

Quality Control Instrumentation
for Paint and Coating Installations

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Appalachian Underground Corrosion Short Course

A large pipeline stretching across a desert landscape with snow-capped mountains in the background. The pipeline is supported by concrete pillars and runs from the foreground into the distance. The background features a range of mountains with patches of snow under a clear blue sky. Utility poles are visible along the pipeline route.

Quality Control Instrumentation for Paint and Coating Installations

Learning Outcomes

- Identify organizations responsible for writing inspection standards
- Identify inspection check points
- Describe basic inspection equipment
- Identify industry guides for verifying surface preparation and coating thickness

Purpose of Quality Inspection

- Verify the quality of surface preparation and coating application
- Help ensure the longevity of the paint/coating system



Causes of Coating Failures

- Poor surface preparation
- Inadequate mixing and thinning
- Inadequate coating application
- Unfavorable environmental conditions
- Incorrect selection of coating
- Manufacturing issue with coating



Prevention of Coating Failures

- On-site quality assurance and quality control (QA/QC) to verify specification compliance



Industry Associations & Terms

- **ASTM** — ASTM International (formerly American Society for Testing and Materials)
- **NACE** — NACE International
- **SSPC** — The Society for Protective Coatings

- **WFT** — Wet Film Thickness
- **DFT** — Dry Film Thickness
- **Mill Scale** — Bluish-black oxide layer that forms on the surface of hot-rolled carbon steel
- **Mil** — 0.001"
- **Micron** (micrometer) — $25.4 \mu\text{m} = 1 \text{ mil}$

Inspection Sequence

- Inspection Checkpoints
 - Pre-surface preparation
 - Measurement of ambient conditions
 - Evaluation of compressed air cleanliness
 - Surface preparation
 - Witnessing coating mixing
 - Inspection of coating application

(continued)

Inspection Sequence

- Inspection Checkpoints (*continued*)
 - Determination of dry film thickness
 - Evaluating cleanliness between coats
 - Pinhole and holiday detection
 - Evaluating cure/hardness
 - Evaluating adhesion

Pre-Surface Preparation Inspection

- Condition of the substrate
 - Presence of grease, oil, dirt, etc.
 - Presence of weld spatter
 - Presence of sharp edges
 - Presence of excessive pitting
 - Installation of protective coverings



Ambient Conditions & Surface Temperature

- What are we measuring?
 - Air Temperature
 - Relative Humidity
 - Dew Point Temperature
 - Surface Temperature



Measuring Ambient Conditions

- Measuring Instruments

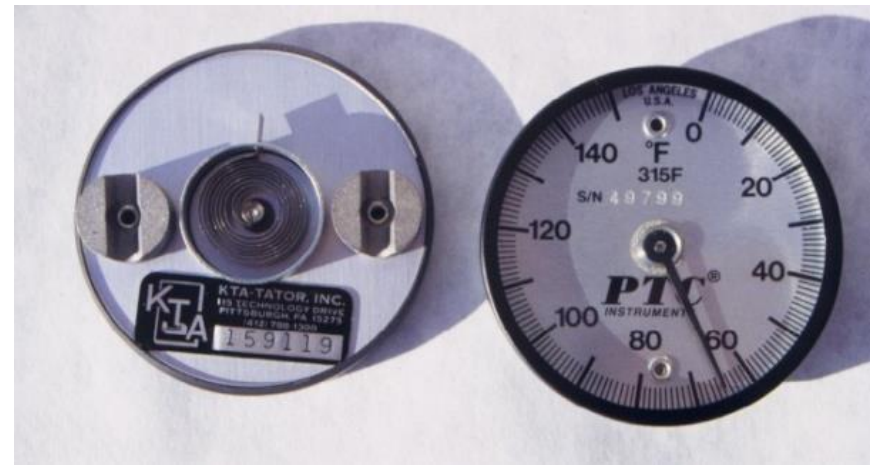
- Sling Psychrometers*
- Battery-powered Psychrometers*
- Electronic Psychrometers

