Executive Summary

This report has been prepared as an outcome of discussions within the Coatings Working Group of the Institute of Corrosion's Corrosion Engineering Division (CED), where it was agreed to produce a number of technical guidance documents and make them available through the CED technical area of the Institute of Corrosion website. This document is intended to give a brief insight into the types of preparation methods that are available for surfaces before coatings are applied, the equipment used and how this is related to industry standards. To this end the three most common pre-coating surface preparation methods, namely abrasive blasting, hand and power tool methods, and water jetting, are discussed in some detail. The way these three methods are carried out is discussed, with particular attention to detail being given to water jetting, which is less well known than the other two. The advantages and disadvantages of each method are also indicated.
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1 Introduction

Approximately 80% of paint failures are caused by either poor surface preparation or poor paint application. No matter how good the paint is, it will not perform to its full capabilities on a poorly prepared surface or if poorly applied.

Visual inspection should be conducted on all steel items prior to surface preparation. This will determine the surface preparation methods suitable for the structure in question along with the level of pre-preparation requirements. Such treatment should occur prior to the main surface preparation process. Pre-coating preparation could include a grinding or filling process to remove laminations, flame cut edges and weld spatter (ISO 8501-3) and/or to achieve rounding or smoothing of corners and welds. The procedure removes any potential weak spots or irregularities to provide a better surface for obtaining an even film build.

Different levels of surface preparation may be achieved through different cleaning methods. The three main types of surface cleaning methods are discussed in more detail below.

2 Abrasive Blast Cleaning

2.1 Introduction and Methods

Abrasive blast-cleaning is the common term for all methods using abrasives that are propelled toward the surface to be cleaned at very high speed. Typically this speed can be around 220 mph (350 km/h) on impact. This process produces a surface profile, the quality of which will influence the performance of any protective paint coating.

With high durability systems, it is essential to remove all mill scale and old coatings, as well as other contaminants, if the coating systems are to perform at their best.

One advantage of blast cleaning is that it provides a surface profile (anchor pattern) that can be tailored to suit the coatings being used. Hand-held blasting systems are widely used, although semi-automatic/robotic systems with vacuum recovery of waste are also available.

Attributes that should be monitored during blast cleaning include the profile or degree of roughness, dust and salt levels, and non-visual contamination. Note that abrasive blast cleaning increases the surface area of the steel which results in an increase in coating adhesion. The profile will differ depending on the size and type of abrasive used for example garnet, aluminium oxide, copper slag, steel shot or grit. The surface profile can contribute to the adhesion value of a coating and it is an important aspect of coatings and corrosion protection.

It should, however, be noted that grit blasting introduces the possibility of incorporating small pieces of grit into the surface; the composition of the included particles will depend on the abrasive used. These particles can be highly detrimental to the ability of the coating to prevent corrosion. For example, they can activate the surface electrochemically, for example by creating crevice corrosion effects. Ideally, precautions should be taken to ensure that such residual particles are not present under coatings on grit blasted metal surfaces; a visual check should be carried out and any particles observed should be removed (e.g. with a stiff wire brush).

2.2 Standards (general)

The Swedish SA standard classification (SA 1.0 – 3.0, see below) has for many decades been used to describe the surface finish level achieved by the Abrasive Blast cleaning process.

SA3 blast standard is deemed as the cleanest possible surface finish from blast cleaning and it is normally produced in a factory environment using engineering controls and automated blast machines with metallic abrasives. SA2½ is typically achieved on working sites, for example when
refurbishing previously coated structures, where access is sometimes difficult and temporary provisions such as encapsulation, heating and dehumidification are used to control the works.

Blast cleaning should always be specified to an agreed standard, for example by using visual standards such as those described in ISO 8501-1 (see Figure 1 and Table 1). The use of a visual standard as one of the criteria for determining whether the correct blast finish has been achieved is strongly advised, as the visual standard can quickly resolve any dispute arising based on an individual’s perception of the surface finish after abrasive blasting standard (e.g. Sa 2, Sa 2½ or Sa 3).

