



SURFACE PREPARATION

Ferrous Metal

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PURPOSE

This section describes ferrous metal surface preparation methods for both above and below water. Method selection will be based on the type of metal, condition of the metal, application experience, budget and condition of the current coating system.

INTRODUCTION

To obtain the best results from a paint system the best possible surface preparation consistent with the degree of sophistication of the system is required. The quality of the paint and surface preparation (i.e. the removal of rust, scale, salt, grease, dirt and loose paint) are the most important factors in determining the lifetime of the paintwork, and therefore the length of time the surface will be protected. First class preparation has the potential to extend the protective life of any paint system.

There are often several surface preparation methods available - dependent on the type of surface. The methods selected will depend on a number of factors including environmental conditions and cost.

The cost of proper surface preparation may seem expensive but the benefits of extended coating life and reduced maintenance costs will almost always more than offset any additional surface cleaning cost.

SURFACE CONTAMINANTS

Mill Scale

The complete removal of mill scale and rust is critical in order to limit its corrosive properties. Mill scale is generally found on new steel as a hard brittle coating - it consists of distinct layers of various iron oxides and is formed during the hot rolling process in the manufacture of steel. Painting over mill scale is not satisfactory, as mill scale is not firmly or permanently bonded to the steel. Eventually the scale will lift off, causing paint coatings to flake and corrosion to occur. The cathodic nature of mill scale means that partial removal is not sufficient - the galvanic cells established between the scale and scale free areas induce accelerated corrosion, resulting in pitting of the steel surfaces. This is particularly so in aggressive environments.

Rust

Rust is a form of hydrated ferric oxide formed by the action of water and oxygen on iron and steel surfaces and occupies a much greater volume than the original steel. It is for this reason that rust forming beneath a paint layer is able to rupture a coating. All areas of rust should be completely removed - any rust remaining will act as a nucleus for further rusting.

Oil, Grease Fat and Perspiration

Oil, grease, fat and perspiration deposits cannot be removed by mechanical methods of cleaning. The simplest method of removal is to use a solvent emulsifiable degreaser or biodegradable detergent. Apply the degreaser liberally to the contaminated surface, allow to stand for a short time, then hose off with fresh water. Besides liquid solvent degreasing, other methods include:

- Solvent vapour cleaning.
- Alkaline cleaning.
- Biodegradable detergent.

Please refer to AS 1627.1 Metal Finishing - Preparation and Pretreatment of Surfaces - Removal of Oil, Grease and Related Contamination.

SURFACE PREPARATION OF WELDS

One of the most common causes of corrosion is welds and adjacent areas. Proper surface preparation of these areas will ensure a longer protective life for metal parts and equipment. Surface preparation is most important and represents the first stage in weld protection. Breakdown of protective coatings in areas around welds is generally caused by the failure to remove harmful deposits formed during welding, such as:

- Alkaline slag - from the weld flux - this reduces adhesion and durability of paint films.
- Condensed flux fumes - produces similar alkaline conditions.
- Spatter from welds - it is not uncommon for beads of spatter to reach 600 microns in diameter. Paint coatings of normal film build would not cover these even in three coats and hence weld spatter presents vulnerable points for rusting to occur.
- Oxides - produced by the heat of welding.

An effective method of retreating welded areas prior to painting is as follow:

1. Remove weld spatter by grinding with a power tool, or hand filing.
2. Grind all welds and high points smooth.
3. Remove any surface contaminants that result from welding.
4. Rinse thoroughly with fresh water and allow to dry.

1. POWER AND HAND TOOL CLEANING

Power and hand tool cleaning are the least effective of all the recognised surface preparation methods for steel. Tightly adherent mill scale, rust in deep pits, angles and corners are difficult to remove by these methods. Power tool and hand tool cleaning methods are questionable economically and must be constantly supervised for the specification to be met. This method of surface preparation is not suitable for aggressive environments. Full details can be found in AS 1627.2 Metal Finishing - Preparation and Pretreatment of Surfaces - Power Tool Cleaning.

St2 / Pst2

Most adherent rust and mill scale is removed. The surface is roughened by the impact tool and has a semi-bright (dull silvery) appearance. The remaining mill scale has a slightly burnished appearance. The prepared surface approximates St2 / Pst2 (AS 1627.9).

