Waterproofing Roof Penetrations – New Solutions

By Lawrence Evensen

A combination of drawings and specifications encompass the requirements for a construction project. Although far more like a technical paper than a novel, these combined documents can in some ways be seen as the concise narrative detailing the design and construction of a project. The goal of the designer is to create comprehensive documents telling the building's "story." Unfortunately, some drawings and specifications leave out somany details that they read more like a Sherlock Holmes mystery, but without the "gotcha" finale to tie up the loose ends. This can be particularly true when it comes to roof penetrations.

In this case, the mystery is what component will provide a watertight assembly for each of the various penetrations shown on the roof plan. Without penetration details and complete specifications, the story is incomplete, and the roofing installer is left to assume unfair responsibilities or attempt to interpret the design team's intention.

An understanding of roof flashings and counterflashings and how they perform their waterproofing tasks is a necessity. This article concentrates on roof penetrations and the methods of installing the aforementioned products and systems to aid in comprehensive roof plans. Following some of the practices suggested in this article should result in a smoother-running construction project.

Specifying Dilemma

The building envelope designer must be extremely diligent when writing the specifications for roofing details, because the results of poor planning are confusion and a higher risk of litigation. A roof membrane is a watertight, nonpermeable cover unless damaged, penetrated, or bypassed. In a perfect world, roofing contractors would not have to deal with complications that typically arise during the construction process, and there would never be any leaks.

A dilemma is created for the design professional when other trades such as electric, refrigeration, structural steel, air conditioning, and other contractors install their products and break the watertight cover in some way. Only clearly written designs directed at each of the trades will place waterproofing responsibility in the hands of the individuals with the expertise and knowledge required to create failsafe waterproof penetration solutions. When the chain of responsibility for waterproofing a roof penetration is not clear, conflicts result, since most subcontractors are concerned with only the equipment or structure they have contracted to produce. It is imperative that subcontractors take responsibility for the roof penetrations they create and start caring about how their work affects the overall building envelope. Only clearly written specifications put the responsibility of proper waterproofing into the contracts of each of the responsible parties. If specifications and details are clearly defined in advance, the roofing contractor is not placed in the impossible position of creating details for penetrations that are proprietary to the various subtrades. Closing this gap goes a long way toward keeping water from bypassing the monolithic roof cover and keeps the lawyers at bay.

Flashing Basics

Over the centuries, roof construction has evolved to include two waterproofing techniques: flashings and counterflashings. These materials create a rise in the roof's membrane high enough to keep the elements from entering the waterproofing membrane, with a cover over the rise.

The roof-rise feature, or flashing, facilitates water runoff as long as weather conditions are not extreme enough to overflow the rise. The cover of the flashing or counterflashing is designed to allow water to shed over or around the flashing opening. There are many classes of roof flashings and counterflashings, including those products specifically designed for:

- Bases,
- Chimneys,
- Copings,
- Eaves and fascias,
- Valleys, and
- Roof penetrations.

For each class of flashing, the law of gravity and the rules of physics for the water's flow are the same. The roof flashing is constructed to rise higher than the highest expected water level from a weather event and is counterflashed to cap its opening, allowing gravity to direct water away.

Potential Problems with Penetration

Flashings for roof penetrations, projections, and equipment stands are designed with the flashing/counterflashing methodology. Pipes, conduits, vents, and support legs use a sleeve or "jack" flashing to create the rise in the roof's level.

As a general rule of thumb, roofing product manufacturers follow the guidelines of the National Roofing Contractors Association's (NRCA) *Roofing and Waterproofing Manual*. In the third edition of its "Handbook of Approved Roofing Practices," Sections 1 and 2 recommend using a metal flashing or inserting roof jacks into the membrane for projections through the roof's membrane no lower than 203 mm (8 in), and no higher than 356 mm (14 in) above the finished roof level on low-slope roof applications. In the 2007 *Roofing and Waterproofing Manual*, the verbiage has been replaced by a detail drawing. The notes on the detail include the following: "Penetration pockets are not the preferred flashing method at the penetrations because they may be a constant maintenance problem." (See *Figure 1*.)