Table 1 also lists the relevant National Association of Corrosion Engineers (NACE) standards and the Society for Protective Coatings (SSPC) definitions (see references for a link to the full definitions).

<table>
<thead>
<tr>
<th>Abrasive Blast Cleaning</th>
<th>ISO 8501-1</th>
<th>SSPC</th>
<th>NACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>White Metal</td>
<td>Sa3</td>
<td>SSPC-SP 5</td>
<td>NACE No. 1</td>
</tr>
<tr>
<td>Near-White Metal</td>
<td>Sa 2½</td>
<td>SSPC-SP 10</td>
<td>NACE No. 2</td>
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<td>Commercial</td>
<td>Sa 2</td>
<td>SSPC-SP 6</td>
<td>NACE No. 3</td>
</tr>
<tr>
<td>Sweep</td>
<td>Sa 1</td>
<td>SSPC-SP 7</td>
<td>NACE No. 4</td>
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<tr>
<td>Original</td>
<td></td>
<td>SSPC-SP 14</td>
<td>NACE No. 8</td>
</tr>
</tbody>
</table>

Table 1: Levels required for various applications for Blast cleaning standards

Also note that there are two further standards in the ISO 8501 series which are important: ISO 8501-2 “Preparation grades of previously coated steel substrates after localized removal of previous coatings” and ISO 8501-3 “Preparation grades of welds edges and other areas with surface imperfections”.

2.3 Additional standards

The following standards from the ISO 8502 and ISO 8503 series should also be consulted where they are relevant. A summary of each of the important ones is given below:

This standard describes a method for assessing the amount of dust remaining on cleaned steel surfaces that have been prepared for painting. It provides pictorial ratings for assessing the average quantity of dust. It also provides descriptive classes for assessing the average size of the dust particles. The method described is a qualitative test that is useful for a steel surface, before cleaning, corresponding to rust grade A, B or C as defined in ISO 8501-1. It can be used as a ‘pass/fail’ test or to provide a permanent record of the amount of dust present on a surface.


This standard describes a method for extracting soluble contaminants from a surface for analysis, by the use of flexible cells in the form of adhesive patches that can be attached to any surface, regardless of its shape (e.g. flat or curved) and its orientation (i.e. facing in any direction, including downwards). The method is suitable for use in the field to determine the presence of soluble contaminants before painting or a similar treatment is applied. Part 6 of ISO 8502 does not cover the subsequent analysis of the contaminants that have been collected. Methods of analysis suitable for field use are described in other parts of ISO 8502.


This part of ISO 8502 describes a field method for the assessment of the total amount of water soluble salts, the salts being regarded as forming one single contaminant. The more aggressive contaminants causing corrosion and blistering (the ionic species) can easily be dissolved off and determined rapidly by this method. Consequently, the less aggressive and not so easily dissolved minor part of contaminant will remain un-assessed. For additional information on the test method, its potential and its limitations, see Bresle, Å., Conductometric determination of salts on steel surfaces, Materials Performance, June 1995, Vol. 34, No. 6, pp. 35-37, NACE International, Houston TX, USA.


This standard specifies the requirements for ISO surface profile comparators, which are intended for visual and tactile comparison of steel substrates that have been blast-cleaned with either shot abrasives or grit abrasives. It also includes definitions of the terms used in the ISO 8503 series and requirements for the care of ISO surface profile comparators.


This standard describes a visual and tactile method for assessing the grade of the profile produced by one of the abrasive blast-cleaning procedures described in ISO 8504-2. The method uses ISO surface profile comparators for assessing, on-site, the roughness of surfaces before the application of paint or other protective treatments. The method is applicable to steel surfaces that have been blast-cleaned by use of either shot abrasives or grit abrasives, but it is only applicable to grades Sa 2½ and Sa 3 of ISO 8501-1, where the entire surface under test shows an overall blast-cleaned appearance. It is applicable to surfaces that have been cleaned with either metallic or non-metallic abrasives.
3 Hand and Power Tool Cleaning

3.1 Methods

Hand tool cleaning can be an ideal method to prepare small areas, areas with difficult access, or areas where the use of blast cleaning is not permitted or it is impractical. There are many different tools available to manually prepare surfaces; some of the most common include:

- **Rotary wire brush** - available in various forms to fit specific machines, including cup and radial form, knotted or crimped bristles. Wire brushes have good resistance to wear and tear.