St3 / Pst3

All visible rust and mill scale are removed and the surface has the appearance of bright steel (silvery). This condition is only obtained by the use of a power disc sander and impact tool. The prepared surface approximates St3 / Pst3 (AS 1627.9).

2. BLAST CLEANING (ABRASIVE CLEANING)

Blast cleaning is the removal of rust and mill scale by the use of compressed air to project a high velocity stream of abrasive such as aluminium oxide, garnet, grit or steel shot onto the metal surface. The impact of these high speed particles cuts away the mill scale and rust, leaving a clean steel surface. The cutting action leaves small indentations over the entire surface and these are often referred to as 'surface profile'. A blast cleaned surface is well adapted to receive and retain paint coatings.



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Abrasive blast cleaning AS 1627.4 is the recommended standard for this method of surface preparation. Four classes of abrasive blasting are recognised and are summarised as follows:

Sa 1 - Light Blast Cleaning

This is often referred to as Whip Blasting. Cleaning to this standard required that loose mill scale, loose rust and foreign matter are removed. Surface preparation to Sa 1 (AS 1627.9).

Sa 2 - Medium Blast Cleaning

Cleaning to this standard requires that mill scale, rust and foreign particles are substantially removed and that grey metal is visible. Surface preparation to Sa 2 (AS 1627.9).

Sa 2½ - 'Near White' Blast Cleaning

Cleaning to this standard requires that mill scale, rust and foreign particles are removed to such a degree that the only traces remaining are slight stains in the form of spots or stripes. Surface preparation to Sa 2½ (AS 1627.9).

Sa 3 - 'White Metal' Blast Cleaning

Cleaning to this standard requires the entire removal of all mill scale, all rust and all foreign particles. The cleaned surface shall have a uniform metallic colour. Surface preparation to Sa 3 (AS 1627.9).

3. HYDROJETTING / WET ABRASIVE BLASTING

Hydrojetting is a surface preparation method which uses high-energy water to remove coatings, corrosion products and other surface contamination such as oil/grease etc. The energy of the water striking the surface is used to achieve its cleaning effect. Hydrojetting does not provide a surface profile like abrasive blasting, and flash rusting will occur immediately. In this case, specialist coating systems are required.

Following is a list and description of various water cleaning/jetting methods:

1. **Low Pressure Water Cleaning**
Cleaning performed at pressures less than 34 MPa (5,000 psi). Typically used for cleaning oil, grease and other contaminants from the surface - in conjunction with detergents. It may remove loose flaking paint.
2. **High Pressure Water Cleaning**
Cleaning performed at pressures from 34 to 70 MPa (5,000 to 10,000 psi). Typically used for cleaning oil, grease and other contaminants from the surface - in conjunction with detergents. It may remove thin film coatings and loose flaking rust.
3. **High Pressure Water Jetting**
Cleaning performed at pressures from 70 - 170 MPa (10,000 to 25,000 psi). Typically used for the removal of red oxide corrosion products (haematite), black oxide corrosion products (magnetite), many paints and chemical contaminants.
4. **Ultra High Pressure Water Jetting**
Cleaning performed at pressure above 170 MPa (25,000 psi). Typically used to remove most mill scale, paints, chemical contaminants and radioactive material. It may remove base metal with prolonged application.



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Surface Profile

While ultra high pressure water jetting will remove all rust, scale, old paint etc. It will not create a surface profile and will only expose the original surface profile achieved/specified during the initial preparation of the steel.

The pressure of the equipment provides an indication on the maximum achievable standard and specifying the pressure does not mean that the substrate is cleaned correctly. The distance between the gun and the substrate is important - with an output pressure of 200 MPa (29,000 psi) bar, the water pressure at 15 - 20cm from the nozzle is insufficient to remove reasonably adherent corrosion or coatings.

The advantages of hydrojetting are:

- Spark hazard avoidance.
- Dust reduction.
- Water soluble salts removal.
- Deteriorated paints removal, layer by layer if the intercoat adhesion is bad.
- Roughening and cleaning of existing intact paint systems.
- Operational in unfavourable weather conditions.
- Removal of deleterious amounts of water soluble surface contaminants that may not otherwise be removed by dry abrasive blasting alone, specifically in the bottom of pits and craters of severely corroded metallic substrates.
- Removal of surface oil and grease.
- Removal of rust.
- Removal of existing coatings.

