

## A Word About Galvalume®

Nucor has many mills and facilities that produce many products, but Nucor does not produce Galvalume. Galvalume is a product developed by Bethlehem Steel.

### Field Painting of Galvalume® Sheet

Pre-painted Galvalume and bare (unpainted) Galvalume sheet are both recognized as premium products in the metal building industry. Although neither product requires field painting in normal use, there are reasons why field painting may be desirable:

- The coatings, either the topcoat and primer or the Al-Zn coating, have been damaged during shipping, storage, on-site fabrication, or erection.
- The building has been erected in an overly aggressive environment such as severe salt water marine, and premature corrosion is occurring.
- The coating has been severely damaged by an overdriven fastener, drill bit, or other mechanical means.
- It is desired to change the color of pre-painted the Galvalume sheet.
- The customer has decided to paint bare Galvalume sheet for aesthetic purposes.

As with other metallic-coated or pre-painted sheet steels, Galvalume sheet can be easily field painted by following established procedures and using readily available paints. A clean, dry coating, whether bare or pre-painted, is crucial to provide a good base for paint. Careful selection of the paint system is necessary to insure its compatibility with the metal or painted coating and to promote adhesion. However, the application of any field-applied coating may have warranty implications. Please review with your building panel supplier.

### Surface Preparation:

The surface to be painted must be clean and dry. Dirt should be removed by washing with water. Grease and oil may be removed from Galvalume sheet with a mild detergent (e.g., one-third cup Tide® per gallon of water) followed by a thorough rinse. Degreasing solvents such as mineral spirits may also be used. For more stubborn surface stains, stronger cleaners such as Oakite 84M produced by Oakite Chemical (50 Valley Road, Berkeley Heights, NJ, 07922, (908) 464-6900) can be used on bare Galvalume sheet. All of the above must be followed by a thorough rinse of the Galvalume surface since most cleaners are mildly corrosive. Abrasive materials, such as wire brushes and steel wool, should not normally be used on coated steel products. Their use may remove the protective coating and decrease the life of the product. One exception is preparing rusted areas: careful wire brushing is then necessary to remove the rust. The damaged coating should be removed back to areas of tight adhesion and the edges of the existing coating feathered. When there is severe rusting, grit blasting or power sanding may be necessary to completely remove the rust. Remember to use only the least damaging method to attain a clean surface.

## **Primers:**

No priming is required to touch-up or repaint pre-painted Galvalume sheet. For best results, the supplier of the original paint system should be consulted to assure compatibility with the field-applied system. When painting bare Galvalume sheet, priming is strongly recommended.

Etch Primers: When using etch primers, only two-pack etch primers, also called butyral wash primers, are recommended. They are commonly used under a variety of finish coats and never by themselves. When the components are mixed, the pot life is limited to about 6 to 8 hours and a thin translucent film should be applied, preferably by spray. Brush application is suitable for small touch-up areas. Etch primers can be overcoated after 30 minutes air drying and should be covered within 3 to 4 hours. Since they are water-sensitive, they should not be applied in damp or excessively humid conditions.

Zinc Dust/Zinc Oxide Primer: Oil-based zinc dust/zinc oxide primers are two-component systems most effectively used as a primer or self-priming finish coat for roofing, guttering, etc. They are available from many paint companies as Federal Specification TT-P 641, Type 1 or in proprietary formulations. When used without a separate top coat they will have a gray matte appearance and tend to chalk excessively outdoors. Resistance to chalking can be improved by the addition of aluminum flake pigment to the zinc dust paint (approximately 2 lb/gal).

The first stage of preparation is to thoroughly mix the oil-based medium so that the pigment is evenly distributed throughout the mixture. Then pour off a little of the oil-based medium and mix it with zinc dust to make a paste. This paste form is the best method for adding the zinc dust to the oil-based medium. The manufacturer's recommended proportions of zinc dust to oil-based medium must be followed. Once the zinc dust/oil medium paste is added to the remaining oil medium and thoroughly mixed, the complete mixture should not be stored in sealed containers, since pressure can build from the generation of hydrogen.

Under good conditions, zinc dust/zinc oxide primers should dry for a minimum of 48 hours outdoors or 72 hours indoors before applying a finish coat.

Water-Based Acrylic Primers: Some water-based acrylic primers contain an anti-corrosive pigment. These primers offer excellent performance, provided the finish coats are also water-based formulations. Over painting with oil-based paint considerably reduces the adhesion of the entire system.

## **Finish Coats:**

Without Primer: As discussed in the primer section, zinc dust/zinc oxide with aluminum flake pigment may be used effectively as a self-priming finish coat.

Relatively high gloss water-based, self-priming 100% acrylic paints are available for direct application to Galvalume sheet. The color white should not be used in severe environments because it contains considerably less anti-corrosive pigment than other colors. As with the water-based acrylic primers, these paints should not subsequently be top coated with oil-based paints.

