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# INSPECTION INSTRUMENTS FOR THE PIPELINE COATING INDUSTRY

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# PREFACE

**The first of three volumes, this eBook provides information on the proper use of test instruments and kits for verifying the quality of surface preparation of new pipe in the shop, field splices (girth weld areas), existing pipe in the field and structural steel in general, prior to the application of protective coatings. Verifying the quality of coating application both during and post-application will be the subject of Volumes 2 and 3, respectively.**

Successful corrosion prevention using protective coating systems is based in part on the quality of the surface preparation and the coating system installation. To verify quality, we rely heavily on data generated by coatings inspection instruments and on visual inspection of the prepared surfaces. We rely on this same information to determine contractual compliance with the project specification. This eBook was prepared with both the novice and the experienced coatings professional in mind. While it does not include every inspection instrument from every manufacturer, it does

contain a cross-section of common instruments and test kits, with references to industry standards throughout. Instrument use however is only part of the coatings inspection equation. It must be combined with thorough knowledge of the project specification and field practicality.

Formal training in coatings inspection techniques remains a critical component. This publication is not intended to replace formal training, but rather to supplement the learning process before, during and after training.



# **Volume 1: Verifying the Quality of Surface Preparation**

## **Introduction**

Common quality control checkpoints associated with surface preparation include:

- Verifying Grease/Oil Removal (SSPC-SP 1)
- Verifying Abrasive Cleanliness (SSPC/ASTM)\*
- Determining Compressed Air Cleanliness (ASTM D4285)
- Measuring Surface Profile (ASTM D4417/NACE SP0287/SSPC-PA 17)\*
- Verifying Surface Cleanliness (SSPC/NACE/ISO)\*
- Detecting Surface Soluble Salt Concentrations\*

\*The focus of Volume 1 is on the use of instruments, kits & visual guides associated with four of the six checkpoints.



# ABRASIVE CLEANLINESS

Abrasive cleanliness is an indirect or automatic requirement of the SSPC/NACE surface cleanliness standards for abrasive blast cleaning. Further, the SSPC Abrasive Standards (AB 1, AB 2, AB 3 and AB 4) all require the abrasive (whether new or reused) to be clean. There are two parameters associated with abrasive cleanliness; oil contamination and water-soluble contaminants that result in elevated conductivity.

## Verifying Abrasive Cleanliness- Oil.

ASTM D7393, "Standard Practice for Indicating Oil in Abrasives" describes a method for determining whether an abrasive is contaminated with oil. To perform this test, place about 1" of abrasive into a clean, clear glass or plastic container, then add clean tap water one inch above the abrasive level (Figure 1).



Figure 1

The water should be between 68° and 95°F. Cover and shake the abrasive/water sample vigorously for one minute, then remove the cover and allow the abrasive to settle for 5 minutes. Observe the surface of the water for an oil film or sheen. Discard the abrasive and document the results.

## Verifying Abrasive Cleanliness - Water Soluble Contaminants

The second parameter for assuring an abrasive is clean is described in ASTM D4940, "Standard Test Method for Conductimetric Analysis of Water Soluble Ionic Contamination of Blasting Abrasives." To perform this test, add 300mL (10 oz.) of distilled water (available from most grocery stores) to 300 mL (10 oz.) of abrasive. Stir the abrasive/water slurry for one minute, then allow the slurry to sit undisturbed for 8 minutes. Re-stir for an additional one minute (total extraction time of 10 minutes), then filter and discard 10 mL (0.3 oz.) of the extract solution through laboratory-grade filter paper (e.g., Whatman).



Figure 2

Filter the remaining extract and test the solution for conductivity using a temperature-compensating conductivity meter. Test the water used for the extraction for conductivity, and subtract this value (known as the "blank") from the conductivity value obtained from the abrasive extract. A kit containing all of the equipment and supplies for conducting 25 abrasive ionic contamination tests is shown in Figure 2. If the project specification references SSPC/NACE surface cleanliness standards for abrasive blast cleaning and/or the SSPC abrasive (AB) standards listed previously, the maximum allowable threshold of water-soluble contaminants is 1,000 microsiemen ( $\mu\text{S}$ ), which is 1 millisiemen (mS).

Annual calibration of the conductivity meter is critical to achieving confidence in the data that is generated on the abrasive, as is verification of accuracy of the meter prior to each use. Procedures for calibration and verification of accuracy are described next.

# CALIBRATION AND VERIFICATION OF ACCURACY OF THE CONDUCTIVITY METER

Calibration of the temperature-compensating conductivity meter (Figure 3) using standard solutions across the range of the meter for its intended use (in this case up to 1,000  $\mu\text{S}$ ) can be performed by an instrument supplier or an accredited calibration laboratory. Annual calibration is recommended. A Certificate of Calibration is typically provided listing the calibration checkpoints and tolerance relative to the standard solutions used, along with the manufacturer's stated accuracy of the meter.

Verification of accuracy should be performed by the inspector prior to each use (if multiple tests are performed daily, then verification once daily is adequate). A single standard solution (mid-range; e.g. 445  $\mu\text{S}$ ) is adequate. This standard solution is provided in the kit shown in Figure 2.



Figure 3

Place a small amount of the standard solution in the cap of the conductivity meter, then place the cap over the probes. The value displayed should match the standard solution value ( $\pm 5 \mu\text{S}$ , or 440-450  $\mu\text{S}$  for the 445 solution). Readings that fall outside of the acceptable range often indicate that the probe is defective and that the meter should be replaced.

