Steel

DESCRIPTION OF THE SUBSTRATE

Steel is one of the few substrates encountered in both heavy industrial and commercial/architectural applications.

While exposures in building environments are certainly less corrosive than those found in industrial or marine situations; some indoor environments could face constant moisture (indoor pools), aggressive chemicals (labs or sanitation areas) that would also require the same high performance corrosion-resistant coatings that are typically specified for ‘industrial’ applications.

Steel is exposed to the environment, especially moisture and oxygen, that energy is released and the iron returns to its natural iron ore state. We refer to the pure iron ore that forms on the surface as “rust”.

During the steel making process, hot rolled structural steel forms a thin layer of iron oxide on the surface called “mill scale”. Mill scale differs from steel in composition as well as electrical properties, so if moisture is present, a process called “galvanic corrosion” will occur where the steel corrodes to protect the mill scale. As galvanic corrosion progresses, ultimately the mill scale is sticking to rust, not steel, and pops off leaving behind a compromised surface of exposed steel and loose scale.

ASSESSMENT & DSD LEVELS

The surface environment and exposure to elements ranging from chemicals, water, salt, air, UV, etc. all impact the service life of the existing coating(s). Steel can show a wide variety of problems for recoating, particularly if there has been no maintenance program in place.

To help quantify the condition of the existing coatings you should use two sources of standards:

MPI DSD Levels
SSPC VIS-2 – visual standards

SSPC VIS-2 is a book of photographs and diagrams that depict the various degrees of spot, general, and pin-point rusting on painted steel surfaces along with scale and description of standard rust grades.

Likely causes of failures on exterior steel include:

- Age of the coating(s)
- Poor or inadequate surface preparation prior to the application of the previous coating(s)
- The previous coating system was inappropriate for the exposure environment

Likely causes of failures on interior steel would include:

- Abrasion or damage to the surface
- Improper surface preparation prior to the application of the previous coating(s)
- The previous coating system was wrong for the exposure

Other problems that may have contributed to failures include:

- Shop primers that were not appropriate and/or may not have been top-coated in a timely fashion
- Design flaws including: intricate configurations, galvanic corrosion caused by other metals in close proximity, sharp edges, etc.
DSD 0 – ideal surface, a color or gloss change may be preferred
DSD 1 – slightly deteriorated coating on steel surfaces
DSD 2 – moderately deteriorated coating on steel surfaces
DSD 3 – severely deteriorated coating on steel surfaces
DSD 4 – substrate damage to the steel surface.

CRITERIA FOR CHOOSING THE RIGHT COATING

The primary consideration in choosing a coating for steel is the service environment. The degree of protection required is proportional to the aggressiveness of the exposure and some applications may require the use of high performance coatings normally used in industrial situations. The end use of the item to be painted also plays a role in the decision (e.g. exterior steel handrails in a marine environment).

An important note to keep in mind is the surface preparation that is required prior to a repaint job. If the exiting paint film has been damaged to the point where an abrasive blast cleaning is required and it cannot be done for environmental reasons, the type of paint system must be carefully considered. It is also imperative to refer to the paint manufacturer’s data sheet to verify how the surface must be prepared and cleaned to assure that the product(s) perform properly.

Adhesion is best achieved when the primer properly “wets out” the surface, penetrating the tiny surface irregularities of the steel, and preventing corrosion form developing under the film and causing lifting, blistering, and ultimately failure of the finish system.

COATING PRODUCTS & SYSTEMS

Guidelines for primers

- Quick-setting primers require abrasive blasting (SSPC-SP 6 Commercial Blast Cleaning).
- Surface-tolerant primers (MPI # 23) have a slower drying time and provide good wetting on steel that has only received hand or power tool cleaning.
- Alkyd anti-corrosive metal primers (MPI # 79) provides good anti-corrosive properties on well cleaned Steel (SSPC-SP 6) and are tolerant of power tool cleaning to SSPC-SP 3.
- Care must be taken with the use of water based anti-corrosive primers (MPI # 107) as these may not be suitable for poorly cleaned (prepared) surfaces.

Specifying the right finish (gloss level)

- Lower sheens are usually recommended for low traffic/contact levels as they tend to mark and burnish easily, however they are easier to “touch-up”.
- Eggshell offers a good balance between durability and reflectance.
- Semi-gloss and gloss offer better washability, resistance to water, and abrasion resistance.

