



Designation: F2170 – 16b

Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using in situ Probes¹

This standard is issued under the fixed designation F2170; 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 (ϵ) 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 stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

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:*²

[E104 Practice for Maintaining Constant Relative Humidity by Means of Aqueous Solutions](#)

[E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods](#)

[F710 Practice for Preparing Concrete Floors to Receive Resilient Flooring](#)

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.

¹ 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.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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 Excessive moisture in floor slabs after floor covering has been installed can cause floor covering system failures such as debonding, peaking and deterioration of finish flooring and coatings and microbial growth.

5.2 Manufacturers of such systems generally require moisture testing to be performed before installation on concrete. Internal relative humidity testing is one such method.

5.3 Moisture test results indicate the moisture condition of the slab only at the time of the test and in the specific locations tested.

6. Apparatus

6.1 *Hole Liner*, made of plastic or non-corroding metal. The liner shall have the shape of a hollow right circular cylinder and shall be between 0.37 to 0.75-in. (10 to 20 mm) outside diameter.

6.1.1 The liner shall have a solid sidewall that is open only at the bottom and at the top. Slots, holes, or other penetrations in the sidewall of the liner are not permitted. Two or more deformable circumferential fins located around the exterior circumference near the bottom of the liner shall be provided to

create a positive seal against the concrete. The liner shall be of sufficient length to extend from the bottom diameter of the hole to the surface of the concrete. See Fig. 1.

NOTE 1—The purpose of the liner is to isolate the probe from the sidewall of the hole so that moisture only enters into the sensor from a specific depth at the bottom of the hole. The specified diameter range will usually permit the hole to intersect a sufficient volume of cement paste to provide adequate moisture interaction with the sensor for accurate measurement. Smaller diameter holes may intersect only a single aggregate particle at the bottom of the hole and therefore produce inaccurate results. If the user observes that the bottom of the hole is occupied by a single aggregate particle, do not use that hole.

6.2 *Humidity Probe and Digital Meter*—Relative humidity and temperature sensors in cylindrical probe, designed such that when the probe is installed to its full depth within the hole liner, the following geometrical considerations shall be met:

6.2.1 The sensing elements of the probe shall be located within 0.625 ± 0.125 in. (15.9 ± 3 mm) of the base of the liner and the probe sealed or gasketed within itself and the liner such that the volume of air being measured cannot escape upward beyond 0.625 ± 0.125 in. (15.9 ± 3 mm) within the probe itself or the liner. See Fig. 2.

6.2.2 Obtain probes from a manufacturer with NIST traceable calibration equal to or better than ± 2 % relative humidity at 50 % relative humidity and ± 2 % relative humidity at 90 % relative humidity.

NOTE 2—Calibration by end-users using saturated salt solutions in accordance with Practice E104 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.

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. Use of dust collection equipment and appropriate personal protective equipment such as an approved respirator may be required to control worker exposure to respirable crystalline silica produced from drilling concrete. 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.³

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.⁴

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.

8.2 Check probe calibration within 30 days before use by the following procedure:

8.2.1 *Calibration Check Procedure, Saturated Salt Solutions*—Prepare saturated salt solutions in accordance with Practice E104. Follow probe manufacturer’s recommended procedure for exposing probes. Check probes at relative humidity (RH) equal to or greater than 75 % RH. Record the as-found relative humidity of the probe and the nominal

³ *Recommended Work Practices for Removal of Resilient Floor Coverings*, Resilient Floor Covering Institute, 401 East Jefferson St., Suite 102, Rockville, MD 20850.

⁴ *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.

