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December 4, 2013
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Manitowoc County Courthouse Sheet Metal Survey

Introduction

The Manitowoc County Department of Public Works, represented by Gerald Neuser, requested Renaissance Roofing, Inc. to perform a visual inspection of the exterior of the courthouse including the areas at the clerestory up to the base of the dome, and the lantern on top of the dome. This inspection is intended to establish and overall sense of the condition of the existing sheet metal cladding, and to identify any items that need immediate attention. It was also the goal of Renaissance Roofing to be able to present some recommendations for potential repairs or areas that may need restoration. Additionally, Mr. Neuser provided Renaissance Roofing with some historic photographs to help identify some of the decorative elements that are absent at present. The inspection was performed by Renaissance Roofing on September 24th, 2013. A man basket suspended from a hydraulic crane was used. This method allowed relatively close inspection of the south, west, and north elevations as well as the lantern at the top of the dome. The east elevation was not reachable due to the physical limits of the equipment. The conditions observed were typical on each of the three elevations that were inspected; it can safely be assumed that they are similar on the fourth (east elevation). During this inspection numerous photographs were taken to help convey conditions that were observed. Some of the photographs have been notated and presented with this survey summary. Also accompanying this survey are some details taken from Revere Copper Products book Copper and Common Sense.

Clerestory

The clerestory includes the area surrounding the windows above the new copper panels that were installed during the project that was completed in 2010, up to the first ledge above the windows. Some issues seen in these areas include failing seams in the decorative copper, wood window frames needing replacement, nesting birds inside decorative elements, some of the decorative elements are in need of replacement, fasteners meant to attach the cornice to the structure are failing, and the use of sealants in some areas has been necessary to keep out the weather. Also, noted on the historic photo, are some changes made from the original appearance in previous repair/restoration efforts.

Failing seams are in many locations are due to some poor craftsmanship and some design issues at the time of the original installation. Some of the joints used here are not typically used in exterior applications; they lack sufficient overlap to allow for proper soldering. Butt joints rely on the strength of the solder alone, this type of joint appears to be used at most of the corner mitered joints. The solder is not strong enough on its own to resist cracking over time.

The half round window sashes appear to be near the end of their service life at most locations. However the sashes of the windows on the north elevation do appear to be in much better condition. It is recommended that these sashes be replaced in the near future.

The decorative copper column capitals have openings where they meet the walls large enough to allow birds to nest inside them. This activity accelerates the deterioration of these elements. It may be possible to close these openings with sheet metal to prevent this from continuing. The column capitals are beginning to wear through and are collapsed and dented in several locations. Replacement of these elements in the near future is recommended.

Numerous fasteners have pulled through the decorative copper cornice. This can be seen is several pictures. The fasteners that were used appear to be steel so the copper has corroded the heads enough that the simply have pulled through. This area of major concern since it is difficult to tell if the cornice is attached in another way than these failed fasteners. The cornice does appear to be sagging, which would indicate these fasteners are necessary in maintaining the integrity of the system.

Sealants appear to be a key to keeping out moisture in multiple locations. Using sealants creates a constant maintenance issue. It is difficult to predict how long sealants will last in a particular location or condition and therefore requires constant investigation looking for potential leaks and failures. It is much preferred to design systems that do not rely on sealants at all. It is most likely the case that the original intention was not to rely on sealants but, failures due to poor design or craftsmanship led to their use.

Ledge above Clerestory

This area includes the ledge directly above the decorative cornice and the vertical surfaces just below the upper ledge. This ledge appears to be nearing the end of its service life. The copper panels have some failing seams and areas of ponding water. The vertical surfaces are missing some decorative elements, there are numerous protective fastener caps missing, as well as failed or missing fasteners that attach the sheet metal to the structure.

The horizontal surfaces appear to be wearing thin and have some cracked seams in a few locations. The type of joint used here is not typical or recommended for this application. The double lock joint appears to have been used here. This joint is difficult to solder properly, solder does not draw all the way through the joint in many cases. (see detail sheet 2.3) A soldered single lock joint is recommended for flat roofing. There are also several areas that are collapsing and collecting water (ponding). This indicates that there is not sufficient support under the copper roofing. The thinner gauge copper that is recommended to be used in roofing applications needs to not have a solid continuous backing, to prevent sagging and to help resist damage from hail strikes or damage caused from foot traffic. A number of design considerations and recommendation for flat seam copper roofing are included with this summary. (see detail pages 3.C.2-3.C.5)

Each elevation originally had three sets of stamped ornaments located on vertical panels as noted in the photographs. The remaining elements are in poor condition and missing parts in some locations. Enough of the original ornaments currently exist that they could be duplicated and replaced. There are some other decorative elements missing. Two decorative brackets are missing from the vertical surface on the east elevation. There a stamped ornament that is attached to these brackets. This stamped ornament is missing from a few of these brackets on other elevations.