**Used in conjunction with psychrometric charts*



Measuring Surface Temperature

- Dial-Type Thermometer
 - Position & stabilize for minimum of 2 minutes
- Thermocouple-Type Thermometers
 - Stabilize quickly
- Infrared (non-contact) thermometers



Electronic Psychrometers

- Measure/Record:
 - Air Temperature
 - Surface Temperature (ST)
 - Relative Humidity
 - Dew Point Temperature (DP)
 - Spread between DP and ST

Features

- Auto-logging
- Data uploading using software
- Audio/visual alarm
- BlueTooth® Data Output



Measurement of Ambient Conditions

- Measurements are obtained and recorded every four hours, more often if conditions are worsening
- Measurements are obtained where the work will be/is being performed
- Measurements may be obtained *automatically*



Measurement of Ambient Conditions

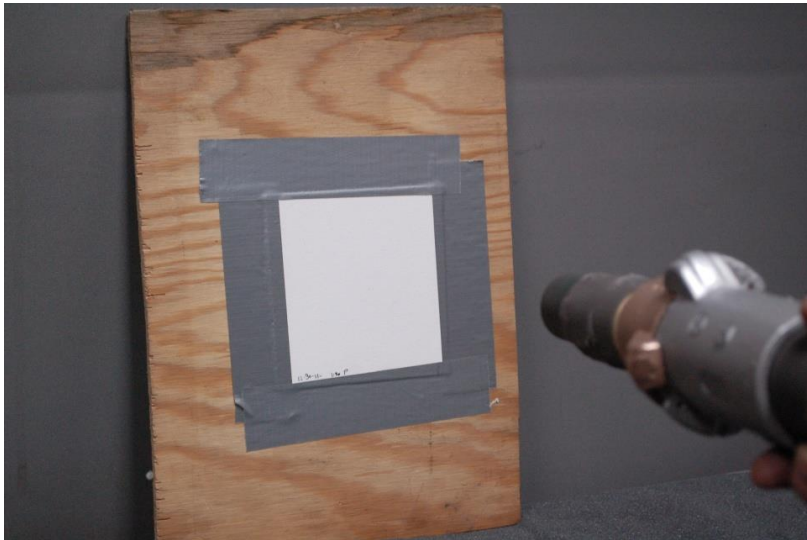
- Relative Humidity: The amount of moisture in the air, as a percentage of total saturation
- Dew Point: The temperature at which moisture in the air condenses on a surface
- A surface temperature at or below the dew point temperature will result in condensation

Measurement of Ambient Conditions

Final surface preparation and coating application should not begin until the surface temperature is at least 5°F (3°C) above the dew point temperature.



Evaluation of Compressed Air Cleanliness



- Compressed air must be clean and dry
- Indirect (automatic) requirement of SSPC Surface Preparation Standards
- “Blotter test” (ASTM D4285)
 - Exhaust compressed air at 18–24" for ~1 minute onto “collector”
 - Visually assess air cleanliness
 - Assess prior to use and at frequent intervals

Abrasive Cleanliness

- What are we concerned about?
 - Oil
 - Water soluble contaminants



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Abrasive Cleanliness

- Why are we concerned about abrasive cleanliness?
 - Contamination on abrasive can be transferred to the surface
 - SSPC Abrasive Specifications all require testing for cleanliness (oil & water soluble contaminants)
 - SSPC/NACE joint surface preparation standards for abrasive blast cleaning list abrasive cleanliness as an indirect requirement of the standards

Abrasive Cleanliness

- Vial test
 - Oil film (ASTM D7393)
 - Tap water
 - Visual assessment
 - No visually detectable oil
 - Conductimetric Analysis (ASTM D4940)
 - Deionized water
 - Conductivity meter
 - $\leq 1000 \mu\text{S}/\text{cm}$



Surface Preparation

- Two-fold purpose of surface preparation
 - Surface cleanliness
 - Surface profile (anchor pattern)



