# SURFACE PREPARATION

The single most important function that can influence paint performance is the quality of surface preparation. For optimum service life, the surface must be completely free of all contaminants that might impair performance and should be treated as such to assure good and permanent adhesion of the paint system. The quality of surface preparation has a direct relation with the lifetime of a system. Even when using surface tolerant paints it cannot be emphasized enough that better surface preparation always result in longer lifetimes.

Surface preparation consists of primary surface preparation and secondary surface preparation. The primary surface preparation aims to remove mill scale, rust, corrosion products, and foreign matter from a steel surface prior to application of a shop primer or primer.

The secondary surface preparation aims to remove rust and foreign matter, if any from a steel surface that has been already coated with a shop-primer or paint, prior to application of anti-corrosive system. All rust, rust scale, heavy chalk, or deteriorated coatings must be removed by a combination of solvent or detergent washing, hand or power tool cleaning or abrasive blasting. Glossy areas of sound previous coatings need not be removed but should be mechanically abraded or brush blasted to create a surface profile which increases coating adhesion.

Prior to use any of method of surface preparation, it is essential to remove all soluble salts, oil, grease, drilling and cutting compounds and other surface contaminants. Perhaps the most common method is by solvent washing, followed by wiping dry with clean rags. The wiping clean is critical, because if this is not carried out thoroughly the result of solvent washing will simply spread the contamination over a wider area. Proprietary emulsions, degreasing compounds and steam cleaning are also commonly used. Recommended procedures are described in International Standard ISO 8504:1992(E) and SSPC-SP1.

**High pressure fresh water cleaning.**

Fresh water cleaning is always necessary to remove salts, fouling, any loose paint and other contaminants. Usually, fresh water cleaning is done immediately as it any fouling is easier to remove when it is has not dried up completely. A water pressure of 500 bar (approx. 7000 psi) is typically used from removal surface contamination and fouling organisms such as algae- and shell fouling.

**Hand tool cleaning**

Loosely adhering mill scale, rust and old paint coatings may be removed from steel by hand wire brushing, sanding, scraping and chipping. However, these methods are incomplete, and always leave a layer of tightly adhering rust on the steel surface. Methods for hand tool cleaning are described in SSPC-SP2 and should be to ISO 8501-1:1988 grade St 2-B, C or D.
Hand tool cleaning is very useful when the deployment of power tool is not feasible and economical and the job is localised / small. After cleaning the surface is brushed, swept, dusted and blown off with compressed air to remove all loose matter.

## Power tool cleaning

Examples of mechanical tools are rotary wire brushes, sanding disc and needle guns. Power tool cleaning is in general more effective and less laborious than hand tool cleaning for the removal of loosely adhering mill scale, paint and rust. However, power tool cleaning will not remove tightly adhering rust and mill scale.

Care should be taken, particularly with power wire brushes, not to polish the metal surface as this will reduce the key for the subsequent paint coating.

Preparation grades with powertool cleaning are specified according to International Standards method ISO 8501/1: 1988 and relevant preparation grades are St2-B, C or D and St3-B, C or D.
SSPC-SP11 describes the various degrees of surface profile that can be achieved by power tool cleaning.

## Blast cleaning

Blast Cleaning is based on the principle of an abrasive jet of particles in a compressed air stream impinging on the surface, removing impurities, millscale, rust and old paint. Abrasive blast cleaning is the most thorough and widely used method of surface preparation in the shipbuilding and repair industry. Different degrees of surface cleanliness are possible and depend in part on the surface condition prior to treatment and also to the length of time for which the surface is exposed to the abrasive jet. In addition to cleaning the surface, the abrasive particles will impart a surface roughness to the steel.

However, prior to blasting, steelwork should be degreased and all weld spatters removed. If salts, grease or oil is present on the surface it will appear to be removed by the blasting process, but this is not the case. Although not visible, the contamination will still be present as a thin layer, and will affect the adhesion of subsequent coatings. Any presence of salts can be checked by measuring the conductivity of water that has been used to wash a certain small area of a (blast) cleaned surface.

Furthermore weld seams, metal slivers and sharp edges revealed by the blasting process should be ground down, as paint coatings tend to run away from sharp edges, resulting in thin coatings and reduced protection. Weld spatter is almost impossible to coat evenly, in addition to often being loosely adherent, and it is a common cause of premature coating failure.

