METAL ROOFING FROM A TO Z
ALUMINUM TO ZINC

PART VII: Penetrations and Rooftop Equipment Mounting for Low-Slope Standing-Seam Metal Roofs

By Rob Haddock

Editor's Note: This is the seventh and final article in a series about metal roofing in today's market. The series provides an in-depth look at materials and their uses, coatings, system designs, and installation techniques. It is reprinted with the permission of metalmag.

Standing-seam metal roofing offers a durable, sustainable alternative to other roof types, with its ability to provide maintenance-free service for three or four decades. Sadly, this long life span is often sabotaged with the mounting of essential rooftop equipment and ancillary mechanicals.

Regardless of the roof type involved, consultants (this one included) generally agree that the best way to prevent roof-related problems is to clear the rooftop of everything possible and just let it function as a roof—not a mechanical equipment platform! Often, however, such a perfect roof eludes us; and it becomes necessary or convenient to mount HVAC equipment, along with the screens to hide it, piping to fuel it, scuttles to access it, and walkways to service it. And then the list of rooftop mountings goes on to include satellite dishes, lightning protection, solar panels, advertising signage, and fall protection systems to maintain all of the above.

To help achieve relatively trouble-free roofs, this segment endeavors to provide some basic understanding of the dos and don'ts in situations where rooftop equipment mounting is unavoidable.

PENETRATION-FREE ATTACHMENT

A good first rule about any rooftop mounting is to avoid penetrating the membrane whenever possible. While this may seem obvious, this tenet is often violated with standing-seam metal. The norm for attaching things seems to involve anchoring the item to the structure through the roof. When this happens, it not only threatens weather integrity, but it also violates the membrane's thermal cycling behavior by inadvertently "pinning" the panel to the structure. Such a point of attachment will fatigue and fail from forces of thermal expansion within a short time. Fortunately, scores of items and equipment can be securely mounted to metal rooftops without any penetration whatsoever, actually making metal roofing more user-friendly than other roof types.

In terms of mounting ancillaries, metal roofing can make use of special seam-clamping hardware that grips the standing seam without puncturing the membrane (*Figure 1*). Unlike many other types of roofing, metal is a rigid, high-tensile material. The seam area creates a beam-like structure that can provide convenient anchorage for walkways, solar arrays, condensing units, gas piping, and the like without harming the roof's weathering characteristics. Mechanicals can be safely and cost-effectively secured to these seam clamps, leaving the roof membrane penetration-free (*Figures 2* and *3*). They provide incredible holding strength (up to several thousand pounds on some profiles and gauges), last the life of the roof, and preserve thermal cycling characteristics. Using seam clamps whenever possible will eliminate a multitude of unwanted holes and unnecessary problems.

Clamps should be made only of noncorrosive metals—typically, aluminum with stainless steel mounting hardware. These metals are compatible with virtually anything found on a metal roof, except copper. In cases where a copper roof has been specified, brass clamps should be used with stainless steel hardware.

The clamps should be attached to seams with round-point setscrews to prevent galling or other damage that can lead to corrosion. It is also important to remember any

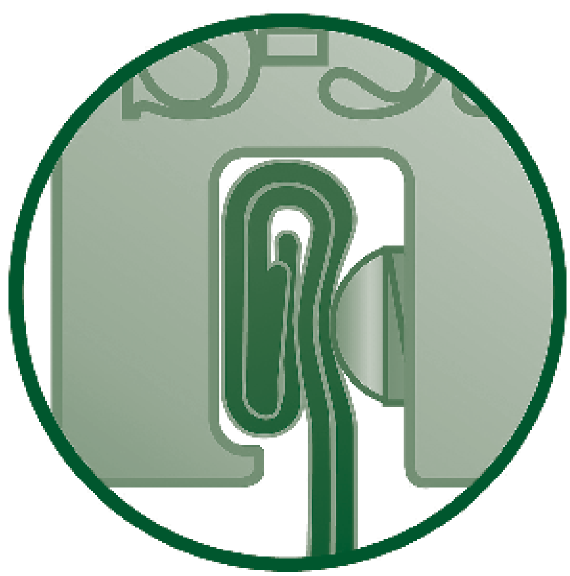

Figure 1 – This illustration shows a profile of clamping hardware affixed to standing-seam metal.

loads introduced into the clamp will be transferred to the panels and their anchorage to the structure. Consequently, anchorage must be capable of withstanding the added load.