Steep-slope roof applications can have a rise as minimal as 63.5 to 76 mm (2.5 to 3 in), since the grade virtually guarantees that a water event will not be high enough to overflow the flashing, even in extreme weather conditions.

Many penetrations through a roof covering can be waterproofed using the respective manufacturer's standard details. Round penetrations—such as plumbing vents, electrical conduits, HVAC chiller lines, domestic water lines, and natural gas pipes—can be matched to a pipe flashing jack with the proper outside diameter. Nearly all designers call out a flashing method at these locations.

It is the responsibility of the general contractor to ensure the appropriate installer provides properly sized flashing for each of the roof penetrations on a project. However, when the roof penetration is not a standard round geometry or is not detailed on the drawings, or when subcontractors do not provide the

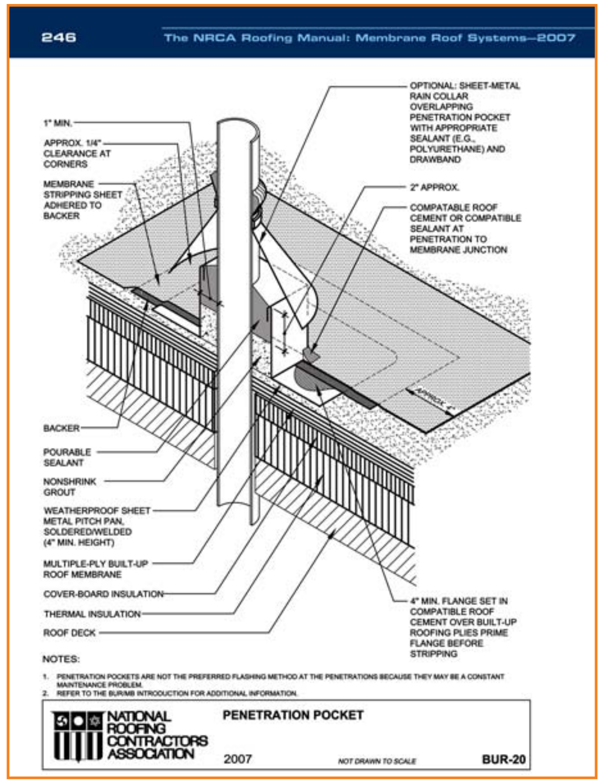

Figure 1 – NRCA penetration pocket drawing.

Photo 1 – Front of St. Luke's Outpatient Center.

necessary flashing as part of their work, the roofing professional is forced to create a waterproofing detail on the fly. This is complicated by the great variety of structures and mechanical devices used on a roof.

For example, many structures have equipment located on the roof. For safety or aesthetic reasons, this equipment is often hidden behind screens. The screens are built out of very solid materials (e.g., structural steel) to ensure the capability to withstand high wind loads. It is not unusual for equipment screens to employ several hundred roof penetrations made from square, angle-iron, or H-beam steel. The use of nonround steel support structures at these locations makes standard details difficult to write, creating a problem for the roofing contractor that can be especially complex to solve.

Help From Above for St. Luke's

To better understand the need for clarity in waterproofing specifications, it can be useful to see the lessons learned from a previous project. St. Luke's Outpatient Center is a new medical facility located in St. Louis, Missouri (see *Photo 1*). In late 2007, Ryan Freeman, the job superintendent of McCarthy Building Companies, discovered the roof details provided by the roofing material's manufacturer were inadequate. He was faced with 120 steel support posts (102 or 152 mm [4 or 6 in] tall) that were part of the equipment screen. If the posts were improperly waterproofed, the leaks would have been numerous.

The flashing detail included a site-fabricated flashing to be created by the roofing crew out of the white, single-ply roof product. The plan was to make the flashing, seal the top edge against the steel post, and draw it tight using a stainless-steel band clamp. The problem with this technique is that no matter how much torque is applied to the clamp, there will be loose gaps on the flat part of the square post. Square pegs do not fit in round holes.