Where good quality water-based 100% acrylic paints are used on Galvalume sheet, etch priming is not necessary to obtain adhesion, but should be used to upgrade corrosion performance.

With Primer: For normal environments, Bethlehem has found good corrosion performance with a zinc chromate butyral wash primer in combination with a solvent-based siliconized acrylic topcoat. Water-based systems may also be available that would perform well. The paint manufacturer should always be consulted to determine specific product recommendations for good performance with Galvalume sheet.

For severe marine and industrial exposure, the more protective double finish coats such as polyurethanes or vinyls should be used. In applications where Galvalume sheet will come into contact with soil and groundwater, two coats of a two-pack coal tar epoxy paint are extremely effective. Edge priming is not essential.

Asphalt-Based Fiber Coating: Another system that has been tested and used successfully for repair painting of Galvalume sheet is Uniflex 500®, an asphalt-based, fiber aluminum system available from Kool Seal, Inc. (1499 Enterprise Parkway, Twinsburg, Ohio, 44087, (800) 321-0572). This coating is normally applied directly over the Galvalume sheet and is silver gray in color. Severely damaged areas that have developed significant rust may require spot priming; consult Kool Seal for specific recommendations.

General Rules: Regardless of which paint system is selected for repainting or repairing Galvalume sheet in the field, the following general rules should be practiced.

- Read the manufacturer's instructions and observe them explicitly.
- Thorough mixing is essential.
- It is not advisable to use different brands of primers and finishing coats in conjunction with one another.
- Do not over paint water-based paints with oil or organic solvent type paints. At all times, it is important to avoid excessive paint film thickness such as may occur in the valleys of formed roofing panels.
- Where extensive areas are to be covered, spray painting can lower cost while giving acceptable results. The paints used, however, must be formulated for this purpose.
- Good safety practices are imperative. Many of the paint systems available can give off toxic fumes and cause reactions when in contact with the skin. Proper safety equipment should be used with adequate ventilation at all times.

## Guidelines for Field Painting Bare and Pre-painted Galvalume Sheet

	Touch-up/Repainting of Pre-painted Galvalume Sheet	Painting of Bare Galvalume Sheet	Repair Painting of Damaged or Corroded Galvalume Sheet
<b>Cleaning</b>	<ul style="list-style-type: none"> <li>Wipe or wash away all loose dirt and debris</li> <li>Use detergent or solvent to remove oil and grease</li> <li>Rinse thoroughly</li> </ul>		<ul style="list-style-type: none"> <li>Remove any surface stains with approved cleaners</li> <li>Completely remove all rust to bare metal using the least damaging method practicable</li> <li>Wipe or wash away all loose dirt and debris</li> <li>Use detergent or solvent to remove oil and grease</li> <li>Rinse thoroughly</li> </ul>
<b>Drying</b>	<ul style="list-style-type: none"> <li>All surfaces should be completely dry</li> </ul>		
<b>Priming</b>	<ul style="list-style-type: none"> <li>Not necessary</li> </ul>	<ul style="list-style-type: none"> <li>Two-pack etch primers</li> <li>Zinc dust/zinc oxide</li> <li>Acrylic</li> </ul>	
<b>Topcoats</b>	<ul style="list-style-type: none"> <li>Siliconized acrylic</li> <li>Uniflex 500</li> <li>Zinc dust/zinc oxide</li> <li>Acrylic</li> <li>Polyurethane or vinyl (severe marine/industrial)</li> <li>Coal tar epoxy (contact with soil or ground water)</li> </ul>		

## **Galvalume Technical Bulletins**

### **Design, Construction and Maintenance Guidelines for Galvalume® Sheet**

Roofing panels made of Galvalume sheet will provide many years of trouble-free service when properly installed and maintained. Bethlehem works closely with its customers to monitor product performance through roof inspections over a wide range of designs and environments. As a result, we have developed a number of guidelines which may be helpful to builders in achieving a good-looking, long-lasting Galvalume sheet roof.

#### **Standing Water:**

Standing water conditions should be avoided by providing free drainage of water from the roofing panels. In multi-slope roofs, where it may be impossible to avoid creating ponding areas, a valley gutter or other device should be incorporated into the design to aid water drainage.

#### **Accessory Materials:**

Copper, lead and unprotected steel should not be used with Galvalume sheet. Galvalume sheet should also not come into direct contact with wet wood or uncured concrete. Wood retains moisture for long periods of time and can shorten the life of a panel in direct contact. Uncured concrete is extremely alkaline and may dissolve the protective coating. Many flashing, parapet and fascia designs are fabricated from galvanized steel. Galvanized, however, does not provide the long-term durability of Galvalume sheet and can cause run-down rust stain onto the Galvalume sheets.

