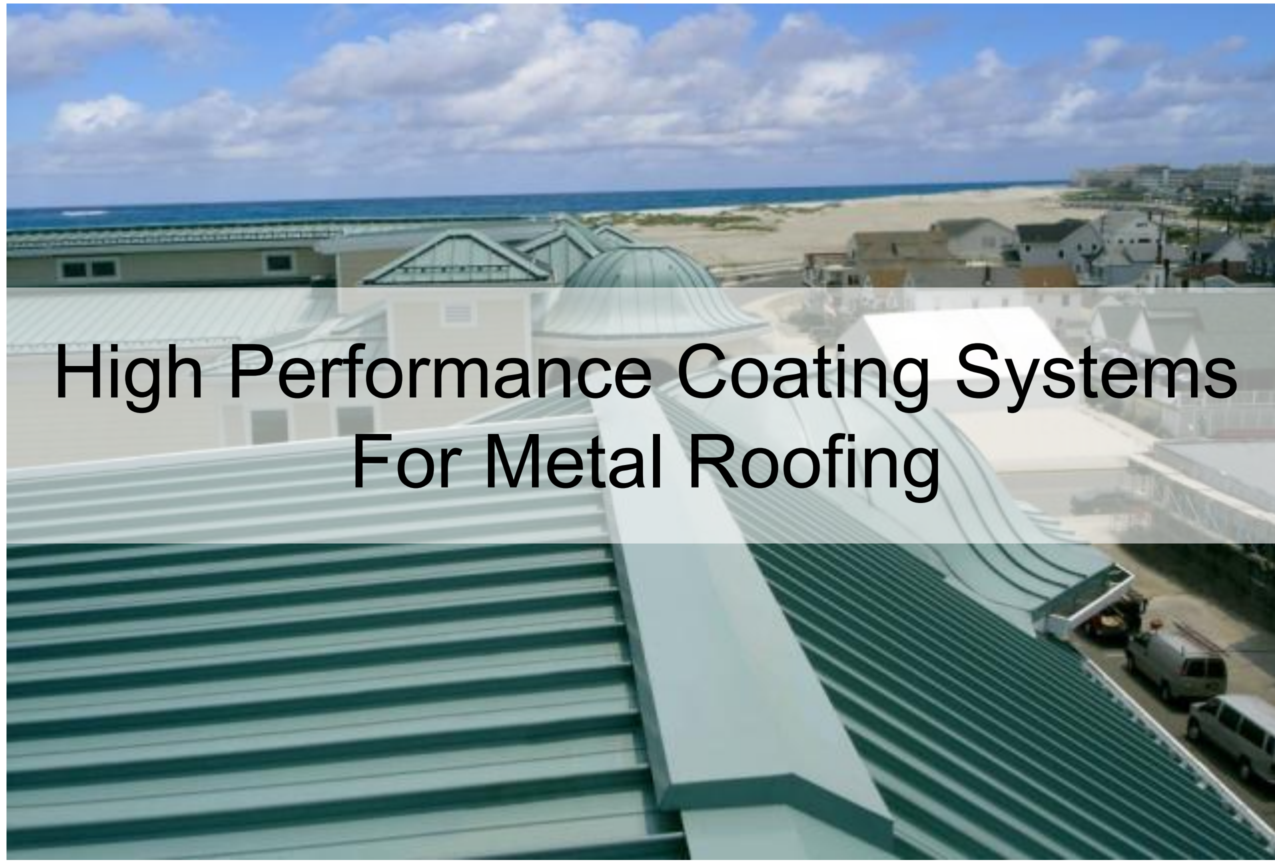
valspar

if it matters, we're on it.®

Valspar Corporation
P.O. Box 1461
Minneapolis, MN 55440
Tel: 612-851-7598
Fax: 612-486-7967
Toll-Free: 1-888-306-2645
Email: coilhelp@valspar.com
Web:
www.valsparcoilextrusion.com



High Performance Coating Systems For Metal Roofing

High Performance Coating Systems For Metal Roofing

Presented By: Valspar Corporation
P.O. Box 1461
Minneapolis, MN 55440

Description: Discusses the relationship between cool metal roofing and high performance coating systems, including how to evaluate the effectiveness of a roof coating and the efficiency of the coil coating process.

Learning Objectives

At the end of this program, participants will be able to:

- discuss the environmental and energy saving benefits of cool roofing
- define solar reflectance and thermal emittance, and using these terms discuss how to evaluate a cool roof relative to industry standards and green building program requirements
- identify the components of paint and their role in determining the performance characteristics of a roof coating system
- describe the continuous coil coating process and the benefits of this pre-paint metal surface treatment, including its durability, and UV and corrosion resistance, and
- discuss industry test methods and approvals of coatings for cool metal roofing.

Cool Roofing and Green Building

The Evolution of Green Design

The goal of green design is to create high performance buildings. Often called "sustainable design," it evolved from a variety of concerns, experiences, and needs.

- The 1970s oil crisis led to a global awareness of the need for energy efficiency in the design of buildings and consumer goods.
- Recycling efforts in the U.S. during the 1970s and onward soon became commonplace, and the building industry recognized that it had a significant role to play in the reduce, reuse, recycle initiatives.
- In the 1980s, the potential causes of "sick building syndrome" were identified, and concerns for worker health and productivity became an issue for employers, building owners, and the construction industry. Emissions from toxic materials were monitored and measured.
- Also, starting in the 1980s, building projects in water-scarce areas recognized the need to focus on water conservation strategies from site planning to the installation of water efficient plumbing products.

Early green designs usually focused on one issue at a time, mainly energy efficiency or the use of recycled materials. However, green building architects in the 1980s and 1990s began to realize that the integration of all the factors mentioned here would produce the best results and, in essence, a "high performance" building.

Green Design

Design and construction practices that significantly reduce or eliminate the negative impact of buildings on the environment and their occupants are often called “green design” or “sustainable design.” These practices cover five broad areas:

- sustainable site planning
- safeguarding water and water efficiency
- energy efficiency and renewable energy
- conservation of materials and resources, and
- indoor environmental quality.

Choosing to use green design products and services in a new or retrofit building project has numerous advantages for the individual, the community, and the global environment.

Urban Heat Island Effect

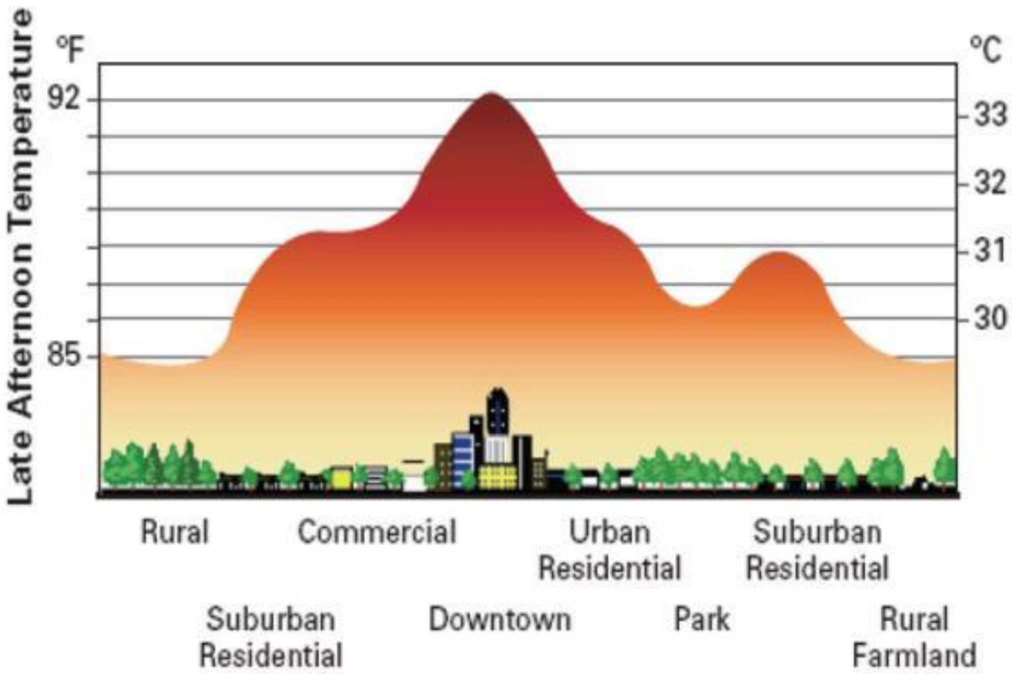
The term “heat island” is used to describe built-up urban areas that are hotter than their surrounding rural areas. The urban heat island effect is common to cities in industrialized nations where the outside air temperatures are 5 to 10 degrees Fahrenheit hotter than outlying areas.

