



# Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using *in situ* Probes<sup>1</sup>

This standard is issued under the fixed designation F 2170; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This test method covers the quantitative determination of percent relative humidity in concrete slabs for field or laboratory tests.

1.2 The values given in parentheses are for information only.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

Specific warnings are given in Section 7, 10.3.2, and 10.4.4.

## 2. Referenced Documents

### 2.1 ASTM Standards:

C 511 Specification for Moist Cabinets, Moist Rooms, and Water Storage Tanks<sup>2</sup>

E 104 Practice for Maintaining Constant Relative Humidity by Means of Aqueous Solutions<sup>3</sup>

F 710 Practice for Preparing Concrete Floors to Receive Resilient Flooring<sup>4</sup>

## 3. Terminology

### 3.1 Definitions:

3.1.1 *relative humidity, n*—ratio of the amount of water vapor actually in the air compared to the amount of water vapor required for saturation at that particular temperature and pressure, expressed as a percentage.

3.1.2 *service temperature and relative humidity, n*—average ambient air temperature and relative humidity that typically will be found in a building's occupied spaces during normal use.

## 4. Summary of Test Method

4.1 This test method comprises two procedures for forming holes in concrete into which a relative humidity probe is

placed. Procedure A for hardened concrete involves drilling a cylindrical hole in concrete with a rotary hammerdrill, then placing a hollow sleeve to line the hole. Procedure B is an alternative procedure for fresh concrete, which involves forming a cylindrical hole in concrete by placing a hollow cylindrical tube in the formwork, then placing and consolidating concrete around the tube. The liner or tube permits measurement of RH at a specific, well-defined depth in the concrete.

4.2 Methods of probe calibration and factors affecting equilibration are described in Section 8.

## 5. Significance and Use

5.1 Moisture permeating from concrete floor slabs affects the performance of flooring systems such as resilient and textile floor coverings and coatings. Manufacturers of such systems generally require moisture testing to be performed before installation on concrete. Internal relative humidity testing is one such method.

5.2 Excessive moisture permeating from floor slabs after installation can cause floor covering system failures such as debonding and deterioration of finish flooring and coatings and microbial growth.

5.3 Moisture test results indicate the moisture condition of the slab only at the time of the test.

## 6. Apparatus

6.1 *Humidity Probe and Digital Meter*, with relative humidity and temperature sensors in cylindrical probe, with external diameter less than approximately 0.75 in. (20 mm), and accuracy  $\pm 2$ -3 % from 0 to 100 % relative humidity. Obtain probes from a manufacturer with a NIST-traceable calibration certificate stating the range of calibration and the accuracy over that range. Probes shall be calibrated at 95 % relative humidity or higher, in addition to lower relative humidity levels.

NOTE 1—Calibration by end-users using saturated salt solutions in accordance with Practice E 104 is not recommended due to the technical difficulties of maintaining sufficiently accurate reference standards. Checking with salt solutions is an acceptable method of assessing probe performance.

6.2 *Hole Liners*, plastic or non-corroding metal tubes, inside diameter not more than 0.04 in. (1 mm) greater than the probe's external diameter, of sufficient length to seal the hole to the desired depth.

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee F06 on Resilient Floor Coverings and is the direct responsibility of Subcommittee F06.40 on Practices.

Current edition approved July 10, 2002. Published September 2002.

<sup>2</sup> *Annual Book of ASTM Standards*, Vol 04.01.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 11.03.

<sup>4</sup> *Annual Book of ASTM Standards*, Vol 15.04.

NOTE 2—Liners with projecting circumferential fins at the bottom end are desirable to provide a seal near the bottom of the hole.

6.3 *Rotary Hammerdrill, Carbide Drill Bits, Vacuum Cleaner Equipped with HEPA Filter, and Brush*, for drilling holes in concrete and removing drilled dust from the holes. Drill bit diameter shall not exceed 0.04 in. (1 mm) larger than the external diameter of the hole liner.

