Surface preparation

Maintenance and repair

Introduction

This guideline presents a survey of key elements relevant for surface preparation during repair and maintenance. The guideline is not intended to give a complete description of all surface preparation methods used in the industry. For more detailed information, consult the actual standards behind the described methods whenever these are available.

Maintenance and repair work is characterised by the following:

- The substrate has previously been painted and old paint must be removed partly or in full.
- Often access is hampered by other on-going site activities, environmental restrictions as well as restraints in relation to time and climate.

Content

The guideline covers these topics:

- Purpose of surface preparation
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Purpose of surface preparation

A proper surface preparation is essential for ensuring that applied paint achieves its optimal performance regarding adhesion and anticorrosive properties.

Typically, the surface preparation requirements are divided in two major categories. Requirements to the cleanliness of the surface and requirements to the roughness profile of the surface.

Cleanliness requirements

- Low salt level. High salt contamination can result in paint blisters and promote corrosion.
- No oil and grease. Oil and grease can cause delamination/ flaking of the paint layer applied.
- Free of dust. Dust can result in loss of adhesion.
- Free of rust or other corrosion products. Rust gives poor adhesion and can result in blistering.
- Free of mill scale: Mill scale can cause galvanic corrosion and poor adhesion.

Roughness profile

The purpose of the roughness profile is to secure an anchor profile for optimal adhesion of the new paint. This requires that the surface has an adequate roughness where previous paint has been removed and that any remaining paint has the adequate adhesion.

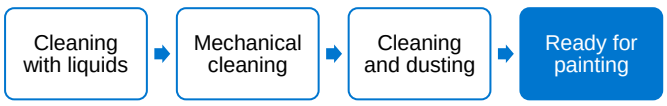
The roughness profile is rated according to the Grit comparator or the Shot comparator as defined in the requirements of the paint specification. Please find more information on roughness in ISO 8503-2:2000. Overview of the primary roughness grades is shown in Table 1.

Roughness profile	Rz (µm) Grit comparator	Rz (µm) Shot comparator
Finer than fine	< 20	< 20
Fine	20 - < 50	20 - < 40
Medium	50 - < 90	40 - < 80
Coarse	90 - < 130	80 - < 110
Coarser than coarse	> 130	> 110

Table 1. Roughness grades according to ISO 8503-2:2000.

Surface preparation process

The overall surface preparation process can be divided in three steps as shown below:



The purpose of each step is to, respectively:

- Remove oil, grease, soluble salts, loose paint and debris.
- Remove rust, loose and intact paint - and create roughness.
- Remove debris, dust and other remains from the mechanical treatment.

Cleaning with liquids

Water cleaning
Water cleaning is utilising the cleaning effect of pressurised hot or cold water. The pressure should be minimum 7-10 bar. The cleaning process will become faster and more efficient with increasing pressure.

Depending on pressure, the method can both be used for cleaning of already coated surfaces and for removal of loose adhering paint. According to ISO 8501-4:2006, water cleaning above 700 bar is called High Pressure Water Jetting (HPWJ). At these pressures, paint with good adhesion (sound intact paint) is also removed.

The cleaning effect of pressurised water can be enhanced by adding suitable detergents to the water and by heating. If using detergent, the surface must be rinsed with clean, fresh water. The method will remove oil and grease, soluble salts, dust and loose paint.

Steam cleaning
Steam may be used instead of water. This is particularly suited for very greasy surfaces.

Emulsion cleaning
The emulsion is sprayed directly on the surface. After a certain reaction time, the emulsion/dirt is rinsed off with clean fresh water. The method will remove oil, grease and soluble salts.

Alkaline cleaning
The alkaline cleaner is sprayed directly on the surface. After a certain reaction time, the cleaner is rinsed off with clean fresh water. The method will remove oil, grease and soluble salts.

Solvent cleaning
Only suited for small areas due to solvent evaporation. The solvent is applied manually to the surface with a rag soaked in solvent. The method will remove oil and grease, but there is a risk of hydrocarbon contaminants being relocated instead of being completely removed. The method will not remove soluble salts.

