Best Practices for the Design and Installation of Thermoplastic Roofing Systems

Part 3 of 4: Roof Pipe Penetration Flashing Details

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PROPER DETAILING OF roof penetrations is a vital part of a every completed roofing assembly. Any penetration through a low-slope roof assembly could represent a potential point for leaks or breaches during the life cycle of the roof. Roof penetrations come in a range of shapes, sizes, and materials, and they may be in varying proximity to each other and other types of penetrations. Whether the project involves new construction or reroofing, roofing system manufacturers and design professionals develop very specific detailing procedures for these penetrations to reduce the risk of breaches. To ensure project success, the roofing installation crew should be well versed and trained in the roof manufacturer's recommended installation techniques and have the competency to achieve the design details provided by the project architects and building enclosure consultants.

This article offers general guidance on flashing requirements for various scenarios. These scenarios involve individual penetrations, clusters of penetrations, penetrations in close proximity to other types of flashing conditions, and the various methods to flash these penetrations.

INDIVIDUAL ROOF PENETRATION TYPES AND PENETRATION CRITERIA

Pipe penetrations can be polyvinyl chloride (PVC) pipes; stainless steel pipes; cast iron pipes; acrylonitrile-butadiene-styrene (ABS) drain, waste, and vent fittings; galvanized steel collars; structural steel; copper condensation lines at HVAC units; or rigid and flexible electrical conduits. The typical size, spacing, height, and flashing requirements for these penetrations are described herein.

To be flashed with flashing membrane or a premanufactured pipe boot individually, each penetration must meet the following criteria:

- The penetration should be at least 1 in. (25.4 mm) in diameter. Penetrations that are smaller than 1 in. in diameter are best flashed by other methods, which are discussed later in the liquid-applied or penetration-clusters sections of this article.
- The individual penetrations must extend above the roof so that a minimum of 8 in. (203 mm) of flashing material can be installed above the horizontal roof membrane plane, as required by the roof manufacturer specifications.
- The individual penetrations must be a minimum of 12 in. (305 mm) apart from each other and away from other flashings at walls or curbs to accommodate the membrane flashing minimum coverages.
- The temperature of the pipe must not exceed 150°F (66°C), as higher temperatures would damage the membrane flashing. There are methods to flash these "hot pipe" types of penetrations with metal collars, as discussed later in this article.
- The penetration must have a smooth, continuous surface, such as flexible conduit with a monolithic membrane skin, or be a rigid penetration insert such as metal, PVC, stainless steel, or iron. If the penetration is flexible, it must be secured above the roof surface such that the penetration flashing will not move or flex. An uncoated metal or plastic conduit is not a suitable conduit material to be used or flashed on a rooftop, as this type of conduit can allow moisture to enter and pass through the flashing and into the building interior.
- Individual wires, such as electrical or thermostat control wires, should be encased in a rigid conduit to be flashed as an individual roof penetration.
- Insulated pipes must not be flashed onto the insulating material or insulation cover, even if the cover is monolithic, such as a wrapped insulated water line, gas line, or similar. There is potential for condensation to form on the exterior surface of the pipe, given the optimum humidity and temperature occurs. This condensation would be present between the pipe surface and the interior surface of the pipe insulation wrap. The insulation wrap could rupture and leak, which could introduce moisture into the assembly. Insulated pipes must be flashed directly to the pipe, with a break in the insulating cover (removing a small piece of the insulation so that the roof flashing can be installed directly onto the pipe). They should never be flashed to the insulation wrap or cover.
- Wood post penetrations and supports should never be flashed into a roof system because of the moisture intrusion potential.

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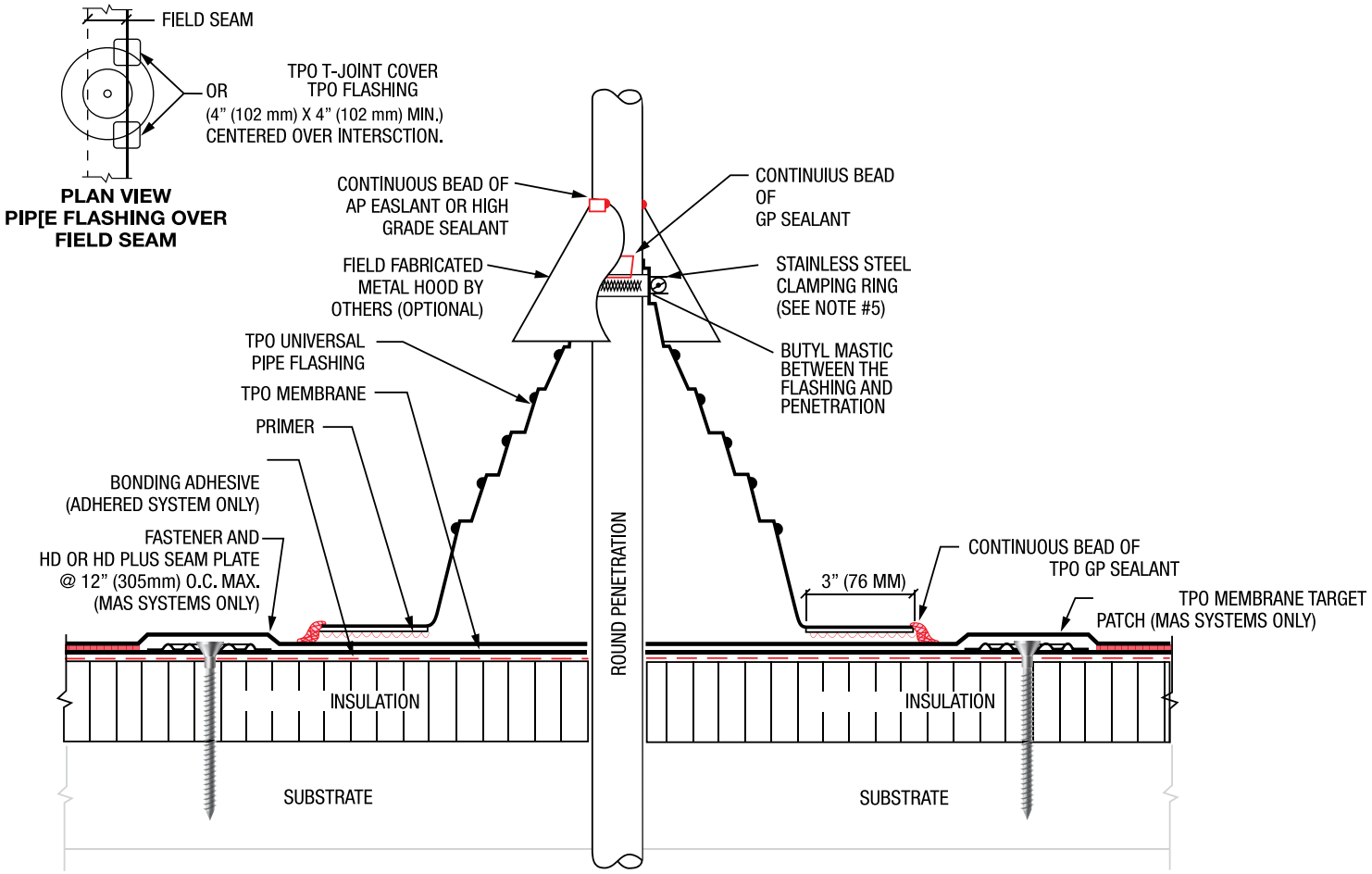