Importance of Surface Preparation

- Surface preparation is the most important factor affecting coating system performance
- Surface conditions affecting coating life:
 - Presence of oil/grease
 - Presence of salts or other chemicals
 - Presence of dust/dirt
 - Presence of corrosion products
 - Presence of old coatings

Surface Cleanliness

SSPC/NACE Surface Cleanliness Standards

- SSPC-SP1: Solvent Cleaning
- SSPC-SP2: Hand Tool Cleaning
- SSPC-SP3: Power Tool Cleaning
- SSPC-SP5/NACE 1: White Metal Blast Cleaning
- SSPC-SP6/NACE 3: Commercial Blast Cleaning
- SSPC-SP7/NACE 4: Brush-off Blast Cleaning



(Continued)

Surface Cleanliness

SSPC/NACE Surface Cleanliness Standards

- SSPC-SP10/NACE 2: Near-White Metal Blast Cleaning
- SSPC-SP11 & 15: Power Tool Cleaning
- SSPC-SP WJ-1/NACE WJ-1 thru WJ-4



Visual Guides for Surface Cleanliness

SSPC VIS 1 “Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning”

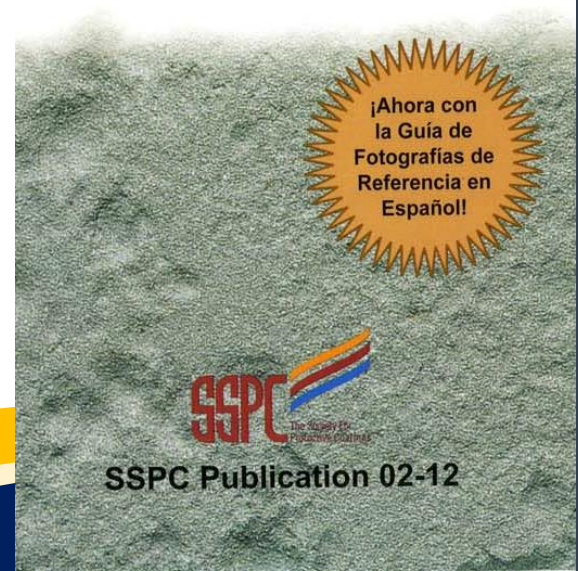
- Step 1: Assess initial condition (A, B, C, D, G₁, G₂, G₃)
- Step 2: Locate photograph of level of surface preparation (SP7, SP6, SP10, SP5), based on initial condition
- E.g., C SP10



