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Paper

COMPARISON OF SSPC-NACE and ISO WATERJET CLEANING STANDARDS FOR COATINGS REMOVAL

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ABSTRACT

The current SSPC-NACE series "Joint Surface Preparation Standard Waterjet Cleaning of Metals" which covers four levels of cleanliness is compared to the ISO 8501-4 "Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness — Part 4: Initial surface conditions, preparation grades and flash rust grades in connection with high-pressure water jetting." ISO 8501-4 revision is underway. The current "Joint SSPC Surface Preparation Standard/ NACE Standard Practice: Wet Abrasive Blast Cleaning" series is compared to the wet abrasive blast section of ISO 8504-2 "Preparation of steel substrates before application of paints and related products — Surface preparation methods — Part 2: Abrasive blast-cleaning" which is in the Final Draft International Standard (FDIS) stage and will be published shortly. Every global contractor should be aware of similarities and differences.

1. INTRODUCTION

Coatings removal and subsequent application of paints and coatings require a depth of knowledge which is beyond industrial cleaning. Lou Vincent estimated that 85% of premature coatings failures occur because of the condition of the substrate upon which the paint is applied. Many waterjet contractors want to "clean" or remove coatings" but to be successful they must learn the language and details which concern the corrosion managers of the ultimate client. If the firms work globally, they have to be familiar with not only the standards of their home country but of global standards which in the coatings industry means ISO standards. Coatings are more than cosmetic; coatings and paints are the first line of defense against corrosion. At first glance, the ANSI, NACE, SSPC and ISO standards seem to be interchangeably, but the devil is in the details. This author has worked on US and ISO standards for years, and still gets surprised in the face-to-face discussions where each country is vying for "their" national body words and emphasis.

2. WATERJET CLEANING

What is the same? SSPC-NACE WJ-1, WJ-2, WJ-3, WJ-4 and ISO 8501-4 describe conditions for four levels of cleanliness, ranging from "removal of loose material" to clean to bare substrate." The abrasive blast cleaned documents came first. Inspectors are trained and certified predominately on the abrasive blast standard language and the abrasive blast photographs. This unconscious comparison with abrasive blast can, and does, lead to disagreements on field sites, and sometimes back in the testing labs.

The ISO 8501-4 was originally written with language from the abrasive cleaned standards and includes all the levels of cleanliness. The SSPC-NACE documents started with completely different language from an earlier "pressure washer" concept and the first edition included four levels of cleanliness in one document; later editions separated SSPC-NACE into four documents.

There is a pretreatment section in standards. In all cases, it is assumed that the surface is free from oil and grease, and that the heavier layers of old rust have been removed, typically by chipping tools. In the case of WJ cleaning, often the pretreatment for removal of oil can be skipped, but then the cleaned surface should be examined for areas of water droplets before paint application.

What is different? The US documents started with the descriptive language, followed with guidance photographs. ISO standards started as visual pictures with little description. Their initial language was simple but based on prior abrasive standards. When it came time to describe the four levels of visual cleanliness, the ISO 8501-4 [REF 1] left off the "highest" level because the author, or project leader, could not see the difference as clear as in the "standard" abrasive photos, and moreover, had left no room in the descriptive language. SSPC-NACE has the Surface Preparation separated into 4 documents. [REF 2-5]

In 2002 as the ISO WJ document was being written, the project leader didn't understand that abrasives clean from the top down, leaving material in pits and crevices; waterjet cleans from the pits and crevices up, leaving material on the top. This effect comes from the hydraulic push between layers. Consequently, the project leader did not accept descriptions or photos of Wa 3.