The surface appearance resulting from blast cleaning has been defined by several bodies;

- American (ASTM D 2200 and SSPC VIS. 1 & 2)
- British (Standard BS 4232)
- German (Standard DIN 18364)
- Japanese (JSRA SPSS, 1975).
- Swedish (SIS 05 5900)

The table below gives a summary of the different qualities in surface preparations used by some standards.

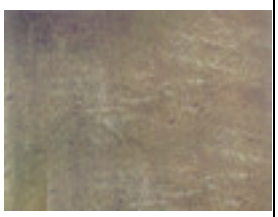
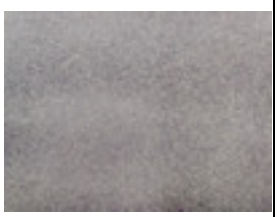
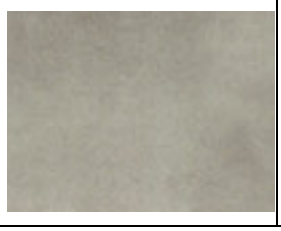
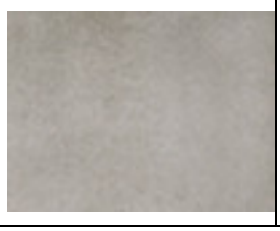
| Description | Swedish SIS 05 5900 | American SSPC-SP | International ISO-8501-1 |
|---|---|---|---|
| White metal | Sa 3 | SSPC - SP 5 | Sa 3 |
| Near white metal | Sa 2½ | SSPC - SP10 | Sa 2½ |
| Commercial blast | Sa 2 | SSPC - SP 6 | Sa 2 |
| Brush-off blast | Sa 1 | SSPC - SP 7 | Sa 1 |
| Power tool cleaning | St 3 | SSPC - SP 3 | St 3 |
| Hand tool cleaning | St 2 | SSPC - SP 2 | St 2 |

The most widely used was the Swedish Standard (SIS 05 59 00 "Pictorial surface preparation standard for paint steel surfaces") which also sought to define the initial condition of the steel. This standard was taken over by International Standard ISO 8501/1: “Rust grades and preparation grades of uncoated steel substrates after overall removal of previous coatings”.

**Table 2. Initial condition of steel as per ISO 8501-01.**

| Rust grade | Pictorial example | Description |
|---|---|---|
| A |  | Steel covered completely with adherent mill scale and with, if any, little 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 scrapped, but with little pitting visible to the naked eye. |
| D |  | Steel surface on which the mill scale has rusted away and on which considerable pitting is visible to the naked eye. |

**Table 3. Pictorial examples of surface preparation according to ISO 8501-01.**

| Cleaning standard | Initial steel condition (see also table 1). | | | |
|---|---|---|---|---|
| | A | B | C | D |
| St2 – Hand tool cleaning | Not applicable |  |  |  |
| St3 - Power tool cleaning | Not applicable |  |  |  |
| Sa1 -Brush-off blast | Not applicable |  |  |  |
| Sa2 - Commercial blast | Not applicable |  |  |  |
| Sa2.5 -Near white metal |  |  |  |  |
| Sa3 - White metal |  |  |  |  |

*Pictures given herein are indicative only.*

**Type of abrasives.**

The surface profile obtained during blasting is important, and will depend on the abrasive used, the air pressure and the technique of blasting. Too low a profile may not provide a sufficient key for coating, while too high a profile may result in uneven coverage of high, sharp peaks possibly leading to premature coating failure, particularly for thin film coatings such as blast primers. The following table gives a brief guide to typical roughness profiles obtained using various types of abrasive.

| Type of Abrasive | Mesh Size Max. | Height of Profile |
|---|---|---|
| Very fine sand | 80 | 37 microns (1.5 mils) |
| Coarse sand | 12 | 70 microns (2.8 mils) |
| Iron shot | 14 | 90 microns (3.6 mils) |
| Copper slag 1.5-2.0mm grain size | | 75-100 microns (3-4 mils) |
| Iron grit No. G16 | 12 | 200 microns (8.0 mils) |

This so-called "profile" roughness can be a very important "key" for anchoring of paint systems.
Mineral slag blasting grit generally gives faster rates of cleaning and lower health risk (from shattered grit) than does sand. Grit also gives more effective cleaning, especially for pitted substrates, and some grades can be recycled.

**Surface Profile**

Surface profile indicates the roughness of blast cleaned surface. “Surface Profile is an Independent Factor” and it has no relation to the standard of cleanliness. The profile of roughness obtained during blasting is important and will depend upon the abrasive media, the air pressure, and technique of blasting.

