

# A Comparison of ISO and NACE- SSPC Development of Surface Preparation Standards including Dry Blast and High Pressure Water Jet Cleaning Methods

Lydia M. Frenzel, Ph.D.  
Advisory Council  
San Marcos, TX U.S.A.  
Prepared for Pipelines Rehabilitation  
Berlin, Germany, October 2012

## **Abstract:**

Pipelines are prepared for coating following the surface preparation standards of NACE Int., SSPC, and ISO.

A comparison is made of the standard development process and the published language between the coatings surface preparation as issued by NACE International and SSPC for the United States country standards, and the ISO International Standards. Dry Abrasive Blast (ISO 8501-1; NACE No. 1/SSPC- SP-5, NACE No. 2/SSPC-SP 10, NACE No. 3/SSPC-SP 6, NACE No. 4/SSPC-SP 7) and WaterJet Cleaning standards (ISO 8501-4, NACE WJ-1/SSPC-SP WJ 1, “Waterjet Cleaning of Metals—Clean to Bare Substrate (WJ-1)”; NACE WJ-2/SSPC-SP WJ 2, “Waterjet Cleaning of Metals—Very Thorough Cleaning (WJ-2)”; NACE WJ-3/SSPC-SP WJ 3, “Waterjet Cleaning of Metals—Thorough Cleaning (WJ-3)”; and NACE WJ-4/SSPC-SP WJ 4, “Waterjet Cleaning of Metals—Light Cleaning (WJ-4).) are included. This comparison is significant as there are long standing differences between the documents that lead to contractual and interpretation disputes.

## **1. Introduction**

Why talk about standards and why do experts from around the world spend time on standards? The ‘STANDARD’ is our road map. It can be used in any place, on any site, in any instance, by all involved people. Without “STANDARDS,” no work contract could be executed.

In simple terms, “Standard Language” defines the end product found in the contractual documents.

The Owners know what they are accepting.

The Contractors know what they are supplying

The Coatings Manufacturers know what they are warranting.

The longevity of the pipeline depends upon the success of the coating system. If the coating system fails prematurely, then the pipeline will fail. Coating systems depend upon successful surface preparation. Surface preparation consists of three main components:

Visual cleanliness,

Profile, or anchor pattern, or roughness,  
And invisible contaminants such as salt, oil, grease, or chemicals.

On a global scale, ISO ( International Organization for Standardization, Geneva Switzerland) is the primary source for standards for many activities, not just paint and coatings. ISO membership is comprised of various national standard organizations.

ANSI. (American National Standards Institute, New York, USA) is the administrator and coordinator of the United States private sector voluntary standardization system. ANSI is the USA member to ISO.

Within the USA, various private sector organizations contract with ANSI to provide the expertise for specific projects. NACE Int. (National Association of Corrosion Engineers, Houston, Texas USA) has contracted with ANSI to provide the technical expertise for Coatings and Surface Preparation issues to ISO. ASTM (American Society for Testing and Materials, West Conshohocken, Pennsylvania, USA) develops and delivers international voluntary consensus standards in 135 countries. ASTM contracts with ANSI to provide technical expertise in testing methods to ISO.

NACE and SSPC (Society of Protective Coatings, Pittsburgh, Pennsylvania USA) cooperate and jointly develop standards for surface preparation for all types of metals and concrete. The standards in this paper have joint NACE and SSPC designations.

This paper focuses on the dry abrasive blast cleaning and the water jet cleaning standards of ISO and NACE. NACE has established CIP (Certified Inspector Programs) to provide inspectors trained and tested to NACE standards all over the world. The NACE CIP started 28 years ago and has provided over 19,000 certified inspectors globally. NACE CIP is the world's most recognized coating inspector certification program. Inspectors trained and certified to NACE or inspectors trained and certified to ISO standards will likely have different interpretations.

## **2. Standards Development**

Both ISO and NACE have a hierarchy for development, with checks and balances. Because NACE submits their comments through ANSI who then submits the comments to ISO, the USA, or country, standard process for development must conform to both ANSI and ISO requirements.

Typically the participating countries for coatings include: Sweden, Germany, United Kingdom (BSI), Netherlands (NEN), United States (NACE), Japan, France (AFNOR), Finland, Belgium, Portugal, South Africa, Korea, and Australia. There are certainly many more countries who might be involved, but discussions, in my experience, arise between Germany, Sweden, Norway, United Kingdom, Netherlands, Japan, Sweden, and the United States delegates.

At ISO,

- First a country must submit a new work item proposal (NWI) to the appropriate Technical Committee (TC 35).
- If it is accepted, and if a minimum of countries agree to participate, then a task group is formed. During this response, the country who proposed the work typically provides a chair and author to write the document.
- A committee draft (CD) is prepared by the author who is normally the chair of the Working Group (WG) under a specific Subcommittee (SC).
- The committee draft (CD) is circulated for comments.
- The chair-author of the Working Group (WG) resolves the comments.
- This cycle is repeated, until a Final Draft International Standard (FDIS) is issued for review and comment.

Each country has one vote. You can make comments, but once the FDIS is sent, the comments are set aside until the next review period.

Similarly, at NACE

- Someone proposes a new standard or guide.
- This new proposal is circulated to the Specific Technology (ST) group that will be the sponsor. If it is accepted, then a Task Group (TG) is formed, and a chair, who is generally the person who proposed the work and will be the author, is selected.
- The Task Group (TG) Chair produces a draft, and it is circulated for comments, typically not a “ballot.”
- The draft is also circulated to the Recommended Practices Committee Chair (RPC) who is responsible to see that the proper format is followed.
- The draft continues to evolve through comment and ballot cycles until all the comments are addressed, and, in the case of technical negatives, are resolved through written communication.

In the case of cooperative standards that are joint between NACE and SSPC, there is a joint task group consisting of senior members from both societies to resolve differences.

What is different between NACE and ISO? NACE has several opportunities for face-to-face meetings, extended email, and informal discussion to resolve differences. We reach consensus by dynamic discussion and resolved all technical negatives in writing.

ISO handles all communication by email/mail written documentation as they originate from country organizations. The face-to-face meetings are infrequent. The chair compiles the comments and sends out his resolution. By the time the country, ie NACE, gets the comments, the time to build consensus between the participating countries is over.

At ISO, the country experts that are submitting comments are remote or isolated from the chair of the task group, or author of the documents. At NACE, the chair/author is working continually to accept editorial modifications.

At ISO, once a level of review is reached, you cannot go back.

As an example, in reviewing the chair comments that are sent out after a ballot, we, the NACE Technical Advisory Group (TAG) often agree that BSI-United Kingdom saw something that we missed, but the chair/author has already ruled on their comment. If the chair/author doesn't agree with the comment, it isn't accepted. The interaction of the country delegates between one another to say "Do you see the same thing that someone else sees?" is missing.

As a recent example, the USA had voted negatively on a Committee Draft for profile measurement with specific technical comments and suggested language. At that level, the document couldn't proceed to a Final Draft International Standard (FDIS). About 6 months later, at a meeting in Europe, the USA head of delegation had an ad-hoc meeting with the author/chair. At that ad hoc meeting, the chair accepted the technical arguments, and was to amend the Draft to include the changes. The exact words proffered by the USA were not necessarily adopted at the ad hoc meeting so much as the chair agreed in principal to accept the argument. On the basis of this understanding, the USA withdrew its negative, and agreed to proceed to FDIS. The formal minutes of the Working Group meeting denote that the draft would move to FDIS.

However, when the FDIS came out for final ballot some months later, only part of the technical comments had been included in the new draft. In the ISO system, the chair does not typically offer the intermediate drafted document to the specific countries that had proffered comments. The rest of the countries have no way of knowing that the agreed changes were not included.

The USA reluctantly voted negative on the FDIS with the same comments that had been proffered earlier. Our items of concern remained in the Standard. The FDIS didn't change in wording, and it will be likely 5 years before it is reviewed again.

In the USA NACE system, a technical negative must be clearly resolved by the chair in writing. In addition, there are two other review and over-sight levels that can suggest changes. Any negative technical comments that are not resolved must accompany the ballot before final acceptance within the Society up to the Board of Governors or Standard Review Committee.