At the time of publication, the European WJ cleaning systems were predominately 15,000 psi to 20,000 psi (103 MPa to 138 MPa), which is a mix of hydraulic and cavitation actions which led to partial paint layer removal. The USA contractors had quickly moved to the >30,000 PSI (207 MPa) which had cavitation as the major cleaning method to chip away the paint layers to the substrate. The difference in threshold energy between the 20,000 psi (138 MPa) and the 40,000 psi (276 MPa) is critical to removal of coatings layer by layer or stripped down to the metal substrate. The Project Leader for ISO 8501-4 didn't think, in his experience, that waterjetting equipment could achieve the highest level of cleanliness, that is surface preparation which promotes top performance. The coatings manufacturers, notably International Paint and Hempel who did the initial research, ascertained that the performance was of highest quality. International Paint, in 1994, advocated for WJ cleaning, particularly for marine applications where invisible salt was causing corrosion problems so that ships broke up at sea. The loss of ships led to coatings in ballast tanks being designated a primary requirement for Safety Of Lives At Sea (SOLAS) regulations.

STG Guide No. 2222 is the first published reference on high-pressure WJ use in coatings removal. The photos clearly show an underlying black iron oxide layer on the metal which is not removed. [REF 6] This set of reference photo verify that water permeates or diffuses over time through the paint and forms an inert black oxide layer at the substrate. STG Guide No. 2222 was a hindrance to accepting WJ as a cleaning technique, because the conventional wisdom was to remove coating to the bare "gray" steel coloration, not leave old rust layer on the substrate. Never mind that this oxide layer formed under the coating over time and was not the root cause of any coating failure. IN STG No. 2222, only a field specimen which had not been installed on a ship, but had been in the yard, exhibited gray metal when the coating was removed. STG Guide No. 2222 reinforced the Project Leader's idea that WJ couldn't clean to bare substrate.

Thus ISO 8501-4 was published (2006) with no representative photograph of Wa 3, and a definition table which included Wa 1, Wa 2, and Wa 2 ½ and only the following wording for Wa 3:

"NOTE: This part of ISO 8501 does not imply that cleanliness is limited to Wa 2½, but achieving a greater degree of cleanliness could involve a disproportionate increase in time." [REF 1 clause 5 Preparation Grades]

The origin of comparison of "abrasive cleaned" substrates with "WJ cleaned substrates" is important because inspectors make decisions on VISUAL observation. The NACE and SSPC standards started as words to describe the end product based on pressurized water cleaning. The photographs were guides. The WJ standards started with very different descriptions and have gradually moved towards the more established language for the abrasive cleaning. This move towards "abrasive" language makes the unexperienced inspectors think that the WJ clean visual will be the same as the abrasive clean visual. ISO and SSPC-NACE have different titles for the visual levels of cleanliness to emphasize that WJ methods are different from abrasive methodology.

Table 1 Comparison of the Titles and Numbering of SSPC-NACE to ISO standards

Cleaning (abrasive blast)	SSPC/NACE #	Cleaning (water alone)	SSPC/NACE	ISO 8501-4 (2002)
White metal	SP 5/ SP 1	Bare substrate	WJ- 1	
Near White metal	SP 10/SP 2	Very thorough	WJ-2	Wa 2 1/2
Commercial Industrial	SP 6/SP 3 SP 14/SP 8	Thorough	WJ-3	Wa 2
Brush Off	SP 7/SP 4	Light	WJ-4	Wa 1

The language in the ISO had to be revised to include Wa 3. When talking to a group of people who might be using either ISO of SSPC-NACE documents, use the title as the numbers can be confusing.

Current Language in ISO 8501-4 (2006)

Table 2 — Descriptions of the surface appearance after cleaning

Wa 1	Light high-pressure water jetting When viewed without magnification, the surface shall be free from visible oil and grease, loose or defective paint, loose rust and other foreign matter. Any residual contamination shall be randomly dispersed and firmly adherent.
Wa 2	Thorough high-pressure water jetting When viewed without magnification, the surface shall be free from visible oil, grease and dirt and most of the rust, previous paint coatings and other foreign matter. Any residual contamination shall be randomly dispersed and can consist of firmly adherent coatings, firmly adherent foreign matter and stains of previously existent rust.
Wa 2½	Very thorough high-pressure water jetting When viewed without magnification, the surface shall be free from all visible rust, oil, grease, dirt, previous paint coatings and, except for slight traces, all other foreign matter. Discoloration of the surface can be present where the original coating was not intact. The grey or brown/black discoloration observed on pitted and corroded steel cannot be removed by further water jetting.

