CLEANING OF STEEL AND REMOVAL OF RUST 1490

a ten page issue

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DERUSTING METHODS

The effective life time of a coating applied onto a steel surface is dependent to a very large extent on how thoroughly the surface has been prepared prior to painting.

Surface preparation consists of primary surface preparation which aims to remove mill scale, rust and foreign matter from a steel surface prior to the application of a shop primer (prefabrication primer) or primer.
Secondary surface preparation aims to remove rust and foreign matter, if any, from a steel surface coated with a shop primer (prefabrication primer) or primer prior to application of the anticorrosive paint system.
A steel surface can be derusted in the following ways.

Wire brushing

Wire brushing, usually done with rotating wire brushes, is a conventional method, not suitable for the removal of mill scale, but suitable for the preparation of weld seams. The main disadvantage is, that treated surfaces are often not completely free of corrosion products and tend to become polished and contaminated with oil. This decreases the adhesion of priming paints and the performance of a paint system.

Chipping

Chipping or mechanical chipping is usually done in combination with wire-brushing. It is sometimes suitable for local repairs with conventional or special formulated paint systems. It is not suitable for general preparation of surfaces to be coated with epoxy or chlorinated rubber paints. It can be used for the removal of thick rust scale and economizes in later blasting operations.

Needle hammer

To remove rust, paint etc. from corners and angles in order to achieve a cleaned surface with a profile.

Flame cleaning

Flame cleaning involves de-rusting by thermal treatment making use of burning equipment (acetylene or propane and oxygen). It removes almost all mill scale, but rust to a lesser extent. Therefore this method cannot meet the requirements of modern paint systems.

Disc sanding

Disc sanding involves use of rotating discs covered with abrasive material. It is used for local repairs. The quality of these discs has been very much improved, and these can give good standards of preparation.

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Sweep blasting

A hand operated form of superficial blast cleaning in which a primed or coated steel surface is roughened and is free of almost all visible contamination. (except oil contamination or traces of rust)

A: light sweep, purpose: roughening of intact coating and improving the adhesion of subsequent coats

Abrasive: fine (0,2-0,5 mm) is most suitable when the paint surface under treatment is not to be destroyed

B: heavy sweep (approx ISO-Sa1), purpose: removing of not sound coating areas - layers

Abrasive: small to medium (0,2-0,5/0,2-1,5 mm)

Reference: Repainting of old metallic structures, limited blast cleaning scale Technical Guide, November 1993 Laboratoire Central des Ponts et Chaussées 58,bd Lefebvre, F 75732 Paris Cedex 15

Dry blast cleaning

The impingement of a high kinetic energy stream of abrasive onto the surface to be prepared. It is either hand operated by jet or automatically by impeller and is the most thorough method of derusting. Centrifugal blast cleaning, compressed air blast cleaning and vacuum blast cleaning are well known types.

Shot

The particles are as far as practical spherical and solid and should not contain more than the minimum practical amount of 'tails' and irregular shapes. Primers to be used for shot blasted steel should be checked on performance.

Grit

The particles show good angularity form with sharp cutting edges and should be substantially free from 'half-rounds' (i.e. shot split in half).
Unless otherwise stated in the specifications a mineral grit should be used.

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Water (abrasive) cleaning/jetting
(Terminology NACE)

Different types of water (abrasive) cleaning/jetting are in use
Below you will find the most commonly used ones
For more info see also information sheet 1498 (Hydrojetting)

Water (abrasive) blast cleaning

Some examples of these techniques are given below, not pretending to be complete. New developments with wet blasting methods are presented regularly, improving the efficiency and reducing the amount of water or grit.

- **LOW PRESSURE WATER ABRASIVE BLAST CLEANING**
  Pressure = 6-8 bar
  Water consumption = 90-300 l/hour
  Cleaning speed = 10-16 m²/hour, depending on material to be removed

  Result: a surface cleanliness and blasting profile as required can be obtained.

- **LOW PRESSURE HUMIDIFIED ABRASIVE BLAST CLEANING**
  Pressure = 6-8 bar
  Water consumption = 5-60 l/hour
  Cleaning speed = 10-16 m²/hour, depending on material to be removed

  Result: a surface cleanliness and blasting profile as required can be obtained.

- **ULTRA HIGH PRESSURE WATER JETTING (UHPWJ)**
  Pressure - more than 1700 bar
  Use: Complete removal of all coatings and rust.
  The result can be compared with dry abrasive blast cleaning, but with flash rust after drying.
  The original blasting profile will be maintained.

