Roofing Screws

Figure 1: Metal Roof Made to Look Like a Tile Roof

Although metal has been a material option for roofs for hundreds of years, because of challenges posed by high cost, lousy appearance, and poor longevity, it has only recently become a feasible mainstream choice. In fact, today in the United States metal roofing represents one of the fastest growing areas in the residential roofing segment. It is now possible to choose from a selection of metal roofing solutions that either provide large, continuous panels or metal alternatives to traditional roofing materials such as slate, tiles, shakes, and shingles in attractive designs and at affordable prices. Although some of these solutions are more expensive in the short-term than their traditional roofing options, their superior durability and life expectancy makes them a smarter long-term investment. Of course, like any roofing material they must be securely fixed to the roofing substructure to protect the interior spaces below. Since metal roofing solutions exhibit their own unique qualities and challenges, many of these solutions require special or different fasteners from nails and staples used with traditional roofing solutions. As metal roofing has grown then, so has the need for innovation and engineering in the fasteners for this market space.

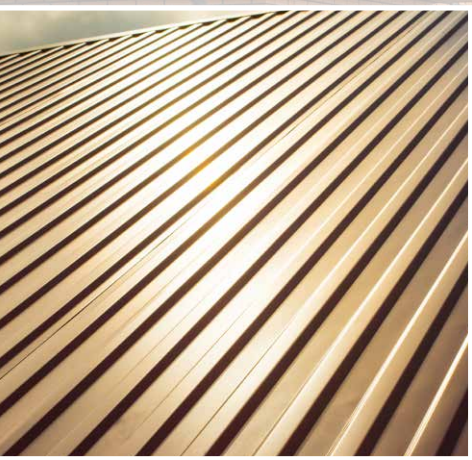

Figure 2: Example of a Standing Seam Roof

Figure 3: Installation of Exposed Fastener Metal Roof System

Metal Roofing

Metal roofs can be classified into three distinct categories: Exposed Fastener Panel Type, Standing Seam Type, and Specialty Panel Type.

- **Specialty Roofing Panels:** These include both small and large metal panels that have been fabricated to reproduce the look of ceramic tile, slate, shakes, and shingles (See Figure 1). Just like the items they are made to mimic, the panels are fastened at their top and the attaching fasteners subsequently hidden by the next panel above. These types of systems normally do not require specialty fasteners and often use the same or similar fasteners to the ones utilized by the traditional products they replace.
- **Standing Seam Systems:** Standing Seam roofs are connected to the roof substrate by hidden clips. These clips are screwed to the substrate, often with special low profile head screws, but without regard to special sealing because the screws are covered with the roof panel and thus not vulnerable to water intrusion and exposure (See Figure 2). Panels are interlocked together at the seams. Metal roofs undergo considerable expansion and contraction from changing heat and cold conditions. Because a Standing Seam Roof essentially "floats" over the roof substrate there is no limitation in the length of the roof panel, and they often are seamless and uninterrupted. Standing seam roofs cost more to install but have a cleaner look and, more importantly, last longer.
- **Exposed Fastener Systems:** Exposed Fastener System roof panels are installed directly into the roof understructure and are the most economical of all the metal roofing types (See Figure 3). The fasteners must be able to pierce the metal roofing panel and self-tap into the supporting understructure. For this reason, there are different versions for wood and metal connections. Since the fasteners are exposed on the surface of the roof, they must also have the capability to seal the penetration from water intrusion. The screws used in this method normally possess an external hex flange or washer head with a bonded EPDM or Neoprene washer. The heads and washers are usually painted to match the color of the roofing panel. When properly installed the washer is compressed to form a tight seal around the roof penetration. Since the panels are constrained by the fasteners holding them down and the metal panels undergo significant expansion and contraction with temperature changes, roof panels are usually limited to no longer than about twenty-five feet (about eight meters) in length. Therefore, they may be overlapped over long spans.

Roofing Materials

Today there are a variety of material choices. When properly installed some of these materials are known to last a hundred years or more.

- **Steel:** Steel is the strongest and least expensive metal roofing material. It is usually galvanized or coated with an Aluminum-Zinc alloy called Galvalume and then painted. Steel roofing panels will generally last 30 to 50 years.
- **Aluminum:** Aluminum is lighter, softer, and more expensive than steel but will withstand the elements better than steel, especially in areas of salt air or acid rain. Aluminum roofing panels are almost always painted and will last 30 to 50 years.
- **Copper:** Copper is the longest lasting, most expensive, and perhaps most attractive of the metal roofing material choices. Copper forms a natural patina over time and copper roofs have been known to last up to 200 years.
- **Terre:** Terre used to refer to a roof made of tin with a lead coating. Today it is stainless steel that is sandwiched between layers of tin. It does not hold paint but can last more than one hundred years.
- **Zinc:** Zinc is often alloyed with Titanium for added strength and corrosion. It will last 80 to 100 years.