Table 3 is the **proposed** language which is being balloted currently and will undergo editorial revision. The revised language has to be adopted by a consensus process of about 30 countries.

Table 3 — PROPOSED Descriptions of the surface appearance after cleaning

Wa 1	**Light water jetting** When viewed without magnification, the surface shall be free from visible oil, grease and dirt, loose or defective paint coatings, loose rust and other foreign matter. Any residual contamination shall be dispersed and can consist of firmly adherent coatings, firmly adherent foreign matter and firmly adherent rust.
Wa 2	**Thorough water jetting** When viewed without magnification, the surface shall be free from visible oil, grease and dirt, and most of the rust, previous paint coatings and other foreign matter. Any residual contamination shall be dispersed and can consist of firmly adherent coatings, firmly adherent other foreign matter and firmly adherent traces of rust.
Wa 2 ½	**Very thorough water jetting** When viewed without magnification, the surface shall be free from all visible rust, oil, grease and dirt. Slight traces of firmly adherent thin previous rust; slight traces of firmly adherent thin paint coatings and slight traces of other foreign matter can remain. Any residual contamination shall be dispersed. Discoloration of the surface can be present where the original coating was not intact.
Wa 3	**Water jetting to bare substrate** When viewed without magnification, the surface shall be free from all visible previous rust, oil, grease, dirt, previous paint coatings, and from all other foreign matter. The steel surface might, or might not, appear uniform. Discoloration of the surface can be present where the original coating was not intact.

NOTE 1 Acceptable variations in appearance that do not affect the degree of surface cleanliness defined in the above table include variations caused by composition of the metallic substrate, original surface condition, thickness of the metal, weld metal, mill or fabrication marks, heat treating, heat-affected zones, and differences resulting from the initial abrasive blast cleaning abrasives or the abrasive blast pattern if previously blast cleaned, or waterjet cleaning pattern.

NOTE 2 The grey or brown/black discoloration observed on pitted and corroded steel cannot be removed by further water jetting.

Mill scale is treated as foreign matter. Specks of mill scale under existing coatings will be revealed. Older structures might have intact mill scale under the coatings. Foreign matter and mill scale might be present on Wa 1, Wa 2, Wa 2 ½, but is removed for Wa 3.

What new photos are coming up in the ISO 8501-4 document? What change is occurring now? The ISO committees are adopting a new set of photos and changing the language so that the highest level of visual cleanliness can be included. Photos for level Wa 3 are included, and the new photos for Grade D and Inorganic Zinc are being adopted. As a project leader (PL), this author originally

was working with the Working Group (WG) convener at the Swedish Institute of Standards who had not seen or used WJ, but who had experience with abrasive cleaning. This is not an unusual occurrence, even though WJ had been around for over 30 years. It is challenging to educate someone over the internet.

The photographs had to be considered and selected. The original photographs of painted surfaces were part of a Hempel publication. [REF 7] Some of the series just needed to have the Wa 3 (SSPC-NACE WJ-1) photo added. The panels are depicted in a 1:1 scale.

Figure 1 Deteriorated multi-layer coating DCA to Very Thorough Cleaning ISO Wa 2 ½ SSPC-NACE WJ 2

Figure 2 Deteriorated multi-layer coating DCA to Bare Substrate Cleaning ISO Wa 3 SSPC-NACE WJ 1

Wa 2 ½ reveals specks of black mill scale (center of photograph) on the substrate which remained from the prior construction; the substrate is not visible initially, or at preparation grade Wa 1. DCA Wa 3 illustrates the removal of the specks of mill scale. The anchor pattern or profile under the mill scale specks is different from the anchor pattern or profile of the surrounding substrate; the difference can be observed.

