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

We've Come A Long Way Baby!

- 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"

Quality Control Inspection of Coatings: Past & Present/Future

- 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

Ambient Conditions & Surface Temperature

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

Ambient Conditions & Surface Temperature

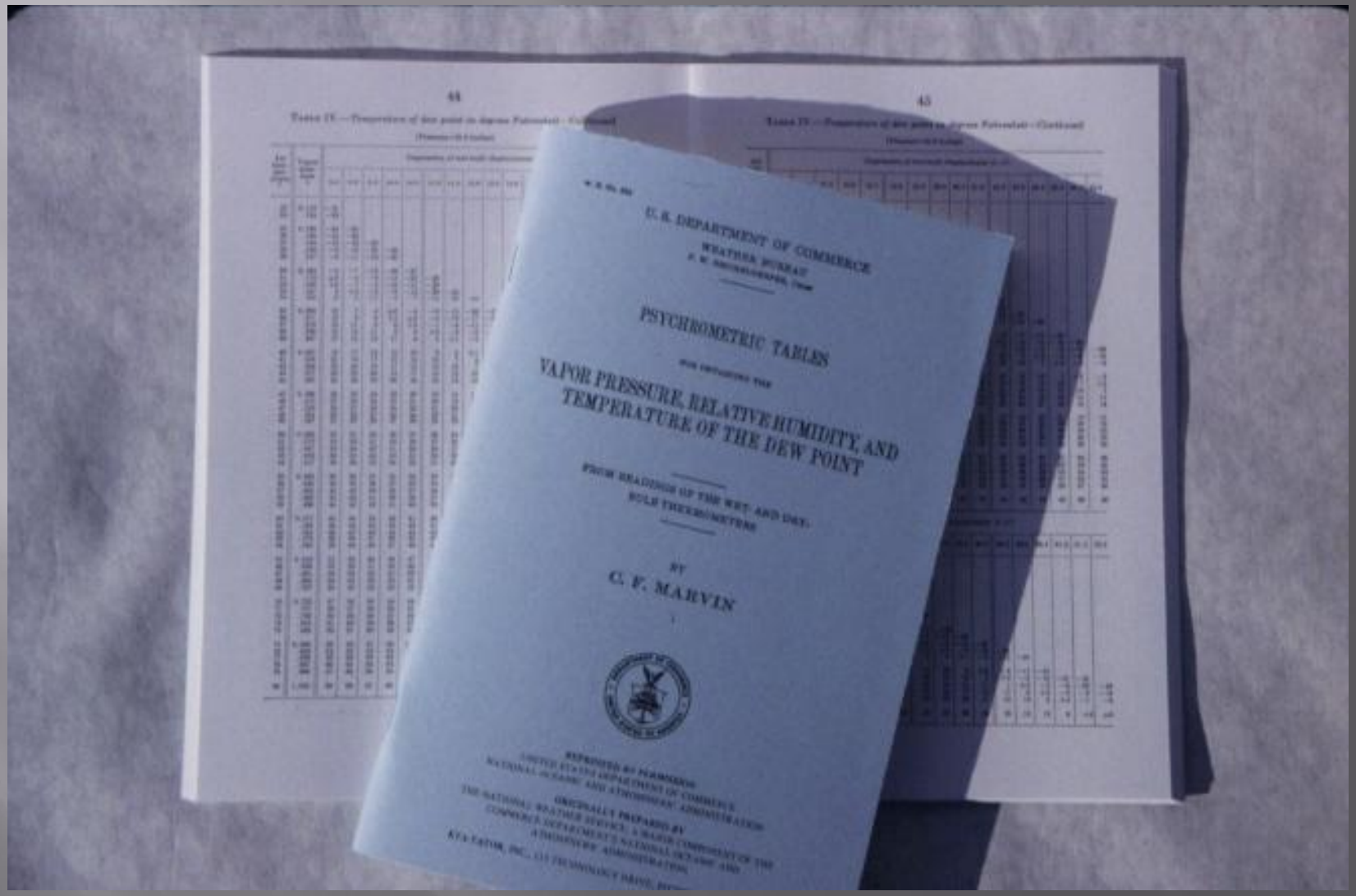
- Why are we measuring?
  - Verify air & surface temperatures are within the allowable ranges
  - Verify minimum or maximum amount of moisture in the air
  - Verify surface temperature is warmer (minimum 5°F) than the dew point to preclude condensation