The process within ISO and NACE are similar, as for all the countries that participate in ISO procedures. The ISO consensus process is, in my opinion, more remote. I have observed very valid comments by my German, British, and Dutch colleagues apparently go unanswered.

### **3. Standard List**

ISO sets up a list of anticipated standards and numbers them sequentially. NACE, along with SSPC, has standards which are numbered as they were developed.

Technical Committee ISO/TC 35, is responsible for *Paints and varnishes*, The Subcommittee SC 12 is responsible for *Preparation of steel substrates before application of paints and related products*. SC12 has issued four documents. ISO 8501 consisting of

the following parts, under the general title *Preparation of steel substrates before application of paints and related products —Visual assessment of surface cleanliness*:

8501-1 Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings

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

8501-3 Part 3: Preparation grades of welds, cut edges and other areas with surface imperfections

8501-4 Part 4: Preparation grades of coated and uncoated steel substrates after removal of rust and previous coatings by high pressure water jetting

ISO TC 35/ SC12 has issued 13 documents under ISO 8502 Preparation of steel substrates before application of paints and related products —*Tests for the assessment of surface cleanliness*. These standards include field and laboratory tests, extraction, chloride, oil and grease, water-soluble salts, conductometric methods, the Bresle Method, and rigid conductivity meters.

ISO 8503 covers Surface roughness characteristics of blast-cleaned steel substrates; ISO 4628 covers Evaluation of degradation of paint coatings.

ISO 8501-1 originated as a series of photographs that includes scraping and wire-brushing, as well as abrasive blast cleaning.

The NACE Recommended Practices are:

Joint Surface Preparation Standard

- NACE No. 1/SSPC-SP 5 White Metal Blast Cleaning
- NACE No. 2/SSPC-SP 10 Near-White Metal Blast Cleaning
- NACE No. 3/SSPC-SP 6 Commercial Blast Cleaning
- NACE No. 4/SSPC-SP 7 Brush-Off Blast Cleaning
- NACE No. 8/SSPC-SP 14 Industrial Blast Cleaning

Traces of tightly adherent mill scale, rust, and coating residues are permitted to remain on 10 percent of each unit area of the surface in NACE No. 8.

SSPC-SP 2 Hand Tool Cleaning

SSPC-SP 3 Power Tool Cleaning

SSPC-SP 11 Power Tool Cleaning to Bare Metal

The above documents provide the written standards or Recommended Practices. The visual photographs are in SSPC VIS-1 Visual Standard for Abrasive Blast Cleaned Steel (Standard Reference Photographs) and SSPC- VIS 3 “Visual Standard for Power- and Hand-Tool Cleaned Steel (Standard Reference Photographs).

ISO 8501-4 is a combination of visual reference photographs originally produced by International Paint and Hempel Marine Coatings, and text that is similar to 8501-1.

The NACE Recommended Practices, published in 2012, are:

Joint Surface Preparation Standard

- Waterjet Cleaning of Metals—Clean to Bare Substrate (WJ-1)
- Waterjet Cleaning of Metals—Very Thorough Cleaning (WJ-2)
- Waterjet Cleaning of Metals—Thorough Cleaning (WJ-3)
- Waterjet Cleaning of Metals—Light Cleaning (WJ-4)

The Reference photographs are in NACE VIS 7/SSPC-VIS 4, Guide and Visual Reference Photographs for Steel Cleaned by Waterjetting

Visible Cleanliness Preparation Grades  
Analogous between NACE and ISO

Cleaning Grade (abrasive) NACE, SSPC	Cleaning Grade (water alone) ISO, NACE	NACE abrasive	NACE SSPC	SSPC abrasive	ISO Abrasive Water
White metal	Bare metal	1	WJ-1	SP-5	Sa 3
Near-White	Very Thorough	2	WJ-2	SP-10	Sa 2 ½ Wa 2 1/2
Commercial	Thorough	3	WJ-3	SP-6	Sa 2 Wa 2
Industrial	Thorough	8	WJ-3	SP-14	
Brush Off	Light	4	WJ-4	SP-7	Sa 1 Wa 1

### 3. Comparison of Blast Cleaning by Abrasive and Cleaning by Water Jetting

ISO originally published its standard for dry blast cleanliness in collaboration with the Standaardiseringskommissionen/Sverige (SIS, Stockholm Sweden) with “Pictorial Surface Preparation Standard for Painting Steel Surfaces” as a set of photographs, with very little text. The photograph is the primary standard.

This emphasis on photographs, along with the adoption of language that described dry abrasive blast cleaned surfaces, is continuing to lead to confusion between practices based on ISO 8501-1 or 8501-4 and the SSPC- NACE Versions. SSPC (Pittsburgh PA) and NACE International (Houston, TX) uses words as primary source. NACE and SSPC recognize that no set of pictures will illustrate all conditions.

Joint Surface Preparation Standard NACE NO. 5/SSPC-SP 12 “Surface Preparation and Cleaning of Steel and Other Hard Materials by High- and Ultrahigh-Pressure Water Jetting Prior to Recoating” is the standard document for the American continents and for NACE or SSPC Certified Inspectors who work globally. It was withdrawn in 2012 in favor of four separate documents because engineers were lax in specifying the specific preparation grade.

NACE NO. 5 was first published in 1995 and was revised in 2002. There has been a continual revision with a new revision published in 2012. These revision are primarily driven by our mistake in initially adopting language that was very similar language in the blast cleaning standards. Waterjet cleaned surfaces appear visually very different from blast cleaning surfaces.

For example, the 1995 language for WJ-2 was very similar to the blast cleaning language. The 1995 Language for WJ-2

WJ-2 The 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.

The 2012 Language for WJ-2

*Very Thorough Cleaning (WJ-2): A metal surface after Very Thorough Cleaning, when viewed without magnification, shall have a matte (dull, mottled) finish and shall be free of all visible oil, grease, dirt, rust, and other corrosion products except for randomly dispersed stains of rust and other corrosion products, tightly adherent thin coatings, and other tightly adherent foreign matter. The staining or tightly adherent matter shall be limited to no more than 5 percent of each unit area of surface and may consist of randomly dispersed stains of rust and other corrosion products or previously applied coating, tightly adherent thin coatings, and other tightly adherent foreign matter.*

The 2012 Language for WJ-1:

*Clean to Bare Substrate (WJ-1): A metal surface after Clean to Bare Substrate, when viewed without magnification, shall have a matte (dull, mottled) finish and shall be free of all visible oil, grease, dirt, rust and other corrosion products, previous coatings, mill scale, and foreign matter.*

The 2012 Language for WJ-3

*Thorough Cleaning (WJ-3): A metal surface after Thorough Cleaning, when viewed without magnification, shall have a matte (dull, mottled) finish and shall be free of all visible oil, grease, dirt, rust, and other corrosion products except for randomly dispersed stains of rust and other corrosion products, tightly adherent thin coatings, and other tightly adherent foreign matter. The staining or tightly adherent matter shall be limited to no more than 33 percent of each unit area of surface and may consist of randomly dispersed stains of rust and other corrosion products or previously applied coating, tightly adherent thin coatings, and other tightly adherent foreign matter.*

2012 Language for WJ-4

*Light Cleaning (WJ-4): A metal surface after Light Cleaning, when viewed without magnification, shall be free of all visible oil, grease, dirt, dust, loose mill scale, loose rust and other corrosion products, and loose coating. Any residual material shall be tightly adhered to the metal substrate and may consist of randomly dispersed stains of rust and other corrosion products or previously applied coating, tightly adherent thin coatings, and other tightly adherent foreign matter.*

What happened when the document was first published? In 1995, the persons using waterjet cleaning understood that coatings and foreign matter, and rust stains will remain on the surface. The persons who had not used waterjetting expected the surface to look like an abrasive blast cleaned surface with stains. After all, the language was nearly the

same. The 2012 language clarifies that materials will remain on the metal substrate which is in contract to abrasive blast cleaning.

Tightly adherent materials are permitted in NACE No. 4 Blast Cleaning. However, NACE No. 1, 2, 3, only allow random staining, light shadows, minor discoloration caused by stains of rust, stains of mill scale, or stains of previously applied coating. The surface should be **free** of all visible oil, grease, dust, dirt, mill scale, rust, coating, oxides, corrosion products, and other foreign matter

In their Water Jetting standard 8501-4, the ISO countries made the same mistake that the USA did for their language. The ISO adopted language close to the abrasive blast cleaning and did not adopt language that fit the available photos. As a consequence, the highest preparation grade was left out in the description table and in the photos, even though photos were available.

