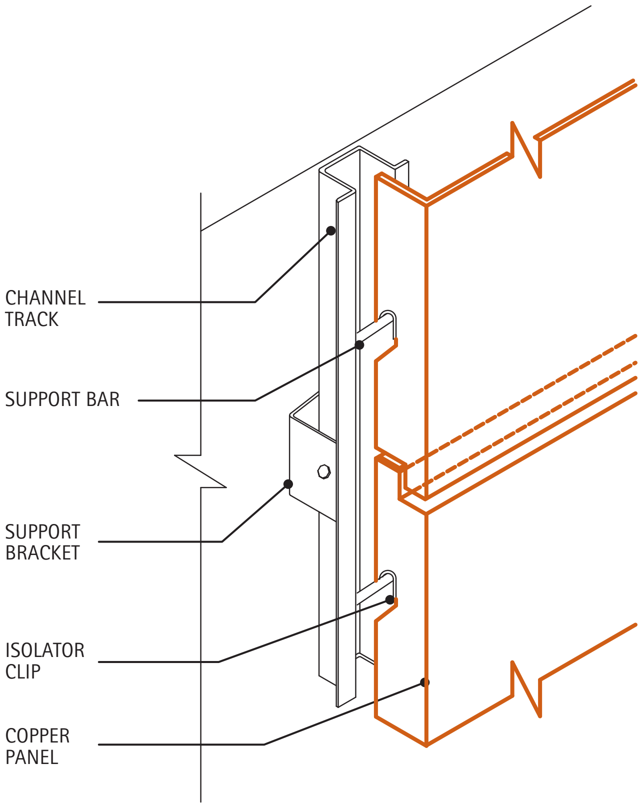
The support brackets are fastened to the structure. Channel tracks are bolted to the support brackets. The copper screen panels are hung onto the support bar in the channel track.



Although such a system does not necessarily have any insulation, insulation may be added within the cavity, as shown.

12.9D. Isometric View

This detail shows the relationship of the various parts. Once all the panels are in place, any water that passes between vertical joints is channeled down the channel track.



12.10. Curtain Wall Systems

Description: The details shown in this plate are from the Seagram Building in New York City, completed in 1957. They represent the methods used in the bronze and glass curtain wall system. The bronze mullions run the full height of the building. Brown-colored plate glass spans between the mullions, and 1/8" thick **Muntz Metal** spandrel panels are used at each floor slab. The result is a very uniform color among the exterior materials.

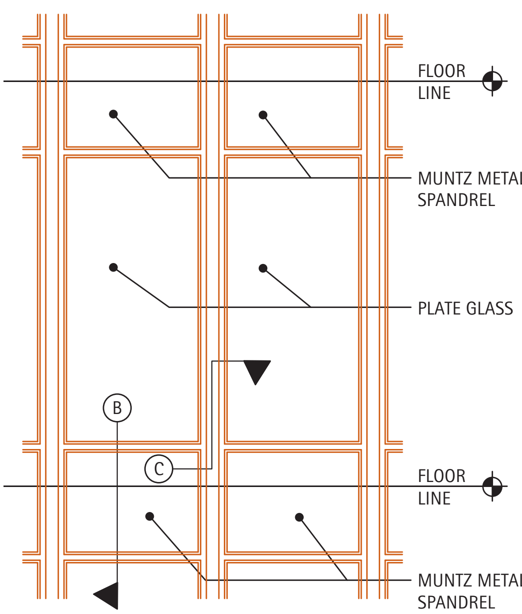
These details demonstrate the approach used to construct a copper alloy curtain wall in a historically significant building. Today's standards would require a higher level of moisture and thermal control. Modern construction methods and materials would certainly improve the moisture and thermal control of the exterior skin.

Substrate: This system supports itself from floor slab to floor slab. No substrate is required.

Fastening Method: Steel brackets are used at every floor slab.

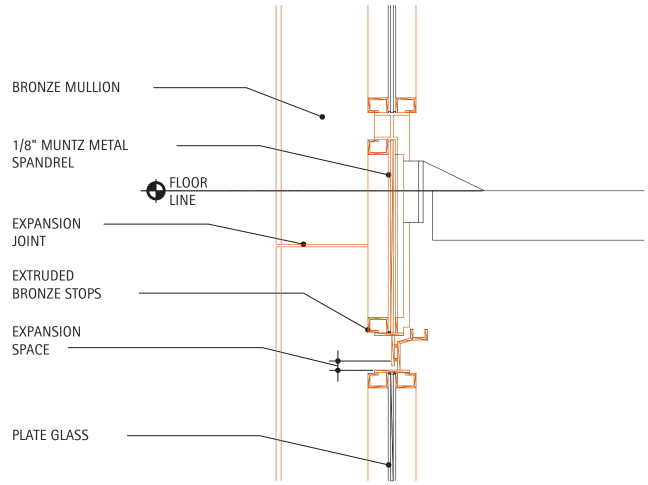
12.10A. Typical Elevation

This diagrammatic elevation shows the relationship of the various curtain wall components to the floor slabs, and indicates the locations of Sections 12.10B and 12.10C.



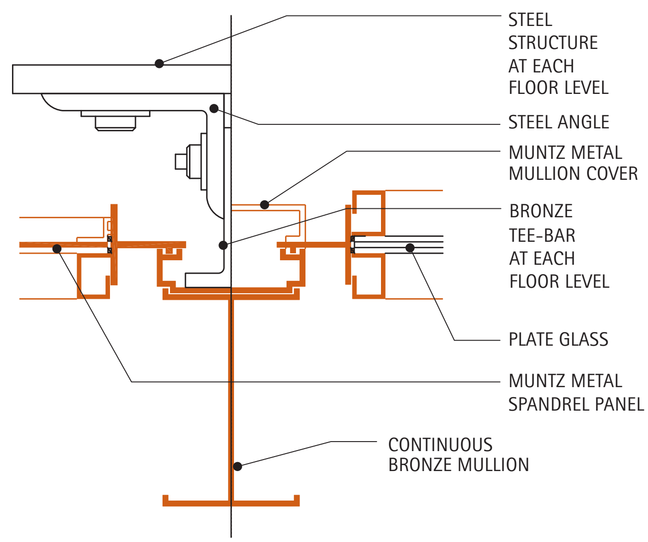
12.10B. Section At Horizontal Joint

The muntz metal spandrel panels are used to conceal the floor slab and spandrel beam at each floor. **Expansion Seams** in the bronze mullions are required to accommodate vertical movement.



12.10C. Section At Vertical Joint

This section shows two different conditions. The left side is cut through the spandrel panel. The steel structure is used to support the curtain wall at every floor slab. The bronze Tee-bar is bolted to the steel angles. The Tee-bar is plug welded to the continuous bronze mullions.

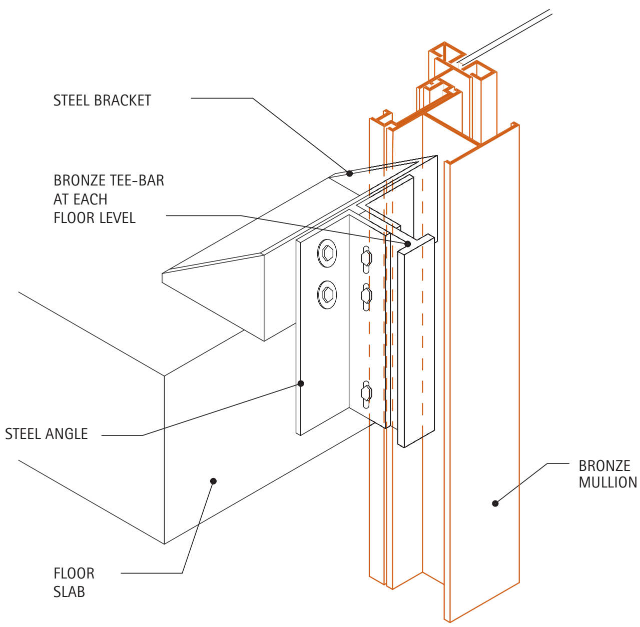


The right side of the detail shows the condition at the window. A muntz metal panel is used to cover the inside face of the curtain wall.

In both cases, the spandrel panels and glass are held by extruded bronze frames.

12.10D. Isometric View

This detail shows how the structural steel bracket and angles hold the bronze Tee-bar, and their relationship to the bronze mullion.



13. DOMES, SPIRES AND VAULTS

Introduction

Domes, spires, and vaults are designed in a wide variety of shapes. They are not limited to simple geometry, such as circular domes and conical spires. Complex curved surfaces and multi-faceted designs can easily be formed in copper. The concepts shown in this section, can be adapted to any of these situations.

The details shown in this section are based on the principles of standing seam, batten seam, flat seam, and diagonal flat seam roofing. When detailing a dome, spire, or vault, the substrate, underlayment, fastening, and seam design recommendations given in the **8. Roofing Systems** section generally apply. The designer should also consider the effects of variations in slope. For example, a transverse seam detail near the base of a dome (which is at a high pitch) is not recommended for the top of the dome (where the pitch is low).

Special attention should be given to the areas where domes and spires intersect adjoining roof surfaces. The resulting valleys require details to prevent "back-up" of water, especially in cold climates prone to ice and snow.

The proper ventilation of the underside of domes, spires, and barrel vaults is particularly important. The location of vents at the bases of cupolas and at the caps terminating domes and spires must be addressed.

The location and design of vents is dependent on project location, climate, and use. The designer is urged to address these issues on a project-by-project basis.

For both simple and complex shapes, it is usually easier to lay out the roofing pans and panels directly on the dome than it is to develop them from drawings. The pans or panels can be field or shop fabricated, but the dimensions should be generated and dictated by the size and shape of the dome.

Equipment Available:

Special equipment is available to form copper into curved shapes. Such equipment is particularly useful in fabricating spherical copper caps and for “stretching” portions of copper flashing to accommodate curved surfaces.