In search of a better solution, Freeman contacted RNC Enterprises' Ron Carter, a local technical advisor for innovative construction products. Carter suggested installing storm collars over the field-fabricated flashings to provide the waterproofing that each square post required. (NRCA approves storm collars for this design purpose.) The steel support posts had already been installed, so any counterflashing would need to be a retrofit design.

Choosing the appropriate product was the next challenge. Any storm collar used for these posts had to fit certain design criteria. The storm collar needed to be:

- A retrofit design (as the equipment screen posts had already been installed),
- Installed using the existing roofing crew labor,
- Made of a material compatible with the metal posts, without worry of corrosion to the post or structure,
- Free of sharp edges,
- Able to spring back into place in the event of disturbance by workers or pedestrians walking on the roof, and
- Aesthetically in line with the building's white roof covering.

Additionally, the storm collars had to have a life expectancy of at least 20 years, the intended duration of the roof.

Carter used retrofit storm collars made of ethylene propylene diene monomer (EPDM) rubber as the counterflashing. By ordering these products with square cutouts sized exactly to match the metal posts, he ensured that the storm collars were suitable for the field-fabricated roof detail. There were neither corrosion compatibility issues nor sharp edges. Further, if the rubber is impacted by pedestrian traffic, it bends and springs back automatically. Installed using a simple nut driver, the "off-the-shelf" collars can open up to wrap

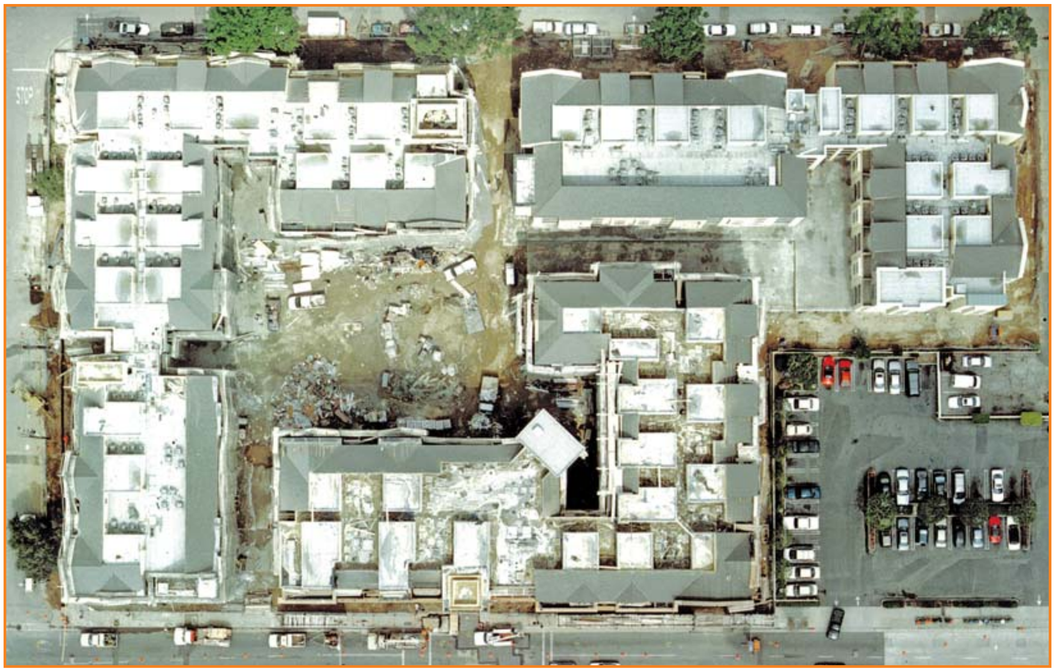

Photo 2 – Trammell Crow Residential project in Pasadena, California, seen from the air.

around myriad geometric shapes while creating the rise in roof level needed.

A/C Specifications Are Not Always Cool

By utilizing the same roof rise and cover technique, one can write almost all other odd or difficult roof penetration waterproofing specifications.

The luxury apartments built by Trammell Crow Residential at the corner of Walnut Street and Colorado Boulevard in the city of Pasadena, California, provide another example that illustrates how a common problem can be solved. The project includes 265 dwellings that are cooled using individual split central air-conditioning systems. (See *Photo 2*.)