SSPC-VIS 1

Guide and Reference Photographs
for Steel Surfaces
Prepared by

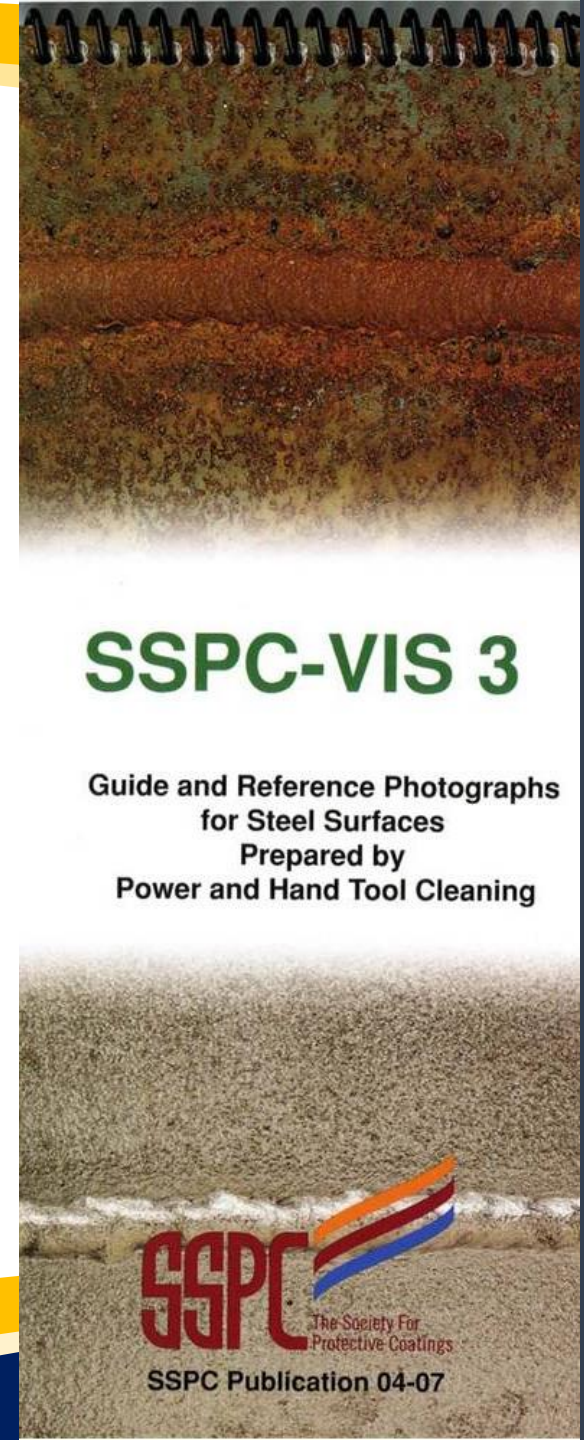
Dry Abrasive Blast Cleaning



SSPC Publication 02-12

Visual Guides for Surface Cleanliness

- **SSPC VIS 3** “Guide and Reference Photographs for Steel Surfaces Prepared by Hand and Power Tool Cleaning”
 - Step 1: Assess initial condition (A,B,C,D,E,F,G)
 - Step 2: Locate photograph of level of surface cleanliness (SP2, SP3, SP11, SP15), based on initial condition
 - E.g., G SP 15



SSPC-VIS 3

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



SSPC Publication 04-07

Visual Guides for Surface Cleanliness

- Establish a project-specific surface cleanliness standard (use visual guide)
- Verify removal of abrasive and dust from surface prior to primer application



Surface Profile

- Measurement of surface roughness created by power tool cleaning or abrasive blast cleaning
- Surface profile must be specified separately from surface cleanliness



Measurement of Surface Profile

- Surface Profile Standards
 - ASTM D 4417
 - Method A (visual comparator)
 - Method B (depth micrometer)
 - Method C (replica tape)
 - NACE SP02-87 (replica tape)
 - SSPC-PA 17, “Procedure for Determining Conformance to Steel Profile/Surface Roughness/Peak Count Requirements”

Measurement of Surface Profile

- Method B – Depth Micrometer
 - Instrument base sets on peaks of the profile while a conical-shaped point projects into the valleys
 - Features:
 - Memory
 - BlueTooth® Data Transfer
 - Statistical analysis of data and using software



Measuring Surface Profile

- Method C – Replica Tape
 - Replica tape used in conjunction with a spring-loaded micrometer
 - Digital RTR:
 - Automatically deducts 2 mils of Mylar thickness
 - Can upload data via USB connection of Blue Tooth



Frequency of Surface Profile Measurements

- No. of readings indicated in ASTM standards
- No. of locations *not* indicated in ASTM standards
- No. of locations may be indicated by the project specification
- SSPC-PA 17 provides no. of locations to characterize the surface

Number of
Readings
(to
determine
location
average)

- Based on Test Method (unless otherwise specified)
- ASTM D 4417
 - “Sufficient” number of readings for Method A (visual comparator)
 - 10 readings per “location” for Method B (depth micrometer)
 - 2 readings per “location” for Method C (replica tape)



Number of Locations (to characterize the surface)

- SSPC-PA 17
- Minimum of three 6" x 6" locations
 - Per surface preparation "apparatus"
 - Per work shift or 12-hour period (whichever is shorter)

SOLUBLE SALT (IONIC) CONTAMINATION



- Soluble salt contamination can be chlorides, sulfates, or nitrates. All can be found in a soil environment.
- Soluble salts will increase soil conductivity and accelerate the corrosion of the steel pipe.
- If the salts are not removed, the adhesion of the pipe coating may be compromised.

