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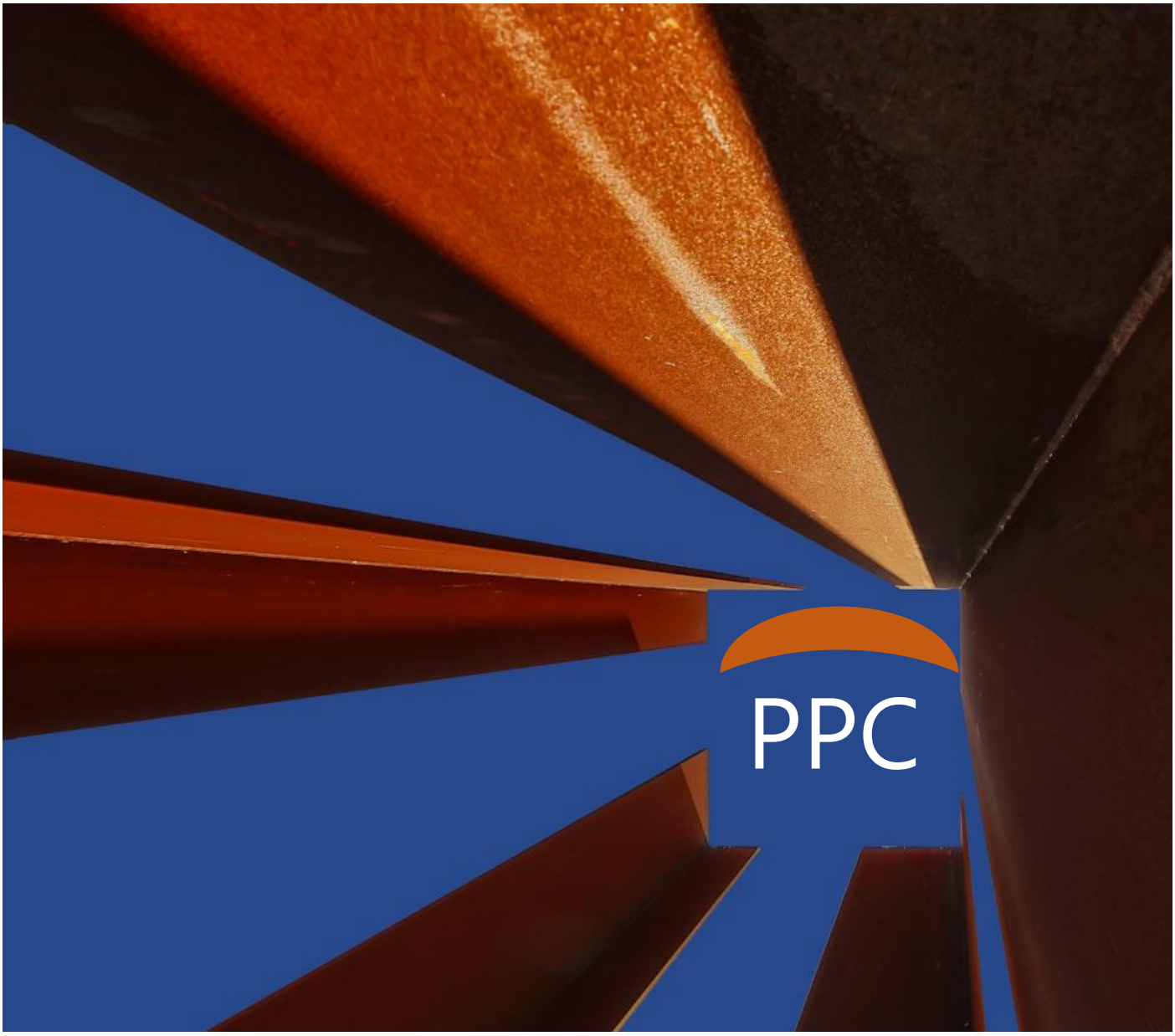


PPC Guide to Surface Preparation

Surface preparation of steel is critical for optimal adhesion of coatings and longevity. It involves cleaning to remove contaminants, abrasive blasting to eliminate rust and scale, and creating a suitable surface profile.

Afterward, thorough cleaning and rust inhibition ensure a clean, dry surface ready for coating application. Proper preparation enhances coating performance and prevents premature failure.

Introduction to Rust Grades

When red-hot steel is processed in a steel rolling mill, it reacts with air and forms a layer on the steel surface, which is called Mill Scale. It is bluish-back in colour, usually less than 0.1mm thick, and relatively brittle. It adheres to the steel surface and protects it from atmospheric corrosion.