To specify the roughness, a variety of values are used, such as Rz, Rt, and Ra.

Rz = average peak to valley height = blasting profile.
Rt = maximum peak to valley height
Ra = average distance to an imaginary center line which can be drawn between peaks and valleys = C.L.A. = Center line Average (ISO 3274)
Rz = 4 to 6 times C.L.A. (Ra)

Rz is also referred to as Blasting profile.

Generally the profile height of steel should be in between 1/2 and 2.5 mils and not more than one third of the total dry film thickness of the coating system.
Too high a profile will result in uneven coverage of high sharp peaks possibly leading to premature coating failure.
Too low a profile may not provide a sufficient key of coating. For some product a minimum surface profile is mandatory as indicated in our product data sheet.

## Spot blasting

Spot blasting is localised abrasive cleaning often carried out in ship repair, especially on the outside hull, where patchy corrosion or damage has occurred. It can be used to yield surfaces that are cleaned to Sa 2 or better but often surrounding intact areas are peppered with stray grit.
These areas should be treated as in the inclusion of grit in the final coating system may lead to premature failure of the system. It is therefore required to mark areas to be spot blasted and subsequently mechanically "feather" the damage round the area using rotary disc or sander.

## Hydro blasting / Water jetting

Water jetting or hydro blasting as a surface preparation technique is being used more and more in shipyards.
A major advantage of using water pressure as an abrasive is the lower impact on environment and health because less dust is generated than is the case with grit blasting. It also constitutes less of a safety risk caused by sparks and reduces the amount of salt remaining on the surface.
As with blast cleaning, prior to hydro blasting, water insoluble foreign matter such as oil and grease must be removed.

**Table 4. Definitions and suitable water pressures range.**

| Definition | Pressure (Bar) | Pressure (psi) | Flow rate (l/min) |
|---|---|---|---|
| Low pressure water cleaning | < 68 | < 1000 | |
| High pressure water cleaning | 68-680 | 1000 to 10.000 | 90 - 50 |
| **High pressure hydro blasting** | **680-1700** | **10.000 to 25.000** | **50 - 25** |
| **Ultra high pressure hydro blasting** | **> 1700** | **> 25.000** | **Down to 12** |

High pressure water cleaning is used to clean a ship from fouling, dirt and salts. However, when we speak about hydro blasting as a surface preparation tool only the definitions high pressure hydro blasting or ultra high pressure hydro blasting is meant. Please note that Hydro blasting is also referred to as water jetting or hydro jetting but in Transocean documentation only the term hydro blasting is used.

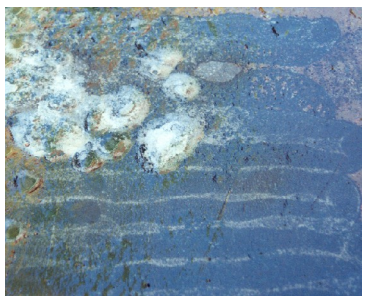
The flow rate determines the reaction force felt by the operator. High flow rates mean strong reaction forces meaning that the operator will be exhausted after some time of cleaning. Lower flow rates mean reduced reaction forces which results in less fatigue for the worker and therefore not only the equipment is easier to handle but also increases productivity. Typical production rates are given in table 5.

**Table 5. Relation water pressure, effect of cleaning and production rates.**

| Pressure (bar) | Removal of; | Typical speed ($m^2$/hr) |
|---|---|---|
| Up to 500 | Fouling, salt and dirt. | 300 |
| > 1000 | Also loose rust and paint.<br>Firm adherent paint remains. | 150 (machine) |
| > 2000 | All coatings.<br>Restores original roughness profile. | 5 (handgun)<br>100 (machine) |
| > 4000 | All coatings.<br>Creates roughness profile. | |

The appearance of steel after hydro blasting is different than grit blasting. Hydro blasted surfaces tend to look dull, even before they “flash rust”.
The right picture gives a close up of the steel area after hydro blasted at 2000 bar.
The rotating nozzle leaves a circular pattern on the steel. Some flash rust is visible too.

In addition steel, with active corrosion pitting, shows a mottled appearance after hydro blasting. Mottling occurs when the corrosion products are washed out of the pits, leaving a bright patch, and the surrounding areas are left a dull grey, brown to black colour. This pattern is the reverse of that left by abrasive blasting, where anodic pits are often dark, due to corrosion products not being entirely removed, and the surrounding areas are bright.