Coating systems for steel:

- Alkyds – both quick-dry and conventional alkyds. Moderately priced interior and exterior applications from flat to gloss finishes. Quick-dry systems require a high level of surface preparation (SSP-SP 6).
- Latex – Used in non-aggressive situations. Water based anti-corrosive primers require SSPC-SP 6 commercial blast. For interior situations conventional, high performance or institutional low VOC/low odor latex systems may be used.
- W.B. Light Industrial Coating – used for interior or exterior applications where a higher performing paint system is required but the very high performance of an epoxy is not required. These products are suitable for locations subject to cleaning with chemical cleaners. Their chemical and water resistance makes them ideal for use in commercial and light industrial installations such as drycleaners or labs.
- W.B. Epoxy – The waterborne epoxy chemistry has evolved over the past few years and performance properties have improved. Although most cannot be truly compared to a solvent based epoxy they do...
cure to a highly durable, abrasion, detergent and chemical resistant finish suitable for high traffic areas in commercial, public or moderate industrial locations.

- **Dryfall systems** – used primarily on overhead steel trusses, beams, etc. where it is difficult to protect the items or areas below from overspray. These areas to be coated with dryfall must not be exposed to high humidity, condensation or abrasion. Whether the dryfall coating used is an alkyd or latex, you must first prime the steel with and anti-corrosive primer, typically an alkyd. Consult the manufacturer’s technical data sheets for the dryfall distance, temperature and humidity for application as these differ between products. If the spray gun is too far from the surface it will result in “dry spraying” which directly affects adhesion.

- **Fire Protection** – Intumescent coatings may be applied as fire protection on steel – they create an insulating charred (sacrificial) layer that keeps the steel below a critical temperature by expanding up to 30 times the original applied thickness when exposed to fire. Products are rated by how long they provide the protection (typically 1 – 3 hours). A primer and a finish coat may also be required as part of the system. There are two general types – single component acrylic/vinyl/polyvinyl acetate coatings and multiple component epoxy fireproofing products. Both types have very specific recoat windows and the epoxies require specialized equipment and certified contractors to apply them. Underwriters Laboratories – UL (and ULC in Canada) is the recognized authority that evaluates and approves an intumescent coating for a certain fire rating. Most intumescent applications result in a rougher or orange-peel appearance therefore back-rolling after spraying and the addition of a topcoat will enhance the final appearance.

**Systems for more aggressive environments:**

- **Zinc, Epoxy, Urethanes** – a three coat system comprised of a zinc primer, epoxy intermediate and polyurethane topcoat is commonly specified for steel in corrosive industrial and marine environments. Inorganic and organic zinc primers provide “galvanic protection” for the steel. Inorganic primers require more diligent surface prep, are trickier to mix and apply and can be more difficult to topcoat. The epoxy intermediate coating increases the film build and barrier protection as well as provides an ideal surface for the polyurethane topcoat. The two-component polyurethane topcoat offers excellent chemical, solvent, impact and abrasion resistance; they resist strong solvents for graffiti removal and provide good gloss and color retention.

- **Moisture Cured Urethanes** – These systems provide similar performance to the two-component systems, however they are easier to apply and can be applied in difficult conditions and environments. Moisture-cured urethane zinc primers and topcoats can cure at temperatures as low as 20°F and at a relative humidity as high as 95%.

- **Epoxy, Polyurethanes** – Epoxy, polyurethane systems require a minimum surface preparation of SSPC-SP 6 Commercial Blast. At times, under the right conditions, the primer and topcoat can be replaced with a single coat of high build self-priming epoxy top-coated with one or two coats of polyurethane.

- **Epoxy systems** – Epoxies can chalk and yellow in direct sunlight so their use as topcoats is somewhat limited to interior applications. These systems offer much greater chemical, abrasion and solvent resistance than alkyd systems and allows for easier removal of dirt and stains. For interior or exterior metal decks, non-slip epoxies as the topcoat are required if the surface will exposed to any water, oil or excessive humidity.

- **Aluminum finishes** – An aluminum finish over an alkyd primer is primarily for surfaces that will not be exposed to traffic (e.g. steel trusses hidden in a residential or commercial drop ceiling) and corrosion resistance may be caused by condensation.

**SURFACE PREPARATION**

Good surface preparation is imperative on steel substrates to maximize the adhesion of a new re-coating system. Three things that influence what degree of cleaning is necessary on steel surfaces:

1. The service environment – the more severe the environment the more stringent the surface preparation must be.
2. The coating system also dictates the type and amount of surface cleaning. The manufacturer’s data sheet should always be consulted.
3. Access to the substrate and regulatory restrictions can affect the decision regarding surface cleaning.

