INSPECTING METAL ROOFS

Welcome to the InterNACHI video course on inspecting metal roofs, I'm your instructor, Kenton Shepard.

This course is designed to help you recognize and identify defects and damage, to determine the sources of those problems as often as possible, and to make good recommendations.
The sections on inspecting for damage from wind and hail were developed with the cooperation of members of the insurance and roofing industries.

We'll cover common types of metal roofing products and their performance characteristics. Along with metal roofing, we'll cover related components like underlayment, flashing and fasteners.

You'll learn the general, industry-accepted methods for installation, where to look for defects, how to recognize them, how to determine how serious they are, and how to tell when metal roofs are at or near the end of their useful lives.

Although we'll use common terminology throughout this course, you should keep in mind that different names for the same things are sometimes used in different parts of North America. Which terms you choose are not as important as making sure that you explain conditions clearly and in a way that will be understood.

You'll see metal roofs installed both as panels of various widths and profiles and as smaller pieces which have been formed to look like tiles, shakes or slate. Some of these can be difficult to tell from the real thing at a distance.

STRUCTURAL and ARCHITECTURAL METAL ROOFING

Most metal roofing products are designed to be installed over a supporting roof deck which bears the structural loads and transfers them down through the walls to the building foundation and then to the soil. These products are called "architectural" metal roofing.

"Structural" metal roofing products are usually thicker than architectural products and are installed without a supporting roof deck. They typically rest on purlins which are spaced according to the manufacturer's requirements.

The term "purlin" in this case describes framing members typically installed parallel to the ridge and meant to support metal roofing. The term "purlin" also refers to a system of braces used in conventional roof framing to reduce the distance spanned by rafters. Structural panels are more common in commercial, industrial or agricultural applications

In manufacturing a broad variety of metal roofing products, different kinds of metal are used either alone or mixed together in different combinations to form alloys.

An important way in which metal roofing products fail is through corrosion, so we're going to cover that first. That way you can bear it in mind as we look at the different properties of metal roofing products and their manufacturing and installation processes.

ENERGY STATE of METALS

Metal exists in nature as oxides … aluminum oxide, iron oxide and so on… and the oxide form is metal's simplest form or what we call its "lowest energy state"; it doesn't take any energy to get metal into a low energy state, it's already there. When we mine, refine, combine, cast or roll metal, we put it into a "high-energy state"… it takes a lot of energy to get metal into this state.

High energy metals are generally the least resistant to corrosion, called the "least noble" metal.

Low-energy metals are the most resistant to corrosion, called the "most noble" metal.

Metals like to be in their simplest form but we like to take different metal oxides and combine them, process them and manufacture things out of them. Things like metal roofing! Metal in a high energy state… like metal roofing… is always trying to find a way to get back into a low energy state, and it does this through a natural process we call corrosion.

Corrosion first weakens metal and then turns it from rust into dust.

CORROSION

Corrosion is a defect in metal roofs and if you understand a little bit about what causes it, you'll have a better idea of where to look for it. Three types of corrosion affect metal roofs… Galvanic, Crevice and Filiform. We'll tackle galvanic corrosion first…

Galvanic corrosion

Galvanic corrosion is an electrical process.

When dissimilar metals are connected by an electrolyte… like water… the metal in the highest energy state… the least noble metal… will corrode. Electrons will actually flow from the least noble metal to the most noble metal and that… is galvanic corrosion.

The severity of corrosion depends on the type and amount of moisture. For example, the potential for corrosion is greater near a seashore than in a dry atmosphere. Moisture in the air in a coastal environment contains salt. Salt water conducts electricity better and so moist, salty air is more likely to cause corrosion than moist air that's not salty.

Galvanic corrosion does not happen with dry conditions since there's no electrolyte to carry the current between the two metals.

Imagine a steel panel protected by a zinc coating, which is a very common roofing product. At areas where the panel is cut, or holes drilled, both zinc and steel can be exposed to moisture, and since zinc is the least noble of the two metals, the zinc will corrode.

Look for galvanic corrosion anywhere a panel has been cut, punctured, abraded or scratched.

Crevice corrosion

The second type of corrosion is crevice corrosion. Crevice corrosion takes place when small volumes of stagnant moisture are held next to a surface long enough for moisture to penetrate the protective coating. The crack or crevice has to be large enough for moisture to enter, but small enough to create a stagnant zone where moisture just sits. Crevice corrosion usually takes place in cracks a few thousandths of an inch wide rather than wider grooves or slots of say… 1/8" wide.

