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

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[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.

NOTE 4—Making a slit in the side of the bag to stretch around a relative humidity probe has proven to provide a reliable seal.

9.4.2 Record the relative humidity and temperature within the bag at one hour intervals and calculate absolute humidity, humidity ratio or dew point.

9.4.3 Record the temperature and humidity when three consecutive measurements show no change in absolute humidity as calculated from the meter readings (this will be approximately within ±2.0 percent relative humidity and ±1.0°C).

9.5 Measure moisture content with the meter to be calibrated.

9.5.1 Take three measurements on each specimen. One within 2.5 cm (1 in.) from each end, and one from the approximate center of the specimen. Record each measurement and report the average of the three measurements.

9.5.1.1 For pin type meters stab the pins through the plastic bag taking care to avoid any marking printed on the surface of the bag.

9.5.1.2 For pinless type meters remove the specimen from the bag to take the measurements. Support the specimen on a low-density polystyrene foam block at least 25 mm (1 in.) thick on a wooden surface with no metal braces.

9.6 Remove the specimen from the bag and weigh. Report the weight and calculate and report the moisture content by weight.

9.7 Continue to dry the specimens stepwise in accordance with Section 11.

10. Determine Time Step for Drying

10.1 Determine the time step necessary to dry a typical specimen by increments sufficiently close together to permit development of an accurate calibration curve for the instrument. In selecting time increments target ten (10) data points separated by equal steps in moisture content as measured by the meter being calibrated. A minimum of five (5) data steps are necessary for sufficient precision. Adjust time steps as necessary to provide a minimum of five (5) data points including the maximum and minimum readings.

10.1.1 The range of moisture content that is of interest may vary with different types of gypsum board products, by composition of a product by a specific manufacturer in a specific geographical location.

10.1.2 The range of interest for standard drywall is typically between 0.3 and 8.5 % moisture content by weight. This typically corresponds to an ERH of about 30% to 95% at 20°C (88°F). Typically, hand held moisture meters are able to measure moisture in gypsum panels within this range. Moisture levels above and below this range are outside of the measuring capabilities of most meters.

10.2 Drying may be accomplished by use of a convection oven, or by air drying by allowing circulation of room air around samples.

10.2.1 *Convection Oven*—Dry samples in accordance with the procedure set forth in Section 8.

10.2.2 *Air Drying*—Dry in room with samples in a rack permitting air circulation on all sides. Arrange so that there are no strong air currents across samples that could promote uneven drying.

10.3 The time step and moisture content by weight will need to be adjusted for the characteristics of the specific type of gypsum board for which the meter is being calibrated. For example, the following values have been found typical for ½ in. thick standard drywall panels.

10.3.1 Drying by oven typically requires:

10.3.1.1 30 minute time step between 16 and 2 % moisture content by weight.

10.3.1.2 15 minute time step below 2 % moisture content by weight.

10.3.2 Air drying typically requires one (1) hour time steps at all moisture contents.

11. Dry Specimens in Steps

11.1 Dry specimens in steps of duration as determined above. At each step measure temperature, relative humidity, and moisture content by weight and moisture content according to the meter in accordance with the following procedure:

11.2 Perform all measurements in a room maintained at 23 ± 3°C (73 ± 5°F).

11.3 After sample has completed a drying step the surface of the sample will more dry than the interior due to evaporation from the surface. It is also possible that the sample will not have dried evenly from side to side or front to back. Also the temperature of the surface may be cooled by evaporation. As such it is necessary to seal the sample in a zip sealed plastic bag until the moisture content of all parts of the sample reach equilibrium and the atmosphere in the bag reaches moisture equilibrium with the sample.

11.4 Determine the absolute humidity of a trapped environment that is in moisture equilibrium with each specimen. Absolute humidity (or humidity ratio) is used for this purpose as relative humidity varies with temperature, and temperature is likely to vary during the course of the test. Absolute humidity, humidity ratio and dew point are independent of temperature and can be calculated from the temperature and relative humidity that are typically measured by direct read instruments.

11.4.1 After each sample drying step seal in a zip sealed plastic bag. Insert a temperature/relative humidity probe through the wall of the bag and seal tightly.

NOTE 5—Making a slit in the side of the bag to stretch around a relative humidity probe has proven to provide a reliable seal.