Except from ISO/ DIS 8501-4 (published in 2006)  
Description 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, grease, loose rust, and foreign matter. Any residual contamination shall be 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 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 2 ½	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 foreign matter. Discoloration of the surface may be present where the original coating was not intact. The gray, brown/black discoloration observed on pitted and corroded steel cannot be removed by further water jetting.

8501-4 Note: This [WaterJet] standard does not imply that the cleanliness is limited to Wa 2 ½ but achieving a greater degree of cleanliness may involved a disproportionate increase in time.

Commentary

When the waterjet documents were being drafted, these are verbal arguments that I heard for not including the photographs for “Clean to Bare Metal”:

- “The French don’t want to include some of the photos.” During the time I was involved, France didn’t send a delegate to the meetings, nor did they ever



comment that there were too many photos. On the contrary in 2007, after the WJ standard were published, a country expert from Denmark emailed to me a copy of a document from CEFRACOR, Center Français de l'antiCorrosion ([www.cefracor.org](http://www.cefracor.org)) dated 2005 to ask that 8501-4 be modified to "Add Wa 3 préparation grade." There were six main principals that the French wanted; the USA agreed with all of them. This document was not circulated to the ISO working group during the ISO discussion time. I do not know that the Working Group Chair was aware of this document. We, the USA, could have used this support.

- "There are too many photos."
- "There is not much difference between ISO 3 and ISO 2 ½ so we will not include the photos. We will ask and wait for new photos." Since these photographs were issued by companies for purposes of customer education, and not funded by ISO, it is very unlikely that new photos will be taken.
- "We don't clean to such a high degree in Europe. It will cost too much and take too much time, so we won't include the photo for highest degree of cleanliness." My response at the time was that "The amount of time and cost in abrasive blast cleaning to go from Sa 2 ½ to Sa 3 (NACE 2 to NACE 1) has never been a consideration for inclusion/exclusion in a surface preparation standard. Why is it an issue with waterjet cleaning?" This is a very false obstacle. The contractor, owner, and coatings manufacturer cooperate on the preparation grade in accordance with the expected performance and economics of the project.

ISO 8504-1 effectively sends the message that the waterjet cleaning is inferior, not different, to abrasive blast cleaning. I continue to receive calls from European inspection and arbitration firms who are trying to resolve "Standards" differences between contractors and owners.

#### **4. Reference Photographs**

### **Comparison of Dry Blast Cleaning and WaterJet Cleaning**

Make no mistake. Cleaning with abrasives (dry or wet) and cleaning with water alone are two different processes. Both are being used. They require difference descriptions.

Dry or Wet Abrasive	WaterJet
New and Repair	Repair
Makes new profile	Exposes profile under paint or corrosion
Erases from the Top	Shears at interface, lifts from bottom
Looks Uniform	Exposes all problems
Cleans top	Gets into crevices
Leaves crevices alone	Can leave detritus material at the top

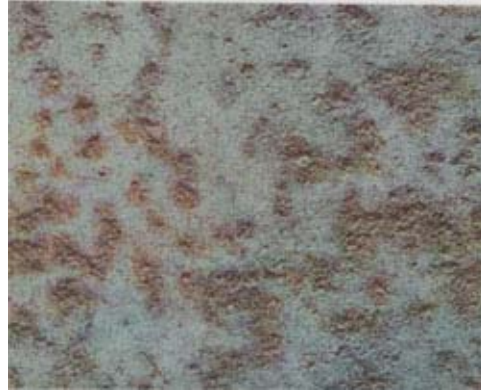
Examine the photographs for abrasive blast cleaning. Grade D –heavily pitted steel and compare the ISO standards and NACE reference photographs.

8501-1

ISO Grade D Blast Cleaning



**Figure 1 ISO D Sa 1**



**Figure 2 ISO D Sa 2**

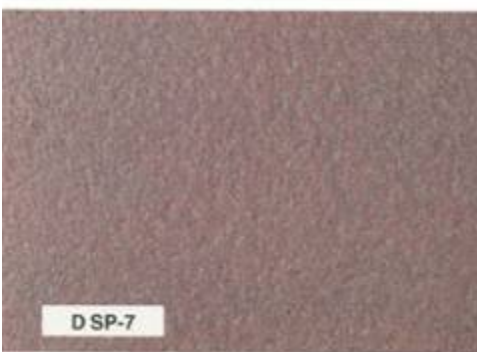


**Figure 3 ISO D Sa 2 1/2**

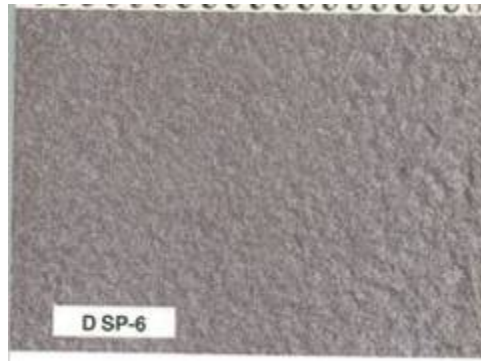


**Figure 4 ISO D Sa 3**

Compare the above to the analogous NACE (SSPC) Blast Clean Photos for Grade D



**Figure 5 NACE SP-7**



**Figure 6 NACE SP-6**



**Figure 7 NACE SP-10**

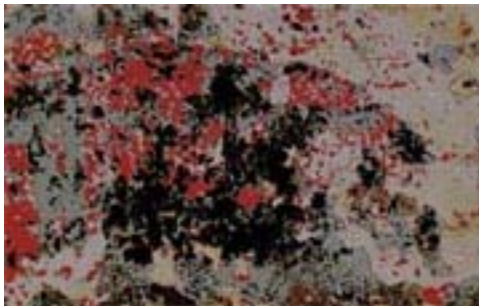


**Figure 8 NACE SP-5**

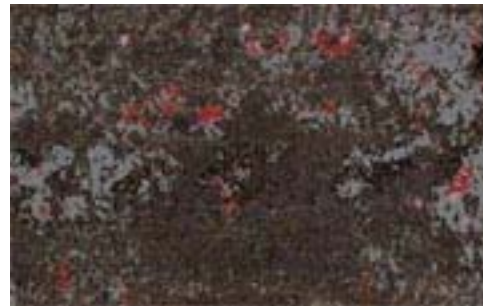
It is obvious that NACE does not allow the brown stains in the commercial and near-white blast cleaning while ISO allows brown stains in the thorough and very thorough blast cleaning. Inspectors trained on only one of the sets of photographs might well not accept the appearance of the other set of reference photographs.

Both ISO and the NACE/SSPC photographs have adopted photographs originally published by Hempel Skibsfarve-Fabrik A/S, Copenhagen, Denmark in accordance with the NACE-SSPC language. The Advisory Council has permission to reproduce Hempel photographs. Hempel requested that the scale be included on all photographs.

This old coating series was adopted by **both** ISO and NACE/SSPC for inclusion in their Standards.



**Figure 9 WJ 4 Wa 1**



**Figure 10 WJ 3 Wa 2**



**Figure 11 WJ 2 Wa 2 1/2**

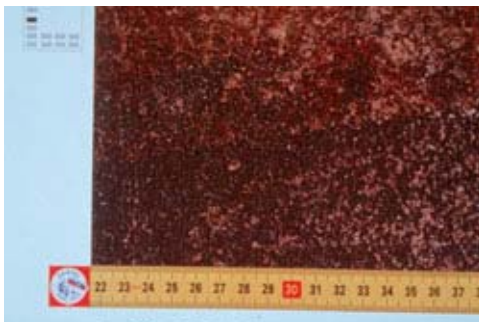


**Figure 12 WJ 1 (not in ISO series)**

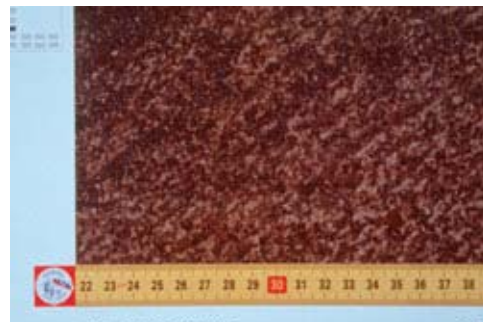
ISO did not include the WJ-1 which corresponds to ISO Wa 3. The WJ 2 revealed black mill scale present under the coatings. The difference between Figure 11 and 12 is the removal of the mill scale.