However, when the steel is stored outdoors, the mill scale breaks down and since it is electrochemically cathodic to steel, the steel rusts at the exposed areas.

Mill Scale & Rust often create problems and must be removed by mechanical surface preparation.

There are four levels (designated as “rust grades”) of carbon steel. The grades A,B,C & D are represented in ISO 8501-1 pictorial reference plates as the degree of the surface rusting seen on the steel and are described below.

Rust Grade	Description as per ISO 8501-1	Comment
A	Steel surface largely covered with adhering mill scale but little, if any, rust.	This grade of steel is not often seen as storage in distributor yards degrades the condition in open weather exposure.
B	Steel surface which has begun to rust and from which the mill scale has begun to flake.	Can be seen as structural sections before fabrication. Fabrication, cutting, and welding further increase surface rusting by removing reminders of the mill scale at work sites on the steel. Preferred steel for tank construction.
C	Steel surface on which the mill scale has rusted away or from which it can be scraped, but with slight pitting visible under normal vision.	Commonly seen as the surface condition of steel left in yards as steel stocks are exposed to the weather. Suitable for structural fabrication but the surface will require heavier blasting to remove corrosion from minor pitting.
D	Steel surface on which the mill scale has rusted away and on which general pitting is visible under normal vision.	Not suited for new construction as the pitted surface requires longer surface preparation and pitting may be found to be deep after blasting. It is not suited for tank fabrication and is not allowed for offshore fabrication by most owners.

Pre-Treatment

Introduction

Before any surface preparation is done it is vital that the surface to be coated is visually inspected and all of the metal defects that are visible and sometimes not visible are removed.

Pre-treatment, before coatings are applied, is the most decisive single factor regarding expected lifetime and, thus, the cost-effectiveness of the protective system. A poorly pre-treated steel surface which leaves behind sharp edges, weld spatter, weld smoke, oil, and other contamination such as oil residues or soluble salts will reduce the coating's ability to adhere well to the substrate. Permeation of water vapour through the coating film can then lead to the formation of blisters or lead to corrosion under the coating. Consequently, the actual lifetime of the paint system may be reduced to a fraction of its intended design life.

A coating specification always starts with the pre-treatment preparation requirements. This will include but is not limited to cleaning, sanding, and surface roughening to bring the surface that is to be coated to the best condition so that the first coat & subsequent coats will adhere well.

Pre-Blasting Preparation

Pre-blasting preparation involves the following activities :

Rounding or smoothing of:

- Sharp edges
- Corners
- Welds

Grinding of:

- Laminations
- Flame cut edges
- Weld spatter

Standards for Pre-Blasting Preparation

A commonly used reference standard for steel preparation is the ISO 8501-3:2006

"ISO 8501-3:2006 Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness – Part 3: Preparation grades of welds, edges and other areas with surface imperfections"

This standard has tables with sketches of various steel imperfections and the acceptable grades of finish after the imperfections have been treated. The following table below is taken from ISO 8501-3 2006 as an example. Inspection should always be done with the aid of the full and official standard.

The Key to a Good Coating Job

Mechanical adhesion of paint is associated with surface roughness or “anchor pattern”. The anchor pattern is the surface profile formed by peaks and valleys on the substrate. By increasing the number of hills & valleys, the surface area of the substrate increases which in turn gives an improved adhesion. Blast-cleaning to a surface roughness of 50 microns may increase the surface area up to 45-50 % compared with a smooth plate.

Surface preparation methods include both mechanical cleaning and blast-cleaning. For mechanical cleaning, we have two main methods, hand tool cleaning and power tool cleaning. For blast-cleaning, we have several methods which will be described later in this chapter.

For large surfaces, mechanical cleaning is more expensive than blast-cleaning. It is therefore used mainly for local repairs, removal of rust spots and treatment of damaged or burnt areas, and welding seams. Results can be very variable, and the process will generally be a relatively slow one in order to be effective. On heavily rusted surfaces, heavy deposits have to be removed before more thorough surface preparation methods are employed.

After hand or mechanical tool cleaning and before painting, re-clean the surface if it does not conform to the specification. Before painting, remove dirt, dust, or similar contaminants from the surface. Acceptable methods include brushing, blowing off with clean dry air, or vacuum-cleaning.