Mechanical cleaning

The purpose of mechanical cleaning is to remove rust, loose and intact paint as well as weld spatter. Depending on method, various cleaning grades and roughness profiles are generated.

Hand and power tool cleaning

Tools for manual cleaning are typically used for removal of rust and old loosely adhering paint. In general, both productivity and achieved roughness are low.

Hand tool cleaning
The hand tools cover a wide range of wire brushes, scrapers, spatulas, synthetic abrasive pads and manual chipping hammers. The tools are very easy to use and ideal for smaller areas and irregular constructions.

Power tool cleaning
The power tools can be pneumatic or electrical. They cover a wide variety of rotating wire brushes, grinders and needle guns. As for the simpler manual tools, they are very easy to use and ideal for smaller areas and irregular constructions. Productivity is a bit higher than for the hand tools, but still in the low end.

Cleaning grades
The cleaning grades possible to obtain are (ISO 8501:2007):
- St 1: Not relevant - unsuitable for painting
- St 2: Thorough hand and power tool cleaning
- St 3. Very thorough hand and power tool cleaning.

Roughness
In general, it is not possible to achieve a roughness profile that is higher than *finer than fine* with hand tools, see Table 1. Only for certain power tools, such as a “bristle blaster”, a *fine* roughness profile of about Rz 25-40 µm can be achieved.

Note, that after cleaning to grade St 3, it is of outmost importance that polished areas are roughened with coarse sand paper, grain size about 40, before painting.

Finishing treatment
For small areas, use clean solvent-wetted rags to remove dust and other remaining loose contaminants. For larger areas, use brushes or vacuum cleaners.

Abrasive blasting

Abrasive blasting is the process of forcibly propelling a stream of hard, abrasive particles at high velocity against the surface to be cleaned.

The cleanliness achieved by blast cleaning is evaluated according to ISO 8501-1:2007, which is a photographic standard with pictures showing the result of different degrees of cleaning for different rust grades of steel.

The preparation grades for blast cleaning are:
- Sa 1: Light blast cleaning
- Sa 2: Thorough blast cleaning
- Sa 2½: Very thorough blast cleaning
- Sa 3: Blasting to visual clean metal

Abrasive blasting can be divided in two main groups depending on how the blast media is propelled. By air as in dry abrasive blasting or by air/water as in wet abrasive blasting. The processes are described in more details in ISO 8504-2:2000.

Dry abrasive blasting
The primary methods are:

- Centrifugal abrasive blasting - abrasives are propelled by large rotating wheels or impellers and compressed air.
- Compressed air abrasive blasting- abrasives are propelled by compressed air.
- Vacuum abrasive blasting - abrasives are propelled by compressed air, but the blast nozzle is enclosed in a suction head that ensures that blast media and contaminants are removed from the surface during operation.

The characteristics of the three methods in a repair and maintenance process are described in Table 2 below.

Method	Suited for	Disadvantage	Achievable cleaning grade
Centrifugal	Repair, if portable equipment is used.	Normally not suited if large stationary equipment is used (laborious set up).	Sa 3, steel of all rust grades.
Compressed air	Large work pieces/large structures of various geometry.	May create high amounts of dust depending on type of blast media.	Sa 3, steel of all rust grades.
Vacuum	Small areas and when dust is not acceptable.	Lower productivity as compared to methods above.	Sa 2½. Sa 3 is achievable.

Table 2. Characteristics of methods for dry abrasive blasting.

Sweep blasting
The term sweep blasting is used for blasting using less abrasive force. The aim is to create roughness and hereby improve adhesion. The blasting process should lightly roughen the surface without removing a significant amount of paint.

Sweep blasting is not covered by any standard. The assessment is based on a visual evaluation of the surface, that should appear uniform and matt.

Wet abrasive blasting
The advantage of wet abrasive blasting is that dust is controlled and soluble salt are removed. Non-metallic, disposable abrasives are recommended.