ISO also adopted only part of the Grade C photographs by Hempel. There can be a large visual difference as Grade C steel is cleaned by waterjet. Grade C steel that is produced artificially by blasting and then exposure in a condensation chamber will develop a striped appearance as the water streams down the plates. Grade C that is produced by blasting steel and leaving it out to weather yields a much more even pattern.

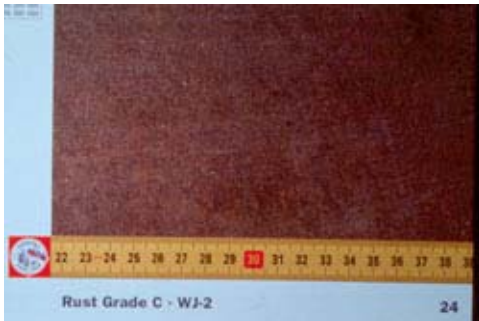
These stripes are NOT removed in the waterjet cleaning process.



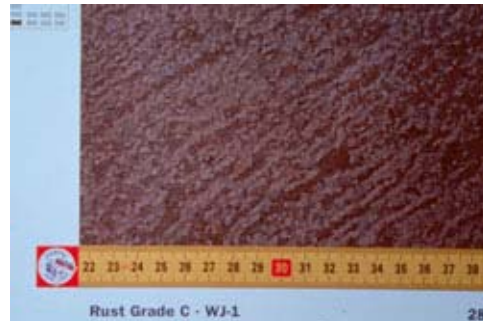
**Figure 13 Grade C WJ 4 Wa 1**



**Figure 14 WJ 3 Wa 2**



**Figure 15 WJ 2 Wa 2 ½**



**Figure 16 WJ 1 (not in ISO series)**

Hempel combined two different steel plates in this series. The Grade C example in WJ 2 or ISO Wa 2 ½ had been developed by two different methods. With the inclusion of WJ 1 (ISO Wa 3), it would be clear that the waterjet cleaning does NOT clean off the stripes. If a person uses only the ISO 8501-4, he might well think that the dark striations would be removed in the Water Jet cleaning process. This omission leads to erroneous conclusions.

## 5. Summary

1 NACE and ISO have come to surface preparation language and photographs from two different paths.

2. The inclusion of rust stains in ISO 8501-1, and the exclusion of rust stains by NACE standards could lead to contractual disagreements by inspectors and specifiers;
- 2 The adoption of language by ISO for the WaterJet Standard 8501-4 that imitates the abrasive blast cleaning of 8501-1, and the exclusion of photos that depicts ISO Wa3 surface preparation grade can, and does, lead to confrontations between contractors and owners and inspectors.
3. Examples are limited to Grade C and D, and to old multiple coats because pipeline rehabilitation will have areas of heavy corrosion where the coating has failed.
- 4 Both ISO and NACE standards are encountered globally in many sectors, including pipelines rehabilitation.
- 5 Caution is advised that your procurement (contract) document writers and your certified inspectors should be aware and familiar with both sets of documents.

### **Reference Organizations:**

International Organization for Standardization (ISO)  
1 ch. de la Voie-Creuse,  
Case postale 56  
CH-1211 Geneva 20, Switzerland

NACE Int.  
1660 S Creek Dr.  
Houston, TX 77084-2906 USA

The Society for Protective Coatings (SSPC)  
40 24<sup>th</sup> St, 6<sup>th</sup> Floor  
Pittsburgh, PA 15222-4656 USA

ASTM International (ASTM)  
100 Barr Harbor Dr.  
West Conshohocken, PA 19428-2959 USA

Hempel Skibsfarve-Fabrik A/S  
150 Lundtofevej,  
2800 Lyngby Denmark

# A Comparison of ISO and NACE- SSPC Development of Surface Preparation Standards including Dry Blast and High Pressure Water Jet Cleaning Methods

Lydia M. Frenzel, Ph.D.  
Advisory Council  
San Marcos, TX U.S.A.  
Prepared for Pipelines Rehabilitation  
Berlin, Germany, October 2012

## **Abstract:**

Pipelines are prepared for coating following the surface preparation standards of NACE Int., SSPC, and ISO.

A comparison is made of the standard development process and the published language between the coatings surface preparation as issued by NACE International and SSPC for the United States country standards, and the ISO International Standards. Dry Abrasive Blast (ISO 8501-1; NACE No. 1/SSPC- SP-5, NACE No. 2/SSPC-SP 10, NACE No. 3/SSPC-SP 6, NACE No. 4/SSPC-SP 7) and WaterJet Cleaning standards (ISO 8501-4, NACE WJ-1/SSPC-SP WJ 1, “Waterjet Cleaning of Metals—Clean to Bare Substrate (WJ-1)”; NACE WJ-2/SSPC-SP WJ 2, “Waterjet Cleaning of Metals—Very Thorough Cleaning (WJ-2)”; NACE WJ-3/SSPC-SP WJ 3, “Waterjet Cleaning of Metals—Thorough Cleaning (WJ-3)”; and NACE WJ-4/SSPC-SP WJ 4, “Waterjet Cleaning of Metals—Light Cleaning (WJ-4).) are included. This comparison is significant as there are long standing differences between the documents that lead to contractual and interpretation disputes.

## **1. Introduction**

Why talk about standards and why do experts from around the world spend time on standards? The ‘STANDARD’ is our road map. It can be used in any place, on any site, in any instance, by all involved people. Without “STANDARDS,” no work contract could be executed.

In simple terms, “Standard Language” defines the end product found in the contractual documents.

The Owners know what they are accepting.

The Contractors know what they are supplying

The Coatings Manufacturers know what they are warranting.

The longevity of the pipeline depends upon the success of the coating system. If the coating system fails prematurely, then the pipeline will fail. Coating systems depend upon successful surface preparation. Surface preparation consists of three main components:

Visual cleanliness,



# Comparison of ISO and NACE Surface Preparation Standards

Pipeline Rehabilitation Workshop

Berlin 2012

Lydia Frenzel, Ph.D.

[lydiafrenzel@advisorycouncil.org](mailto:lydiafrenzel@advisorycouncil.org)

Tel: +1 512-392-2210

## The Value of National and International Standards

- Without 3<sup>rd</sup> party Standards, contracts can't be issued.
- Standards are our ROAD MAP- any time, any place- any project
- **Owners** know what they are accepting
- **Contractors** know what they are supplying
- **Coatings Manufacturers** know what they are warranting



## Standards and Photos Copyright Holders

- International Organization for Standardization (ISO) Geneva Switzerland
- NACE Int. (NACE) Houston TX USA
- The Society for Protective Coatings (SSPC) Pittsburgh PA USA
- Hempel Skibsfarve-Fabrik A/S Lyndberg Denmark
- International Paint England

## ISO and NACE Standards are NOT IDENTICAL!

- Every country has organizations for policy, regulations, standards.
- Consensus- coming to agreement
- Companies have internal policies and standards
- The consensus process is Similar, but different. There is much more face-to-face discussion for resolution of differences.

## ISO TC 35 / SC 12 & SC 14

- ISO TC 35 (Paints and Varnishes)
  - SC 12(Preparation of Steel Substrates)
  - SC 14 (Protective Paint Systems)
- Polderdijk-NEN- Netherlands- TC 35 Sec.
- Harjung- BSI- UK SC 12 Sec.
- Diether-DIN- Germany- SC 14 Sec.

## USA Liaison with ISO is ANSI (American National Standards Institute)

NACE has contract with ANSI for  
specific Surface Preparation and  
Paint Responsibilities

- NACE Staff- Ed Barrett
- Head of Delegation is usually
  - Ken Tator- KTA Tator
- About 20 country experts
- ASTM- does test methods

## Are your Inspectors trained on ISO or NACE Photos and Definitions?

- ISO Standards- International Consensus
- NACE (SSPC) Standards – USA, and places where NACE Certified Inspectors are found.
  
