

## FERROUS VS. NON-FERROUS METALS

Metal substrates are widely used in both residential and commercial construction due to their strength, durability, and versatility. However, not all metals behave the same when exposed to the environment or when prepared for coating systems. A key distinction in metal substrates is whether the material is ferrous or non-ferrous.

Understanding the differences between these two categories is important when selecting appropriate surface preparation methods, primers, and protective coatings. Each type of metal has distinct characteristics, corrosion behaviors, and coating challenges that must be addressed to ensure long-term performance.

### Ferrous vs. Non-Ferrous Metals in Building Construction

Ferrous Metals (Contain Iron)	vs.	Non-Ferrous Metals (Do Not Contain Iron)
<p><b>Common Examples in Buildings</b></p>  <ul style="list-style-type: none"> <li>• Structural Steel Beams &amp; Columns</li> <li>• Carbon Steel Pipes</li> <li>• Steel Decking</li> <li>• Cast Iron Pipe</li> </ul> <p><b>Key Characteristics</b></p> <ul style="list-style-type: none"> <li>• Magnetic</li> <li>• High structural strength</li> <li>• Susceptible to rust and corrosion if unprotected</li> <li>• Typically requires protective coatings or galvanization</li> </ul>	<p>vs.</p>	<p><b>Common Examples in Buildings</b></p>  <ul style="list-style-type: none"> <li>• Aluminum Window Frames &amp; Curtain Walls</li> <li>• Copper Flashing &amp; Roofing</li> <li>• Stainless Steel Railings &amp; Fasteners</li> <li>• Zinc Roofing &amp; Panels</li> </ul> <p><b>Key Characteristics</b></p> <ul style="list-style-type: none"> <li>• Generally non-magnetic</li> <li>• Higher corrosion resistance than ferrous metals</li> <li>• Often used where durability or appearance is important</li> <li>• Usually require specialized primers for coating adhesion</li> </ul>

### Ferrous Metals

Ferrous metals are metals that contain iron as their primary component and are widely used in construction due to their strength and structural capacity. These materials typically exhibit high strength and load-bearing capability and are usually magnetic. However, the presence of iron also makes them susceptible to oxidation when exposed to moisture and oxygen. When unprotected, ferrous metals can develop rust, which progressively deteriorates the metal surface. Because of this vulnerability, ferrous metals are commonly protected using coatings, galvanization, plating, or other corrosion-resistant treatments to extend service life.

Ferrous metals are widely used in structural and industrial construction due to their strength and load-bearing capacity. Typical ferrous metals encountered in construction include:

### Non-Ferrous Metals

Non-ferrous metals are metals that do not contain significant amounts of iron. These materials generally do not rust and often provide greater resistance to corrosion in many environments. As a result, they are frequently used in applications where corrosion resistance, lighter weight, or electrical conductivity is important. Many non-ferrous metals also develop stable oxide layers that protect the underlying metal from further deterioration.

Several common building materials fall into the non-ferrous category, including aluminum, copper, zinc, brass, and stainless steel. These materials are widely used in architectural construction for components

such as window frames, flashing, roofing systems, fasteners, decorative hardware, and façade elements.

Non-ferrous metals are generally lighter than ferrous metals, particularly in the case of aluminum. They often exhibit good electrical and thermal conductivity and typically resist corrosion better than iron-based metals. In many cases, these materials form a protective oxide film on the surface that slows further deterioration.

## Corrosion Behavior of Ferrous and Non-Ferrous Metals

All metals are susceptible to some form of corrosion, which is the deterioration of metal resulting from chemical or electrochemical reactions with the surrounding environment. The way corrosion occurs, however, differs significantly between ferrous and non-ferrous metals.

Ferrous metals are particularly prone to oxidation when exposed to moisture and oxygen. In this process, iron reacts with oxygen and water to form iron oxide, commonly known as rust. Rust is porous and non-protective, meaning it does not form a barrier that prevents further corrosion. Instead, corrosion can continue beneath the rust layer, leading to progressive deterioration of the metal. This process can result in structural weakening, surface scaling, coating failure, and continued corrosion beneath paint films. Because rust does not protect the metal surface, protective coatings are typically required to prevent ongoing deterioration.

Non-ferrous metals generally corrode differently. Instead of forming rust, many develop stable oxide layers that protect the metal beneath. For example, aluminum forms aluminum oxide, copper develops a protective patina, and zinc forms zinc carbonate when exposed to atmospheric conditions. These oxide layers often act as natural corrosion inhibitors that slow further deterioration.

Although non-ferrous metals are generally more corrosion resistant, they can still experience corrosion-related issues under certain conditions. These may include surface oxidation or chalking, localized pitting corrosion, galvanic corrosion when dissimilar metals are in contact, and surface staining. While corrosion in these metals may progress more slowly than in ferrous metals, it can still interfere with coating adhesion if surfaces are not properly prepared.