Here are some typical areas where moisture can collect…

1. in micro-cracks in the protective coating. These tiny cracks are created during the forming process or where metal has been dented, bent or folded.
2. in crevices beneath the heads of fasteners; especially over-driven fasteners. Over-driven fasteners can create an indentation that will hold water.
3. where fibrous fastener gaskets wick water into the space beneath the gasket where it can remain long enough to cause corrosion.
4. between panels that are stacked and stored like the corrosion you see here trapped beneath debris;
5. this corrosion began beneath an old furnace blower motor left lying on the roof.

Crevice corrosion can also start beneath deposits of sand, dirt, or corrosive products.

Filiform corrosion

The third type of corrosion is filiform corrosion. Filiform corrosion appears as a thin filament; usually beneath paint, but sometimes beneath metal coatings.

This filament consists of an active head and a corrosion product tail. Exactly what that corrosion product is, depends on what metal is corroding.

An "active head" means that active corrosion takes place only at the head of the filament, so corrosion doesn't spread out uniformly, it only moves forward from the very tip of the filament. Filiform corrosion doesn't weaken metal structurally, but it's a cosmetic issue. Corrosion begins at panel edges and usually proceeds in a straight line. It appears as a network of corrosion product tails, but an actively corroding head will not cross the tail of another filament. So that's one way to recognize it.

Filiform corrosion is most common in environments with a relative humidity between 65% and 90%. Humidity below 65% doesn't affect metal. Humidity above 90% often causes corrosion to appear as blistering.

In a few minutes we'll look at the methods used to prevent corrosion, but first let's take a look at the metals commonly used for metal roofing products and their important characteristics.

METALS used for ROOFING

Naturally-weathering

Some types of metals are naturally resistant to corrosion and can be left exposed to weather with

a minimum of protection from corrosion. Copper and aluminum are the most common…

NATURALLY-WEATHERING METAL

Copper

Copper is very durable, lasting up to 100 years, and it's fairly expensive. You'll see it used most often on higher end homes and commercial buildings, usually as panels or flashing, but sometimes as shingles.

Although it's copper-colored right after it's installed, it begins to oxidize immediately, going through a series of color changes turning first to brown and eventually stabilizing as green.

This chart shows the general time frame of color changes, but actual times will vary with location. Runoff from the green patina it develops, called verdigris (**VEHR**-dih-gree) will stain painted surfaces, masonry and other metals. Verdigris actually forms a protective barrier coating which helps give copper its long service life. Copper is one of the more noble metals and will corrode most other metals with which it's likely to come into contact.

You'll be identifying copper through its color. If you're not sure, you can find an inconspicuous spot to scratch. The scratch should be copper-colored.

Aluminum

Aluminum also has a long service life and will not corrode by itself, so it's a good choice for coastal and other high-corrosion climates, but it is subject to galvanic corrosion when it's in contact with other metals in the presence of moisture.

You'll see it in a lot of different styles because it's so easily formed… it is "ductile"; remember that term from asphalt shingles? That means that it's soft and easily-shaped. In fact, the folds and ridges created by heavy forming actually add strength to aluminum roofing.

Almost all modern aluminum roofing is pre-painted. New coatings technology allows steel or aluminum roofing to be manufactured to resemble both new copper and 2weathered copper, so don't be too quick to call a roof copper in your report.

Although aluminum is extremely energy-intensive to produce, aluminum roofing has a re-cycled content of 90 to 95%, most of it as post-consumer beverage cans, so it's actually a very energy-efficient and environmentally-friendly product.

The advantages of aluminum are its…

- corrosion-resistance
- strength
- its light weight (it weights less than 100 pounds per square)
- and its availability in many styles

The disadvantages are that it's…

- more expensive to produce than steel, and…
- It's less hail-resistant than steel

Steel
This home is covered in corrugated steel. It has no protective coating at all and was left to corrode naturally. In the dry climates of many western states, this roofing can last a hundred years or more.

These gutters are galvanized. The outside of the gutters was etched with muriatic acid to encourage rusting so that it would match the roof more closely. The interior of the gutters were left rust-free. This roof was several years old when this footage was shot.