11.4.2 Record the relative humidity and temperature within the bag at one hour intervals and calculate absolute humidity, humidity ratio or dew point.

11.4.3 Record the temperature and humidity when three consecutive measurements show no change in absolute humidity as calculated from the meter readings (this will be approximately within ±2.0 percent relative humidity and ±1.0°C).

11.5 Measure moisture content with the meter being calibrated.

11.5.1 Take three measurements on each sample. One within approximately 25 mm (1 in.) from each end, and one from the approximate center of the sample. Record each measurement and report the average of the three measurements.

11.5.2 For pin type meters stab the pins through the plastic bag taking care to avoid any markings printed on the surface of the bag.

11.5.3 For pinless type meters remove the sample from the bag and take the measurements. Support sample on low-density polystyrene foam as least 25 mm (1 in.) thick on a wooden surface with no metal braces.

11.6 Remove the sample from the bag and weigh. Report the weight and calculate and report the moisture content by weight.

11.7 Continue the next drying step.

11.8 Repeat drying until measurements at all drying steps have been secured.

12. Board Type Correction Factor Determination

12.1 Regress the moisture meter scale reading (X) against the corresponding moisture content (Y) for each given type board or panel specimen in the sample by regression analysis. The equation for the regression line ($Y = a + bX + cX^2$) shall be used to establish the coefficients (a, b, c) for determining the actual moisture content (Y) from the meter scale readings (X) over the range from the minimum to the maximum moisture contents inclusive.

13. Report

13.1 Record and report the following sample information: moisture content, size (dimensions in each plane), gypsum board or panel type, thickness, applicable ASTM standard specification, and relative as-received density. For all materials, the appropriate sample information shall be recorded together with adequate data to identify the product and its constituents. The following meter information shall be recorded: manufacturer and model, reference temperature, applied voltage, and electrode type and configuration, and electric field or circuit type.

14. Precision and Bias

14.1 The precision and bias for this test method has not been determined.

15. Keywords

15.1 conductance meters; dielectric meters; moisture content; moisture gradients

ANNEX

(Mandatory Information)

A1. CHARACTERISTICS OF HAND-HELD MOISTURE METERS

A1.1 Conductance Meters

A1.1.1 *Standardization and Calibration*

A1.1.1.1 Periodic standardization shall be performed on the meter to test the integrity of the meter and electrodes. Laboratory calibration procedures are intended to provide reference data under controlled conditions that include the gypsum board or panel and the ambient variables. Field calibration tests on different types of gypsum board and panels shall be performed only with a meter that has been standardized and properly compensated for temperature and pin configuration for the specific types of gypsum board or panels being examined. Initially, standardization shall be performed before each period of use. The time interval may be extended if experience shows that the particular meter is stable for a longer time under equivalent use conditions.

A1.1.1.2 *Standardization*—The meter circuit shall be tested by connecting external resistors to the electrode pins, noting the corresponding MC (moisture content) value, and comparing with manufacturer's data. At least two and preferably three points shall be used to standardize the meter. The manufacturer shall indicate (in the manual, on the meter or meter scale, or on the supplied resistance standard) the meter model, gypsum board or panel type, and number of pins for which the resistances are valid.

NOTE A1.1—Most manufacturers only provide a resistor for one calibration point.

A1.1.1.3 *Field Calibration*—Under field conditions, the laboratory calibration procedure is impractical, particularly because of moisture gradients. The procedure in section 8.1.2 should be applied to develop a meaningful relationship between meter reading and actual MC. All field calibrations must be referenced to oven-dry tests to determine precision and bias. Standardization procedures (section 8.1.1) must be followed to assure valid field calibration at the specific field conditions during testing. Special care must be taken to minimize errors caused by the influence of specimen temperature on readings. Specimen size for field testing may be full size or sections thereof.

A1.1.2 *Conductance Meter Operations*

A1.1.2.1 *Readings:*

(1) Range—The gypsum board core and face paper have different maximum moisture contents that can differ significantly. The gypsum core, the core-to-paper bond strength, or both, may lose integrity before approaching the core pore saturation point, while the paper approaches its fiber saturation point. Due to dissimilar hygric properties, the moisture content expressed as a percentage of the dry weight of the gypsum board or panel is a composite of the individual core and paper moisture contents. Meter scales extend above the pore space free water limit only to permit temperature corrections of moisture contents up to this point, and do not imply reliability of readings above the pore space free water point.