Figure 1. Standard prefabricated pipe boot penetration flashing detail.

FLASHING METHODS

Flashing methods for pipe penetrations vary in accordance with the specified length of the roof manufacturer's warranty, the roof system assembly and attachment method, the geographic location and climate zone of the site, and the membrane type. The typical methods are described here.

Prefabricated Flashing Boots

The following criteria are for the standard installation of prefabricated flashing boots:

- The pipe/penetration should be round and at least 1 in. (25.4 mm) in diameter. Square, I-beam, or other irregularly shaped penetrations should be flashed via other methods, as discussed later.
- The pipe/penetration must also be open/unattached to any structure or equipment at the top, as the pipe boot must be pulled down over the penetration.
- The penetration must be tall enough to accommodate the full height of the pipe boot without distorting the boot (8 in. [203 mm] minimum). Typically, this requirement means that a structural support post cannot be flashed with a pipe boot as the post is normally welded or bolted to some type of assembly that it is supporting.
- The premanufactured pipe boot cannot be cut vertically to allow it to wrap around the penetration.
- The penetration must be at least 12 in. (305 mm) away from other penetrations. The deck flange of the pipe boot must rest fully on one plane or roofing membrane and should not overlap another pipe boot flange. Butyl mastic is placed between the top edge of the pipe boot and penetration surface; a stainless-steel hose clamp is installed over the top edge of the pipe boot; and, when the clamp is tightened, the clamp pressure forms a watertight seal between the flashing and penetration with the butyl mastic.
- Most roof manufacturers will require that any exposed butyl mastic that remains on the pipe surface above the top of the pipe be removed. A bead of elastomeric sealant is installed between the top of the pipe boot and the pipe surface to protect the butyl mastic from exposure to sunlight, heat, and humidity. Sunlight, heat, and humidity will degrade the butyl mastic. Rain hood collars are optional.

Figure 1 illustrates a standard detail for a prefabricated pipe boot penetration. **Figure 2** shows an example of incorrect installation.

Field-Wrapped Pipe Flashing

The following are criteria for the standard installation of a field-wrapped pipe flashing:

- Penetration can be round, rectangular, or irregularly shaped. Irregularly shaped penetrations should not be flashed with prefabricated flashing; rather, liquid- applied flashings should be used.
- If the penetration is round, it should be 1 in. (25.4 mm) in diameter or larger. Field wrapping of small-diameter pipes is very difficult and should only be attempted by veteran hand-welding technicians.
- Field-wrap flashing is a multistep process with very particular flashing overlap coverage tolerances, which make this option very labor intensive.

Figure 2. Example of an incorrectly installed prefabricated pipe boot penetration. The wrong sealant was used at the exposed surface against the pipe, and T patches are missing where the pipe boot flange crosses field seams.

- A stainless-steel hose clamp is installed over the top edge of the pipe boot over round penetrations, and when the clamp is tightened, the clamp pressure forms a watertight seal between the flashing and the penetration. A stainless steel clamping band will not provide consistent compression on square or irregularly shaped penetrations.
- Most roof manufacturers will require that a bead of elastomeric sealant is installed between the top of the pipe boot and the pipe surface to complete the detail.

Figure 3 presents a standard detail for field-fabricated pipe flashing for a mechanically attached roof system. **Figure 4** shows an example of incorrect installation.

Liquid-Applied Flashing

The following are criteria for standard installation of liquid-applied flashing:

- The penetration can be any shape, size, and diameter. It may be composed of any material except wood or any other porous material.