The sheet metal is attached to the structure in many locations with an exposed fastener. These exposed fasteners have a protective cap soldered over them to keep the weather out. There are numerous caps that are missing, and in some cases fasteners that are either missing or pulled through the copper. The vertical sheet metal is fastened directly to the steel structure with what appears to be ferrous screws. The appropriate fastener to use when attaching copper to steel should be made from brass, or stainless steel. Additionally, a washer should also be used to prevent the fastener from pulling through the copper sheet metal. (see detail sheet 2.7)

Upper Ledge/Base of Dome

This area includes the upper ledge where the pedestals for the pyramid shaped boxes are located. Also include are the vertical surfaces above this ledge just below the base of the dome. This area is nearing the end of its service life. The same design flaws exist on the flat surfaces here, as noted in the "Ledge above Clerestory section of this report. Evidence of cracked seams, ponding water, use of joining and fastening methods that are not preferred are noted. There are numerous protective fastener caps missing, and failed or missing fasteners that attach the sheet metal to the structure on the vertical surfaces. Also noted in an attached historic photo are the missing decorative round windows and the original spheres that were located at the corners of the upper ledge.

Lantern

The lantern on top of the dome has several significant issues. The overall condition of the lantern's sheet metal cladding is poor. The roof has large tears and dents and the walk platform is in poor condition. The ceiling inside the lantern has many tears and appears to lack sufficient attachment points. Exposed fasteners are rusting, and they do not have any protective caps over them.

It is difficult to determine the cause of some of the tears and dents but it could be assumed that the lack of continuous support behind the copper is mostly to blame. A much heavier gauge of copper should be used if continuous backing is not provided under thin gauge copper. If efforts to repair or replace some of these areas it could lead to complete failure and perhaps material being blown off of the structure. There are some exposed pieces of wood that project out of the columns at the top where they meet the ceiling. It is not exactly clear what purpose this serves, but it can probably be assumed, that it was used in an effort to shore up the structure or the cladding in a relatively recent repair.

The overall condition of the walk platform is poor. There doesn't appear to be any cracked seams but the copper does appear to be wearing thin. There is evidence of ponding water in some areas. The copper is not continuously backed on some of the horizontal surfaces, thus the copper is sagging/collapsing. The railings around the platform are in fair condition. There is one missing spindle and some rusted hardware and some small holes where hardware was previously attached.