Hand Tool Cleaning

Hand tool cleaning is one of the oldest methods of surface preparation of steel surfaces. A hand-tool-cleaned surface is free from loose rust, loose paint, and loose millscale. It is not intended that adherent millscale, rust, and paint should be removed by this process. Millscale, rust, and paint are considered adherent if they cannot be removed by lifting with a dull putty knife.

Scraping, wire brushing, and chipping are used as methods for removing rust & old paint. Before hand-tool cleaning, make sure that dirt, grease, and oil have been removed from the surface. A hand tool-cleaned surface is desirable for applications where a low-cost cleaning method is required, and a short-life paint system can be tolerated. A coating with good penetrating properties (epoxy mastic) gives the best result.

When scraping or wire brushing manually, much effort is needed to remove as much rust as possible. Since only a few square feet per hour can be satisfactorily cleaned, this method should be limited to small areas and when a high level of surface cleanliness is not required.

Power Tool Cleaning

There are two main types of power tools.

- Rotary cleaning tools
- Impact tools

In general, the rotary cleaning tools are the most effective ones in removing paint and rust, while the impact tools are more effective in removing scale and pack rust. Common rotary cleaning tools are wire brushes, coated abrasives, and non-woven abrasives.

Wire brushes can remove paint, loose mill scale, rust & weld slag, but tend to smoothen or burnish a surface and give bad adhesion for a coating. Do not use high-speed wire brushing as a surface preparation method before painting.

Coated abrasive (disc grinding) can remove paint, loose mill scale and rust, but tends to clog up when paint is removed and may remove some of the substrate material. Non-woven abrasive does not clog up as much when removing paint and it can take a surface to bare metal and yet remove only negligible bare metal.

Common impact tools are :

- Pneumatically driven hammers or rotary hammers
- Needle guns
- Chisels

These impact tools are very noisy, slow and subject to damaging the steel substrate, but are effective for removals of rough scale, including heavy laminated scale. The use of needle guns should be limited to welds, corners, uneven edges etc. as the impact of the needles can cause an unacceptable profile on flat surfaces. “Non-spark” tools may be necessary in areas subject to fire or explosion hazards.

ISO 8501-1 has two grades of cleanliness after hand and power tool cleaning on rust grades B, C and D St 2 & St 3.

Grades of Surface Preparation by Power Tool Cleaning

This method covers the preparation of surfaces by removing loose mill scale, damaged paint, rust, and corrosion products by hand-held power tools such as rotary wire brushes, abrasive discs or sanders (according to ISO 8501-1).

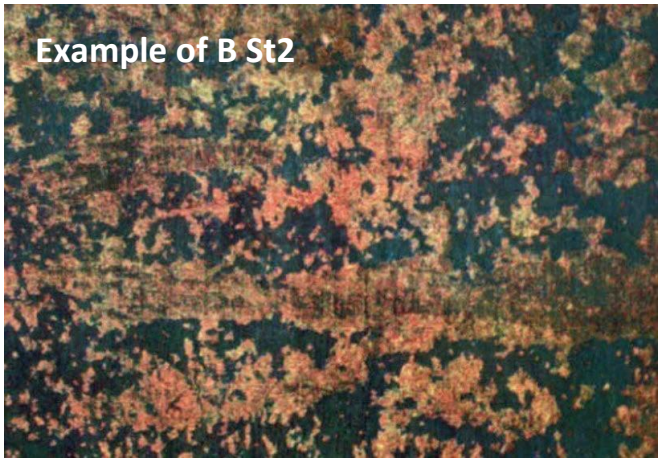
Surface preparation by hand and power tool cleaning is designated by the letters "**St**".

Two preparation grades, designated St 2 & St 3, can be achieved using hand and power tool cleaning. Preparation grade St 1 is not included as it would correspond to a surface unsuitable for painting.

ISO 8501-1 St 2 Thorough Hand and Power Tool Cleaning

"When viewed without magnification, the surface shall be free from visible oil, grease, and dirt, and from poorly adhering mill scale, rust, paint coatings, and foreign matter".