13.1. Circular Dome with Diagonal Flat Seam System

Description: The details show a circular dome capped with a ventilated copper cap. The cap is designed to allow for air to flow out of the dome, while preventing any water, from entering. The cap must also be designed to withstand local wind loads.

On the low-pitch areas near the top of the dome, the seams must be soldered to ensure water- tightness. As the pitch of the dome increases, sealant may be used in the seams. Near the base of the dome, where the pitch exceeds 6" per foot, no solder or sealant is required. See **8.1. Special Roofing Design and Installation Considerations** for more information.

At the base, the copper panels are usually 8 to 12 inches square. The practical panel sizes that can be efficiently fabricated and installed are 4 to 6 inches minimum and 16 to 18 inches square, maximum. There are a constant number of panels around the perimeter of the dome. They diminish in size as they get closer to the top.

Diagonal flat lock panels are particularly well- suited for covering irregular curved surfaces.

A cornice is shown at the base of the dome. A built-in copper gutter can be used, to control run-off as shown in **Detail 13.1E**. A copper cap, like the one shown in **Detail 13.2A**, can be used at the top as an alternative.

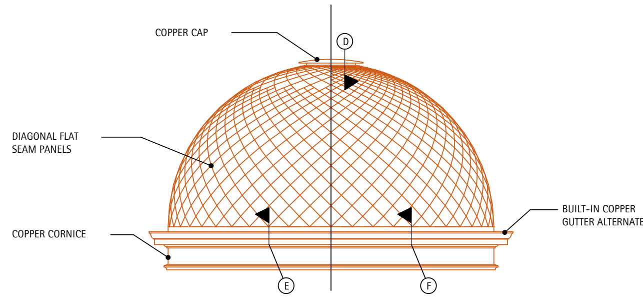
The minimum recommended weight for the panels is 16 ounce copper.

Substrate: Continuous nailable substrate.

Fastening Method: **Cleats**

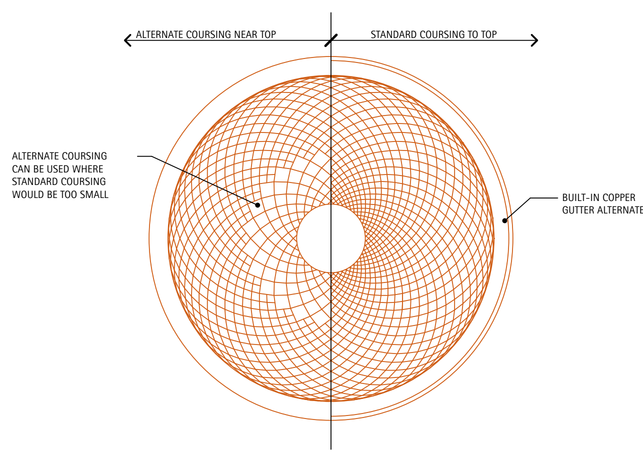
13.1A. Elevation

This detail shows the continuous panel seam that runs from cornice to cap, and the spiral effect of the diagonal copper panels on a circular dome.



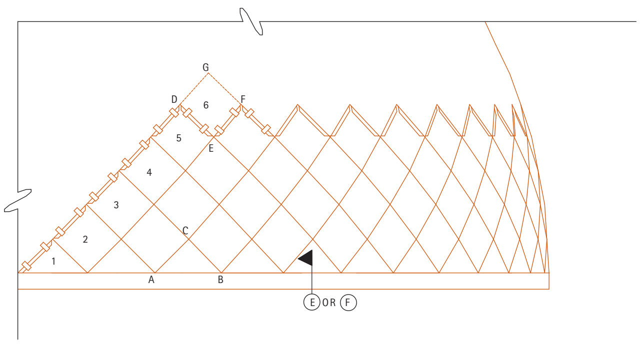
13.1B. Plan

The diminishing size of the copper panels is clearly visible. When designing this type of dome, consideration should be given to the size of the panels, as they can get very small. If their size becomes too small to construct, panel sizes can be modified by deleting every other seam and doubling the resulting panel size, as shown in the left half of the detail.



13.1C. Partial Elevation

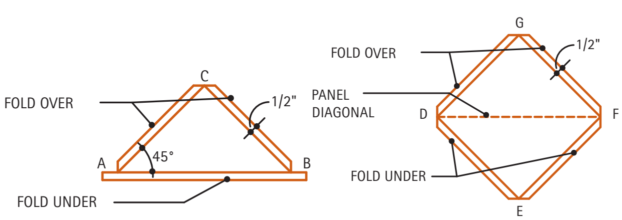
This elevation shows a typical panel layout on the dome. First, determine the number of full panels required to circle the dome based upon its size and the desired appearance of the cladding. Determine the diagonal (AB) of the first course by subdividing the dome perimeter into equal divisions. Form the half panel starter course with the required folded seams and attach to dome with cleats and fasteners.



The length of the diagonal of the next course can now be measured directly from the upper points of the previous course.

13.1D. Patterns

Pattern for Course 1 The first course is a half panel as shown. The flange along the bottom is folded under to lock into the base flashing below, as shown in **Detail 13.1E**.



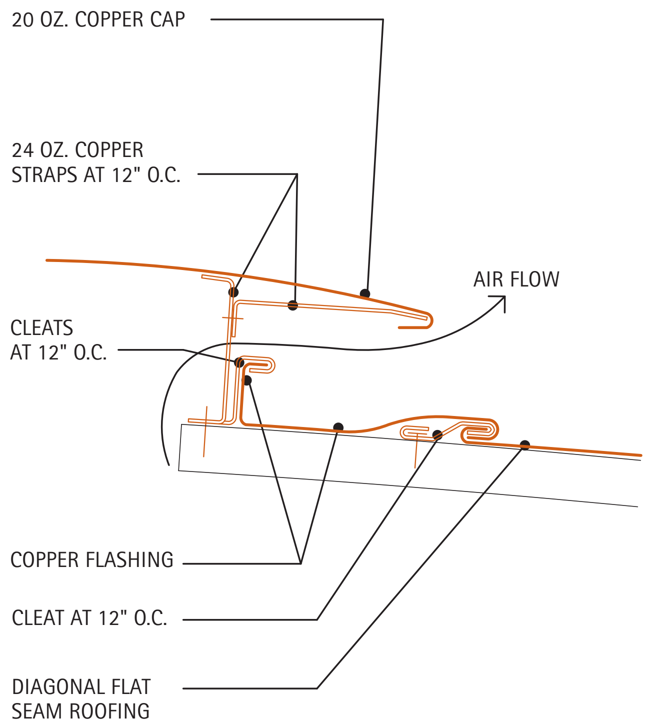
PATTERN FOR COURSE 1

PATTERN FOR COURSE 6

Pattern for Course 6 The dimension DF is determined after the panels for course 5 are laid out.

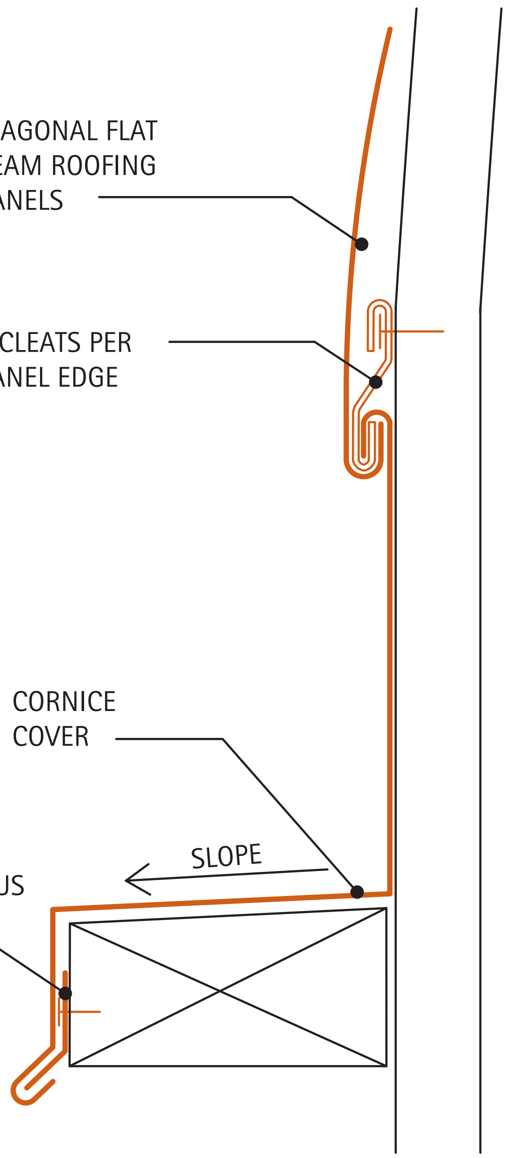
13.1E. Section at Cap – Venting

The cap shown is made of 20 oz. copper. Its design allows for air to flow out from the top of the dome. If venting is not desired, a non-venting cap may be used, see Detail E on Plate 4.7.4. The cap is support by 24 oz. copper straps secured to the dome, and spaced at 12" on center, or closer as needed to meet structural requirements. The upper edge of the diagonal flat seam roofing panels are cleated to the dome. Copper flashing, formed to follow the opening in the dome, is locked into the upper edge of the roofing. The inside edge of this flashing is fastened with cleats to the deck. Special equipment may be required to stretch the copper into the proper shape.



