Achieving Surface Preparation Standards by Waterjetting

First came all kinds of standards for waterjetted surfaces. Now there’s a guide to meeting the standards.

Waterjetting is becoming a commonly used method of surface preparation, particularly in maintenance painting programs, for a variety of reasons.

• Waterjetting has environmental and safety advantages because it suppresses the dust normally created in surface preparation operations.
• Major paint manufacturers now produce coatings that can be applied directly to a waterjet-cleaned surface.
• Waterjetting penetrates deep into the pits of a steel surface to remove foreign matter, chlorides, and other corrosion-inducing products, enhancing the performance of the protective coating system.

As a result of the increasing use of waterjetting, written and visual standards have been produced in recent years to classify surfaces prepared by waterjetting. Table 1 lists the waterjetting standards commonly used in the protective and marine coatings industry in Europe and the U.S.

The written standards define acceptable levels of surface preparation by waterjetting. The visual standards illustrate how substrates cleaned to those levels of preparation should look.

This article is based on the HAMS-Guide, a booklet produced by Paul Hammelmann Maschinenfabrik GmbH of Oelde, Germany, a supplier of waterjetting equipment. The Guide reviews the provisions of these standards, the surface conditions obtained by various degrees of waterjetting, and the operating parameters of equipment needed to achieve those surface conditions. Although the operating parameters in the Guide are based on the performance of Hammelmann equipment, they can be used by contractors and end users as a

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general guide to the performance of typical waterjetting equipment.

Information in the Guide and How It Was Developed

The Guide includes the following operating parameters for both manual and semi-automatic waterjetting equipment:
- operating pressure,
- flow rate of the water,
- power rating of the pump, and
- removal rate of coating materials and contaminants.

Manual systems are defined as those run by a human operator, while semi-automatic systems refer to robotic equipment.

The Guide notes that the energy needed to achieve a certain level of surface preparation depends on the condition of the material to be removed and the desired degree of cleanliness. Intact rust and tightly adherent coatings require more energy to remove than loose rust or flaking coating material. The performance examples cited are based on the company’s experience in removal of coatings from ships’ hulls.

The parameters for the semi-automatic units are actual working rates of waterjetting performed at a shipyard in Hamburg, Germany, as well as testing on ships there, according to the company. The manual removal rates come from a variety of sources, starting with the company’s tests on sections of old ship hulls and backed up by feedback from customers and agents. Information also was obtained from demonstrations given at shipyards around the world.

Travel speed along the hull and stand-off distance of the blasting head are controlled for the semi-automatic equipment, so the guide presents uniform removal rates for that category of equipment. The removal rates quoted for semi-automatic systems are based on the maximum ever achieved and then reducing them by half to reflect actual shipyard conditions. For hand-held equipment, average ranges of removal rates are presented to account for variations in types of equipment as well as differences in how human operators perform their job.

In addition, the Guide notes that the removal rates included in its pages are for flat surfaces only and, therefore, cannot be applied to girders, H-beams, pipes, or angular structures on which waterjetting also might be used.

Organization of the Guide

The Guide is organized according to the various visual standards on waterjetting. While it reproduces the visual references found in those standards, the Guide notes that it is not a substitute for the standards themselves. “We must stress that this is a guide and not a definitive document. We strongly recommend that you obtain the original publications referred to herein,”

<table>
<thead>
<tr>
<th>Standard</th>
<th>Surface reference for</th>
<th>Publisher</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSPC-SP 12/NACE 5</td>
<td>X</td>
<td>Society for Protective Coatings (SSPC) and NACE International, U.S.</td>
</tr>
<tr>
<td>Hempel’s Photo Reference</td>
<td>X</td>
<td>Hempel Paints Ltd., Denmark</td>
</tr>
<tr>
<td>International Hydroblasting Standards</td>
<td>X</td>
<td>International Paint Ltd., UK</td>
</tr>
<tr>
<td>STG Guide No. 2222</td>
<td>X</td>
<td>Schiffbautechnische Gesellschaft e.V., Germany</td>
</tr>
<tr>
<td>Jotun Guidelines on Flash Rusting</td>
<td>X</td>
<td>Jotun Paints, Norway</td>
</tr>
</tbody>
</table>

Table 1: Commonly Used Standards and Guidelines for Waterjetting
Evolution of Ultra-High Pressure Waterjetting Equipment

by Richard Schmid, Flow International Corporation

The need for waterjetting standards and guidance in meeting them has become more urgent as ultra-high pressure (UHP) waterjetting has become more feasible for large-scale surface preparation projects previously restricted to dry abrasive blasting. Production rates for UHP technology have increased dramatically as the equipment has evolved from hand-held tools, to semi-automated tools, to fully-automated machines that provide 100 percent containment of spent water and paint debris. This article reviews the evolution of UHP equipment. Other factors relating to the viability of UHP are detailed elsewhere.\(^1\)

**Hand-Held Tools**

One of the largest elements limiting the widespread use of UHP waterjetting has been productivity. Until recently, the most common type of UHP tools were hand-held tools (Fig. 1). And only 3 years ago, productivity levels of hand-held UHP lances were one-quarter to one-third that of hand-held abrasive nozzles, which limited commercial viability. UHP waterjet coating removal rates generally fell into the 20-30 sq ft/hr (2-3 sq m/hr) per hand-held UHP tool, compared to productivity ranges of 90-120 sq ft/hr (8-11 sq m/hr) per nozzle for abrasive blasting.