Summary

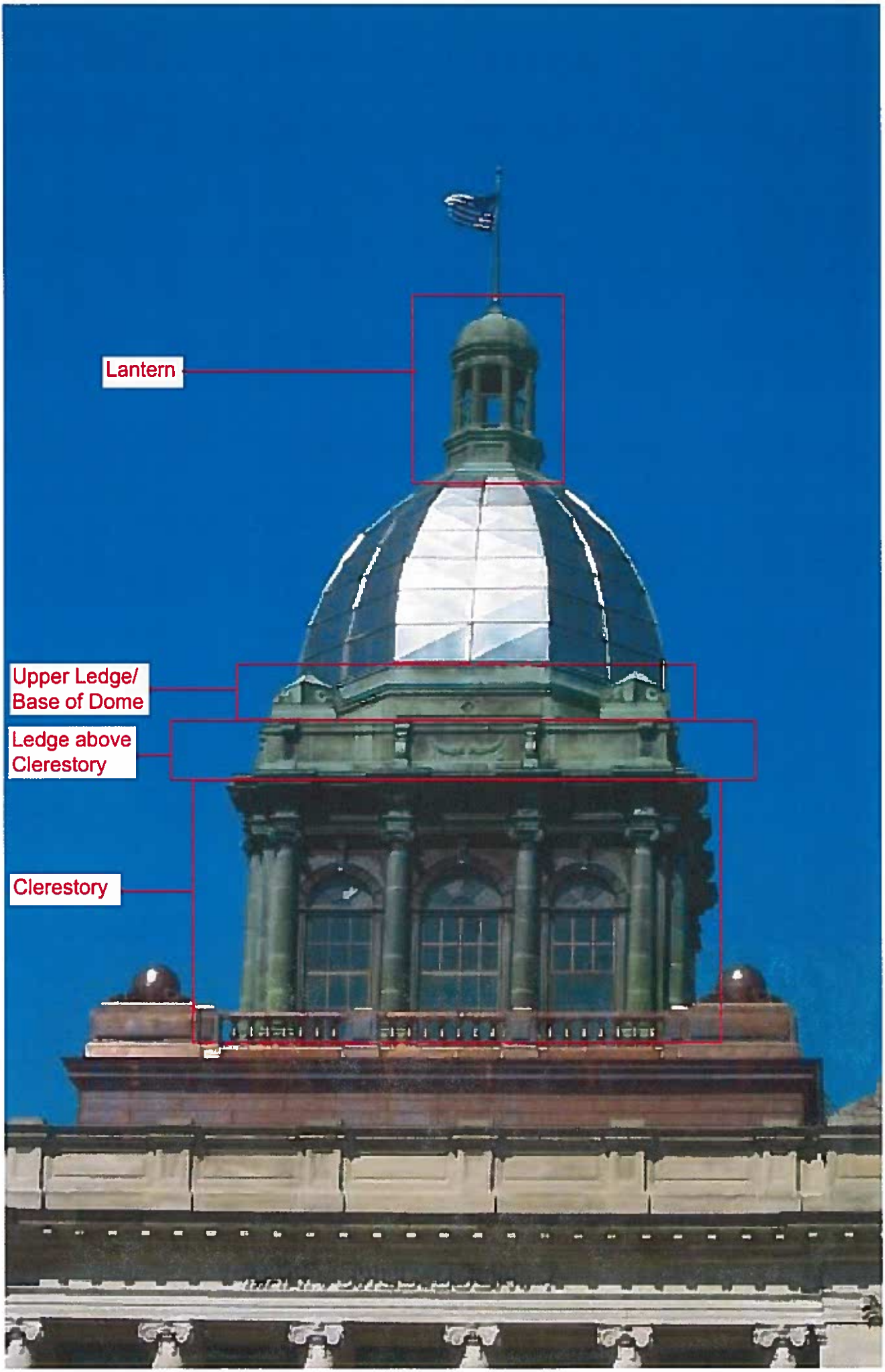
The overall condition of the copper cladding in the areas surveyed is fair. In our opinion, replacement of most of the copper cladding will be required in the near future. It is important to remember that any water leaking on to the steel structure can have corrosive effect. It is difficult to determine at this time if there are any significant corrosion occurring, but the existence of failing seams and holes indicates that it could be occurring.

The Lantern is an area of major concern. The wind and weather have progressively destructive effects on sheet metal that has tears and holes in it. There are major failures due to age and design flaws. We recommend the roof of the lantern be replaced with a better system that incorporates solid backing beneath the copper.

There are efflorescence and dark streaks on the interior walls and ceiling below the corners of the upper ledge. It is uncertain if this is a result of current leaks or past leaks that have been repaired, the existence of failing and cracked seams suggest that there is active leaks. The flat horizontal surfaces are most likely the cause. These areas are nearing the end of the service life and repairs to old soldered seams are impossible. It is impossible to clean the old seams well enough to solder them effectively. Complete replacement will be necessary in the near future.

The vertical surfaces on the areas above the clerestory need immediate attention. At the very least, replacing the fasteners and protective caps should be done. If however, the decision to replace the flat surfaces on the ledges is made, these areas should be replaced at the same time to ensure a weather tight assembly is accomplished. If replacement efforts are made, it may also be wise to make some design changes to provide a solid backing to the copper cladding on the vertical surfaces and using hidden fastener methods of attachment, as opposed to relying on exposed fastener hold downs.

The clerestory appears to be in relatively good condition. The capitals however, should be replaced, and an effort to install them so that there a no openings that allow birds to get inside them, should be made. The use of sealants in these areas will continue to be a maintenance issue. A full restoration of this area would be necessary to eliminate the reliance on sealants. The half round wood windows could be expected to last a number of years with consistent maintenance, but it may be wise to replace them if any other restoration efforts are made. The effort to access these areas safely is costly and therefore an effort to combine scopes of work would ultimately save money.


Lantern
Upper Ledge/
Base of Dome
Ledge above
Clerestory
Clerestory

Double-lock Seam

Historically, double-lock seams were used to join flat sheets of copper (usually four feet [4'] long) together to produce rolls or coils. These were then taken onto a roof and formed into standing seam roofing using tongs, mallets and "dogs."

