Quality Control Instrumentation for Paint and Coating Installations

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AUCSC

Appalachian Underground Corrosion Short Course


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 system
- Manufacturing issue with the coating

Prevention of Coating Failures

- Conform to the project specification and manufacturer's instructions
- Verify specification compliance by conducting in-process quality assurance and quality control (QA/QC) inspection

Industry Associations & Terms

- **AMPP:** Association for Materials Protection & Performance
- **ASTM**: ASTM International (formerly American Society for Testing and Materials)
- **NACE**: NACE International (now AMPP)
- **SSPC**: The Society for Protective Coatings (now AMPP)
- **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 µm = 1 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

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

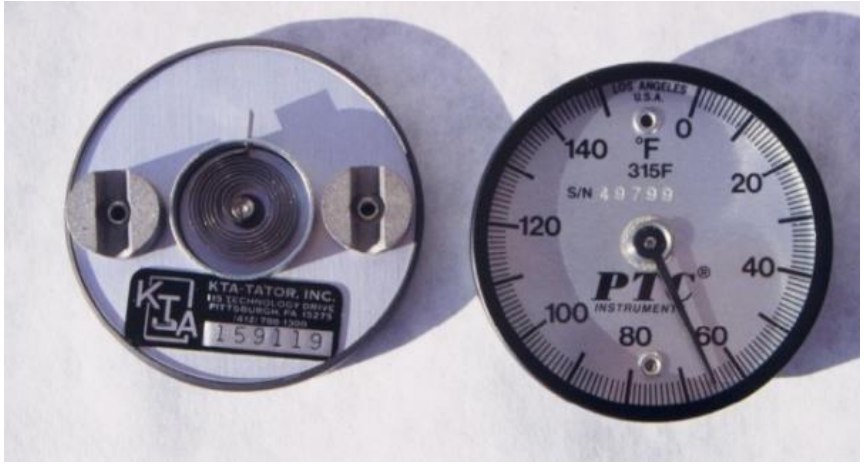
Measuring Ambient Conditions

- Measuring Instruments
  - Sling Psychrometers*
  - Electronic Psychrometers
  - Data Loggers

**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 (Ta)
  - Surface Temperature (Ts)
  - Relative Humidity (RH)
  - Dew Point Temperature (Td)
  - Delta between DP and ST (Ts-Td)

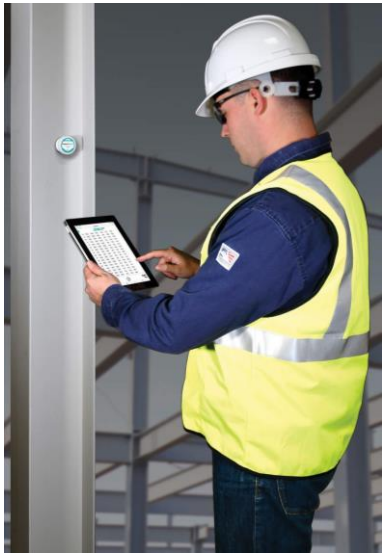
Features
- Auto-logging
- Data uploading using software
- Audio/visual alarm
- BlueTooth® Data Output

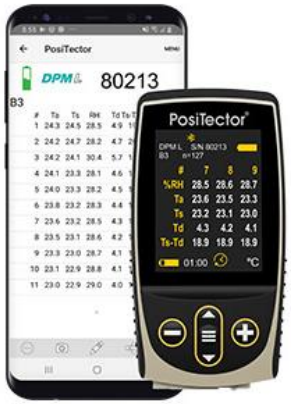
Measurement of Ambient Conditions

- 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***

DeFelsko PosiTector Dew Point Meter Logger (DPM L)

- Attaches to steel structures using magnet
- Measures/records environmental parameters independently for up to 200 days (-40 to 375°F). Stored datasets are downloaded to a gage body or Apple/Android smart device
- Records data at user selected intervals from 1 min. to 8 hrs.
- Sealed enclosure: weatherproof, dustproof, shockproof
- Internal memory storage of 10,000 datasets (60,000 readings)
- Every stored dataset is date and time stamped