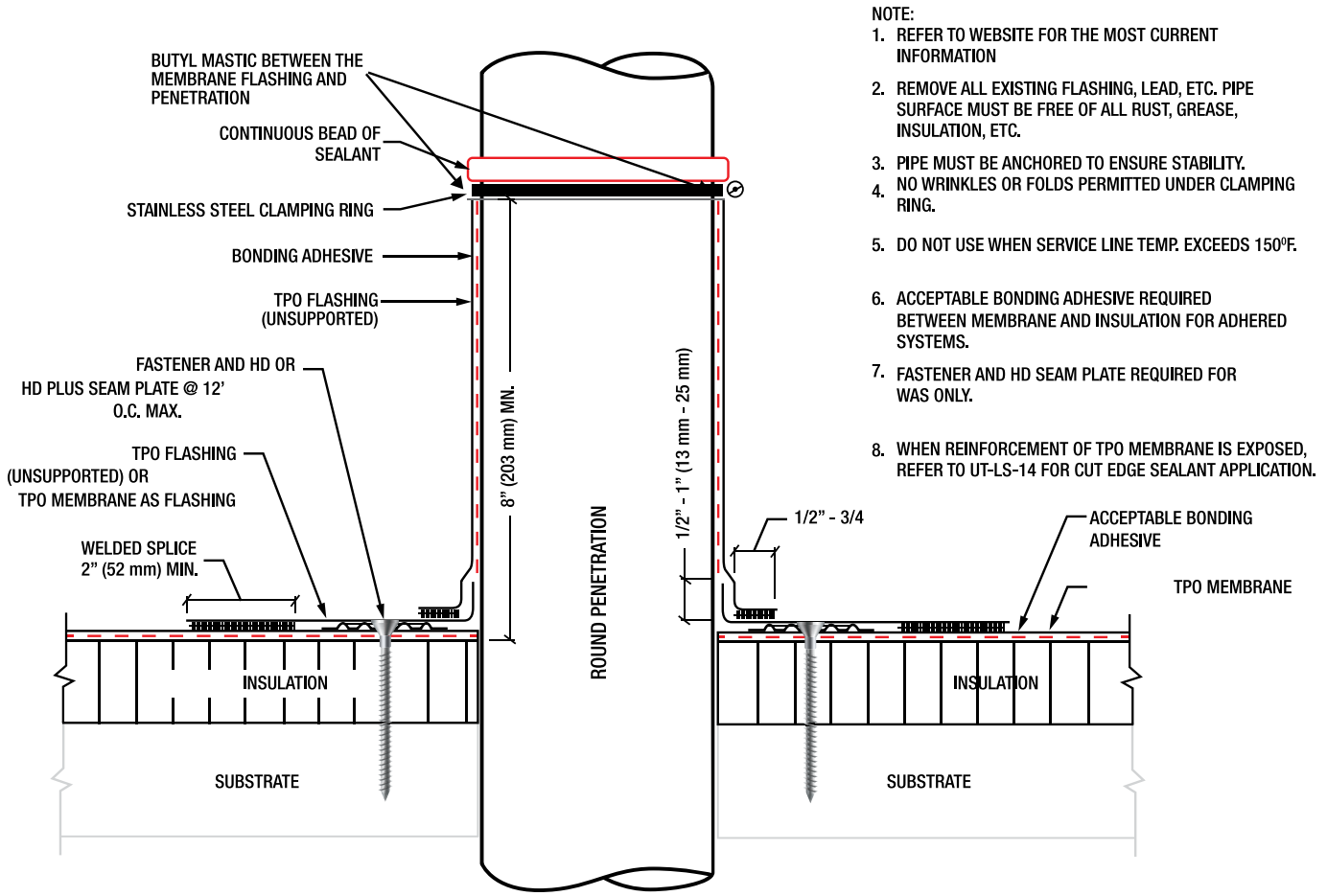

Figure 3. Standard field-fabricated pipe flashing detail for a mechanically attached roof system. The fasteners and seam plates are not required for adhered roof systems.

Figure 4. Example of incorrectly installed field-fabricated pipe flashing. The flashing is too high, and butyl mastic is exposed on top of the pipe. Wrinkles are evident in the 1-in. (25.4 mm) horizontal flange of the vertical flashing wrap.

Figure 5. Application of standard liquid-applied flashing on an I-beam.

- The surface of the penetration must be cleaned and abraded using sandpaper or a stiff-bristle wire brush. Abrading the surface helps ensure that the liquid-applied flashing achieves a solid "bite" onto the surface of the penetration.
- The liquid-applied flashing is installed in three layers: a base coat followed by a reinforcement scrim to be embedded into the base coat, followed by the top coat. Please refer to the specific roof manufacturer specifications for their installation techniques for and drying or curing times between application steps.

The process described here has been simplified. The complete process includes other steps, such as using masking tape to establish the perimeter edges of the flashings onto the roof surface, precutting the reinforcement scrim to fit onto the penetration, and so on.

Figures 5 and **6** illustrate the installation of liquid-applied flashing.

Penetration Clusters and Sealant-Pocket Flashing

The following are criteria for the standard installation of penetration clusters or sealant - pocket flashings:

- All penetrations should be rigid or affixed to a structurally stable or secured element to prevent movement, which could crack or cause voids in the pourable sealant.
- All penetrations should be spaced at least 1 in. (25.4 mm) apart and have 1 in. of clearance from the sides of the sealant pocket pan walls. This requirement ensures that the pourable sealant is able to fully encapsulate and seal the individual penetrations and properly adhere and seal the sealant pan.
- The pan must be at least 2 in. (50.8 mm) deep because manufacturers require a minimum depth of pourable sealant of 2 in. *(50.8 mm)* The pan may need to be deeper to accommodate various penetration connection points or other items. The bottom portion of these deeper pans can be filled with polyisocyanurate insulation, lightweight concrete, or similar products to avoid more than a 2-in. *(50.8 mm)* depth of pourable sealer.
- All penetrations and the interior surface of the metal pan must be cleaned and primed with the manufacturer's approved primer. This priming will ensure that the pourable sealer bonds with all surfaces.
- The pourable sealant must "crown" in the center of the pan so as to provide positive slope to prevent water from accumulating or ponding on top of the sealant.
- All two-part pourable sealer products must be properly mixed to ensure that they cure properly after installation. Several one-part pourable sealant products are shipped in premixed packaging by the manufacturer and do not require thorough mixing in the field before installation.

Figure 7 illustrates a standard detail for sealant pocket flashing. **Figure 8** illustrates an example of incorrect installation.