# MEASUREMENT OF SURFACE PROFILE

The surface profile, anchor pattern, or roughness is defined as the maximum average peak to valley depth (or valley to peak height) created during surface preparation (Figure 4). The terms are most commonly associated with abrasive blast cleaning and are the result of the impact of the abrasive onto the substrate, although, some impact-type power tools can also produce a roughness in a steel surface. Surface profile is important because it increases the surface area to which the coatings can adhere, providing a mechanical anchor to enhance the adhesion of the coating. Generally, heavier coatings require a deeper surface profile than coatings of lesser thickness.

Surface profile determinations are commonly made in the field or shop using one of three instruments: a visual comparator, a depth micrometer, or replica tape. All three methods are described in ASTM D4417,

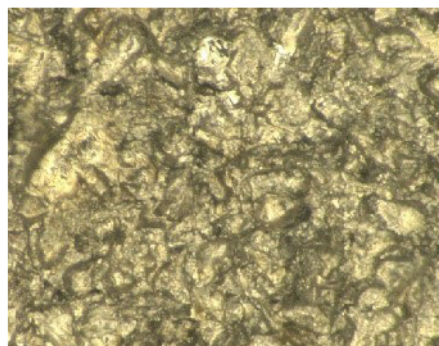


Figure 4

“Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel.” Equipment is also available for determining peak count per ASTM 7127, but this is not addressed in this Ebook. Recent advances in technology enable acquisition of peak density measurements directly from replica tape using a Replica Tape Reader. Traditional and novel methods of quantifying surface roughness characteristics are explored next.

Two of the more traditional methods for measuring surface profile depth include the use of a depth micrometer (Method B in ASTM D4417) and replica tape (Method C in ASTM D4417). Each is briefly described next.

## A Depth Micrometer (Figure 5)

consists of a 60° conical pin that projects from a flat base. First, zero the instrument on a float glass plate (included with the instrument) and verify accuracy using a specially-designed shim placed onto the glass plate (with a notch of a known depth, also included with the instrument) prior to each use. Next position the probe of the instrument on the cleaned substrate. The base automatically rests on the tops of the "peaks." Push downward (slightly) so that the 60° conical pin projects into the valleys of the profile. The depth of the profile, relative to the height of the peaks is displayed by the gage. Obtain a minimum of 10 readings in each location ((SSPC-PA 17, "Procedure for Determining Conformance to Steel Profile/Surface Roughness/Peak Count Requirements" states that a minimum of 3 - 6" x 6" locations should be measured for the area prepared during the work shift or 12-hour period, whichever is shorter), and report the maximum value after discarding any outliers, which are unusually high or low readings that cannot be repeated. That is 12-14 readings may be required to obtain 10 representative readings.



Figure 5

The standard also allows the average of the ten readings to be reported. The method of reporting the profile in each test area (highest repeated reading or average) should be agreed upon in advance. It is important to pick the instrument up and place it down for each reading, rather than drag it across the profile; otherwise, the point can become blunted, yielding erroneous readings.

*Note: According to ASTM D4417, SSPC-SP 15 (Commercial Grade Power Tool Cleaning) and SSPC-SP 11 (Power Tool Cleaning to Bare Metal), this method is the only suitable method for quantifying the surface profile depth generated by impact-type power tools.*





Newer models have a remote probe (Figure 6) for taking surface profile measurements in difficult access areas, like the underside of a pipe.

## Calibration

Calibration of a depth micrometer can be performed by the instrument manufacturer, authorized service dealer or an accredited calibration laboratory. Annual calibration is recommended. A Certificate of Calibration is provided listing the manufacturer's stated accuracy, the readings from the instrument and the associated deviation (if any). The calibration often includes a visual inspection of the probe for wear. Probe tips are replaceable. Based on the degree of variation from the manufacturer's stated accuracy, the calibration provider may recommend repair or replacement of the instrument.

## Replica Tape

is described in ASTM D4417, Method C and NACE SP02-87, Field Measurement of Surface Profile of Abrasive Blast-Cleaned Steel Surfaces Using a Replica Tape. The Testex Press O Film Replica



Figure 6

Tape consists of compressible foam attached to a uniform, 2 mil film of Mylar® (a non-compressible polyester film). The tape is available in three ranges: "Coarse" for profile measurements from 0.8 to 2.5 mils; "X Coarse" for measurements from 1.5 to 4.5 mils; and "X-Coarse Plus" for measurements from 4 to 5 mils. The X-Coarse Plus tape may be used to measure surface profile up to 6 mils or so, provided the tape is pre-measured to verify that an adequate thickness of compressible foam is available to measure the depth.

Remove the paper backing and attach the tape to the blast cleaned steel surface, foam side down. Using medium pressure, vigorously rub the Mylar with a burnishing tool (Figure 6). The peaks and valleys of the profile conform to the compressible foam and the peaks will ultimately touch, but not alter the thickness of the Mylar, as the Mylar is non-compressible. Remove the tape from the surface once the white Mylar is uniformly gray and measure the compressed foam and Mylar using a light spring loaded micrometer. This provides a reading from the upper or outermost surface of the Mylar to the high spots on the foam (corresponding with the valleys of the profile).