Figure 3 – Seam clamps allow even cumbersome ancillary items to be attached to metal roofs without penetrating the rooftop.

Figure 2 – Seam clamps have made rooftop mounting so simple and cost-effective that metal roofing is now the preferred roof type for mounting photovoltaic solar arrays. Close-up of PV panels with shadow (close-up view of clamp attachment is inset to lower left corner).

MOUNTING HVAC WITH STRUCTURAL CURBS

In the case of HVAC and plumbing vents, the roof membrane must often be penetrated, so the aforementioned "good first rule" simply does not apply. The soil stack must carry gases from the interior to the exterior, and the HVAC unit must either transfer inside air out, outside air in, or both.

In these situations, holes in the roof are unavoidable, and the challenge is to waterproof the penetration area while maintaining thermal cycling integrity. There are a few rules about handling these kinds of rooftop penetrations in low-slope standing-seam metal that can help ensure a trouble-free installation.

Most small, bottom-ducted HVAC units are curb-mounted, using a preformed structural equipment curb specially manufactured to integrate with the specific roof profile (*Figure 4*). This curb carries the unit's weight, seals to the roof, and maintains the system's thermal cycling integrity. It is important to engage a company specializing in manufacturing curbs for the metal roofing industry. (These companies can usually be identified by the metal roofing manufacturer.)

The best curb is an all-welded design using sheet aluminum at least 2 mm (0.08 in.) thick (not coated carbon steel). Sheet steel does not weld well in thin gauges, and it heat-warps when welded. Additionally, the protective Galvalume™ coating must be burned off at welds and cannot be suitably restored. Aluminum welds exceptionally well and does not heat-warp because of its low

Figure 4 – Preformed structural curbs support weight and seal tightly to the roof.

melting temperature. It is very compatible with sheet steels used for roofing and can provide decades of trouble-free service when correctly designed, fabricated, and installed.

Common mistakes include dropping roof equipment curb scope-of-work into HVAC or sheet metal sections of the specification. Although this may be prudent practice with other roof types, it is not so with metal. With limited exception, HVAC and sheet metal contractors do not understand principles of rooftop waterproofing, nor do they understand thermal movement characteristics of standing-seam metal roofing. The result can be design and installation that either violates thermal cycling issues, weatherproofing issues, or both. Installation that "pins" the curb flange through the roof and into the structure is a common faux pas, and the use of surface-applied sealants that are ineffective for long-term performance is also a frequent malpractice.

Another common mistake is selecting a curb/flashing design that may be appropriate for steep-slope metal roofing with underlayment (water-shedding or hydrokinetic design), but is not at all appropriate for low-slope, hydrostatic (watertight design) metal roofing. A suggested practice is to insist that the roof manufacturer approve all rooftop attachments, penetrations, and appurtenances—curbs included. The manufacturer should know the type of curb that is compatible with his system. And when long-term weathertightness warranties are specified, they should include all rooftop attachments and penetrations—especially curbs.

The curb design should provide that the curb flange underlays the roof panels at the upslope end and overlays them at the downslope end (no "back-water" laps). This is normally accomplished by terminating the curb's side flanges by marrying them into a panel seam at either side. The curb walls are built up to a minimum height of 152 mm (6 in.) and flanged at the top to provide an adequate structural mounting surface for the equipment. The sides are also beveled to compensate for the roof slope and to provide for level mounting of the unit. The 6-in. minimum height provides that the mechanical unit's interface to the curb is well above the drainage plane of the roof and, therefore, more forgiving of installation error on the part of the mechanical contractor when waterproofing the equipment to the curb.

As this type of structural curb is "floating" (i.e., moves thermally with the roof), there are weight constraints. These curbs can accommodate units weighing up to about 454 kg (1000 lb.) placed anywhere on the roof—even heavier units, if located near the roof's point of fixity where movement is minimal. They are ordered from a manufacturer for a predetermined roof location, specific roof type, and by equipment model number (or in lieu thereof, exact equipment dimensions).