Types of Steel Surface Cleaning:

- Solvent cleaning – usually required prior to mechanical surface preparation and removes dirt, oil, grease, dust, chalk, etc. Solvents generally used include: denatured alcohol, naphtha, mineral spirits, toluol and kerosene. It is very important to rinse the residue of the solvent cleaner away to prevent adhesion problems. (SSPC-SP 1 and MPI RSP-2)
- Hand or Power tools – Typical hand tools are wire brushes, sanders and chipping hammers used to remove loose rust and loose mill scale. (SSPC-SP 2 and MPI RSP-1). Power tools can include grinders, rotary and cup brushes, power sanders, needle scalers, and rotary wire brushing tools, etc. SSPC has three specifications for power tool cleaning depending on the level or degree of cleanliness required. SSPC-SP 3 is the least stringent method where minimal surface preparation is required – removal of loose material (paint, mill scale, or rust). SSPC-SP 15 is the intermediate level which requires removal of all material but allows for more staining, streaks or discoloration. SSPC-SP 11 is the most rigorous and requires removal of all material except for slight residues in pits and also requires that the tools create a minimum one mil profile. MPI RSP-4 covers power tool cleaning but refers to SSPC-SP 3, 11 and 15 for procedures on steel.
- Wet methods of surface preparation – wet surface prep methods can include blasting with water and abrasive or just water. Wet blasting can produce surface cleanliness and anchor profiles similar to dry blasting procedures. Water jetting or waterblasting is defined as the use of water alone at high or ultrahigh pressures. The pressure is measured in pounds of pressure per square inch (psi). Water pressures for steel can be 40,000psi or higher. (SSPC-SP 12 and MPI RSP-5, or NACE No.5).
- Air Abrasive Blasting – is usually the most often specified method and most thorough method for cleaning steel when removal of all traces of corrosion or previous coatings is required. Air compressors feed compressed air to an ASME (or equivalent) certified blast pot that contains the abrasive. This compressed air forces the abrasive into a hose fitted with a blast nozzle. People using this equipment must always wear a NIOSH-approved “C” air-fed respirator. Abrasive blasting creates a surface profile or anchor pattern that promotes good adhesion of the primer. There are different heights of surface profile that suitable for different coatings (i.e. thinner coatings require a low anchor profile of 2 mils, whereas thicker coatings may require a surface profiles of 4 -5 mils – it is imperative to check the manufacturer’s product data sheet to ascertain this information). Profile height depends on the size, shape, type and hardness of the blast medium along with the blasting air pressure, angle of impact and the hardness of the surface. Blast abrasives may include: sand, coal, nickel, copper, crushed glass, steel shot and grit, and aluminum oxide. (SSPC-SP 5, 6, 7, 10, and 14 – and MPI RSP-7)

SSPC publishes the most-commonly referenced standards for steel surface preparation as well as standards for blast abrasives (SSPC-AB 1-3) and visual standards (SSPC-VIS 1 – 5) that inspectors or contractors can use to quantify the amount of corrosion and coating failure prior to painting operations, as well as verify the cleanliness of the surface after cleaning.

Steps for Surface Preparation of Steel

- Clean the surface of any dirt, oil, grease, etc. by power washing.
- If the surface coating is glossy, it must be de-glossed using either a mechanical or chemical means.
- Any corrosion or loose coating must be removed. Corrosion requires hand or power tools to be used. A combination of power washing and hand or power tool cleaning may provide a satisfactory surface for maintenance painting.
- Areas with heavy corrosion or rust (MPI DSD 3) require a minimum of SSPC-SP 6 Commercial Abrasive Blast Cleaning. If this is not possible SSPC-SP 15 Commercial Grade Power Tool Cleaning may be specified.

Dealing with Problem Areas
• Sharp edges and intricate configurations – all sharp edges (from slag and welds) should be ground to a smooth surface. Bar joists with close back-to-back angles or around nuts and bolts may require smaller power tools to properly remove the corrosion.

• OEM (Original Equipment Manufacturer) metal roofs – the area must be cleaned of any dirt or foreign substances. If the current coating is glossy it must be de-glossed for an adequate profile. If the former coating has adhesion problems, it may need to be completely removed down to the OEM finish to assure proper adhesion of future coatings.

MPI DSD Levels on Steel
• DSD 1 – Surfaces may have slight corrosion stains, slight to moderate erosion or chalking, and slight peeling or flaking through all coats to the primer (which remains intact). There may be slight mildew stains or sagging and contaminants such as oil and grease, dirt and dust. Rust stains can be removed by hand or power tool cleaning or with an oxalic acid solution per MPI RSP-12. Sags, runs and glossy surfaces can be sanded. All bare areas must be primed.

• DSD 2 – Surfaces may show localized blistering, slight to moderate alligatoring, corrosion and flaking and peeling which may extend to the substrate. There may also be corrosion staining, moderate erosion, chalking or mildew. Surface prep may require solvent cleaning. All loose and flaking paint must be removed to a minimum of SSP-SP 6, if practical, and areas that extend to bare substrate must be primed.