Reasons for the low productivity included operating pressures that were in the 30,000-36,000 psi (4,400-5,200 MPa) range as well as slow nozzle rotation speeds. But recent advances have increased the productivity level of these tools dramatically. For example, pressure ranges have increased to 40,000 psi (5,800 MPa); higher nozzle rotation speeds in the 3,000-3,500 rpm range augmented advances in operating pressures; and advances in nozzle technology have improved productivity. These higher pressures and nozzle advancements have pushed productivity to rates comparable to hand-held abrasive blasting. Typical removal rates for UHP are now 80-100 sq ft/hr (7-9 sq m/hr), making UHP comparable to dry abrasive blasting of similar coatings from similar substrates.

Hand-held tools are versatile and will always be required for detail work, smaller projects, and areas that larger machines cannot reach. However, despite advances in their technology, they are limited in productivity because of operator fatigue and the amount of thrust that an operator can handle. Theoretically, productivity could be increased by adding more volume (power), but human operators can safely handle only a limited volume, about 3 gal./min (11 L/min) at 40,000 psi (5,800 MPa). This volume equates to about 30 lbs (14 kg) of thrust, which limits productivity.

One other limitation of hand-held tools is that they may leave surfaces wet long enough for light flash rusting to form. Of course, most manufacturers now have coatings available that can be applied directly over light surface rust with no additional surface preparation steps. Occasionally, however, such as in conditions of high humidity or rain, an additional surface preparation step after hand-held waterjetting is needed before coating application.

Figure 1 - Hand-held waterjetting
*Photos courtesy of Flow International Corporation*

According to the revised introduction of the publication, Hempel’s Photo Reference to SSPC-SP 12/NACE 5

The joint SSPC/NACE standard, SSPC-SP 12/NACE 5: Surface Preparation and Cleaning of Steel and Other Hard Materials by High- and Ultrahigh-Pressure Water Jetting Prior to Recoating, was jointly published in 1995 by 2 U.S. technical organizations, the Society for Protective Coatings (SSPC) and NACE International.

The standard defines 2 kinds of cleaning, 1 for nonvisible contaminants and 1 for visible contaminants. The cleaning of nonvisible contaminants is described by 3 levels of surface conditions, ranging from SC-1, a surface free of all detectable levels of contaminants, to SC-3, a surface with less than...
50 µg/cm² of chloride and sulfate contaminants. The cleaning of visible contaminants is defined by 4 degrees of cleaning by waterjetting. The 4 end conditions range from the highest degree of cleaning, designated in the standard as WJ-1, in which all visible rust, coatings, mill scale, and foreign matter are removed, to the lowest degree of cleaning, WJ-4, in which only loose material is removed. (The standard also defines 4 pressure ranges, including high pressure and ultra-high pressure waterjetting.)

Hempel Coatings of Lyngby, Denmark, recently developed a “Photo Reference for Steel Surfaces Cleaned by Water Jetting,” which shows various initial conditions of steel substrates followed by a series of photos of that same substrate after being cleaned to the levels of preparation described in the SSPC/NACE standard. (A
joint task group from SSPC/NACE is working on a draft visual standard of its own for surfaces cleaned by waterjetting.)

For instance, included in Hempel's Photo Reference are depictions of a steel panel with an initial condition of Rust Grade C and how it looks after being cleaned to 3 of the levels of preparation defined in the SSPC/NACE standard (WJ-3, WJ-2, and WJ-1). Rust Grade C is a steel surface completely covered with rust but with little or slight pitting visible, according to ISO 8501-1 (Preparation of Steel Substrates Before Application of Paints and Related Products—Visual Assessment of Surface Cleanliness—Part 1: Rust Grades and Preparation Grades of Uncoated Steel Substrates and of Steel Substrates After Overall Removal of Previous Coatings).

The Guide supplements the photos with information about the operating parameters of waterjetting equipment needed to achieve the different levels of preparation. It also provides estimates of the typical cleaning rates at those parameters.