(2) Moisture Content Readings—Conductance moisture meters can be used to determine "point" moisture content directly at different depths within the gypsum board or panel. Average moisture content can be obtained through the thickness by integrating moisture content versus thickness.

(3) Moisture Gradients—Unless the moisture distribution and measuring techniques are well understood, readings can be easily misinterpreted. Four special problems should be considered:

(a) Noninsulated electrodes (see section 9.3).

(b) Nonparabolic gradients—Gypsum board consists of gypsum core to which paper facings are laminated on the face and back surfaces. Face and back papers can differ in their respective hygric properties and both have markedly different hygric properties than the gypsum core, resulting in different wetting and drying characteristics for these components. Therefore, the assumption of a continuous parabolic moisture profile through the thickness of the test specimen will rarely be valid.

(c) Surface Moisture on Electrode—Surface films of moisture, particularly from condensation on the electrode (insulated pin holder) may cause larger errors. Keep electrodes clean. Store and use electrodes under noncondensing conditions.

(d) High Surface MC on Sample—High surface MC of the material from condensation, wetting, and high relative humidity can cause excessively high readings if noninsulated pins are used.

(4) Drift—Direct current conductance meters may show appreciable drift toward lower MC when readings are taken at the upper portion of the MC range. If such drift occurs, take the reading as soon as possible after the pins are driven in and voltage applied.

A1.1.2.2 *Temperature Corrections:*

(1) Temperature Effect on Meter—Meter circuits can be temperature-sensitive. Therefore, frequent zero or span adjustments, or both, may be necessary during use. The manufacturer shall indicate the optimum range of temperature for operation of the meter without loss of accuracy due to temperature. It is recommended that whenever possible, the meter be equilibrated with the measurement environment before readings are taken. In no case shall temperature or humidity alter the operating characteristics of a meter (that has been equilibrated and adjusted) to the degree that the accuracy is impaired.

(2) Temperature Correction—Temperature corrections are obtainable from manufacturer's data, published data, or using built-in adjustments in the meter. Temperature corrections require special care to obtain the specimen (not air) temperature, and may be unreliable to correct some board types. A reference temperature of 25°C (77°F) shall be standard for zero correction. Clearly indicate the reference temperature at some point on the meter. Always make temperature correction before other corrections for panel formulations (such as water resistant panels).

A1.1.2.3 *Electrodes:*

(1) Preferred electrodes for the conductance meter for gypsum board or panel measurements are of a two-pin type, insulated except for the tips. If noninsulated pins are used, the gypsum board or panel must be tested for surface moisture content (A1.1.2.1(3d)). If any other electrode is used, the readings must be adjusted as specified by the manufacturer or incorporated into the scale corrections for the particular type of gypsum board or panel to be tested. In no case shall different pin configurations be used interchangeably on the same meter without the appropriate corrections.

(2) Noninsulated Pins—Noninsulated pins will bias the reading toward the highest moisture content in contact with the pins. If noninsulated pins are used, a higher surface than core MC can cause a misleading reading at the depth of the pin tips. This can be tested by noting the indication at initial contact and as the pins are driven in.

(3) Extension Electrodes—Unless extension electrodes, for example, nails, are insulated except at the tips, the precautions for noninsulated pins apply.

(4) Implanted Electrodes—Special precautions are necessary to minimize errors caused by changing electrode contact pressure and electrode-substrate contact resistance, particularly when the electrodes are implanted in moist material to monitor drying. It is especially important that dc voltage not be applied continuously in order to minimize the buildup of contact interfacial resistance from ion migration.

NOTE A1.2—The use of low frequency ac, intermittent dc, or switched dc voltages can virtually eliminate irreversible ionic migration.

A1.2 Dielectric Meters

A1.2.1 *Standardization and Calibration*

A1.2.1.1 Periodic standardization shall be performed on the meter to test the integrity of the meter and electrode. Laboratory calibration procedures are intended to provide reference data under controlled conditions which include the specific type of gypsum board or panel and the ambient variables. Field calibration tests on various types of gypsum boards or panels shall be performed only with a meter that has been standardized and properly compensated for temperature and for the specific type of gypsum board or panel being examined. Initially, standardization shall be performed before each period of use. The time interval may be extended if experience shows that the particular meter is stable for a longer time under equivalent use conditions.