The primary methods are:

- Compressed air wet abrasive blasting - water is added up- or downstream of the nozzle.
- Compressed air moisture injection abrasive blasting - propelled by compressed air, water is added upstream of the nozzle.
- Slurry abrasive blasting - the abrasive is dispersed in the water.
- Pressurized-liquid abrasive blasting - the abrasive is dispersed in the water under pressure.

The water for wet abrasive blasting needs to be fresh water with a low salt content to avoid corrosion. If corrosion inhibitors are added to the water, the surface should be carefully rinsed with fresh water after blasting.

For all wet abrasive cleaning procedures, the slurry left on the surface after blasting should not be allowed to dry, but should be immediately rinsed off with fresh water.

The dry slurry will form a very hard layer that can only be removed with some difficulty using high pressure water jetting and large amounts of water. The characteristics of the four methods are described in Table 3.

Method	Suited for	Disadvantages	Achievable cleaning grade
Compressed air	All kind of structures and for applications with different rust grades.	Will result in flash rust and cover the cleaned surface by a slurry.	Sa 3, steel of all rust grades.
Compressed air moisture injection	All kind of structures and for applications with different rust grades. Small consumption of water, limited amount of flash rust formation.	Does not remove salt. Will give flash rust.	Sa 3, steel of all rust grades.
Slurry	Smaller items. Removes soluble salts.	Will result in flash rust and cover the cleaned surface by a slurry. Not possible to achieve medium and coarse roughness profile.	Sa 3, steel of all rust grades. Only a fine roughness profile is achievable.
Pressurized-liquid	All kind of structures and for applications with different rust grades.	Will result in flash rust and cover the cleaned surface by a slurry.	Sa 3 is achievable for all rust grades.

Table 3. Characteristics of methods for wet abrasive blasting.

Abrasives
Abrasives are divided in two groups, metallic and non-metallic (mineral/synthetic) abrasives.

The preferred abrasives for repair and maintenance are the non-metallic, synthetic abrasives that are either recycled or only used one time. The Grit comparator is used to rate the roughened surface. Find more information in ISO 11126-3 to -7, see Table 4 and 5.

Synthetic abrasives	Standard	ISO Comparator
Copper refinery slag	ISO 11126-3:2018	grit
Coal furnace slag	ISO 11126-4:2018	grit
Nickel refinery slag	ISO 11126-5:2018	grit
Iron furnace slag	ISO 11126-6:2018	grit
Fused aluminium oxide	ISO 11126-7:2018	grit

Table 4. Typical abrasives used for maintenance and repair.

Size category	Abrasive size	Recommended for
Small	> 0.2 mm – 0.5 mm	Cleaning of irregularities
Medium	> 0.5 mm – 1.0 mm	General roughness and cleanliness
Large	> 1 mm	Roughness

Table 5. Roughening effect of different abrasive sizes.

Finishing treatment
After dry abrasive blasting, remove all loosely adhering debris, blast cleaning material and dust by vacuum cleaning, brush or compressed oil free air.

After wet abrasive blasting, wash all surfaces from the top in a downwards movement with fresh water to remove any remaining residues of blasting material and other residues. This action can be speeded up by blowing with compressed air or vacuum cleaning. It is important that the washing-drying-painting process is done in one continuous process without any delay to minimise the build-up of flash rust.

Water Jetting

Water jetting is the process of directing a pressurised jet stream of water against the surface to be cleaned to remove paint and rust from previously coated areas.

Since there are no solid abrasives added to the water, the surface will not obtain a new roughness profile; the original profile will be maintained.

On the other hand, in comparison with wet abrasive blasting, the method will not generate any slurry to be removed afterwards by rinsing. Furthermore, the method has the benefits that it does not generate dust and is very effective for removing soluble salts.

Just as with wet abrasive blasting, flash rust will be formed very fast and it is important to coat the surface as fast as possible after cleaning. See section on Flash rust.