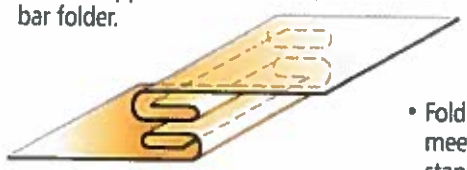
With the widespread use of longer sheets and modern sheet metal forming equipment and techniques, double-lock seams are seldom used today except for historical restoration.

Double-lock seams are suitable only when joining sheets in one direction. They are not suitable for flat seam roofing or wall cladding.

Presented here are two methods of forming double-lock seams.

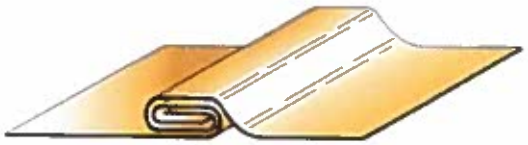
Method 1: This method produces a double-lock seam generally one-half inch (1/2") in width. Since it requires sufficient space to slide the two double-folded edges together, it usually requires that the adjoining sheets be double-folded by a bar folder. There are three simple steps:

- Double-fold end of each adjoining sheet in opposite direction with bar folder.



01_BC_25 METHOD 1 DOUBLE LOCK SEAM-A

- Slide these double-folded edges together to form a double-lock joint.



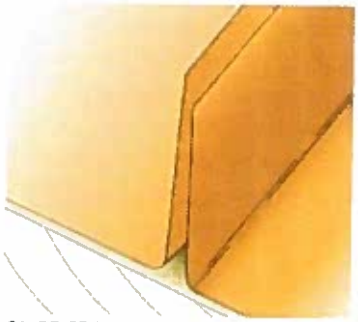
01_BC_26 METHOD 1 DOUBLE LOCK SEAM-B

- Dress down joint with mallet to form flat, double-lock seam.

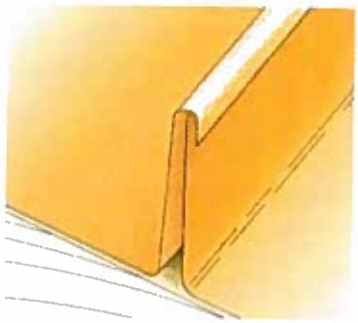
Method 2: This method is used for producing a double-lock seam when sufficient space is not available for sliding the two folded edges together (method 1), or when the double-lock seam is formed in the field. However, it does not require machine folding.

- Bend both edges at right angles – one with one edge one-half inch (1/2") higher than the other.
- Bend higher edge over top of lower edge.
- Fold both edges, thus joined, to meet base of sheet and form standing lock.
- Lay standing lock flat – to complete double-lock seam.

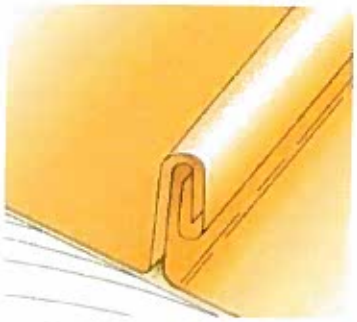
The four steps in forming a double-lock seam are:



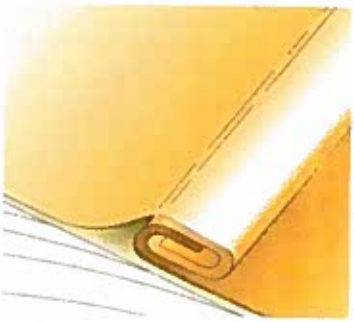
01_BC_27 METHOD 2 DOUBLE LOCK-1



01_BC_28 METHOD 2 DOUBLE LOCK-2



01_BC_29 METHOD 2 DOUBLE LOCK-3

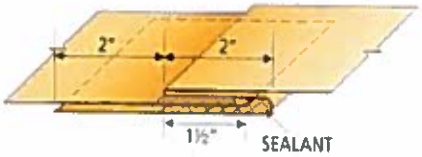


01_BC_30 METHOD 2 DOUBLE LOCK-4

Slip Expansion Seam

This type of seam is a variation of the loose-lock expansion seam. It is particularly useful on fascias, metal roof edge flashings, and similar locations where a smooth, inconspicuous seam is desirable. It is important that the dimensions shown be followed.