#### **Fastener Selection:**

Bethlehem has found that the following fastener materials offer the compatibility and long-term corrosion resistance necessary for use with a Galvalume sheet roof: 300 series stainless steel, zinc alloy cast heads, plastic heads, and aluminum or steel heavily coated (> 1 mil) with zinc or cadmium, both with a dichromate topcoat. The best fastener recommendations are available from your supplier or fastener manufacturers.

#### **Fastener Installation:**

When installing screws, whether they be self drillers or self tappers, use only as much pressure as necessary to seat the fastener seal. Excessive pressure can cause depressions of panel joints and drip edges. These indentations collect dirt and debris which interfere with free water drainage. Overdriving fasteners can also destroy the sealing washer. If screws are installed at an angle, the sealing washer may not seat and the roof could leak.

#### **Sealants Selection:**

When selecting a sealant for panel lap joints or other areas, use a premium material that provides the long-term resiliency and flexibility necessary to effectively seal the joints for the life of the Galvalume sheet roof. The best selection advice would come from a sealant supplier or manufacturer. Careful attention should be paid to the compatibility between the sealant and Galvalume sheet with regard to both its adhesion and corrosivity of the curing by-products. Some RTV sealants, for example, will release acetic acid which is corrosive to the coating.

#### **Sealant Application:**

Sealants and caulks should be applied only in amounts necessary to make an effective seal. Some sealant materials can discolor as they weather and, although they may not be corrosive or

harmful to the Galvalume sheet, have an unappealing appearance that may distress a building owner. Excess or smeared sealant should be removed with recommended solvents.

### **Lock Seaming:**

For standing seam roofs, the portable lock seamer must be properly aligned and maintained to insure that the rolls do not cut through the protective Galvalume sheet coating. A misaligned lock seamer can fail to properly close the seam, resulting in leaks.

### **Roof Structures:**

Roof-mounted equipment, such as air conditioning units, are often mounted on small, uncoated steel channels or I-beams. Any uncoated steel used on a Galvalume sheet roof should be given proper surface preparation, then painted with a high-quality maintenance primer and compatible top coat. If left unprotected, the rust will bleed onto the Galvalume sheet panels, resulting in an unsightly stain.

### **Air Conditioner Drains:**

Air conditioner drains should be fabricated from plastic pipe of suitable diameter and extended at least to the rain gutter, and preferably well past the gutter. Drain water from air conditioners contains dissolved copper from the condensation coils that can cause rusting of Galvalume sheet panels in a very short time.

### **Clean-up:**

After erection has been completed, the roof panels and gutters should be swept to remove dirt and debris such as unused fasteners, metal filings, pop-rivet stems, and pieces of flashing. For instance, the shank of a fastener left lying on a roof will rust very quickly and will run down onto the panel causing an unsightly stain.

Mud and dirt tracked onto the roof panels, as well as greasy hand and footprints, can be removed by washing with a cleaner consisting of 1/3 cup mild detergent (e.g., Tide) in one gallon of water applied with a mop or soft broom. The roof should then be thoroughly rinsed with water. High pressure spray application and strong alkaline detergents should not be used.

If washing with a detergent solution is found to be inadequate, solvents such as mineral spirits or Stoddard solvent can be used to remove more stubborn stains. More aggressive and highly volatile solvents such as acetone or toluene should be avoided for safety reasons, as well as their incompatibility with many paint systems used on building panels. The compatibility of any solvent on paint should be tested or known prior to its use.

### **Periodic Maintenance:**

At least once a year, the building owner should have the following roof maintenance performed:

- Check panels, rain gutters, and downspouts to ensure they are clear and allow free drainage of rainwater from the roof. Valley gutters and grates should also be cleaned.
- Remove accumulations of leaves, branches, and other debris at ridge caps and in corners.
- Check the condition of auxiliary equipment such as air conditioner supports, drains, and housings. Any exposed metal that can rust or has rusted should be painted.
- Remove any trash that has been thrown on the roof that can clog drains or cause silt buildup.

### **Compatibility of Materials Used in Metal Building Construction**

In the metal building industry there are a number of alternative choices for materials used for roofing and siding panels, fasteners, flashings, and other trim elements. How and where these various components are installed in relation to one another will have a direct impact on the effective life of a metal building or retrofit application. A decision to use one material rather than another should take into account the compatibility among components that will be in direct contact with, or in close proximity to, one another.

#### **What to Avoid:**

The table on the following page provides a quick reference guide for comparing the compatibility among the more widely used materials in the metal building industry. Use of the table and careful consideration of materials specification will help you avoid problems in three general situations: direct contact, standing water and rainwater runoff.