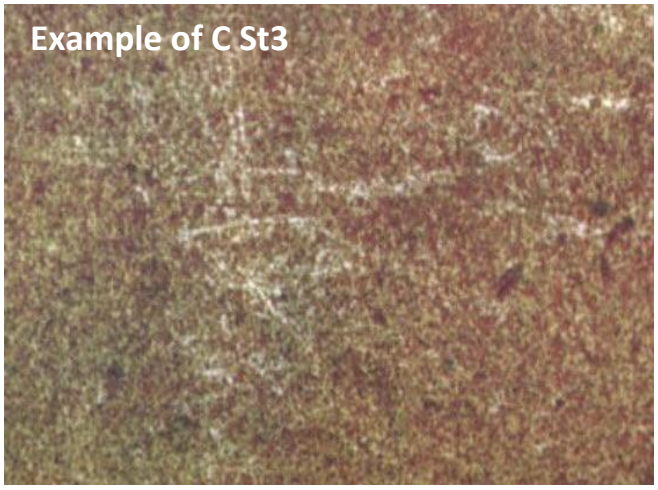
Reference grades : B St2, C St2 & D St2



ISO 8501-1 St 3 Very Thorough Hand and Power Tool Cleaning

"As for St 2, but the surface shall be treated much more thoroughly to give a metallic sheen arising from the metallic substrate"

Reference grades : B St3, C St3 & D St3



Abrasive Blast Cleaning

Blast-cleaning is the common term for all methods using abrasives that are propelled toward the surface to be cleaned at very high speed. Different kinds of abrasives are propelled either by high velocity compressed air, centrifugal force or by a high-velocity stream of water to remove rust, mill scale, existing coatings and other contaminants from the substrate.

The different methods of blast-cleaning are :

- Centrifugal abrasive blast-cleaning
- Compressed-air abrasive blast-cleaning
- Vacuum or suction-head abrasive blast-cleaning
- Moisture-injection abrasive blast-cleaning
- Wet abrasive blast-cleaning
- High-pressure and ultra-high-pressure water-jetting

Of the above, the most common methods today are dry abrasive blast cleaning, centrifugal abrasive blast cleaning, and high-pressure water jetting.

Grades of Surface Preparation by Abrasive Blast Cleaning

This part covers the preparation of surfaces according to the four levels of cleanliness in abrasive dry blasting as stated in ISO 8501-1. Surface preparation by blast cleaning has the following designations: Sa 1, Sa 2, Sa 2½ and Sa 3.

To achieve cleanliness levels Sa 1 or Sa 2, only very light blast cleaning is required. On the other hand, very thorough blast cleaning is required to achieve a cleanliness of Sa 2½ or Sa 3.

ISO 8501-1 Sa 1 Light Blast Cleaning

"When viewed without magnification, the surface shall be free from visible oil, grease, and dirt, and from poorly adhering mill scale, rust, paint coatings, and foreign matter".

Reference grades : B Sa 1, C Sa 1 and D Sa 1.

This degree of preparation is the closest ISO Standard to NACE No 4/ SSPC SP7 but is not equivalent to the NACE No. 4/SSPC SP7 Standard.

ISO 8501-1 Sa 2 Thorough Blast Cleaning

"When viewed without magnification, the surface shall be free from visible oil, grease and dirt, and from poorly adhering mill scale, rust, paint coatings and foreign matter. Any residual contamination shall be firmly adhering".

Reference grades : B Sa 2, C Sa 2 and D Sa 2.

This degree of preparation approximates to NACE No 3 /SSPC-SP 6.

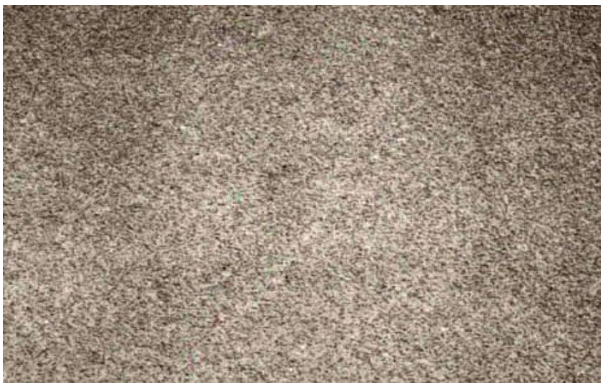
ISO 8501-1 Sa 2½ Very Thorough Blast Cleaning

“When viewed without magnification, the surface shall be free from visible oil, grease and dirt, and from poorly adhering mill scale, rust, paint coatings and foreign matter. Any remaining traces of contamination shall show only as slight stains in the form of spots and stripes”.

Reference grades : A Sa 2½, B Sa 2½, C Sa 2½ & D Sa 2½.

This degree of preparation approximates to NACE No 2 /SSPC SP 10.

ISO 8501-1 Sa 3 Blast Cleaning to Visually Clean Steel



“When viewed without magnification, the surface shall be free from visible oil, grease, and dirt, and from poorly adhering mill scale, rust, paint coatings, and foreign matter. It shall have a uniform metallic colour”.

