

WHITE PAPER



Part 1: Metal Roofing from A (Aluminum) to Z (Zinc)

History and Materials

The roots and technology of metal as a cladding material date back to Biblical times. It has always been coveted as a premium roofing option but, historically, has been handicapped by a generally higher initial cost than many other options. Today's trends point toward evaluating the long-term costs of owning a roof as more landfills are overburdened with former building components that were discarded because of shortsighted budget-conscious building objectives. The life-cycle costs and environmental appeal of metal truly have some advantages.



▲ A lead roof was chosen for this cathedral in Köln (Cologne), Germany. The cathedral was built in the 13th century.

As metal roofing gains popularity and is specified for more projects, inevitably more failures will occur because of misuse or some perception that metal is magic and will do anything. While material

failures are highly unusual, the common pitfalls are inappropriate product selection to suit job specifics and misapplication of the selected products.

Using metal roofing systems involves a good deal of science, so making uninformed design decisions about materials and systems is a bit like playing Russian roulette. Some knowledge and understanding of basic elements of system design, material selection and installation will certainly improve the odds for a successful roofing project and a satisfied (and dry) customer for many years to come while (hopefully) reducing gainful employment for a slew of trial lawyers.

Choosing Metal

One of the first issues to address is what sort of metal should be used. There are a number of choices available, including copper, terne, aluminum, stainless steel, carbon steel, zinc, lead and even titanium. All have pros and cons.

Some soft metals—copper, lead and terne-coated stainless—can have a life expectancy measured in centuries. They also carry a premium price tag and call for a high degree of fabrication and installation skill. I refer to these metals as “crafted roofing” metals. They are favored over coated steel in most of Western Europe. They are also favored here in the U.S. for high-end and historical applications. Their inorganic surface finishes and oxidation characteristics give them timeless beauty and maintenance freedom not enjoyed by organic finishes (painted metals), and they are easily solderable.

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Zinc

Titanium zinc, the soft, gray metal that enjoys immense popularity in Germany and other European nations, is also increasing in popularity here. It is a crafted metal and available in different surface finishes, including pre-weathered. Popular thicknesses are 0.7 mm and 0.8 mm.

Zinc requires some special considerations in fabrication to avoid fracturing of the finished product, as well as care in detailing and underlayment, because the material has a low tolerance for subsurface moisture. Zinc is also easily soldered, but be careful—its melting temperature is much lower than other solderable metals. With appropriate precautions, zinc can have an expected life of nearly a century. ASTM B69 “architectural rolled zinc” is the specification reference for zinc sheet.

Terne

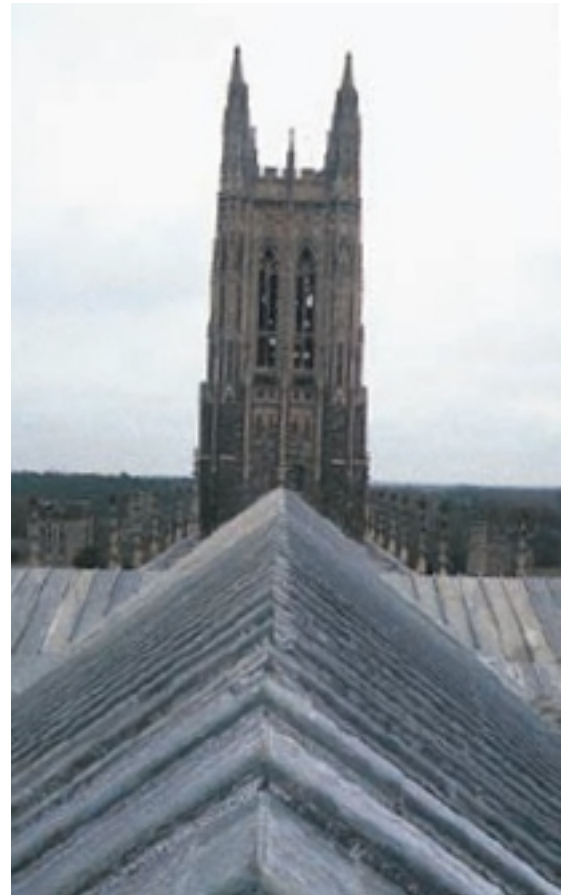
Terne has a life expectancy greater than many other options and a moderate cost, but it requires repeated maintenance (painting). Many early 20th century terne roofs can still be seen all over the eastern U.S. Use of this tin-lead alloy coated steel is responsible for the popular misnomer, “tin roof.”