Coated Steel
We try to prevent corrosion in steel panels by applying different kinds of coatings to the base metal… usually steel. The manufacturing process starts with a large coil which unrolls, allowing a long steel strip to travel along a series of rollers through various apparatus which clean it, treat it and coat it. Coatings are one of two basic types: Barrier coatings and galvanized coatings

Barrier Coatings
Barrier coatings function by depriving metal of the catalyst it needs to corrode… moisture. Paints are a good example of barrier protection.

Paints are applied at coil-coating facilities where the metal is cleaned, etched to ensure good bonding before being coated with paint before being baked.

The process for applying barrier coatings like primer and paint are similar to the process for applying metal coatings.

Heavily-formed products like slate, tile and shakes formed from metal may have a coating applied after forming to help seal any microscopic cracks that might develop in the coil-applied coating during the forming process.

Types Of Paint
Three main types of paint-type coatings are used in the North American metal roofing industry: acrylic emulsions, polyesters, and Flouropolymers.

Acrylic emulsions
Water-based acrylic emulsions are one of the most common and environmentally-friendly. Application includes a primer and topcoat. Acrylics don't carry warranties for fading or chalking.

Polyesters
The Polyester group includes a number of formulations which, like acrylics, are generally lower cost finishes and subject to fading and chalking over time.

Flouropolymers
Flouropolymers are high-quality paints which are highly resistant to solvents and acids and have properties similar to Teflon.

You'll also see some other coatings…

Granular coatings
Stone coatings are similar to asphalt shingle granules and are used on shake, tile and slate

profiles. Stone coatings can develop the same moisture-related microbial problems as asphalt shingles- algae, lichen and moss. Granular coatings are most common on metal shingles.

Reflective pigments

Reflective pigments were first developed by the military to help camouflage tanks against infrared detection. These pigments reflect a larger spectrum of sunlight than conventional pigments and can help reduce cooling costs.

Paint films have microscopic defects which allow moisture, salt, acid rain and other corrosive agents to pass through and encourage corrosion of the underlying metal. Even if there are no defects in the coating, all paints are semi-permeable membranes in which corrosives can slowly migrate through and reach the metal surface.

Galvanized Coatings

Galvanized steel is one of the most common metal roofing products and consists of a steel base covered with a protective coat of zinc or aluminum. The protective coating is sacrificial, since zinc and aluminum are less noble than steel.

The coating protects the steel at scratches and cut edges and also provides barrier protection, meaning that the coating helps keep moisture from reaching the steel base.

With a few exceptions, all galvanized steel systems are coated with a base coat of paint of some sort.

Metal coatings are applied by passing the steel strip through a bath of molten metal. The degree to which the metal coating protects the steel and extends the lifespan of the metal roofing depends on the thickness of the galvanized coating.

Because it's vulnerable to corrosion, galvanized steel is not a good choice for coastal areas or areas with elevated levels of corrosive air pollution.

If moisture should find a way around or through the barrier coating, galvanic coatings can still protect the steel base metal from corrosion. Galvanic coatings are metal or metal alloys which are less noble than the steel base coil; coatings like zinc and aluminum. This means that the coating will corrode before the steel base.

Let's take a look at the coil coating process.

The advantages of galvanized steel are…

- it's lower cost compared to most other metals
- it's high strength
- paint bonds to it well and…
- it's available in a wide variety of styles

The disadvantages are that…

- it may have a shorter lifespan than other metals, especially if it's not installed properly, …and
- it may be more difficult to install properly. It has to be sheared instead of saw-cut.

Galvalume

Galvalume is a metal roofing product consisting of a steel strip coated with a metal alloy. The alloy is 45% zinc and 55% aluminum. It looks similar to galvanized steel but the visible crystals are smaller and close together, giving it a smoother appearance.

The combination of zinc and aluminum enhances both the positive and negative affects of aluminum. Because aluminum is corrosion-resistant, Galvalume is more corrosion-resistant than galvanized steel, but because aluminum provides barrier protection instead of galvanic protection, scratches and cut edges are less well protected.

Tension-bend staining

Pre-painted Galvalume is vulnerable to "tension bend staining". When the steel is formed into different shapes, the protective coating will be stretched thin over areas of deep folds or sharp bends.

Over time, microscopic cracks can develop in these areas which expose the steel core to the elements and allow corrosion to begin. Over time, this corrosion will expand beneath the metal coating.