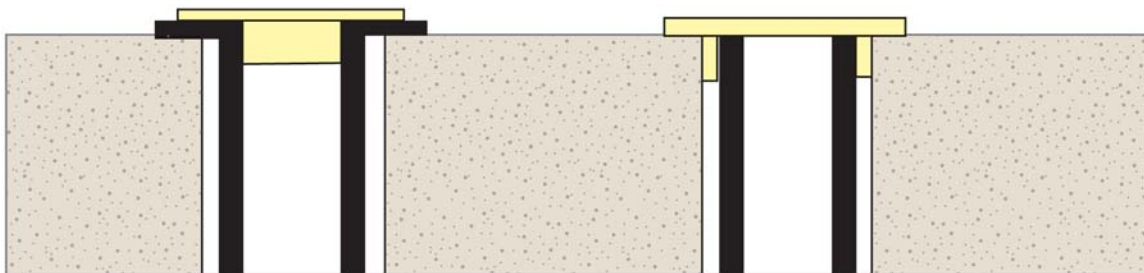


FIG. 1 Example Hole with Liner

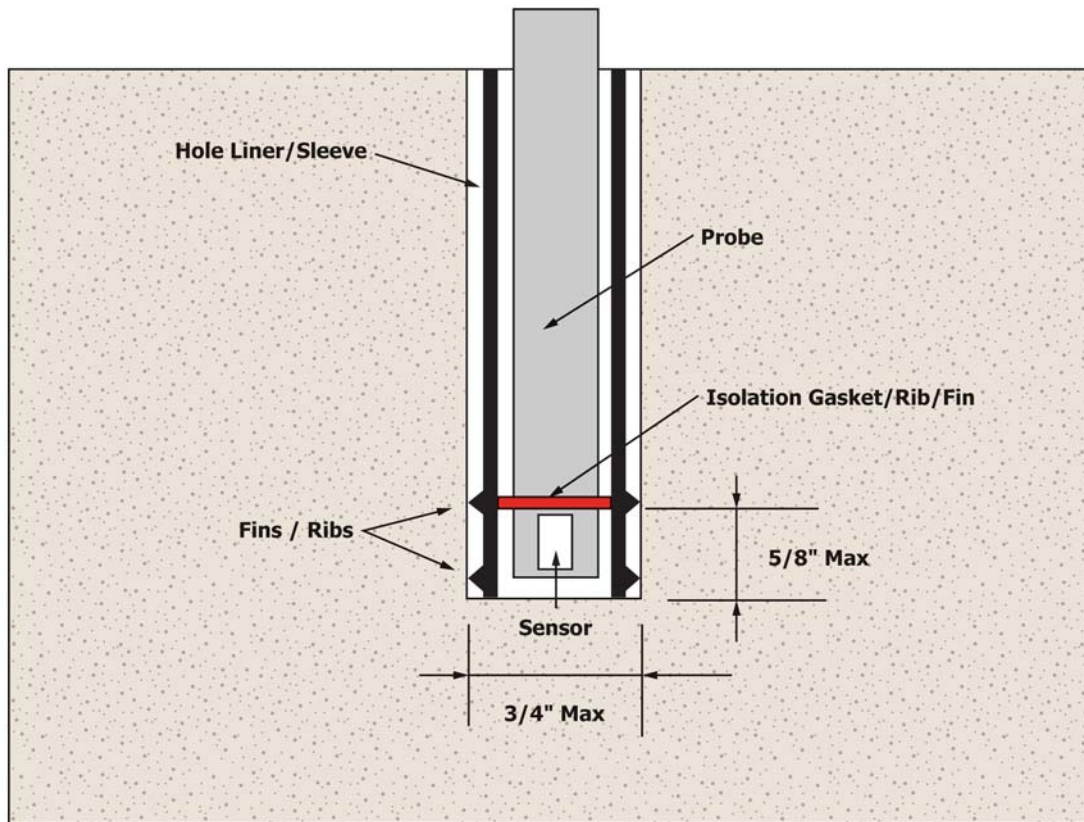


FIG. 2 Example % RH - Probe Element Position

relative humidity of the salt solutions. If the as-found relative humidity differs from the nominal relative humidity by more than 2 % RH (below 90 % relative humidity) or by more than 3 % RH (from 90 to 100 % relative humidity), recalibrate the probe before use or discard.

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 ft² (100 m²) and at least one additional test for each additional 1000 ft² (100 m²).

10.1.2 Select test locations to provide information about moisture distribution across the entire concrete floor slab, especially areas of potential high moisture. 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 (Example: slab on ground with vapor retarder below, or slab on metal deck)	40 % (Example: 1.5 in. (40 mm) deep in 4-in. (100-mm) thick slab)
Slab drying from top and bottom (Example: elevated structural slab not in metal deck)	20 % (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 a 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 F710, 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 holes were drilled, time in hours that probes equilibrated in holes, and date and time when 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 The precision of this test method is based on an interlaboratory study of Test Method F2170, conducted in March 2014. Six analysts participated in the study, testing randomly spaced locations on two concrete slabs. Each analyst was asked to report eighteen test results for this study. Practice E691 was followed for the study design; the details are given in an ASTM Research Report.⁵

12.1.1 *Repeatability limit (r)*—Two test results obtained within one laboratory shall be judged not equivalent if they differ by more than the “*r*” value for that material; “*r*” is the interval representing the critical difference between two test results for the same property, obtained by the same operator using the same equipment on the same day in the same laboratory.

12.1.1.1 Repeatability limits are listed in Table 1.

12.1.2 *Reproducibility limit (R)*—Two test results shall be judged not equivalent if they differ by more than the “*R*” value for that material; “*R*” is the interval representing the critical difference between two test results for the same property, obtained by different operators using different equipment in different laboratories.

12.1.2.1 Reproducibility limits are listed in Table 1.

⁵ Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:F06-1011. Contact ASTM Customer Service at service@astm.org.

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*.

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