Terne-coated stainless requires no maintenance and is a solderable material, but it bears a very hefty pricetag as does zinc, lead, titanium and lead-coated copper.

Terne is most commonly used in 28 and 30 gauge, while 26 and 28 gauge are most common for terne-coated stainless. Terne falls under the carbon steel classification of ASTM 625; terne-coated stainless is ASTM A240. There are no federal specification numbers for either of these metals.

Lead

Lead is one of the longest-lasting metals known to man and has been used for more than a millennium on some of the most elegant castles and cathedrals throughout Europe. It may well outlast any other roof type, metallic or not, even in a salt-spray



▲ Lead-coated copper, one of the longest lasting metals, covers the roof of the chapel at Duke University.



▲ Greater detail and weather integrity can be accomplished with soft-crafted metals as shown on the Kronborg Castle in Denmark.

environment. But lead has a very high thermal coefficient and significant weight, so it must be appropriately designed. The most popular lead applications are “batten-roll” profiles using gentle, radiused folds and joints. Lead has many unique qualities and installation methods. “Lead burning” is practiced by fewer mechanics. Because of these facts, lead’s high cost and the bad rap it is receiving from environmental protagonists, the application of sheet lead is becoming a lost art in North America. It’s a pity. Metals like terne, copper and stainless, which have typically offered lead or lead alloy coatings, are now using other alloys like tin-zinc to have more “politically correct” public appeal.

Copper

Architectural copper is specified as ASTM B370 and lead-coated copper is ASTM B101. Copper is designated by the ounce-weight, or the weight of 1 square foot of copper in ounces. A 12- by 12-inch piece of copper may weigh 12 to 48 ounces, depending on its thickness. The most common roofing sheet is 16 or 20 ounce; 16-ounce is 0.0216 inches in theoretical thickness while 24 ounce would be 0.0323 thick.

Titanium

Titanium is an option that has recently found its way onto the roofing materials list through its use on the high-profile Guggenheim Museum in Bilbao, Spain. It is unique in appearance; has an inorganic finish; features a thermal coefficient even lower than steel; and offers incredible strength, durability and corrosion resistance. It also has an elite price tag above other metals and only one domestic producer, but it will almost certainly grow in use as more designers learn of its benefits.

The reference number for architectural titanium is ASTM B265 and the most commonly used size is 28 gauge in 4-foot widths. It is also available in coils and custom lengths.



▲ The Dome of the Rock, finished in 691 following the Arabian conquest of Jerusalem, is believed to have originally donned a gold roof. It is now gold-leafed aluminum.

Aluminum

High-tensile aluminum is more affordable as a base metal. It also offers some structural capabilities, but has an extremely high coefficient of expansion, which causes a great deal of thermal movement. Still, this material is a cost-effective alternative for salt-spray coastal environments, as well as acid-rain environments where the longevity of coated-steel alternatives may be a bit lacking and budgets do not allow lead or lead-coated alternatives.

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Although it is preferred for salt-spray and acid-rain environments, the detailing must provide for increased thermal movement, and fabrication methods must allow for its more brittle behavior. Aluminum is easily painted by modern coil-coating methods; organic color finishes can be provided at moderate added cost. Another benefit of this metal is that its installation practices are generally consistent with those of coated-steel products; therefore, the availability of installation contractors is widespread.

Aluminum is specified as ASTM B209. The most common thickness for roofing is 0.032 inches

with 0.040 inches running a close second. The most common sheet alloys are 3004 and 3105, and the tempers for these alloys are 3105–H14 and 3004–H36.

Steel

Of all the available base metals, steel is the lowest cost and has excellent structural characteristics. Because steel rusts, a protective coating must be selected. Coated carbon steel is the most common choice for metal roofing in North America, primarily for economic reasons. It is only logical, then, that significant development and improvements for metallic coatings used on carbon steel have originated here in the U.S.