- NACE- largest global certified inspector program-
- FROSIO- inspector certification
- Commercial Training Organizations

- ISO 8501-1 Visual for Blast Cleaning (1988)
  - Covers Steel cleaned by Abrasive (4 preparation grades) and
  - Manual Cleaning Scraping-wire-brushing (2 prep grades)
- ISO 8501-4 Waterjet Cleaning (2006)
  - Covers Steel cleaned by Waterjetting (3 preparation grades)
- NACE has separate Standard for Each Preparation Grade (4) (1995, rev 2012)
  - Separate Text and Photographs (2001)
    - 11 Separate Documents

## Dry Film Thickness Measurements

- Rob Francis, JPCL, Dec 2009, P. 22
- SSPC- PA 2
- Australia Standard AS 38943.3
- ISO 19840
- Int. Maritime Org. (IMO) MSC 215 (88) Performance Standards for Protective Coatings (PSPC) which uses the above standards

## Dry Film Thickness (cont)

- Protocols- Where to Take
- How Many
- Several Comparison Examples
- Ballast Tanks for New Build

### IMO PSPC

- 300,000 m<sup>2</sup>
- 1 gauge measurement/second



## Dry Film Thickness (Cont)

Measure Type	SSPC-PA 2	AS 3894.3	ISO 19840	PSPC
No. Spot	15,000	15,000	30,000	300,000
No. Measure	45,000	15,000	30,000	300,000

Time to measure 45,000 12 person-hours  
Time to measure 300,000 83 person-hours  
(450 pages of A4 Sheets of paper at 650 measurement per page.)

Assume 1 measurement/second

## Dry Film Thickness (end)

- Conclusions by Rob Francis
- Protocols are Significantly different from one another
- Range of requirements on sampling
- Range of Requirements on number of measurements

**BE AWARE of Details!**

- Abrasive Cleaning erases differences and moves towards **uniform** appearance.
- WaterJet Cleaning removes material and reveals/**retains** all the defects that are under the coatings.
- WaterJet typically **leaves** material on the surface.

## Nominal Hierarchy of Blast Cleanliness Standards for Visual Contaminants

SSPC	NACE	SSPC	ISO	
Abrasive Blast	Dry Blast		8501-1	
"White Metal"	No. 1	SSPC-SP-5	Sa 3	
"Near White"	No. 2	SSPC-SP-10	Sa 2 1/2	
"Commercial"	No. 3	SSPC-SP-6	Sa 2	
"Brush-Off"	No. 4	SSPC-SP-7	Sa 1	
WaterJet or HydroBlast			ISO 8501-4	SSPC NACE
Clean to Bare Substrate				WJ-1
Very Thorough Cleaning			Wa 2 1/2	WJ-2
Thorough Cleaning			Wa 2	WJ-3
Light Cleaning			Wa 1	WJ-4

## Analogous Standards – Visible Cleanliness

Cleaning Grade (abrasive) NACE, SSPC	Cleaning Grade (water alone) ISO, NACE	NACE abrasive	NACE SSPC	SSPC abrasive	ISO Abrasive	Water
White metal	Bare metal	1	WJ-1	SP-5	Sa 3	
Near-White	Very Thorough	2	WJ-2	SP-10	Sa 2 ½	Wa 2 1/2
Commercial	Thorough	3	WJ-3	SP-6	Sa 2	Wa 2
Industrial	Thorough	8	WJ-3	SP-14		
Brush Off	Light	4	WJ-4	SP-7	Sa 1	Wa 1

## How Did We Drift Apart?

- ISO Started as a Swedish Corrosion Institute Pictorial Standard with minimal description
- NACE (SSPC) started as a written description and then added standard reference photos.
- The first SSPC VISUAL was the Swedish Corrosion Institute Photos

## Agree? or Disagree? A Matter of Semantics

- **ISO** Mill scale, rust or a paint coating is considered to be **poorly adhering if it can be removed** by lifting with a blunt putty knife.
- **NACE** Mill scale, rust, and coating are considered **tightly adherent if they cannot be removed** by lifting with a dull putty knife after abrasive blast cleaning has been performed.

# Svensk Standard SIS (1967,1982)



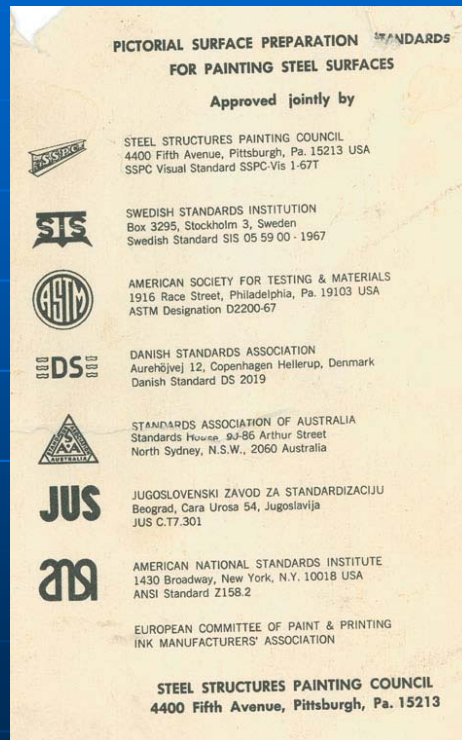
## Preparation grades. Blast cleaning

It is assumed that prior to treatment the steel surface has been cleaned of dirt and grease, and that the heavier layers of rust have been removed by chipping.

- Sa 1** Light blast cleaning. Loose mill scale, rust and foreign matter shall be removed. The appearance shall correspond to the prints designated Sa 1.
- Sa 2** Thorough blast cleaning. Almost all mill scale, rust and foreign matter shall be removed. Finally, the surface is cleaned with a vacuum cleaner, clean dry compressed air or a clean brush. It shall then be greyish in colour and correspond in appearance to the prints designated Sa 2.

- Sa 2<sup>1/2</sup>** Very thorough blast cleaning. Mill scale, rust and foreign matter shall be removed to the extent that the only traces remaining are slight stains in the form of spots or stripes. Finally, the surface is cleaned with a vacuum cleaner, clean dry compressed air or a clean brush. It shall then correspond in appearance to the prints designated Sa 2<sup>1/2</sup>.

- Sa 3** Blast cleaning to pure metal. Mill scale, rust and foreign matter shall be removed completely. Finally, the surface is cleaned with a vacuum cleaner, clean dry compressed air or a clean brush. It shall then have a uniform metallic colour and correspond in appearance to the prints designated Sa 3.





## Separate but Equal?

- ISO and NACE and SSPC were together in 1982 on Blast Cleaning.
- By 1988, ISO had adopted SIS.
- By 1989, NACE and SSPC had separate photos and text for Abrasive Blast Cleaning.
- Why- ISO allowed some **mill scale** to remain on **thorough** cleaning (2). US experts decided to have all mill scale removed.

## Sa 2 Thorough Blast Cleaning (1967 1982)

- **Almost all** mill scale, rust and foreign matter shall be removed. Finally, the surface is cleaned with a vacuum cleaner, clean dry compressed air or a clean brush. It shall then be greyish in colour and **correspond in appearance to the prints designated Sa 2.**

## Sa 2 1/2 Very Thorough Blast Cleaning (1967 1982)

- Mill scale, rust and foreign matter shall be removed to the extent that only traces remaining are slight stains in the form of spots or stripes. Finally, the surface is cleaned with a vacuum cleaner, clean dry compressed air or a clean brush. It shall then **correspond in appearance to the prints designated Sa 2 1/2.**

## Sa 3 Blast Cleaning to Pure Metal (1967 1982)

- Mill scale, rust and foreign matter shall be removed completely. Finally, the surface is cleaned with a vacuum cleaner, clean dry compressed air or a clean brush. It shall then have a **uniform metallic** colour and **correspond in appearance to the prints designated Sa 3.**

## ISO 8501-1 (1988) Blast Cleaning, Sa

- Surface preparation by blast –cleaning is designated by the letters “Sa”
- Prior to blast-cleaning, any heavy layers of rust shall be removed by chipping. Visible oil, grease and dirt shall also be removed.
- After blast-cleaning, the surface shall be cleaned from loose dust and debris.