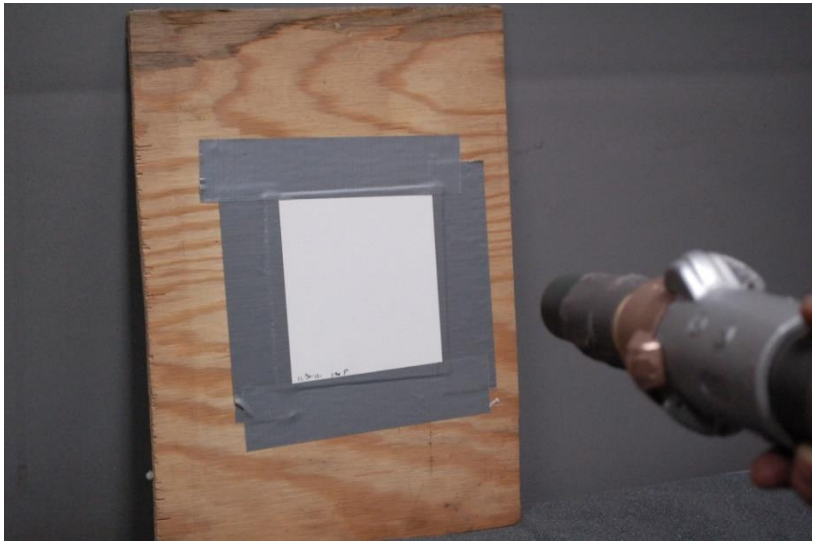


Measurement of Ambient Conditions

- 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

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
    - ≤ 1000 µS/cm (SSPC AB Stds.)

