New SSPC Moisture Testing Guide and Pinhole Standard

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Moisture Testing Guide and Pinhole Standard Learning Objectives

- Identify 5 methods for determining the presence of moisture in wall assemblies
- Compare the depth of moisture detection for each of the methods and reporting units
- Explain the recommended frequencies for moisture testing
- Explain the classifications of pinholes
- Explain the pinhole examination and classification process
SSPC-Guide 23, Field Methods for the Determination of Moisture in Concrete and Masonry Walls and Ceilings, EIFS, and Stucco

- First draft January 2013
- Published July 2017

- ASTM standards available for the detection of moisture content in cementitious substrates – focus is floors
- Guide 23 fills the void for guidance on moisture content of walls
1.1 This Guide describes common field methods for the determination of moisture content in painted and unpainted exterior concrete and masonry walls (CMU, brick, stone [manufactured and natural], poured-in-place, pre-cast, and tilt-up), Exterior Insulation Finishing Systems (EIFS), stucco, and concrete and masonry ceilings (panels, planks and cast-in-place). Many of the ASTM test methods cited in this Guide were developed for use on floors, but the methods are also suitable for use on walls and ceilings. References to relevant industry standards and recommendations for selecting test locations, frequency of testing, and acceptance criteria are provided. Methods other than those included here may also be suitable for use.
SSPC-Guide 23 – Key Points of Discussion

• Procedures for conducting 5 methods of moisture detection in walls
• Table 1 - Suggested Test Frequency of Walls Prior to Painting
• Table 2 - Suitability of Test Methods/Probe Configurations on Various Substrate Types
• Table 3 - Portion of Substrate Assessed and Reporting Units
5 Test Methods for Detecting Moisture

- Method 1 - Plastic Sheet Method
- Method 2 - Electrical Impedance Moisture Meter
- Method 3 - Radio Frequency Moisture Meter
- Method 4 - Electrical Conductivity (Resistance) Moisture Meter
- Method 5 - Relative Humidity Probes
Method 1 – Plastic Sheet Method

- ASTM D4263, *Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method*
- Appendix X2.2 of ASTM F710, *Preparing Concrete Floors to Receive Resilient Flooring*
Method 1 – Plastic Sheet Method (con’t)

- Tape perimeter of sheet of polyethylene to surface
- 4 mils (0.1mm) or thicker
- Approximately 18 x 18 inches (457 x 457 mm)
- Different shape acceptable if it covers the same minimum surface area
Method 1 – Plastic Sheet Method (con’t)

- Allow to remain in place a minimum of 16 hours (and ideally 22 to 26 hours from morning to morning) and examine underside of sheet or surface for moisture
Method 1 – Plastic Sheet Method (continued)

- Variation (Appendix X2.4.4.3 of ASTM F710) suggests using a moisture meter (Methods 2, 3, or 4) before attaching the sheet, then again after removal.
Method 1 – Plastic Sheet Method (con’t)

• Cautions
  – If surface previously coated with a barrier or retarder coating, it may provide a barrier to the evaporation of moisture, providing misleading results
  – Before installation of sheet, allow surface to dry after a rain event (2 to 24 hours) or after visible evaporation of dew (min 4 hours)
  – If significant rainfall occurs during the test period, results may be void
  – Loss of adhesion of the tape can void the test
Method 2 – Electrical Impedance Meter

- Method 2 - Electrical Impedance Moisture Meter
Method 2 – Electrical Impedance Meter (con’t)

- Electrical impedance of a material varies in proportion to its moisture content.
- Electrical impedance of the concrete beneath the instrument is measured by transmitting an alternating electric field from one end of the instrument, through the substrate, to the other end of the instrument.
- Results provided as % moisture content (typically from 0 to 6%).

(Source: ASTM F2659)
Method 2 – Electrical Impedance Meter (con’t)

- Direct contact with the substrate is required so there is no loss of signal sensitivity
- Existing paint should be removed before testing, but the Guide includes a procedure for determining the effect that paint may have on the results:
  - Take readings through the paint in a 6” x 6” area
  - Mechanically remove the paint
  - Repeat the readings in the same area
  - Compare the results to determine the effect of the paint
Method 2 – Electrical Impedance Meter (con’t)

- Cautions:
  - Allow surface to dry after a rain event (2 to 24 hours) or after visible evaporation of dew (min 4 hours)
  - Reading through paint may effect the results
Method 3 – Radio Frequency Moisture Meter