To minimize the amount of bending, Galvalume is generally limited to simpler profiles which lessen the chances of tension bend staining. Like galvanized steel, most Galvalume is painted. Although Galvalume was invented by Bethlehem steel in 1972 and was originally a brand name, because of its widespread use, it's become something of a generic term.

Both galvanized steel and Galvalume weigh 100 to 150 pounds per square and contain about 35% recycled materials.

The advantages of Galvalume are that:

- It's very corrosion-resistant
- It's strong, and…
- It's relatively inexpensive

The main disadvantage of Galvalume is that it's available in only a limited number of styles due to tension bend staining.

Other less common metals used for roofing are zinc, stainless steel and terne.

Damaging Conditions

The important properties of coatings for metal roofing products include resistance to:

- Color fading as UV degrades pigments
- Chalking
- Moisture-related problems
- Abrasion
- Staining
- Corrosion (pollution or salt spray)
- Cracking caused by flexing, and…
- Damage from solvents or acids

Most of these properties are tested for according to ASTM standards, which you are not responsible for confirming.

Surface Defects

Surface defects can be caused by the manufacturing process and some types may result in premature failure. Surface defects include:

- **Blistering**, caused by the expansion of gas in or under the paint.
- **Chatter** appears as a series of traverse marks in the paint or metal.
- **Caternary or oven scratches** show as streaks in the paint parallel to the panel length.
- **Dirt lines** show as lines parallel to the length and are caused by a particle trapped between the applicator roll and the strip. Dirt lines can also be caused by an air bubble trapped in the paint.
- **Paint splatter** can happen during the manufacturing process
- **Pin holes** are usually caused by degassing in the metal coating resulting in tiny holes which penetrate through the paint to the metal.
- **Roll nicks or marks** are repetitive marks that appear at regular intervals.
- **Skipping** is an irregular paint application caused by improper contact between the applicator roll and the strip.
- **Staining** is a discoloration of the surface of the paint.
- **Stretcher strain** is a deformation of the metal substrate resulting in elongated lines or marks which may be highlighted by the paint.
- Water staining is a white rust which forms on aluminum surfaces exposed to moisture.

OIL-CANNING

"Oil canning" is a term used to describe ripples in metal panel roofs. It's seldom seen in metal shingle type roofs, corrugated or heavily-formed roofs. "Heavily-formed" means that the roofing has extreme bends and folds pressed into it as part of its architectural profile.

Oil canning can have a variety of causes including problems with steel coil manufacturing, panel fabrication or installation. It can be the result of one part of the metal coil, like the center or one side, being longer than the other parts.

You don't need to identify the cause. Oil canning is a cosmetic issue unless it's caused by structural movement, in which case it may result in leakage at some point.

Metal Roof Installation

Steep Slope-Low Slope

Almost all metal roofing products can be installed on steep-slope roofs. The metal roofing industry defines "steep-slope" as roof with a pitch of 3&12 or greater. Some products can be installed on roofs with a slope as low as 2&12, but slope limitations vary by manufacturer…and confirmation of compliance to manufacturer's specifications lies well beyond the scope of your inspection.

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Confirming proper installation would require you to identify the product's manufacturer and research the installation requirements.

Metal roofing should never be installed at a slope lower than the minimum recommended by the manufacturer. Occasionally, someone will attempt to get away with installation on a slope lower than that recommended by the manufacturer by installing waterproof underlayment. This is insufficient and the installation is defective.

Roof Sheathing

Solid sheathing is a typical roof deck for metal roofing although it can be installed over closely-spaced boards and some types can be installed over battens, which are sometimes called "strapping".

Underlayment

Architectural metal roofing is designed to be installed over underlayment. This is especially crucial when metal roofing is installed over an existing roof-covering material.

Since structural panels have no deck on which to install underlayment, they may develop problems if they're installed in homes which generate significant amounts of moisture or which have poorly ventilated attics which produce condensation.

You probably won't be able to confirm the presence of underlayment in homes with metal roofs and structural panels are rare in residential construction.

Synthetic underlayment is especially good beneath metal panels because panels sometimes stick to felt paper and it wrinkles as the panels expand and contract.

Metal Panel Roofs

Metal panels commonly used as residential roofing come in a variety of profiles. In high-quality roofing, panels will be continuous from ridge to eve and vary in width. You will also see some panels that overlap and some withy seams that butt or interlock.