Due to the lack of vegetation and soil moisture in a metropolis, direct sunlight and heat is easily absorbed by dry, exposed man-made structures (buildings, roads, etc.) thus increasing surface and ambient air temperatures in the built-up landscape. The elevated temperatures result in higher energy costs to cool a building.

In addition, urban heat islands:

- change regional weather patterns
- increase photochemical smog and pollution levels
- compromise our air quality
- raise the temperature of our waterways, and
- impact our health and that of our environment.

Example: Urban Heat Island Effect



This graph illustrates how the spread of homes and buildings has increased the holding of heat in the center of the metropolis, in this case Atlanta, GA. As seen, the urban heat island is significantly warmer than its surrounding rural areas.

Resource: U.S. Environmental Protection Agency (EPA), State and Local Climate and Energy Program, Heat Island Effect, www.epa.gov/heatisld/index.htm

Mitigating the Heat Island Effect

Today's headlines about increased energy costs and environmental concerns are changing how building owners, construction professionals, and architects select building materials and how they design for energy performance.

The roof can be one of the least energy efficient components of the building envelope, which has brought many viable re-design options to the forefront. One of them is cool metal roofs.

Technology and advances in coatings and finishes have qualified metal roofing as a recognized "cool roofing" product with the following key national green building initiatives.

- Cool Roof Rating Council (CRRC, www.coolroofs.org)
- U.S. Environmental Protection Agency's (EPA) ENERGY STAR® Reflective Roof program (www.energystar.gov)
- California Energy Commission's Building Energy Efficiency Standard, Title 24 (www.energy.ca.gov/title24)
- LEED® green building certification program, a point-based system developed by the U.S. Green Building Council (USGBC, www.usgbc.org)

What Is a Cool Roof?

A cool roof is one that reflects the heat emitted by the sun back into the atmosphere, keeping the temperature of the roof lower and thereby reducing the amount of heat transferred into the building below. The coolness level of a roof is determined by several factors including geographical location, climate, materials in the building envelope, facility design, and insulation used.

Two key properties that are important to the temperature that a roof will reach in direct sunlight are:

- solar reflectance (SR), the amount of solar energy that is immediately reflected from a surface, and
- thermal emittance (TE), the amount of heat energy a surface can re-emit in the form of infrared energy into the atmosphere.

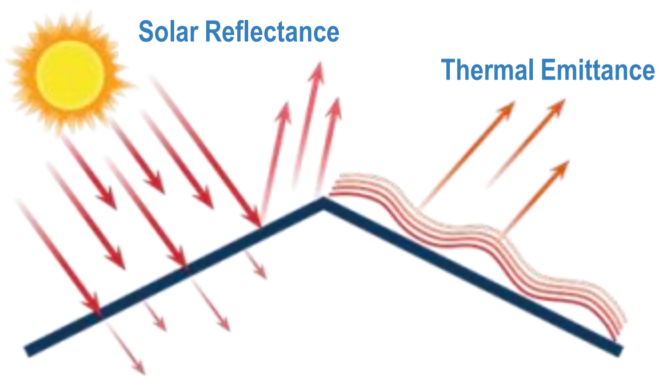
A cool roof with a high solar reflectance and a high thermal emittance will have a lower surface temperature compared to that of a roof with a low solar reflectance and a low emittance. A lower surface temperature translates into less heat gain into the structure below, resulting in a cooler building, which means less energy used and lower energy bills.

Solar Reflectance (SR) and Thermal Emittance (TE)

Both SR and TE are factored on a scale from 0 to 1, with 1 being the most reflective or emissive. Remember:

- the greater the amount of solar energy reflected from the roof surface, the less energy the building will need to cool down (this is especially important in the South), and
- the greater the emissivity, the greater the ability of a surface to cool itself through radiative heat loss; the faster a surface can cool down, the less energy the building needs to be cool.

Ultraviolet, visual, and infrared spectra are components of natural sunlight. A compilation of these three components is measured to determine the reflectance value of a surface (i.e. infrared radiation 42%, visible light 52%, and ultraviolet 6%).



Solar Reflectance (SR) and Thermal Emittance (TE)

As solar radiation strikes the outer surface of a roof, a portion of that energy leaves as reflected radiation. The amount of reflected energy is measured as a ratio and depends on the reflectivity of the roof's surface (i.e. if 90 percent of the solar radiation is reflected away, the reflectivity of that roof's surface is 0.90). The remaining solar energy is absorbed by the roof; however, some of it can be re-emitted. The amount of re-emitted energy is measured as a ratio and depends on the emissivity of the roof's surface (i.e. if 70 percent of the energy is re-emitted, the emissivity of that roof's surface is 0.70). The re-emitted energy is really ultra-high wavelength light, rather than heat, so it does not contribute to the heat island effect.

Energy that is not reflected away or re-emitted can heat a roof's surface whereby the flow of ambient air causes convection heating, potentially contributing to higher urban temperatures (heat island effect). In certain metal roofing profiles, a built-in "dead" or vented airspace can enhance energy savings by reducing conductive heat transfer, but the balance of the total solar radiation becomes absorbed energy and enters the building as part of the net heat flux into the roof.

Defining a Cool Roof: ENERGY STAR®

ENERGY STAR® qualifying criteria for a cool roof is as follows:

- Low-slope (less than 2:12 pitch, 2 inches of rise over 12 inches of run) – must have initial SR of 0.65 and an SR of 0.50 after three years of service life (low-slope SR is only met by a white coating).
- Steep-slope (2:12 pitch or greater) – must have an initial SR of 0.25 and an SR of 0.15 after three years of service life.

Improving SR Values

Improvements to SR values can be made even though roof coatings may already comply with the 0.25 steep-slope level. This is achieved with cool pigment technology, the use of infrared pigments, examples of which can be seen below. The values shown here illustrate how different colors may have different SR values. Consult individual manufacturers for detailed data about specific color palettes.

Standard .67 Cool .72

Standard .47 Cool .56

Standard .21 Cool .33

Standard .25 Cool .30

Standard .14 Cool .28

Standard .11 Cool .28

Standard .08 Cool .26

Impact on Temperature and Energy Consumption

Rule of thumb:

- for every 1% (0.01) increase in roof reflectance, the surface temperature decreases 0.5° to 1°F
  (i.e. the brown color on the previous slide can lower the temperature through the roof by 18°F simply by raising the TSR from 0.08 to 0.26)

and

- for every 10% (0.10) increase in roof reflectance, cooling/heating energy costs drop $0.02/sf (in warm climates)

Source:
U.S. Department of Energy's (DOE's) Oak Ridge National Laboratory (ORNL, www.ornl.gov) and U.S. Lawrence Berkeley National Laboratory (LBNL, www.lbl.gov).
DOE 2 model, LBNL models, ORNL calculator, EnergyPlus model.

LEED® Green Building Certification Program

The LEED® green building certification program is a point-based system where points are awarded for actions taken during design, construction, and use phases to reduce the impact a project and its construction will have on the environment and natural resources. The program has five main categories:

- Sustainable Sites (SS)
- Water Efficiency (WE)
- Energy & Atmosphere (EA)
- Materials & Resources (MR), and
- Indoor Environmental Quality (IEQ).

Two additional categories, Innovation in Design (ID) and Regional Priority, apply to actions not specifically addressed in the five main categories.

LEED credit requirements cover the performance of materials in aggregate, not the performance of individual products or brands. Therefore, products that meet the LEED performance criteria can only contribute toward earning points needed for LEED certification; they cannot earn points individually toward LEED certification.

LEED Credits

Consult individual manufacturers for specific information about LEED programs and relevant credits, but as seen here, a cool metal roof with a coating system with solar reflectance and emittance properties may help a building project satisfy the requirements of earning LEED credits in the following categories:

- EA Credit 1: Optimize Energy Performance
- SS Credit 7.2: Heat Island Effect – Roof
- MR Credit 1: Building Reuse
- MR Credit 4: Recycled Content

Benefits of Cool Roofing

Cool roof requirements appear in national and local energy codes, green building initiatives, and energy rebate programs because a cool roof:

- reduces air conditioning use and lowers utility bills
- mitigates the urban heat island effect
- increases occupant comfort and reduces the occurrence of health issues associated with poor air quality and smog
- lowers maintenance costs and extends roof life, and
- assists a building project in meeting or exceeding today’s energy and building codes.

The remainder of this course will look at ecological and economical ways to finish metal roofing. Metal roofs are already recognized as sustainable, durable building components and as such are used in a variety of applications. Cool metal roofs, finished with the proper coating system, not only benefit the environment globally and locally, but can also significantly reduce a building’s carbon footprint, energy consumption and cooling/heating loads.

Cool Metal Roofing

Benefits of Cool Metal Roofing

In addition to lowering energy costs, there are many benefits to having a cool metal roof.

