

# WHITE PAPER



## Part 7: Metal Roofing from A (Aluminum) to Z (Zinc)

### Rooftop Equipment Mounting and Penetrations for Low-Slope Standing-Seam Metal Roofs

Standing-seam metal roofing offers a durable, sustainable alternative to other roof types and can provide maintenance-free service for five to ten decades. Sadly, this exceptional lifespan often is sabotaged with the mounting of essential rooftop equipment and ancillary mechanicals.

Regardless of the roof type involved, consultants 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. However, such a perfect roof continues to elude us, as it becomes necessary or convenient to mount HVAC equipment, screens to hide it, piping to fuel it, scuttles to access it and walkways to service it. The list of rooftop mountings also may include plumbing vents, satellite dishes, lightning protection,

snow retention systems, solar collectors, advertising signage, and fall-protection systems to maintain all the foregoing.

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

#### Penetration-free Attachment

A good “first rule” about any rooftop mounting is to avoid penetrating the membrane whenever possible. While this may seem obvious, the 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 can also violate 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.

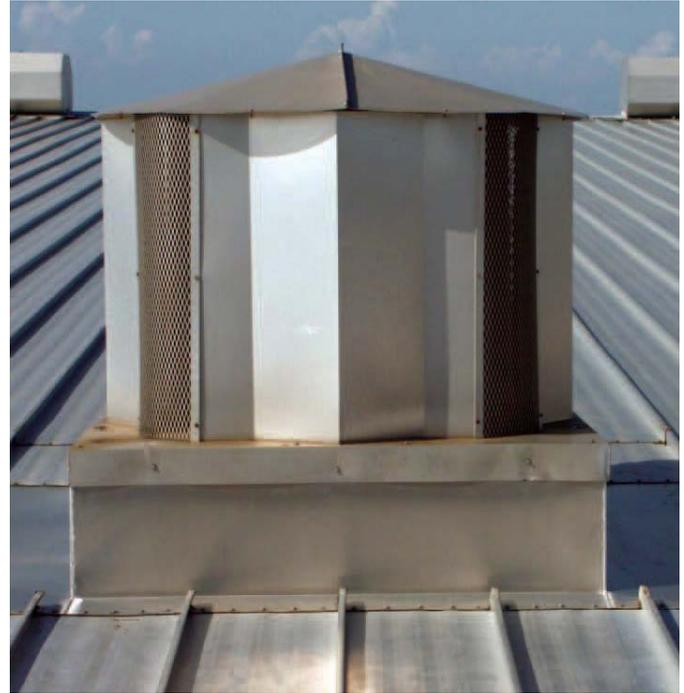
In terms of mounting ancillaries, metal roofing can use special seam-clamping hardware that grips the standing seam without puncturing the membrane. Unlike many other types of roofing, metal is a rigid, high-tensile material. The seam area creates a beam-like structure that can provide convenient anchorage for walkways, solar arrays, condensing units and gas piping 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. Seam clamps can provide holding strength of up to several thousand pounds on some profiles and gauges, last the life of the roof and preserve thermal-cycling



▲ Metal roofing can make use of special seam-clamping hardware that grips the standing seam without puncturing the membrane. Seam clamps have made metal roofing a preferred roof type for mounting photovoltaic solar arrays.

characteristics. Using seam clamps when possible for ancillary mounting will eliminate unwanted holes and other potential 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 (with which there are dissimilar metallurgy issues.) Dissimilar metals in electrolytic contact will induce galvanic corrosion of the less noble metal. In cases involving copper roofing, brass clamps should be used with stainless-steel hardware. Seam clamps generally integrate with the profile and seam folding, and in some way “pinch” the seam material to anchor them in place. Preferred methods of doing this involve setscrews tightened against the seam causing a dent in the seam material



▲ Pre-formed structural curbs support weight and seal tightly to the roof.

that in turn creates a mechanical interlock of the setscrew, seam and clamp, providing the greatest holding strength and durability. Setscrews should have round, polished points to prevent galling metallic coatings, which can lead to corrosion. In like fashion, and regardless of the method of engagement, any clamp device should avoid any sharp points or nodes that could potentially pierce or gall metallic coatings of steel or cause fatigue and fracture points of other metals.

It also is important to remember that any 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. The best practice is to utilize clamps that have been appropriately tested for material and seam-specific holding strength; be sure in-service load does not exceed that of the published holding strength, including factors of safety. The roof manufacturer should also be consulted with respect to approval of devices used.