Installation details sealing the panels to the curb at its upslope end are similar to the details used to seal the roof panels at their eave end. They involve tape and/or tube-grade butyl concealed within the joints and metal closure components, depending on the panel's rib geometry. All details are hydrostatic in nature. Panel ribs are terminated well upslope of the curb wall to allow easy drainage to the sides of the curb. Upslope curb flange dimensions must provide for this.

At the downslope joint, the curb flange mates over the flat plane of the roof panels. Rib caps furnished loose or welded integrally into the curb flange serve to terminate the panel seams. This is again accomplished with butyl tape and tube seals concealed within the joints. The downslope joint thus created is normally reinforced beneath the assembly with a "backup" plate or channel. The side flanges are likewise sealed to the roof panels with butyl inside the mating components. All joints are completely hydrostatic with concealed sealants.

Other substructural components may be employed to facilitate the installation, and this type of curb is often furnished with

Figure 5 – Frame-mounted HVAC unit using pipe supports extending down to the building structure and flashed through the roof using rubber pipe flashings.

board stock insulation mounted to the curb walls. Installation of all critical seals (especially those at seam interfaces) is of paramount importance, and fasteners must be to the "dry" side of sealant beads or through them. It is also important that such a curb and its components are fastened together without pinning to the building structure.

The resulting assembly is free to move thermally with roof panels, while sealing completely into the roof "bathtub style," in lay terms, or, in accordance with ASTM International E2140, *Standard Test Method for Water Penetration of Metal Roof Panel Systems by Static Water Pressure Head*, in more technical terms. Diverters should be used on the upslope flange of the curb, and whenever possible, the unit should be oriented so the smallest dimension opposes the flow of water (e.g., if a unit is 1 x 1.5 m [3 x 5 ft.], the 1.5-m dimension should be parallel to the slope of the roof).

Figure 6 – Frame-mounted HVAC units using seam clamps that avoid roof penetration.

FRAME-MOUNTED HVAC

When it is necessary to mount heavier equipment, the unit is sometimes kept above the roof on a galvanized steel frame. The frame is constructed using round pipe legs so that they can be flashed with rubber pipe flashings (*Figure 5*). These legs extend through the roof to supporting structural members below. Such a mounting is stationary—that is to say, there will be differential movement between the frame and the roof.

Depending on the unit's weight, the support frame can also be mounted on seam clamps to avoid pipe penetrations through the roof (*Figure 6*). The ribs of structural metal panels normally support point loads of at least 68 kg (150 lb.), and ASTM standards for structural standing-seam roofing require this. In other words, a unit weighing 680 kg (1500 lb.) and spanning five panel seams can be mounted this way, resulting in ten bearing points on the five seams.

When ducting a frame-mounted unit through the roof, it is always advisable to use the smallest hole possible. That is to say, a very large unit may only require a very small duct penetration. A small curb of the same type described earlier is used to waterproof the ducted hole(s) in the roof. In this case, the curb need not be structural, as it supports no weight, but acts as a flashing only around the duct passing through the roof. The curb style is the same in all other respects.

If the unit is mounted on a stationary frame, the curb must be slightly larger than the actual duct size to allow differential thermal movement between the two. If the unit is mounted to seam clamps, then this is unnecessary as the unit and curb move together in tandem.

DOUBLE CURBS

When larger HVAC equipment size and weight are involved, the unit is frequently mounted on a structural curb, which is integral to the building's structural framing system. When such a design is employed, a second "flashing curb" is used for waterproofing reasons. The concept here is that the first curb (or frame) supports the weight of the unit, and the second does the waterproofing and integrates into the roof system.

In this case, there is differential movement between the two, so the outer "flashing curb" is oversized to the first, and a counterflashing of either metal or flexible membrane is married to the unit to shed water over the outer curb. The outer curb is of the same design and material as previously described. Again, it need not be as heavy-gauge, as it supports no weight. Installation details of the outer (flashing) curb connection to the roof are also the same as previously described with hydrostatic seals. Because there is differential movement, the joining of the counterflashing is sometimes done with hydrokinetic (water-shedding) details. This is acceptable because the joint is sufficiently above the drainage plane of the roof. Alternatively, hydrostatic detailing can also be performed when flexible membrane flashings are used.