For example, the guide shows that to clean a steel substrate with an initial condition of Rust Grade C to a level of WJ-1 with manual equipment would require an operating pressure up to 2,500 bar (37,500 psi), a water flow rate of 20 L/min (5 gal./min), and a power rating of 90 kW. The average cleaning rate under these conditions in a dockyard is estimated at 6 to 10 sq m/hr (65 to 110 sq ft/hr).

The parameters for cleaning the same substrate to WJ-1 with semi-automatic equipment would be an operating pressure of 2,500 bar (37,500 psi), a water flow rate of 100 L/min (26 gal./min), and a power rating of 460 kW, according to the Guide.

The Guide includes cleaning levels illustrated in Hempel's Photo Reference based on 4 other initial conditions: an old coating with intercoat flaking and slight under-rust, a red epoxy shop primer, a grey zinc silicate shop primer, and Rust Grade D (a steel surface completely covered with rust, on which general pitting is visible).

In each case, the equipment operating parameters listed in the guide are the same for comparable levels of cleanliness, regardless of the initial condition. The Guide explains that the booklet is intended to provide guidance rather than a definitive list of operating parameters for each condition and cleaning level; moreover, the booklet notes that the guide shows the pressure and flow rate, using its own equipment, that will achieve the result in the visual reference. All initial conditions are different, but 2,500 bar (37,500 psi) of pressure will achieve a WJ-1 surface in each case, for example, according to the Guide. Variation occurs in the cleaning rates and operating pressure/flow rates between each of the levels of cleanliness.

International Paint's Hydroblasting Standards

Several years ago, International Paint developed hydroblasting standards to meet its marine customers’ requirements as well as its own internal needs. The standards relate to the cleaning of bare, rusty steel without mill scale, since mill scale generally is removed in the paint shop by abrasive blasting. The standards do not describe previously coated steel.
Rust grades C and D were selected as representative initial surface conditions, and 2 degrees of cleanliness were developed: HB 2 (Thorough Hydroblast Cleaning), which is equivalent to Sa 2, and HB 2½ (Very Thorough Hydroblast Cleaning), which is equivalent to Sa 2½.

For the reasons explained above, the same equipment operating parameters are listed for HB 2 and HB 2½ for both Rust Grade C and Rust Grade D.

STG Guide No. 2222
The third set of visual standards for waterjetting included in the Guide is STG Guide No. 2222 (Definition of Preparation Grades for High-Pressure Waterjetting Without Addition of Solid Abrasives of Corroded and Coated Steel Surfaces at Different Initial Conditions) developed by Schiffbautechnische Gesellschaft e.V. in Germany. It defines 3 preparation grades, designated as Dw 1, Dw 2, and Dw 3, for waterjetting of corroded and coated steel surfaces.

The definitions in STG Guide No. 2222 are illustrated in photographic references. For this standard, the Guide includes 2 initial conditions—an old coating consisting of several layers and Rust Grade C—along with the top 2 levels of preparation (Dw 2 and Dw 3).

Flash Rusting Definitions
In addition to the 3 visual standards for waterjetting, the Guide includes the definitions of flash rusting offered by International Paint in its Hydroblasting Standards and Jotun Paints of Sandefjord, Norway, in its guidelines on degrees of flash rusting.

International has defined 3 degrees of flash rusting—light, moderate, and heavy. Jotun has developed 4 levels—no flash rusting (JG-1), slight flash rusting (JG-2), moderate flash rusting (JG-3), and considerable flash rusting (JG-4).

Hempel also defines 3 levels of flash rusting—a yellow-brown layer (FR-1), a red-brown layer (FR-2), and a heavy red-brown layer (FR-3).

The Guide does not include the photo references for these 3 sets of definitions of flash rusting, but they are available from the companies.

Conclusion
As waterjetting continues to develop a stronghold among surface preparation techniques in the protective and marine coatings industry, written and visual standards will assume more importance in achieving high quality workmanship. Guidelines of expected cleaning rates and equipment operating parameters, such as those compiled in the Guide described here, can provide useful supplementary information for contractors and end users when used in conjunction with the standards themselves.

Where to Get Copies
The Guide is available in English and in German/English versions. Copies can be obtained from Paul Hammelmann Maschinenfabrik GmbH, Postfach 3309, 59282 Oelde, Germany; +49/2522 760; fax: +49/2522 76444. Copies of the coating manufacturers’ standards mentioned in this article are available from the company that developed each.

Requests for STG Guide No. 2222 should be sent to Schiffbautechnische Gesellschaft e.V., Lämmersieth 72, 22305 Hamburg, Germany. Copies of SSPC-SP 12/NACE 5 are available from SSPC, 40 24th Street 6th Floor, Pittsburgh, PA, 15222, U.S.; +1/412/281-2331; fax: +1/412/231-9992; and from NACE International, P.O. Box 218340, Houston, TX 77218-8340, U.S.; +1/281/228-6200; fax: +1/281/228-6300.