For better (tighter) securement to the understructure, the tailpiece of the formed lock section may be secured with copper or copper alloy nails. If the lock is to be watertight, it is filled with sealant before the end of the adjacent length of flashing is inserted into it.

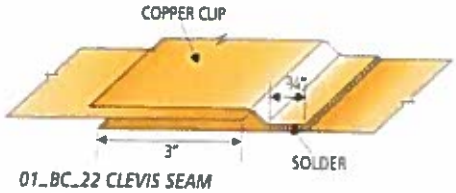


01_BC_21 SLIP EXPANSION SEAM

Clevis Seam

This type of seam is similar to the slip expansion seam. The difference is in the forming of the lock: A separate strip of copper is soldered to the underside of the end of one length of flashing to form the lock. Then, the end of the adjacent length of flashing is inserted between flashing piece and the soldered strip, to form the clevis seam.

Because of the tight fit of the clevis, this seam is seldom filled with sealant.



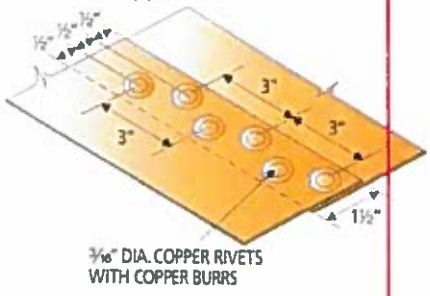
01_BC_22 CLEVIS SEAM

Riveted Seam

The riveted seam method is used for joining copper sections that are 24-ounce or more in weight (thickness). To develop a rigid seam that is at least as strong as these heavier coppers, it is necessary to lap, rivet and solder the adjacent pieces or sections.

The adjacent pieces or sections are lapped one-and-one-half inches (1-1/2"), then rivets, three-sixteenth-inch (3/16") diameter, are installed in two staggered rows, spaced three inches (3") apart, one-half inch (1/2") from the edges. When solid rivets are used, copper burrs or washers should be placed under the peened heads – to prevent damage to the parent metal.

Because of reduced joint strength, Revere does not suggest the use of smaller diameter blind rivets for structural joints in 24-ounce or heavier copper.



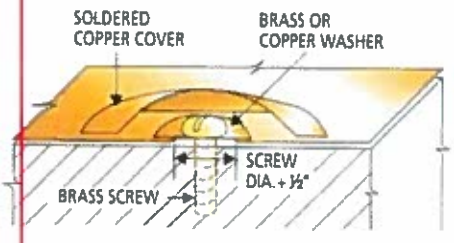
01_BC_23 RIVETED SEAM

Hold-downs

Copper hold-downs are used to prevent the lifting of wide, flat portions of metal installations from the understructure while at the same time allowing for the normal expansion movement of the copper under thermal changes. Hold-downs are placed along such installations as wide gutters, extended gutter tailpieces and wide apron flashings. They are spaced longitudinally at not more than four feet (4'), transversely at eighteen inches (18").

A hole is first drilled through the sheet copper. This hole is one-half inch (1/2") greater in diameter than the diameter of the screw that will secure the copper. This screw, when used in wood, should be brass, No. 12 x 7/8 inch, round head. When used in masonry, a similar screw – but with expansion shield – should be used. In either case, a large copper or copper alloy washer, one-and-one-quarter inches (1-1/4") in diameter, should be placed under the head of the screw. The screw should be taken up sufficiently to keep the metal flat – but not to resist its movement.

After the hold-down is in place, a copper cap, formed of 16-ounce copper, is soldered over the hold-down installation – to provide watertightness. Care must be taken to insure that only the cap – not the washer and/or screw – are soldered.



01_BC_24 HOLD DOWNS

Flat Seam Construction

Before the widespread use

of single-ply roof systems, most flat seam copper installations involved the covering of flat or nearly flat roofs. In these cases, small copper panels were joined with locked and soldered flat seams to provide *watertight* membranes. Flat seam roofs afforded decades of trouble-free service but they were labor intensive and unforgiving of installer error.

During the twentieth century a host of inexpensive, "easy to install" products designed to cover flat roofs were introduced. As a result, most flat seam construction today is used in the restoration of historic projects, on curved surfaces such as domes, on small accent roofs, or as vertical wall cladding.

Despite this, properly designed and correctly installed flat seam copper roofing is an excellent way of providing decades of trouble-free service and watertight protection.