- ASTM F2659, Standard Guide for Preliminary Evaluation of Comparative Moisture Condition of Concrete, Gypsum Cement and Other Floor Slabs and Screeds Using Non-Destructive Electronic Moisture Meters
- ASTM F2659 describes an electrical impedance meter (Method 2), but Appendix X2 includes a drawing of an instrument that emits a radio frequency to determine moisture content, suggesting that Method 3 is also covered by the standard

(Source: ASTM F2659)
Method 3 – Radio Frequency Moisture Meter (con’t)

- Instrument can detect moisture through existing paint
- Results are presented on a relative scale, rather than percent moisture (scale from one manufacturer below)

<table>
<thead>
<tr>
<th>Color Code</th>
<th>Meter Reading</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green Zone</td>
<td>0 to 145</td>
<td>safe air-dry conditions</td>
</tr>
<tr>
<td>Yellow Zone</td>
<td>146 to 230</td>
<td>moisture levels are higher than normal</td>
</tr>
<tr>
<td>Red Zone</td>
<td>230 to 999</td>
<td>excessive moisture levels</td>
</tr>
</tbody>
</table>
Method 3 – Radio Frequency Moisture Meter (con’t)

• **Cautions:**
  
  – Allow surface to dry after a rain event (2 to 24 hours) or after visible evaporation of dew (min 4 hours)
  
  – Certain minerals in masonry can impact the accuracy (e.g., iron ore deposits and high concentrations of salts in masonry will yield excessively high results)
  
  – Metal surfaces within the range of the sensor can yield high results (e.g., door frames, wire reinforcement in mortar joints)
  
  – Instrument must be in complete contact with the surface (no air gaps). If not, results may be lower than actual
Method 4 – Electrical Conductivity (Resistance) Meter

- Appendix X2.2 of ASTM F710, *Preparing Concrete Floors to Receive Resilient Flooring*
- Instrument measures the electrical conductivity of the substrate between two electrodes
- Conductivity varies in proportion to moisture content
Method 4 – Electrical Conductivity (Resistance) Meter (con’t)

• Measurement options:
  – Surface measurement - press electrodes directly against the surface
  – Drive masonry nails ¼” into substrate and touch electrodes to heads
  – Drill holes to desired measurement depth – use insulation probes or create probe extensions – insulate with electrical tape
  – Drill holes through block face and use insulated electrodes to examine the cavity (e.g., to examine core fill insulation)
Method 4 – Electrical Conductivity (Resistance) Meter (con’t)

• Results are presented on a relative scale, rather than percent moisture (scale from one manufacturer below)

<table>
<thead>
<tr>
<th>Color Code</th>
<th>Meter Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green Zone</td>
<td>&lt;85 units</td>
</tr>
<tr>
<td>Yellow Zone</td>
<td>85 to 95 units</td>
</tr>
<tr>
<td>Red Zone</td>
<td>&gt;95 units</td>
</tr>
</tbody>
</table>
Method 4 – Electrical Conductivity (Resistance) Meter (con’t)

• Cautions:
  – Allow surface to dry after a rain event (2 to 24 hours) or after visible evaporation of dew (min 4 hours)
  – Certain minerals in masonry can impact the accuracy (e.g., iron ore deposits and high concentrations of salts in masonry will yield excessively high results)
  – Wire reinforcing in mortar joints can cause the results to be excessively high if the probes contact the metal
  – Loosely or partially filled insulation in block cavities may reduce conductivity, providing results that are lower than actual
Method 5 – Relative Humidity Probes

- ¾” or 5/8” diameter holes are drilled into concrete to a specific depth, a plastic tube or liner inserted, and capped.
- The air space humidity reaches equilibrium in 72 hours and the RH is read at that time.
Method 5 – Relative Humidity Probes (con’t)

- The hole needs to be deep enough to provide a representative assessment of humidity
- The depth is affected by the drying conditions of the concrete structure
- There are no standards that address the depth for walls, but ASTM F2170 provides guidance for slabs, which may be of help
  - When drying from one side of the slab, the measurement depth is 40% of the depth of the slab
  - When drying from both sides of the slab, the measurement depth is 20% of the depth of the slab
Method 5 – Relative Humidity Probes (con’t)
Method 5 – Relative Humidity Probes (con’t)

- After 72 hours, remove the cap and read the RH and temperature
- If agreed upon by all parties, including the instrument manufacturer, lesser equilibrium times (as soon as a few hours) can be used to determine the approximate RH
- For lesser times, record the RH at the point where the meter does not drift by more than 1% over a 5-minute period
Method 5 – Relative Humidity Probes (con’t)