Challenges

Although all three metal roof types exhibit application challenges, the exposed fastener system exhibits the greatest challenge related to the fasteners. Thus, purchasers of these systems must wrestle with the question of whether the added cost for premium longer lasting solutions is justified while installers must be very careful and intentional about how they install the fasteners that are specified. To perform properly, some of the fastener challenges that must be overcome with exposed fastener systems are:

- **Condition of the Seal:** The screw must be able to cleanly penetrate the metal panel and generate an effective and long-lasting seal. Screws that are installed off-angle, under tightened, or over tightened may upon installation or over time begin to leak. Thus, a successful roof seal is not only a function of how well the installer seats the screw but often also a function of the screw design, quality of manufacture, and type of sealing element.
- **Sealing Material:** Sealing washers come in two varieties and two different materials, bonded and non-bonded washers and EPDM (Ethylene Propylene Diene Monomer) and Neoprene materials. A bonded washer is one where the rubber gasketing material is bonded (adhered) to the bottom of a slightly beveled metal washer (See Figure 4). The ID and OD of the rubber gasket are slightly smaller than those of the metal washer it is attached to. This provides an overhang at the outer edge protecting the gasket from UV rays and a small amount of interference from the ID to retain the washer to the screw and to guarantee a tight seal around the screw itself. During installation, the bevel in the metal washer flattens providing an even stress distribution across the surface of the rubber washer. This prevents the screw head from embedding into the washer and squeezing out at its periphery. This is particularly advantageous because when overtightened the rubber gasketing material will want to creep away from the ensuing stress concentration which contributes to loss of clamp load and sealing capability.

Figure 4: Example of Bonded Dealing Washer

Figure 5: Example of Corrosion to the Roof Panels Around the Fastener

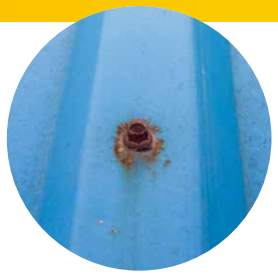

Figure 6: Example of Corrosion to the Head of the Fastener and the Metal Roofing Panel

Bonded washers can also be larger in diameter because the metal washer is able to distribute pressure over its entire area. This provides a greater sealing area and makes it harder for water to penetrate the roof panel. Non-bonded washers are limited in diameter by the size of the bearing diameter of the hex flange or washer head or, when utilized, a head cap. Both EPDM and Neoprene are good choices for roof sealing, although EPDM is considered superior since it has better heat, light, and ozone resistance than Neoprene.

- **Embrittlement of the Sealing Material:** One of the challenges of using Neoprene and EPDM sealing material is vulnerability to environmental exposure. These materials are susceptible to temperature changes and get stiffer in the cold and creep in the heat. Prolonged exposure to such temperature cycles eventually weakens the gasketing material. Worse than the temperature cycling, however, is the exposure to UV radiation. These materials are embrittled by UV rays so that the unprotected periphery that is exposed ultimately breaks down and potentially opens pathways for water intrusion.
- **Damage to Sealing Material:** Burrs and debris that are created when the screws pierce the roofing panel can tear the gasketing material creating pathways for water intrusion. It is important, therefore, that the screws be designed with sharp and efficient piercing points that either prevent or minimize the creation of burrs.
- **Corrosion and Head Appearance:** Exposed screws must be durable so that they do not corrode while in service. Screws that begin to rust will, in the best case, be unsightly against the uncorroded roof panels but, in the worst case, begin to weep and leave streaks or stains of rust from each fastener. Additionally, care must be taken in proper fastener material selection to prevent negative galvanic interactions with some of the roof panel material types. Galvanic corrosion can result not only in corrosion to the fastener, but depending on the metal pairing, to the roof panel. Once again, this could result in unsightly corrosion but also damage to the roof panel around the screw, opening leak pathways (See Figures 5 and 6). Head appearance is also important and usually screws are painted to match the color of the roofing panels. Not all paint is the same, however, with liquid applied paint being far less durable than powder coated paint. Paint type is important because paint methods that provide poorer adhesion may be vulnerable to damage during installation which can lead to premature corrosion.