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

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Surface Cleanliness

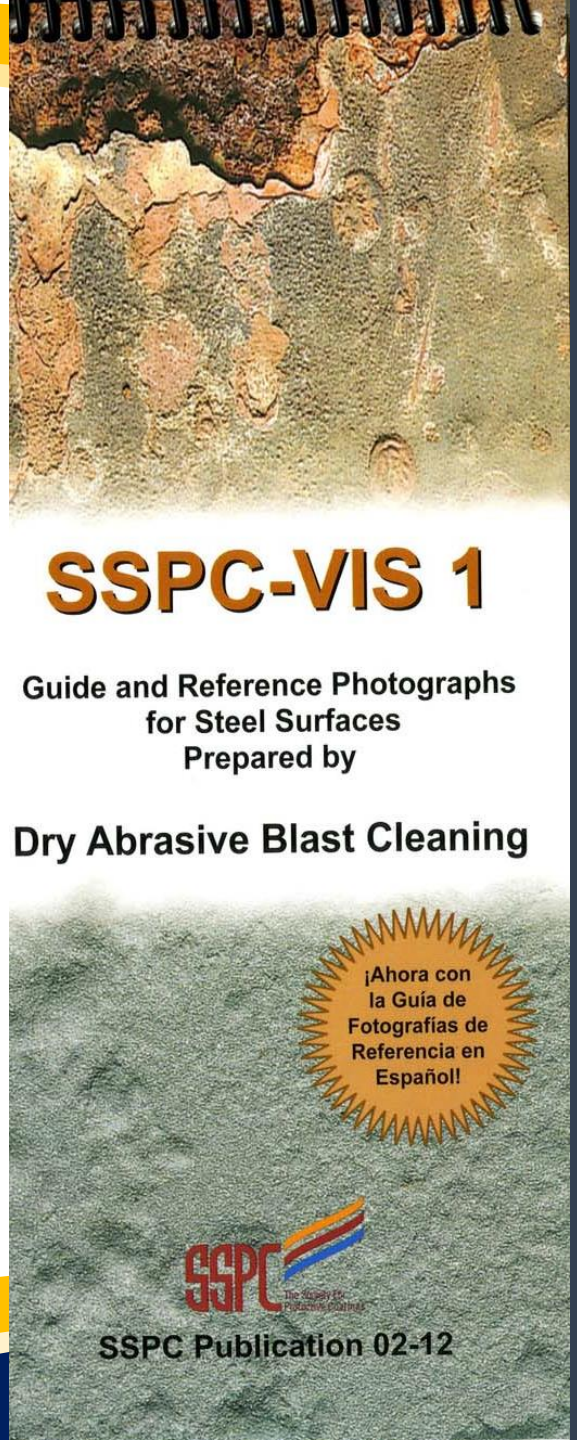
SSPC/NACE Surface Cleanliness Standards

- 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

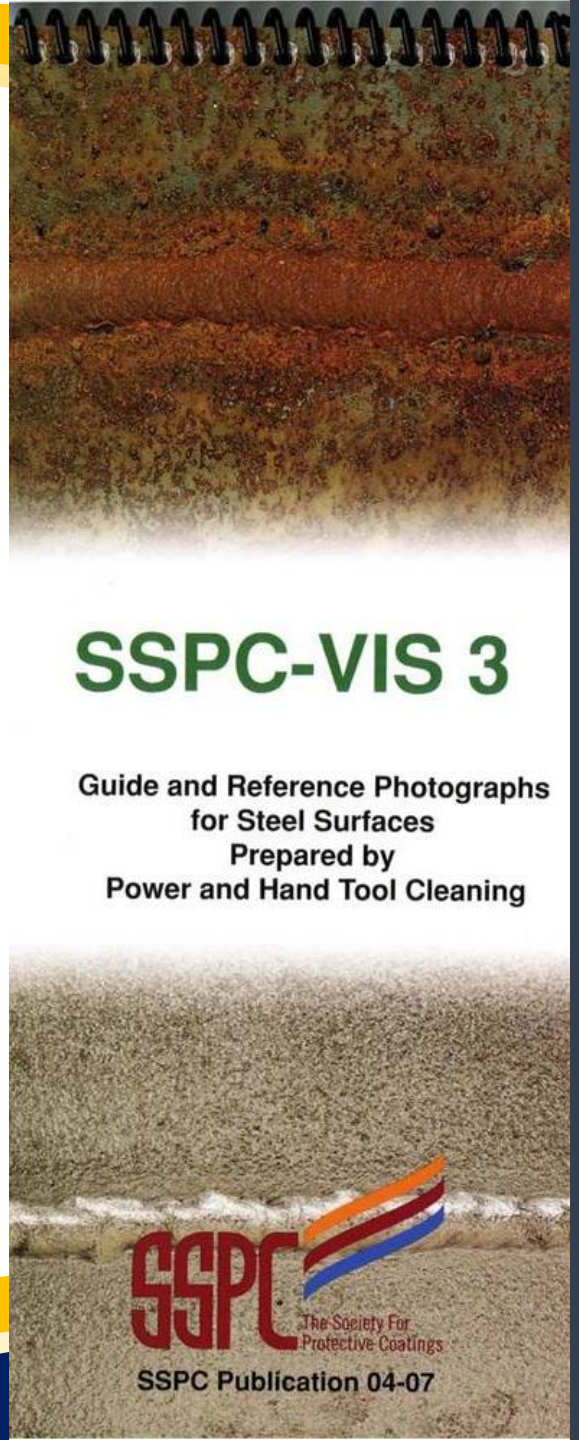
SSPC VIS 1 "Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning"

- Step 1: Assess initial condition (A, B, C, D, G_1, G_2, G_3)
- Step 2: Locate photograph of level of surface preparation (SP7, SP6, SP10, SP5), based on initial condition
- E.g., C SP10



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



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

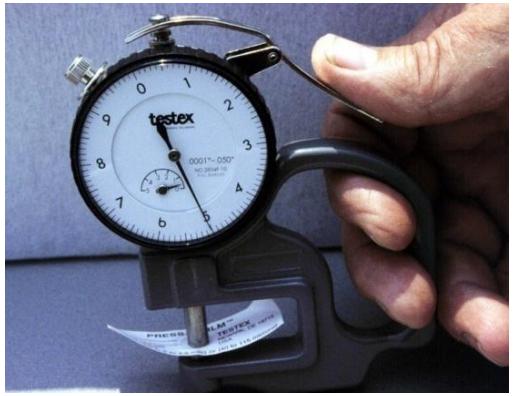
- Surface Profile Standards
  - ASTM D 4417
    - Method A (visual comparator)
    - Method B (depth micrometer)
    - Method C (replica tape)
  - NACE SP02-87 (replica tape)
  - SSPC-PA 17, “Procedure for Determining Conformance to Steel Profile/Surface Roughness/ Peak Count Requirements”

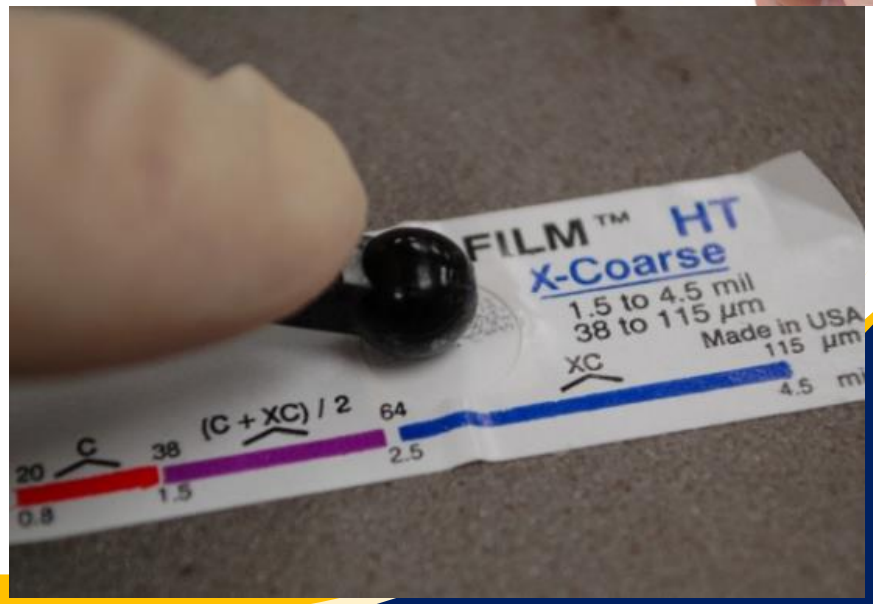
Measurement of Surface Profile

- 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

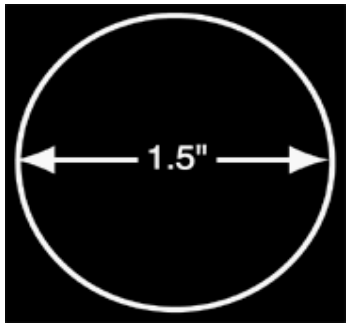
- Two standards that address the nondestructive measurement of coating thickness on metals
  - ASTM D7091
  - SSPC-PA 2