The cleanliness achieved by water jetting is evaluated according to ISO 8501-4:2006, which is a pictorial standard showing the result of three different degrees of water jetting:
- Wa 1: Light water jetting
- Wa 2: Thorough water jetting
- Wa 2½: Very thorough water jetting.

According to ISO 8501-4:2006, water jetting can be divided in two main groups depending on the pressure. Ordinary water jetting and high pressure water jetting (HPWJ).

Water Jetting
Pressure is 700 bar and below. This pressure will remove poorly adherent paint, but not any sound intact paint. It is recommended to keep the minimum pressure above 300-350 bar to effectively remove loosely adherent paint.

High Pressure Water Jetting
Pressure is above 700 bar and will remove loose and sound intact paint as well as rust. Pressure needs to be adjusted according to the purpose of the actual job. At pressures above 1700 bar also linings as well as mill scale may be removed, although the process will be slow.

NACE standard for water jetting
Water jetting is also described in SSPC-SP 12/NACE No. 5 stating four different preparation grades: WJ1, WJ2, WJ3, WJ4. Note, that in the NACE standard, cleaning grade *decreases* from WJ1 to WJ4.

Feathering

An important concept in relation to repair is the concept of feathering. The aim of feathering is to avoid sharp edges between intact paint and the original surface in order to ensure good contact between new and old paint. See illustration 1.

Feathering is typically done by hand and power tools.

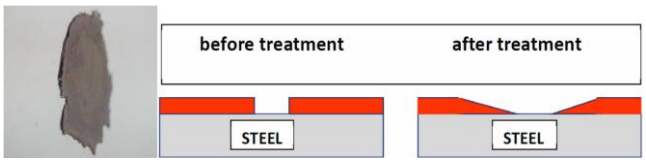


Illustration 1. Feathering reduces sharp edges.

Flash rust

It is important to minimise flash rust before painting and to coat the surface as fast as possible after cleaning. The allowed level of flash rust depends on the succeeding paint and will be stated in the specification and/or specified in the product data sheet.

ISO 8501-4:2006 defines three grades of flash rust, assessed according to pictorial rust examples:
- L: Low flash rust
- M: Medium flash rust
- H: Heavy flash rust

In general, grade H is not recommended for overcoating, whereas grades L and M could be acceptable for a primer.

Surface preparation for most common substrates

Carbon Steel, including cast iron and Corten steel

Hand and power tools
Remove oil and grease by fresh water washing with a suitable detergent followed by fresh water rinsing to remove remaining salts and other contamination. Solvent cleaning may also be applied for small areas.

Clean to bare steel in the selected areas according to the cleaning grade as specified in the specification or Product Data Sheet of the product to be applied.

Feather around the edges and roughen the area of intact paint around the overlap zone of the repair with a suitable hand tool. Finally remove any remaining dust before applying the new paint.

Abrasive blasting
Remove any oil and grease by fresh water washing with a suitable detergent followed by fresh water rinsing to remove remaining salts and other contamination.

Clean to bare steel in the areas to be repaired according to the cleaning grade as specified in the specification or Product Data Sheet of the primer to be applied.

Feather around the edges of the repaired areas. Roughen the painted area around the overlap zone of the repair with a light sweep blasting and remove any remaining dust before applying the paint.

Water Jetting
Remove paint in the area to be cleaned to a cleaning grade as specified in the specification or Product Data Sheet of the primer to be applied.

Feather around the edges and roughen the area of intact paint around the overlap zone of the repair. Remove any remaining dust with compressed oil free air.

Stainless steel

Hand and power tools
Remove oil and grease by fresh water washing with a suitable detergent followed by fresh water rinsing to remove remaining salts and other contamination.

Clean to bare metal in the selected areas to be repaired. Feather around the edges and roughen the area of intact paint around the repair with a suitable hand tool. Finally remove any remaining dust before applying the new paint.

Abrasive blasting
Remove any oil and grease by fresh water washing with a suitable detergent followed by fresh water rinsing to remove remaining salts and other contamination.