Screws

- **For Wood Applications:** Screws for wood applications may be made of either hardened carbon steel or stainless steel. Naturally, the stainless steel variety has superior corrosion resistance to those made of carbon steel. However, the austenitic grades of stainless steel make poor choices for self-drilling or self-piercing points. Therefore, many of these roof screws may be made of the stronger but poorer corrosion resistant 410 martensitic stainless steel. Screws for wood to metal applications usually have either a sharp Type #17 point or a small #1 drill point. In either case, the point provides sufficient piercing capability to make it through the thin roofing panel but not enough strength to pilot holes in thicker metal trusses and purlins. These screws are usually Hi-Lo or spaced high-thread styles of threads for easy tapping into wood. Head styles are shared between wood and metal applications with the most common head form being hex flange or washer head varieties.
- **For Metal Applications:** Screws for metal applications are usually either hardened carbon steel or bi-metallic. Since stainless steel does not perform well in drilling through thicker metal, screws entirely made of stainless steel are seldom used in these applications. Instead drill point screws made of carbon steel are most common. There is a drill screw variant, however, that is bi-metallic with the upper body and head made of stainless steel and the drill point and thread forming zone made of hardened carbon steel. These are produced by friction welding the two materials together. The lower half is hardened carbon steel and houses the drill point and thread forming threads while the upper half is stainless steel and houses the upper threads and head. Screws for metal applications usually come with either a #3 or a #5 drill point. The #3 point is capable of self-drilling thicknesses up to 0.210" and a #5 capable of 0.500" thick material. Like screws for wood applications the heads are usually either a hex flange or hex washer head design.

Figure 7: Example of Roof Mounting Solar Fastener System

Sealing Washers

- **Non-Bonded:** A Non-bonded sealing washer is simply a washer of EPDM or Neoprene. It can be slipped onto the screw and retained by making the ID of the washer a little smaller than the OD of the screw. These washers perform similarly to an O-ring except that the cross-sectional geometry of these washers is not narrow and round like an O-ring but flat and rectangular like a flat washer. These washers rely on the underhead bearing surface of the screw to distribute load and compress them. With the head of the screw providing the only protection from exposure, they are more prone to potential embrittlement from UV rays.
- **Bonded Washers:** A bonded washer adheres the EPDM or Neoprene washer to the underside of a flat or slightly beveled metal washer. The metal washer is slightly larger in OD and ID, so that the smaller rubber washer ID retains it to the screw and the slightly larger OD of the metal washer protects the rubber washer underneath from most UV exposure as well as providing more evenly distributed compression. Naturally, bonded washers are more expensive than the non-bonded variety. However, neither is completely effective in protecting the rubber washer from exposure to the elements and, most importantly, from UV radiation.
- **Capped Heads:** Although technically not a washer, there are some premium roofing screws that have added a zinc-aluminum alloy or stainless-steel cap to the head. These oversize caps serve not only to improve the corrosion resistance of the hardened carbon steel screw below, but they fit over the rubber washer completely encapsulating it from the surrounding environment. In this way it is pretty well protected from the elements and far less prone to embrittlement.

Solar Fasteners

Increasingly solar panel installations are being made on residential and commercial buildings these days. Although the screws associated with mounting these solar voltaic panels are completely independent of the screws used to fix the roofing panels, it is worth a mention here. Like roofing panels, roof mounted solar panels must be firmly fixed to prevent them from being damaged or torn off in a storm or by gusting winds. Therefore, the panels are fixed to a framework of mounting rails. These rails must be rigidly fixed to the structural underbody of the roof. The screw systems that typically make up this mounting hardware are a sophisticated combination of screw, sealing washer, bracket, and mounting nut (See **Figure 7**). Like the roofing screws described above, the screws in these systems are also designed with self-tapping threads and self-piercing or self-drilling points to effectively work in wood or steel. Although usually much larger in diameter than the screws for fixing roofing panels, these screws often are bi-metallic to provide hardened carbon steel on the portion of the fastener going into the roof substructure and stainless steel for the portion extending above the surface of the roof. Like the exposed fastener screws, these fasteners have a sealing washer to seal the roof penetration from water intrusion.

Wrap-up

Exposed metal roofing screws, although simple in concept, must address multiple challenges. Like many similar fastening situations, there are multiple choices for a user to make, and various levels of performance that can be achieved. The user, therefore, must educate themselves on whether it is wiser in the long run to purchase a more premium fastener for the initial installation and avoid potentially costly rework later in the life of the roof or use less costly fasteners to ease the cost of roof installation. In any event though, there are many choices and those producing, purchasing, and installing these fasteners should know a little bit about them to be able to make the most informed choices on how to proceed. ■