A1.2.1.2 *Standardization*—The meter shall be standardized using a nonhygroscopic reference material to provide one (or preferably, two) reference points on the scale. This reference material is often supplied by the manufacturer. The meters must also be equipped to permit a zero adjustment with no material in the electrode field.

A1.2.2 *Dielectric Meter Operations*

A1.2.2.1 *Readings:*

(1) Range—The normal range of moisture sensing in both power-loss and capacitive-admittance meters is from 0 % to the pore space water saturation point. Semiquantitative readings above pore space saturation point are possible with the capacitive-admittance meter. The scale may be in arbitrary units or direct-indicating for a particular reference species if

calibration for the reference panel composition has been carried out according to acceptable calibration procedures.

(2) Moisture Content Readings—Dielectric moisture meters can be used to determine the average moisture content within the entire depth of the gypsum board or panel.

(a) Minimize the possibility of reading adjacent material (read-through) by either supporting the sample ends to create an air gap of at least 25 mm below the sample or place the sample on a similar thickness of nonhygroscopic, low density foam such as polystyrene or polyurethane. Electrode conformance with the surface may present a special problem with warped samples, especially if the electrode is rigid. If measurements must be made on warped samples, the two sided measurement procedure will indicate if the warp confounds the measurement.

(b) The calibration procedure in these test methods is unique to each thickness as well as type of gypsum board or panel. A special calibration must be made for each thickness of board or panel.

NOTE A1.3—Because of the laminated construction of gypsum boards or panels with paper or glass facings, stacking samples to achieve a greater equivalent thickness will not yield accurate results. This differs from procedures for measurements of thin samples of solid wood (see Test Method D4444).

(3) Moisture Gradients—Unless the moisture distribution and measuring techniques are well understood, readings can be easily misinterpreted. Three special problems should be considered:

(a) Surface Moisture on Electrode—Surface films of moisture on the meter, particularly from condensation on the electrode, may cause abnormally high readings, particularly for power-loss meters. Meters should be stored and used under noncondensing conditions.

*(b) High Surface Moisture Content on Sample*High surface moisture content of the material from condensation, wetting, or high relative humidity can cause excessively high readings, particularly with a power loss meter.

*(c) Low Surface Moisture Content on Sample*All dielectric meters have a biased, greater response to moisture nearer the electrode, therefore, for samples that contain moisture gradients, values determined even after panel composition and temperature corrections are qualitative at best, and no limits of accuracy can be implied. However, an increase in accuracy should be obtained if corrected readings taken on both sides of the material are averaged.

A1.2.2.2 *Temperature Corrections:*

(1) Temperature Effect on Meter—Meter circuits can be temperature-sensitive, therefore, frequent zero adjustments may be necessary during use. The manufacturer shall indicate the optimal range of temperature for operation of the meter without loss of accuracy due to temperature. It is recommended that whenever possible, the meter be equilibrated with the measurement environment before readings are taken. In no case shall temperature or humidity alter the operating characteristics of a meter (that has been equilibrated and adjusted) to the degree that accuracy is impaired.

(2) Temperature Correction—Temperature corrections must be made from data supplied by the manufacturer or developed for the particular meter model. Temperature corrections require special care to obtain panel (not air) temperature. A reference temperature of 25°C (77°F) shall be standard for zero correction. The reference temperature should be clearly indicated at some point on the meter. Unless temperature calibration data are supplied by the manufacturer or available in the literature, use of such meters is restricted to ambient conditions between 20 and 30°C.

A1.2.2.3 *Type Corrections:*

(1) Type Correction—Manufacturer's data for the particular meter for either the dial calibration gypsum board type or corrections for other types of gypsum panels should be used only if the data have been developed in accordance with acceptable calibration procedures.

A1.2.2.4 *Electrodes:*

(1) The depth of field penetration for dielectric meters shall be given at least qualitatively. Electrodes of power-loss meters should be spring-loaded to assure reasonable contact pressure unless contact pressure has been demonstrated not to influence readings. The electrode sensing area should be small enough that the field will not extend beyond the sample edge and large enough to provide reasonable integration.