- Cautions:
  - Allow surface to dry after a rain event (2 to 24 hours) or after visible evaporation of dew (min 4 hours)
  - When used on floors, the ASTM standard requires the ambient conditions to be in balance or controlled.
  - There are no standards that establish the effect of outdoor conditions (e.g., rain, direct sunlight) on the results, but RH probes have been used to determine the approximate RH of stable dense walls
Methods for Testing Moisture Content
*Subsurface readings can be taken by driving nails into the surface or drilling holes and using insulated probes.
SSPC-Guide 23 – Comparison of Moisture Content and Relative Humidity

• Source: *Moisture in Concrete and Moisture-Sensitive Finishes and Coatings*, published by Cement Concrete & Aggregates Australia (CCAA), Sydney 2007

• Approximately 75% RH in concrete equates to a moisture content of ~2%

• CCAA states that because of the tiny capillaries in concrete, a concrete substrate can be nearly saturated with water vapor and still only register a moisture content of 5%
SSPC-Guide 23 Suitability of Test Methods by Substrate Type (Table 2)

<table>
<thead>
<tr>
<th>Substrate Types/Textures</th>
<th>Method 1 Plastic Sheet</th>
<th>Method 2 Impedance</th>
<th>Method 3 Radio Frequency</th>
<th>Method 4 Conductivity*</th>
<th>Method 5 RH Probe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poured Concrete/ Tilt up</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Precast - smooth</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Precast - textured</td>
<td>Marginal</td>
<td>Poor</td>
<td>Marginal</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Smooth CMU</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Split-faced CMU</td>
<td>Marginal</td>
<td>Poor</td>
<td>Marginal</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Grout (when surrounded by block)</td>
<td>Good</td>
<td>Poor</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>EIFS, Stucco</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Painted Surfaces</td>
<td>Marginal</td>
<td>Marginal</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
</tbody>
</table>

* For detection of moisture below the surface, holes must be drilled in the substrate. See Section 4.4.1.
SSPC-Guide 23 – Test Frequency (Table 1)

- Test each substrate type (e.g., tilt up, CMU, poured)
- Test frequencies need to properly characterize the substrate

**TABLE 1**

<table>
<thead>
<tr>
<th>Area Being Coated in a Given Day</th>
<th>Method 1 Plastic Sheet*</th>
<th>Method 2 Impedance</th>
<th>Method 3 Radio Frequency</th>
<th>Method 4 Conductivity</th>
<th>Method 5 RH**</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 10 m² (≤ 1000 ft²)</td>
<td>3 tests</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 to 500 m² (1001 to 5000 ft²)</td>
<td>5 tests</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>501 to 1000 m² (5001 to 10,000 ft²)</td>
<td>10 tests</td>
<td></td>
<td>Locate test zones every 7 to 10 m (25 to 35 ft) of wall, and test at 3 heights within each zone.</td>
<td>Same as Method 1</td>
<td></td>
</tr>
<tr>
<td>&gt; 1000 m² (&gt;10,000 ft²)</td>
<td>10 tests for first 1000 m² (10,000 ft²) plus 1 test for each additional 175 m² (2,000 ft²)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Test frequency differs from recommendations in ASTM D4263.
** One probe in cavity and one probe in mortar joint in each location.
SSPC-Guide 23 – Test Locations

- Test each environmental exposure (e.g. sheltered vs. unsheltered portion of the wall)
- When selecting locations, note that moisture content can be elevated in grouted cells, bond beam locations, mortar joints, adjacent to control joints, and around leaking gutters, downspouts and windows
Laboratory Moisture Saturation Testing

- Appendix 1 – Laboratory Moisture Saturation Testing for Walls
- Often used for historic structures where non-modern materials may effect the readings from moisture meters
Laboratory Moisture Saturation Testing (con’t)

- **Field**
  - Representative samples of substrate removed and double bagged

- **Laboratory**
  - Absolute percentage of moisture saturation determined as received and moisture readings taken (Methods 2, 3 and/or 4)
  - Sample immersed for min 48 hours
  - Percentage of moisture saturation determined and instrument readings taken upon removal from immersion and after drying for 30 to 60 minute intervals until completely dry
  - Goal is to correlate percent saturation with moisture meter readings for rapid in-situ analysis
  - Saturation level commonly considered excessive when >35%
SSPC-PA 18, Standard for Visual Evaluation of Pinholes in a Concrete or Masonry Coating

- First draft February 2014
- Sent to SSPC Board 2017
- Expect publication by Dec 2017
- Disputes occur regarding pinholes in finish coats, but no guidance has been available to classify pinholes, establish an assessment protocol, and provide acceptance criteria
- PA18 was developed to satisfy this need
SSPC-PA 18, Scope

1.1 This standard is intended for evaluation of pinholes in the cured finish coat of a single or multi-coat system. It establishes frequency categories for classification of the quantity of pinholes that occur in protective coating systems after application to concrete or masonry substrates. It provides a procedure for defining areas of applied coatings to be inspected for pinholes to assign the appropriate frequency category. Acceptance criteria for various frequency categories as determined by the service environment of the coated area are also included.
SSPC-PA 18, Definitions

- **Evaluation Zone**: An evaluation zone consists of an easily definable area such as exterior north wall or the interior south wall on the first floor or other area description agreed to by the contracted parties.