- **Reciprocating impact tool (needle gun)** - this tool consists of a group of steel needles that are struck by a piston, like a chisel. The needles project out of the gun simultaneously and they will strike the surface individually and hence adapt to irregular surfaces. This is most effective on brittle or loose surface contaminants.

- **Grinders or sanders** - for example, cutter bundles or stars are hardened steel washers that are grouped together on an axis and rotate individually. These are used in metal and non-metal surface preparation, grinding concrete, and for generation of non-slip surfaces.

- **Rotary impact or scarifying tools** - generally consist of an abrasive material spinning at high speeds, using centrifugal force to project cutters or hammers against the surface. These tools accomplish most cleaning jobs rapidly and leave surfaces fairly smooth, but frequently leave oil or grease on the surface. The surface must be cleaned of oil and grease before using rotary cleaning tools.

While it is possible to achieve an acceptable standard of surface cleanliness with power tools, the surface profile is unlikely to be the same as that achieved with abrasive blasting because they do not produce a uniform pattern. Preparation of welds, in particular, by this method can lead to coating failure due to insufficient surface profile (i.e. less than Swedish Grade 3, 2.5 or 2, the exact requirement depending upon the particular job specification). Each tool is capable of producing variable standards of cleanliness on the surface and this may differ in visual appearance dependant on the method used.

3.2 Standards

The visual appearance levels required for hand and power tool cleaning standards are listed in Table 2.

<table>
<thead>
<tr>
<th>Standards</th>
<th>ISO 8501-1, -2, -3</th>
<th>SSPC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand and Power Tool Cleaning</td>
<td></td>
<td>SSPC-SP1</td>
</tr>
<tr>
<td>Solvent Cleaning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand Tool Cleaning</td>
<td>St2 or St3</td>
<td>SSPC-SP2</td>
</tr>
<tr>
<td>Power Tool Cleaning</td>
<td>St2 or St3</td>
<td>SSPC-SP3</td>
</tr>
<tr>
<td>Power Tool Cleaning to Bare Metal</td>
<td></td>
<td>SSPC-SP11</td>
</tr>
</tbody>
</table>

Table 2: Hand and power tool cleaning standards

The same set of standards as given in section 2.2 are also relevant to hand and power tool cleaning.

4 Water Jetting

4.1 Introduction

High Pressure (HP) and Ultra-High Pressure (UHP) water jetting are commonly used for the removal of coatings from steel structures in connection with maintenance painting. The suitability of HP or UHP should be considered carefully. Ideally a detailed site survey should be undertaken and
specific site constraints established before work commences. Key factors to consider are as follows:

- Access to surface water drain or foul sewer for waste water discharge.
- Protection of services such as electric cables, plastic pipes or ducts and other soft materials such as brick and wood. A protective material such as thin tin or aluminium sheet is normally adequate.
- Prevention of water spray causing a nuisance to the public (especially when adjacent to roads, footpaths or rail tracks).
- Containment of waste water stream.
- Access to the work face – a mobile elevating work platform (MEWP) or scaffolding should be available to enable a man to work in a standing position, holding a safety lance (minimum ideal platform width 1.5m).
- Noise of the exposed water jet at the work face, which is similar to that of open abrasive blasting (in the region of 103 dB).
- It is sometimes possible to use a UHP water-jetting head incorporating a vacuum shroud for waste containment and vacuum recovery. Such heads are available in either hand-held or remote control variants.

Given that the above criteria can be complied with, the following aspects should then be considered.