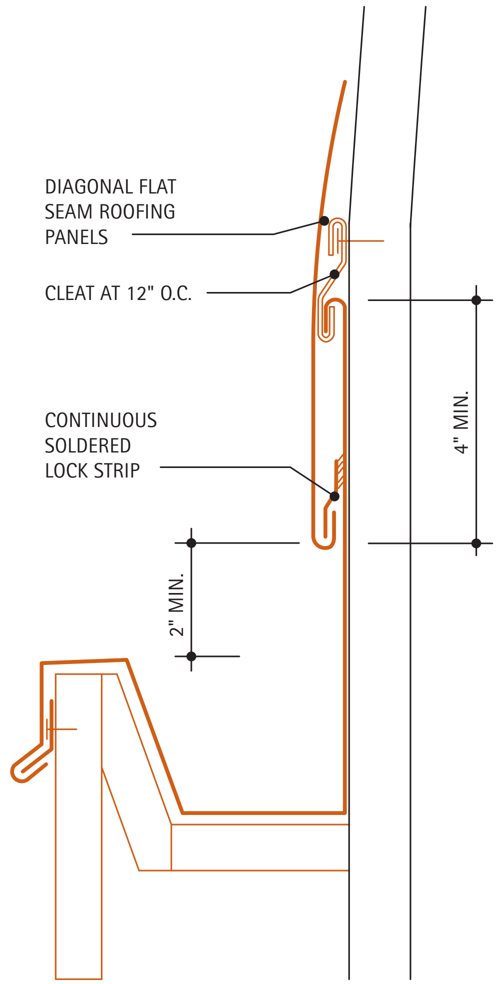
13.1F. Section at Cornice

This detail is used to transition from the dome to a cornice condition. The cornice cover is turned up, hooked under the first course of the dome panels, and fastened with cleats.



13.1G. Section at Gutter

This detail can be used to transition from the dome to a **built-in gutter**. The gutter liner is fastened with cleats at 12" o.c. and is overlapped 4" by the dome panels. A lock strip is soldered to the gutter liner and engages the first course of the dome panels.



For Additional Information:

- **8. Roofing Systems**, for general information on roofing system requirements.
- **9. Flashings and Copings**, under the appropriate sections for flashing details.
- **10. Gutters and Downspouts**, for gutter flashing details.
- **12.6. Diagonal Flat Lock Systems**, for variations of diagonal flat lock panels.

13.2. Circular Dome with Standing Seam System

Description: Copper standing seam panels can readily be applied to domes. The basic principles of standing seam roofing apply, see **8.2. Standing Seam Roofing**. The differences are that the pans are elliptical and the seams are curved to fit the shape of the dome. See **13.8. Steps for Dome Panel Layout**.

The standing seams converge throughout their run from the base to the crown of the dome. At the crown, the seams are laid flat and terminate at a spun copper cap. See **Detail 8.2B** for similar condition. For seams converging to less than 6" spacing, alternate panels can be deleted and replaced with larger panels in order to facilitate installation, as shown in the left side of **Detail 13.2B**.

The transverse seams are staggered on adjacent pans. Since the pitch of the dome varies from the top to the bottom of the dome, different transverse seam details must be used at different locations. Where the pitch is below 6" per foot, a "low pitch" design must be used, as shown in **Detail 13.2C**. Where the pitch exceeds 6" per foot, the "high pitch" detail, shown in **Detail 13.2D**, can be used. See **8.1. Special Roofing Design and Installation Considerations** for special slope detail requirements.

Substrate: Continuous nailable substrate.

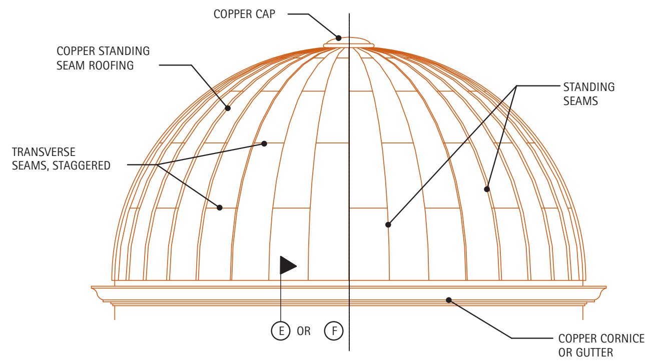
Fastening Method: **Cleats**. The spacing of cleats should be at approximately 12" o.c. along the radial seams. For domes approaching 6 feet in diameter, cleat spacing should be approximately 4" o.c.

The minimum recommended weight for standing seam pans is 16 ounce cold rolled copper.

The minimum practical diameter for a 3/4" high standing seam dome is 6 feet. For smaller domes, soft temper copper should be specified.

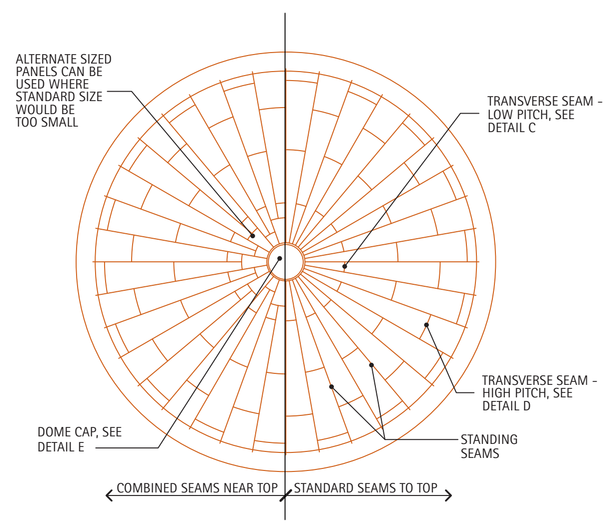
13.2A. Elevation

This detail illustrates staggered transverse seams. A spun copper cap is used to flash and terminate the top of the dome. A cupola or a similar ornamental termination is also suitable.



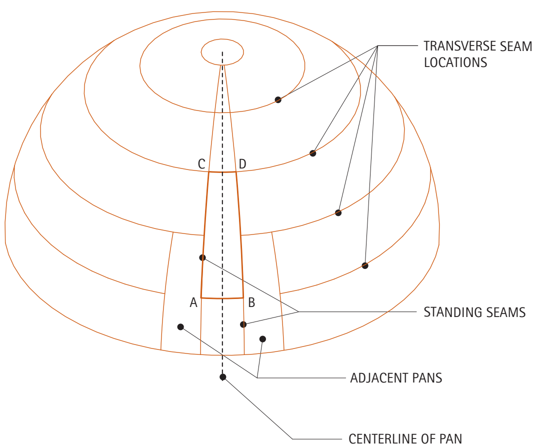
13.2B. Plan

The converging pattern of standing seams is shown. The cap should be sized such that the seams are not less than 6" apart where they terminate at the perimeter of the cap.



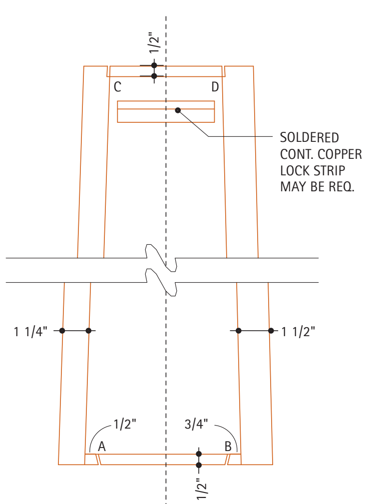
13.2C. Layout of Pattern

The number of pans required to complete the dome depends upon its size and the seam spacing chosen. Standing seam roofing pans typically finish 12" to 18" wide. Once the number of pans is determined, lines can be drawn on the dome to locate both the standing seams and the transverse seams. The size of each pan can then be measured directly on the dome. For example, the points ABCD correspond to the corners of a pan.



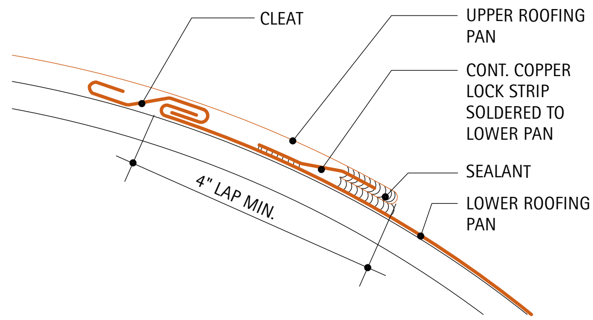
13.2D. Pan Layout

The pans outlined in Detail A can be field or shop fabricated. For a one-inch standing seam, the long sides of the pans are cut to the dimensions shown and turned up. At the upper end of the pan, the copper is folded over. A continuous copper lock strip is soldered to the pan for low pitch transverse seams. This strip is not required for steep pitch seams. The bottom edge of the pan is folded under. See **13.8. Steps for Dome Panel Layout**. Panel blanks are roughly elliptical in shape.



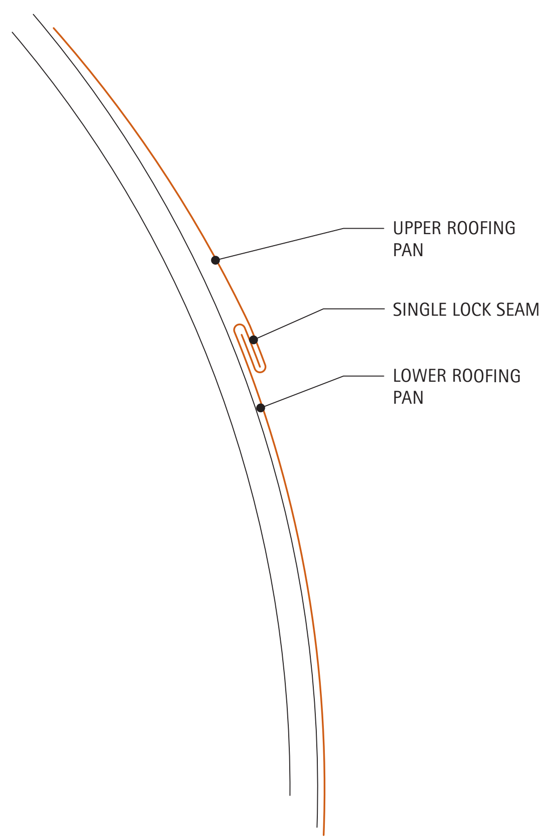
13.2E. Transverse Seam – Low Pitch

This seam is used where the roof pitch is less than 6" but greater than 3" per foot, to reduce the chance of water penetration. The cleat shown is used to help position and hold the pan during installation and to resist wind uplift.