- **HIGH PRESSURE WATER JETTING (HPWJ)**
  Pressure - from 700 to 1700 bar
  Use: Most paints and corrosion products will be removed, Magnetite and hard tightly adherent coating may be left but can be removed with difficulty.
  The original blasting profile will be maintained.

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Water cleaning

- **LOW PRESSURE WATER CLEANING (LPWC)**
  Pressure - lower than 350 bar
  Use: Removal of salt, dirt and poorly adherent surface contamination. Mainly washing of surface

- **HIGH PRESSURE WATER CLEANING (HPWC)**
  Pressure - from 350 to 700 bar
  Use: Loose paint, rust, debris and material in pits will be removed, but black iron oxide (Magnetite) will remain. A uniform matte finish cannot be achieved.

- **STEAM CLEANING**
  Pressure = 100-120 bar
  Use: Removal of water soluble or water emulsified contamination; the substrate dries quicker compared to a water rinsed substrate.

ISO STANDARDS

When specifying a precise degree of de-rusting and cleaning of a steel surface prior to painting, PPG PMC uses the ISO standard ISO 8501-1-1988 and ISO 8504-1992.

ISO 8501-1

Applicable to bare mill-scaled or rusty steel

This indicates the following rust grades:

A = steel surface largely covered with adherent mill scale but little, if any, rust.
B = steel surface which has begun to rust and from which the mill scale has begun to flake.
C = steel surface on which the mill scale has rusted away or from which it can be scraped, but with slight pitting visible when viewed normally.
D = steel surface on which the mill scale has rusted away and on which general pitting is visible when viewed normally.

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DEGREES OF PRIMARY SURFACE PREPARATION	The ISO standard indicates six preparation degrees. The following standards are often used in specifications:
ISO-St Hand and power tool cleaning	Surface preparation by hand and power tool cleaning, such as scraping, wire-brushing, machine-brushing and grinding, is designated by the letters 'St'. Prior to hand and power tool cleaning, any heavy layers of rust shall be removed by chipping. Visible oil, grease and dirt shall also be removed. After hand and power tool cleaning, the surface shall be cleaned from loose dust and debris.
ISO-St2 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.
ISO-St3 Very thorough hand and power tool cleaning	As for St2, but the surface shall be treated much more thoroughly to give a metallic sheen arising from the metallic substrate
ISO-Sa Blast cleaning	Surface preparation by blast cleaning is designated by the letters "Sa" Prior to blast cleaning, any heavy layers of rust shall be removed by chipping. Visible oil, grease and dirt shall also be removed. After blast cleaning, the surface shall be cleaned from loose dust and debris.
ISO-Sa1 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.
ISO-Sa2 Thorough blast cleaning	When viewed without magnification, the surface shall be free from visible oil, grease and dirt and from most of the mill scale, rust, paint coatings and foreign matter. Any residual contamination shall be firmly adhering.
ISO-Sa2½ Very thorough blast cleaning	When viewed without magnification, the surface shall be free from visible oil, grease and dirt and from mill scale, rust, paint coatings and foreign matter. Any remaining traces of contamination shall show only as slight stains in the form of spots or stripes.

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ISO-Sa3 blast cleaning to visually clean steel

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

Remark

The photographs in the ISO Standard publication are given as illustration only. They do not represent the complete preparation degree, which also includes a cleaning operation which is not visible in the photographs. (colorless contamination).

Equivalents

As far as blast cleaning is concerned, equivalents according to British and American standards are given in the following table.

ISO 8501-01	BS 4232	SSPC-Vis 1 *	
Sa3	1st quality	White metal	SP 5
Sa2½	2nd quality	Near white	SP 10
Sa2	3rd quality	Commercial	SP 6

* for more details see SSPC-SP com

Roughness of blast cleaned steel

To specify the roughness, a variety of values is used.
Such as R_z, R_t and R_a.

R_z = average peak to valley height = blasting profile
R_t = maximum peak to valley height
R_a = average distance to an imaginary centre line which can be drawn between peaks and valleys = C.L.A. = Centre Line Average (ISO 3274)

Normally PPG PMC uses R_z values.

Blasting Profile (R_z) = 4 to 6 times C.L.A. (R_a).

The direct measuring of the dft of primers applied onto blast cleaned steel in a thickness up to 30 µm is very inaccurate. A primer dft of 30 µm and more gives an average thickness and not the thickness present on the peaks.

