Designation: C1789 – 14

Standard Test Method for Calibration of Hand-Held Moisture Meters on Gypsum Panels[1]

This standard is issued under the fixed designation C1789; 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 applies to the calibration of handheld moisture meters for gypsum board, glass faced gypsum panels and fiber-reinforced gypsum panels by means of electrical conductance and dielectric meters. The test uses wetted test specimens which are dried down in at least 5 steps to determine the moisture content based on the weight loss in comparison to the dry weight. The test also supplies the ERH values for each of the drying steps.

1.2 This test method has not been evaluated for the influence of paint or wall covering materials on the indicated moisture content of a gypsum board or panel substrate.

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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C473 Test Methods for Physical Testing of Gypsum Panel Products
C1177 Specification for Glass Mat Gypsum Substrate for Use as Sheathing
C1178 Specification for Coated Glass Mat Water-Resistant Gypsum Backing Panel
C1278 Specification for Fiber-Reinforced Gypsum Panel
C1396 Specification for Gypsum Board
D4442 Test Methods for Direct Moisture Content Measurement of Wood and Wood-Base Materials
D4444 Test Method for Laboratory Standardization and Calibration of Hand-Held Moisture Meters

2.2 *ASHRAE Standard:*[3]

2009 ASHRAE Handbook – Fundamentals, Chapter 1 – Psychrometrics, American Society of Heating, Refrigerating and Air-conditioning Engineers

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *absolute humidity, d_v, n*—the ratio of the mass of water vapor to the total volume of the moist air sample.

3.1.2 *admittance, n*—inverse of impedance, a measure of how easily an electric current can flow through a material.

3.1.3 *conductance meters, n*—conductance meters are those that measure predominantly ionic conductance between points of applied voltage, usually dc.

3.1.3.1 *Discussion*—Conductance meters generally have pins that penetrate into the material being measured. Direct-current conductance meters are commonly referred to as "resistance" meters. Most commercial conductance meters are high-input impedance (about 10^{12} Ω), wide-range (10^4 to 10^{12} Ω) ohmmeters. Their scales are generally calibrated to read directly in moisture content (oven-dry mass basis) for a particular calibration material and at a specific reference temperature.

3.1.4 *dew-point temperature, t_d, n*—the temperature at which a sample of moist air being cooled at constant pressure and moisture content reaches 100 percent relative humidity.

3.1.4.1 *Discussion*—The dew-point temperature is the temperature at which water condensation begins to occur on a cooled surface in contact with moist air.

3.1.5 *dielectric meters, n*—meters that measure primarily by admittance or power loss.

3.1.5.1 *Discussion*—Dielectric meters generally do not have pins that penetrate into the material being measured. There are two general types of dielectric meters that may be arbitrarily categorized by their predominant mode of response – admittance (or capacitance) and power loss. Both have surface contact electrodes and readout scales that are usually marked in

[1] This test method is under the jurisdiction of ASTM Committee C11 on Gypsum and Related Building Materials and Systems and is the direct responsibility of Subcommittee C11.01 on Specifications and Test Methods for Gypsum Products.

Current edition approved June 1, 2014. Published July 2014. Originally approved in 2013. Last previous edition approved in 2013 as C1789 – 13. DOI: 10.1520/C1789-14.

[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] Available from American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE), 1791 Tullie Circle, NE, Atlanta, GA 30329, http://www.ashrae.org.

arbitrary units. Most dielectric meters operate in the r-f frequency range, generally between 1 and 10 MHz. Admittance meters respond primarily to the capacitance (dielectric constant) of the material being measured. Power loss meters react primarily to the resistance of the material. Readings of dielectric meters are significantly affected by the relative density (specific gravity) of the specimen material.

3.1.6 *equilibrium moisture content, EMC, n*—the moisture content of a material that is in thermodynamic equilibrium with the surrounding air at a given temperature and relative humidity.

3.1.7 *equilibrium relative humidity, ERH*—the relative humidity of the air in a sealed chamber that is in thermodynamic equilibrium with a sample of material in that chamber.

3.1.8 *humidity ratio, W, n*—the ratio of the mass of water vapor to the mass of dry air contained in a sample of moist air.

3.1.9 *moisture content, MC, n*—the ratio of the mass of water in a material to the oven-dry mass of the sample expressed as a decimal fraction or percentage.

3.1.9.1 *Discussion*—Oven-dry refers to the removal by heating of all adsomcrbed and free water in the interstitial pores of the material. Crystalline water such as contained in gypsum molecules is not included.

