

HYDROJETTING

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Hydrojetting is the surface preparation of steel using high-energy water to remove coatings, corrosion products and other surface contamination such as oil/grease etc.

It relies totally on the energy of the water striking the surface to achieve its cleaning effect.

At present there is a wide and liberal usage of process terminology throughout the marine industry, by shipowners, shiprepairers, contractors and paint manufacturers which is confusing and in some instances costly.

The advantages of hydrojetting are:

- avoidance of spark hazard
- reduction of dust
- removal of water soluble salts
- removal of deteriorated paints, layer by layer if the intercoat adhesion is bad
- roughening and cleaning of existing intact paint systems
- operational in unfavourable weather conditions

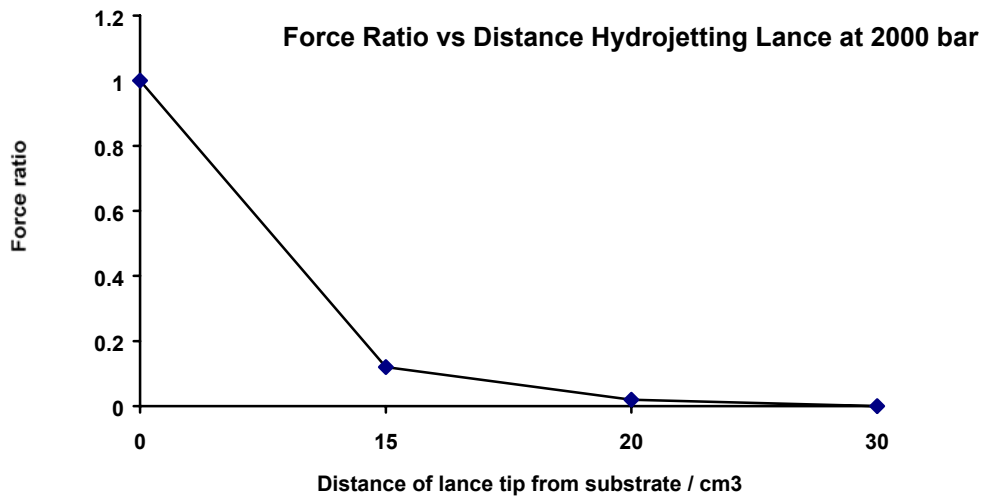
Definitions

Water Cleaning/Jetting - (Water Only)

Pressure	Terminology NACE
< 350 bar (5000 psi)	Low Pressure Water Cleaning (LPWC)
350 - 700 bar (5000 - 10,000 psi)	High Pressure Water Cleaning (HPWC)
700 - 1,700 bar (10,000 - 25,000 psi)	High Pressure Water Jetting (HPWJ)
> 1,700 bar (25,000 psi)	Ultrahigh Pressure Water Jetting (UHPWJ)

N.B. The pressure of the equipment only gives an idea about the maximum achievable standard and specifying the pressure does not mean that the substrate is cleaned correctly. The distance between the gun and the substrate is important. With an output pressure of 2000 bar, the water pressure at 15 - 20 cm from the nozzle is insufficient to remove reasonably adherent corrosion or coatings.





The angle of the gun tip to the surface is also of primary importance for removal of surface layers although this is dependent on the equipment on what is being removed. Therefore a standard should be specified as well as a pressure.

Substrate Cleaning at Differing Pressures

Pressure	Substrate Cleanliness
< 350 bar (5000 psi)	Removal of dirt, and poorly adherent surface contamination. Mainly washing the surface.
350 - 700 bar (5000 - 10,000 psi)	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.
700 - 1,400 bar (10,000 - 25,000 psi)	Most paints and corrosion products will be removed, Magnetite and hard tightly adherent coating may be left but can be removed with difficulty.
1,400 - 2,400 bar (25,000 - 35,000 psi)	All corrosion, including Magnetite can be removed as well as all paint types. Tightly adherent mill scale may remain.
> 2,400 bar (35,000 psi)	At these pressures mill scale can also be removed but it may not be economical.



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Standards - NACE/SSPC

- WJ-1 A WJ-1 surface shall be free of all previously existing visible rust, coatings, mill scale and foreign matter and have a matte metal finish.
- WJ-2 A WJ-2 surface shall be cleaned to a matte finish with at least 95% of the surface area free of all previously existing visible residues and the remaining 5% containing only randomly dispersed stains of rust, coatings and foreign matter.
- WJ-3 A WJ-3 surface shall be cleaned to a matte finish with at least two thirds of the surface free of all visible residues (except mill scale), and one third containing only randomly dispersed stains of previously existing rust, coatings and foreign matter.
- WJ-4 A WJ-4 surface shall have all loose rust, loose mill scale and loose coatings uniformly removed.

The above definitions are from SSPC-SP 12/NACE no 5 standard however, there are no visual standards for these definitions. Until they are ready Sigma Coatings is using the visual reference SSPC-VIS 4(1) NACE No 7 which do not exactly match the definitions.

N.B. Whilst hydrojetting can remove existing coatings, soluble salts and contamination it will not impart a profile to the steel, any profile present after hydrojetting will be the original blast profile (if blasted) or from corrosion (pitting).

Sigma Coatings recommendation: more than 1,700 bar (25,000 psi)

Slurry Blasting - Water/Abrasive

Generic name for all types of abrasive blasting that contain water, varying from introducing small quantities of water into a stream of dry abrasive to injection of a small quantity abrasive into a high pressure water stream.

One of the major advantages of slurry blasting is the removal of soluble salts combined with the creation of a profile. However, the removal of the slurry can be a problem and it is always advisable afterwards to wash the surface down with fresh water prior to coating application in order to remove any abrasive from the surface.