Hot-Pipe Flashing

As previously mentioned, any penetration that will exceed 150°F (66°C) in surface temperature cannot be flashed directly with thermoplastic membrane because the heat will degrade the flashing. The hot-pipe flashing options are limited as follows:

- There must be a separation or metal collar that is sized larger that the hot penetration. The space between the collar and the hot pipe must be sized such that the temperature of the collar will stay below 180°F (82°C).
- If the diameter of the collar is less than 12 in. (305 mm), the hot collar can be installed over the membrane and flashed in a method similar to that for the field-wrapped pipe condition (described previously).
- If the diameter of the collar is more than 12 in., the hot-collar deck flange must be supported by wood blocking that is secured to the structural deck. The hot collar is installed over the roof membrane, which is installed over the wood blocking. The metal flange is secured into the wood blocking with approved fasteners installed at the prescribed rate for the assembly.
- The hot collar is then flashed in a manner similar to that for the field-wrapped pipe condition (described previously).

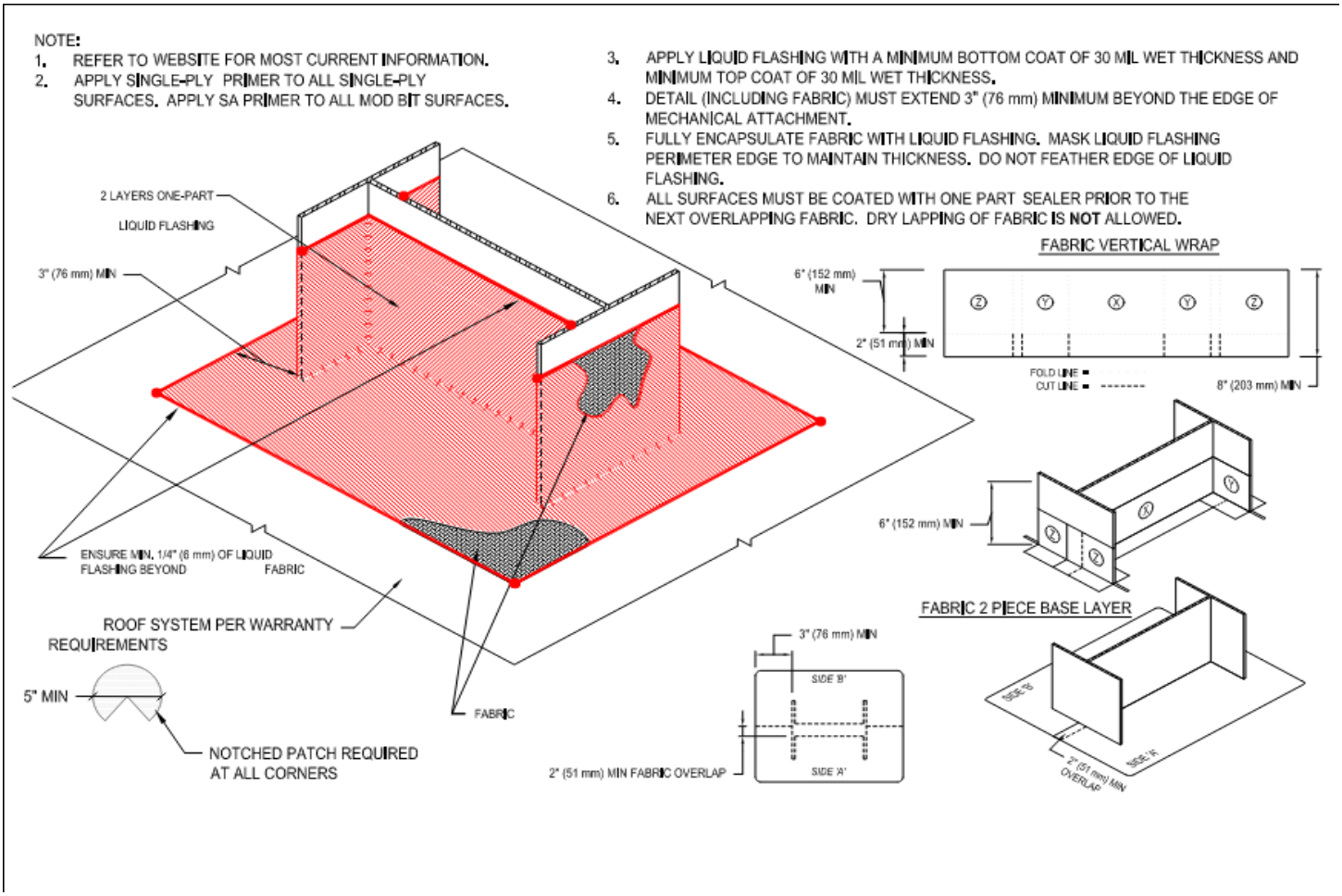

Figure 6. Standard detail for the installation of liquid-applied flashing on an I-beam.