Design Considerations

Locked and soldered flat seam roofing should be:

1) Of plain or coated copper only. Because of susceptibility of damage to the patina, pre-patinated copper is not suggested for locked and soldered flat seam roofing.

2) Installed with a "brick bond" type pattern so that four (4) panels do not converge at one point. (Joining four panels at one point creates a condition that is impossible to solder properly.)

3) Constructed of 20-ounce cold rolled (H00) copper. Thinner (lighter) copper may be subject to damage caused by roof traffic; heavier (thicker) copper is difficult to form into locked seams and is difficult to solder.

4) Made from sheets not more than eighteen inches (18") by twenty-four inches (24") before forming locks. Small panels are necessary to minimize oil-canning and insure that the copper is adequately secured.

Large areas of locked and soldered flat seam roofing should be divided into sections that are separated by expansion battens. Each section should not be more than thirty feet (30') in any direction.

As discussed later in this section, flat seam wall cladding is not limited to the above considerations. Flat seam wall cladding may use 16-, 20- or heavier ounce weight plain, alloy-coated or pre-patinated copper. It may also employ larger panels, and does not require expansion battens or soldering.

General Requirements

Locked and soldered flat seam copper roofing must be installed over wood, plywood, or similar nailable surface.

The surface to receive the copper should be dry and smooth – free from projecting nail heads or other obstructions. The entire surface should be covered with an approved underlayment. Historically, this has been asphalt saturated roofing felt, lapped two inches (2"). Ideally, the saturated felt would be secured with copper nails driven through sheet copper washers; the underlayment should NOT be fastened with metal or plastic "tin tabs" that are raised above its surface.

As discussed in previous sections, to function properly standing and batten seam roofs must be free to expand and contract with temperature changes. However, for flat seam roofs to function properly expansion movement must be restricted. This has led to a discussion as to the role of smooth building paper with locked and soldered flat seam roofing.

While "bleeding" of asphalt from saturated felts may restrict movement and is therefore desirable, the same "bleeding" during soldering may compromise the soldered seam. As a result, Revere suggests a layer of smooth building paper be laid over saturated felts immediately before soldering of the copper. The purpose of this paper is to prevent asphalt from being drawn into the seam during soldering.

Recently, a wide range of "improved" underlayments has been made available. These include "peel and stick" self-sealing membranes, "breathable" products, etc. Many of these products are "temperature sensitive" and can degrade at temperatures required for soldering – over 400°F. In Revere's opinion such underlayments are of limited value under locked and soldered flat seam roofing.

Flat Seam Construction 3C

At-a-Glance

For flat or nearly flat roofs, seams locked and soldered. For curved surfaces (such as domes), seams filled with sealant.

SHEETS:

- Revere 20-ounce cold-rolled (HOO) copper
- Maximum pan size: 18" x 24"
- Plain, or alloy-coated copper

SEAMS:

- 3/4", locked and soldered
- Edges (to be soldered) pre-tinned
- Corners notched

CLEATS:

- Revere 20-ounce copper
- Secured to wood deck or nailers with two copper, copper alloy or stainless steel fasteners

EDGE STRIPS:

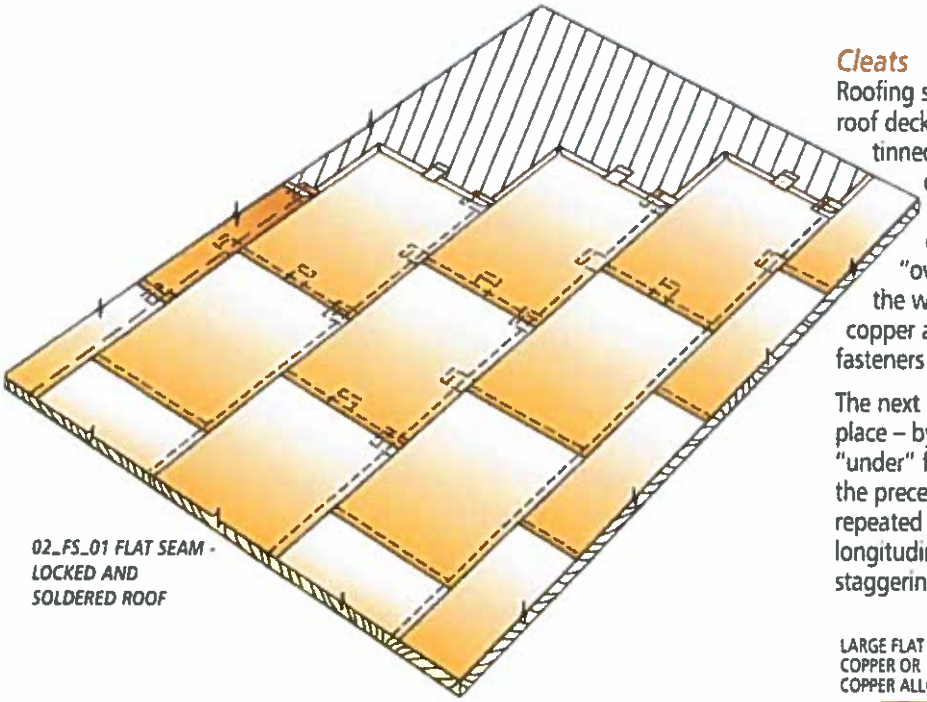
- Revere 20-ounce cold-rolled (HOO) copper
- 8' or 10' lengths
- Ends lapped at least 1"
- Secured with copper, copper alloy or stainless steel fasteners, spaced 4" apart