Currently an ISO standard for hydro blasting preparation standards is in preparation. The German STG2222 - 1992 standard is referred to in Transocean documentation. This standard describes three DW grades, DW 1, DW 2 and DW 3.
In table 6 a further description of the DW grades is given.
The STG 2222 standard has the advantage that it also describes conditions in which the presence of firm adhering, old coating systems after hydro blasting is possible. Transocean believes that a standard, which includes substrates with remaining old coating systems gives a better view of what is possible nowadays in shipyards. However, the level of flash rust is not described in STG-2222.

Flash rusting is the result of light oxidation of the steel, which occurs as hydro blasted steel dries off. The appearance changes from a light, ginger colour in to an orange-red dusty layer.
Flash rusting can be prevented by the use of water soluble chemical corrosion inhibitors. These inhibitors may leave a crystalline layer on the steel surface as the water evaporates, which can then lead to a loss of adhesion and osmotic blistering, if coatings are applied over this type of surface.

Transocean therefore does not favour the use of corrosion inhibitors. In case inhibitors are used, they must be thoroughly washed off with fresh water before application of the first layer of paint.

Transocean has various products available, which are compatible with hydro blasting and some products may even be applied when steel is still damp. In such cases, the level of flash rusting acceptable for recoating is not an issue.
In other cases flash rusting can be described into 3 categories.

| | |
|---|---|
| Light | Present as a ginger coloured surface staining that will partially discolour the original metallic surface and will not be heavy enough to easily mark objects brushed against it. |
| Medium | Present as a yellowish layer which obscures the original metallic surface and will be heavy enough to mark objects brushed against it. |
| Heavy | Present as red-orange powdery rust that obscures metallic surface and easily marks objects. |

Heavy flash rusting is not acceptable for coating application and it may be removed or reduced by brushing with a hard bristle brush, or by washing down with high pressure fresh water cleaning, at pressures above 68 bar (1,000 p.s.i.).

### Wet slurry blasting

Wet abrasive blasting may be performed with low or high pressure fresh water to which a relative small amount of abrasives is introduced, and in some cases inhibitors are added to prevent flash rusting (however, as a general rule it is recommended not to use inhibitors when cleaning areas are to be immersed during service). This reduces the amount of airborne dust and sand. It is necessary to rinse the surface after blasting to remove sand and debris

### Sweep blasting

Sweep blasting is the treatment of a surface by quickly passing a jet of abrasive across the surface. It is typically used as a tool to get some surface roughness on an existing, firm adhering coating in order to facilitate inter coat adhesion. The level of effectiveness depends on the skill of the operator, the type of surface and particle size of abrasive. In general, a fine grade of abrasive (0,2-0,5 mm) is recommended as larger particle sizes would destroy the existing coating too much.

## Table 6. Surface preparation standards used in Transocean documentation.

| Preparation standard | Reference to SSPC. | Description |
|---|---|---|
| HPFWC= high pressure fresh water cleaning (pressure 70-700 bar) | | This method is routinously used on ships in drydock to clean the underwater area of fouling, salts, loose adhering paint and other foreign matter. |
| Solvent Cleaning SP-1 | SSPC-SP1 | Foreign matter other than oil and grease should be removed by scraping or brushing followed by HPFWC. Removal of oil, grease, dirt, soil, salts and contaminants by cleaning with solvent, alkali, emulsion or steam. After cleaning remove dirt, dust and other contaminants by vacuuming or blowing with clean, dry air. |
| Thorough Hand- and Power tool cleaning ISO-St2 | SSPC-SP2 | When viewed without magnification, the surface must be free from visible oil, grease and dirt and from poorly adhering mill scale, rust, varnish coating and foreign matter. |
| Very Thorough Hand- and Power tool cleaning ISO-St3 | SSPC-SP3 | Similar to St2 but the surface must appear very thoroughly treated to give a metallic sheen arising from the steel surface. |
| Brush off Blastcleaning ISO-Sa1 | SSPC-SP7 | When viewed without magnification, the surface must be free from visible oil, grease and dirt and from poorly adhering mill scale, rust, varnish coating and foreign matter. |
| Thorough Blastcleaning ISO-Sa2 | SSPC-SP6 | When viewed without magnification, the surface must be free from visible oil, grease and dirt and from most of the mill scale, rust, varnish coating and foreign matter. Any residual contamination must appear firmly adhering. |
| Very Thorough Blastcleaning ISO-Sa2½ | SSPC-SP10 | When viewed without magnification, the surface must be free from visible oil, grease and dirt and from most of the mill scale, rust, varnish coating and foreign matter. Any remaining traces of contamination shall show only as light stains in the form of spots or stripes. |
| "White metal" Blastcleaning ISO-Sa3 | SSPC-SP5 | When viewed without magnification, the surface must be free from visible oil, grease and dirt and from mill scale, rust, varnish coating and foreign matter. It shall have an uniform metallic colour. |
| Hydro jetting DW2 (STG-2222) | | Loosely adhering mill scale, rust and poorly adhering coatings are removed. Various spots of old coating systems and firmly adhering mill scale is still present. Thin coatings on previously blastcleaned surfaces are predominantly removed. Before drying a weak sheen arises from the metal surface which disappears during drying due to flash rust formation. |
| Hydro jetting DW3 (STG-2222) | | As DW2. Firmly adhering mill scale is still present. From firmly adhering rust at most thin dark oxide layers and/or slight residues in the roughness valleys are present. From firmly adhering old coatings residual areas having spots with damages, various scattered small spots and residues in the roughness valleys may be present. Thin coatings on previously blastcleaned surfaces are predominantly removed. Before drying a distinct sheen arises from the metal surface which disappears during drying due to flash rust formation. |