The following advice applies to all the curbs described above:

- All-welded, aluminum curb construction should be used.
- Curbs must be equipped with diverters on the upslope flange.
- Upslope curb flanges should underlay roof panels.
- Lower curb flanges should overlay roof panels.
- Curb walls should be a minimum of 152 mm (6 in.) in height.
- Curb and installation should be "floating" (i.e., not pinned to the building structure).
- All seals should be accomplished with butyl tape/tube grade within the joints (not exposed sealants), with careful attention to marry seals at panel seams.
- Curb sidewalls should occur a minimum of 6 in. from the nearest adjacent seam location to allow sufficient drainage to the sides of curbs.
- Roof and structural manufacturers should be kept "in the loop" for weather integrity and structural-support adequacy issues.

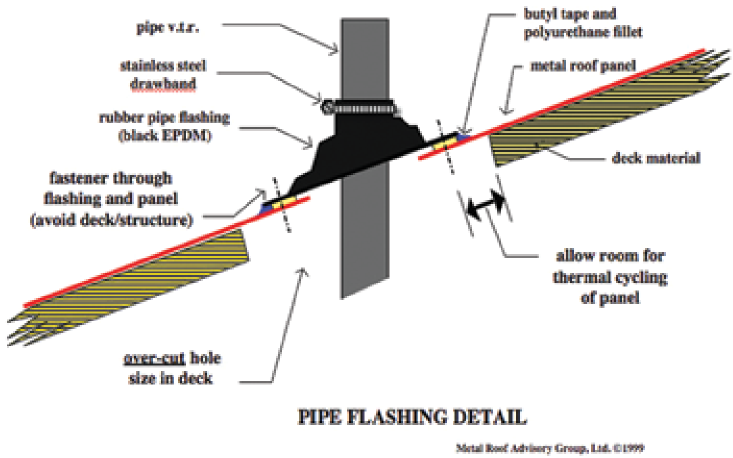

Figure 7

Ideally, excess butyl tape should be trimmed away and a bead of one-part polyurethane sealant filleted around the joint thus created (base to roof). This bead hides and protects the butyl from direct exposure to sunlight, ensuring a longer life. After a service life of 25 years or so, this assembly is easily replaced.

When attaching the pipe flashing, it must be anchored to the roof panel only and not to the building structure or deck. To do so would create an inadvertent "pinning" of the panel, violating its freedom of thermal movement. Ideally, these flashings should be centrally located on the roof panel so there is free drainage to both sides without seam interruption.

If the location of the pipe interrupts a seam and it cannot be relocated, a preformed adapter plate can be fabricated to span both panels adjacent to the seam and the pipe flashed per the above directions to the adapter plate. Most companies that premanufacture curbs will make such adapter plates on request.

When installing pipe flashing, the following advice is applicable:

- Use unitized black EPDM rubber pipe flashings.
- When possible, the pipe flashing should be centrally located in the roof panel.
- Stainless steel draw bands should be employed.
- After butyl tape has been used beneath the base, fillet with one-part polyurethane.
- The pipe flashing should never be pinned to the structure or deck.

ROUND PENETRATIONS

Round shapes, such as plumbing vents, should be flashed through the roof using ethylene propylene diene monomer (EPDM) rubber pipe flashings (*Figure 7*). Although these parts are widely available in various colors, black has the greatest ultraviolet (UV) resistance and, hence, the longest life.

Standard installation is to cut an undersized hole and stretch-fit the rubber to the pipe. Using a stainless steel draw band at the top of the flashing to further secure it will ensure the flashing never inverts itself and will typically add about five years of life to the assembly. The part has an integral aluminum compression ring laminated to the rubber base, which should be sealed to the roof panel using butyl copolymer tape. It should then be secured using #14 x 22-mm (7/8-in.) "lap-tek" screws with #1 drill point at 51-mm (2-in.) centers through the compression ring, rubber, and butyl and into the metal panel.

CONCLUSION

Rooftop mountings and penetrations are a challenge for any roof type or material. Following these simple guidelines can help ensure trouble-free and enduring performance for a state-of-the-art low-slope metal roof system.

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