## 7. Hazards

7.1 *Silica and Asbestos Warning*—Do not sand, dry sweep, dry scrape, drill, saw, beadblast, or mechanically chip or pulverize existing resilient flooring, backing, lining felt, paint, asphaltic cutback adhesives, or other adhesives. These products may contain asbestos fibers or crystalline silica. Avoid creating dust. Inhalation of such dust is a cancer and respiratory tract hazard. Smoking by individuals exposed to asbestos fibers greatly increases the risk of serious bodily harm. Unless positively certain that the product is a nonasbestos-containing material, presume that it contain asbestos. Regulations may require that the material be tested to determine asbestos content. The Resilient Floor Covering Institute's (RFCI) recommended work practices for removal of existing resilient floor coverings should be consulted for a defined set of instructions addressed to the task of removing all resilient floor covering structures.<sup>5</sup>

7.2 *Lead Warning*—Certain paints may contain lead. Exposure to excessive amounts of lead dust presents a health hazard. Refer to applicable federal, state, and local laws and guidelines for hazard identification and abatement of lead-based paint published by the U.S. Department of Housing and Urban Development regarding appropriate methods for identifying lead-based paint and removing such paint, and any licensing, certification, and training requirements for persons performing lead abatement work.<sup>6</sup>

7.3 *Wet Concrete Warning*—Contact with wet (unhardened) concrete, mortar, cement, or cement mixtures can cause skin irritation, severe chemical burns, or serious eye damage. Wear waterproof gloves, a long-sleeved shirt, full-length trousers, and proper eye protection when working with these materials. If you have to stand in wet concrete, use waterproof boots that are high enough to keep concrete from flowing into them. Wash wet concrete, mortar, cement, or cement mixtures from your skin immediately after contact. Indirect contact through clothing can be as serious as direct contact, so promptly rinse out wet concrete, mortar, cement, or cement mixtures from clothing. Seek immediate medical attention if you have persistent or severe discomfort.

## 8. Calibration

8.1 Recalibrate probes at least annually or more frequently if exposed to environmental conditions that affect measurement accuracy.

<sup>5</sup> *Recommended Work Practices for Removal of Resilient Floor Coverings*, Resilient Floor Covering Institute, 401 East Jefferson St., Suite 102, Rockville, MD 20850.

<sup>6</sup> *Lead-Based Paint: Interim Guidelines for Hazard Identification and Abatement in Public and Indian Housing*, U.S. Department of Housing and Urban Development, NTIS Order Number PB91-144311. Available online from [www.fed-world.gov](http://www.fed-world.gov).

8.2 Check probe calibration within 30 days before use by either of the two following procedures:

8.2.1 *Calibration Check Procedure 1, Saturated Salt Solutions*—Prepare saturated salt solutions in accordance with Practice E 104. Follow probe manufacturer's recommended procedure for exposing probes. Record the as-found relative humidity and the nominal relative humidity of the salt solutions. If the as-found relative humidity differs from the nominal relative humidity by more than 2 % (below 90 % relative humidity) or by more than 3 % (from 90 to 100 % relative humidity), recalibrate the probe before use.

8.2.2 *Calibration Check Procedure 2, Compressed Dry Air and Moist Room*:

8.2.2.1 *0 % Relative Humidity*—Connect one end of a tube to a compressed gas cylinder containing zero-grade or drier compressed air or an inert gas such as nitrogen. Insert the relative humidity probe into the other end of the tube. Allow the gas to flow at several millilitres per minute until the probe reaches equilibrium (less than 1 % relative humidity drift in 5 min). Record the percent relative humidity.

8.2.2.2 *100 % Relative Humidity*—Place the probe in a moist room or chamber meeting the requirements of Specification C 511 for at least 30 min. Allow the probe to reach equilibrium (less than 1 % relative humidity drift in 5 min). A thin, moisture vapor permeable membrane surrounding the sensing element will inhibit condensation on the sensing element. If condensation occurs, remove the probe from the moist environment and allow to dry before repeating the measurement. Record the percent relative humidity.

8.2.2.3 If checking reveals the probe output differs from 0 by more than 2 % or from 100 % by more than 3 %, recalibrate the probe before use.

## 9. Conditioning

9.1 Concrete floor slabs shall be at service temperature and the occupied air space above the floor slab shall be at service temperature and service relative humidity for at least 48 h before making relative humidity measurements in the concrete slab.

## 10. Procedure

10.1 *Number of Tests and Locations*:

10.1.1 Perform three tests for the first 1000 ft<sup>2</sup> (100 m<sup>2</sup>) and at least one additional test for each additional 1000 ft<sup>2</sup> (100 m<sup>2</sup>).