## Surface preparation of other metals.

### Aluminium

The surface should be clean and dry. Any corrosion salts should be removed by light abrasion and water washing. The cleaned surface should then be abraded or very lightly abrasive blasted using low pressure and non-metallic abrasive (e.g. garnet). Alternatively, the aluminium can be etched by using an acidic solution or etch primer. Transocean Gelclean 0.03 can be used for this purpose. Please consult the technical datasheet and safety precautions before use.

### Galvanised steel

The surface should be clean and dry. Degreasing of most galvanised surfaces requires some effort to obtain a clean surface. Any white zinc corrosion products should be removed by high-pressure fresh water washing, or fresh water washing with scrubbing. When using the preferred method of surface preparation, i.e. sweep blasting, it is still advisable to fresh water wash to remove soluble zinc salts. Many coatings based on non-saponifiable polymers can be applied directly to galvanised surfaces prepared in this way.
When sweep blasting is not possible, then an acid etch solution or etch primer should be used to passivate the surface and provide a key for further paint coatings.
When steel has been treated with a passivating treatment immediately after galvanising, then this must either be allowed to weather off over a period of several months exterior exposure or be abraded before application of a coating. In general etch treatments have no effect on fresh materials of this type.

### Stainless steel

Stainless steel does not require any particularly specialized surface pretreatment prior to coating. These surfaces should be free from oil, grease, dirt and other foreign materials by chemical cleaning. The development of a surface profile on stainless steel is highly recommended to assure good coating adhesion. A profile depth of between 1.5 and 3.0 mils is suggested for most coating systems. Because stainless steel is a very hard metal, abrasive blasting is recommended to impart a continuous surface profile.

## Surface preparation of concrete.

| | |
|---|---|
| New Concrete | Fresh concrete should be permitted to harden at least for 28 days at 23°C and 50% relative humidity. The moisture content of the concrete / masonry should be less than 6%. All soft or loosely bound surfaces should be cleaned down to a hard substrate. Sweep abrasive blasting is the effective and preferred method to do so. Large cracks or holes should be repaired with a non-shrinking compound. When abrasive blast cleaning is not desired or not feasible, acid etching is an alternative option. In less critical areas where blasting is not practical, wire brushing has to be adopted to remove laitance, followed by treating with dilute hydrochloric acid (10%). |

| | |
|---|---|
| Old concrete | Remove the surface contaminants like grease, oil, etc., by solvent wiping or by 10% caustic solution. Preferably the surface has to be prepared by light blasting. In case, blasting is not practical, etch the surface to get a good profile by treating white dilute (10%) hydrochloric acid.<br>Remove acid and contaminants by liberal wash with water. Ensure that acid solution does not retain on the surface and joints. Allow the surface to dry thoroughly before applying primer. Any cracks should be cut out and filled with suitable filler prior to painting. |

For more details about cleaning concrete refer to ASTM D4259 – Abrading concrete or ASTM D4258 – Surface cleaning of concrete.
In general the first coat on concrete is thinned down to amount up to 25% to facilitate penetration and to enhance adhesive properties.

**Wood surfaces**

Dirt, grease / oil should be removed by one or more chemical cleaning methods. Knots, nails, holes, cracks etc., should be filled with appropriate filler compound. Scrap off loose adherent coating if any and sand to an even surface, chalky surface should be washed cleanly and dried well before coating.