Relevant Standards - SSPC-VIS 4 / NACE VIS 7

WJ-1 Clean to Bare Substrate

WJ-2 Very Thorough or Substantial Cleaning

WJ-3 Thorough Cleaning

WJ-4 Light Cleaning

SSPC-SP 12 / NACE No.5 - describes various degrees of cleaning - with no flash rust.

SSPC-VIS 4 / NACE VIS 7 - describes eight different initial conditions / rust grades of steel prior to surface preparation.

This recommendation is for greater than 170 MPa (25,000 psi).



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Soluble Salts

Hydrojetting significantly reduces the level of soluble salts on the steel surface. If these salts are not removed prior to painting they can cause osmotic blistering and lead to failure within a very short time. Levels of above 10 - 20 $\mu\text{g}/\text{cm}^2$ have been shown to cause coating failure particularly under immersion conditions.

Dry blasting does give partial removal of these soluble salts, however, it also tends to trap contaminants in crevices and foldovers created when the surface is deformed during dry abrasive blasting.

Soluble salt levels are specified in the NACE hydrojetting standard. They are not specified in dry blasting standards, but are carried out for tank coating work and for other areas where there is a high risk for the presence of soluble salts. Generally speaking one of the main advantages of hydrojetting, if carried out correctly, is the removal of soluble salts and for this reason it is not considered necessary to specify soluble salt concentrations as a part of the surface preparation standard unless it is suspected that they have not been removed.

Recommendation - soluble salt testing is only necessary as part of the surface preparation standard in special cases.

Refer AS 3862, AS/NZS 3894.6 and ISO 8502-2.

Which water should be used?

Fresh potable water alone should always be used - never seawater. If seawater is used followed by fresh water washing, then the steel is initially exposed to high levels of chlorides. With corroded steel, it is possible to identify where salt levels are highest (corroded areas) - this is impossible with a surface hydrojetted with seawater and fresh water rinsed. While the surface can be tested for chlorides it is impractical to test the entire area and to assess if they have all been removed, until the coating breaks down.

Recommendation - always hydrojet with fresh water.

4. SLURRY BLASTING - WATER/ABRASIVE

This is the generic name for all types of abrasive blasting that contain water - from introducing small quantities of fresh potable water into a stream of dry abrasive, to injection of a small quantity of abrasive into a high pressure water stream.

One of the major advantages of slurry blasting is the removal of soluble salts combined with the creation of a profile. However, the removal of the slurry can be a problem and it is always advisable afterwards to wash the surface down with fresh water prior to coating application in order to remove any abrasive from the surface.

NACE standards were only produced for hydrojetted surfaces.



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Flash Rust

Flash rust is inevitable when steel is cleaned with water without the use of an inhibitor. This leads to problems when trying to evaluate the degree of cleanliness of a hydrojetted steel surface as the formation of flash rust means that the substrate condition is constantly changing. Experience has shown that the steel cleanliness should not be judged when the substrate is wet.

The performance of a system applied to a hydrojetted surface is partly governed by the degree of flash rusting. The flash rusting can be divided into three categories:

- Light (L): Present as tightly adhering and appears as a surface staining that will partially discolour the original metallic surface and will not be heavy enough to easily mark objects brushed against it.
- Medium (M): Present as a layer which obscures the original metallic surface and will be heavy enough to mark objects brushed against it.
- Heavy (H): Present as powdery rust that obscures the metallic surface and easily marks objects brushed against it.

For more details and definitions, please consult SSPC-VIS 4 / NACE VIS 7.

However it is very difficult to quantify the amount of flash rust as it is constantly changing. Procedural changes can be made to reduce the flash rust formation and keep the interval between a dry substrate and coating application as short as possible. As good working practice the following should also be adopted:

- Reduce the time between completely wet and completely dry.
- Keep the interval between a dry substrate and coating application as short as possible. Some coatings do have some tolerance to damp surfaces and can be applied under certain conditions.
- Accept only firmly adherent flash rust.
- Never mechanically wire brush to remove flash rust - this will result in polished surfaces and rehydrojetting may be required.

Factors affecting the speed of flash rusting:

- Soluble salts on the substrate.
- Drying time of steel / humidity / temperature.