Panels sometimes have ribs formed into the field for added strength and wind resistance and the side edges are formed to interlock, creating vertical seams in the finished roof.

Types of Seams

Seams are a weak point in the system and a variety of profiles are used on different roofs to prevent moisture penetration. Here are some of the more common…

Standing seam

Standing seams are one of the most common. The name describes a profile in which- as you can see here the parts of the seam where separate panels join are elevated above the roof, allowing runoff to drain down the panel without coming into contact with the seam between panels.

Some standing seams are protected from moisture intrusion by being folded over by a special handheld power tool. Some are shielded from moisture penetration by a long, thin cap that may slide over the seam or snap down over it… and some panels may simply snap together at their edges.

Flat seam
Flat seams start out as standing seams and are folded over by machine to form a water-resistant seam

Overlap
Overlapping seams usually have a sealant or gasket installed between the panels. Overlapping seams are typical of less expensive metal panels.

Fastening Methods
There are two types of fastening systems for metal panel roofs; through-fastening and concealed clips.

Through-fastening
Through-fastening systems use fasteners that penetrate the metal and which have gaskets designed to keep the penetration from leaking. Large-head screws with neoprene washers are the most common.

Fasteners are often exposed and are typically driven through areas where panels overlap and/or through other locations specified by the manufacturer like those you see here.

Thermal expansion and contraction of the metal roofing and possibly movement of the substrate can cause through fasteners to loosen or back out over time. Metal roofing with loose or missing fasteners will suffer reduced wind resistance and should be mentioned in your report.

Through-fastened systems are also more vulnerable to oil canning. Because through-fasteners don't allow metal to freely expand and contract, they may cause oil-canning, especially in roofs with larger panels.

Clip fastening
Clip fastening systems use clips which fasten directly to the roof deck and are incorporated into the panels at the seams, which leaves the clip concealed from view. Clips are usually found on more expensive roofing systems and typically allow for expansion and contraction of the panels.

Common installation mistakes
Let's look at some mistakes commonly made when installing metal roofs:
Installing metal panels over existing asphalt shingles with no underlayment.
As the metal panels expand and contract with changes in temperature, over time, the granules embedded in the asphalt shingle surface will act as sandpaper, and abrade the protective zinc coating off the underside of the metal panels. This condition can leave the panel vulnerable to corrosion from condensation.

Leaving out rake trim
The rake trim fastens the panel edges down and prevents wind from getting beneath and lifting the panels.

Improper penetrations
Penetrations in metal panels will be different from penetrations in roof covering materials installed shingle-style, but not quite this different! Expanding foam is not an acceptable method for sealing roof penetrations!

A number of fastener-related problems may cause leaks or corrosion. Fasteners may be…

- Over-driven
- Under-driven
- Driven crooked
- Missing
- Protruding
- Poorly anchored- this can be a problem when fastener miss the purlin and are removed and the hole left exposed or poorly patched.
- Fasteners not designed for use with the metal roofing can be a problem.
- Failure to use a fastening method that will accommodate movement from thermal expansion and contraction.

Other types of problems associated with metal panel roofs are:

- Missing or poorly installed flashing and counter-flashing
- Poorly-sealed or flashed roof penetrations
- Lack of sealant maintenance

Let's take a few minutes to talk with a representative from the metal roof industry.

Walking metal Panel roofs

KENTON

Metal roofs can be slippery when they're dusty or wet. Stay off them if these conditions exist. Soft-soled shoes or roof boots will help you maintain traction.

Where you step will depend on the type of roofing installed and the underlying structure. If you step where you see screws, you should be stepping on the support structure; that's the theory anyway. It's a good idea to determine what the support structure is before you walk the roof. That way you help minimize unpleasant surprises. Falling through a metal roof can be an extremely unpleasant surprise.

METAL SHINGLES

Metal roofing is also available as shingles. Shingles come in a variety of types.

You may see them flat and smooth like these. These shingles were installed on a home within a half-mile of the coast in California, which would help account for the corrosion.

More commonly, metal shingles are formed. They may be designed to mimic shakes like those you see here. These shingles are smooth and somewhat low-end.

Higher-end metal shingles are often covered with a coating similar to asphalt shingle granules. They're commonly called "stone-coated". These first two are designed to mimic shakes and this one is designed to mimic tile.