3.1.10 *relative humidity, ϕ, n*—the ratio of the amount of water vapor in air to the amount of water vapor in saturated air at the same temperature and pressure.

3.1.10.1 *Discussion*—Equivalent to the ratio of the partial pressure of water vapor in the air to the saturated vapor pressure at the same temperature and pressure.

3.1.11 *test uncertainty ratio, TUR, n*—comparison between the accuracy of the Unit Under Test (UUT) and the estimated calibration uncertainty stated with a confidence level of 95 % (K=2).

3.1.12 *water activity, A_w, n*—the ratio of the water vapor pressure in a material to the vapor pressure of pure water at the same temperature.

3.1.12.1 *Discussion*—Water activity is an intrinsic property derived from fundamental principles of thermodynamics and physical chemistry. It is a measure of the energy status of the water in a system. Commonly used for food preservation analyses, it can be interpreted here as the amount of water in a porous material that is available to impact the performance characteristics of the material or to support mold growth.

4. Summary of Test Method

4.1 These test methods provide a method for calibrating the scale on conductance and dielectric meters for various types of gypsum boards and panels for use in field measurement of moisture content during storage, construction and use in building assemblies.

4.2 The calibration is based on the MC of the test specimen. The corresponding ERH is determined by use of a calibrated direct read relative humidity meter.

4.3 ERH is essentially equivalent to water activity Aw which is a measure of the amount of moisture in a material that is available to impact the performance characteristics of that material.

4.4 Due to the various core and/or facing additives that are used to modify the moisture absorption characteristics, strength and/or other properties for specific applications, a separate calibration is required for each type of gypsum board or panel to be measured.

4.5 The test method has the following steps:

4.5.1 Measure the dry weights of the test specimens.

4.5.2 Determine the time step for the drying intervals that will provide sufficient data points to develop a calibration curve.

4.5.3 Saturate the samples with water.

4.5.4 Dry the samples in steps, recording after each interval the moisture content by weight of each sample and the temperature, relative humidity (ERH), and absolute humidity of the atmosphere in moisture equilibrium with each sample.

5. Significance and Use

5.1 This Standard Test Method is intended for use in calibrating hand-held meters to accurately read from approximately 30 to 90% ERH. Moisture content is related to the ERH or water activity of a material.

5.2 Hand-held meters provide a rapid means of sampling the moisture content of gypsum boards and panels during manufacture and for field inspection during and after building construction. However, these measurements are inferential, that is, electrical parameters are measured and compared against a calibration curve to obtain an indirect measure of moisture content. The electrical measurements are influenced by the actual moisture content, a number of other gypsum board and panel variables, environmental conditions, the geometry of the measuring probe, and the design of the meter. The maximum accuracy can only be obtained by an awareness of the effect of each parameter on the meter output and correction of readings as specified by these test methods.

5.3 Electrical conductance and dielectric meters are not necessarily equivalent in their readings under the same conditions. When this test method is referenced, the type of meter that is being used must be reported with the relevant ranges for precision and bias as specified in this standard.

5.4 Both types of meters are to be calibrated with respect to ERH as described in this standard.

6. Apparatus

6.1 Laboratory equipment for moisture content determination by direct method:

6.1.1 *Forced Air Oven*—Vented electric furnace capable of maintaining a steady-state temperature of 45 ± 3°C (113 ± 5°F).

6.1.2 *Environmental Chamber*—Chamber capable of maintaining a controlled temperature of 20 ± 2ºC (68 ± 4ºF) and relative humidity within the range 30 to 90 % ± 5 %.

6.1.3 *Electronic Balance or Scale*—Electronic scale capable of weighing each test specimen to within ±0.10 g (±0.0035 oz).

6.1.4 *Relative Humidity Test Meter*—The meter shall be capable of reading between 30 and 90 % relative humidity. The calibrated test uncertainty ratio (TUR) of this meter shall not be less than 4:1 over the range of measure cited.

6.1.4.1 Meter shall have removable temperature/humidity probes that can be sealed into sealed plastic bags.

6.1.5 *Humidity Box*—Insulated box made of materials impervious to water vapor such as plastic or sheet metal, sealed with a gasketed lid. Open trays of clean, distilled water are positioned in the box so as to keep the atmosphere within the box saturated with water vapor. Open mesh shelving or racks are used to support samples above the water.

6.1.6 *Zip Sealed Plastic Bags*—Commercially available plastic freezer weight plastic food storage bag with a zipper type closure that seals and prevents water vapor transmission.

6.1.7 *Psychrometric Chart*—Graphical presentation of the thermodynamic properties of moist air.