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 11 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

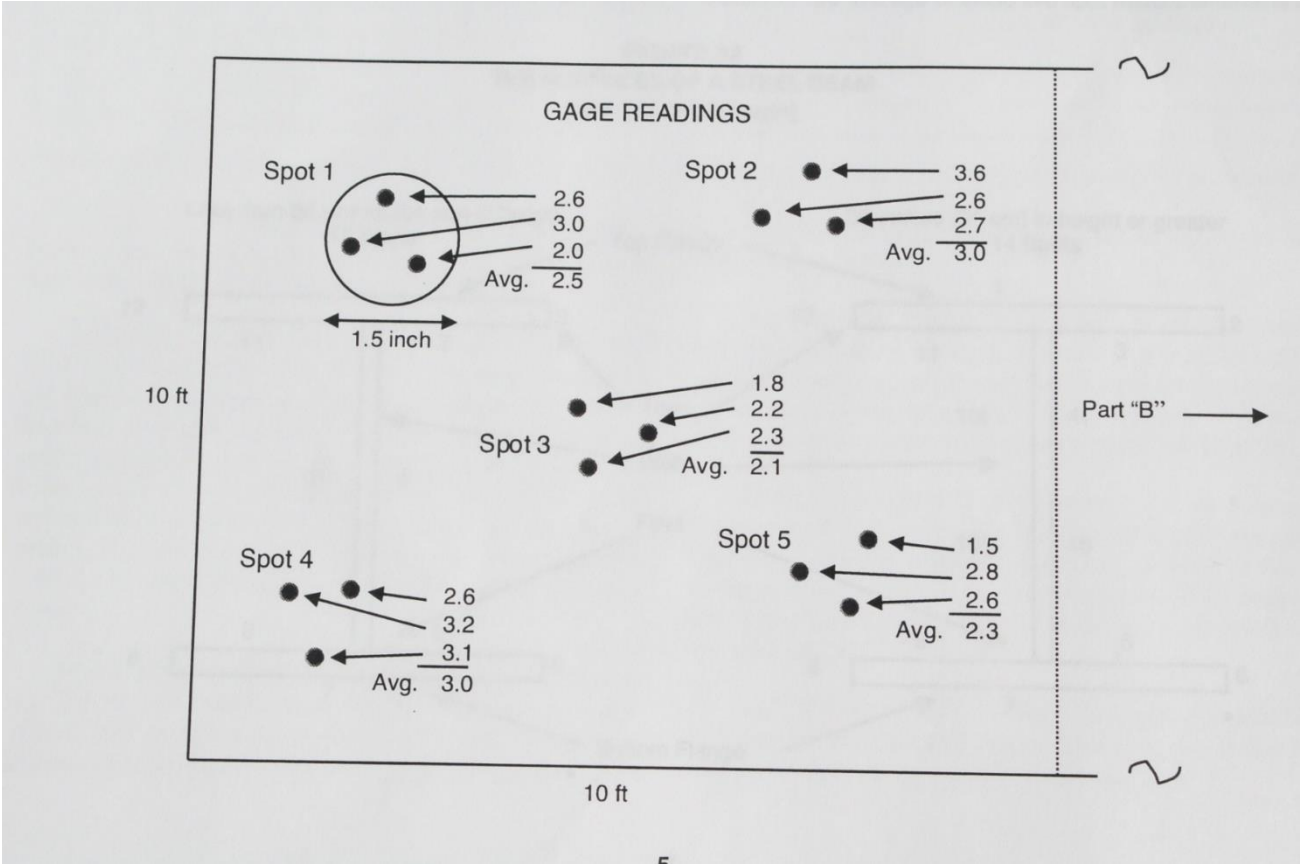
Verification of Type 2 Gage Accuracy

- 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

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 in 10-20 mil range

Holiday/Pinhole Detection NACE SP0188

- High Voltage (spark testing)
  - Non-conductive coatings over conductive substrates
  - Over 20 mils coating thickness
  - PosiTest HHD has auto-voltage setting based on coating thickness input

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 x 6.71 = 8388 volts (8.4 kV)

Hardness Testing

Durometer Shore D Test (ASTM D2240)

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

Questions?

Session Break