### 4.2 Equipment

The equipment used in water jetting includes a high pressure pump unit, high pressure hoses, a jetting tool and sometimes a vacuum waste recovery system. Pumps used for commercial high pressure jetting operate up to 1700 bar (24,650 psi). Pumps for ultra-high pressure jetting operate at pressures greater than 1700 bar/24,650 psi. These pump units are typically powered by industrial diesel engines or, in some cases, three-phase electric motors. There are many types of jetting tools and lances available, each designed for different tasks. These include, hand-held safety lances, hand-held blast heads incorporating a vacuum shroud, tracked robotic units, remote control vacuum crawler units, and internal and external pipe jetting equipment.

### 4.3 Safety

Any water jetting work must be carried out in accordance with the UK Water Jetting Association (WJA) guidelines and only a contractor or specialist sub-contractor who is a member of the WJA should be considered for HP or UHP water jetting work.


Special attention must be paid to water jetting Safe Working Practices, in particular to the following:

- Selection of the appropriate impermeable PPE for operators (relating to the specific application).
- The reaction force of the water jet through the hand-held lance to the operator must meet WJA guidelines (250N maximum) – see nozzle flow/reaction force calculator for guidance.
- The length of barrel fitted to the hand-held lance must meet WJA guidelines.
- Noise from the water jet – the closer the nozzle is held to the surface, the lower the noise created and the more effective it is at removing coatings and corrosion. The longer the exposed water jet, the more noise created.
4.4 General

Almost all types of deteriorated existing coatings and corrosion product can be removed using UHP water jetting at pressures between 2500 bar and 3000 bar (36,000 psi and 45,000 psi). As a guide, a water flow rate of between 20 and 25 litres per minute should be sufficient. This would involve the use of a hand-held safety lance with a rotary head, or a semi-automatic remote control UHP blast system that incorporates a vacuum shroud. Remote control vacuum-shrouded systems are available on the market. These offer full containment of the waste stream and leave the surface warm and dry. Surfaces blasted with systems using vacuum shrouds generally leave little or no flash rusting. However, generally, vacuum shroud systems are only suitable for large flat areas such as bridge decks/soffits, bulk storage tanks or large marine structures.

Hand-held safety lances should be used to augment the remote control system to cut in areas where the remote system cannot reach, such as edges and behind pipes or other interfering steel braces, etc. Hand-held lances may be the only viable solution on complicated structures constructed of steel sections with narrow flat surface areas.

Considerable care shall be taken to avoid damaging sound coatings on any adjacent surface.

Only fresh water of a quality agreed by the engineer should be used for UHP jetting. Generally a town water supply is sufficient.

4.5 Advantages of Water Jetting

The advantages of water jetting are as follows:

- Existing surface profiles can be revealed, negating the need for additional abrasive blasting.
- Water jetting reduces the amount of solid waste; wash water can be filtered to remove solid particles, tested for contaminants and disposed of as non-hazardous waste, or re-used.
- Many coating manufacturers have materials that can be applied onto water jetting prepared surfaces.
- It can sometimes be referred to as a dustless system, which mitigates disturbance.
- It is more effective at removing soft elastomeric materials, such as rubber, than alternative techniques.
- No abrasive is used, thus avoiding expensive landfill costs.

For maintenance painting, light- and medium-flash rusting is generally acceptable; hence the supervising inspector/engineer should finally determine whether the existing rust level is acceptable.

The level of flash rusting should be compared with the pictorial reference given in BS EN ISO 8501-4 and agreed after consultation with the contractor. Normally flash rusting should be removed by a sweep blasting (i.e. light blasting that does not remove the entire surface layer) with UHP water or dry abrasive.

Soluble salt levels after final UHP water jetting preparation must comply with limits stated by the specified coating manufacturer.

Residual water must be removed from all areas; any water that does not drain naturally should be physically removed by suction, mopping or similar means.

Waste water discharged into the foul water sewer or surface water drainage must be of a quality acceptable to the Environment Agency or the local water authority as appropriate. This may involve filtering out the majority of suspended solids and possibly holding the filtered water in tanks until the results of water quality testing are available, together with any discharge consent being obtained.
If little or no blast profile is present after UHP water jetting preparation, the surface may require abrasive jetting to add additional profile. However, for maintenance painting applications, adding profile by abrasive jetting after UHP water jetting has proved unnecessary in some cases.