Ambient Conditions & Surface Temperature

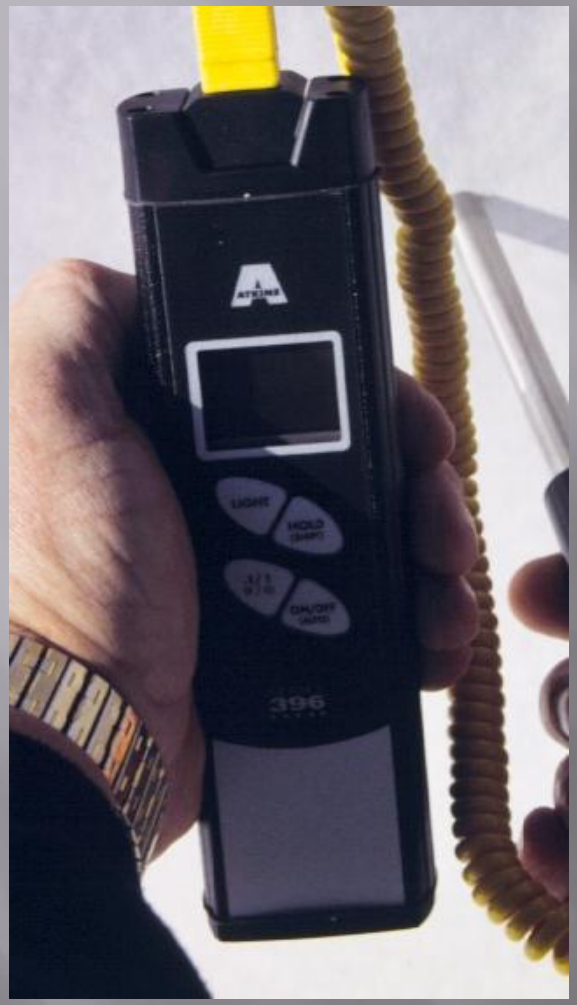
- How we measure
  - Sling Psychrometers*
  - Battery-powered Psychrometers*
  - Electronic Psychrometers
  - Analog, Thermocouple-type & Non-contact Thermometers

* *In conjunction with psychrometric charts*

Sling Psychrometer

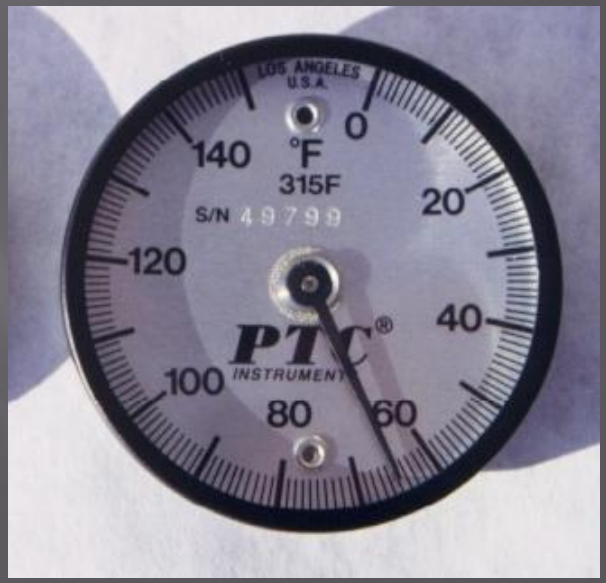


US Weather Bureau Psychrometric Charts for Relative Humidity and Dew Point Temperature