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

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## Mounting HVAC with Structural Curbs

In the case of HVAC and plumbing vents, the roof membrane often must be penetrated. The soil stack must carry gases from the interior to the exterior and the HVAC unit must transfer inside air out, outside air in or both. Holes in the roof are unavoidable; 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. 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 typically can be identified by the metal roofing manufacturer.

### **In terms of mounting ancillaries, metal roofing can use special seam-clamping hardware that grips the standing seam without puncturing the membrane.**

The best curb is an all-welded design using sheet aluminum at least 0.080 inch thick. Coated carbon steel tends to heat-warp when welded. Additionally, the protective Galvalume or galvanized coating is burned off at welds and cannot be suitably restored. Aluminum welds exceptionally well and does not heat-warp because of its low 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.

It is a common mistake in specification writing to place the equipment-curb scope of work into HVAC or Sheet Metal sections of the spec. Most 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 violates thermal-cycling and/or weatherproofing issues. 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 also is a frequent malpractice.

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

The best curb design should provide that the curb flange underlays the roof panels at the upslope and overlays them at the downslope, allowing no "back-water" laps. This normally is 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 6 inches and flanged at the top to provide an adequate structural mounting surface for the equipment. The sides also are tapered to compensate for the roof slope and provide for level mounting of the unit. The 6-inch minimum height ensures 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.

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Because this type of structural curb is “floating,” (meaning it moves thermally with the roof), there are weight constraints. These curbs can accommodate units weighing up to about 1,000 pounds placed anywhere on the roof. Heavier units can be accommodated if they are located near the roof’s point of fixity where movement is minimal. Structural curbs are ordered from a curb manufacturer for a predetermined roof location, specific roof type and by equipment model number. Without a model number, exact equipment dimensions can be used.

The installation details that seal the panels to the curb flange at its upslope end are similar to details used to seal the roof panels at their eave end. Installation involves tape and/or tube-grade butyl polymer concealed within the joints and metal closure components, depending on the panel’s rib geometry. All details are hydrostatic in nature for low-slope roofing. 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 that are furnished loose or welded integrally into the curb flange serve to terminate the panel seams. This also is accomplished with butyl tape and tube seals concealed within the joints. The downslope joint that is created typically is 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; often this type of curb is furnished with board stock insulation mounted to the curb walls. Installation of all critical seals, especially those at seam inter-faces, is of paramount importance, and fasteners must be to the “dry” side of sealant beads or through them. It also is important such a curb and its components are



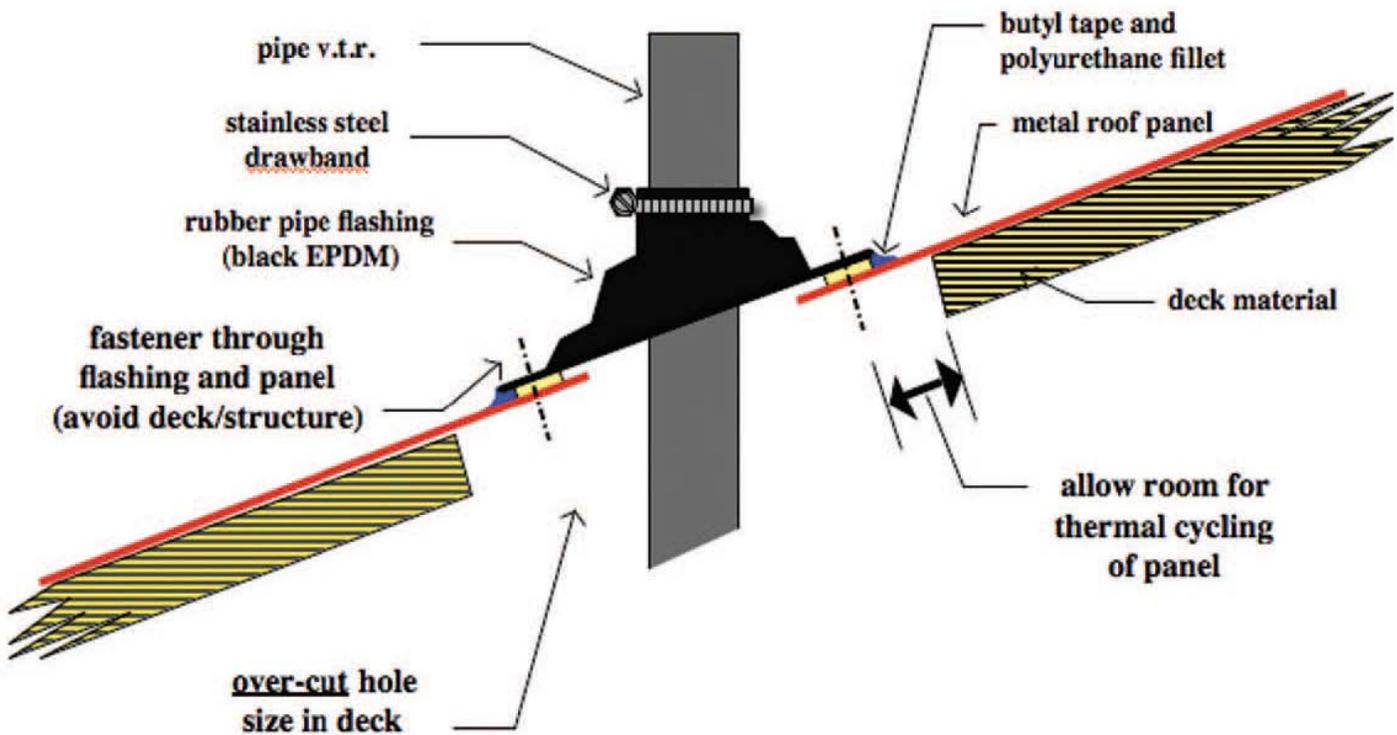
▲ This frame-mounted HVAC unit uses pipe supports that extend to the building structure and are flashed through the roof using rubber pipe flashings.