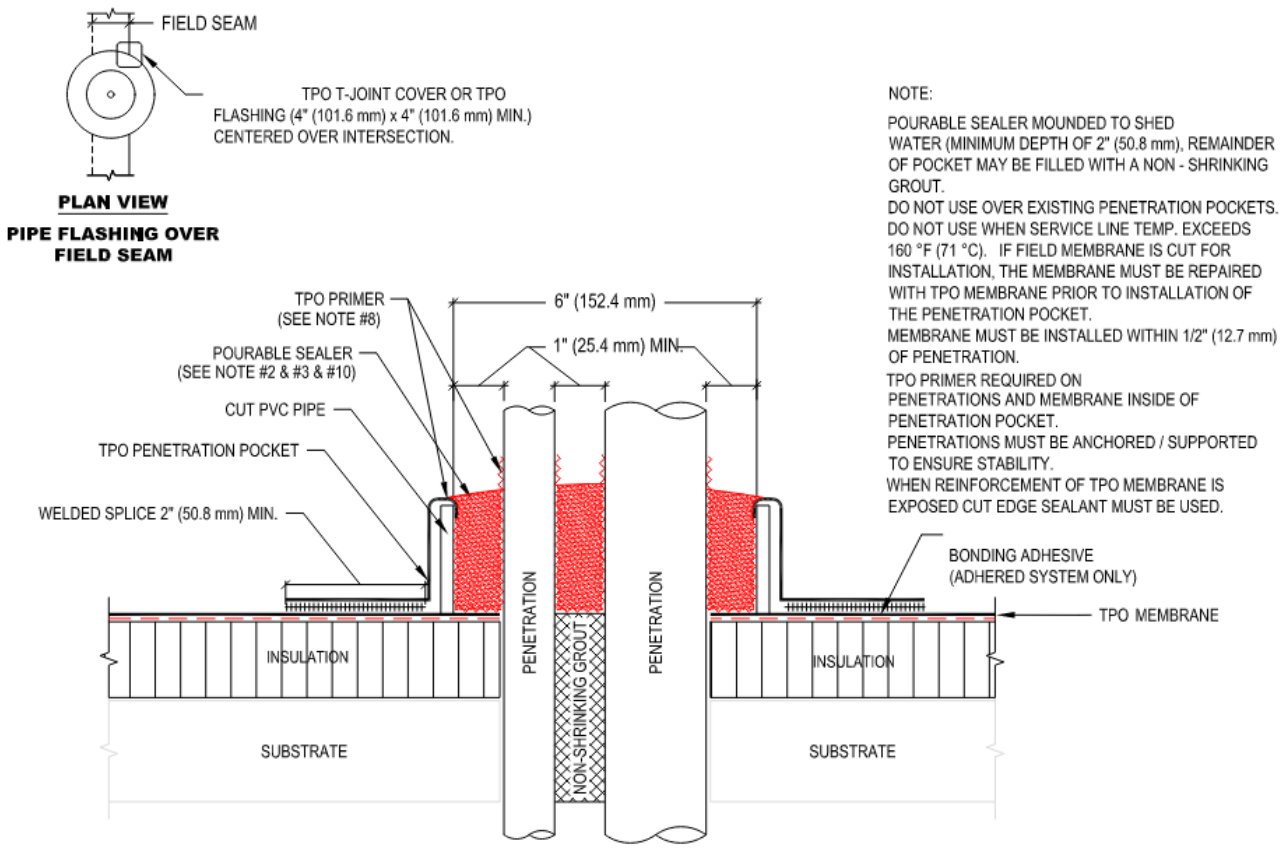

Figure 7. Standard sealant-pocket flashing detail.

- The hot-collar flange can also be installed onto the structural deck with the roof insulation, roof membrane, and flashings installed as shown in **Fig. 9**.

Expansion-Joint Flashings

This section focuses on expansion-joint details recommended by roofing material manufacturers. Many of the manufacturer-approved methods for incorporating their specific flashing materials in expansion-joint flashing assemblies are included in their roof system labor and material warranties. There are also many different models and manufacturers of aftermarket expansion-joint assemblies. Most of these would not be covered by the roof manufacturer's warranty and are not discussed here.

Roof-to-Roof Expansion Joints

Roof level–to–roof level expansion joints are among the most common types of roof expansion joints (see **Fig. 10**). Considerations and requirements for this detail are as follows:

- The roofing membrane must be secured to the structure or to wood blocking that is secured to the structure on both sides of the expansion joint.
- A vapor barrier or reinforced sheet good product that will support compressible or loose-fill insulation must be attached to the substrate. This insulation should be installed within the expansion-joint void in order to mitigate thermal loss and condensation issues at the expansion joint.
- The sheet good product and insulation must also support the foam backer rod. The backer rod diameter should be 1.5 times the width of the expansion joint so that it will not fall through the joint opening. The backer rod provides support for the roof membrane should any movement occur at the expansion joint. Closed-cell backer rod is recommended.
- The expansion-joint cover flashing must be wide enough to provide a hot-air weld that is at least 2 in. (50.8 mm) wide on either side of the membrane-securement fastening plates.
- If the expansion joint is longer than

Figure 8. Example of incorrectly installed sealant - pocket flashing. The sealant in the pan is not crowned, and the contractor did not prime the thermoplastic olefin membrane flashing or the pipe before installing the pourable sealer.