- Copper and copper-containing brasses, lead (for flashing or as contaminants in other materials) and graphite (from pencils used to mark components) should not be used in any construction where Galvalume® or aluminum-coated sheet is specified.
- Wherever possible, standing water conditions should be avoided.
- Drainage of rainwater from one component onto or over another building element should take into account the materials involved. The table should be consulted before materials are specified for roofing, flashing, fasteners, rain gutters and other components to avoid future problems.

#### **Why?:**

Galvanic Corrosion: Galvanic corrosion can occur when two dissimilar metals are in direct electrical contact with each other. This contact can consist of either the metals touching one another, or the metals connected by some other means of completing the electrical circuit. By dissimilar metals, we mean metals or alloys that have different reactions when exposed to corrosive environments such as our atmosphere and rainwater.

## BUILDING PANEL MATERIAL

Panel, Flashing or Accessory Material	Galvalume	Pre-painted Galvalume	Galvanized	Pre-painted Galvanized	Aluminum-Coated Type II
Galvalume	Compatible		Compatible, although galvanized may have a shorter life and will eventually have an adverse effect on Galvalume.		Compatible, although inferior resistance of aluminum-coated steel to standing-water and cut-edge corrosion could result in rust-staining of adjacent Galvalume materials.
Pre-painted Galvalume	Compatible		Compatible, although galvanized may have a shorter life and will eventually have an adverse effect on Galvalume.		Compatible, although inferior resistance of aluminum-coated steel to standing-water and cut-edge corrosion could result in rust-staining of adjacent pre-painted Galvalume materials.
Galvanized	Compatible, although galvanized may have a shorter life and will eventually have an adverse effect on Galvalume. Small areas of unpainted galvanized subject to water runoff from Galvalume panels should be avoided		Compatible	Compatible, although small areas of unpainted galvanized subject to water runoff from painted panels should be avoided.	Compatible, although galvanized may have a shorter life and may eventually have an adverse effect on aluminum-coated steel. Small areas of unpainted galvanized subject to water runoff from aluminum-coated steel should be avoided.
Pre-painted Galvanized	Compatible, although galvanized may have a shorter life and will eventually have an adverse effect on Galvalume.		Compatible		Compatible, although inferior resistance of aluminum-coated steel to standing-water and cut-edge corrosion could result in rust-staining of adjacent pre-painted galvanized materials.
Aluminum-coated Type II	Compatible, although inferior resistance of aluminum-coated steel to standing-water and cut-edge corrosion could result in rust-staining of adjacent bare or pre-painted Galvalume panels.		Compatible, although inferior resistance of aluminum-coated steel to standing water and cut-edge corrosion could adversely affect the galvanized coating and/or result in rust-staining of adjacent bare or pre-painted galvanized panels.		Compatible
Copper	Not compatible -- direct contact or exposure to water runoff may seriously affect Galvalume		Compatible		Not compatible -- direct contact or exposure to water runoff may seriously affect aluminum-coated steel.
Lead	Not compatible-avoid contact				
Stainless Steel	300 series grades are compatible. 400 series grades with >1.0 mil zinc or cadmium coatings are compatible.		300 series grades are compatible. 400 series grades with >1.0 mil zinc or cadmium coatings are compatible.		300 series grades are compatible. 400 series grades with >1.0 mil zinc or

Due to a continuing process of product improvement, information contained herein is subject to change without notice.

			cadmium coatings are compatible.
Graphite	Not compatible -- avoid contact	Compatible	Not compatible -- avoid contact
Plastics	Compatible	Compatible	Compatible

Precautions were mentioned previously concerning the use of copper, lead, and graphite with Galvalume and aluminum-coated sheet. The field of corrosion study has defined an "activity" scale, shown schematically at left, which shows zinc and aluminum more active than copper, lead, or graphite. The farther they are apart on the scale, the more dissimilar they are and the stronger the potential for reaction between them. When a galvanic "couple" is formed by electrical contact, the more active metal will sacrifice itself (or dissolve) to protect the less active component of the couple. A couple consisting of aluminum and graphite, for instance, will corrode the aluminum away much faster than the copper would dissolve in a copper/graphite couple.

On a metal building, when copper, lead or graphite either come in contact with, or in the case of copper used in close proximity to Galvalume or aluminum-coated sheet coatings, the coatings will corrode much faster than normal. The protective oxide film which naturally forms on aluminum surfaces is broken down by copper, lead, or graphite in localized areas. When this occurs, pitting corrosion ensues which is a highly accelerated form of attack. Zinc coatings are not generally subject to pitting when in contact with the same materials. Therefore, the galvanic corrosion reaction is slower and spread over a wider area.