Sustainability: Metal roofs last much longer than most non-metal roofing products. The materials used contain recycled content and are 100% recyclable at the end of their useful life.

Durability: Metal roofs have the greatest ability to perform over a long period of time in a wide range of weather conditions making them an ideal choice for school, government, commercial, industrial, and institutional buildings.

Fire and Wind Resistance: Metal roofs are extremely fire resistant and can be designed to withstand strong winds and storms.

Light weight: Depending on the type of metal used, a metal roof can be 1/8 the weight of other roofing products, placing a lighter load on the structure and foundation and thereby extending the life of the entire building.

Aesthetics: A metal roof can be painted to color match the design theme of a structure.

Retains Solar Reflectance: Oak Ridge National Laboratory research has shown that metal roofing retains solar reflectance over time better than other roofing products because it resists the growth of organic matter and sheds dirt more readily than other materials.

Why Build With Steel?

Both steel and aluminum are used in the manufacture of a cool metal roof, although steel is the most commonly used.

Why build with steel?

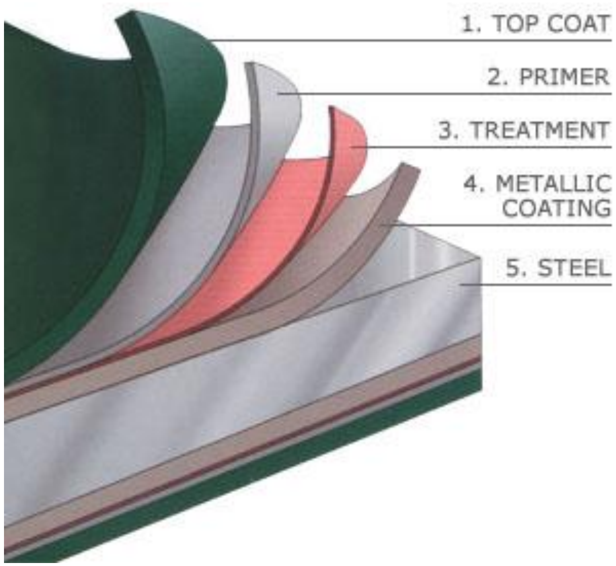
- In weight, pound for pound, steel is a very economical metal roofing and siding material.
- The life cycle costs of steel roofing make it an attractive investment.
- Steel is strong and remains durable for the service life of the roof.
- Steel is the most recycled material in the world.
- 64% of all new steel in the U.S. is manufactured from recycled steel.

Components of a Cool Metal Roof

The performance of a metal roof panel is dependent upon the substrate which composes the base metal (in this case steel) and a metallic coating. Aluminum panels do not usually contain a metallic coating.

A metallic coating is essentially the backbone of a metal panel and is critical to the panel's performance, longevity, and resistance to corrosion. It is applied on both sides of the raw steel using a hot-dip process.

In a top coating system, paint is applied to a metal roof panel when colored panels are desired and to provide a protective coating with SR resistance. In the coil coating process, explained later in the course, the coating is applied to the coil, not the panel. The coil is then formed into the roof panel.

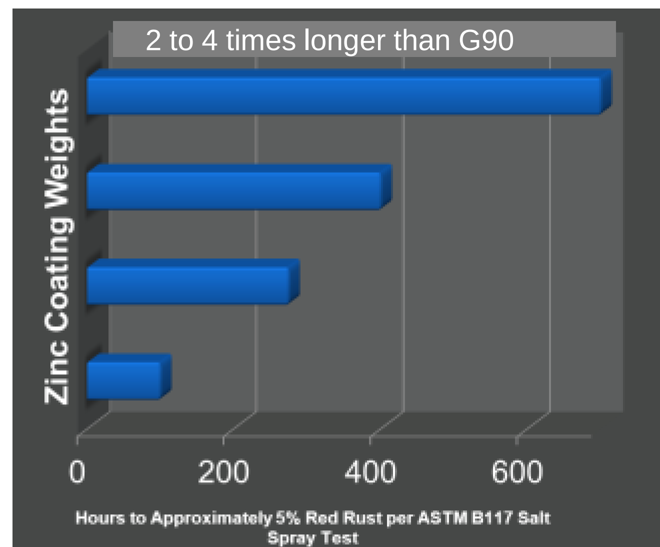


Levels of Substrate Protection

A Galvalume™ coating for metal roofing is an aluminum-zinc alloy—a mixture of aluminum (55%) and zinc (45%). It is produced in either AZ50 or AZ55 coating weights, where AZ stands for aluminum/zinc, and the 50 or 55 means there is 0.5 or 0.55 of an ounce of coating per square foot of the total area (on both sides).

A galvanized (G) coating for metal roofing is produced in either G60 or G90 coating weights. The numbers indicate how many ounces of zinc is applied to every 100 square feet of surface.

The “Red Rust” or “Salt Spray” tests measure corrosion resistance. This chart compares the amount of time it takes each type of steel panel to acquire 5% red rust. The test is conducted with a salt spray to force corrosion so elapsed time can be measured. Notice that the higher the level of zinc, the better the panel performs.



Purpose of Metallic Coatings

As shown on the previous slide, metallic coatings improve the corrosion resistance of metal. Corrosion can affect the structural integrity and durability of metals and alloys. Overall metal loss may be insignificant, but localized corrosion can lead to pitting, cracking, and eventual fracture, causing leakages or more serious failure of building components. There are two general types of corrosion protection.

- **Sacrificial** corrosion protection is where the protective coating reacts in the corrosive media, meaning that the coating, rather than the steel, is attacked. Eventually, the sacrificial coating will be completely corroded away leaving the bare steel to rust. Galvanized, Galvalume™ and Galfan® (5% aluminum-zinc alloy) are excellent sacrificial coatings.
- **Barrier** corrosion protection is where the protective coating repels the corrosive media. There is very little attack by the corrosive media on the barrier type coating. Galvalume™ and aluminum coated sheets are excellent barrier coatings.

Galvalume™ is listed in both the sacrificial and barrier categories, and as such is proving to be a high performance product for standing seam roofing. The zinc provides protection on exposed edges and places where the coating may become scratched, and the aluminum provides an excellent barrier to corrosive media.

Coating/Paint Systems

What Is Paint?

The three main components of paint are:

- resin (the film former and the way we generally refer to the coating)
- pigment (for color and opacity), and
- solvent (diluents that enable us to properly control application).

Additives are formulated into coatings to enhance the performance of paint. Additives are used to control foam, flow, and leveling. Viscosity modifiers are used to improve settling and catalysts are used to accelerate a chemical reaction, but are not consumed.

A typical gallon of liquid paint will comprise:

- solvent
- pigment
- resin, and
- additive.

What Is Paint?

Paint is a dispersion of pigment into a resin/binder. A paint manufacturer must suspend the particles as best as possible to enable the applicator to have a homogeneous product to apply to a surface.

A paint mixture is reduced to a liquid or paste form before being used to protect or color a surface. The paint finish provides the aesthetic qualities that consumers, building owners and designers want to see on their roofs.

Paints used on metal roofs are manufactured using a specific paint technology. In the coil coating process, the roofing material is uncoiled and painted in a flat sheet form. The paint is flexible enough that the metal can be re-coiled, formed or stamped into the final roof form. Coil coatings are discussed further later in the presentation.

Resins

Resins are composed of polymers, extremely large molecules that are assembled from a combination of many small molecules.

The primary function of resin is to act as the "glue" in a paint formulation by binding all of the components together. In terms of paint, resin, binder, and vehicle are interchangeable terms.

The resin is the primary source for a coating's durability and physical properties. It increases the physical strength and chemical resistance of the coating film, and allows for the curing process—a chemical reaction—to occur while paint is drying.

Resins

Common resins used in the manufacture of paint coatings for metal include:

- vinyl or plastisol
- polyester
- acrylic
- silicone polyester (SMP), and
- fluoropolymer.

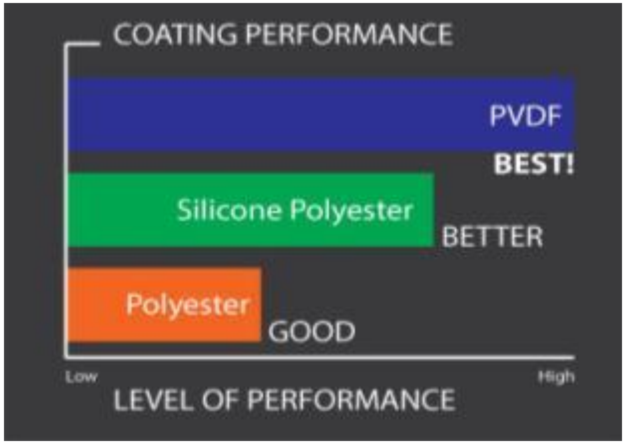
Resins differ in their ability to withstand UV degradation, and this criteria should be considered when selecting a roof coating for a specific location and application.