Deteriorated Coating B is a heavy layer which came from the Hempel publication. [REF 7]

Figure 3 Deteriorated coating B to Very Thorough Cleaning ISO Wa 2 1/2 SSPC-NACE WJ 2

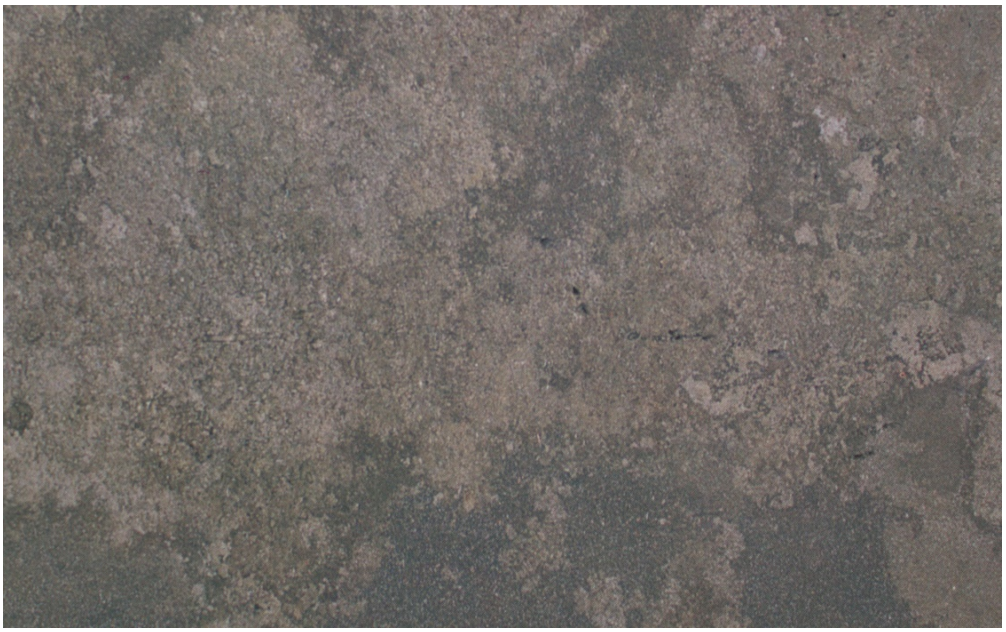

Figure 4 Deteriorated coating B to Bare Substrate Cleaning ISO Wa 3 SSPC-NACE WJ 1

Figure 3 still has remnants of old corrosion rust and paint on the substrate WA 2 ½ ; the remnants are removed in Figure 4 Wa 3.

The entire series for Condition Grade C steel was replaced. The original Grade C photos had come from Hempel, but the Hempel photo for Wa 2 ½ was a different plate from the Wa 1, Wa 2, and Wa 3 guidance photos. The Swedish convener selected a different photo set which is not depicted in this paper.

It is difficult to photograph, without magnification, the difference between a surface where almost all of the old original rust is removed, and the substrate profile or texture and color is different from the surrounding areas. The absence/presence can be seen in field conditions, particularly if the observer can scratch the substrate. The observer just can't help himself to think that the profile or texture should move to uniformity because that is what his field experience has taught him to expect from abrasive blast cleaning.

The entire series for Inorganic zinc was replaced.