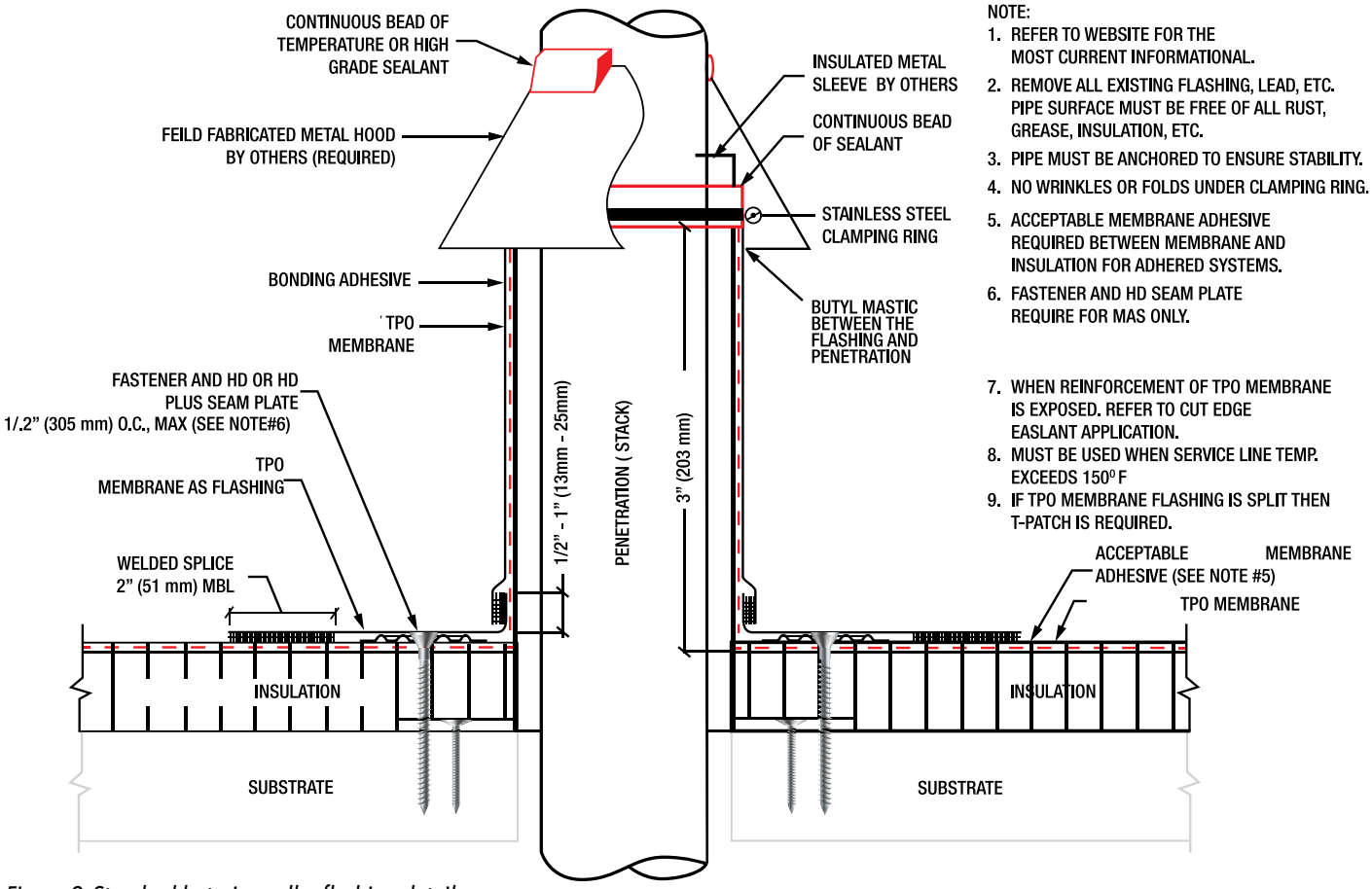

Figure 9. Standard hot-pipe collar flashing detail.

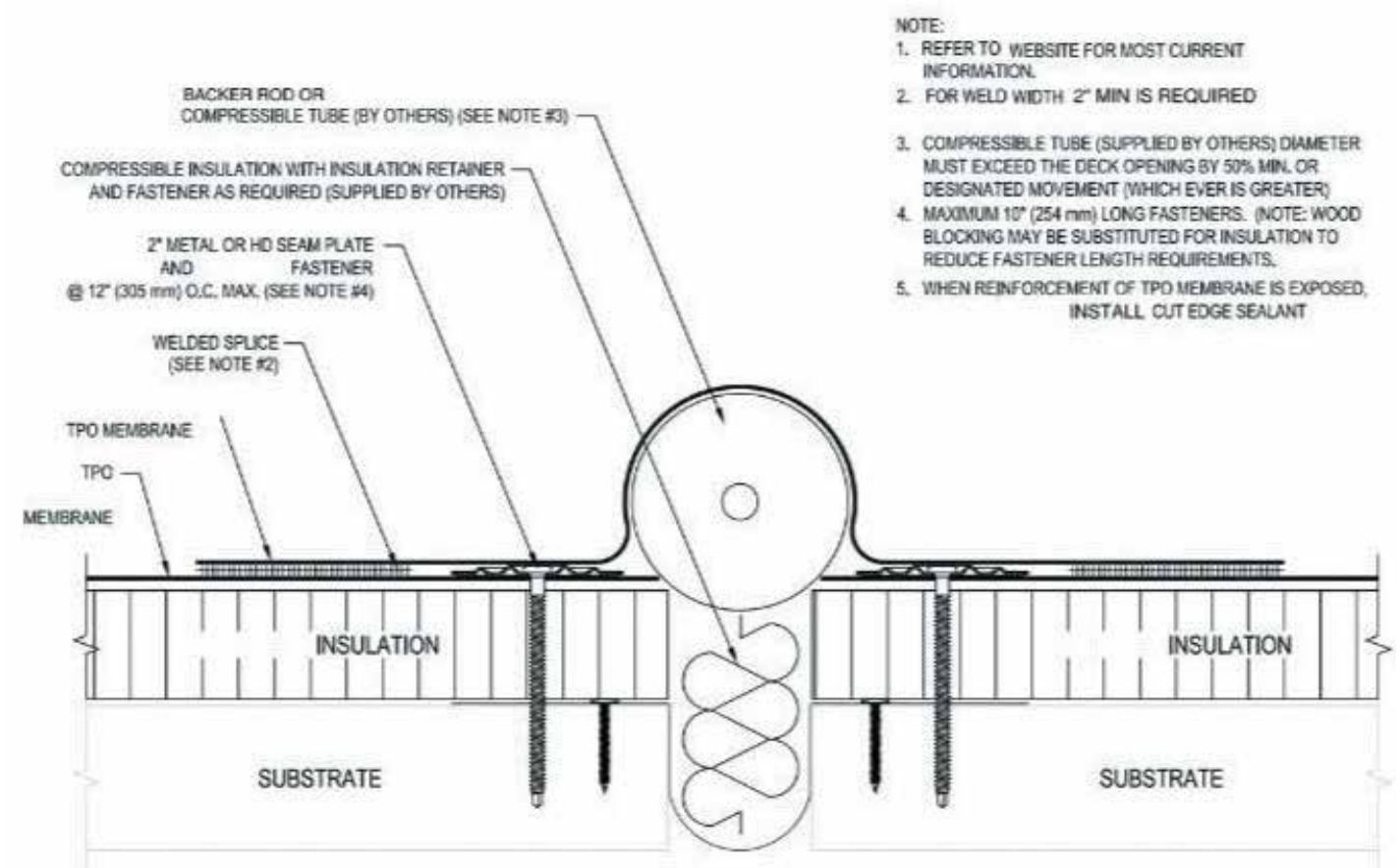

Figure 10. Standard roof-to-roof expansion-joint flashing.