• DSD 3 – The surface may show moderate to heavy peeling, extensive alligatoring, and moderate to heavy blistering, corrosion, corrosion staining, cracking, chalking or mildew. Surface preparation will include all those required in DSD levels 1 and 2 as well as feathering of any blistered areas that have been abraded. In some instances the previous coating(s) must be removed to bare metal using either SSPC-SP 6 or SSP-PC 15.

COATING APPLICATION

Environmental conditions are extremely important with steel surfaces as air temperature, surface temperature, humidity and dew point can affect not only the surface prep but also the coating process. Freshly cleaned steel surfaces should be painted within a very short window as flash rusting can form in a very short period of time.

Coating Application Tips:
• Stripe coating (i.e. brushing the coating on the areas prior to spray application) sharp edges, back-to-back angles, bolts, etc. to assure that the areas have sufficient film build to resist corrosion.

• Thinning – Always check the manufacturer’s technical data sheet to ensure that you are using the correct thinner as well as the correct amount at the correct time.

• Spraying – the equipment must be cleaned properly between different types of paint. If a solvent was used it must be rinsed with potable water and cleaned with isopropyl alcohol (or compatible solvent) then rinsed again prior to using a water based coating.

• Issues with Moisture and Temperature – for waterborne coatings to cure the moisture must evaporate from the paint film. Under normal conditions, paint will be water-sensitive for 6 to 12 hours after application and must be protected from rain or condensation on the surface. High humidity will change the curing times which are presented on the technical data sheet.

• Dry Time and Recoat Time – always check & follow the manufacturer’s instructions. Standard recoat time for water based coatings ranges from 4 – 12 hours. Some inorganic zinc rich coatings will dry in about an hour but before applying a topcoat you must wait for a full cure (as they cure with the moisture from the air).

• Packaging – some high performance coatings require mixing two or three components just prior to application. Some contain a base and a catalyst – called or labelled Part A and Part B.

• Mixing – It is critical to follow the manufacturer’s mixing instructions exactly regarding the order and the amounts (mixing ratios). Unmixed material can cause soft spots, various color shades and differing glosses. Zinc-rich paints need to be mixed or stirred constantly or the zinc dust will settle to the bottom.
Other epoxies and polyurethanes require a wait time between mixing and application for the coating to “react” in the can.

- **Pot Life** – this is the length of time that the coating is mixed to when it becomes unusable. Some specialty coatings have a very short pot life and must be applied by plural-component spray equipment. Thinning the coating will not extend the pot life. Pot life can also be affected by air and material temperature. Check the technical data sheet for the pot life at various temperatures.
- **Issues with Zinc Primers** – Zinc primers are usually sprayed as the zinc dust settles quickly. Brush or roller use would only be warranted for spot touch-up. The use of an agitator or stirrer in the spray pot is mandatory to keep the zinc dust suspended in the coating.

**INSPECTION & QUALITY CONTROL**

**Inspection Checklist for Cleaned Steel**

- Check for dust, dirt, chalking or grease on the steel surface visually or by using a clean white tissue or cloth across the area.
- No rust scale should be left on the steel.
- Mill scale should be tight and not removable.
- Blasted Steel (SSPC-SP 6, SSPC-SP 10 or SSPC-SP 5) should be free of all mill scale, rust and old paint if present. Refer to the SSPC visual standards to verify the cleanliness of the blasted surface.
- Non-visible contaminants – such as soluble salts that remain on the surface after abrasive blasting can lead to premature paint failures especially in aggressive environments. There are test kits to determine the level of soluble salts on the surface. There are also commercially available soluble salt removal kits.
- Solvent cleaned steel – (for removal of grease or oil) should be free of any remnants of the solvent cleaner and the pH of the surface should be neutral (pH should not exceed the pH of the rinse water).
- Substrate temperature – the surface temperature should be checked and recorded prior to application and should fall within the manufacturer’s recommendations for the product.
- Profile depth – of the blasted surface should also be checked and fall within the paint specification. There are various tools to measure surface profile.

**Inspection Checklist for Paint Application**

- Verify that the correct paint is being used.
- Verify film thickness. Dry film thickness can be measured using non-destructive gages.
- Dryness – check the condition of the paint to see that it has dried properly.
- Completeness of the coverage – verify that there are no pinholes (holidays) and that coverage is satisfactory on edges, rivets, welds, bolts and areas that are not easily accessible.
- Check for brush marks, runs and sags.
- Check for wrinkling of dry paint which is sometimes caused by a coating that is applied too thickly.
- Test the adhesion of the dried coating.
- Inspect for defects such as orange peeling, blisters, pores, crazing, cracking, etc. that indicate improper application.