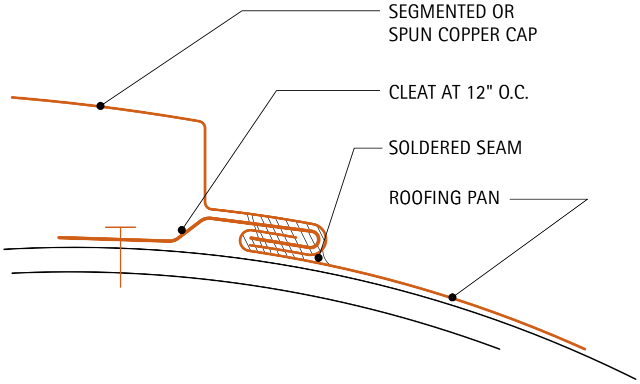
13.2F. Transverse Seam – High Pitch

This loose lock seam is used where the roof pitch is 6" per foot or greater. It should not be used near the dome apex, where water, snow, or ice can accumulate due to the shallow dome pitch. The high pitch transverse seam is identical to **Detail 8.2C** Detail 2.



13.2G. Dome Cap Detail – Non Venting

Dome cap flashing can be achieved in a wide variety of ways, including segmented or spun copper caps, finials, or spires. The detail shows a copper cap that is locked and soldered into the upper edge of the roofing pans. Cleats are used to fasten the copper pan to the dome substrate. This detail may be used where a vent is not desired at the top of the dome. If venting is desired, a vented cap may be used, see **Detail 13.1D**.



For Additional Information:

- **8. Roofing Systems**, for general information on roofing system requirements.
- **8.2. Standing Seam Roofing**, for information on standing seam roofing.
- **9. Flashings and Copings**, under the appropriate sections for flashing details.

Equipment Available: Special tools are available to stretch the standing seams onto curved surfaces.

13.3. Circular Dome with Flat Seam System

Description: Flat seam roofing is very well-suited for use on domes and other more complex shapes. The dome panels are based on the 18"x 24" flat seam system design concepts. On the low-pitch areas near the top of the dome, the seams must be soldered to ensure watertightness. As the pitch of the dome increases, sealant may be used in the seams. Near the base of the dome, where the pitch exceeds 6" per foot, no solder or sealant is required. See **8.1. Special Roofing Design and Installation Considerations**, for more information. For information on cornice and gutter treatments, see **13.1. Circular Dome with Diagonal Flat Seam System**.

Battens or ribs are used with flat seam roofing for decorative or functional reasons. If fully soldered seams are used, expansion battens,ribs, or seams must be used to allow for expansion and contraction. Battens can be made watertight, as shown in **Detail 13.7A**, for use where water, snow, or ice can build-up. In other areas, the batten and rib designs shown in **Detail 13.3C and Detail 13.3D** can be used.

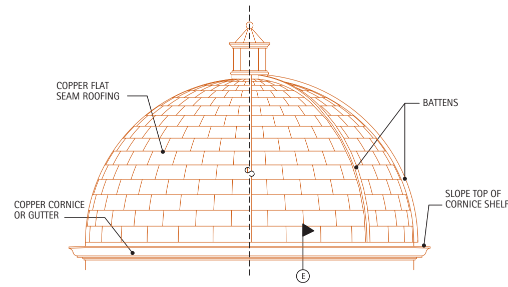
The minimum recommended weight for the flat seam panels is 20 ounce copper.

Substrate: Continuous nailable substrate.

Fastening Method: **Cleats**.

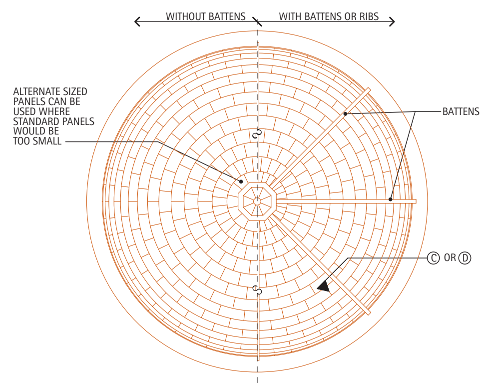
13.3A. Elevation

The elevation shows flat seam roofing with and without battens, on a circular dome. The battens or ribs can be purely for aesthetic purposes, and they can have a wide variety of shapes and sizes. The detail shows a decorative cupola at the top of the dome. If desired, a flat, copper cap can be formed to provide a very low profile at the top. The cap should be locked and soldered to adjacent flat seam roofing panels.



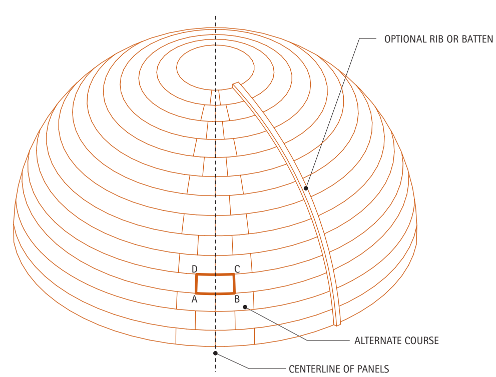
13.3B. Plan

The detail shows the overall layout of the flat seam dome. Note that the panels decrease in size as they converge towards the dome apex. Alternate panels can be deleted and replaced with larger panels in order to facilitate installation.



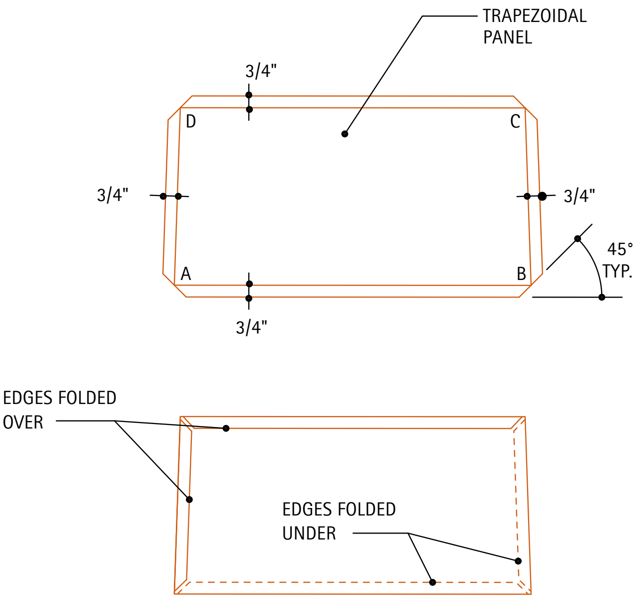
13.3C. Dome

The flat seam panels are laid out from the base of the dome to its apex. Once the number of panels for the first course has been determined, the panels can be cut, formed, and cleated to the dome. Unlike some other roofing patterns, the number and size of panels for each course can vary, as long as the transverse seams are staggered on adjacent courses.



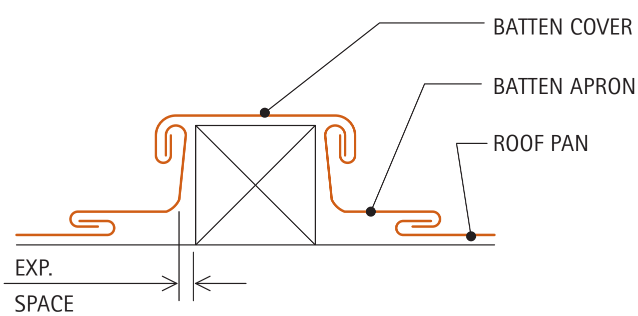
13.3D. Typical Panel

The panels are trapezoidal to fit the dome's curved surface. The upper edge and one side are folded over; the lower edge and second side are folded under. A minimum of 3/4" fold is required to ensure interlocking of adjacent panels.



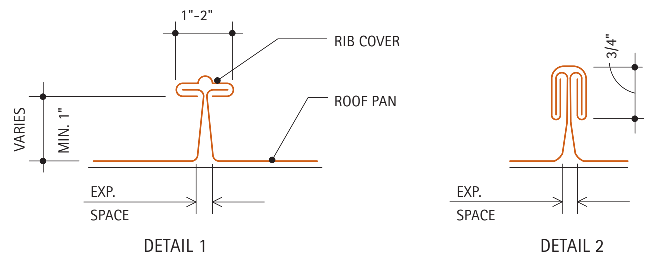
13.3E. Typical Batten

Where battens are used, a wide range of sizes and shapes can be designed. This detail shows a typical batten. An important consideration is space for expansion, which can be accommodated as shown, or by tapering the battens as shown in the **8.3. Batten Seam Roofing**.



13.3F. Alternate Ribs

These designs provide the space for expansion.



Detail 1 is recommended for warm climates with low wind conditions. **Detail 2** is recommended in climates with high winds, or ice or snow accumulations. In both cases, the ribs should be filled with sealant for slopes less than 6 inches per foot.

For Additional Information:

- **8. Roofing Systems**, for general information on roofing system requirements.
- **8.5. Flat Seam Roofing**, for information on flat seam roofing.
- **8.1. Special Roofing Design and Installation Considerations**, for information on solder and sealant requirements.
- **9. Flashings and Copings**, under the appropriate sections for flashing details.
- **Table 8.1C**, for soldering and minimum slope requirements.

13.4. Standing Seam Roof on Conical Spire

Description: The details show a conical spire clad with copper standing seam roofing. Spires usually have long seam runs (see **Detail 13.4C**). However, due to the difficulty of handing long pans on steep slopes, the pans are typically constructed using shorter lengths.