Flat Seams

For estimating materials to cover one square (100 square feet) of roof:

	Square feet of copper
Copper Sheets (18" x 24")	126
Cleats (2" x 3")	5-1/2
Total Required	131-1/2
Nails (1")	1 pound
Soldered seams	140 lineal feet

Flat Seam Construction

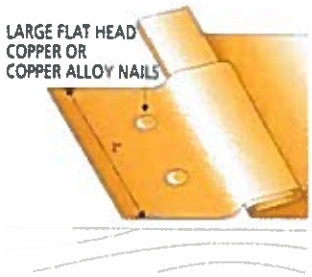


02_FS_01 FLAT SEAM - LOCKED AND SOLDERED ROOF

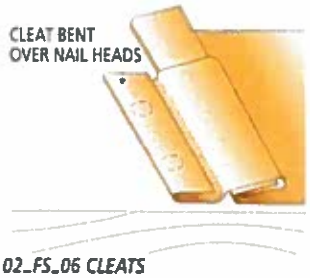
Cleats

Roofing sheets are placed on the roof deck and secured with pre-tinned cleats made of 20-ounce cold rolled copper. The cleats are engaged in each of the two adjacent "over" folds, and secured to the wood roof with two copper, copper alloy or stainless steel fasteners per cleat.

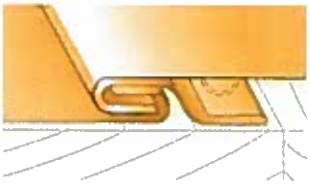
The next sheet is then locked in place – by engaging one of its "under" folds with an "over" fold of the preceding sheet. This is repeated for sheets both longitudinally and transversely, staggering the transverse seams.



02_FS_05 CLEATS



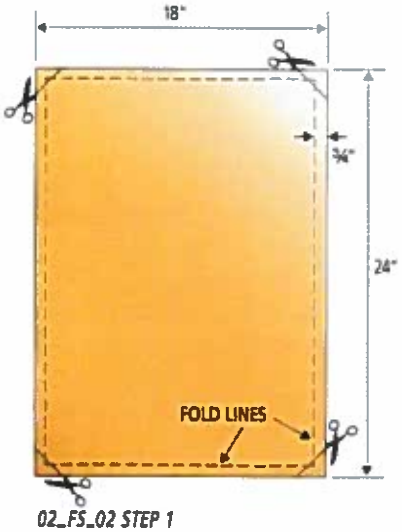
02_FS_06 CLEATS



02_FS_04 INTERLOCKING OF SHEETS

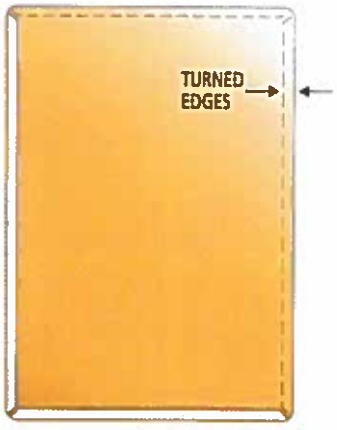
Roofing Sheets

Roofing sheets should be 20-ounce cold rolled copper, not more than eighteen (18") by twenty-four inches (24") before forming locks. Corners should be notched as shown in the details below.