### Rainwater Run-off

The compatibility table also contains guidelines for selection of materials when one component will drain rainwater onto another. Pure rainwater contains very little dissolved metal. When it contacts galvanized steel, for example, it will dissolve some zinc from the coating. As the water drains onto another area, such as a lower roof elevation, it will be less corrosive relative to the pure water. Where there is a building element with a less active coating over one with an inferior coating, there will be accelerated corrosion of the lower element. Such a situation occurs where rainwater drains from a pre-painted Galvalume roof into an unpainted galvanized gutter. In industrial, acid rain, or marine environments these effects will be accelerated due to the increased corrosivity of the rainwater.

### Standing Water

New applications of metal roofing require that roof slopes be minimized to as low as 1/4:12. At times, areas of roofs can be flat depending on the particular building. These conditions, either by accident or intent, can create areas where water can collect and remain for extended periods of time with subsequent possibility of accelerated corrosion. Where an unfavorable galvanic couple exists, as discussed above, the presence of standing water for prolonged periods will allow the corrosion reaction to continue for a longer time than it normally would. Even in cases where an adverse couple does not exist, enough water can complete the necessary electrical contact and corrosion will proceed as long as the water maintains the circuit.

The appearance of roofing panels can suffer even when all materials within a water-ponding area are compatible. Aluminum-coated steel panels are not as resistant to standing water as Galvalume sheet. When the aluminum-coated panel begins to rust, the standing water can disperse and deposit rust particles on an adjacent Galvalume sheet panel, resulting in an unsightly stain.

### Coating Weight and Thickness Designations for Coated Sheet Steels

Questions are frequently asked about the coating weight and thickness designations of the coated sheet steel products used in the metal building industry. This Technical Bulletin is designed to answer these questions, provide you with the appropriate specification references, and allow you to quickly convert between coating weights and thicknesses.

The most commonly used coated sheet steel products in the metal building industry today are: Galvalume®, galvanized, and aluminum-coated, type 2. Another newer product is Galfan®. All of these coatings are applied in a continuous coil line operation using the hot-dip coating method: the hot- or cold-rolled steel strip is passed through a molten metal bath followed by gas wiping to control the amount of coating applied. Because of the different densities of the coatings, the coating thickness will vary for a given coating weight when comparing these various products.

### Coating Weights:

The table below gives the ASTM Specification for the corresponding coating, as well as examples of coating weight designations used in the metal building industry.

Coating	ASTM Specification	Typical Coating Designation
Galvalume	A792	AZ50, AZ55
Galvanized	A653	G60, G90
Aluminum-coated, type 2	A463	T2 65, T2 100
Galfan	A875	GF60, GF90

The numbers within the designations refer to the total coating weight on both sides of the sheet in hundredths of an ounce per square foot (oz/ft<sup>2</sup>) of sheet. Thus, an AZ55 Galvalume coating would have a minimum total of 0.55 oz/ft<sup>2</sup> of coating, or, analogously, a T2 100 aluminum, type 2 coating would have a total coating weight of at least 1.00 oz/ft<sup>2</sup>.

The concept of "per square foot of sheet" is significant. When coating weights are specified in this manner, as most hot-dipped coatings are, the total amount of coating on both sides of the sheet is referenced, not the amount on each individual side.

In most cases, the coatings are applied relatively equally to both sheet surfaces. However, hot-dipped coatings are difficult to control precisely from side to side. Generally, the ASTM specifications covering hot-dipped coatings include a stipulation that "...it can normally be expected that not less than 40% of the single-spot check limit will be found on either surface."

This means, for example, that a G90 galvanized coating will have at least 0.32 oz/ft<sup>2</sup> of coating on each side of the sheet. This value is derived from the single-spot requirement for G90 of 0.80 oz/ft<sup>2</sup> total on both sides of the sheet. 40% of 0.80 oz/ft<sup>2</sup> is 0.32 oz/ft<sup>2</sup>.

### Preventing Wet Storage Staining of Galvalume® Sheet

Unpainted and pre-painted Galvalume sheet products are well known for providing a long, trouble-free life when used for roofing panels, siding panels, and other building components. However, there are certain precautions which should be observed in the handling and shipping of Galvalume sheet products. One of the consequences that can result when these precautions are not followed is wet storage stain. This Technical Bulletin will explain storage stain, how it can be prevented, and how to remove it if it occurs.

**What Is It?:**

Storage stain is a dark gray to black stain that can occur on coils and tightly packed stacks of sheets or panels of Galvalume sheet. In its very early stages, it can appear as a white stain similar to the storage stain that can form on galvanized steel. Although storage stain is usually superficial, it is unattractive and can progress quickly to a more severe state if the cause of the stain is not eliminated. When it is severe, there can be a substantial loss of coating material and subsequent reduction of service life. The storage stain itself will not worsen once a panel is in place.