Appearance of Steel

Hydrojetted steel has a different appearance than dry blasting, even before flash rusting.

Generally surfaces look dull and pitted steel can have a mottled appearance. This is caused when the corrosion products are washed out of the pits leaving a bright steel surface and the surrounding areas are left dull grey, brown to black in colour (ferric oxide). Which is the reverse of a dry abrasive blasted surface where the failure to remove corrosion products from the pits gives a dark pit whilst the surrounding steel is a bright silver colour.

Damp/Dry Substrate

Prior to recoating the substrate should be dry - use water sensitive paper as per FTS Guidelines. For certain coatings a damp substrate is acceptable.



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EXISTING SYSTEMS

At 14 - 21 MPa (2,000 - 3,000 psi) existing paint can be removed, however, at 7 - 10 MPa (1,000 - 1,500 psi) only loosely adherent paint can be removed. If an existing system is left on the steel surface then there is a risk of island formation. Water can creep under the apparently 'tightly adherent coating' which is subsequently overcoated, leading to failure. Secondly, an existing paint film may be sufficiently thick that when overcoated there is an edge effect, where a freshly applied paint film moves away from a sharp edge and less paint is applied to the edge. This can be avoided by:

- High pressure removal of all existing coating.
- Feather all existing edges back to firm edge (i.e. discing).
- Stripe coat also edges of existing system.

Ballast Tanks

With ballast tanks there are still a number of practical problems, which make it difficult to achieve a uniformly acceptable standard of surface preparation. These problems are:

- Complex form (i.e. stiffeners etc).
- Poor visibility - constant water vapour (mist) present in the tank.
- Constant high humidity leading to - high levels of flash rust, and
- difficulty in achieving dry substrate prior to recoating.

Special attention should be paid to these items.

PREPARATION ON UNDERWATER SURFACES

Fouling, loose paint and other contaminants should be removed by High Pressure Water Cleaning. Any fouling and/or loose paint remaining after High Pressure Water Cleaning is to be removed by scraping or sweep blasting. The removal of an oil or grease belt can be achieved by scraping heavy deposits from the surface, and High Pressure Water Cleaning in combination with the use of suitable detergents. This should be followed by a thorough fresh water wash and drying prior to blasting and/or repainting. It may be necessary to blast clean such areas after this operation when oil has penetrated the underlying paint systems.

Rusty spots should be pre-treated by blast cleaning and touched up with an anticorrosive system within the requirements given in the relevant specifications. If water (abrasive) blast cleaning is applied, a suitable primer should be used, followed by the system as described in the specification.

CAST IRON

Dry Abrasive Blast

Abrasive blast using a non-metallic grit, to achieve a surface similar to AS 1627.4, Sa 2½. Clean the surface to remove all preparation residue.

Wet Abrasive Blast

Wet abrasive blast using a non-metallic grit to achieve a surface similar to AS 1627.4, Sa 2½. Flash rusting will occur almost immediately. High pressure water wash using clean, fresh water to remove all blasting residue.



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Pickling: (Chemical Cleaning)

Pickling is a method of preparing steel surfaces either by chemical reaction in acid or alkali solutions, electrolysis or a combination of both of these.

Weld spatter and slag should be removed by mechanical abrasion and contaminants such as dirt, oil and grease should be solvent cleansed prior to pickling.

On removal from the pickling bath the object must be well drained, rinsed thoroughly and dried. It should be primed as quickly as possible after drying.

A properly pickled surface can be considered as being almost equivalent to 'White Metal' blast cleaning.

Pickling has a number of disadvantages and restrictions and the most important of which are:

- It can only be conducted as a 'Shop Process'.
- Priming must be conducted on the same day as pickling and prior to erection or fabrication.
- Various pickling methods involve hydrogen - this will embrittle steel and seriously affect high tensile and case hardened steel, particularly in steel sections.
- Incomplete removal of pickling solutions because of article design, poor drainage or poor rinsing will eventually give rise to breakdown of the coating system.
- Although the cleaned surface is almost equivalent to that obtained by 'White Metal' blast cleaning, it does not provide a 'profile surface' necessary for some coating systems.

Relevant standard: AS 1627.5 - "Pickling Steel Surfaces".

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