## Rust vs. Corrosion

The terms *rust* and *corrosion* are often used interchangeably, but they are not the same. Corrosion is the broader term describing the deterioration of metals caused by chemical or electrochemical reactions with the environment. This process can occur with many types of metals, including aluminum oxidation, copper patina formation, and galvanic corrosion between dissimilar metals (Figure 1).



Figure 1

Rust, however, is a specific form of corrosion that occurs only on iron and iron-containing metals. Rust forms when iron reacts with oxygen and moisture, producing iron oxide on the surface of the metal. Unlike the protective oxide layers formed on many non-ferrous metals, rust does not provide protection and instead allows corrosion to continue beneath the surface.

Another important corrosion mechanism affecting metal assemblies is galvanic corrosion. This occurs when two dissimilar metals come into electrical contact in the presence of an electrolyte such as water or moisture. Under these conditions, one metal becomes the anode and corrodes preferentially, while the other metal becomes the cathode and remains protected.

Examples of situations where galvanic corrosion may occur include steel fasteners installed in aluminum panels, copper components in contact with steel, or aluminum components touching stainless steel in wet environments. Proper design practices, including the use of isolation materials or protective coatings, can help minimize the risk of galvanic corrosion.

## Coating Considerations for Metal Substrates

Because ferrous and non-ferrous metals behave differently in terms of corrosion and surface chemistry, coating systems must be selected and applied accordingly.

Ferrous metals generally require protective coating systems designed to inhibit rust and prevent moisture exposure. These systems may include rust-inhibitive primers, epoxy primers, zinc-rich primers, and durable topcoats such as urethanes or acrylic finishes.

Surface preparation is critical and is typically performed in accordance with SSPC (The Society for Protective Coatings) surface preparation standards, which establish uniform procedures for cleaning steel prior to coating application. Common SSPC standards used for ferrous metals include:

- **SSPC-SP1 — Solvent Cleaning:** Removal of oils, grease, and contaminants before further surface preparation.
- **SSPC-SP2 — Hand Tool Cleaning:** Removal of loose rust, mill scale, and paint using hand tools such as wire brushes and scrapers.
- **SSPC-SP3 — Power Tool Cleaning:** Cleaning using powered wire brushes, sanders, or grinders to remove corrosion and old coatings.
- **SSPC-SP6 — Commercial Blast Cleaning:** Abrasive blasting to remove most rust, mill scale, and old coatings while allowing minor staining.
- **SSPC-SP10 — Near-White Metal Blast Cleaning:** A more thorough abrasive blast cleaning method that removes nearly all visible rust, mill scale, and coatings.

These preparation standards help ensure that steel surfaces are properly cleaned and profiled to promote coating adhesion and long-term corrosion protection.

## Common Coating Issues on Metal Substrates

When metal surfaces are not properly prepared or protected, several types of coating failures may occur. Adhesion failure is common and often results from surface oils, contaminants, smooth non-porous surfaces, or oxidation layers that were not removed prior to coating application.

Another common issue is underfilm corrosion, which occurs when moisture penetrates a coating system and causes corrosion beneath the paint film. This condition can lead to blistering, rust staining, and coating delamination. Flash rusting may also occur when freshly cleaned ferrous metal surfaces are exposed to humidity or moisture before primer application. In some cases, flash rust can develop within minutes or hours after surface preparation.

Galvanized metal surfaces can present additional adhesion challenges. Newly galvanized steel may contain passivation oils or zinc salts that interfere with coating adhesion. Proper cleaning and the use of compatible primers are essential to achieve durable coating performance.

## Key Takeaways

Surface preparation and proper coating selection are critical to the long-term performance of metal substrates in building construction. Eliminating oils, grease, dirt, rust, oxidation, and other surface contaminants, while also creating the appropriate surface profile, helps coatings achieve the adhesion and durability needed for service. The use of compatible primers further strengthens system performance by improving bonding and helping address the specific challenges associated with each type of metal.

Ferrous and non-ferrous metals are both common in residential and commercial construction, but they do not behave the same when exposed to weathering or when prepared for painting. Ferrous metals are vulnerable to rusting, while non-ferrous metals may resist rust yet still present adhesion challenges or develop other forms of corrosion. Recognizing these differences is essential to selecting the right preparation methods, primers, and coating systems.

When metal substrates are not properly identified, prepared, and coated, even a high-quality finish can fail prematurely. By understanding how these materials differ and by treating surface preparation as a critical part of the coating system rather than a preliminary step, specifiers, contractors, and building owners can significantly improve durability, appearance retention, and long-term protection.

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