UV degradation results in chalking of the coating film, essentially a failure of the coating system.

Resins: Performance Qualities

Different resins offer different performance qualities. For example:

- Vinyl or plastisols lose their plasticizers as they age, and they embrittle, chalk and fade as a result.
- Polyesters and acrylics are considered low-end and as such are used for interior applications.
- Silicone polyesters use silicone to help improve the performance properties of the polyester resin and are a lower cost alternative to higher priced formulations.
- Fluoropolymers have long been known for their non-stick properties and high chemical and UV resistance.
  - Polyvinylidene fluoride (PVDF) is able to withstand extended exterior exposure to water, humidity, temperature, UV rays, oxygen, and atmospheric pollutants. In a high performance coating, PVDF is at least 70% of the binder, and acrylic usually composes the remaining 30%.



Resins: Coating Comparison

This chart put together by the National Coil Coating Association (www.coilcoating.org) compares the performance properties of different types of coatings. It provides only general information and is not intended as a specification. Consult individual coating manufacturers for information pertaining to specific coating products.

Coating Type	Humidity Resistance	General Corrosion Resistance	Color Performance	Abrasion Resistance	Gloss Retention	Forming
70% PVDF	Excellent	Very Good	Excellent	Very Good	Excellent	Excellent
30% Silicone Polyester	Excellent	Good	Very Good	Good	Very Good	Good
Polyester	Very Good	Good	Good	Good	Good	Good

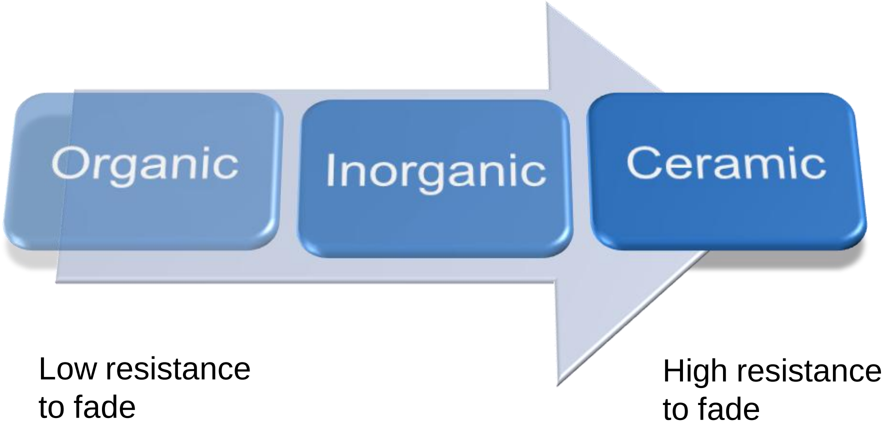
Pigments

Pigments are added to paint to provide color and can be blended to create a desired color to suit the aesthetics of an application. Pigments also provide an opacity to UV light by either absorbing or reflecting light, which often ensures a longer life for the coating. If a resin chosen for a coating system is UV transparent, the pigment must provide UV blocking protection for the primer layer.

Pigment can affect a coating in two ways. It can increase porosity which makes the coating less corrosion resistant, and increase hardness and surface roughness which lowers the coating’s gloss level.

Pigments: Performance Qualities

The performance properties of the final film are affected by the pigments used in the coating mix. Organic pigments have a very bright appearance, but have a low resistance to fade. Ceramic pigments have a high resistance to fade.



Solvents

Solvents are chosen for their compatibility with the paint system and their evaporation rate.

Solvents are mainly used as a thinner (diluent) to help maintain and control the viscosity of the paint so that it can be applied. However, solvents serve other usages in the coating as well, such as to dissolve and disperse solid resins (i.e. vinyl), and to help film coalescence.

Solvents are the volatile ingredients in paint. During the bake process of a metal roof coating, the solvents are released and incinerated, leaving the pigment and resins on the substrate.

Paint: Manufacturing Process

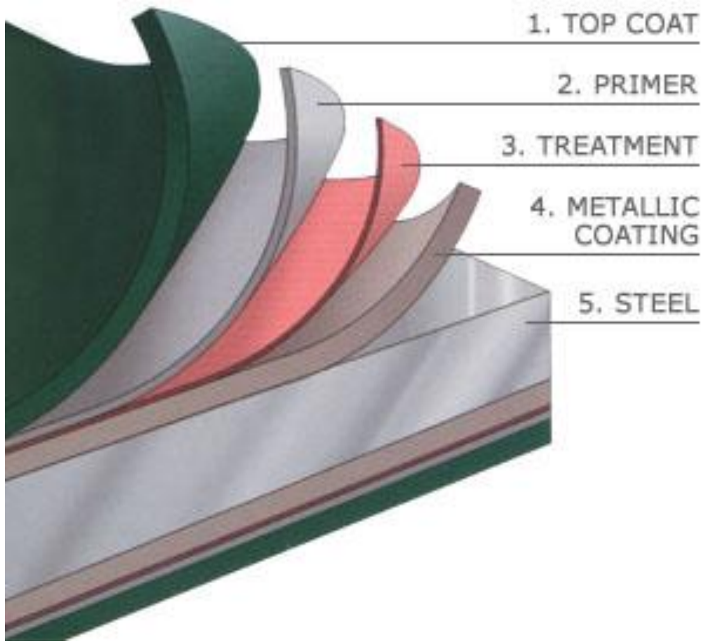
The paint manufacturing process is largely a matter of dispersing pigments adequately in resins and solvents.

- Dry pigments are combined and added to a container that already contains pre-measured amounts of a specified resin and solvent.
- A high speed disperser (mixer or blender) in which propellers revolve provides the dispersing action required to mix the ingredients.
- The mixture is then pumped over to a second machine, called a media mill. The media contained in the mill may be glass beads, zirconium, steel shot or sand. The hard particles help break up the clumps of pigment into the small sized particles required to produce a homogenous paint solution.
- Finally, the balance of resin and solvent is added to the dispersion to complete the batch of paint.

The Paint System

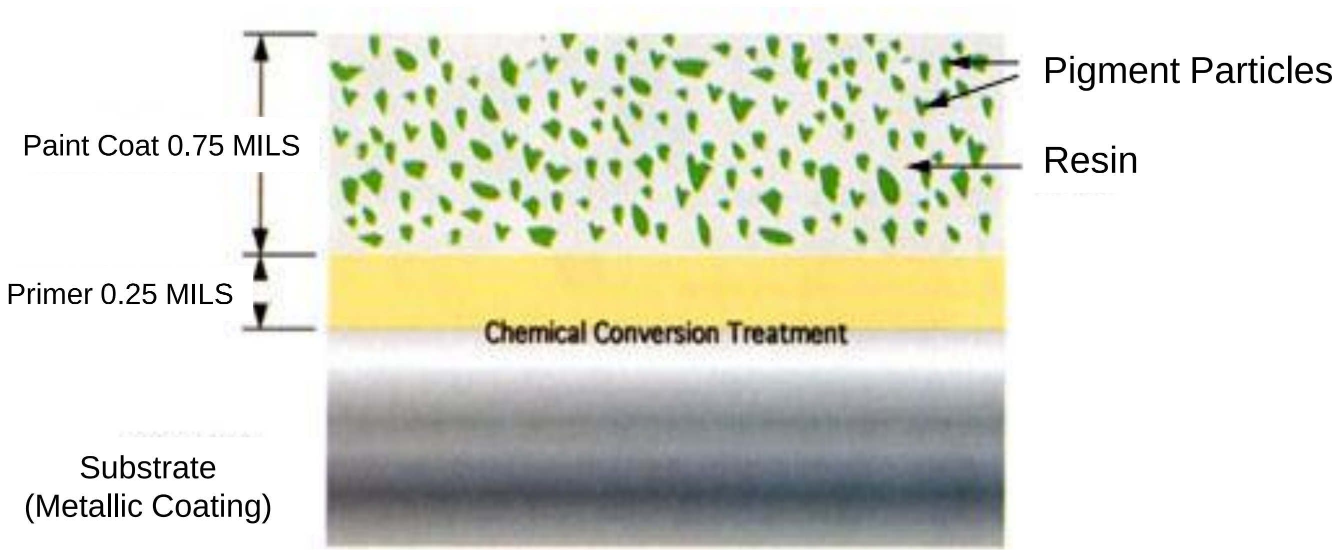
As seen earlier, this graphic depicts an entire integrated roofing system of steel, the metallic coating, pretreatment, primer, and top coat. The pretreatment aids the primer in adhering to the metallic coating. The primer provides added corrosion protection and a solid base for the top coat, and the top coat provides both an appealing color and enhanced corrosion protection.