Thermocouple-type surface temperature gage

Non-contact infrared surface temperature gage

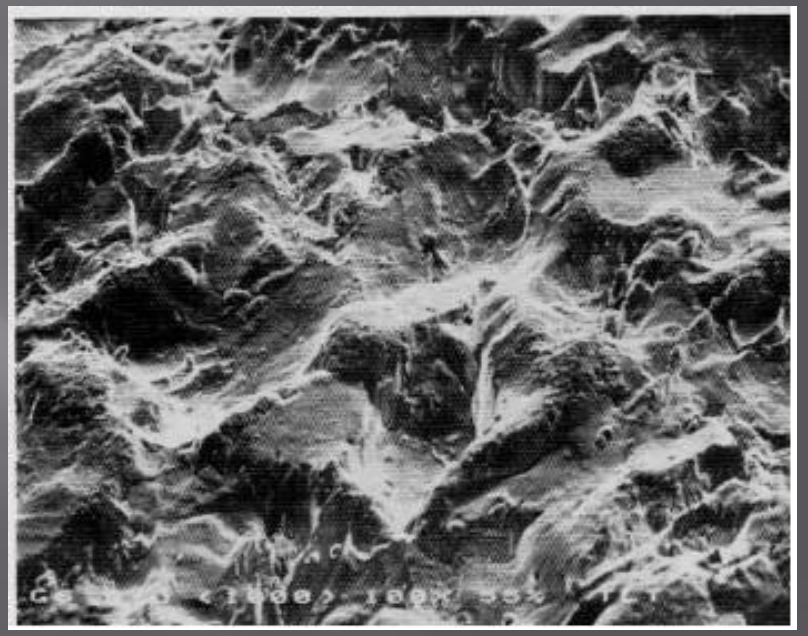


Analog surface temperature gage

Electronic (digital) psychrometers (some with data logging, data management and wireless technology)

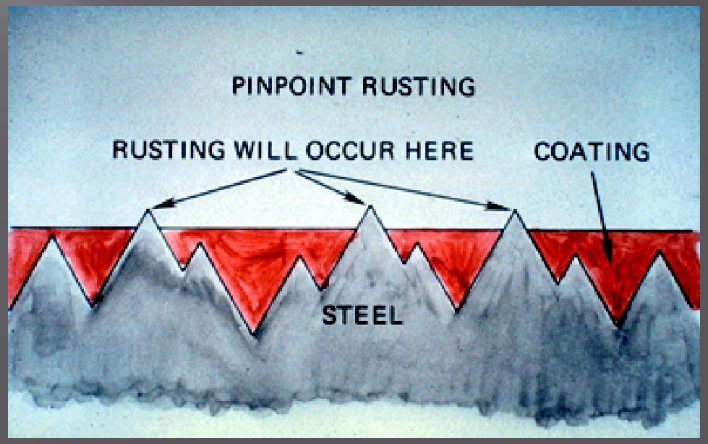
Measuring Surface Profile

- 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



Measuring Surface Profile

- 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

Measuring Surface Profile

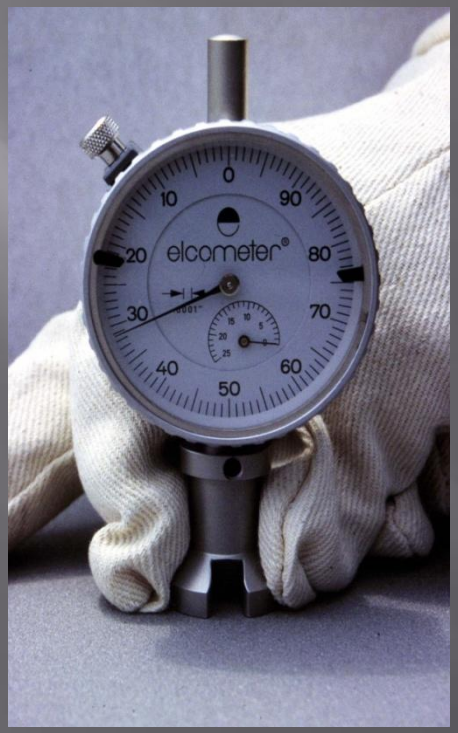
- Method A: Visual Comparator (1970's)
  - Illuminated magnifier
  - Comparator Discs
    - S: Sand
    - G/S: Grit/Slag
    - SH: Shot

Measuring Surface Profile

- Method A - Visual Comparator:
  - Select Disc (based on abrasive type)
  - Attach Disc to Comparator
  - Examine Surface
  - Select Segment(s)