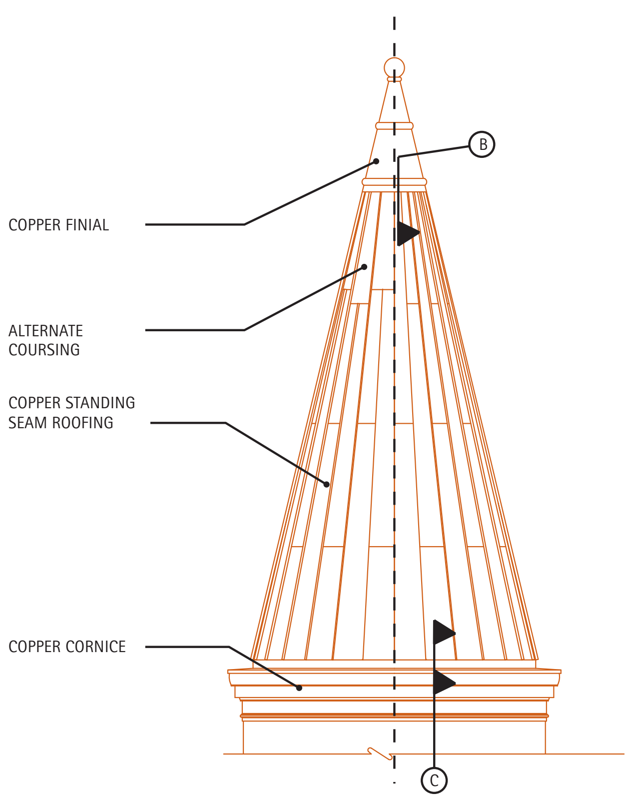
The minimum recommended weight for standing seam spire roofing is 16-ounce copper.

Substrate: Continuous nailable substrate.

Fastening Method: **Cleats**.

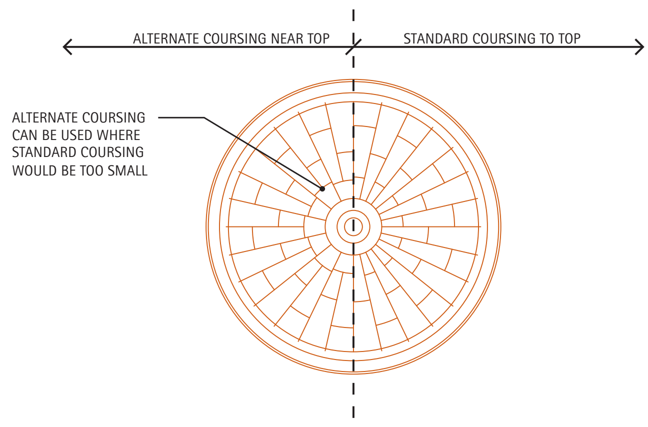
13.4A. Elevation

This detail shows the "short". pans of copper standing seam roofing, with transverse seam joining successive pans. A finial is used to cap the top of the spire. Alternate coursing of the pans may be used near the top, to simplify construction. See the plan on **Detail 13.4B**.



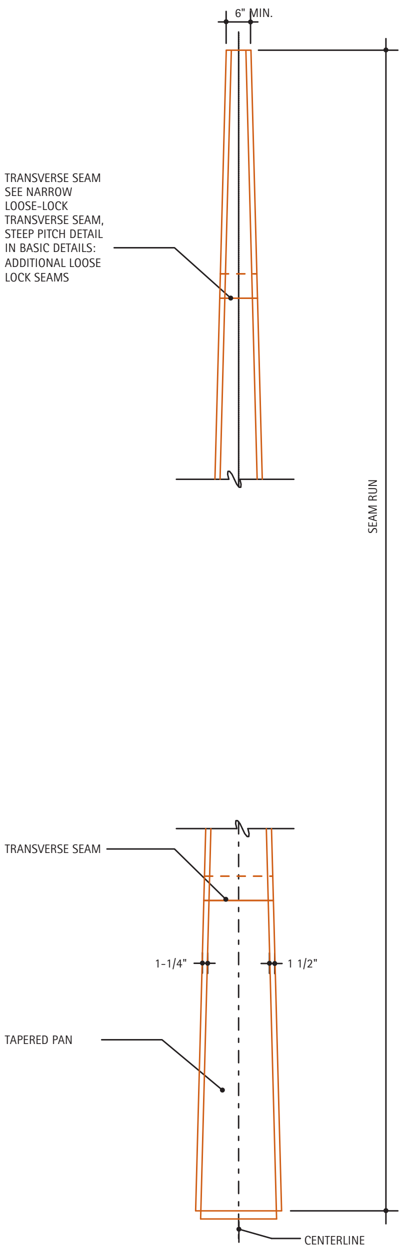
13.4B. Plan

This detail shows the 28 pans used on this particular spire. The number of pans depends on the diameter and height of the spire and on the desired seam spacing Since the pans taper towards the spire apex, special attention is required to limit the seam spacing to 6" or more. For seams converging to less than 6" spacing, alternate panels can be deleted and replaced with larger panels in order to facilitate installation, as shown in the left side of **Details 13.4A** and **13.4B**. The copper finial should be sized such that the standing seams are not less than 6" apart where they terminate at the perimeter of the finial.



13.4C. Pattern Layout

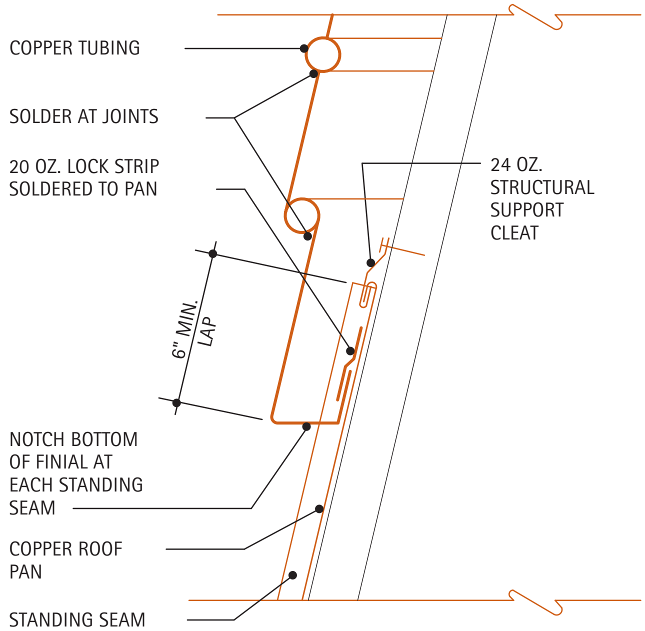
The detail shows the layout of a single seam run. Note the tapered shape of the pan. The minimum pan width is 6". If the standard seam layout would result in narrower pans, then alternate pan coursing should be used, see **Detail 13.4A** and **Detail 13.4B**.



In order to minimize thermal movement, the maximum length of a single pan is 10 feet. The sides of the pan are turned up to form the standing seam. At the base, the roofing pan is turned down to form a lock.

13.4D. Section

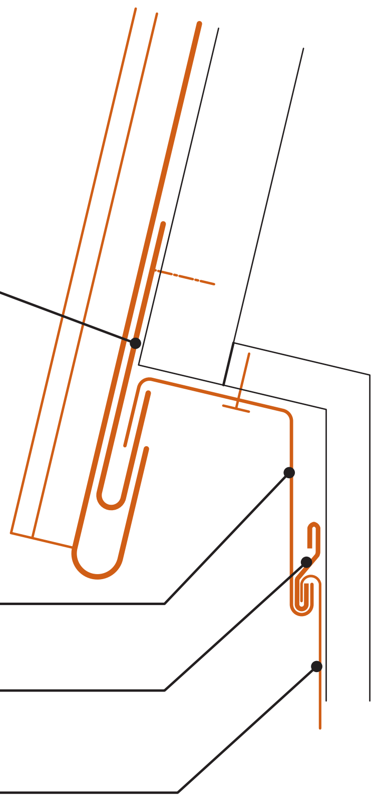
This detail shows the transition between the copper finial and the copper standing seam roofing. The finial can be fabricated out of decorative elements, such as the copper tubing shown.



The roofing pans extend at least 6" under the finial. Copper lock strips are soldered to each pan and engage the lower edge of the finial. Notches must be cut into the bottom of the finial to accommodate each standing seam. Due to the steep slopes on most spires, the pans may, during construction, be suspended from cleats at their upper edge. Such cleats should therefore be designed as structural support elements and their size, weight, spacing, and fastening determined by a structural engineer.

13.4E. Section

A continuous copper lock strip is nailed to the lower edge of the spire at 3" o.c. The copper roofing pans and cornice closure strip are locked onto this strip. A copper cornice is used at the base of the spire.



For Additional Information:

- 8. Roofing Systems, for general information on roofing system requirements.
- 8.2. Standing Seam Roofing, for information on standing seam roofing.
- 9. Flashings and Copings, under the appropriate sections for flashing details.

13.5. Flat Seam Roofing on Octagonal Spire

Description: Flat seam roofing is used on all the segments of the spire. Battens are used between segments. A copper finial flashes and tops the spire.