Subtract the thickness of the mylar (2 mils) from the gage dial to determine the maximum surface profile depth (e.g., 3 mils in Figure 8). The gage dial may also be preset to "8" (-2 mils) to auto-correct for the Mylar thickness. When doing this, the reading on the gage dial is the profile - no subtraction is necessary. Obtain a minimum of 2 readings in each location (SSPC-PA 17, "Procedure for Determining Conformance to Steel Profile/Surface Roughness/Peak Count Requirements")



Figures 7 (top) and 8 (bottom)

states that a minimum of 3 - 6" x 6" locations should be measured for the area prepared during the work shift or 12-hour period, whichever is shorter).

If the measurement (obtained with either the Coarse or X-coarse replica tape) is between 1.5 and 2.5 mils, obtain a second measurement with the other tape (that is, if the X-coarse replica tape was used to obtain the first measurement, use the Coarse tape for the second measurement).

If the second measurement is also between 1.5 and 2.5 mils, average the two measurements together. If the second reading is less than 1.5 mils or greater than 2.5 mils (but remains within the useable range of the replica tape), use that measurement and discard the first measurement. This is illustrated in Figure 9 below.

The replica tape will reportedly retain the impression indefinitely, provided it is stored in a cool area with no pressure applied. Conceivably, replicas of profile depths could be kept on file permanently for future reference.

A Testex linearizing micrometer specially designed to be used with Testex Press-o-Film Replica Tape effectively removes the need to preset the dial to 8 (-2) or deduct 2 mils from the gage reading, provided the gage indicator is set properly (as shown in Figure 10). Note however that the maximum surface profile depth that can be measured using this micrometer is 5 mils, so use of the X-Coarse Plus replica tape beyond 5 mils (as described previously) is not feasible with the linearizing micrometer.

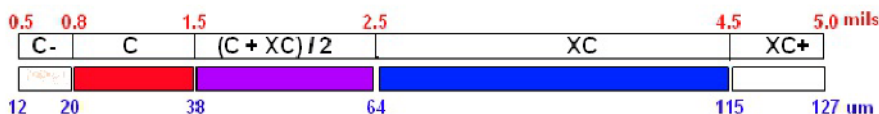


Figure 9



Figure 10



A Replica Tape Reader (RTR; Figure 11) can be used in lieu of the standard micrometer and the linearizing micrometer. Insert the burnished replica tape into the slot and press the gray button. The surface profile is displayed (in mils or microns). The Mylar thickness is automatically subtracted; therefore, no user correction is necessary. Additional information such as peak density (footnote 1) can be acquired from the same replica tape and Advanced Model Replica Tape Reader.



Figure 11

## Optical Grade Replica

**Tape** An Optical Grade Replica Tape (when used in conjunction with an Advanced Model Replica Tape Reader) can provide 3-dimensional images of peak density, or Pd (Figures 12a and 12b).

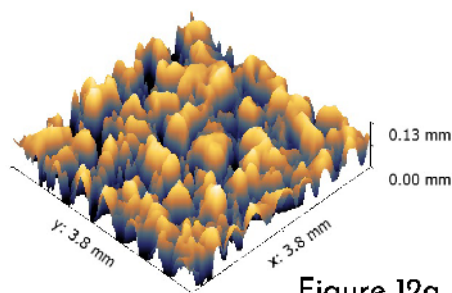


Figure 12a

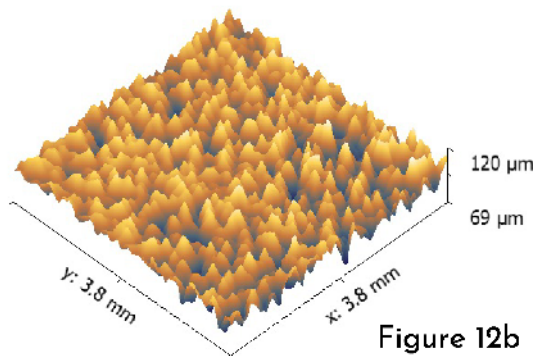


Figure 12b

*Footnote 1: Research indicates that increased peak density can improve coating system adhesion and provide greater resistance to corrosion undercutting when the coating is damaged in service*

It is important to realize that there is little correlation among the methods described herein because each encompasses a different peak count or surface area for its measurement. Therefore, it is advisable that all parties agree upon the method that will be used to determine the surface profile and not deviate from it. Oftentimes project specifications will dictate the method of surface profile measurement.

## Calibration

Calibration of the Testex micrometers and the Replica Tape Readers can be performed by the instrument manufacturer, authorized service dealer or an accredited calibration laboratory. Annual calibration is recommended. A Certificate of Calibration is provided listing the manufacturer's stated accuracy, the readings from the instrument and the associated deviation (if any). Based on the degree of variation from the manufacturer's stated accuracy, the calibration provider may recommend repair or replacement of the instrument. The Testex micrometers can be verified for accuracy in the shop or field using the same certified or

measured shims that are used to verify the accuracy of electronic dry film thickness gages (described in Volume 2 of this series).

## Frequency of Measurement

While ASTM D4417 prescribes the number of readings to take per area, it does not prescribe the number of areas to measure. SSPC-PA 17, "Procedure for Determining Conformance to Steel Profile/Surface Roughness/Peak Count Requirements" fills this gap. It states:

*"Unless otherwise specified, select a minimum of three 6 x 6 inch locations in which to take readings for each specific surface preparation apparatus used during each work shift or twelve-hour period, whichever is shorter. For the purpose of this standard, "apparatus" is defined as an individual blast pot (which may supply multiple nozzles), individual self-contained abrasive recycling/blast cleaning units (which may contain multiple pots), individual stationary or mobile centrifugal cleaning unit, or individual power tool."*

## ASSESSMENT OF SURFACE CLEANLINESS

All surfaces should be visually inspected after surface preparation to ensure compliance with the cleanliness requirements of the governing specification. The SSPC Surface Preparation Standards describe the appearance of various methods of surface preparation (e.g., hand and power tool cleaning, abrasive blast cleaning, etc.), including the type and percentage of residues or stains permitted to remain on the surface.