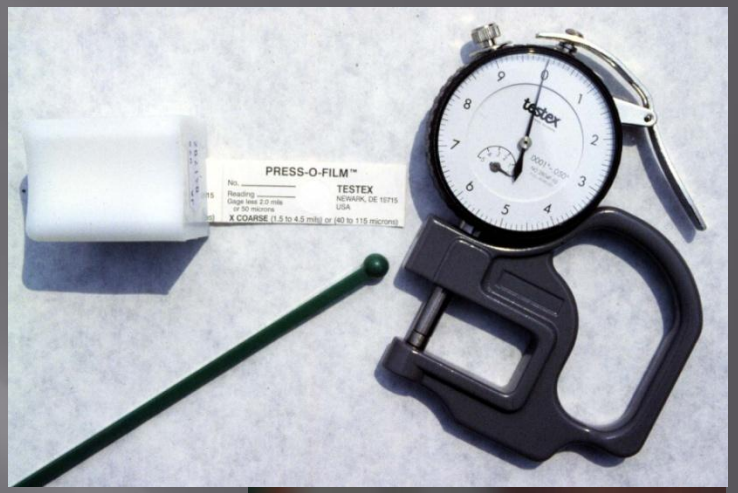
Measuring Surface Profile

- 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”)



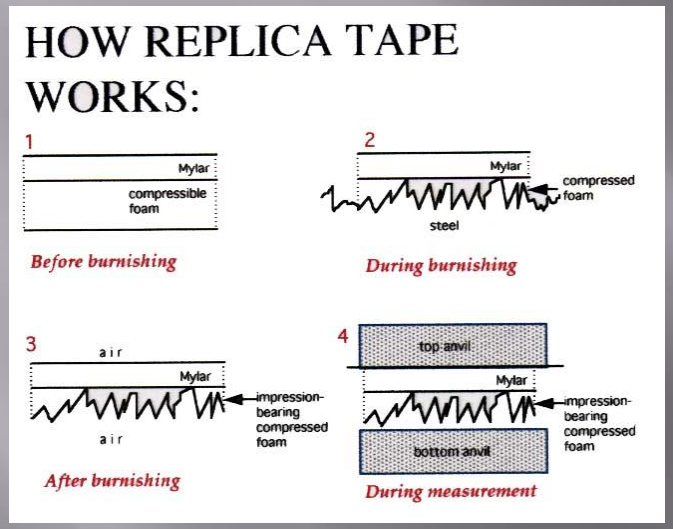
Measuring Surface Profile

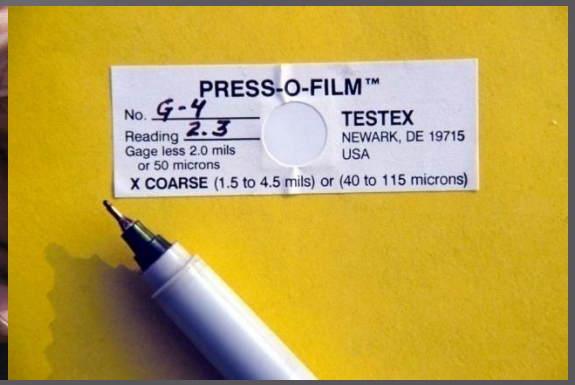
- Method C – Replica Tape
  - Replica tape used in conjunction with a spring-loaded micrometer (analog or digital)
  - Compressible foam attached to 2 mils of polyester film (Mylar®)
  - Digital version of micrometer can upload data



✓Coarse (0.8 – 2.5 mils)
✓ X-Coarse (1.5 – 4.5 mils)
✓ X-Coarse Plus (4.0 – 5.0 mils)