The cause is water or moisture. Water can get into an unwrapped steel coil or lift of cut-length sheets by exposure to rain or high humidity. Even though the coil laps, cut sheets or roll formed panels are tightly packed, moisture can enter the closed surfaces by capillary action. Water often gets on the sheet by condensation. When cold steel is brought in from outside to a warmer building, the moisture in the warm air condenses on the colder steel.

Galvalume has excellent durability in the atmosphere because of the protective, air-formed oxide that forms on the surface. However, the situation is different inside coils or in bundles of closely nested formed panels, because there is no free access to air. If water or moisture is present, a faster type of corrosion occurs due to the lack of an inhibiting oxide film. Under these conditions, storage stain on Galvalume sheet can occur in as little as 24-48 hours.

Even pre-painted Galvalume sheet is not immune to storage stain. Roll forming pre-painted sheets into building panels can result in micro-fracturing of the paint. These very fine micro-cracks are of no consequence on a building and in no way interfere with durability, but they can permit access of moisture to the metal surface. Inside a bundle of painted panels, the same accelerated corrosion can occur as with bare Galvalume sheet.

## **Preventing Wet Storage Stain:**

### **Erectors:**

Erectors should do the following to prevent storage staining of Galvalume sheet:

- Coordinate the fabrication and delivery closely with the need for product in the construction process. Inspect the bundles on arrival at the building site and note on the delivery receipt any exceptions such as damage or corrosion.
- Store the bundles on racks at least one foot above ground level. Do not use uncured lumber.
- Under-roof storage is recommended when possible. If the bundles must be stored in the open on bare ground, a plastic ground cover should be used under the bundles to minimize condensation on the sheets from moisture in the soil.
- Elevate one end of the bundle to allow any moisture to run off rather than puddle on the top of the bundle or between nested panels. Water resistant paper will not keep out puddled moisture beyond its rated moisture vapor transmission time.

### **Stain Removal**

Storage stain on Galvalume sheet is mostly hydrated aluminum oxide which can be very difficult to remove. In mild cases, a solvent such as mineral spirits applied with a soft rag has been known to effectively remove the stain. This method is also used to remove stain from pre-painted Galvalume sheet without damaging the paint.

For more advanced cases on unpainted Galvalume sheet, it is impossible to remove the stain without also affecting the good coating under and around the stained area. The amount of damage to the coating during removal will depend on the method used. In more severe stages, storage stain can be removed from bare Galvalume sheet with a mild household cleanser such as Bon Ami\* or Clorox Soft Scrub\* and a wet sponge or rag. Industrial products such as Oakite 84M\* may also be used, but are more aggressive to the coating. In any case, the Galvalume panel should be thoroughly rinsed with water after the stains have been removed.

Harsh alkaline cleaning solutions and high pressure sprays should be avoided, as these have been known to dramatically alter the corrosion resistance and appearance of the Galvalume coating. Steel wool should not be used for two reasons: It is too abrasive and it can leave behind iron fines which will rust and cause a cosmetic staining problem.

Regardless of what method is used to remove storage stain, remember that the coating has been affected by the stain and cleaning. These areas will have a different appearance than the surrounding coating. And, depending on the severity of the stain, may have a shorter lifetime.

## **Fastener Selection Guidelines for Use with Galvalume® Sheet**

Although there are many selection criteria to consider when choosing a fastener for use on a metal building, one of the most important is the compatibility of the fastener with the panel material. Another aspect of the selection process should also include the expected service life of the fastener relative to the other components used in the building construction. If these other components are made of Galvalume sheet, where service life in excess of 20 years is to be expected, equivalent durability should be expected from the fastener.

Although the best advice for fastener selection will come from your fastener supplier or manufacturer, we offer these guidelines based on our own accelerated laboratory tests and on-site building inspections.

### **Compatibility**

Exposed corrosion resistance is generally a well understood concept. If a material rusts or otherwise fails in a given environment in a relatively short time, it is not acceptable. However, compatibility is more complex in that it not only involves corrosion resistance in the local environment, but also the interaction of materials in intimate contact. Contact can either be direct with the materials physically touching each other, or the contact can be made with an electrically conductive solution such as ponding water. An example of this is exposed fasteners on a metal roof, especially if a rubber or polymeric sealing washer is not used.

### **Galvanic Corrosion**

When a more active metal is in electrical contact with another less active metal, the more active component will sacrifice itself to prevent the other from corroding. This is known as dissimilar metal contact, or galvanic corrosion. Under the right conditions, this type of corrosion can be very aggressive.

For instance, if one were to install an unprotected steel screw in a Galvalume sheet building panel, the zinc in the coating at the area of contact with the screw head would sacrifice itself to protect the screw. Aside from the natural rusting of the screw head itself over time, the panel coating in the area of the screw would be consumed and the panel would begin to rust. In a corrosive environment (i.e. acid rain) the process speeds up considerably due to the increased conductivity of the electrolyte (rain water).