The written definitions for abrasive blast cleaned surfaces are supplemented by SSPC- VIS 1 Guide, which photographically depicts the surface appearance of various grades of blast cleaning over four initial mill scale and rust conditions of steel and three conditions of coated steel (Figure 13). The images in the Guide are visually compared with the prepared surface to determine the degree of cleanliness. SSPC has also produced a visual guide for hand- and power-tool cleaned surfaces (SSPC-VIS 3; shown in Figure 14). Other visual guides

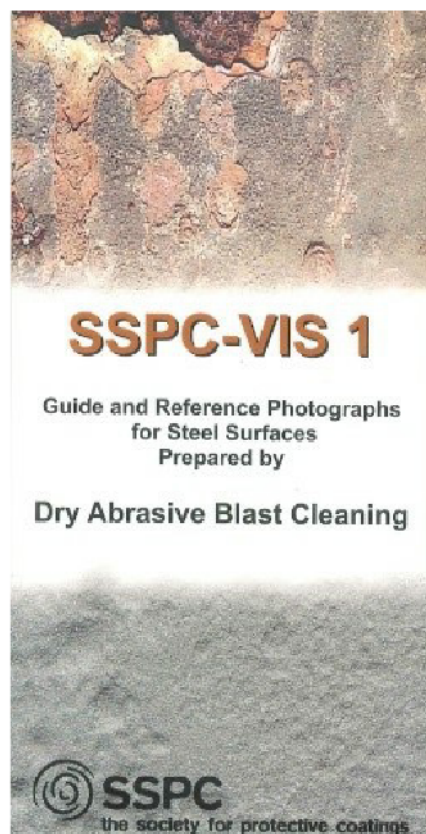


Figure 13 for surface cleanliness evaluation include the ISO Pictorial Standards (8502-1); however, these are only used when ISO surface cleanliness standards (e.g., Sa 1, Sa 2, Sa 2½ and Sa 3) are specified. Additionally, visual guides not discussed in this Ebook are SSPC VIS 4/NACE VIS 7, "Guide and Reference Photographs for Steel Surfaces Prepared by Waterjetting" and SSPC VIS 5/NACE VIS 9, "Guide and Reference Photographs for Steel Surfaces Prepared by Wet Abrasive Blast Cleaning"



# USING SSPC-VIS 1, GUIDE AND REFERENCE PHOTOGRAPHS FOR SURFACES PREPARED BY DRY ABRASIVE BLAST CLEANING

SSPC-VIS 1 is a collection of color reference photographs depicting various initial conditions and different levels of dry abrasive blast cleaning. To use the SSPC-VIS 1 visual guide, follow these four basic steps:

## ***Step 1: Determine the initial condition of the steel surfaces:***

Determine what the existing steel looks like before it is prepared by abrasive blast cleaning. This is called "rust grade" in the visual guide. To do this, locate the reference photographs in the visual guide illustrating the seven possible initial conditions of the steel. The SSPC-VIS 1 Guide illustrates seven Initial Conditions, including:

Condition A: Steel surface completely covered with adherent mill scale; little or no visible rust.

Condition B: Steel surface covered with both mill scale and rust.

Condition C: Steel surface completely covered with rust; little or no pitting visible.

Condition D: Steel surface completely covered with rust; pitting visible.

Condition G1: Weathered coating system over mill scale with extensive pinpoint rusting

Condition G2: Weathered coating system over mill scale with moderate pitting

Condition G3: Weathered coating system over mill scale with severe pitting

Select one or more of the "before" reference photographs that best illustrates the condition of the steel (the steel may be represented by more than one condition).

## ***Step 2: Determine the level of surface cleanliness the specification requires:***

After you select a reference photograph(s) that depicts the existing condition of the steel surfaces (the "before photograph"), reference the project specification to determine the degree of surface cleanliness required.



The degree of surface cleanliness will typically appear in the project specification as one of five possible “levels,” including SSPC-SP7, Brush-off Blast; SSPC-SP14, Industrial Blast; SSPC-SP6, Commercial Blast; SSPC-SP10, Near-White Metal Blast; or SSPC-SP5, White Metal Blast. At this point, you should have both a code for the initial condition (A, B, C, D, G1, G2 or G3) and a code for the surface cleanliness (SP7, SP14, SP6, SP10 or SP5).

### ***Step 3: Locate the reference photograph in the visual guide.***

The SSPC-VIS 1 visual guide illustrates various levels of surface cleanliness selected in Step 2 (after abrasive blast cleaning is completed) for each of the conditions in Step 1. We’ll call these “after photographs.” Table 1 provides the combinations of initial conditions (before photographs) and surface cleanliness levels (after photographs).