## ISO 8501-1 (1988) Sa 2 Thorough Blast-cleaning

When viewed without magnification, the surface shall be free from visible oil, grease and dirt, and from **most of the mill scale**, rust, paint coatings and foreign matter. Any residual contamination shall be firmly adhering (see note 2 to 4.1) See photographs A Sa 2, B Sa 2, C Sa 2, and D Sa 2

## NACE 3 (SSPC SP 6) **Commercial Blast Cleaned Surface**

- A commercial blast cleaned surface, when viewed without magnification, shall be **free of all** visible oil, grease, dust, dirt, **mill scale**, rust, coating, oxides, corrosion products, and other foreign matter. Random **staining** shall be limited to no more than **33 percent** of each unit area of surface (approximately 5,800 mm<sup>2</sup> [9.0 in.<sup>2</sup>]) (i.e., a square 76 mm x 76 mm [3.0 in. x 3.0 in.]) and may consist of light shadows, slight streaks, or minor discolorations caused by stains of rust, **stains of mill scale**, or stains of previously applied coating.

## D Grade



ISO Sa 1 light cleaning



NACE 4/SSPC SP-7 brush off



ISO Sa 2 thorough



NACE 3/SSPC SP-6 Commercial



## D Grade



ISO Sa 2 1/2 Very Thorough



NACE 2/SSPC SP-10 Near-White



ISO Sa 3 pure metal



NACE 1/SSPC SP-5 White

# ISO Thorough –NACE 3 Commercial



ISO C Sa 2 thorough



C SP-6

NACE 3/SSPC SP-6 Commercial



ISO B Sa 2 Thorough

Looks  
Like  
Remains  
Of  
Mill  
Scale



B SP-6

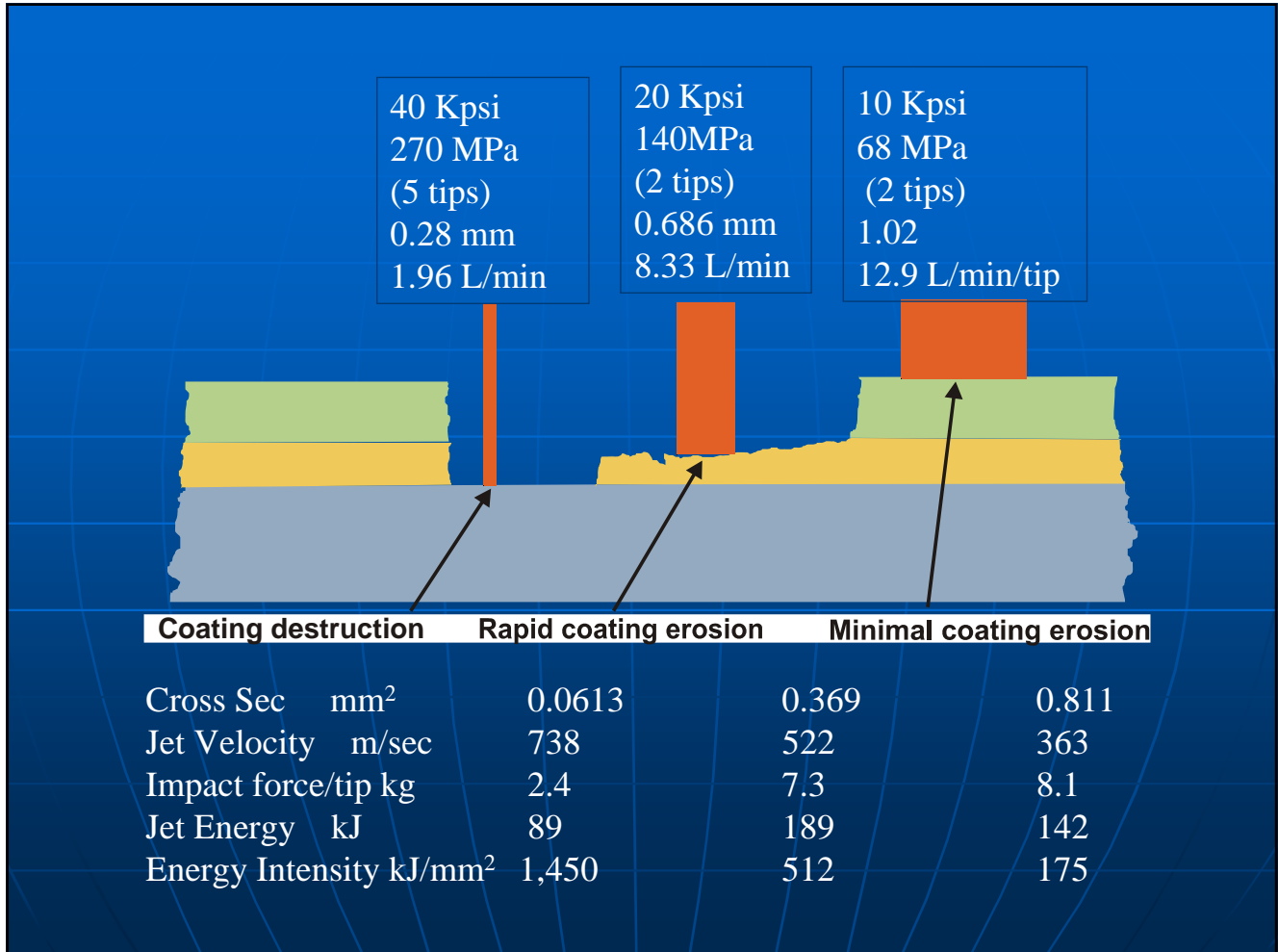
NACE 3/SSPC SP-6 Commercial

## 8501-4 WaterJet Cleaning NACE WJ -1, 2, 3, 4

- Language came first at NACE NO. 5- (SSPC SP-12) in 1994 (started committee in 1985)
- NACE Photos came later
  - 4 Preparation Grades
- 8501-4 is comprised of Photos from Hempel and International Paint (Flash Rust)
- Hempel photos were produced to conform to NACE WJ standards
- ISO Does NOT include **Clean to Bare Metal**
  - 3 Preparation Grades
- US Photos were available but not adopted by ISO
- US Photos are Original, Hempel, and International Paint.

## Terms for Waterjet or Water Jet

- Various common terms for methods of waterjet cleaning: water jetting, water blast cleaning, hydrojetting, aquajetting, hydroblasting, aquablasting, and “cleaning by directing a jet of pressurized water onto the surface to be cleaned.”



You must get the energy to the surface  
to disrupt the bond.



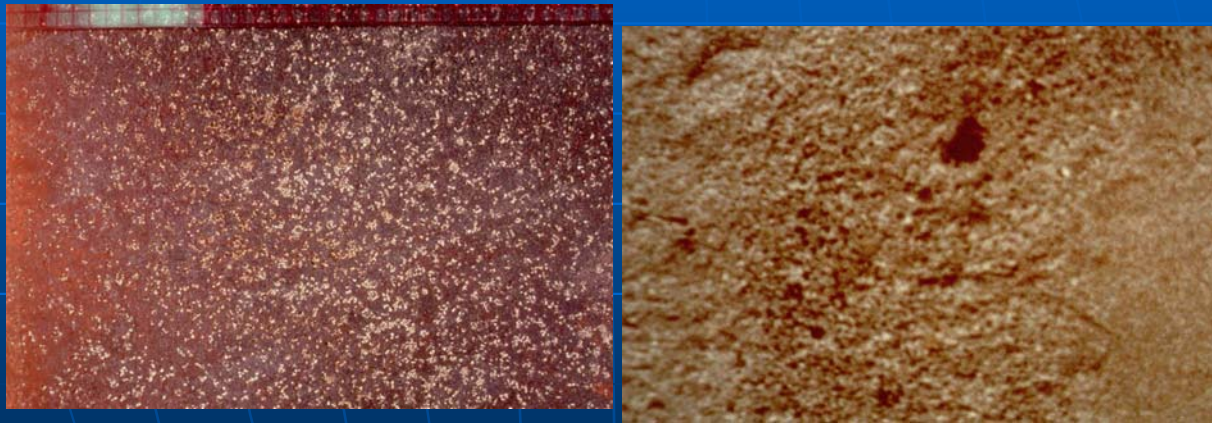
10,000 psi  
68 MPa  
690 Bar

**LONG DWELL  
TIME**

20,000 psi  
140 MPa  
1400 Bar



# 4.8 MPa (48 Bar, 7,000 psi) WaterJet Blast- Reverse of What You Expect from Abrasive Blast



## What Is Staining?

- **Stain or Staining:** (As related to abrasive blast and power tool cleaning methods.) An area of a surface which, when compared to adjacent areas, has an equal surface profile but is discolored (usually darker) with a material having no apparent volume. The material cannot be removed by methods commonly used to remove dust, but can be removed by more thorough abrasive blasting when abrasive blasting is used, or more thorough power tool cleaning when power tool cleaning is used.