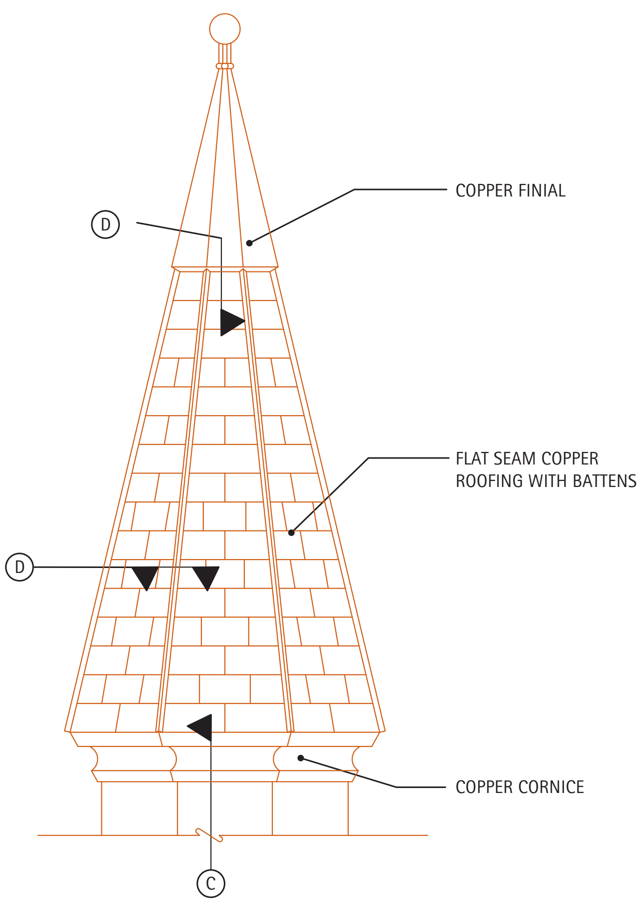
The minimum recommended weight for the panels is 20-ounce copper.

Substrate: Continuous nailable substrate.

Fastening Method: cleats.

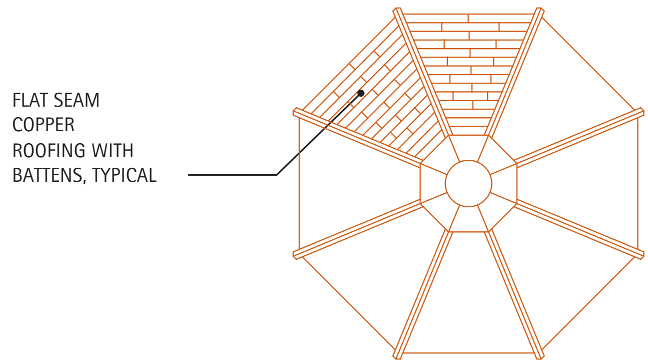
13.5A. Elevation

The copper finial can be simple or decorated. It is constructed similar to Detail 13.4B. The flat seam panels are designed similar to flat seam roofing. The size of the panels is determined by the size of the spire segments.



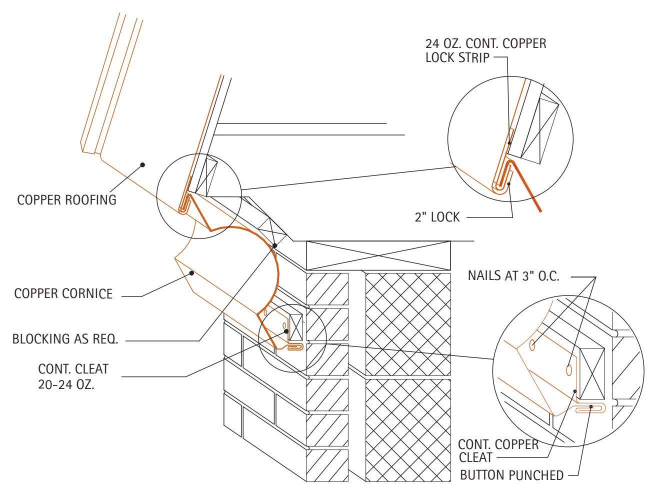
13.5B. Plan

An octagonal spire is shown, but practically any number of segments can be used to form a spire. Each segment is separated from adjacent segments by battens.



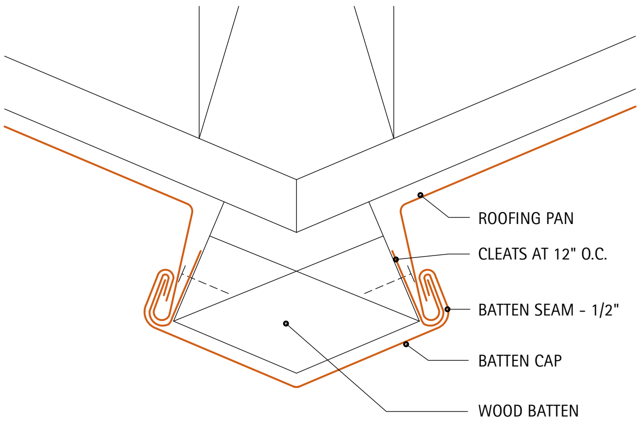
13.5C. Section at Cornice

The upper edge of the cornice is locked into a 24 oz. copper lock strip with a 2" leading edge fold. The bottom edges of the roofing panels are folded and locked around the lock strip. The bottom edge of the cornice is supported by wood blocking and a continuous 20 to 24 oz. cleat.



13.5D. Batten Detail

The battens are shaped to accommodate the change in angle between segments. The outer face of the battens and the caps can have virtually any profile. The batten cap is double locked into the roof panel and cleats.



For Additional Information:

- **8. Roofing Systems**, for general information on roofing system requirements.
- **8.5. Flat Seam Roofing**, for information on flat seam roofing.
- **8.3. Batten Seam Roofing**, for information on batten seam roofing.
- **9. Flashings and Copings**, under the appropriate sections for flashing details.

13.6. Arched Barrel Vault with Standing Seam

Description: Copper standing seam roofing can be readily applied to barrel vaults, by following a number of guidelines. The guidelines, described in **Detail 13.6B** below, address issues of expansion and contraction, and watertightness. The basic details are the same as those for regular standing seam roofing, see **8.2. Standing Seam Roofing**.

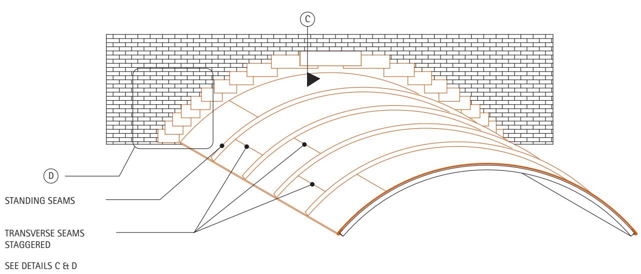
The minimum recommended weight for standing seam roofing is 16-ounce copper.

Substrate: Continuous nailable substrate.

Fastening Method: **cleats**.

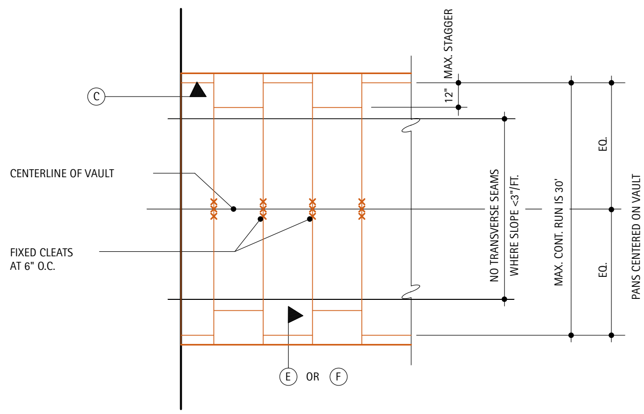
13.6A. Axonometric of Barrel Vault

This detail shows an overall view of a barrel vault that abuts a brick wall. The key elements of the copper roof are indicated - the standing seams and staggered transverse seams. Also illustrated is the stepped flashing used at the wall.



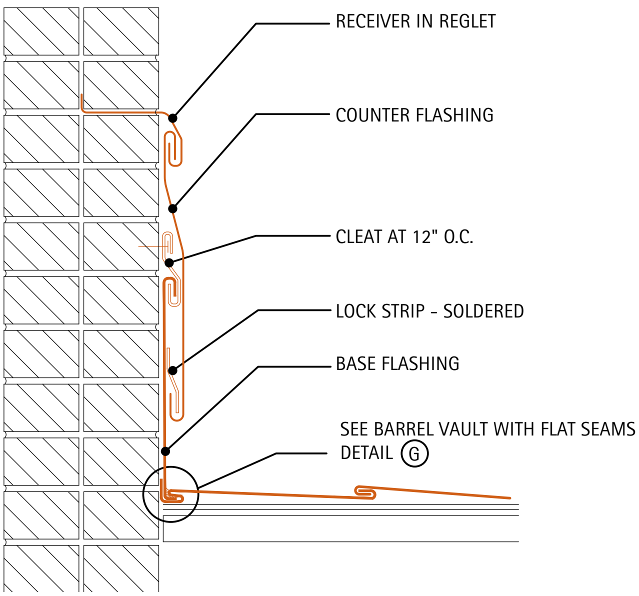
13.6B. Plan

This detail addresses a number of issues critical to achieving a durable, functional, and good looking standing seam roof on a barrel vault. Lay out the roofing pans so that the pattern is centered on the centerline on the vault. Do not locate transverse seams in areas where the pitch of the vault is less than 3 inches per foot. Fill the standing seams in those areas of the vault where the pitch is less than 3 inches per foot with sealant. Stagger transverse seams in adjacent runs. Use fixed cleats to anchor the roofing pans at mid-length at the centerline of the vault. Use expansion cleats to facilitate thermal movement from this mid-length point of anchorage to the end of each run. The maximum pan run should be maintained at approximately 30 feet, see **8.8. Long Pan Systems** for more information.