When UHP water jetting is the only preparation method used then the edges of sound, adjacent coating should be thoroughly abraded to at least 50 mm back from any prepared steel area and the edges should be ‘feathered’ or tapered into the prepared steel area to ensure a smooth transition from the new coating to sound existing coating.

Some maintenance painting contract specifications permit areas of sound coatings to remain. In this case an initial high-pressure water jetting process (less than 1700 bar but normally no less than 700 bar) would probably be prudent. In certain cases, a sweep jet using a fast rotating UHP water jet nozzle may also give the desired result. Trials in advance of the main works should be considered. HP/UHP sweep water jetting will remove loose and flaking material and expose any areas of corrosion or coating breakdown that would not be immediately apparent during visual inspection. HP water jetting should be undertaken with a hand-held safety lance fitted with an orbiting surface preparation nozzle.

When correctly undertaken, this process will expose all areas that require UHP jetting and prepare remaining coatings to a stage where they should require little or no further preparation. Structures affected by traffic fumes or hydrocarbon deposits will need to be treated with a suitable traffic film remover or in extreme cases de-greaser, during the HP water blast process. Traffic film removers are best applied by back-pack spray or brush and diluted according to the severity of soiling. The HP water blast process should remove all traces of detergent; however a suitable test to verify this would be advisable.

### Standards

#### Table 3: Water jetting standards

<table>
<thead>
<tr>
<th>Water jetting standard</th>
<th>ISO 8501-4</th>
<th>SSPC-SP 12</th>
<th>NACE No. 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light water jetting</td>
<td>Wa 1</td>
<td>WJ4 (700 - 800 bar)</td>
<td>Follows SSPC-SP-12</td>
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<tr>
<td>(Above 2,000 bar/UHP)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Thorough water jetting</td>
<td>Wa 2</td>
<td>WJ3 (850 - 1,000 bar)</td>
<td>Follows SSPC-SP-12</td>
</tr>
<tr>
<td>(Above 2,000 bar/UHP)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very thorough water jetting</td>
<td>Wa 2½</td>
<td>WJ2 (1,400 - 2,000 bar/UHP)</td>
<td>Follows SSPC-SP-12</td>
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<tr>
<td>(Above 2,000 bar/UHP)</td>
<td></td>
<td>WJ1 (2,000 - 2,500 bar/UHP)</td>
<td>Follows SSPC-SP-12</td>
</tr>
</tbody>
</table>

### References

#### 5.1 General references and sources


Pictorial Surface Preparation Standards for Painting Steel Surfaces, HMG Paints Ltd, Manchester – This document describes SSPC and SA standards.


http://www.nstcenter.biz/navy-preservation-resources/hand-power-tool/

Society for Protective Coatings (SSPC) definitions:  
http://blastal.com/index_files/definitions.html#sp1

5.2 Standards


ISO 8501-2: 1994 Preparation grades of previously coated steel substrates after localized removal of previous coatings

ISO 8501-3: 2006 Preparation grades of welds edges and other areas with surface imperfections

ISO 8501-4: 2006 Preparation of steel substrates before application of paints and related products - Visual assessment of surface cleanliness - Initial surface conditions, preparation grades and flash rust grades in connection with high-pressure water jetting


NACE No. 1: 1994 White Metal Blast Cleaning

NACE No. 2: 1994 Joint Surface Preparation Standard Near-White Metal Blast Cleaning

NACE No. 3: 1994 Joint Surface Preparation Standard Commercial Blast Cleaning

NACE No. 4: 2000 Brush-Off Blast Cleaning

NACE No. 5: 2002 Surface Preparation and Cleaning of Metals by Water Jetting Prior to Re-coating

NACE No. 8: 1998 Industrial Blast Cleaning
5.3 Further resources
Water Jetting Association - www.waterjetting.org.uk/

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