The next slide details the two-coat paint system that is applied to the substrate



The Paint System

In this illustration of a two-coat paint system, the primer binds the top coat to the substrate and provides additional anti-corrosion protection. This paint system provides the basic protection from the exterior conditions that are prevalent.



The Paint System

A clear coat is used for added protection of the substrate in highly aggressive areas such as coastal and industrial regions. It also allows for the use of brighter and metallic colors by creating a barrier to oxygen and water, thereby reducing oxidation of the pigment. A clear coat improves normal color and gloss retention, and resistance to acid rain and other pollutants.

Paint Application: Continuous Coil Coating

Pre-Painted Metal

There are two types of applications. These coatings can be applied pre-painted or post-painted.

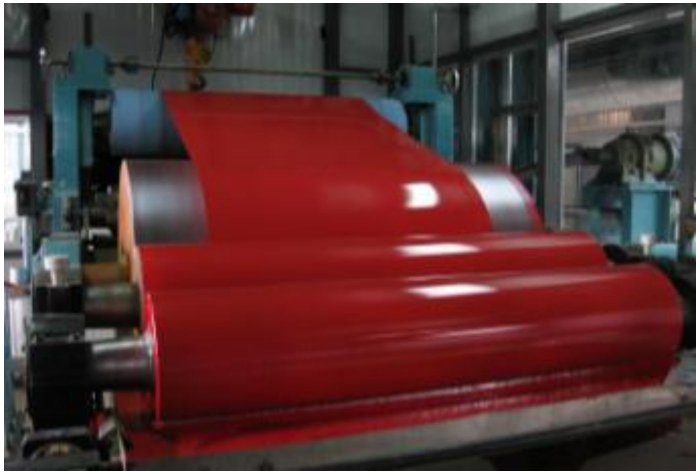
Pre-painted metal production may use liquid paint, powder paint, or a laminate film. The type of substrate and paint system used is determined by the end-use product. Considerations include, but are not limited to the intended application (interior/exterior, residential/industrial), environment (geographic location: rural/urban/coastal), expected service life, and required performance qualities and aesthetics.

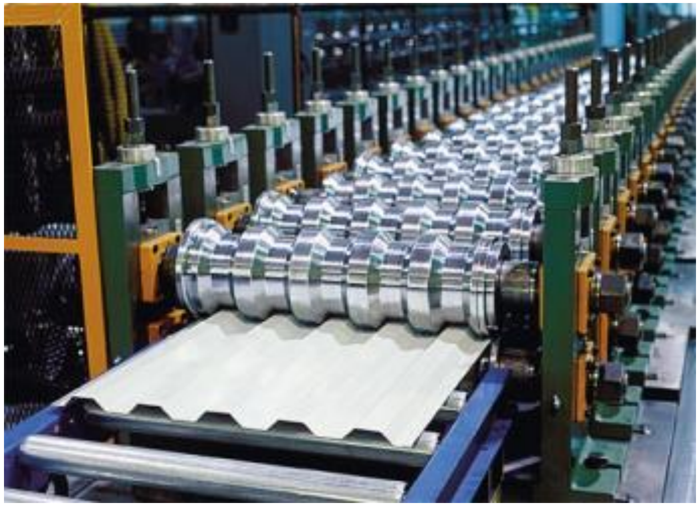
What Is Continuous Coil Coating?

Continuous coil coating is an ecological and economical way to pre-paint thin sheets of steel or aluminum in a continuous process before the manufacture of the end-use building products.

After application, the coil coated metal can be cut, slit, formed, corrugated, profiled, and molded into a variety of shapes for metal building products and systems.

The finished sheets are used in various forms of roofing and cladding, for appliances, furniture and fittings, engineering components, and other finished goods.

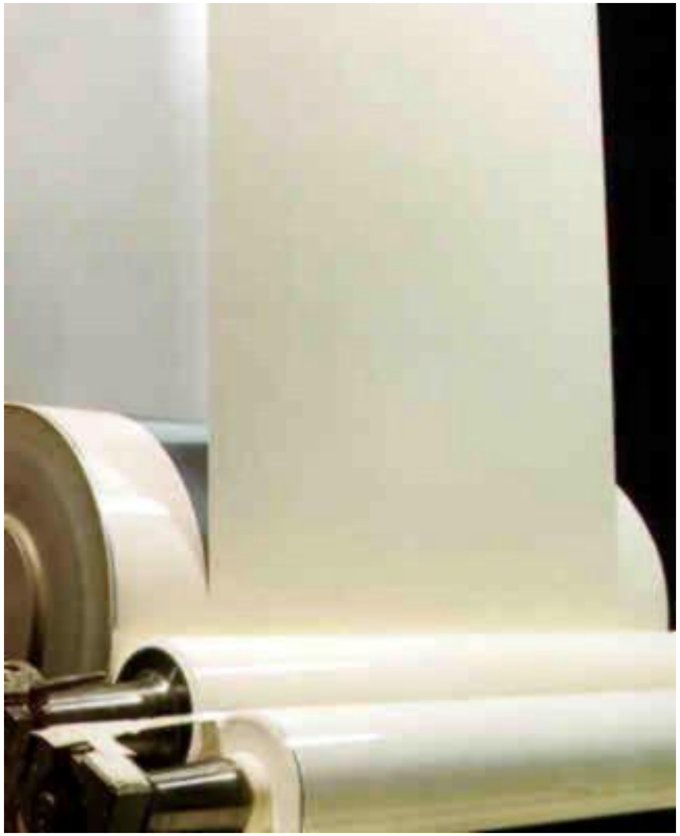




What Is Continuous Coil Coating?

The continuous coil process is automated, which means it can be tested, adjusted, and controlled per the needs of the specification. Since it keeps the metal in a flat sheet form, it has many benefits including:

- a large volume of metal can be coated at a high speed with line speeds up to 1000 feet per minute (< 500 fpm typical)
- both sides of the metal can be coated (manufacturers always coat both sides of the metal at the same time to provide a backer)
- a wide range of coating types, weights, and aesthetics can be used
- the finish has a uniform gloss, color, and thickness, and
- the metal is easily re-coiled at the end of the process.



A line coater—a continuous coil coating operation where the coil moves in one direction and the roller in the other to ensure good flow and uniform paint application.

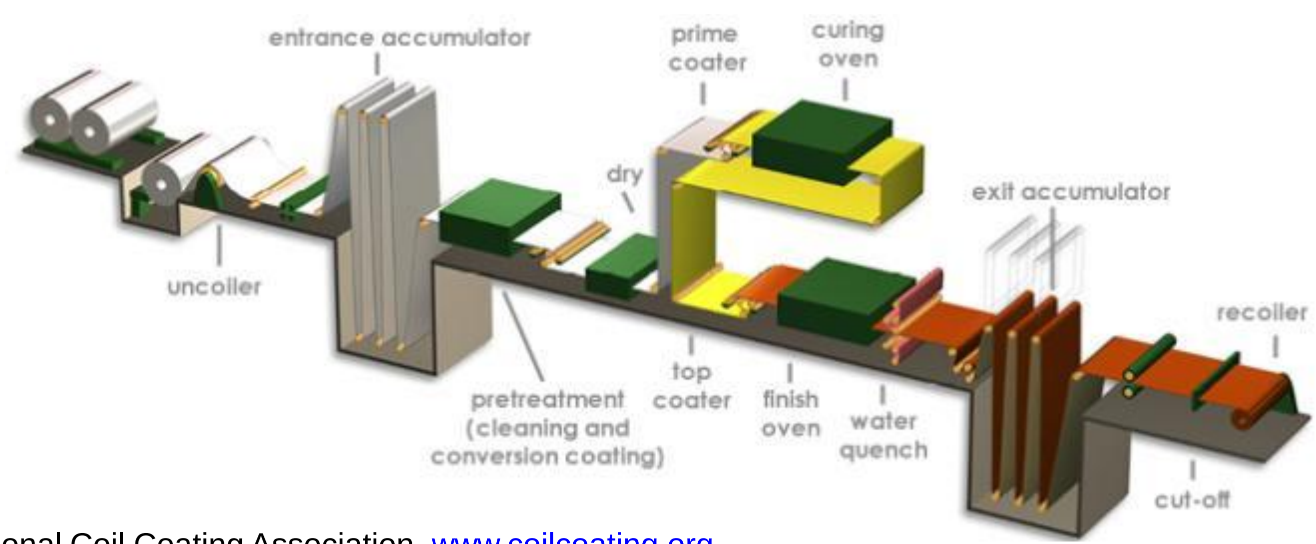
What Is Continuous Coil Coating?

The bare metal substrate is delivered in coil form from the metal manufacturer’s rolling mill. The coating manufacturer cleans the coil before applying a coating system. Once the coating is cured, the metal is re-coiled and sent out to the component manufacturer.

Cold rolled coil is charged into the hot dip line.