MEASUREMENT OF IONIC CONTAMINANTS



Ion-Specific Test Kit



Conductivity Measurement
(not ion-specific)

Witnessing Coating Mixing and Thinning

- Verify product data and SDS on-site (most current versions)
- Verify correct coating materials and thinners on-site (manufacturer, product numbers, colors, batch dates)
- Verify current shelf life
- Verify correct quantity and ratio of components (if multi-component coatings are specified)

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Witnessing Coating Mixing and Thinning

- Witness mixing and thinning procedures
- Verify induction or sweat-in (if required)
- Verify complete kits are mixed
- Verify correct type and quantity of thinner addition
- Monitor pot life of mixed materials
- Verify that application equipment meets coating manufacturer's requirements

Measuring Dry Film Thickness



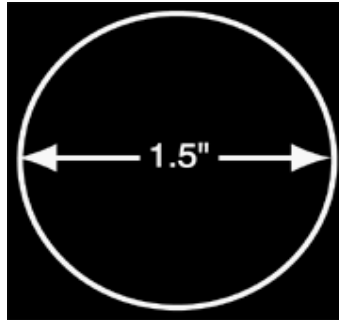
- Two standards that address the nondestructive measurement of coating thickness on metals
 - ASTM D7091
 - SSPC-PA 2

Scope of SSPC-PA 2

- Describes a procedure for determining shop/field conformance to a specified DFT range on ferrous and non-ferrous metals
- Measurements are acquired using commercially available gages (two “types”)
- Procedures for gage calibration, verification of accuracy and adjustment are described
- Procedure for determining conformance to specified thickness range over extended areas is described
- Contains 10 Non-mandatory Appendices

Definitions in SSPC-PA 2

- **Gage Reading:** A single instrument reading
- **Spot Measurement:** The average of three or at least three gage readings made within a 1 ½" diameter circle



- **Area Measurement:** The average of five spot measurements over each 100 square feet of coated surface

Gage Types

Type 1 – Magnetic Pull-off Gages



Type 2 – Electronic Gages



Gage Types, continued

- Type 2 – Electronic Gages

- Electronic circuitry converts reference signal to coating thickness



Calibration & Verification of Accuracy

- ASTM D7091 describes 3 operational steps to ensure accurate measurement:
 - Calibration
 - Verification of Accuracy
 - Adjustment
- Steps are required to be completed before coating thickness data acquisition to determine conformance to a specification
- Focus on Type 2 Gages today

Gage Calibration

- Performed by the gage manufacturer or an accredited calibration laboratory
- Test certificate traceable to a National Metrology institution required
- No standard calibration interval (established based on experience & work environment)
- One year interval is common

Verification of Type 2 Gage Accuracy

- Verify accuracy per manufacturer instructions (use traceable coated standards or *certified shims*)
- Performed as described in ASTM D7091
 - Beginning and end of each work shift (minimum)
 - During (e.g., hourly), if:
 - Obtaining a large no. of readings
 - Gage is dropped or readings are suspect