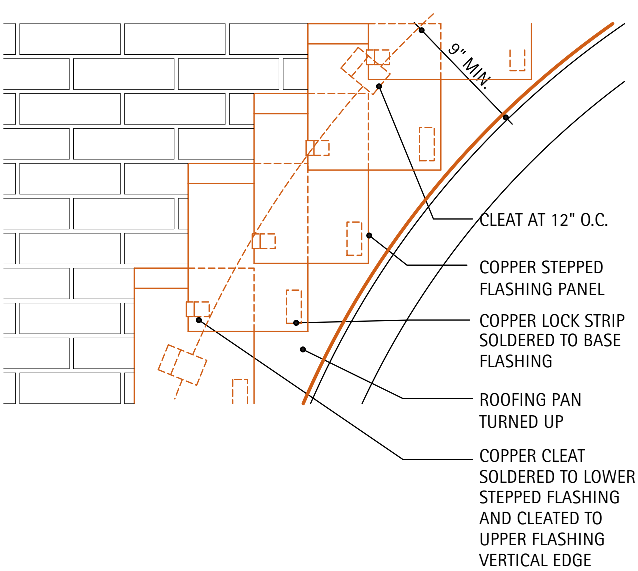
13.6C. Section at Wall

The copper roofing pan and copper base flashing are formed as shown in **Detail 13.6E**. The base flashing extends a minimum of 9" up the wall, where it is held by cleats, spaced a maximum of 12". In brick or other unit masonry walls, stepped counter flashing can be used. The counter flashing is held by a copper receiver laid into the wall, as shown.



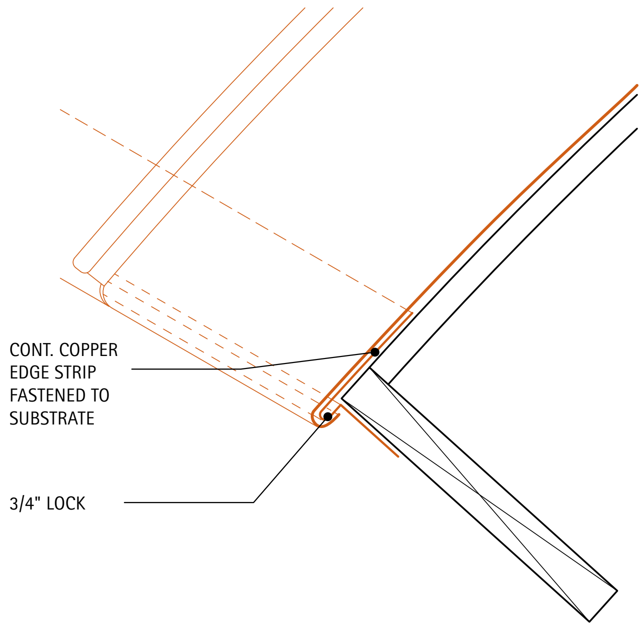
13.6D. Elevation at Wall

This detail shows a close-up of the stepped flashing method used on unit masonry walls.



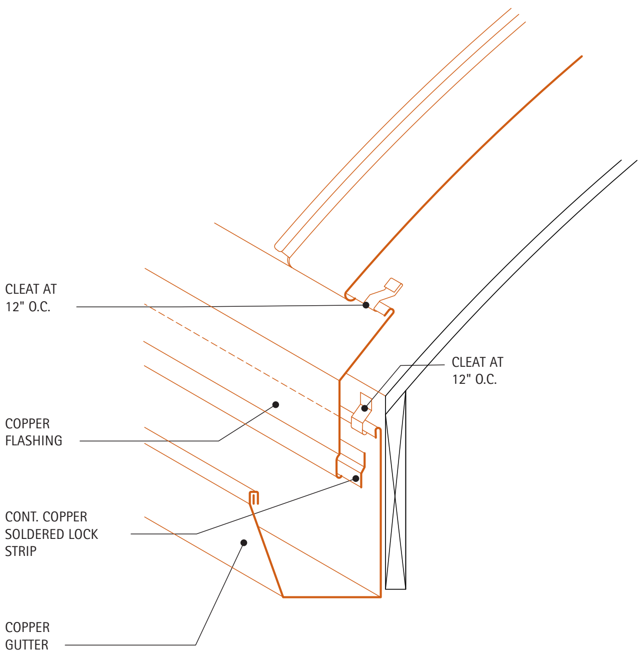
13.6E. Section at Eave

If the roofing pans are longer than 10 feet, then long pan roofing details must be used to accommodate expansion and contraction, see **8.8. Long Pan Systems**.



13.6F. Section

This detail shows one method of incorporating a gutter at the base of a vault. The basic principles of gutter design are described in the **10. Gutters and Downspouts** section. The copper roofing pans are terminated a few inches above the upper edge of the gutter. Copper flashing is used between the pans and the gutter. The flashing is held at its upper edge by cleats, where it locks into the roofing pans. The bottom edge of the flashing is locked onto a continuous copper lock strip, which is soldered to the gutter. This method permits replacement or repair of the various components with minimal disturbance to other components.



For Additional Information:

- **8. Roofing Systems**, for general information on roofing system requirements.
- **8.2. Standing Seam Roofing**, for information on standing seam roofing.
- **8.8. Long Pan Systems**, for information on long pan details.
- **9. Flashings and Copings**, under the appropriate sections for flashing details.

Equipment Available: Special tools are available to stretch the standing seams and the wall flashing over the barrel vault.

13.7. Barrel Vault With Flat Seam

Description: Copper flat seam roofing is an excellent material for covering barrel vaults. Flat seam roofing can be made watertight, where required, see **8.1. Special Roofing Design and Installation Considerations**.

At their crowns, vaults are essentially flat; soldered seams are used in this area and for some distance down each side of the vault. Expansion battens are used to divide the length of the vault into areas not to exceed 30 feet in order to accommodate thermal movement.

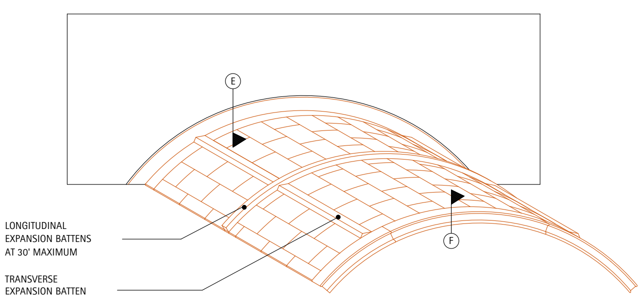
The minimum recommended weight for flat seam roofing is 20-ounce copper.

Substrate: Continuous nailable substrate.

Fastening Method: **cleats**.

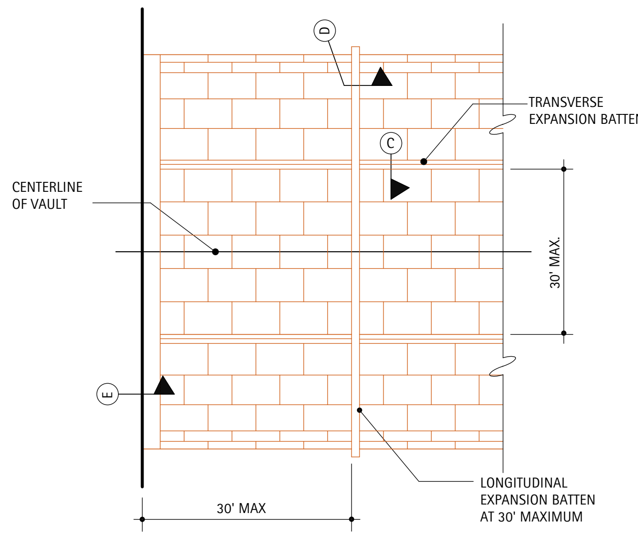
13.7A. Axonometric of Barrel Vault

This detail shows a barrel vault abutting a wall. The flat seam roofing is divided by expansion battens spaced no more than 30 feet apart.



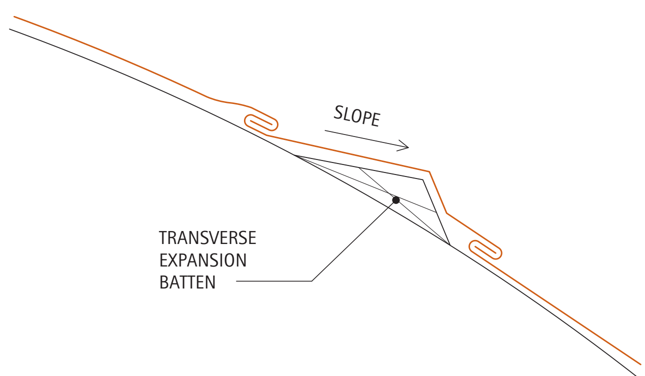
13.7B. Plan

Longitudinal Expansion battens should be positioned so that no more than 30 feet of fully soldered flat seam roofing. The eave conditions can be detailed similar to **Detail 13.6E**.



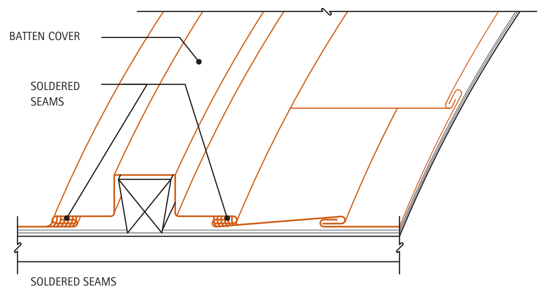
13.7C. Section

For very large vaults, transversely located expansion battens may also be required. Their shape must be designed to allow positive drainage, as shown in the detail. These transverse seams are required to be soldered on low slope application.