## Appearance - NACE

- The gray to brown-black discoloration remaining on corroded and pitted carbon steel that cannot be removed by further waterjet cleaning is allowed. (ISO and NACE)
- Acceptable variations in appearance that do not affect the degree of surface cleanliness include variations caused by composition of the metal, original surface .., thickness, weld metal, mill or fabrication marks, heat treating, heat-affected zones, and differences resulting from the initial ... cleaning pattern if previously ... cleaned.
- Carbon steel surfaces cleaned by waterjet cleaning initially exhibit a matte finish with a color that can range from light gray to dark brown-black....
- ...areas from which coating was removed and areas that were coating-free at the time of cleaning varies even when all visible surface material has been removed.
- Metallic substrates show variations in texture, shade, color, tone, pitting, flaking, and mill scale...
- Direct correlation to existing dry abrasive blasting standards and visual comparators is inaccurate or inappropriate.

# Light Cleaning

## ■ ISO Wa 1 Light Cleaning

- When **viewed without magnification**, the surface shall be free from visible oil, grease, loose rust, and foreign matter.
- Any residual contamination shall be dispersed and firmly adherent.

## ■ NACE No. 4 Light Cleaning

- A metal surface after Light Cleaning, when viewed without magnification, shall be free of all visible oil, grease, dirt, dust, loose mill scale, loose rust and other corrosion products, and loose coating.
- Any residual material shall be tightly adhered to the metal substrate and may consist of randomly dispersed stains of rust and other corrosion products or previously applied coating, tightly adherent thin coatings, and other tightly adherent foreign matter.

# Thorough Cleaning

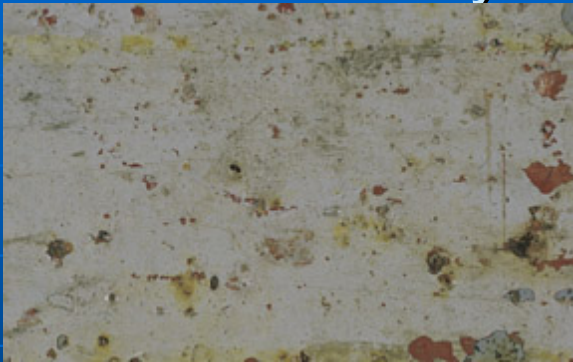
## ■ ISO Wa 2 Thorough Cleaning

- free from visible oil, grease and dirt **and most** of the rust, previous paint coatings and 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.

## ■ NACE No. 3 Thorough Cleaning

- ...shall have a matte (dull, mottled) finish and shall be free of all visible oil, grease, dirt, rust, and other corrosion products except for randomly dispersed stains of rust and other corrosion products, **tightly adherent thin coatings, and other tightly adherent foreign matter.**
- The **staining or tightly adherent matter** shall be limited to no more than **33 percent** of each unit area of surface and may consist of randomly dispersed stains of rust and other corrosion products or previously applied coating, tightly adherent thin coatings, and other tightly adherent foreign matter.

## Condition G (Deteriorated Multi-Coat) USED by ISO and NACE



WJ-4 (ISO-Wa 1)  
Light

WJ-3 (ISO-Wa 2)  
Thorough

Credit: Hempel

## Very Thorough Cleaning

- ISO Wa 2 ½ Very Thorough Cleaning
  - Surface shall be **free from all** visible rust, oil, grease, dirt, previous paint coatings and, **except for slight traces, all foreign** matter.
- NACE No. 2 Very Thorough Cleaning
  - Surface shall have a matte (dull, mottled) finish and shall be **free of all** visible oil, grease, dirt, rust, and other corrosion products except for randomly dispersed stains of rust and other corrosion products, tightly adherent thin coatings, and other tightly adherent foreign matter.
  - The **staining or tightly adherent** matter shall be limited to no more than **5 percent of each unit** area of surface and **may consist** of randomly dispersed stains of rust and other corrosion products or previously applied coating, **tightly adherent thin coatings**, and other tightly adherent foreign matter.

# Bare Metal

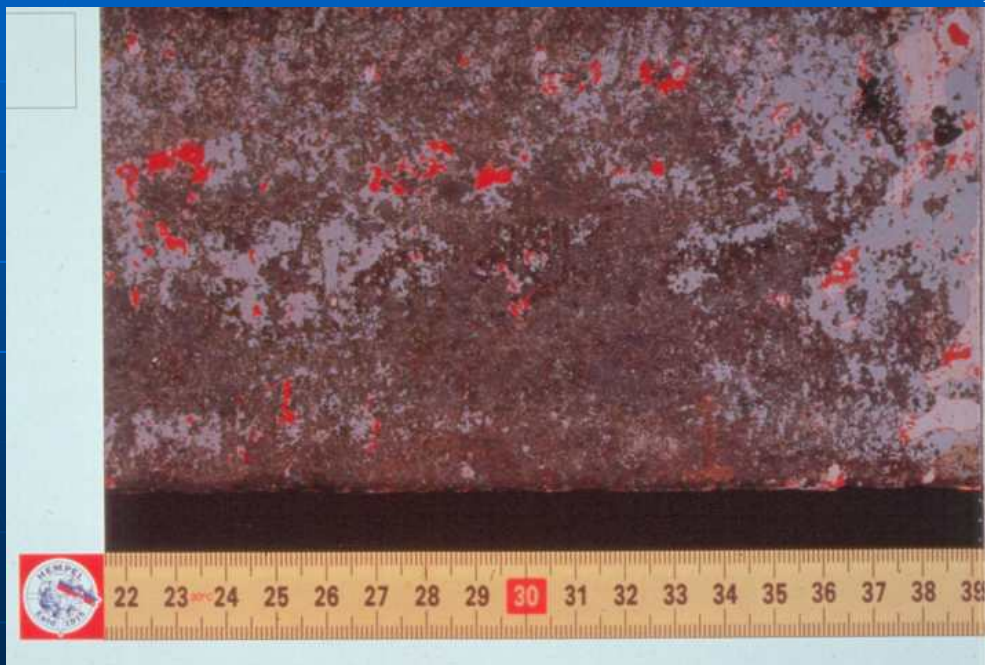
- **ISO Wa 3 Bare Metal**
  - Achieving a greater degree of cleanliness [greater than Wa 2 ½] may involve a disproportionate increase in time.
- **NACE No. 1 Bare Substrate**
  - Surface ... shall have a matte (dull, mottled) finish and shall be free of all visible oil, grease, dirt, rust and other corrosion products, previous coatings, mill scale, and foreign matter.
  - Thin films of mill scale, rust and other corrosion products, and coating are not allowed.





## Old Coating WJ 3 (ISO Wa 2) Thorough Cleaning

You can see  
The mill scale  
Under the Paint.