There are many other factors which can affect the degree of galvanic corrosion in addition to the basic explanation given above. Factors such as the relative exposed area ratio of the metals, their polarization characteristics, the nature of the corrosion products, and the total time of exposure to wetness may affect the degree of corrosion.

## **The Tests:**

Laboratory testing examined the performance of fasteners on bare and pre-painted Galvalume sheet in two corrosive environments: standing water and the 2-liter Kesternich SO<sub>2</sub> (DIN 50018) cabinet. The fasteners were screwed into pre-punched holes in Galvalume sheet panels taken from standard production material. The paint system of the pre-painted Galvalume sheet consisted of a Bethlehem-approved primer with a silicone-modified polyester topcoat.

Standing Water: A standing water environment can simulate the conditions sometimes found on areas of low-slope roofs and at drip edges. The test panels with mounted fasteners were placed flat in shallow plastic trays which were in turn placed in a humidity cabinet at 100% relative humidity at 140°F. The trays were deep enough so that distilled water completely covered the panels and fasteners. After 2000 hours of constant immersion, the panels were removed for evaluation.

Kesternich Test: The Kesternich test is widely used in the industry for studying the corrosion resistance of materials. It most closely simulates a severe industrial environment, incorporating 8 hours exposure to an atmosphere of sulfur dioxide gas and 100% relative humidity at 100°F with 16-hour periods of drying. The panel assemblies were tested for a total of forty 24-hour cycles.

The fastener materials included: 300-series stainless steel (in both solid and other configurations), 400-series stainless steel (with and without a zinc-plated coating), a zinc/aluminum cast alloy, a cast nylon plastic, electroplated zinc and electroplated cadmium. Painted fasteners were not tested due to the large variety of paints available. During the tests, only the exposed heads and washers were evaluated: Other aspects, such as the shanks or the strength of the head, were not taken into account.

## So, What Fasteners Should I Use?

Combining the results of our laboratory tests and field inspections has revealed some clear precautions when choosing a fastener for long-term durability and compatibility with Galvalume sheet building products. The table below summarizes our findings and ranks the materials in order of descending preference.

Fastener	Comments
300-Series Stainless	Offers outstanding overall durability and compatibility in all environments. However, localized undercutting and blistering have been observed on pre-painted Galvalume sheet in severe marine environments. However stainless steel fasteners often cannot produce the clamping action necessary to provide an effective endlap or ridge condition. These are not recommended by Nucor.
Nylon	Does not corrode or affect the Galvalume coating, however, there have been instances of ultraviolet degradation from sun light. It is determined that this type fastener does not provide the clamping force necessary. These are not recommended by Nucor.
Aluminum	In addition to the fasteners tested in the laboratory, field inspections have shown that aluminum fasteners are long lasting and compatible with Galvalume sheet, however, do not provide the clamping force necessary to provide a weathertight seal. These are not recommended by Nucor.
Zinc/Aluminum Alloy or 400-Series Stainless Capped fasteners	<p>Both offer excellent durability and compatibility with Galvalume sheet and provide excellent clamping force required for a weathertight connection.</p> <p>Zinc/aluminum alloy heads may have a tendency to weather to either a white or a medium- to dark- gray color depending on the environment. This oxidation does not affect their service life. This is the fastener recommended by Nucor</p> <p>Uncoated 400-series stainless heads may form a reddish-brown oxide film in the atmosphere. This can also cause a rundown stain on the adjacent building panel. A coating of zinc and a dichromate treatment can enhance the cosmetic appearance of the 400-series material by delaying this onset of surface rust. Capped fasteners, like most fasteners, do not offer inside protection to the carbon steel shank.</p>
Electroplated Zinc and Cadmium Coatings	Neither coating in the thicknesses generally available (0.5 mil or less) offers the long-term durability required for use with Galvalume sheet. Such thin electroplated coatings are consumed in a relatively short time leading to accelerated corrosion of the surrounding Galvalume sheet as it attempts to galvanically protect the exposed steel fasteners. Generally, a minimum of 2 mils of either zinc or cadmium, preferably with a heavy dichromate treatment, is required to provide acceptable durability. These are not recommended by Nucor.

**Other Precautions:**

Building inspections have revealed another area of concern; fastener installation. When a screw is overdriven or driven in at an angle, two potentially harmful things can occur. A sealing washer can be destroyed causing a leak, and the screw head can cut through the coating of a steel panel. Although zinc and 55% aluminum/zinc coatings will protect the damaged area for a time, the damaged area can rust prematurely depending on how much steel is exposed and on the nature of the local environment.