A split system is made up of two copper refrigerant tubes that are connected to an indoor coil and an outdoor condenser heat-pump unit. The smaller of the lines is called a liquid line and the larger, a suction line. The lines are filled with a chemical refrigerant, which has a boiling point low enough that it evaporates at relatively low temperatures and takes heat and moisture out of the air as it passes through a coil that is installed inside each apartment dwelling. The refrigerant travels in a closed loop between the coil and the rooftop condenser.

In addition, a low-voltage wire inside a watertight conduit provides an electrical connection from the coil to the outdoor condenser. The two tubes and conduit combination creates a tightly grouped roof penetration called a "line set." (See *Photos 3* and *4*.)

The 265 heat-pump condenser units on the Trammell Crow project were mounted on platforms located on the flat areas of the multistory buildings' roofs.

Line sets are a prime source of water intrusion, because it is extremely dif-

Photo 3 – Closeup of a line set at the Trammell Crow project.

Photo 4 – Split central air-conditioning units on the Trammell Crow roof.

ficult to seal between the groups of tubes. As a further complication, the large suction-line tube is always insulated with soft foam as an energy conservation measure. Water that gets inside the insulation follows the tube like a highway through the walls of the building, ultimately creating leaks in apartments. The Walnut Street project had first-floor apartments five stories below the roof decks, so a leak at the ground floor could create hard-to-identify, longterm problems. Line sets need to be waterproofed!

Photo 5 – Worker with 12-inch collar on equipment screen footer.

Photo 6 – Close-up of 6-inch, angled storm collar.

EPDM storm collars again offer ideal solutions for this roof penetration problem. In this case, the rise in the roof level was created using a standard 37-mm to 50-mm (1.5-in to 2-in) diameter lead-pipe flashing jack and covering the rise with an EPDM-molded storm collar. The factory-made storm collars are pre-engineered to accept three closely grouped tubes and include two 20-mm (7/8-in) and one 10-mm (3/8-in) nipple holes. When the three independent components of the line sets pass through nipples molded into the rubber collar, each is separated and secured by a stainless-steel hose clamp. A bonus of using rubber is that the assembly has no bimetal contact and zero corrosion potential. (See *Photos 5* and *6*.)

After demonstrating the storm collars to the roof consultant and roofing manufacturer's technical team, Joe Daniels, owner of D7 Consultants, Newport Beach, CA, said, “These provide a simple solution to a common problem we find on the roofs we work on. Let’s use them.” The storm collars were approved.

A plan was put in place to have each line set enter the building through lead-pipe flashings, each with 200-mm- (8-in) high risers that were installed into the roof system following the manufacturer’s standard construction details. The roof installed was a CertainTeed specification number N-N-B5, 5-ply, built-up, smooth-surfaced roof installed over a protective layer of rosin sheet. Because the team used CetainTeed installation details CT-11 or CT-12, the roof flashings were installed in a watertight manner, and the result was a specification that allowed issuance of the manufacturer’s 20-year warranty.

After the roof jack flashing had been completely installed, the rubber storm collars were placed down onto the copper tubes by way of the premolded nipples. The storm collars were located over the already installed lead flashings, and the stainless-steel hose clamps on each of the three nipples permanently secured the storm collars as covers over each flashing. Line set storm collars created a waterproof counterflashing umbrella for any type of pipe jack, keeping the water on the roof.

Conclusion

The NRCA recommends metal flashing or roof jack insertion into the membrane for projections between 203 and 356 mm (8 and 14 in) above the finished roof level. These flashing jacks can be fabricated from many classes of materials, including lead, steel, aluminum, and even single-ply materials. (The material used is often determined through manufacturer preference, design/construction professional experience, compatibility, aesthetics, and cost.) All that is required is a storm collar that attaches to the penetration or group of penetrations, which acts as the counterflashing atop the flashing jack.

The installation of retrofit and standard storm collars to solve these waterproofing problems is an example of how innovative products can improve roof penetration details. By adding storm collars to the roof plan, each penetration becomes manageable, taking the mystery out of inadequately written details.

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