- **Evaluation Spot**: An area similar in size to one concrete masonry unit (CMU) block, approximately 20 x 46 cm (8 x 18 in) or 30 x 30 cm (12 x 12 in), having a total area of approximately 0.09 m\(^2\) (144 in\(^2\)).
SSPC-PA 18, Inspection Frequency

- Defines the number of evaluation spots to be examined based on the size of area to be painted

<table>
<thead>
<tr>
<th>Size of Area</th>
<th>Number of Evaluation Spots</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;300 sq ft</td>
<td>1 spot for each 100 sq ft</td>
</tr>
<tr>
<td>300 sq ft to &lt;1,000 sq ft</td>
<td>1 spot in 3 different 100 sq ft areas</td>
</tr>
<tr>
<td>&gt;1,000 sq ft</td>
<td>1 spot in 3 different 100 sq ft areas in each 1,000 sq ft</td>
</tr>
</tbody>
</table>
SSPC-PA 18, Inspection Distance

- Inspections at each evaluation spot are made without magnification, using normal or corrected vision, at approximately 12 inches (30 cm) from the coated surface.
SSPC-PA 18, Pinhole Classification

- Pinholes are classified based on frequency

<table>
<thead>
<tr>
<th>Classification</th>
<th>Number of Pinholes per Evaluation Spot</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>0 pinholes</td>
</tr>
<tr>
<td>Low</td>
<td>1 to 10 pinholes</td>
</tr>
<tr>
<td>Moderate</td>
<td>11 to 20 pinholes</td>
</tr>
<tr>
<td>High</td>
<td>&gt;20 pinholes</td>
</tr>
</tbody>
</table>
SSPC-PA 18, Pinhole Acceptance Criteria

- Acceptance criteria is based on service environment

<table>
<thead>
<tr>
<th>Classification</th>
<th>Service Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>Interior atmospheric coatings applied to areas such as medical, food, drug, or pharmaeutic clean rooms, or areas frequently wet or washed down</td>
</tr>
<tr>
<td></td>
<td>Immersion coatings</td>
</tr>
<tr>
<td></td>
<td>Floor coatings</td>
</tr>
<tr>
<td>Moderate or less</td>
<td>Atmospheric coatings applied to interior and exterior surfaces in general areas</td>
</tr>
</tbody>
</table>
SSPC-PA 18, Inspection Procedure

- Figure 1 describes a process for making additional evaluations around non-conforming areas to map out the extent of the deficiencies.
- Evaluations are made 3 feet (1 meter) in each direction.
Summary

- SSPC-CS 23 Field Methods for the Determination of Moisture in Concrete and Masonry Walls and Ceilings, EIFS, and Stucco

- Five Methods of Moisture Detection
  - Method 1 - Plastic Sheet Method
  - Method 2 - Electrical Impedance Moisture Meter
  - Method 3 - Radio Frequency Moisture Meter
  - Method 4 - Electrical Conductivity (Resistance) Moisture Meter
  - Method 5 - Relative Humidity Probes

- Results can not be compared - methods assess moisture at different depths within the wall and different units are used

- Test frequency depends on the size of the area to be painted, but generally ranges from 3 to 10 (Methods 1 and 5), and at 3 different heights every 25 to 35 lineal feet of wall length (Methods 2, 3, 4)

- Non-confirming areas are further examined to determine extent of the deficiency
Summary (con’t)

- SSPC-PA 18, Standard for Visual Evaluation of Pinholes in a Concrete or Masonry Coating. Five Methods of Moisture Detection
- Pinhole classifications per evaluation spot (area equivalent to block face):
  - None 0 pinholes
  - Low 1 to 10 pinholes
  - Moderate 11 to 20 pinholes
  - High >20 pinholes
- Examine without magnification at approximately 12 inches (30 cm) from the surface
- Number of evaluation spots is based on size of area being examined, ranging from 1 spot per 100 square feet (10 square meters) to 3 spots per 1,000 square feet (100 square meters)
- Extent of non-complying areas is determined by making additional inspections 3 feet (1 meter) in each direction until all spots are found to be compliant
Questions?

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