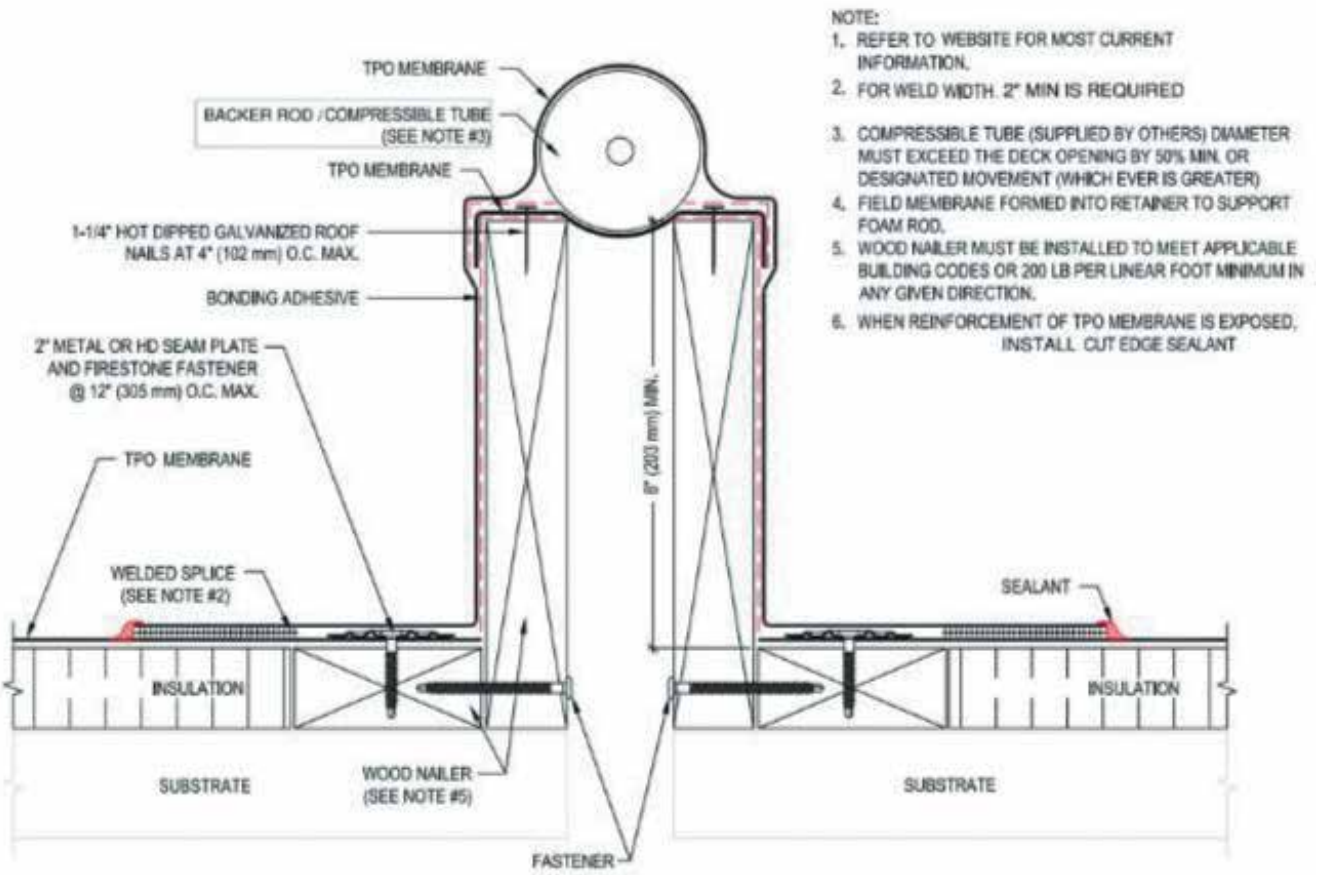

Figure 11. Standard curbed expansion-joint flashing.

standard length of flashing membrane, it is recommended to align the flashing pieces and complete the hot-air weld between the lengths of the flashing on a flat, fire-resistant surface before the cover flashing is installed over the expansion joint. Workers should not attempt to hot-air weld adjoining flashing sheets over the foam rod, as the hot-air-welding process can melt the foam backer rod, and the foam backer rod does not provide a suitably firm substrate for hot-air welding.

Curb-to-Curb Expansion Joints

The curb-to-curb expansion joint is another common type of roof expansion joint (**Fig. 11**). The considerations and requirements for this detail are as follows:

- The roofing membrane must be secured to the structure or to wood blocking that is secured to the structure on both sides of the expansion-joint curb.
- A vapor barrier or reinforced sheet good product that will support compressible or loose-fill insulation must be attached to the substrate. This insulation should be installed within the expansion-joint void to mitigate thermal loss and condensation issues at the expansion joint.

The roofing membrane must be secured to the structure or to wood blocking that is secured to the structure on both sides of the expansion-joint curb.