**Table 1: Combinations of Initial Conditions and Surface Cleanliness Levels in SSPC-VIS 1**

Initial Condition (rust grade)	White Metal (SP-5)	Near White (SP-10)	Commercial (SP-6)	Industrial (SP-14)	Brush-Off (SP-7)
A	A SP-5	A SP-10	No Photo	No Photo	No Photo
B	B SP-5	B SP-10	B SP-6	No Photo	B SP-7
C	C SP-5	C SP-10	C SP-6	No Photo	C SP-7
D	D SP-5	D SP-10	D SP-6	No Photo	D SP-7
G <sub>1</sub>	G <sub>1</sub> SP-5	G <sub>1</sub> SP-10	G <sub>1</sub> SP-6	G <sub>1</sub> SP-14	G <sub>1</sub> SP-7
G <sub>2</sub>	G <sub>2</sub> SP-5	G <sub>2</sub> SP-10	G <sub>2</sub> SP-6	G <sub>2</sub> SP-14	G <sub>2</sub> SP-7
G <sub>3</sub>	G <sub>3</sub> SP-5	G <sub>3</sub> SP-10	G <sub>3</sub> SP-6	G <sub>3</sub> SP-14	G <sub>3</sub> SP-7

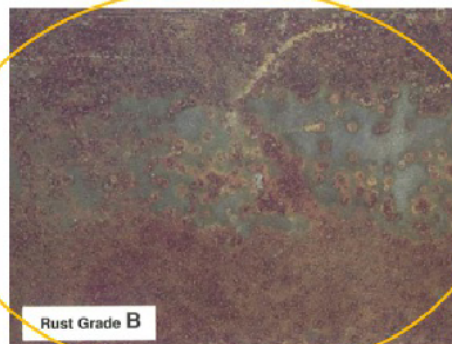
Select the reference photograph in the visual guide by combining the designation for the initial condition (from column 1 in Table 1) and the designation for the specified surface cleanliness level (from columns 2, 3, 4, 5, or 6 of Table 1).

### ***Step 4: Assess the prepared surfaces.***

Example 1: If the steel surface contains both mill scale and rust, select Condition B (image within yellow circle). Assuming the specification requires a Commercial Blast (SSPC-SP 6), select level SP6. Combine the two

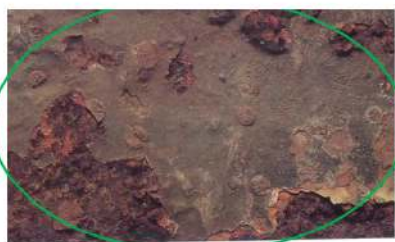


codes (B SP6). Locate the section of the SSPC-VIS 1 visual guide that contains the "before" photograph Rust Grade B and the "after" photographs of the four levels of surface cleanliness. Select the "after" photograph that contains the complete code (e.g. B SP6; red circle). Use this reference photograph to help assess whether the minimum surface cleanliness has been achieved (Step 4).



Example 1  
Images

Example 2: If the steel contains a weathered coating system over mill scale with severe pitting, select Initial Condition G3 (image within green circle). Assuming the specification requires a Near-white Blast (SSPC-SP 10), put the two codes together to arrive at the complete code (G3 SP10), and locate the section of the SSPC-VIS 1 visual guide that contains the "before" photograph Rust Grade G3 and the "after" photographs of the five levels of surface cleanliness. Select the "after" photograph that contains the complete code (e.g. G3 SP10; image within black circle). Use this reference photograph to help assess whether the minimum surface cleanliness has been achieved (Step 4).



G<sub>3</sub> Initial Condition



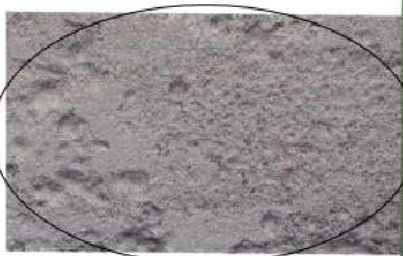
G<sub>3</sub> SP 7



G<sub>3</sub> SP 14



G<sub>3</sub> SP 6



G<sub>3</sub> SP 10



G<sub>3</sub> SP 5

# USING SSPC-VIS 3, GUIDE AND REFERENCE PHOTOGRAPHS FOR SURFACES PREPARED BY HAND AND POWER TOOL CLEANING

SSPC-VIS 3 is a collection of color reference photographs depicting seven initial conditions and three degrees of cleaning for each condition. To use the SSPC-VIS 3 visual guide follow these four steps.

## ***Step 1: Determine the initial condition of the steel surfaces:***

Determine what the existing steel looks like before it is prepared by hand- or power-tool cleaning. This is called "rust grade" in the visual guide. Locate the reference photographs in the visual guide illustrating the seven possible initial conditions of the steel. These "before photographs" depict the condition of the steel "before" it was hand- or power-tool cleaned. The SSPC-VIS 3 guide illustrates seven Initial Conditions, including:

Condition A: Steel surface completely covered with adherent mill scale; little or no visible rust (Rust Grade A).



## SSPC-VIS 3

Guide and Reference Photographs  
for Steel Surfaces  
Prepared by  
Power and Hand Tool Cleaning



Figure 14

Condition B: Steel surface covered with both mill scale and rust (Rust Grade B).  
Condition C: Steel surface completely covered with rust; little or no pitting visible (Rust Grade C).  
Condition D: Steel surface completely covered with rust; pitting visible (Rust Grade D).





Condition E: Previously painted steel surface; mostly intact, light-colored paint applied to a blast cleaned surface.

Condition F: Previously painted steel surface; mostly intact, zinc-rich paint applied to a blast cleaned surface.

Condition G: Paint system applied to mill scale bearing steel; system thoroughly weathered, blistered or stained.