10.1.2 Select test locations to provide information about moisture distribution across the entire concrete floor slab, especially areas of potential high moisture. For slabs on-grade and below-grade, include a test location within 1 m (3 ft) of each exterior wall.

10.2 Determine the appropriate depth for probe holes from the following table:

| Drying Conditions   | Drill-to Depth from Top of Slab                                       |
|---|---|
| Slab drying from top only<br>(Example: slab on ground with vapor retarder below, or slab on metal deck) | 40 %<br>(Example: 1.5 in. (40 mm) deep in 4-in. (100-mm) thick slab)  |
| Slab drying from top and bottom<br>(Example: elevated structural slab not in metal deck)                | 20 %<br>(Example: 0.75 in. (20 mm) deep in 4-in. (100-mm) thick slab) |

NOTE 3—Testing at these depths will indicate the potential equilibrium

relative humidity that will be established within the concrete slab after a low-permeability floor covering is applied.

### 10.3 Procedure A—Drilled Holes:

10.3.1 Use a rotary hammerdrill with a carbide-tipped drill bit to drill holes to required depth. Drill bit diameter shall not exceed 0.04 in. (1 mm) larger than the external diameter of the hole liner. Hole shall be drilled dry. Do not use water for cooling or lubrication; do not wet-core test hole.

10.3.2 Remove dust from the hole using a vacuum cleaner. (**Warning**—Avoid blowing dust from the hole that might become respirable. Wear respiratory protection if necessary to avoid breathing concrete dust while drilling and cleaning holes.)

10.3.3 Insert hole liner to bottom of hole. Place rubber stopper into upper end of liner and seal around liner to concrete at concrete surface with joint sealant, caulk, or gasketed cover.

10.3.4 Allow 72 h to achieve moisture equilibrium within the hole before making relative humidity measurements.

10.3.5 Continue the determination of relative humidity in accordance with 10.5.

NOTE 4—Measurement of relative humidity on concrete powder collected from a drilled hole does not produce results of sufficient accuracy to meet the purposes described in Significance and Use.

### 10.4 Alternative Procedure B—Cast Holes:

10.4.1 Before placing concrete, secure liner tube to formwork or steel reinforcement to avoid displacement of tubes during concrete placement, consolidation, and finishing.

10.4.2 Secure a solid rod slightly smaller than the inner diameter of the liner into the liner so that the bottom end of the rod is flush with the bottom end of the liner at measurement depth and the top end protrudes above the top of the liner. This rod will exclude fresh concrete from entering the liner during concrete placement and consolidation.

10.4.3 Place, consolidate, and finish the concrete, ensuring the liner remains at required depth. Remove the inner solid rod after the concrete hardens and place a rubber stopper into the upper end of the liner.

10.4.4 Holes formed by casting liners in fresh concrete can be used to measure relative humidity as soon as the concrete hardens. (**Warning**—Holes formed in fresh concrete might contain highly alkaline solution (pH>12) that must be removed before placing probes. This solution can cause chemical burns on exposed skin. Remove solution from a hole using a sponge or rag. Wear protective eyewear and gloves. Handle soaked rags or sponges with care. Do not use compressed air to blow solution out of holes.)

### 10.5 Measurement:

10.5.1 Remove the rubber stopper at the top of the liner and insert probe. Seal the probe lead wire to the liner where the wire emerges from the top of the liner. Connect the probe lead wire to the meter, turn on the meter and allow it to warm up as indicated by the manufacturer's instructions.

10.5.2 Allow probe to reach temperature equilibrium before measuring relative humidity. Probe shall be at the same temperature as the concrete before reading. Even a small

difference in temperature will produce a significant error in relative humidity measurement.

10.5.3 Check for drift. Meter reading must not drift more than 1 % relative humidity over 5 min. Equilibration may take several hours to several days depending on factors such as the initial temperature difference between probe and concrete. The meter can be turned off and disconnected from the probe while the probe equilibrates with the concrete.

10.5.4 Record the relative humidity to the nearest percent and temperature to the nearest degree Celsius (Fahrenheit). Also record the location of the hole within the structure and depth of the probe tip below the concrete surface to the nearest 0.04 in. (mm).