Continuous Coil Coating: The Line Process

The bare metal coil is unwound and fed into a line process that is kept moving to prevent any change in temperature of the metal. The metal is cleaned and pretreated before a primer is applied to both sides of the metal. It is then cured at a high temperature (450°F) for approximately 15 to 60 seconds, after which it is allowed to cool before a top coat and backer are applied. A second curing with a slightly longer dwell time takes place as the metal cools down to room temperature. Lastly, the newly coated metal is re-coiled and shipped to the manufacturer for forming into new building components.



Source: National Coil Coating Association, www.coilcoating.org

Continuous Coil Coating: Pretreatments

Proper cleaning and (chemical) pretreatments are important steps in the continuous coil coating process, and will vary depending on the metal being used. An incorrect pretreatment can result in the delamination and failure of a coating, but an efficient cleaning and correct pretreatment will:

- improve paint adhesion
- improve corrosion resistance, and
- make the surface more homogeneous.

Coil Coating and the Environment

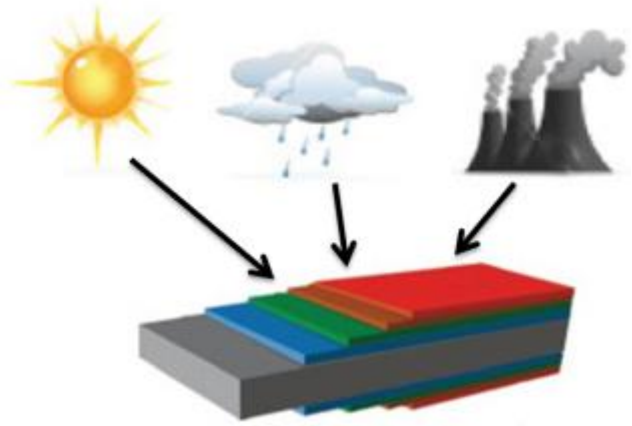
The pre-paint, coil coat industry continues to meet and exceed strict industry environmental standards regarding the production and application of paint. Additional points to consider include the following:

- Coil coating product types are usually based on PVDF fluoropolymer, silicone polyester, and polyester resin technologies.
- Coil coated products are made of recycled content and are recyclable at the end of their service life.
- The line roller coating process is very efficient and very little paint is wasted.
- The factory application process of solvent based coatings allows the coaters to capture and destroy any volatile organic compounds (VOCs) before they escape into the atmosphere (the heat of combustion of the solvents, which are consumed in the process, is used to heat the metal, and any effluent is incinerated), and
- Coil coatings for metal roofing
  - reflect more of the sun’s rays, reducing the amount of energy needed to cool a building
  - emit heat more rapidly than other traditional roofing products, allowing the building to cool faster
  - retain their solar reflectance and admittance properties over time
  - are available in a wide array of cool compliant colors including green, red, white, and black, and
  - have the same long-life performance as the original formulations.

Testing and Coating Performance

Know Your Enemy

Factors such as exposure to the sun (UV light), moisture and humidity, high temperatures, and temperature fluctuations can lead to color changes, chalking, blistering, and corrosion to a protective metal roof coating. Knowing the enemy and understanding how it can affect a painted metal product helps a manufacturer develop and deliver products that meet a project’s specific performance requirements.



Possible causes of a metal roof coating failure include:

- oxidation of binder due to UV exposure
- degradation/oxidation of the pigment
- reaction of the pigment or etching of the surface with atmospheric pollutants
- dirt (picked up or staining), and
- wind-blown sand abrasion.

Know Your Enemy

The coating industry is constantly testing and evaluating how the weather elements interact with paint. For example, we know that exposure to UV light usually starts to break down the coating's molecules, but it is a combination of the sun, heat and moisture that can accelerate the damage more than any one factor alone.

Tests and evaluations are performed to appropriate industry association standards by technical experts. Technology is key to the weather testing of coatings, the formulation of new materials, or the improvement of old formulas. It allows for coating patch and application performance, resin development, and pigment studies. A coating manufacturer continually develops new products to expand and improve current product lines that prevent field failure, improve quality and durability, meet customer expectations, and comply with government and environmental regulations.

Natural Exposure Testing

Weather exposure is a key component to coatings performance. Natural exterior exposure is one of the best ways to see how a coating system will stand up to the test of time. A testing facility in Florida exposes panels at a 45° angle facing south for maximum stress on the coating performance, thus providing weather conditions that are ideal for natural testing. Numerous coated and bare metal panels (in some cases in excess of 100,000) can be monitored simultaneously. Consult individual manufacturers for more information about their test methods and facilities.

Physical Tests

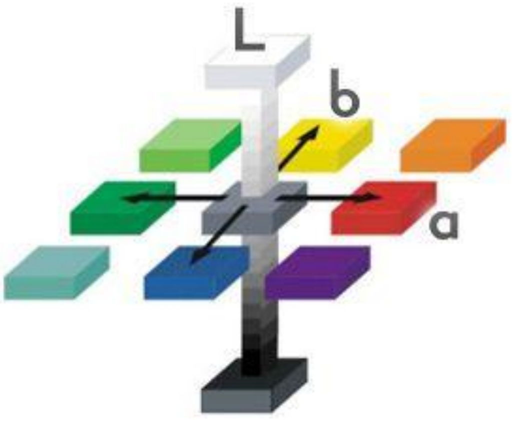
To perform physical tests on a cured film, the film must be cast on a pre-coated primer (see the yellow-green material in the photo). In this photo, the chemist is using a draw-down rod, available in various thicknesses of wire, to cast the wet film in the required mil thickness (1 mil = 0.001 inch) to achieve the dry film specification. The draw-down is then baked at the time and temperature required to assure the proper cure.

Physical Tests

Various color instrumentation is utilized to measure the color of a batch versus the standard. The color is always measured versus the standard and as looked at by the human eye.

Color is measured in three dimensions (as seen on the right). The “L” axis measures light to dark (white to black). The “a” axis goes from red to green and the “b” axis from yellow to blue. This is the convention used in the industry so that all are using common jargon.

Many warranties cite ∆E (Delta E) which refers to the distance that a color has changed from when it was cured to where it is on exterior aging. It is calculated as follows: ∆E = square root of L squared + a squared + b squared. It may be easier to look at the picture and imagine the color changing from 0.0.0 to a point in 3D space away from the start point.



Physical Tests

Various methods are used to determine film thickness. This photo shows a DJH machine which is used to pierce the film. Crosshairs are then put on the hole to determine actual DFT (dry film thickness).

Hardness of the film is determined by using what is known as the pencil hardness test. A number of pencils, each with a different hardness, are held against the film at a specified angle and pushed across the film. The test begins with the hardest pencil and continues until the pencil can no longer gouge the film.

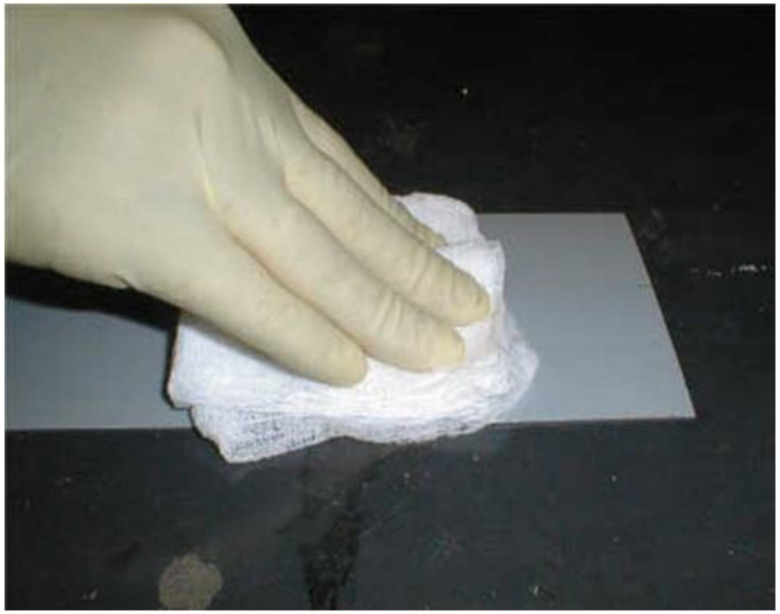
All ASTM (American Society for Testing and Materials) tests have a range which the coating must comply with before being passed along to the next stage.

Physical Tests

The various film gloss levels used in the industry are determined by end use.

The films can be very resistant to solvents. In this image, a cheesecloth is saturated in either MEK or acetone and rubbed across the panel. One rub is determined as up and back. A cured fluoropolymer will take 100 double rubs without breaching the film.