Reference grades : A Sa 3, B Sa 3, C Sa 3 & D Sa 3.

This degree of preparation approximates to NACE No 1 / SSPC SP5.

Flame Cleaning

Flame cleaning, indicated by F1, involves removing thick rust layers through chipping and subsequent power tool wire brushing. However, it's less common now due to limitations. It doesn't eliminate all mill scale or rust, unsuitable for heavy-duty coatings.

Combustion by-products can contaminate surfaces. Despite this, flame cleaning removes some chemical contamination, and leaves surfaces warm and dry, aiding primer coat drying and adhesion. However, its usage is restricted in many areas due to its contribution to air pollution.

Pickling

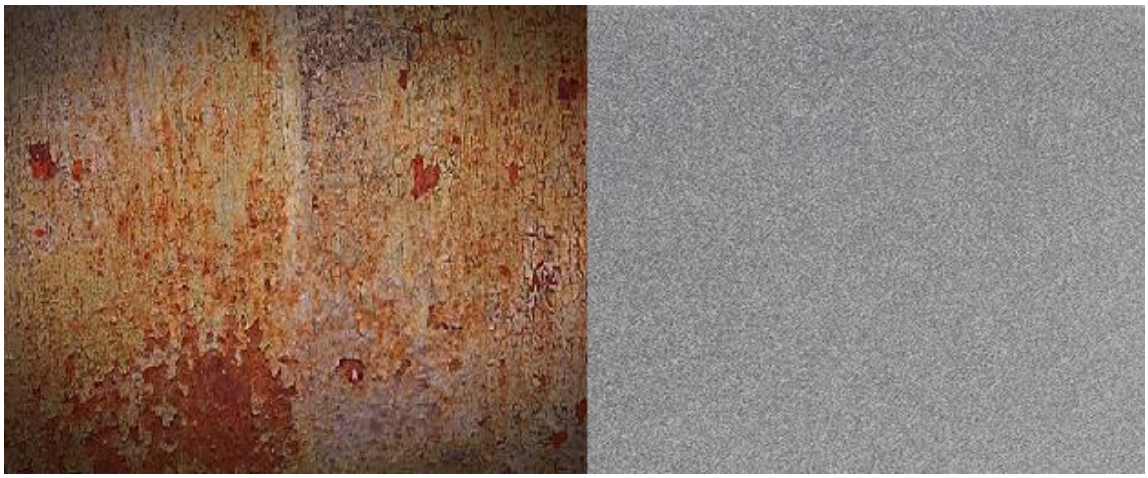
Acid pickling is an old established shop method of removing mill scale from steel. There are several detailed processes still in use, often employing a duplex system of aggressive and passivating acids.

One disadvantage of pickling is that it leaves the steel clean but without the anchor pattern, which is an aid to adhesion with high, build heavy-duty coatings. The only exception to this is when old, corroded, and pitted steel is retreated in the acid baths. The acid cleans off the old paint and corrosion product and leaves the pitted steel ready to paint.

Overview

The ISO 8501 and the SSPC/NACE joint standards are the 2 most commonly referred to standards for surface preparation worldwide. While there are similarities in the visual grades of cleanliness, the respective classification societies have categorized them distinctively different. The table below illustrates the equivalence & compatibility between the different grades of cleanliness across the various standards.

Description	ISO	NACE	SSPC	Australian/NZ
Solvent Cleaning			SSPC-SP 1	AS 1627.1
Manual / Mechanical Cleaning	ISO 8501 – 1 St 2		SSPC-SP 2	AS 1627.7
Mechanical Cleaning	ISO 8501 – 1 St 3		SSPC-SP 3	AS 1627.2
Brush Off Blast Cleaning			SSPC-SP 4	
Blast Cleaning to White Metal	ISO 8501 – 1 Sa 3	NACE No. 1	SSPC-SP 5	AS 1627.4 Sa 3
Blast Cleaning to Near White Metal	ISO 8501 – 1 Sa 2 ½	NACE No. 2	SSPC-SP 10	AS 1627.4 Sa 2 ½
Blast Cleaning Commercial Grade	ISO 8501 – 1 Sa 2	NACE No. 3	SSPC-SP 6	AS 1627.4 Sa 1
Chemical Cleaning			SSPC-SP 8	AS 1627.10



Once you have carried out the required surface preparation, a coating system can be selected to provide adequate protection of the steel in its atmospheric environment, but also for the proposed lifetime of the structure.