Formed metal shingles are usually relatively light gauge metal and easily damaged by walking on them. To put it simply… don't walk them.

These metal shingles might be mistaken for clay tiles from a distance, 2but clay tiles don't often bend when they're stepped on.

Because of the different styles and installation methods used, you'll be using common sense and good judgment in looking for defects in metal shingle roofs. Let's look at some examples

At this sidewall, you can see that the counter-flashing is installed over the wood shingles instead of behind them. This can let runoff enter behind the flashing.

Metal shingles usually come in strips, like asphalt shingles. They're seldom supplied as individual shingles. The vertical joints between strips should be offset to reduce the chances of leakage.

Hips and valleys are especially vulnerable to leakage. Hip cap shingles can be torn off by wind, leaving the roof open to the weather, and valleys are exposed to more runoff than the rest of the roof.

If you could see the roof before it was completed, the methods used to seal these areas might look like this. Whatever method is used, it should keep the water from penetrating the roof.

Hail Damage to Metal Roofs

Metal roof types

Metal is used as a roof-covering material in several forms: metal panels and formed metal shingles and tiles.

Long, narrow metal panels are typically installed up and down the roof and overlap shingle fashion. They may have one of a variety of different seam types. Hail may dent metal panel roofs but seldom causes functional damage since the panels are in direct contact with the substrate over most of their surfaces, leaving them highly resistant to damage from hail. When metal panel roofs suffer functional damage, it's often caused by hail damaging a seam or trim, which can then allow moisture to enter the roof structure.

Functional damage

Possible scenarios in which functional damage to metal panel roofs happens, include severe hail damage to especially vulnerable components like seams, ridge caps, gabled end trim or eve trim. Basically, functional damage is most likely to happen anyplace where panel edges meet and at which damage will allow moisture intrusion and leakage or lower the wind resistance of the affected area.

Formed metal roofing

Sheet metal is formed into various roofing components designed to mimic other types of roofing materials, like shakes, slate and tile. We'll call them metal shingles.

Metal shingles are often roughly the size of asphalt composition strip shingles… several times wider than they are tall. They're often hollow, so their resistance to impact depends on the gauge of the sheet metal from which they're made. Since folds in the field of the unit can add strength, impact resistance is also affected to some degree by the formed profile.

Metal shingle roofs are damaged more easily than metal panels because they typically only rest on the substrate along their edges, leaving most of each shingle unsupported. Indentations from small hail are visible in this photograph, although they aren't serious enough to be called functional damage.

You can see in this photograph the light gauge of which metal shingles are often made and how lightly both field and cap shingles along the hip are supported. Damage from footfall will tend to bend the entire shingle. Hail damage causes round indentations which may or may not accurately reflect the diameter of the hail that caused them, depending on the impact energy of the hailstones.

Hailstones may dent and distort metal shingles so severely that interlocking seams lose their integrity and leak, or they may lose much of their wind resistance. Either of these conditions would be functional damage.

Cosmetic damage is generally not paid for by insurance companies, although this can vary depending on the insurance company, the way the policy is written and other circumstances. There are exceptions.

The contract terms usually describe a "loss" caused by hail, which may involve a loss in the value of the home represented by the hail dents, so if during the inspection you see damage to a metal roof that appears to be hail-related, you should photograph it and mention it in your report.

WIND DAMAGE to METAL ROOFS

You may see one of several types of metal roofs. They come as panels, shingles or tiles. Their wind resistance will vary with the type and profile.

Metal panels

Good quality, properly-installed metal panel roofs generally do well in high wind events. If the edges are well fastened and proper trim is used, wind has very little chance to enter the space beneath the panels, which minimized the chances for inflation.

The smooth surface of the panels promotes good laminar flow and helps limit turbulence, both of which reduce the chances of metal roofing components being pulled loose and blown off, distorted or displaced.

Areas with missing fasteners or rake and eve edges which have missing or improperly-installed components are the most likely to suffer damage from wind. Panels that lose trim at edges or eves may suffer damage from inflation.

Metal shingles

Metal shingles typically have a low profile and also usually do well in wind events. Most are fastened at the top, but also interlock along their sides, and some types also fasten at the butt which helps secure them against wind.

The wind resistance of metal shingles will depend on their design, profile and proper installation.

The End