02_FS_02 STEP 1

Prior to forming the three-quarter-inch (3/4") locks, the edges of the sheets should be pre-tinned with solder on both sides to a width of at least one-and-one-half inches (1-1/2"). The edges of two adjacent sides of each sheet are folded over three-quarter inch (3/4"); the edges of the two other adjacent sides are folded under three-quarter inch (3/4").



02_FS_03 STEP 2

Soldering – Flat or Slightly Sloped Decks

After the roofing sheets are placed, the locked seams are fluxed, mailleted or dressed down, and thoroughly sweated with solder. Soldering should be done using soldering coppers of sufficient weight to transfer enough heat to produce a fully sweated seam. (The heavier the pair of irons, the better their heat retention will be.) Acetylene heated soldering torches can also be used; the tip of the torch should not weigh less than three pounds (3 lbs.)

Due to difficulties of fully sweating the seams, Revere does not suggest the use of "open flame" soldering torches or electric soldering irons for flat seam roofing.

All soldering should be done as soon as possible after the roofing sheets are installed. In no case should soldering be attempted the day following installation (or later). Moisture and dirt will be drawn into the seam causing oxidization and making it difficult, if not impossible, to achieve a fully sweat seam.

Sealant Filled Seams – Curved Surfaces or Domes

On roofs with slopes of more than three inches per foot (3" per 12"), such as domes and spires, seams may be filled with sealant in lieu of soldering. A bead of sealant is applied to the inside of the folded edges of the sheets before they are placed. The roofing sheets are then placed, cleated, and the seams dressed down in the usual manner.

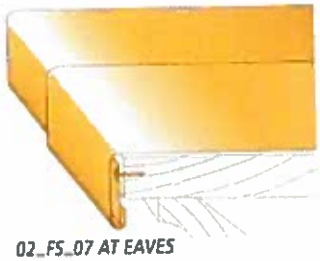
At the top of the curved surface of the dome or where the slope is less than three inches per foot (3" per 12"), seams should be soldered as described above.

Since the compatibility of sealants with copper and their method of application varies within and between types or classes of formulation (e.g., silicones, butyls, acrylics, etc.), sealant manufacturers should be consulted for current guidelines and specifications.

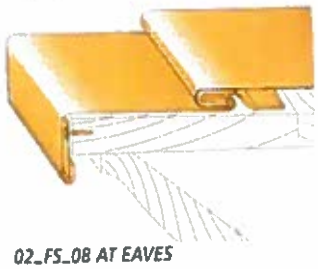
Eaves and Rakes

At both eaves and rakes, the roofing sheet should turn over the edge of the roof deck – and hook three-quarter inch (3/4") over a previously placed edge strip.

In an alternate method, narrow sheets of 20-ounce cold rolled copper, of standard lengths, are placed along the roof edge. The lower edge of these sheets hooks over the edge strip; the upper edge is locked and soldered to the typical roof sheets. The edge strips are lapped at least one inch (1") and secured with copper, copper alloy or stainless steel fasteners, spaced three inches (3") apart.



02_FS_07 AT EAVES



02_FS_08 AT EAVES

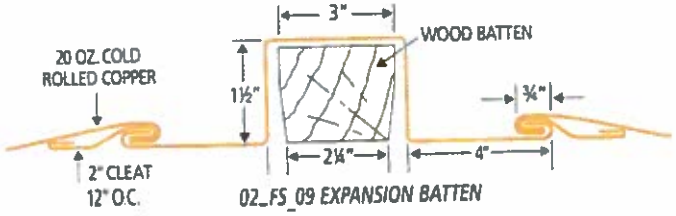
At Vertical Walls

When flat seam roofing abuts a vertical wall, it is locked and soldered into a 20-ounce cold rolled copper base flashing. The copper base flashing extends up the wall eight inches (8") and is counter flashed at least three inches (3"). (See Section 4B on Base and Cap Flashings for details)

Expansion Battens

Large, locked and soldered flat seam roofs are divided into sections separated by tapered wood battens. These battens are three inches (3") wide at the top, tapering to two-and-one-quarter inch (2-1/4") wide at the base and at least one-and-one-half inches (1-1/2") high.

This batten is covered with 20-ounce cold rolled copper in eight- (8') or ten-foot (10') lengths locked and soldered together. The batten cover is formed with right angle bends in one piece with four-inch (4") flanges that extend onto the roof deck. The flanges are locked and soldered to the roofing pans with three-quarter-inch (3/4") locks.



02_FS_09 EXPANSION BATTEN