Verification of Type 2 Gage Accuracy

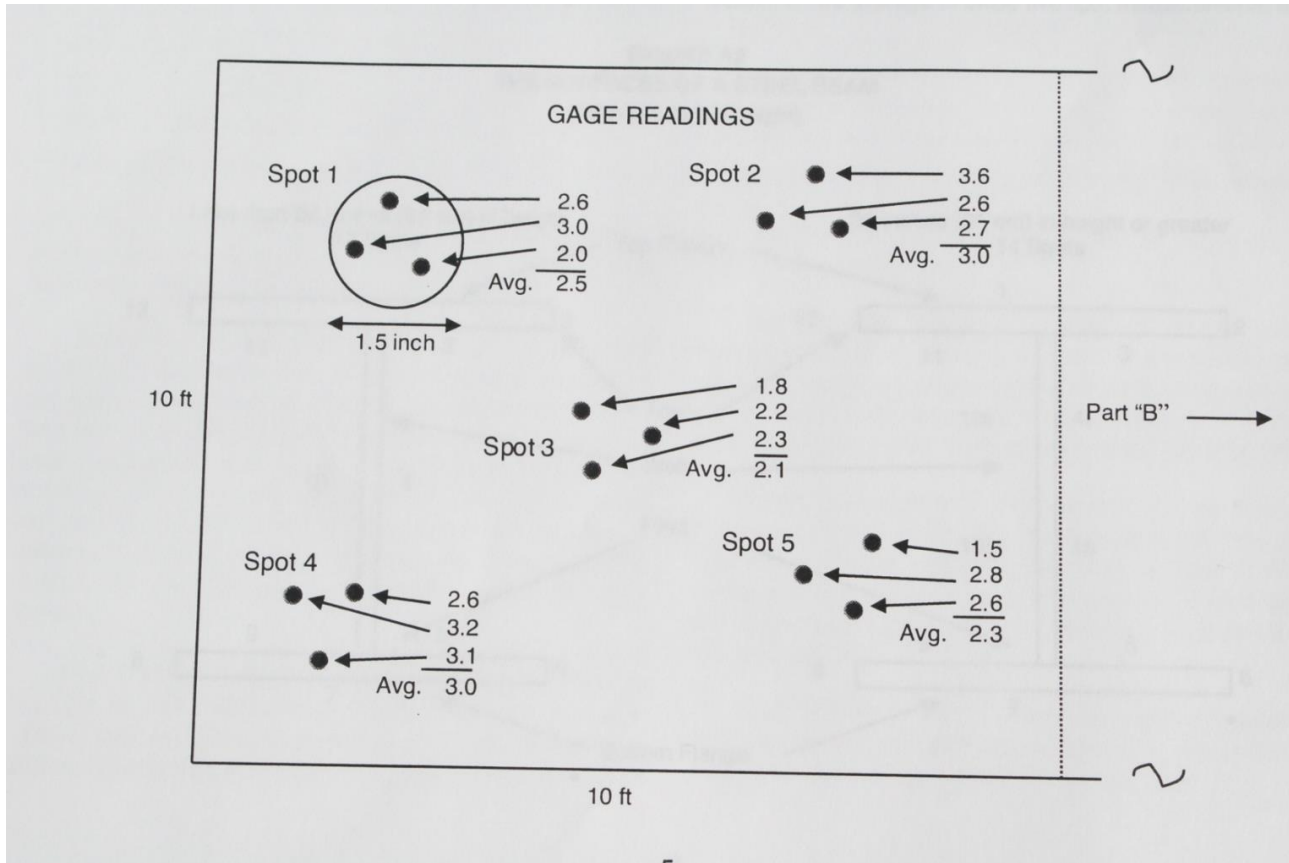
- **Single Point Verification**
 - Select one reference coated standard representing the mid-range of the anticipated coating thickness
 - E.g., 4-6 mils, select 5 mil reference standard
- **Two Point Verification**
 - Select reference coated standards below and above the median anticipated coating thickness
 - E.g., 5 mils, select 3 mil and 7 mil coated standards

Adjustment of Type 2 Gages

- Aligning a gage's thickness readings to those of a known thickness value to improve gage accuracy on a specific surface or within a measuring range
- Corrects for:
 - Surface Roughness
 - Substrate Properties (metallurgy)
 - Curvature
- Use Certified or Measured Shims



Measurement Frequency



Measurement Frequency

- For areas of coating:
 - not exceeding 300 square feet, measure each 100 square feet
 - exceeding 300 square feet and not exceeding 1000 square feet, arbitrarily select and measure 3 random 100 square foot areas
 - exceeding 1000 square feet, arbitrarily select and measure 3 - 100 square feet areas for the first 1000 square feet, and 1 additional 100 square foot area for each additional 1000 square feet, or portion thereof