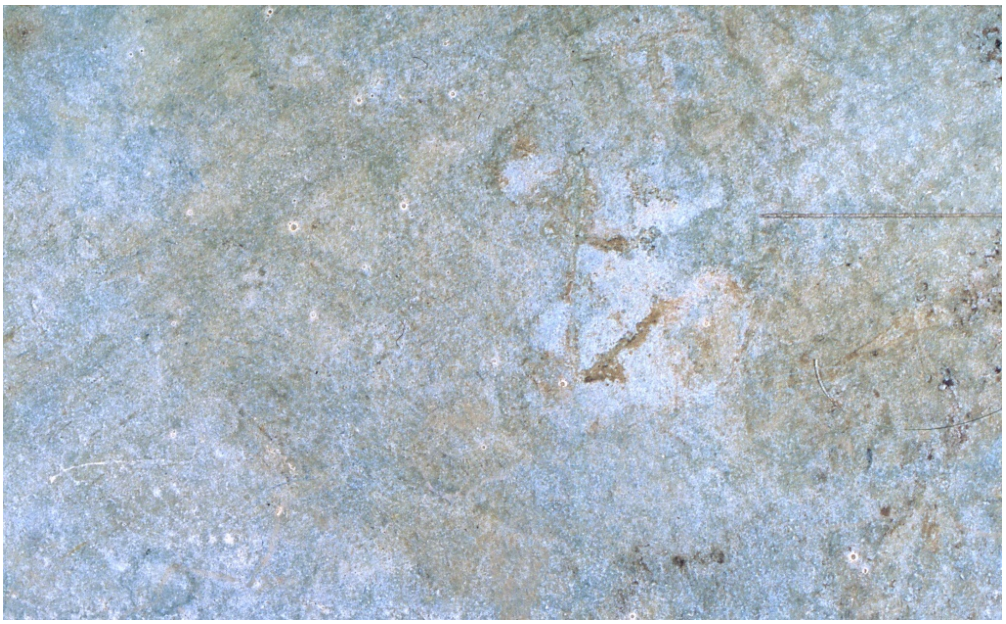

Figure 5 Original Inorganic Zinc

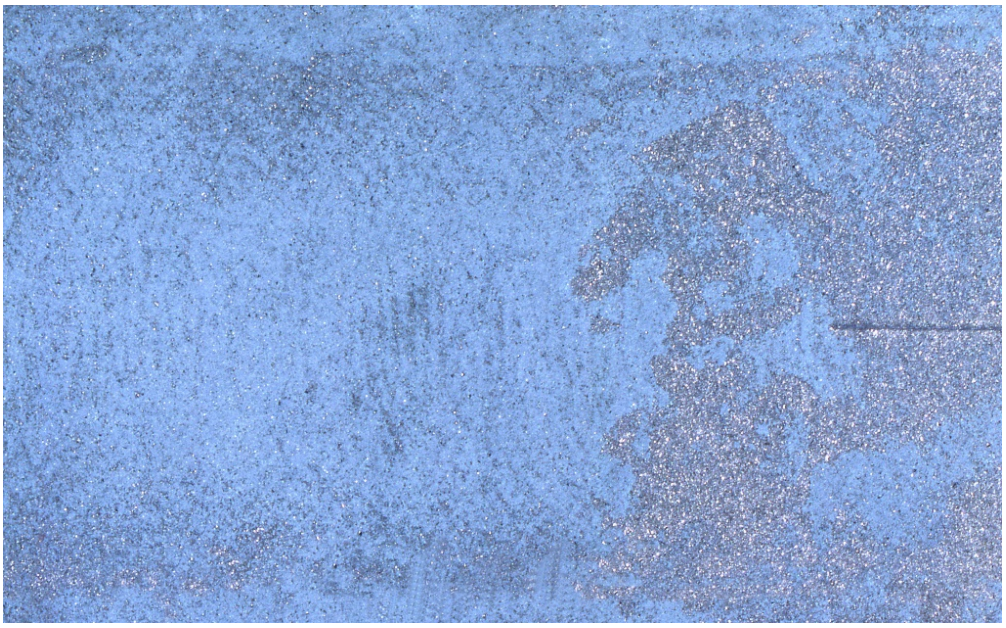

Figure 6 Light Inorganic Zinc cleaned to ISO Wa 1 or SSPC-NACE WJ 4

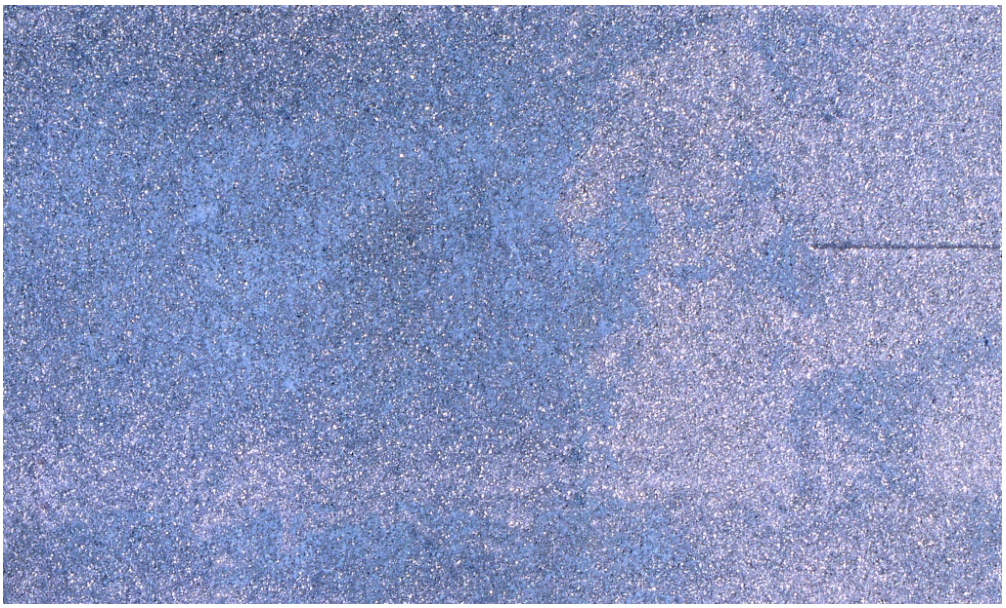

Figure 7 Thorough Inorganic Zinc cleaned to ISO Wa 2 or SSPC-NACE WJ 3