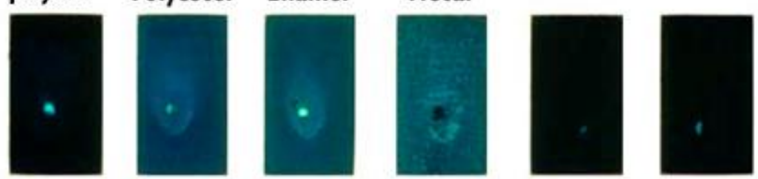
Flexibility is critical as the metal will be post-manufactured into shapes after the film is applied. The “T” bend refers to the number of thicknesses of metal between the two outside in the bend. A special tape is applied on the bend to determine if adhesion is lost. Again, there is a range of performance specified.



Sand Abrasion Test

Resistance to erosion is important in exterior exposure. The sand abrasion test determines the toughness of the film. Sand (the abrasive) is put in the hopper and allowed to fall from a specified height through a guide tube onto the coated panel below. The sand continues to fall until a hole in the film is created, revealing the substrate below. The volume of sand that falls is measure in liters. The amount of abrasive per unit film thickness is reported as the abrasion resistance of the coating on the panel.

	Fluro-polymer	Silicone Polyester	Baked Enamel	Protected Metal	Anodized	Porcelain



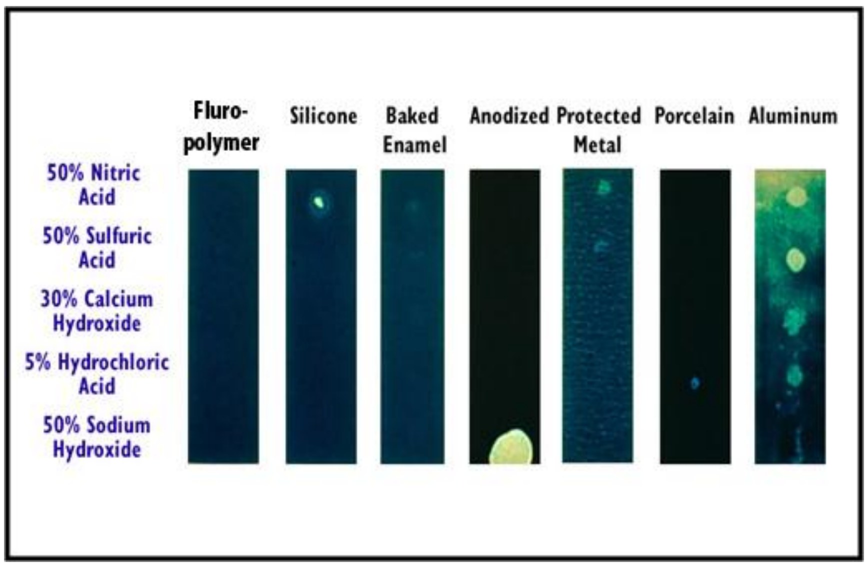
Volume of Sand	75	18	30	135	51	60
Coating Thickness	0.8	0.5	0.9	4.0	0.6	1.5
Coefficient	93.8	36.0	33.3	33.8	85.0	40.0

ASTM D 968

$$\text{Coefficient of Abrasion} = \frac{\text{Volume of Sand (liters)}}{\text{Coating Thickness (mils)}}$$

Chemical Spot Test

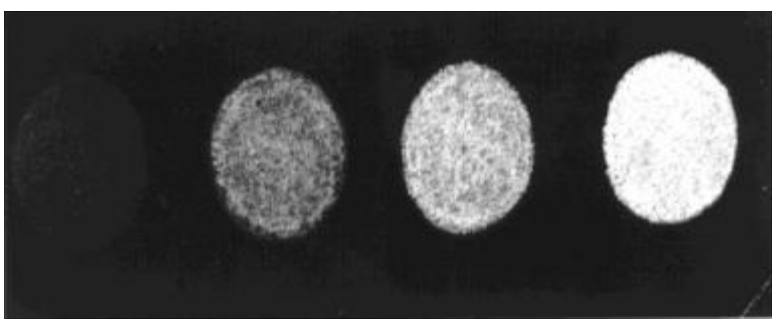
The chemical spot test determines a film's resistance to high acidic or corrosive conditions. A concentrated acid or base is dropped onto the film and covered with a watch glass. After a prescribed period of time, the panel is wiped off and examined. Fluoropolymers are fairly inert and do not change when subjected to such conditions.



Chalking

Chalking is caused by degradation of the resin system at the surface of the finish, due predominantly to exposure to ultraviolet (UV) rays. As the resin system breaks down, resin particles take on a white appearance, and imbedded pigment particles lose their adhesion to the film.

Chalk can easily be rubbed off. The chart below shows degrees of chalking failure where No. 8 on the far left is the lowest rating for chalk presence and No. 2 a high rating since a large amount of chalk is present. The photo on the far right shows a bare tree in winter in the Chicago-land area. Note the exposed markings on the wall behind it where the leaves rubbed off the chalk during the summer months.



No.8 No.6 No.4 No.2

Standards showing degrees of chalking failure

Fading

Fading is caused when substances in the environment attack the pigment in the paint causing it to change in color.

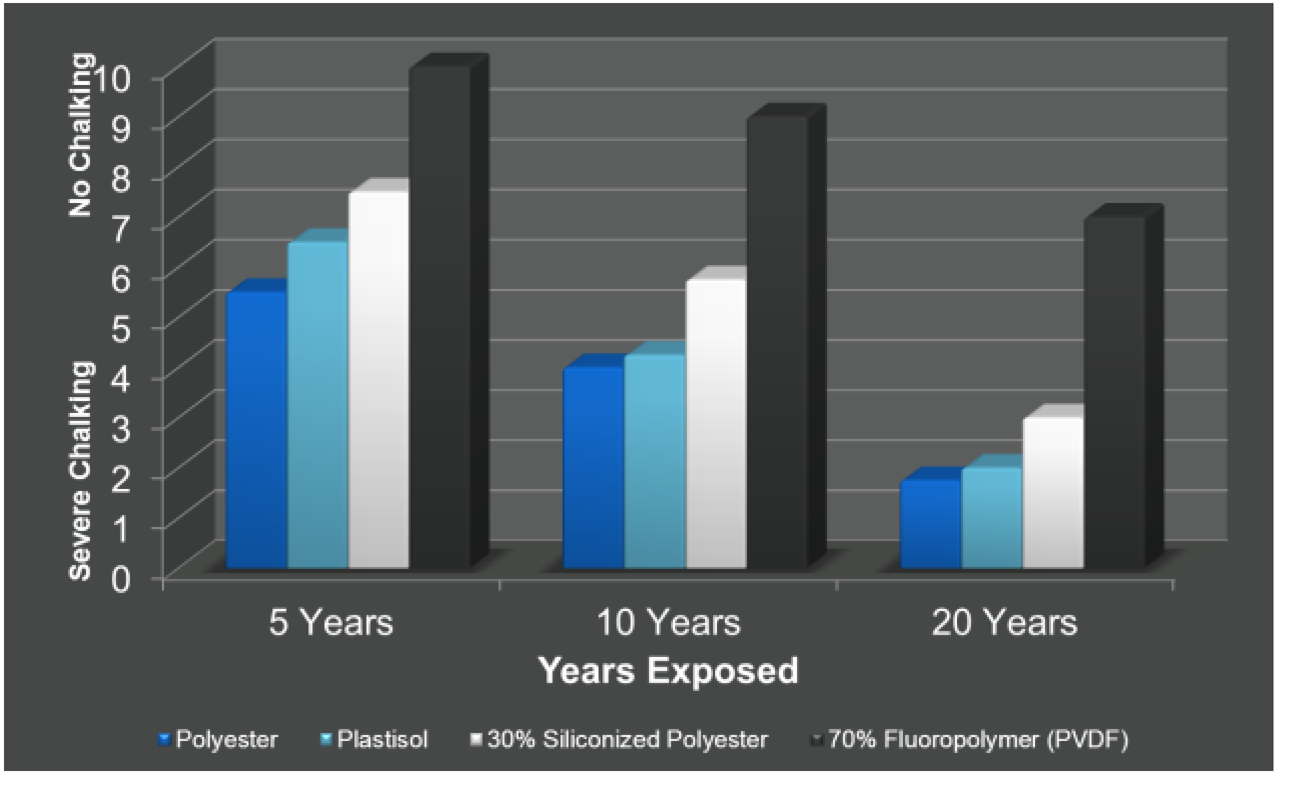
The top photo was taken in 1981 on the shores of Tokyo Bay, about 300 yards away from the water. The 1995 photo directly below shows how the coatings differ in their ability to resist fade.

The bottom photo shows two coatings after six years of exposure in Ohio. Notice the faded coating on the left.