▲ A frame-mounted HVAC unit can be supported without roof penetration by using seam clamps.

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 E 2140, “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. For example, if a unit is 3 by 5 feet, the 5 foot dimension should be parallel to the slope of the roof.



## PIPE FLASHING DETAIL

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### Frame-mounted HVAC

Heavier equipment is sometimes mounted above the roof surface on a galvanized steel frame. The frame is constructed using round pipe legs, so they can be flashed with rubber pipe flashings. These legs extend through the roof to supporting structural members. Such a mounting is stationary, meaning there will be differential movement between the frame and roof panels.

Depending on the unit's weight, the support frame also can be mounted on seam clamps to avoid pipe penetrations through the roof. The ribs of structural metal panels are required by ASTM E 1514, "Standard Specification for Structural Standing Seam Steel Roof Panel Systems," and E 1637, "Standard Specification for Structural Standing Seam Aluminum Roof Panel Systems" to

support point loads of at least 200 pounds. In other words, a unit weighing 1,500 pounds and spanning across five panel seams can be mounted this way, resulting in 10 bearing points on the five seams, each supporting 150 pounds and well within the ASTM requirement.

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 only may require a very small duct penetration. A small, sheet-aluminum, all-welded curb is used to waterproof the ducted hole(s) in the roof as before. But in this case, the curb need not be structural because 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

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to allow differential thermal movement between the two. If the unit is mounted to seam clamps, this oversizing is unnecessary because the unit and curb move together in tandem.

### Double Curbs

Large, heavy HVAC equipment often also is 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 is that the first curb, or frame, supports the weight of the unit and the second curb 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 counter flashing of metal or flexible membrane joins the two, shedding water over the outer curb. The outer curb is of the same design and material as previously described. Again, it need not be of such a heavy gauge because it supports no weight. Installation details of the outer (flashing) curb connection to the roof also are the same as previously described with hydrostatic seals. Because there is differential movement, the joining of the counter flashing is sometimes done with hydrokinetic, or water-shedding, details. This is acceptable because the joint is sufficiently above the drainage plane of the roof. Alternatively, hydrostatic detailing also can be performed when flexible membrane flashings are used.

**Using a stainless-steel draw band at the top of the flashing to further secure it will ensure the flashing never inverts itself and typically will add about five years of life to the assembly.**

### Round Penetrations

Round shapes, such as plumbing vents, should be flashed through the roof using EPDM or silicone rubber pipe flashings. Although these parts are widely available in various colors, black has the

greatest UV-resistance and longest life, and although more costly, silicone will far outlast EPDM.

Standard installation is to cut an undersized hole and stretch-fit the rubber to the pipe. Using a stainless-steel #14 by 7/8-inch "lap-tek" screws with #1 drill point at 2-inch centers through the compression ring, rubber and butyl, and into the metal panel.

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 20 to 25 years (significantly longer for silicone rubber), this assembly is easily replaced.

When attaching the pipe flashing, it must be anchored solely to the roof panel and not into the building structure or deck. To do so would create an inadvertent pinning of the panel, violating 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 as mentioned above to the adapter plate. Most companies that pre-manufacture curbs will make such adapter plates on request.

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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