Here the coating is much thinner than in Figure 6. The lighter-grey blue is the coating; a darker substrate is being revealed.

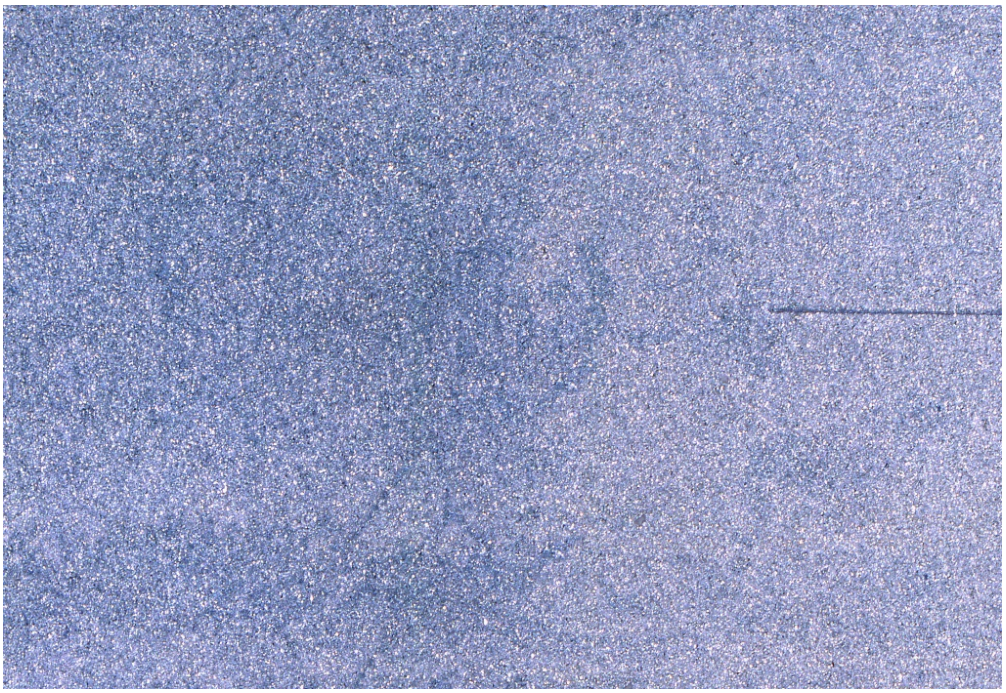

Figure 8 Very Thorough Inorganic Zinc cleaned to ISO Wa 2 1/2 or SSPC-NACE WJ 2

Here the light blue coating is in small specks over the substrate with the darker substrate apparent.