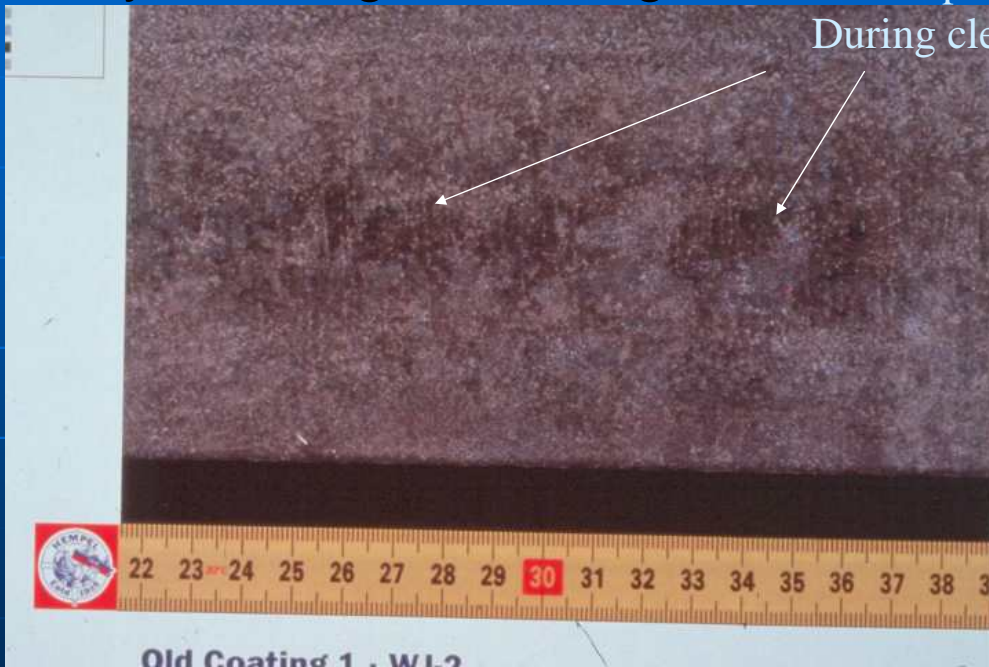


Credit: Hempel



## WJ 2 (ISO Wa 2 ½) Very Thorough Cleaning

The black is  
Mill scale that  
Was exposed  
During cleaning



Inspector must know that you CAN accept mill scale!

## Old Coating WJ 1 (ISO Wa 3) Bare Substrate

Now you  
Have the  
Discoloration  
But mill scale  
Is removed



Credit: Hempel

## Degraded Coating

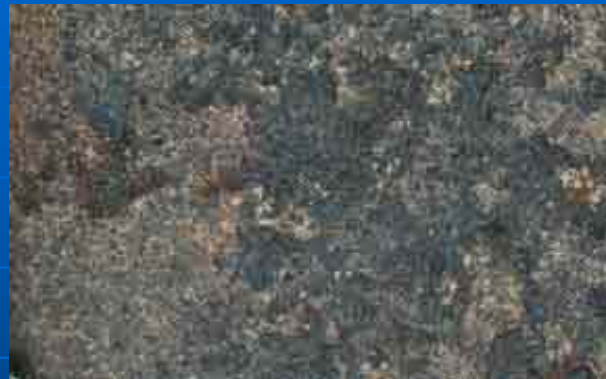


Alternate series that was Available but not selected (in favor of Hempel) but which also exposes underlying difference.

WJ-1, WJ-2, WJ-3



## Grade D Steel NACE photos



WJ-4 Light



WJ-3 Thorough

Photos credit: Frenzel.  
Selected by SSPC/NACE as  
Standard Photos.



D WJ-2 Thorough

D WJ-1 Bare



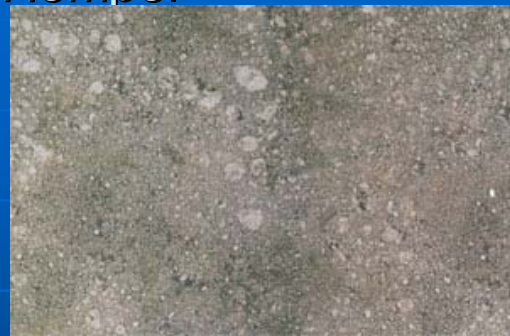
Optimized Removal  
Parameters

## Grade D Steel ISO Photos

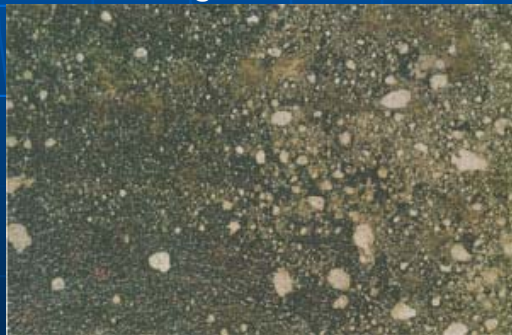
credit: Hempel



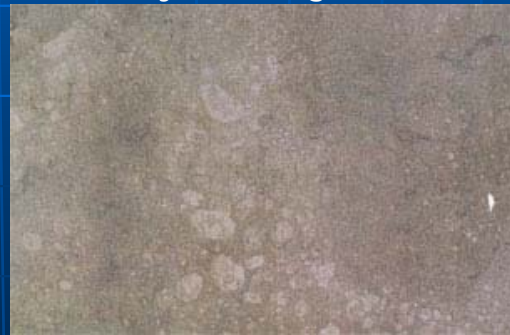
WJ4 Light ISO Wa 1



WJ2 Very Thorough ISO Wa 2 1/2






WJ3 Thorough ISO Wa 2



WJ 1 Bare Metal ISO Wa 3

### Grade C Steel- ISO Photos

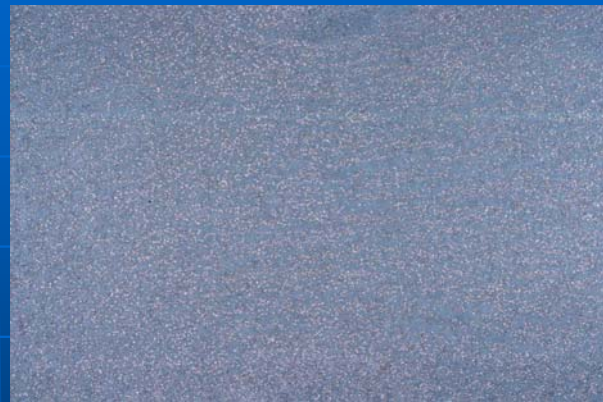
credit: Hempel

		ISO stops at this photo-leaving impression that streaks are removed
WJ-4 Light ISO Wa 1	WJ-2 Very Thorough ISO Wa 2 1/2	
		Streaks Remain
WJ-3 Thorough ISO Wa 2	WJ-1 Bare Metal ISO Wa 3	

## Alternate Grade C Credit: Frenzel



Initial



WJ-4 Light  
ISO Wa 1



## Alternate Grade C Credit: Frenzel



WJ-3 Thorough  
**ISO Wa 2**

WJ-2 Very  
Thorough  
**ISO Wa 2 ½**  
Light Flash

## Alternate Grade C Credit: Frenzel



WJ-2 Very  
Thorough  
ISO Wa 2 ½



WJ-1  
Bare Substrate  
ISO Wa 3

## NACE (SSPC) Grade C credit: Frenzel



C Initial



WJ-3 Thorough ISO Wa 2



WJ-4 Light ISO Wa 1



WJ-2 Very Thorough ISO Wa 2 1/2



## Grade C



WJ-2 Very Thorough ISO Wa 2 1/2



WJ-1 Bare Metal ISO Wa 3

Right side has actually been cleaned twice more than left side.  
Cannot take off more material or erase the heat mark or  
Dark corrosion product.

## The Photographs are **illustrations**.

- You cannot have photographs for all circumstances.
- At some point, the UHP WJ won't take off more material. It appears that for C, the WJ-2 (Wa 2 ½) and WJ-1 (Wa 3) are the same.
- Bare Metal is NOT Uniform. There can be much black discoloration.

## Summary

### How Do we Deal with This Difference?

- Take a close look at details.
- *Owner & Coating Manufacturers* agree in the *beginning* as the bid documents are written so *Contractor* knows what is included and expected.
- At the *beginning* of the project, owner, coating manufacturer, contractor, and *inspector* agree on the acceptable product.
- Be aware of experience/training of inspector.

- Clean to Bare Metal may not have a uniform appearance.
- Black discoloration is acceptable.
- The US will continue to insist that 4 preparation grades be included each time that ISO 8501-4 comes for review.

## The Process

- NACE/SSPC may have 12 on the committee, but ca. 200 people see and comment on each standard.
- The author/chair must notify and get concurrence on each comment and resolution.
- ISO The comments go to the chair, then the country task group sees what the chair decides.
- Miss the opportunity to discuss.