Select one or more of the “before” reference photographs that best illustrates the condition of the steel (the steel may be represented by more than one condition).

***Step 2: Determine the level of surface cleanliness the specification requires:***

After you select a reference photograph(s) that depicts the existing condition of the steel surfaces (the “before photograph”), reference the project specification to determine the degree of surface cleanliness required. The degree of surface cleanliness will appear in the project specification as one of four possible “levels,” including

SSPC-SP2, Hand Tool Cleaning; SSPC-SP3, Power Tool Cleaning; SSPC-SP11, Power Tool Cleaning to Bare Metal; or SSPC-SP15, Commercial Grade Power Tool Cleaning. At this point, you should have both a designation for the initial condition (A, B, C, D, E, F or G) and a designation for the surface cleanliness (SP2, SP3, SP15, SP11).

***Step 3: Locate the reference photograph in the visual guide:***

The SSPC-VIS 3 visual guide illustrates various levels of surface cleanliness selected in Step 2 (after hand or power tool cleaning is completed) for each of the conditions in Step 1. We'll call these “after photographs.” Table 2 provides the combinations of initial conditions (before photographs) and surface cleanliness levels (after photographs).

**Table 2: Combinations of Initial Conditions and Surface Cleanliness Levels in SSPC-VIS 3**

Initial Condition (rust grade)	Hand Tool (SP-2)	Power Tool (SP-3)	Commercial Grade Power Tool (SP-15)	Power Tool to Bare Metal (SP-11)
A	A SP-2	A SP-3	No Photo	A SP-11
B	B SP-2	B SP-3	B SP-15	B SP-11
C	C SP-2	C SP-3	C SP-15	C SP-11
D	D SP-2	D SP-3	D SP-15	D SP-11
E	E SP-2	E SP-3	E SP-15	E SP-11
F	F SP-2	F SP-3	F SP-15	F SP-11
G	G SP-2	G SP-3	G SP-15	G SP-11

Select the reference photograph in the visual guide by combining the code for the initial condition (from column 1 in Table 2) and the code for the specified surface cleanliness level (from columns 2, 3, 4, or 5 of Table 2).

**Step 4: Assess the prepared surfaces.**

Use the reference photograph selected in Step 3 to determine whether the prepared surface(s) meet or exceed the specified level of surface cleanliness. Here are two examples:

Example 1:

The surface contains 100% rust with little or no visible pitting:

**Select Condition C**

The specification requires SSPC-SP 2 Hand Tool

Cleaning: **Select Image C SP2**

Example 2:

The surface contains a thoroughly weathered paint system:

**Select Condition G**

The specification requires SSPC-SP 15 Commercial

Grade Power Tool Cleaning: **Select Image G SP15**

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**Using 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 ISO 8501-1 Visual Guide (Figure 15) is similar in use to the SSPC VIS 1 and VIS 3 Guides previously described, however the images in the guide conform to the ISO surface cleanliness standards and not the SSPC surface cleanliness standards. Therefore, the images in the ISO 8501-1 guide should only be used when ISO surface cleanliness standards are specified.



Figure 15

**Four initial conditions are shown:**

**Condition A:**

Steel surface completely covered with adherent mill scale; little or no visible rust.

**Condition B:**

Steel surface covered with both mill scale and rust.

**Condition C:**

Steel surface completely covered with rust; little or no pitting visible.

**Condition D:**

Steel surface completely covered with rust; pitting visible.

**Two levels of hand and power tool cleaning are shown for each condition:**

St 2: Thorough Hand/Power Tool Cleaning

St 3: Very Thorough Hand/Power Tool Cleaning

**Four levels of dry abrasive blast cleaning are shown for each condition:**

Sa 1: Light Blast Cleaning

Sa 2: Thorough Blast Cleaning

Sa 2 ½ : Very Thorough Blast Cleaning

Sa 3: Blast Cleaning to Visually Clean Steel

Use the ISO 8501-1 guide to inspect prepared surfaces using these three steps:

Step 1: Select the image that closely represents the existing condition of the surfaces.

Step 2: Determine the specified degree of cleanliness for the project specification.

Step 3: Select the image in the ISO visual guide that references both the initial condition code and the surface cleanliness code.

Here are two examples:

Example 1:

Surface contains 100% adherent mill scale..... **Select Condition A**

Very thorough Blast Cleaning is specified (Sa 2 ½) ....

**Select Image A Sa 2 1/2**

Example 2:

Surface contains 100% rust..... **Select Condition C**

Thorough Hand/Power Cleaning is specified (St 2) ....

**Select Image C St 2**



## Assessing Surface Dust

After the specified level of surface cleanliness has been achieved and the surface profile depth has been measured and recorded, the prepared surfaces should be examined to assess whether they contain levels of dust that may interfere with coating adhesion.

Dust and debris remaining on the surface is frequently removed by brushing, compressed air blow down (or double blow down), or by vacuuming. If the compressed air is used, it must first be verified for cleanliness per ASTM D4285, "Standard Test Method for Indicating Oil or Water in Compressed Air" (not discussed in this Ebook). While a "white glove" test is not necessary nor recommended, if gloved fingers are traced across the surfaces and tracks are visually evident on the surface, it may be an indication that excessive dust remains that could interfere with coating adhesion and/or cause application defects. In order to establish an acceptable level of dust, specifications may require testing according to ISO 8502-3: Preparation of Steel Substrates Before Application of Paints and Related Products - Tests for the Assessment of Surface Cleanliness, Part 3: Assessment of Dust on Steel Surfaces Prepared for Painting (pressure-sensitive tape method).