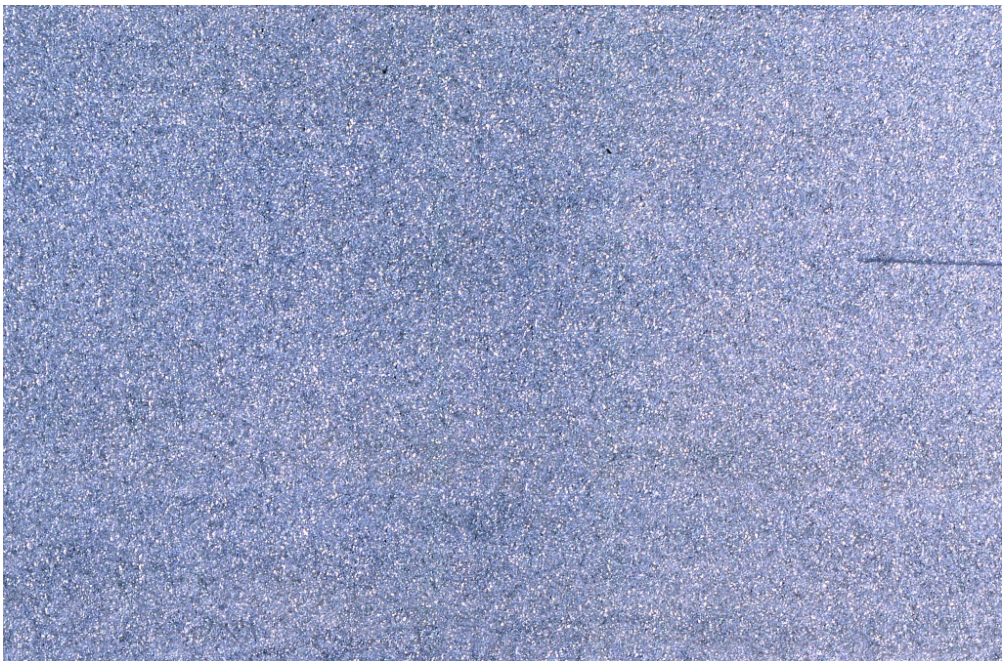

Figure 9 Bare Substrate Inorganic Zinc cleaned to ISO Wa 3 or SSPC-NACE WJ 1

The zinc coating is off, but the variation in the texture leads the observer to think that something is still on the surface.

It is very difficult to photograph gray on gray. The author has concluded the zinc becomes part of the substrate in the same manner as a phosphate coating becomes part of the substrate. Inorganic zinc is not a polymer coating. With UHP WJ there is no removal benefit from the sideways hydraulic thrust because there isn't a coherent layer. The WJ droplet has to hit every part of the substrate. There are "experts" who say that WJ can't remove zinc completely. However, not removing all of the zinc is true also for abrasive blasting.

With the presence of water, the appearance of flash rust can emphasize the spots where the zinc is not removed because the bare substrate turns slightly brown. Some experts apply a copper ion mist on the substrate which will turn color on steel, but not on zinc. Then they have to remove the copper coat. The experts don't seem to apply the same stringent control on abrasive blast cleaning. It is an unconscious effort to discredit WJ cleaning methodology as compared to abrasive cleaning methodology. For years, the author has looked for any failures where WJ was used to remove zinc with another coating being applied and found none.

The SSPC-NACE WJ standards have moved towards the same sections and language as the traditional abrasive blasting standards. This provides familiarity to the contractor, but also leads to misinterpretation. For example, the pre-cleaning to remove oil and grease is a separate step for dry abrasive blasting. When using UHP WJ, this step often is optional, as UHP WJ removes the oil and grease. HP WJ could or could not remove the oil and grease. Contractors must look and inspect the surface for water droplets as compared to a water sheet.

3. WET ABRASIVE BLAST CLEANING

The wet abrasive blast cleaning (WAB) has its own set of SSPC-NACE joint standards. [REF 8-12] The text sections and wordings are very similar to dry abrasive standards, but they cover both "flash rust" and "rust-back."

The Wet Abrasive Blast Cleaning methodology is part of ISO 8504-2. [REF 13]

Clause 5.2.2.1 **Principle** describes the method for Moisture-injection abrasive blast-cleaning (compressed-air moisture-injection abrasive blast- cleaning).