Silicone Polyester | Fluropolymer

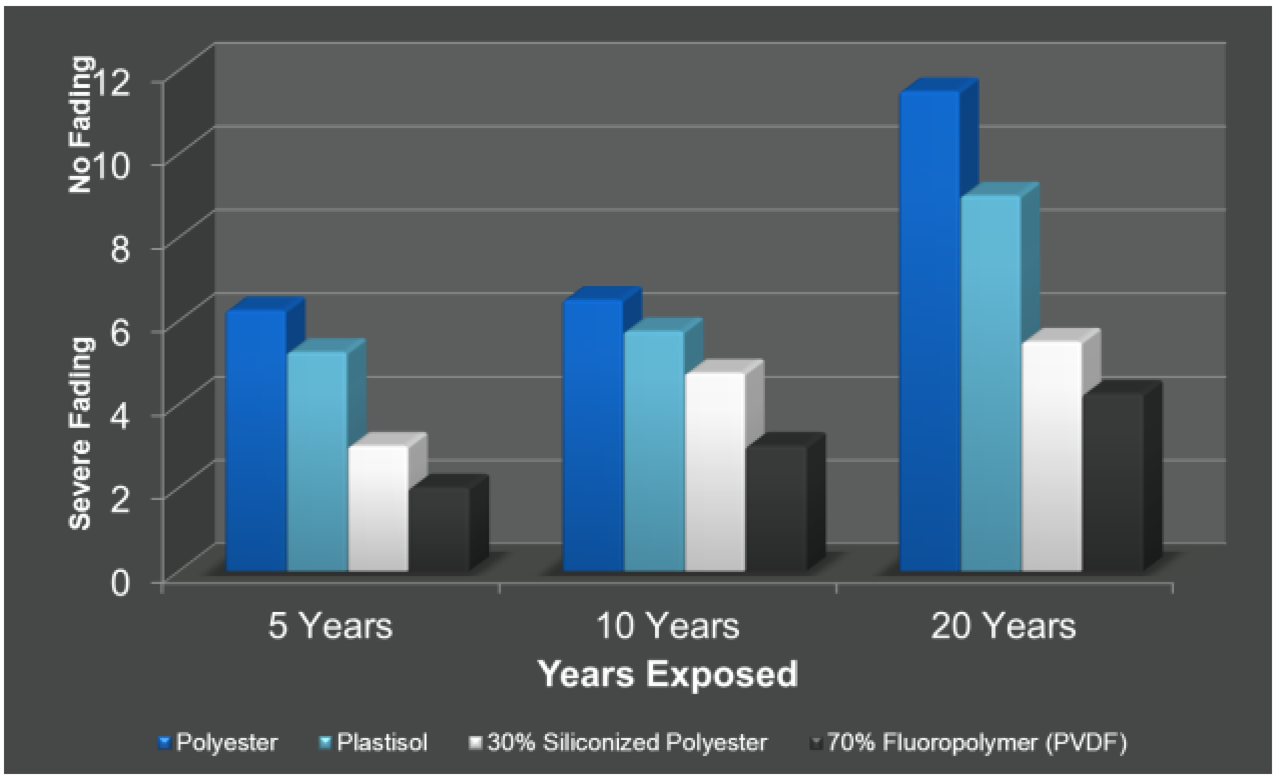
Comparative Performance For Chalking

The chart compares different coatings and their resistance to chalking after specific periods of time at a location in Florida at a 45° angle facing south. The sun exposure at this location is considered to be very severe, up to three times the sun exposure experienced in the Midwest.



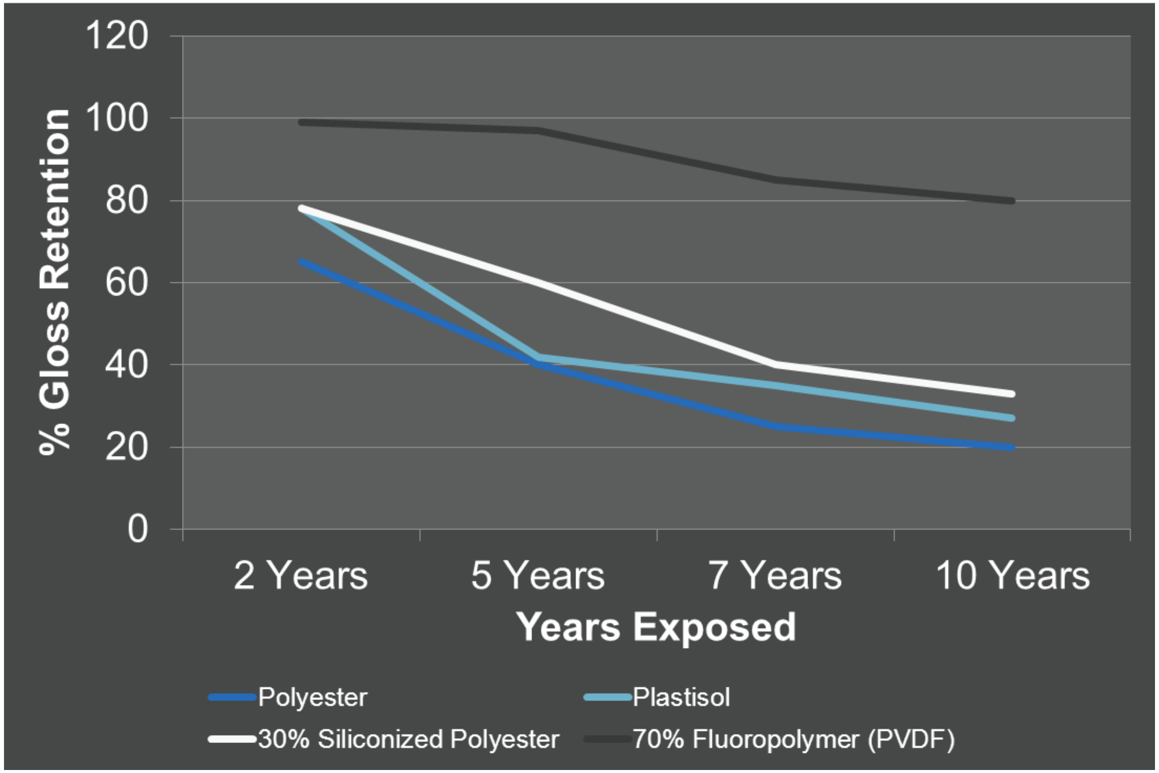
Comparative Performance For Fading

The chart compares different coatings and their resistance to fading after specific periods of time at a location in Florida at a 45° angle facing south. The sun exposure at this location is considered to be very severe, up to three times the sun exposure experienced in the Midwest.



Comparative Performance For Gloss Retention

The chart compares the gloss retention of different coatings after specific periods of time at a location in Florida at a 45° angle facing south.



Summary and Resources

Course Summary

- The term “heat island” is used to describe built-up urban areas that are hotter (5°F to 10°F) than their surrounding rural areas. A cool roof is one that reflects the heat emitted by the sun back into the atmosphere, keeping the temperature of the roof lower and thereby reducing the amount of heat transferred into the building below. Two key properties that are important to the temperature that a roof will reach in direct sunlight are: solar reflectance (SR) and thermal emittance (TE).

- In addition to lowering energy costs, there are many benefits to having a cool metal roof including long service life (sustainability), durability, fire and wind resistance, light weight, aesthetics, and retention of solar reflectance properties.

- Paints used on metal roofs are manufactured using a specific paint technology. In the coil coating process, the roofing material is uncoiled and painted in a flat sheet form. The paint is flexible enough that the metal can be re-coiled, formed or stamped into the final roof form. The continuous coil process is automated, which means it can be tested, adjusted, and controlled per the needs of the specification. It also means a large volume of metal can be coated at a high speed; both sides of the metal can be coated at the same time; a wide range of coating types, weights, and aesthetics can be used; and the finish has a uniform gloss, color, and thickness.

Resources and Key Industry Contacts

The websites of the following resources and key industry contacts were accessed September 12, 2012.

- American Iron and Steel Institute, www.steel.org
- California Energy Commission's Building Energy Efficiency Standard, Title 24, www.energy.ca.gov/title24
- Cool Metal Roofing Coalition, www.coolmetalroofing.org
- Cool Roof Rating Council (CRRC), www.coolroofs.org
- Lawrence Berkley National Lab, http://heatisland.lbl.gov/
- Metal Building Manufacturers Association, www.mbma.com
- Metal Construction Association, www.metalconstruction.org
- Metal Roofing Alliance, www.metalroofing.com
- National Coil Coating Association (NCCA), www.coilcoating.org
- North American Zinc Aluminum Coaters Association, www.steelroofing.com
- Oak Ridge National Lab, http://www.ornl.gov/sci/roofs+walls/
- U.S. Environmental Protection Agency's (EPA) ENERGY STAR® Reflective Roof program, www.energystar.gov
- U.S. Green Building Council, www.usgbc.org

Conclusion