57th Annual Appalachian Underground Corrosion Short Course
QUALITY CONTROL
INSPECTION OF COATINGS: PAST & PRESENT/FUTURE

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History of Inspection/Instruments

- Concept of In-Process Coatings Inspection Nearly a Half Century Old
- Whirling apparatus containing wet & dry bulb thermometers developed in the 1600’s
- First coating thickness gage invented in 1947
Sling psychrometers using dry bulb/wet bulb measurements are still mainstream

Type 1 magnetic pull-off coating thickness gages remain popular, despite the “electronics age”
Common Pipeline Coating Inspection Check Points

- Ambient Conditions & Surface Temperature
- Surface Profile & Cleanliness
- Abrasive Certification & Cleanliness
- Measuring Dry Film Thickness
- Pinhole/Holiday Detection (jeeping)
- Coating Hardness
What are we measuring?

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

- Verify air & surface temperatures are within the allowable ranges
- Verify minimum or maximum amount of moisture in the air
- Verify surface temperature is warmer (minimum 5°F) than the dew point to preclude condensation
How we measure

- Sling Psychrometers
- Battery-powered Psychrometers
- Electronic Psychrometers
- Analog, Thermocouple-type & Non-contact Thermometers

*In conjunction with psychrometric charts*
US Weather Bureau Psychrometric Charts for Relative Humidity and Dew Point Temperature
Thermocouple-type surface temperature gage

Non-contact infrared surface temperature gage

Analog surface temperature gage
Electronic (digital) psychrometers (some with data logging, data management and wireless technology)
What are we measuring?

- Maximum peak-to-valley depth
- Peak density
- Surface “texture” generated by abrasive impingement or some power tools
- SSPC-SP11, SP15 and SP16 invoke a minimum surface profile depth
Why is it important?

- “Anchors” the coating system in place
- Insufficient profile depth could result in poor coating adhesion
- Too much profile depth could cause pinpoint rusting
- Research indicates increased peak density improves coating adhesion and performance
- Surface profile must be “compatible” with the entire coating system
Measuring Surface Profile

- **Surface Profile Standards**
  - ASTM D 4417
    - Method A (visual comparator)
    - Method B (depth micrometer)
    - Method C (replica tape)
  - NACE RP02-87 (replica tape)

- Standards describe “how to”
- Project specification provides acceptance criteria
Method A: Visual Comparator (1970’s)
Illuminated magnifier
Comparator Discs
- S: Sand
- G/S: Grit/Slag
- SH: Shot
Method A - Visual Comparator:

- Select Disc (based on abrasive type)
- Attach Disc to Comparator
- Examine Surface
- Select Segment(s)
Method B - Depth Micrometer

- Instrument sets on peaks of the profile while a conical-shaped point projects into the valleys
- Digital model stores and uploads data for analysis ("paperless")
Method C - Replica Tape

- Replica tape used in conjunction with a spring-loaded micrometer (analog or digital)
- Compressible foam attached to 2 mils of polyester film (Mylar®)
- Digital version of micrometer can upload data

- Coarse (0.8 – 2.5 mils)
- X-Coarse (1.5 – 4.5 mils)
- X-Coarse Plus (4.0 – 5.0 mils)
Measuring Surface Profile

HOW REPLICA TAPE WORKS:

1. Mylar
   compressible foam
   Before burnishing

2. Mylar
   compressed foam
   steel
   During burnishing

3. air
   impression-bearing foam
   Before measurement

4. top steel
   impression-bearing foam
   Mylar
   During measurement

   bottom steel
   impression-bearing foam

   air
   After measurement
Obtain measurement with X-Coarse replica tape

- If reading is 0.8-1.5 mils (red zone), record the measurement using Coarse tape
- If reading is 2.6-4.5 mils (blue zone), record the measurement using X-Coarse tape
- If reading is between 1.5-2.5 mils using X-Coarse, obtain a second reading (same location) with the Coarse tape
- If the reading with the Coarse tape is also within 1.5-2.5 mils inclusive, average the two values
Measuring Surface Profile

- Frequency of Surface Profile Measurements
  - May be stipulated by the project specification
- ASTM D 4417
  - “Sufficient” number of locations for Method A
  - 10 measurements per “location” for Method B
  - 3 measurements per “location” for Method C
- SSPC plans to issue a standard for measurement frequency and acceptability of measurements in 2012
Surface Cleanliness Standards