Measurement Frequency Example

Size of Coated Area: 900 square feet

No. of Areas: 3 areas

No. of Spots: 3 Areas x 5 Spots/Area = 15 Spots

Min. No. of Gage Readings: 15 Spots x 3 Readings/Spot =
45 Gage Readings

SSPC-PA 2, Appendix 7: Measuring Thickness on Coated Steel Pipe Exterior

- Pipe spools measured individually
- Table describes frequency
- Pipe spools < 10 ft: 3 sets of circumferential spot measurements



Table A7

Pipe Diameter	Circumferential Spot Measurements	Interval Spacing
Up to 12 inch (30 cm)	4 evenly spaced	10 ft (3 m) apart
14-24 inches (36-60 cm)	6 evenly spaced	10 ft (3 m) apart
> 24 inches (60 cm)	8 evenly spaced	10 ft (3 m) apart

Recoat Intervals/ Cleanliness

- Verify minimum and maximum recoat times are followed (see manufacturer's product data sheets)
- Verify surface is dry, clean, and free of foreign matter before applying subsequent coats

Final Inspection

- Holiday/Pinhole Detection
- Cure/Hardness Testing
- Adhesion Testing



Final Inspection

- Holiday/Pinhole Detection (“Jeeping”)
 - Holiday - skip or miss
 - Pinhole - tiny hole which may or may not be visible to the unaided eye
 - Mandatory for buried pipe



Holiday/Pinhole Detection NACE SP0188

- Low Voltage (wet sponge)
 - Non-conductive coatings over conductive substrates
 - Up to 20 mils coating thickness
 - Use wetting agent in water (e.g., Kodak Photo-Flo)



Holiday/Pinhole Detection NACE SP0188

- High Voltage (spark testing)
 - Non-conductive coatings over conductive substrates
 - Over 20 mils coating thickness



Determining the Proper Peak Voltage Setting

$$V = K * \sqrt{T}$$

Where:

V = Peak voltage in volts

T = Coating Thickness in Mils

K = Constant:

Coatings \leq 40 mils = 525

Coatings $>$ 40 mils = 1250

Determining the Proper Peak Voltage Setting

$$V = K * \sqrt{T}$$

Example: 45 mil coating

$$1250 \times \sqrt{45}$$

$$1250 \times 6.71 = 8388 \text{ volts (8.4 kV)}$$

Determining the Proper Peak Voltage Setting

NACE SP0188 – Table 1 (suggested settings only)

Mils	Suggested Voltages for High-Voltage Spark Testing
8-11	1,500 V (1.5kV)
12-15	2,000 V (2.0kV)
16-20	2,500 V (2.5kV)
21-40	3,000 V (3.0kV)
41-55	4,000 V (4.0kV)
56-80	6,000 V (6.0kV)
81-125	10,000 V (10.0kV)
126-185	15,000 V (15.0kV)

Hardness Testing

Durometer Shore D Test (ASTM D2240)