When in the specifications blast cleaning to ISO-Sa2½ is mentioned a blasting profile R_Z of 35-50 µm should be obtained using mineral grit unless otherwise mentioned.

Above a R_a roughness of 17 µm (= blasting profile R_Z of 100 µm) it is recommended to use an additional coat of primer to cover the roughness.

A roughness profile above 100 µm often results if heavily rusted steel is blast clean

JAPANESE STANDARDS
Standard for the preparation of steel surface prior to painting SPSS-1984

These establish a systematic standard for secondary surface preparation prior to protective painting when shop primers (prefabrication primers) are used in the construction process of hull or steel structures.

Surface condition

H = shop primed steel surface in way of hand welding
A = shop primed steel in way of automatic welding
F = shop primed steel surface in way of gas-burning
D = shop primed steel surface having white zinc salt
R = shop primed steel surface having rust in the form of spots

GRADES OF SECONDARY SURFACE PREPARATION

The Japanese Standard indicates six preparation degrees.
The following standards are often used in specifications.

SPSS-Pt2

Surface prepared by **wire brushing** for the surface condition A, D and R,by **wire brushing** and **disc sander** for the surface condition H,by **disc sander** for the surface condition F. Almost all rust and foreign matter are fairly removed.

If mentioned for other surface conditions (e.g. primed or coated steel), almost all rust and foreign matter, have to be removed by wire brushing and/or disc sander.

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SPSS-Pt3	Surface prepared by **wire brushing** and (in combination with!) **disc sander** for the surface condition H and A and by **disc sander** for the surface condition F, R and D. Rust and foreign matter are removed to the extent that the surface has a uniform metallic sheen. If mentioned for other surfaces conditions (e.g. primed or coated steel) all rust and foreign matter has to be removed to the extent that the surface has a uniform metallic sheen. Also used for the preparation of primed or coated substrate to remove rust from small areas such as scratches, pinpoints or areas of mechanical damage.
SPSS-Ss	Surface prepared by **light blast cleaning** of slug sands or grits. (Shop primer (prefabrication primer) with the little trace of rust is noticeable.) Also used for the preparation of a primed or coated substrates or galvanized steel to roughen the surface and to remove contamination or traces of rust.
Remarks	In the Japanese Standard the expressions Sd2 and Sd3 are used, which are equivalent to the Swedish expressions Sa2 and Sa3.
ISO 8501-3	Preparation grades of welds, cut edges and other area with surface imperfections.
Grade P2	See illustrations in the standard

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Degree of cleanliness

The ISO and the Japanese Standards give a visual impression of the quality of the derusted steel. However, chemical contamination like water soluble salts etc. are not visible and remains partly on the surface. Presence of excessive amounts of water soluble salts can cause blistering of the coating by osmosis.

Water soluble salts in mineral abrasives.
For tankcoatings the maximum value of water soluble salts in mineral abrasives is 250 µS/cm (conductivity) (ISO 11127-6 1993).
See further sheet 1491

Water soluble salts on the steel surface (ISO 8502-9 1998).
Our maximum acceptable levels of water soluble salts, calculated as mixed salts, on treated substrate prior to coating application depends on the area and expected service conditions.

	mixed salts	conductivity (V=15 ml)
Distilled water	20 mg/m²	(4.0 µS/cm)
Cargo tanks	50 mg/m²	(10.0 µS/cm)
Immersed areas	80 mg/m²	(16.0 µS/cm)
Dry cargo holds	100 mg/m²	(20.0 µS/cm)

Note

Determination of water soluble salts: see information sheet 1468

For water ballast tank areas to be treated in accordance with IMO resolution MSC 215(82) and cargo tank areas of Crude Oil tanks to be treated in accordance with IMO resolution MSC 288(87): water soluble salts limit equivalent to sodium chloride after blasting/grinding must be equal to or lower than 50 mg/m² of sodium chloride.

For areas exposed to atmosphere conditions; We recommend the limit per dry cargo holds as noted in the table. Prior to treatment the substrate should be High Pressure Washed with Fresh (clean) water.
As a guidance we recommend that the conductivity of abrasives prior to treatment should not be higher than **250 µS/cm**.

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REFERENCES

Determination of water soluble salts according to the Bresle method (ISO 8502-6 2006)	see information sheet 1468
Specification for mineral abrasives	see information sheet 1491
Hydrojetting	see information sheet 1498