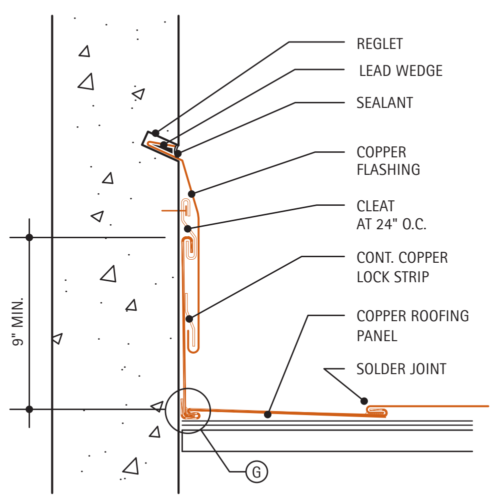
13.7D. Expansion Batten

A wood batten is nailed onto the barrel vault. Copper flashing is formed, as shown, over the batten. For shallow-curved vaults, a single piece batten cover can be used. For steep-curved vaults, a two-component batten cover/apron should be used, see **Detail 13.3C**. Special equipment can be used to stretch the batten cap components to fit the curve of the vault. The flashing is fully soldered to adjacent flat seam roofing panels. Expansion can be accommodated by tapering the battens or by using rectangular battens, but by bending the upturned legs of the flashing at less than 90 degrees, see **8.5. Flat Seam Roofing**.



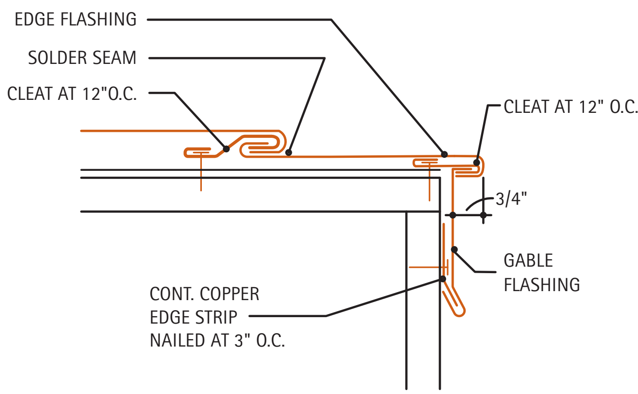
13.7E. Section At Reglet

This section shows how a reglet can be formed or cut into a wall to hold copper flashing. The wall can be constructed of unit masonry or concrete, new or existing. Copper flashing is formed and wedged into the reglet. Its lower end is locked into a continuous copper lock strip, which is soldered to the base flashing. The base flashing is soldered to the roofing pans, as described in **Detail 13.7G**. The reglet is filled with sealant to make it watertight.



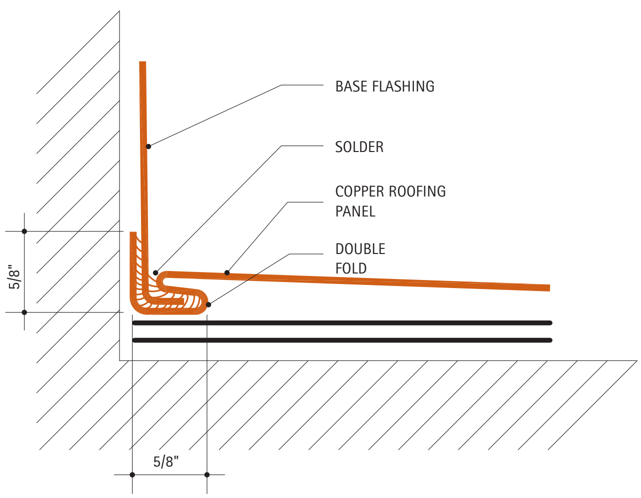
13.7F. Section at Edge

This section shows a method of constructing the condition at a freestanding edge or rake of an arched barrel vault. The copper pan is locked into the edge flashing and the seam is soldered if required by slope. The ¾" fold allows for a straight edge that can compensate for structural irregularities.



13.7G. Detail

The copper roofing pan is formed into a double fold and turned up the wall 5/8". Special stretching equipment can be used to curve this upturned leg to fit the shape of the vault. A base flashing with a minimum 9" vertical leg is cut on a curve to match the barrel vault curve. The lower edge of the base flashing is formed into a 5/8" leg and stretched to fit the curve. This leg of the base flashing is inserted into the roof pan double fold and fully soldered. Cleats, spaced a maximum of 12", fasten the base flashing to the wall. In brick or other unit masonry walls, stepped counter flashing can be used. The counter flashing can be laid into the wall using a receiver and its lower edge fastened by lock strips and cleats, as shown.



For Additional Information:

- **8. Roofing Systems**, for general information on roofing system requirements.
- **8.5. Flat Seam Roofing**, for information on flat seam roofing.
- **8.1. Special Roofing Design and Installation Considerations**, for information on solder and sealant requirements.
- **9. Flashings and Copings**, under the appropriate sections for flashing details.

13.8. Steps for Dome Panel Layout

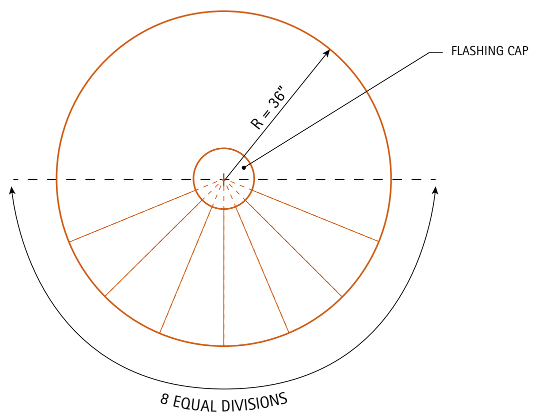
Formulas:

Full Circle Circumference = 2 x Radius x Pi.
Half Circle Circumference = Radius x Pi.
Pi = 3.141592

Domes come in many heights, radii, diameters, shapes and sizes. For our layout example, consider entry canopy designed as a true hemispherical half dome. The height is also the radius “R” and is one half of the base diameter. The base of the dome is the dome equator.

13.8A. Determine Dome Circumference and Panel Width at Base

Calculating the complete dome circumference at the base and dividing that amount by the number of panels will establish the width of each panel at the base.



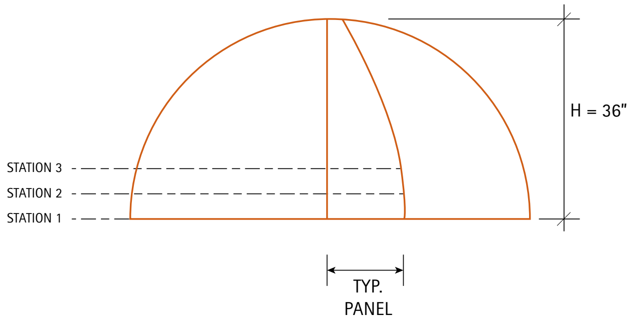
Dome Radius "R" = 36"
Dome Base Circumference "C" = 2 x Pi x R = 2 x 3.141592 x 36 = 226.194624 inches

If one half of a dome is built, the number of total dome panels should be an even number.

Assuming 16 dome panels for the full dome, each panel base dimension at the equator is therefore 226.194624 / 16 = 14.137" wide.

13.8B. Establish Dome Height and Panel Layout Concept

In a perfectly hemispherical dome, the dome height will be equal to its radius, 36 inches. Each of the eight panels will run from the base to the top center (vertex) of the dome. The shape of each panel will gradually decrease from its widest point at the base to its narrowest point at the vertex.



The shape of the panel is determined by two items: The panel length from base to vertex and the decreasing panel widths from base to vertex. The panel length can be determined by calculation. This length is equal to one fourth of the dome circumference or 226.194624 / 4 = 56.549". Since it is difficult to fabricate dome panels to a complete point, each panel length will be stopped approximately 2" short of the dome vertex and fabricated at 54 inches in length.

The panel widths can be determined by slicing the dome in parallel horizontal slices or Stations, each slice represents a full circle of decreasing size. The radius of each of the circles will allow calculating the circumference at that Station. Dividing that Station circumference by 16 will give the width of each panel at that Station. This process is similar to the base panel width calculation.

We now have established that our panels are 14.137 inches wide at the base and 54 inches long. Depending on the dome rib design, additional widths will be added to each panel **(See Table 13.8A)**.

Table 13.8A. Dome Panel Calculations: Calculations for Dome With 36-Inch Radius and Stations at 6 inches

Dome Radius = 36"
Panels quantity = 16
Pi = 3.141592
Circumference = 2 x Pi x Radius

					For Double Locked Seam		*For "T" Style or Dbl. Locked Cap Seam*
Station	*Radius*	*Decimal*	*Circle Circumference ÷ 16*	*Measure from Guide Line*	*Add 1.5" from Guide Line*	*Add 2.125" from Guide Line*	*Add 1.75" from Guide Line To Each Side*
					A. Points	*B. Points*	
1	36	36.000	14.137164	7.0685	8.5685	9.1935	8.8185
2	35 7/16	35.4375	13.91627081	6.9581	8.4581	9.0831	8.7081
3	33 31/32	33.96875	13.33949416	6.6697	8.1697	8.7947	8.4197
4	31 17/32	31.53125	12.38229034	6.911	7.6911	8.3161	7.9411
5	28 7/32	28.21875	11.08147491	5.5407	7.0407	7.6657	7.2907
6	24 3/32	24.09375	9.461591531	4.73079	6.23079	6.85579	6.48079
7	19 5/16	19.3125	7.583999438	3.7919	5.2919	5.9169	5.5419
8	13 31/32	13.96875	5.485514156	2.7427	4.2427	4.8677	4.4927
9	8 1/4	8.2500	3.23976675	1.61988	3.1198	3.7448	3.36988
10	5 5/16	5.3125	2.086213438	1.0431	2.5431	3.1681	2.7931

13.8C. Establish the Number of Dome Panel Stations, Quarter Dome Section

The shape of the panels can be determined by plotting their width at various points up the dome. We will call these points Stations. For a 36-inch radius dome, Stations every 4 to 6 inches apart give accurate results. Larger domes can have stations spaced farther apart and smaller domes, closer together. We will use 6 inches. A partial section of a quarter dome simulates a typical panel section. Make a full scale layout of the dome arc using the 36-inch radius on a sheet of metal. Divide this arc with Stations every 6 inches along the length of the arc. Number the stations from the base up, Number 1 through 10.