- SSPC and NACE issue consensus standards
- Currently SSPC has issued 14 cleanliness standards
- NACE is jointly referenced in 7 of the 14
  - SSPC-SP1
  - SSPC-SP2
  - SSPC-SP3
  - SSPC-SP11
  - SSPC-SP15
  - SSPC-SP8
  - SSPC-SP12/NACE No. 5
  - SSPC-SP7/NACE No. 4
  - SSPC-SP14/NACE No. 8
  - SSPC-SP6/NACE No. 3
  - SSPC-SP10/NACE No. 2
  - SSPC-SP5/ NACE No. 1
  - SSPC-SP13/NACE No. 6
  - SSPC-SP16
Assessing Surface Cleanliness

- How do we assess surfaces for residual rust, paint, mill scale and stains?
- SSPC VIS 1 (Abrasive Blast Cleaning)
- SSPC VIS 3 (Power and Hand Tool Cleaning)
- SSPC VIS 4/NACE VIS 7 (Water Jetting)
- SSPC VIS 5/NACE VIS 9 (Wet Abrasive Blast Cleaning)
What are we concerned about?
- Oil
- Elevated conductivity
Determining Abrasive Cleanliness

Why are we concerned about cleanliness?

- Contamination on abrasive can be transferred to the surface
- SSPC Abrasive Specifications AB1, AB2 & AB3 all require testing for cleanliness (oil & conductivity)
- SSPC/NACE joint surface preparation standards for abrasive blast cleaning list abrasive cleanliness as an indirect requirement of the standards
Determining Abrasive Cleanliness

- How do we determine abrasive cleanliness?

- Vial test
  - ASTM D 7393-07
    - Oil film
    - Coloration/Cloudiness
  - ASTM D 4940
    - Conductivity
    - Requires use of deionized water
    - Procedure differs from D 7393
    - Maximum 1000 µS (per SSPC)
What are we measuring?

- The distance or gap between a gage probe sensor and a metallic substrate using ferro-magnetic principles. This gap or distance is the coating (system) thickness.

Why are we measuring?

- For conformance to a project specification and/or industry standard.
- Coatings have an optimum thickness range, outside of which may show lesser performance.
Measuring Dry Film Thickness

- Standards for Measurement
  - ASTM D 7091 (Coating thickness on ferrous and non-ferrous metal substrates)
  - ASTM D 4138 (Destructive coating thickness)
  - SSPC PA2 (Coating thickness on magnetic substrates)*

*Includes tolerance of measurements and acceptance criteria
Using a Type 1 Gage:

- Verifying gage accuracy using traceable plates
- Measure BMR
- Measure coating
- Deduct BMR

Measured Primer+ Finish Thickness: 7.0 mils
BMR: 0.5 mil
Actual Coating System Thickness: 6.5 mils
Measuring Dry Film Thickness

- Using a Type 2 Gage:
  - Verifying gage accuracy using shims
  - Measure coating
    OR
  - Verifying gage accuracy using traceable plates
    - Measure BMR
    - Measure coating
    - Deduct BMR
When do we measure?

- After the application of each coating layer
- Coating layers are measured cumulatively
- Non-destructive gages cannot distinguish coating layers
- One gage can distinguish & display layers of duplex system
Combining Coating Thickness with Wireless, Digital Technology

- Web-based application for secure, centralized management of thickness readings
- Incorporate digital images
- Upload to database or download data to printer
Assessing Coating Film Continuity

- What are we assessing?
  - Skips or misses in the applied coating system
  - Pinholes

- Why are we assessing?
  - Holidays or pinholes in the coating film provide a pathway for accelerated corrosion
Assessing Coating Film Continuity

- How are we assessing?
  - Two types:
    - Low voltage (wet sponge) for coatings less than 20 mils thick
    - High voltage (spark testers) for coatings greater than 20 mils thick
Assessing Coating Film Continuity

- Optically Active Pigments (OAP) added to coatings during formulation
- Inspection performed using UVA-340 light
- Processed described in SSPC TU 11
- Holidays/undercoated areas:
  - Black or dark spots under UV light
Final Visual Inspection

- Visual Inspection of Difficult Access Areas
  - Use inspection mirrors
Verifying Cure

- Durometer Hardness
- Solvent Rub
Coatings Inspection Training Opportunities

- Coatings consulting/engineering firm
  - Pipeline Coatings Training Course (3 ½ days)
- NACE International
  - Coatings Inspector Program (CIP; 2 weeks)
- SSPC: The Society for Protective Coatings
  - Protective Coatings Inspection (PCI; 1 week)
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