Adhesion Testing

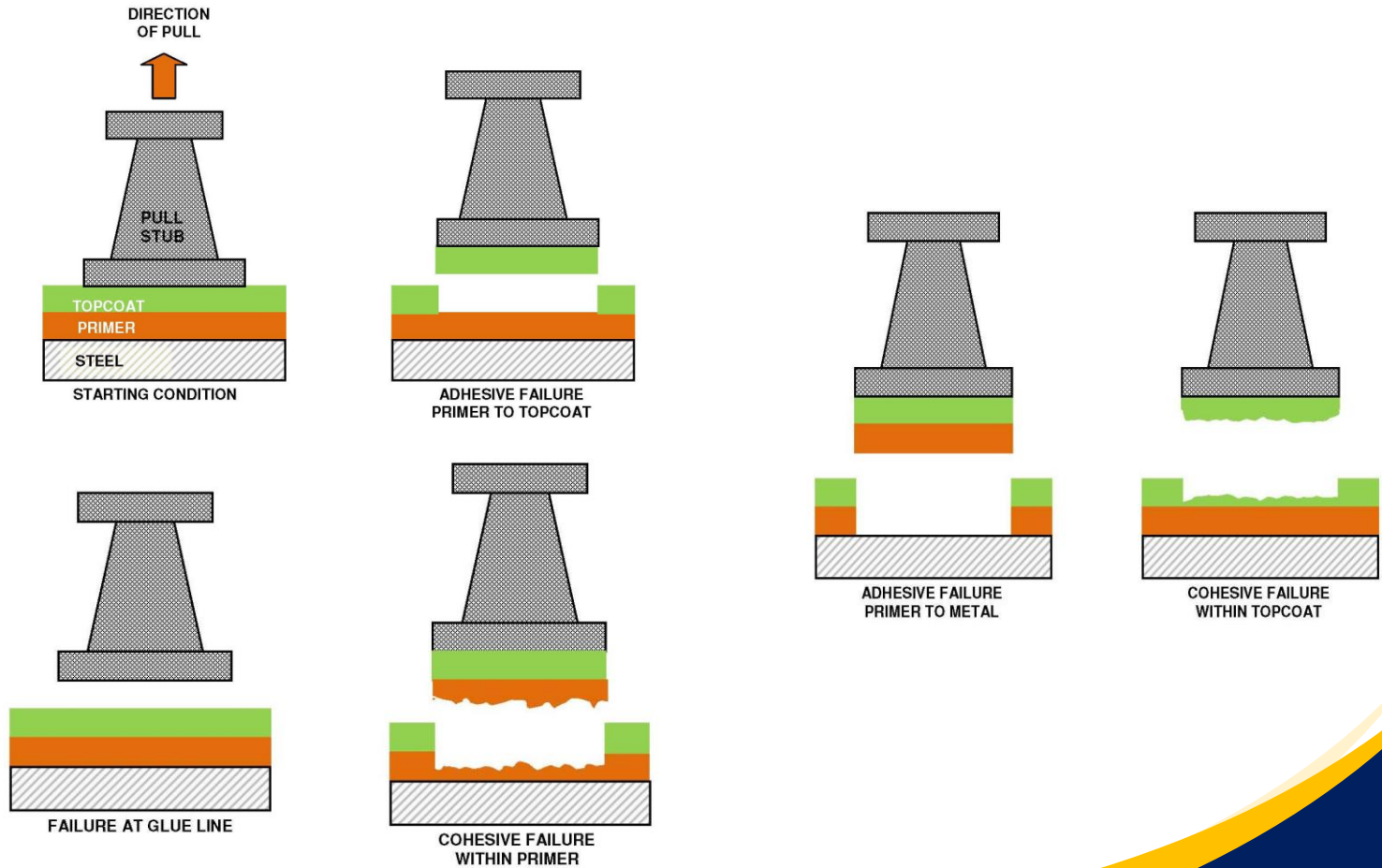
- ASTM D4541 (tensile adhesion)
 - May be invoked for below grade water pipe
 - May be invoked for Powercrete
- ASTM D3359 (shear [tape/knife] adhesion)
- ASTM D6677 (adhesion by knife only)
 - Not common on pipe coatings
- Peel test on some pipe coatings

Pull-off Adhesion Testing (Hydraulic Type V)



- Glue loading fixture
- Position actuator over loading fixture. Attach quick connect coupling to head of fixture
- Apply hydraulic pressure
- Digital display indicates pull-off strength
- Mechanical & pneumatic testers also available
- Curved loading fixtures available

Illustration of Various Locations of Break



Summary

- Identified organizations responsible for writing inspection standards
- Identified inspection check points
- Described basic inspection equipment
- Identified industry guides for verifying surface preparation and coating thickness



Session Break