To perform this test, a special type of clear, pressure sensitive 1-inch wide adhesive tape, a special spring-tensioned roller, a 10X illuminated magnifier and a white backing (e.g., bright white cardboard or paper) are needed. The spring-tensioned roller is not required by the standard unless the testing procedure or results are being disputed. The roller can be replaced by thumb pressure applied to the tape, as described below.

**Step 1:** Discard three full turns of tape from the roll.

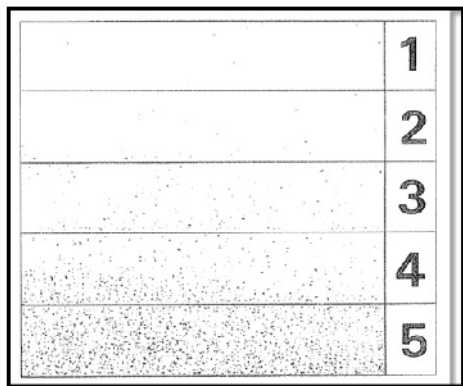
**Step 2:** Remove a test piece of tape approximately 8-inches long, being certain to only touch the two ends (1-inch at each end). Attach (press) approximately 6-inches of the tape (excluding the two - 1-inch ends) to the surface.

**Step 3:** Press the tape to the surface by placing your thumb at one end of the tape, then move your thumb along the tape length (at a constant speed and pressure) three times in each direction (each stroke should take between 5 and 6 seconds to complete). Leave the two 1-inch ends of the tape off the surface. Only the middle 6-inches of the tape should be attached.

## Surface Soluble Salt Detection

**Step 4:** Remove (peel) the tape from the surface at a 180° angle (to the surface). Attach the peeled tape to a white backing.

**Step 5:** Rate the quantity of dust attached to the tape using the Dust Quantity Ratings figure provided in the standard (Figure 16) and compare the results to the specification requirements for the maximum dust rating. The standard requires one test for every 200 square feet of prepared surface that is ready to be coated.



	1
	2
	3
	4
	5

Figure 16

Chemical contaminants on a surface can include chloride, ferrous ions, sulfates and nitrates, among others. Chemicals can be deposited onto surfaces while the structure is in service, during transportation of new pipe/steel to the painting shop, during transportation from the painting shop to the field, or in the field lay down yard. These chemicals are soluble in water, so they can typically be removed from surfaces by pressure washing. The effectiveness of the washing step is dependent on the condition of the surface. That is, contamination is relatively easy to remove from smooth surfaces, but may be more challenging if the surfaces are pitted or are configured with difficult-access areas, as contamination will tend to concentrate in these areas. If the salts are not detected or are not adequately dissolved and rinsed from the surfaces, they can become trapped beneath a newly-installed coating system. If there is a sufficient quantity of water in the service environment, the water-soluble contaminant trapped beneath the coating system can draw the water through the coating film by a process known as "osmosis."

This drawing force will continue until the concentration of salt in water is the same on both sides of the coating film (the concentration reaches equilibrium).

This process creates a build-up of water and pressure beneath the coating film, oftentimes enough to cause blistering of the coating (known as osmotic blistering), underfilm corrosion and premature coating failure.

Additionally, if soluble salts on the surface are not sufficiently removed prior to abrasive blast cleaning, recycled abrasive media can become contaminated.

It is for these reasons that many specifications are now requiring testing of surfaces for chemical contaminants after surface preparation is complete, but before application of the coating. Because this type of contamination cannot be detected visually, the surface must be sampled and the "surface extraction" tested for the contaminant(s) of concern. There are several methods of extraction and analysis to choose from.

SSPC Guide 15, "Field Methods for Retrieval and Analysis of Soluble Salts on Steel and Other Nonporous Surfaces" describes common methods for sampling and analysis of soluble salt contamination. The specification will typically identify whether testing for soluble salts is required, and the sampling/testing method(s) acceptable for the project.

This eBook highlights two procedures, including a non-ion-specific method (conductivity) and an ion-specific method for chloride, sulfate and nitrate contamination. Specific step-by-step instructions are too lengthy to provide in this eBook, but the ISO standard and/or the manufacturer's instructions are relatively easy to follow.



# Non-ion Specific Analysis (Latex Patch/Conductivity per ISO 8502-6/8502-9)

For this procedure, attach a latex patch (Bresle Patch, Figure 17; DeFelsko Patch or PosiPatch, Figure 18) to the surface. The Bresle Patch and Defelsko Patch contain compressible foam with adhesive backing to create the seal. The PosiPatch is attached magnetically. Inject the prescribed amount of distilled water into the patch (Figure 19a/19b) and agitate the water inside the patch. Once the extraction is complete, remove the solution from the patch and place it onto a conductivity bridge (Figure 20) or Soluble Salts Tester (SST, Figure 21). Both methods are suitable for the analysis of all of the extracts. Conductivity results are displayed in microsiemens/cm ( $\mu\text{S}/\text{cm}$ ) or millisiemen ( $\text{mS}/\text{cm}$ ); the SST instrument can also display surface concentrations in  $\mu\text{g}/\text{cm}^2$  or  $\text{mg}/\text{m}^2$ . Either can be compared to the maximum allowable contamination referenced in the project specification.