- The sheet good product and insulation must also support the foam backer rod. The backer rod diameter should be 1.5 times the width of the expansion joint so that it will not fall through the joint opening. The backer rod provides support for the roof membrane should any movement occur at the expansion joint. Closed-cell backer rod is recommended.
- The expansion-joint cover flashing must be wide enough to provide a hot-air weld that is at least 2 in. (50.8 mm) wide on either side of the membrane-securement fastening plates at the base of the expansion-joint curb.
- If the expansion joint is longer than standard length of flashing membrane, it is recommended to align the flashing pieces and complete the hot-air weld between lengths of the flashing on a flat, fire-resistant surface before the cover flashing is installed over the expansion joint. Workers should not attempt to hot-air weld adjoining flashing sheets over the foam rod, as the hot-air-welding process can melt the foam backer rod, and the foam backer rod does not provide a suitably firm substrate for hot-air welding.

Roof-to-Wall Expansion Joints

Roof-to-wall expansion joints are commonly used along transition walls (**Fig. 12**). Considerations and requirements for this detail are as follows:

- The roofing membrane must be secured to the structure or to wood blocking that is secured to the structure on the roof side of the expansion joint.
- A vapor barrier or reinforced sheet good product that will support compressible or loose-fill insulation must be attached to the substrate. This insulation should be installed within the expansion-joint void to mitigate thermal loss and condensation issues at the expansion joint.
- The sheet good product and insulation must also support the foam backer rod. The backer rod diameter should be 1.5 times the width

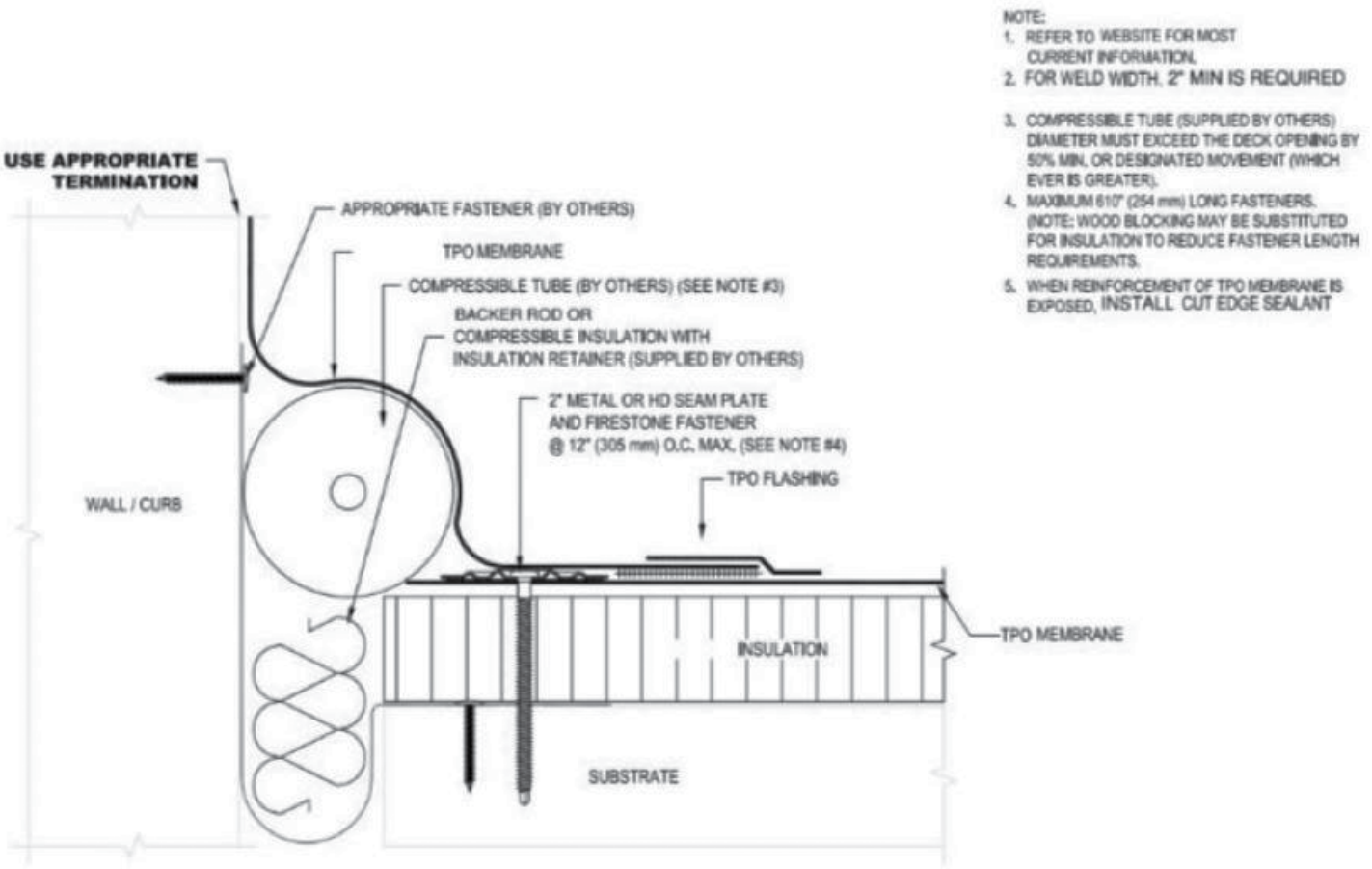

Figure 12. Standard roof-to-wall expansion-joint flashing.

of the expansion joint so that it will not fall through the joint opening. The backer rod provides support for the roof membrane should any movement occur at the expansion joint. Closed-cell backer rod is recommended.

- The expansion-joint cover flashing must be wide enough to provide a hot-air weld that is at least 2 in. (50.8 mm) wide on the horizontal surface of the roof outside of the membrane-securement fastening plates at the base of the expansion joint.
- If the expansion joint is longer than standard length of flashing membrane, it is recommended to align the flashing pieces and complete the hot-air weld between lengths of the flashing on a flat, fire-resistant surface before the cover flashing is installed over the expansion joint. Workers should not attempt to hot-air weld adjoining flashing sheets over the foam rod, as the hot-air-welding process can melt the foam backer rod, and the foam backer rod does not provide a suitably firm substrate for hot-air welding.

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