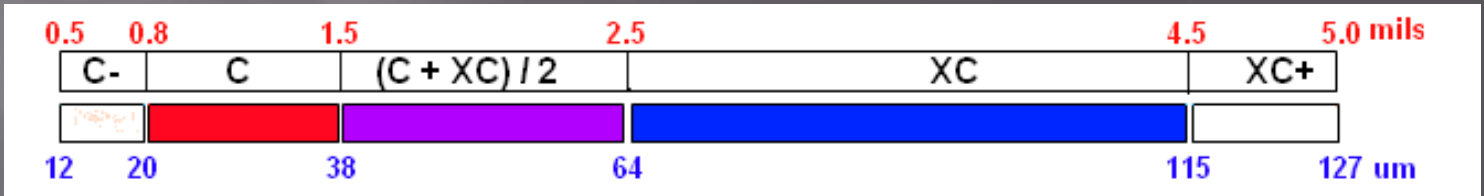
Measuring Surface Profile





Using HT Replica Tape

- 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

Assessing Surface Cleanliness

- 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

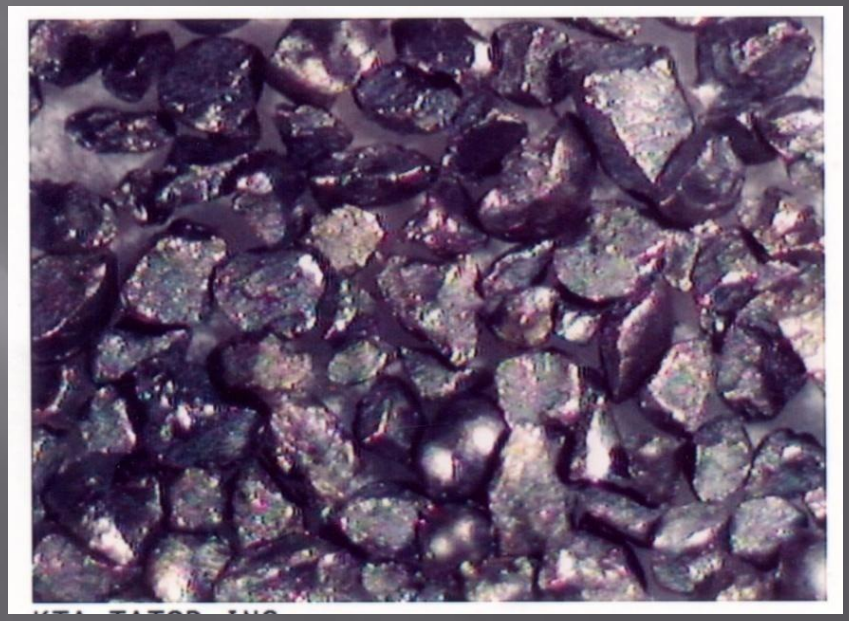
SSPC-SP1
SSPC-SP2
SSPC-SP3
SSPC-SP11
SSPC-SP15
SSPC-SP8
SSPC-SP12/NACE No. 5
SSPC-SP7/NACE No. 4
SSPC-SP14/NACE No. 8
SSPC-SP6/NACE No. 3
SSPC-SP10/NACE No. 2
SSPC-SP5/ NACE No. 1
SSPC-SP13/NACE No. 6
SSPC-SP16

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)

Determining Abrasive Cleanliness

- 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)

Measuring Dry Film Thickness

- 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

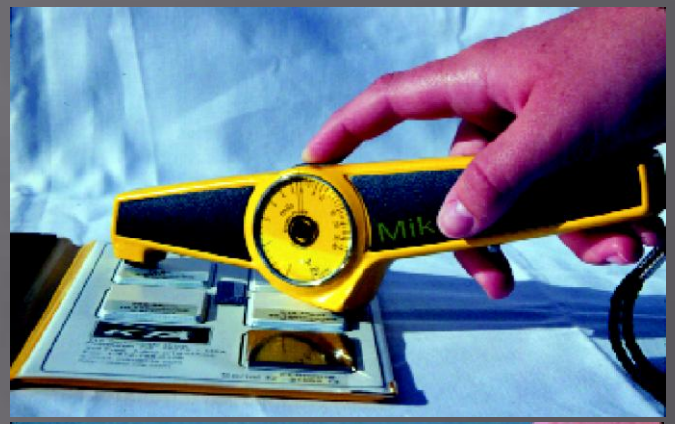
Measuring Dry Film Thickness

- 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*

Measuring Dry Film Thickness

- Using a Type 1 Gage:
  - Verifying gage accuracy using traceable plates
  - Measure BMR
  - Measure coating
  - Deduct BMR



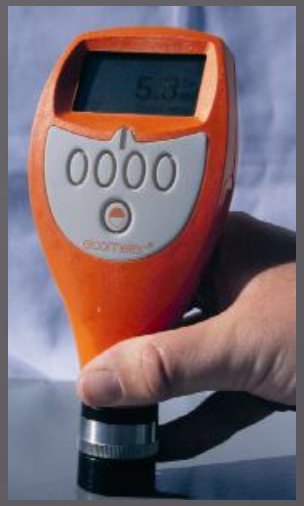
Measured Primer+ Finish Thickness: 7.0 mils
BMR: 0.5 mil
Actual Coating System Thickness: 6.5 mils

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



Measuring Dry Film Thickness

- 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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