Clean to bare metal in the areas to be repaired. Feather around the edges of the repaired areas. Roughen the painted area around the repair with a sweep blasting and remove any remaining dust before applying the paint.

Water Jetting
Remove paint in the area to be cleaned to bare metal. Feather around the edges and roughen the area of intact paint around the repair. Remove any remaining dust with compressed oil free air.

Aluminium

Extruded aluminium sheets, cast aluminium and anodised aluminium

Hand and power tools
Remove oil and grease by fresh water washing with a suitable detergent followed by fresh water rinsing to remove remaining salts and other contamination.

Clean to clean metal in the selected areas. Feather around the edges and roughen the area of intact paint around the repair with a suitable hand tool. Finally remove any remaining dust before applying the new paint.

Abrasive blasting
Remove any oil and grease by fresh water washing with a suitable detergent followed by fresh water rinsing to remove remaining salts and other contamination.

Clean to bare metal in the areas to be repaired. Feather around the edges of the repaired areas. Roughen the painted area around the repair with a sweep blasting and remove any remaining dust before applying the paint.

Water Jetting
Remove paint in the area to be cleaned to bare metal. Feather around the edges and roughen the area of intact paint around the repair. Remove any remaining dust with compressed oil free air.

Concrete

Hand and power tools
Remove oil and grease by fresh water washing with a suitable detergent followed by fresh water rinsing to remove remaining salts and other contamination.

Remove any loose concrete in the selected areas to be repaired. Feather around the edges and roughen the area of intact paint around the repair with a suitable hand tool. Cracks need to be repaired /filled with suitable filler.

Finally remove any remaining dust before applying the new paint, preferably by vacuum cleaning.

Abrasive blasting
Remove any oil and grease by fresh water washing with a suitable detergent followed by fresh water rinsing to remove remaining salts and other contamination.

Remove any loose concrete in the areas be repaired. Feather around the edges of the repaired areas. Roughen the painted area around the repair with a sweep blasting. Cracks needs to be repaired/filled with suitable filler.

Remove remaining dust with vacuum cleaning before painting.

Water Jetting
Remove paint in the area to be cleaned to solid concrete removing all weak layers of concrete. Make sure the concrete is dry before proceeding, less than 4%.

Fill and repair cracks with a suitable filler. Remove any remaining dust before painting.

Fiberglass (GRP)

The surface to be repaired should be wiped with a solvent wetted rag before old paint is abraded to a well adhering layer with a coarse sand paper or lightly sweep blasted.

Feather around the edges and roughen the area of intact paint around the repair with sandpaper. Finally remove dust before painting. Water jetting is not recommended for fiberglass as it may damage the material

Hot Dip Galvanised Steel (HDG)

Hand, power tools and abrasive blasting
High pressure washing is recommended as zinc and aluminium salts formed may be difficult to remove. Do not use detergents. Use stiff brushes, alternatively sweep blasting to remove severe deposits of corrosion products in the selected areas to be repaired.

Feather around the edges and roughen the area of intact paint around the repair with a suitable hand tool.

Water Jetting
Remove loose adhering paint and zinc/aluminium corrosion products in the area to be cleaned. Feather around the edges and roughen the area of intact paint around the repair.

Painted surfaces

High pressure wash to remove to surface contaminants. Adjust the pressure to a level that remove loose paint, but leave sound paint intact. Damaged areas are repaired according to the guidelines given for the other substrate already stated.

Thermally sprayed zinc and aluminium

Hand, power tools and abrasive blasting
High pressure washing is recommended as zinc and aluminium salts formed may be difficult to remove. Do not use detergents. Use stiff brushes, alternatively sweep blasting to remove severe deposits of corrosion products in the selected areas to be repaired.

Feather around the edges and roughen the area of intact paint around the repair with a suitable hand tool.

Water Jetting
Remove loose adhering paint and zinc/aluminium corrosion products in the area to be cleaned. Feather around the edges and roughen the area of intact paint around the repair.

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