10.5.5 Use the relative humidity probe to measure the ambient air temperature and relative humidity above the slab in the vicinity of the hole. Record the relative humidity to the nearest percent, and temperature to the nearest degree Fahrenheit (Celsius).

10.6 Remove the hole liner and fill the hole with a cementitious patching compound to produce a surface finish in accordance with Practice F 710, in Paragraph 4.5 under General Guidelines. Use a patching compound rated by its manufacturer as suitable for the depth of patch.

## 11. Report

11.1 Report the following information:

11.1.1 Name and address of the structure.

11.1.2 Date and time measurements were made.

11.1.3 Name, title, and affiliation of worker performing the measurements.

11.1.4 Locations and depths of probe holes within the structure.

11.1.5 Relative humidity in each probe hole, to the nearest percent relative humidity.

11.1.6 Temperature in each probe hole, to the nearest degree Celsius (Fahrenheit).

11.1.7 Ambient air temperature, to the nearest degree Celsius (Fahrenheit) and relative humidity (to the nearest percent relative humidity) above each probe hole.

11.1.8 Make, model, and last calibration date of the instrument used to make the measurements.

11.2 Report any observations that might affect the interpretation of individual measurements such as standing water on the slab, wet coring operations, weather, or ventilating system operations.

## 12. Precision and Bias

12.1 Precision of this test method is being determined.

12.2 Bias is affected by accuracy of probe calibration and can be strongly affected by equilibration of probes in the concrete. Measurements made too soon after placing a probe in a drilled hole may be significantly higher or lower than measurements made under equilibrium conditions.

## 13. Keywords

13.1 concrete; flooring; floors; moisture; relative humidity

**APPENDIX**

**(Nonmandatory Information)**

**X1. EXAMPLE REPORT FORM**

**REPORT OF RELATIVE HUMIDITY IN CONCRETE**

|                                      |                       |
|--------------------------------------|-----------------------|
| <i>Name and address of structure</i> | <i>Identify Floor</i> |
|--------------------------------------|-----------------------|

| Test Location (use room numbers or building grid) | Depth from top of slab, in. | Relative Humidity in concrete, % | Temperature in concrete, °F | Air Temperature, °F | Air Relative Humidity, % | Notes |
|---|-----------------------------|----------------------------------|-----------------------------|---------------------|--------------------------|-------|
|   |                             |                                  |                             |                     |                          |       |
|   |                             |                                  |                             |                     |                          |       |
|   |                             |                                  |                             |                     |                          |       |
|   |                             |                                  |                             |                     |                          |       |
|   |                             |                                  |                             |                     |                          |       |
|   |                             |                                  |                             |                     |                          |       |
|   |                             |                                  |                             |                     |                          |       |
|   |                             |                                  |                             |                     |                          |       |
|   |                             |                                  |                             |                     |                          |       |
|   |                             |                                  |                             |                     |                          |       |
|   |                             |                                  |                             |                     |                          |       |

*Instrument Used*

|                            |                       |
|----------------------------|-----------------------|
| Make, Model, Serial number | Last calibration date |
|----------------------------|-----------------------|

*Tests performed by*

|                       |      |
|-----------------------|------|
| Name                  | Date |
| Company name, address |      |

## RELATED MATERIAL

BS5325:1996, *Code of Practice for Installation of Textile Floor Coverings*.

BS8203:1996, *Code of Practice for Installation of Resilient Floor Coverings*.

Hedenblad, G., "Drying on Construction Water in Concrete," T9:1997, Swedish Council for Building Research, 1997. (Available from Svensk Byggtjänst, Stockholm.)

Molina, L., *Measurement of High Humidity in Cementitious Material at an Early Age*, CBI Report 3:90, Swedish Cement and Concrete Research Institute, 1990.

New Zealand Federation of Master Flooring Contractors and New Zealand Concrete Research Association, *Manual of Practices and Conditions for the New Zealand Flooring Industry: Concrete Floor Construction*, Wellington, NZ, 1984.

Nordtest Method NT BUILD 439, *Concrete Hardened: Relative Humidity Measured in Drilled Holes*.

*ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.*

*This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.*

*This standard is copyrighted by ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or service@astm.org (e-mail); or through the ASTM website (www.astm.org).*