Overdriving a fastener can also cause a depression in the panel depending on the force used during installation. These depressions can trap and hold water for extended periods resulting in a localized ponding condition.

Fasteners come in a wide assortment of configurations, sizes, materials and strengths depending on the end use. Most fastener manufacturers offer technical, applications, and installation assistance for the use of their products. When you need advice for a specific problem or use, take advantage of the expertise offered by the manufacturers.

## Unpainted Galvalume® Sheet in High Visibility Applications

The premier choice of designers and builders for high-visibility architectural projects is very often pre-painted Galvalume steel sheet. It is extremely durable, very cost-effective, easy to install and available in a wide range of finishes, colors and panel configurations.

Unpainted Galvalume sheet is most often specified for low-slope roofing applications where functional performance is the primary consideration and cosmetic appearance is secondary. Galvalume sheet has clearly demonstrated its outstanding performance in these applications for over 20 years.

In some cases, unpainted Galvalume sheet is being specified for high-visibility applications. The very attractive spangled appearance of the product, along with its excellent long-term durability, has contributed to this trend.

As with any materials used in high-visibility applications, extra care should be taken to maximize the desired appearance. End-users and specifiers should be aware of the following characteristics of unpainted Galvalume sheet which may affect cosmetic appearance.

### **Handling:**

Just as care should be exercised in handling pre-painted materials to avoid damage to the organic finish, care should be taken when handling unpainted Galvalume sheet to avoid marring the metallic coating finish.

Surface Scratches/Abrasion: When the Galvalume sheet surface is abraded or burnished by agents such as hard-soled shoes or objects sliding over the surface, the coating becomes darkened. Although they might be apparent visually, these dark areas are not defects in the material and will not limit the useful life of the product.

Removal of the darkened area is generally impractical once the coating has been abraded, but cleaning with a mild detergent or gentle wiping with mineral spirits (and a thorough rinsing) may help in some cases. Most importantly, care during material movement and installation will help avoid the potential problem before it becomes one.

Fingerprints: Oils, such as the natural oils on one's hands, can cause unpainted Galvalume sheet to darken or smudge from handling. The use of clean gloves is recommended to minimize this marking of the product during handling and installation. Should handling marks occur, they are best removed promptly with mild detergent or alkaline cleaners.

Harsh alkaline or abrasive cleaners should be avoided. Thorough rinsing after any cleaning is important. Even with these cleaning steps, uniform appearance may not be fully achieved and is not guaranteed.

### **Non-Uniform Weathering:**

It is not uncommon for unpainted, metallic-coated sheet panels to exhibit some degree of darkening, or "weathering", on exposure to the atmosphere. Occurring on galvanized, Galvalume, aluminum-coated and other sheet materials, this darkening can occasionally appear non-uniform. Panel manufacturers and building owners have accepted this phenomenon for years as it does not compromise the quality or long-term durability of the product.

The change in visual appearance is strictly a surface phenomenon and is related to the passivation treatment applied to the sheet after the metallic coating has been applied. This treatment produces a film that protects the coated sheet from developing "wet storage stain", which might otherwise occur if coils or nested panels get wet during shipment or storage.

This passivate film retards the natural weathering, or darkening, exhibited by the coated sheet surface. The darkening effect is normally uniform. However, it is possible for an uneven weathering response to occur due to variations in the type and amount of this surface treatment (i.e. when material is obtained from different mills).

If non-uniform surface appearance occurs, it does not represent a deficiency in the material nor does it adversely affect any warranties which may be in place. However, for applications where high-visibility is of particular concern, the end-user can take precautionary steps. The materials supplier should be informed that the project is a high-visibility application and that cosmetic appearance is important. It should also be requested that material be supplied by the same mill. These steps should increase the likelihood of obtaining material which will weather more uniformly.

### **Critical Appearance:**

While steps can be taken to improve the likelihood of obtaining uniform visual appearance on unpainted Galvalume sheet, it cannot be guaranteed. If uniform visual appearance is critical or mandatory as a condition of sale, then pre-painted Galvalume or pre-painted galvanized sheet should be ordered. A wide range of organic coatings and finishes are available, including polyester, siliconized polyester, fluorocarbon, and plastisol formulations. In addition to enhancing the beauty and durability of Galvalume or galvanized sheet steel, these paint systems are designed to provide the uniform visual appearance demanded by such critical cosmetic applications.

## References

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2. W.D. Barker and A.R. Borzillo, "Field Study: Standing Seam Holding Up Well", RSI, pp 30-32 (December 1988).
3. H.E. Townsend, A.R. Borzillo and W.D. Barker, "Performance of Al-Zn Alloy-Coated Steel Sheet After 22 Years of Atmospheric Corrosion Testing", Intergalva, Rome, Italy (June 1988).
4. Technical Bulletins as published by Bethlehem Steel.