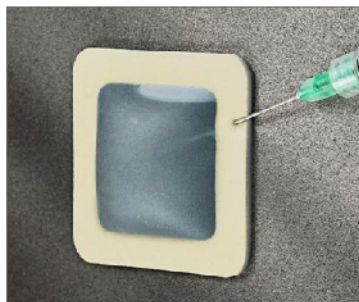


Figure 17



Figure 18

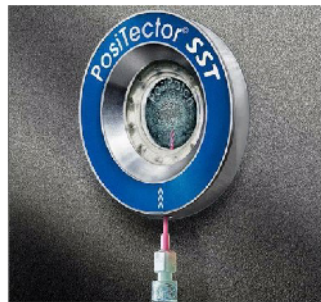


Figure 19a



Figure 19b



Figure 20



Figure 21

This test will not reveal the type of surface contamination; only that some type of water soluble ionic contamination was extracted from the surface, causing an increase in the conductivity of the distilled water used for the extraction.

## Ion-specific Analysis - Chloride-Sulfate-Nitrate (CSN) Test Kit

If ion-specific testing for chloride, sulfate and nitrate surface contamination is required, then a special kit is used to perform both the extraction and analysis. The CSN kit contains latex sleeves, pre-measured extraction liquid, chloride ion detection tubes (Kitagawa), nitrate test strips, and pre-measured chemicals and a meter for sulfate analysis.

A premeasured amount of extraction solution is emptied into the latex sleeve (Figure 22) and the sleeve is attached to the prepared, uncoated surface (Figure 23). An extraction is performed (Figure 24), the latex sleeve removed and the solution analyzed for chloride (Figure 25), nitrate (Figure 26) and/or sulfate (Figure 27). For this method, the reading from the tube, strip and meter (in PPM) is the same as  $\mu\text{g}/\text{cm}^2$ . This only works because the opening of the latex sleeve is  $10\text{ cm}^2$  and the premeasured amount of solution is  $10\text{ mL}$ , so the values cancel one another out.



Figure 22



Figure 23

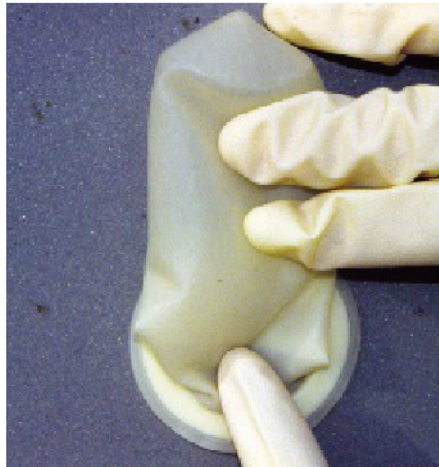


Figure 24

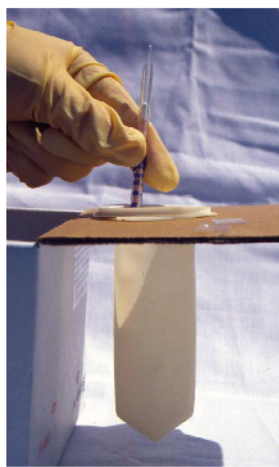


Figure 25

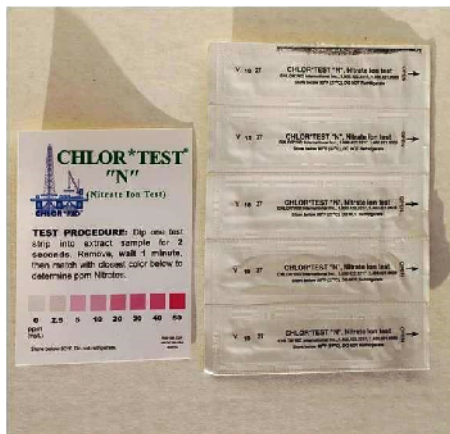


Figure 26



Figure 27

Note that if a determination of chloride contamination alone is required, the extractions obtained using distilled water described above (for the non-ion specific analysis) can be analyzed using a chloride ion detection tube (Kitagawa) or chloride ion detection strip (e.g., Quantab). Because the surface area extracted is known, the ppm chloride values obtained using the strip or tube can be converted to  $\mu\text{g}/\text{cm}^2$  using the following formula:

$$(\text{PPM} \times \text{mL of extraction liquid}) \div \text{surface area tested in cm}^2$$

Example:  $(24 \text{ PPM} \times 3 \text{ mL}) = 72 \mu\text{g}$   
 $72 \mu\text{g} \div 12.25 \text{ cm}^2 = 5.9 \mu\text{g}/\text{cm}^2$

## Conclusion

Surface preparation is considered the foundation for the coating system. In this case, installing a solid “foundation” includes verifying that the surface is prepared according to the project specification prior to application of the primer. This frequently involves quality control check points to verify conformance and to correct deviations before they become nonconformities. Common quality check points include those described in Volume 1 of this eBook series - Inspection Instruments for the Pipeline Coatings Industry. Watch for Volumes 2 and 3 later this year.

## About the Author

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instructor for both SSPC and KTA. Bill authored the first, second and third editions of the KTA publication, Using Coatings Inspection Instruments. He received SSPC's Coating Education Award in 2006, the SSPC John D. Keane Award of Merit in 2011, an ASTM Committee D01 Award of Appreciation in 2016, and the SSPC President's Lecture Series Award in 2017. He is the Chair of the SSPC Dry Film Thickness Committee and Chair of the SSPC Education and Certification Committee. He is also a member of ASTM Subcommittees D01.23 and D01.46.