7. Laboratory Calibration

7.1 This procedure is designed for full-scale calibration of the meter. A minimum of 45 calibration specimens shall be fabricated with a target of ten (10) calibration steps ranging from ERH of 30 to 90 %.

NOTE 1—30% relative humidity represents a practical lower limit on moisture content found in buildings and the accuracy of readings above 90% relative humidity is problematic. The calibration should not be extrapolated below the lowest value tested or above the highest value tested. Material of the type to be calibrated shall be prepared and tested in a manner that is consistent with the following calibration procedures.

7.2 Specimens shall be free of visible irregularities.

7.3 Select a minimum of 45 specimens, each measuring 100 mm wide by 200 mm long (4 in. by 8 in.), for each given sample of board or panel.

7.3.1 The specimens shall be divided into a minimum of three (3) groups of 15 specimens each.

7.3.2 Each specimen shall be assigned a group designation and a specimen number (for example., A-1, A-2, A-3, B-1, B-2, B-3, etc.) and labeled with a pencil or waterproof ink.

8. Determine Dry Specimen Weights and Equilibrium Humidity Ratios

8.1 Determine the dry weight of each specimen.

8.1.1 Place the test specimens into forced air oven set at 45 °C (113 °F). Arrange the specimens so that heated air circulates freely around all sides of the specimens. Use racks or holders to keep the specimens separated sufficiently to allow air flow between the specimens.

8.1.2 Remove and weigh each test specimen at one hour intervals.

8.1.3 The test specimen is deemed to be dry when three consecutive weighings show no change in weight within ±0.10 percent of the dried sample weight.

8.1.4 Record the dry weight of each specimen.

8.2 Determine the humidity ratio of the trapped environment that is in moisture equilibrium with each specimen.

NOTE 2—Humidity ratio is used as the temperature is likely to vary during the course of the test and relative humidity will vary with temperature at constant moisture content. Humidity ratio and dew-point temperature do not vary with temperature at constant moisture content and can be calculated from the temperature and relative humidity values measured by direct read instruments.

8.2.1 Place the specimen in a zip sealed plastic bag to contain it in a trapped atmosphere.

8.2.2 Insert a temperature/relative humidity probe through the wall of the bag and seal tightly.

NOTE 3—Making a small slit in the side of the bag to stretch around the relative humidity probe has proven to provide a reliable seal.

8.2.3 Record the temperature and relative humidity within the bag at one hour intervals.

8.2.3.1 Calculate the humidity ratio using a psychrometric chart or a table of thermodynamic properties of moist air.

8.2.3.2 Record the dry specimen temperature, relative humidity and humidity ratio when three consecutive measurements show no change in humidity ratio as calculated from the meter readings.

9. Saturate the Test Specimens

9.1 As the moisture level for physical damage is an ERH of 80 % (A_w of 0.8) the test specimens must be saturated above this point as a starting point for calibration. The target saturation level is 95 % relative humidity at 20°C (68°F).

9.2 Place specimens in a water vapor saturated atmosphere in an environmental chamber or humidity cabinet with relative humidity equal to or greater than 95 % at 20°C (68°F).

9.2.1 Document the environmental chamber conditions using a calibrated relative humidity sensor.

9.3 Maintain specimens in the water saturated atmosphere until they reach moisture equilibrium with the atmosphere.

9.3.1 Maintain specimens in chamber or cabinet until relative humidity stabilizes at a reading of 95 % or greater.

9.3.2 Remove each specimen and weigh at eight (8) hour intervals.

9.3.2.1 Determine the weight of water in the specimen by subtracting the dry weight of the sample as determined according to Section 8 above.

9.3.2.2 Calculate the specimen moisture content by dividing the weight of water in the sample by the dry weight of the sample and multiplying by 100.

9.3.3 The test specimens are deemed to be saturated when three consecutive weighings show no change in moisture content within ± 0.10 percent.

9.3.4 The length of time required to saturate the specimens can be reduced by soaking each specimen in a saturated gypsum solution long enough to visibly saturate the paper faces of the panel. Soak for no more than one (1) hour.

9.4 After the specimens are saturated determine the absolute humidity of the trapped environment that is in moisture equilibrium with each specimen. Humidity ratio (or absolute humidity) is used for this purpose as relative humidity varies with temperature, and temperature is likely to vary during the course of the test. Humidity ratio, absolute humidity and dew point temperature do not vary with air temperature at constant moisture contents and can be calculated from the temperature and relative humidity that are measured by direct read instruments.

9.4.1 Place the specimen in the trapped atmosphere inside a zip sealed plastic bag. Insert a temperature/relative humidity probe through the wall of the bag and seal tightly.