As far as standards are concerned, the NACE standards were only produced for hydrojetted surfaces.

Soluble Salts

One of the biggest advantages of "Hydrojetting" is the ability to significantly reduce the soluble salts from the steel surface. If these salts are not removed and overcoated they can cause osmotic blistering and lead to failure within a very short time. Levels of above 10-20 $\mu\text{g}/\text{cm}^2$ have been shown to cause coating failure particularly under immersion conditions.

Dry blasting does give partial removal of these soluble salts, however, it also tends to trap contaminants in the crevices and foldovers created when the surface is deformed during dry abrasive blasting.



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Soluble salt levels are specified in the NACE hydrojetting standard. They are not specified in dry blasting standards but are carried out for tank coating work and for other areas where there is a high risk for the presence of soluble salts. Generally speaking one of the main advantages of hydrojetting, if carried correctly out, is the removal of soluble salts and for this reason it is not considered necessary to specify soluble salt concentrations as a part of the surface preparation standard unless it is suspected that they will not have been removed.

Sigma Coatings recommendation - Soluble salt testing is only necessary as part of the surface preparation standard in special cases.

Which water should be used?

Fresh Water never Sea Water

One of the biggest advantages of hydrojetting is the removal of soluble salts (i.e. chlorides) from the steel surface. If seawater is used followed by fresh water washing then the steel is initially being purposely exposed to high levels of chlorides. With corroded steel, it is possible to see where the salt levels are highest (corroded areas), this is impossible with a surface hydrojetted with seawater and fresh water rinsed. Whilst the surface can be tested for chlorides it is impractical to test the entire area there is no way to check they have all been removed until the coating breaks down.

Sigma Coatings recommendation - Always hydrojet with fresh water

Flash Rust

Flash rust is an inevitable when steel is cleaned with water without the use of an inhibitor. This leads to problems we trying to evaluate the degree of cleanliness of a hydrojetted steel surface as the formation of flash rust means that the substrate condition is constantly changing. Experience has shown that the steel cleanliness should not be judged when the substrate is wet.

The performance of a system applied to a hydrojetted surface is partly governed by the degree of flash rusting. The flash rusting can be divided into three categories:

There are basically three levels of flash rust:

- Light (L): Present as a tightly adhering, appears as a surface staining that will partially discolour the original metallic surface and will not be heavy enough to easily mark objects brushed against it.
- Medium (M): Present as a layer which obscures the original metallic surface and will be heavy enough to mark objects brushed against it.
- Heavy (H): Present as a powdery rust that obscures metallic surface and easily marks objects brushed against it.

For more detailed definitions please consult SSPC-VIS4(1) NACE No.7 Standard.

However it is very difficult to quantify the amount of flash rust as it is constantly changing. Procedural changes can be made to reduce the flash rust formation and keep the interval between a dry substrate and coating application as short as possible.



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As good working practice the following should also be adopted:

- Reduce the time between completely wet and completely dry.
- Keep the interval between a dry substrate and coating application as short as possible. Some coatings do have some tolerance to damp surfaces and can be applied under certain conditions.
- Accept only firmly adherent flash rust.
- Never mechanically wire brush to remove flash rust. This will result in polished surfaces and rehydrojetting may be required.

Factors affecting the speed of flash rusting.

- Soluble salts on the substrate
- Drying time of steel / humidity / temperature

Wet Blast Inhibitor

Sigma wet blast inhibitor is available and has been used successfully on a number of projects. Being an amine, it will chemically cure into epoxy films. However care should be taken to avoid very high concentrations, which is a particular problem on horizontal surfaces.

In some countries there are restrictions on the use of this type of product as run off water is classed as chemical waste.

When hydrojetting at pressure above 1,700 bar the heat generated tends to dry the surface relatively quickly and if the above mentioned good working practices are carried out flash rust formation will be limited and there should be no need for a flash rust inhibitor.

Appearance of Steel

Hydrojetted steel has a different appearance than dry blasting even before flash rusting.

Generally surfaces look dull, and pitted steel can have a mottled appearance. This is caused when the corrosion products are washed out of the pits leaving a bright steel surface and the surrounding areas are left dull grey, brown to black in colour (ferric oxide). Which is the reverse of a dry abrasive blasted surface where the failure to remove corrosion products from the pits gives a dark pit whilst the surrounding steel is a bright silver colour.

Damp/Dry Substrate

Prior to recoating the substrate should be dry - use water sensitive paper as per FTS Guidelines. For certain coatings a damp substrate is acceptable.



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Existing Systems

At 2000 - 3000 bar existing paint can be removed, however at 1000 - 1500 bar only loosely adherent paint can be removed. If an existing system is left on the steel surface then there is a risk of island formation. Water can creep under the apparently "tightly adherent coating" which is subsequently overcoated leading to failure. Secondly, an existing paint film may be sufficiently thick that when overcoated there is an edge effect, where a freshly applied paint film moves away from a sharp edge and less paint is applied to the edge.

This can be avoided by:

- Higher pressure remove all existing coating
- Feather all existing edges back to a firm edge i.e. Discing
- Stripe coat also edges of existing systems

Ballast Tanks

With ballast tanks there are still a number of practical problems which make it difficult to achieve a uniformly acceptable standard of surface preparation

These problems are:

- Complex form i.e. stiffeners etc
- Poor visibility - constant water vapour (mist) present in the tank
- Constant high humidity leading to:
 - high levels of flash rust
 - difficulty in achieving dry substrate prior to recoating

Special attention should be paid to these items.

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