This does not imply that other materials do not have their place. In fact, when asked “What is the best roof on the market today?” my response is, “Lead, lead-coated copper or titanium on a 12:12 slope.” This response is not often debated in terms of accuracy but often frustrates the inquisitor because such slopes are rather uncommon and few budgets permit the use of these materials.

Because steel dominates the U.S. market at ratios of about ten to one, let’s focus on the alternatives available when using steel, such as gauge, coating type and coating weight.

The most common gauge thickness used in the commercial roofing market-place is clearly 24, although 26 is used on rare occasions. Because stringent wind test standards (such as ASTM E1592, and the new FM 4471) emerged following Hurricane Andrew and others, we also see more 22-gauge material being used. (The lower the gauge number, the thicker the material: 22 gauge is 0.030 inches minimum in thickness, 24 gauge is 0.024 inches and 26 gauge is 0.018 inches minimum.)

Many contractors and designers believe that, increasing, the thickness will alleviate the problem of “oil canning,” which is a rippling effect in the panel surface caused by stress. It is most pronounced in very flat panels with wider covering dimensions. The stresses that produce oil canning

are caused by a number of factors of which few, if any, have to do with the thickness of the metal. Hence, increasing thickness adds significant cost but may not eliminate the problem. A more cost-effective approach to resolving the potential for oil canning involves:

- Reducing panel width
- Working with a reputable manufacturer
- Using well-tuned roll forming equipment
- Using a panel profile with stiffening flutes in the flat area, if not objectionable
- Insisting on tension-leveled coil stock with close camber and flat-ness tolerances
- Ensuring there is adequate provision for thermal movement within the system’s design and installation
- Being sure the structure and/or deck is smooth and true-to-line

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Another little trick that can be used in architectural installations over a wood deck is to install a strip of backer rod between the deck and panel to cause the “flat” of the panel to arch slightly between seams. See the MCA Tech Bulletin



▲ The Roskilde Cathedral in central Denmark date back to 1170 and features a lead roof.

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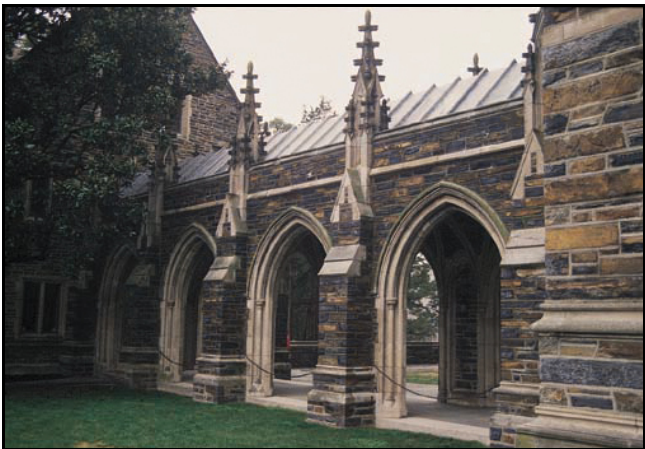
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Other specified variables in steel procurement involve tensile, yield strength, coating type and weight. The mechanical properties relate more to the manufacturing process than end use, so they are often considerations with which the contractor, designer or specifier need not be concerned.



▲ A copper roof tops the Kronborg Castle in Helsingør (Elsinore) Denmark (above, top), which was built in the 1500s and was the setting for Shakespeare's *Hamlet*. This LCC batten roll roof on the chapel of Duke University (above) was installed in the late 1930s. The craft of metal roofing was brought to North America through such European artisans as Paul Revere.

Coating type and weight, however, are rather important decisions, which should be understood by the contractor or specifier. This refers to metallic coating of steel coil, not paint coatings. All steel coil used in exterior applications is coated with a

metallic coating to protect it from corrosion. These coatings are all applied by the continuous hot-dip method and are metallurgically bonded to the base steel. Within the domestic market, there are three distinctive options for coating types: zinc, aluminum and alloys of the two. Within these types, there are also options concerning the rate of application of the coating, designated by weight per square foot (total of both sides). These application rates also result in different thicknesses of coatings.

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Photos courtesy of Metal Roof Advisory Group, Ltd., Colorado Springs, CO, unless otherwise noted.

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