"This method is similar to compressed-air abrasive blast-cleaning (5.1.2) but with the addition, upstream of the nozzle, of a very small amount of liquid (usually clean, fresh water) to the air/abrasive stream, resulting in a blast- cleaning procedure which is dust-free in the suspended-particle size range of less than 50 μm. The consumption of water can be controlled and is usually 15 l/h to 25 l/h.

Clause 5.2.3.1 **Principle** describes the method for Compressed-air wet abrasive blast-cleaning.

"This method is similar to compressed-air abrasive blast-cleaning (5.1.2) but with the addition of liquid (generally clean, fresh water) downstream of the nozzle to produce a stream of air, water and abrasive."

Clause 5.2.4.1 **Principle** describes the method for Slurry blast-cleaning.

"A dispersion of fine abrasive in water or another liquid is directed, with pumps or compressed air, on to the surface to be cleaned."

There are no separate ISO photos nor definitions, just referral to the ISO 8501-1 photos which were made around 1967 with sand. [REF 14] This can lead to confusion in the field because the appearance of wet abrasive blast cleaned substrates is distinctly darker.

4. CONCLUSION

The wording and guidance photographs for the ISO and SSPC-NACE standard series constantly evolve and are merging together. The primary difference is that SSPC-NACE uses percentages to define what is removed from the substrate, while ISO uses language to generally describe traces of material.

ISO experts recognize that the inclusion of the highest level of cleanliness is achievable for WJ cleaning.

The newer photos give a clearer picture for achievable results, since guidance photographs are critical in the implementation of ISO standards.

Both SSPC-NACE and ISO implementation of WJ text are hindered by adopting language parallel to dry abrasive blast cleaning documents. The similarity of language leads the inspector or assessor to expect similar visual results, when the visual appearance is quite different.

The approach to obtaining consensus language for ISO involves the cooperation of around 30 countries, each with a distinct national interest. The approach to obtaining consensus language for SSPC-NACE standards ultimately involves around 100 individuals, each with a corporate interest.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

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

2 Joint Surface Preparation Standard Waterjet Cleaning of Metals—Clean to Bare Substrate (WJ-1)

3 Joint Surface Preparation Standard Waterjet Cleaning of Metals—Very Thorough Cleaning (WJ-2)

4 Joint Surface Preparation Standard Waterjet Cleaning of Metals—Thorough Cleaning (WJ-3

5 Joint Surface Preparation Standard Waterjet Cleaning of Metals—Light Cleaning (WJ-4)

6 Schiffbautechnische Gesellschaft e.V., STG Guide No. 2222, Definition of Preparation Grades for high-pressure water-jetting – without addition of solid abrasives, – of corroded and coated steel surfaces, – at different initial conditions ,1st Edition (1992), Hamburg. Can be purchased directly

7 Photo Reference Water Jetting, HMP STD WJ Photo 01 97, Hempel's Photo Reference for Steel Surfaces Cleaned by Water Jetting, issued by Hempel, Copenhagen, 150 Lundtoftevej, 2800 Lyngby, Denmark, January 1997 [this is out of print]

8 Joint SSPC Surface Preparation Standard/ NACE Standard Practice "SSPC-SP 5 (WAB)/NACE WAB-1 White Metal Wet Abrasive Blast Cleaning

9 Joint SSPC Surface Preparation Standard/ NACE Standard Practice "SSPC-SP 10 (WAB)/NACE WAB-2 Near-White Metal Wet Abrasive Blast Cleaning

10 Joint SSPC Surface Preparation Standard/ NACE Standard Practice "SSPC-SP 6 (WAB)/NACE WAB-3 Commercial Wet Abrasive Blast Cleaning

11 Joint SSPC Surface Preparation Standard/ NACE Standard Practice "SSPC-SP 7 (WAB)/NACE WAB-4 Brush-Off Wet Abrasive Blast Cleaning

12 Joint SSPC Surface Preparation Standard/ NACE Standard Practice "SSPC-SP 14 (WAB)/NACE WAB-8 Industrial Wet Abrasive Blast Cleaning

13 ISO DIS 8504-2 Preparation of Steel substrates before application of paints and related products – Surface preparation methods – Part 2: Abrasive blast- cleaning

14 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