Designation: D7438 – 20

Standard Practice for Field Calibration and Application of Hand-Held Moisture Meters[1]

This standard is issued under the fixed designation D7438; 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 practice applies to the measurement of moisture content of solid wood, including solid wood products containing additives, that is, chemicals or adhesives, by hand-held moisture meters under conditions of end-use.

1.1.1 This practice includes calibration, use, and interpretation of meters for conditions that relate to wood product characteristics, such as nonuniform grain and growth ring orientation, and to end-use process conditions, such as moisture gradients.

1.1.2 Meters employing differing technologies will not necessarily provide equivalent readings under the same conditions. When this practice has been applied, it is assumed that the referenced meter is acceptable unless otherwise specified. Meters shall have been calibrated by Test Methods D4444.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D9 Terminology Relating to Wood and Wood-Based Products

D2915 Practice for Sampling and Data-Analysis for Structural Wood and Wood-Based Products

D4442 Test Methods for Direct Moisture Content Measurement of Wood and Wood-Based Materials

D4444 Test Method for Laboratory Standardization and Calibration of Hand-Held Moisture Meters

D4933 Guide for Moisture Conditioning of Wood and Wood-Based Materials

D6782 Test Methods for Standardization and Calibration of In-Line Dry Lumber Moisture Meters

2.2 *Other ASTM Sources:*

ASTM Standards on Precision and Bias for Various Applications, 1992

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of general terms used in this standard related to wood and wood-based products, refer to Terminology D9.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *conductance meters*—moisture meters that measure predominantly ionic conductance between points of applied voltage, usually direct current.

3.2.1.1 *Discussion*—Direct-current conductance meters have been commonly referred to as "resistance-type" 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 calibrated to read directly in moisture content (oven-dry mass basis) for a particular calibration species and at a specific reference temperature.

3.2.2 *capacitive-admittance meters*—moisture meters that transmit electromagnetic wave energy into the wood to detect the influence of moisture in the wood on these waves as an estimate of moisture content.

3.2.2.1 *Discussion*—Wave energy is most often in the radio frequency range; hand-held meters commonly are placed directly on the wood surface.

4. Significance and Use

4.1 Hand-held meters provide a rapid means of sampling moisture content of wood-based materials during and after

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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.

processing to maintain quality assurance and compliance with standards. However, these measurements are inferential; that is, electrical parameters are measured and compared against a calibration to obtain an indirect measure of moisture content. The electrical measurements are influenced by actual moisture content, a number of other wood variables, environmental conditions, geometry of the measuring probe circuitry, and 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. Appendix X1 is a commentary that provides explanation of the mandatory sections and discussion of historical practices. Appendix X2 addresses the influence of process and wood variables.

4.1.1 This practice provides for calibration and application of wood products that contain commercial characteristics and that reflect the manufacturing environment.

4.2 Most uses of hand-held moisture meters employ correlative (predictive) relationships between the meter reading and wood areas or volumes that exceed that of the direct meter measurement (for example, larger specimens, pieces of lumber, lots). The field calibration section of this practice anticipates the potential need for this type of sampling. These correlative uses are examined in Appendix X3.

5. Standardization

5.1 *General*—Standardization shall be performed to establish the integrity of the meter and electrode under the field conditions of use. The meter circuit shall be tested by applying either the external reference check (calibration block or resistance points) or the internal standardization check (if incorporated into the meter), in accordance with manufacturer's recommendations, noting the corresponding meter response value, and comparing with the manufacturer's data. Standardization shall be done before calibration. If alternate electrodes are to be used with a meter, standardization shall be done for all electrode types and alternate assemblies.

5.1.1 Initially, standardization shall be performed before each period of use. It is possible to extend the time interval if experience shows that the particular meter is stable for a longer time under equivalent use conditions.

5.1.2 Standardization procedures in the field will be affected by the standardization performance of the meter during evaluation under Test Methods D4444. The report of section 5.2.3 of Test Methods D4444 provides this information.

5.2 The standardization shall be carried out with the instrument, including electrodes, at the temperature of the anticipated application. This shall include the range of anticipated conditions; the reference material shall maintain its essential characteristics over this range. The sensitivity of this standardization to temperature of the meter shall be part of the evaluation.

5.2.1 If the environmental conditions change during the usage period beyond those evaluated in the initial standardization, the standardization shall be repeated.

5.2.2 If the manufacturer recommends an area, a method, or a standard specimen for standardization that does not reflect the entire direct measurement area of the meter, this shall be noted as the manufacturer's recommendation.

5.2.3 Field standardization is difficult to carry out under some ambient field conditions and with the electrodes to be used. One example is the use in monitoring in-kiln performance. If the measurement conditions are difficult to reproduce or are transient (for example, in a hot dry kiln), then it shall be understood that the validity of the meter readings are dependent upon the laboratory standardization and manufacturer's recommendations.

6. Calibration

6.1 *General*—Under processing conditions, it is possible that laboratory calibration procedures will be impractical, particularly because of moisture and temperature gradients, nonstandard temperatures, unverified species within commercial species groups, non-straight-grain wood, and common production variables such as mixtures of heartwood and sapwood. Further, it is possible that these process variables will change or invalidate some of the calibration results obtained under laboratory conditions in Test Methods D4444.

6.2 *Methods*—The principles and procedures of calibration in Test Methods D4444 shall be applied to the degree possible and relevant to develop a meaningful relationship between meter readings and actual moisture content (MC).

6.2.1 All field calibrations shall be referenced to direct MC measurements (Test Methods D4442).

6.2.2 Field calibration shall be carried out with meters that have been laboratory standardized and calibrated for appropriate wood variables, such as species and temperature using Test Methods D4444, and subsequently field standardized.

6.3 *Field Variables*—It is acceptable for the calibration to be based on end-use environmental and product and process conditions that are more restrictive than those evaluated by Test Methods D4444. In addition, it is possible that the process conditions will produce interactions that must be considered in the calibration.

6.3.1 Special care must be taken to minimize errors caused by the influence of unintended wood variables, such as density and temperature (uncorrected) on readings. Specimen size for field testing shall be selected to represent the appropriate geometry of the target sample. Field meter readings are conditional upon both the prior standardization and calibration process, the influence of wood variables in the field test, and application information supplied by the meter manufacturer.

6.4 *Calibration Steps*—The field calibration shall be conducted on specimens and in conditions that are representative of the process and are carefully documented. See Appendix X2 for discussion of process variables and wood characteristics.

6.4.1 *Sample Selection*—The number of wood specimens used for the calibration shall be selected following the concepts of Practice D2915, considering the variables to be represented and the desired precision of the calibration. For example, if the sample is to represent grain patterns, moisture gradients, etc. found in a lumber grade, these variables shall be considered in setting sampling criteria. (See also Test Methods D4444.)

6.4.2 *Sample Preparation*—If it is the intent that the sample includes process variables such as moisture gradients, temperature, etc., the measurement and subsequent preservation of these variables prior to and during meter measurement shall be considered part of the sampling process. See Test Methods D4444 for discussion of other relevant issues.

6.4.3 *Testing*—Field calibration shall be based on the relationship of the meter readings to Test Methods D4442 moisture measurement values. When process variables such as temperature and moisture gradients, or both, are transient, calibration that reflects these variables requires special treatment of specimens (such as subdividing specimens) or additional equipment (such as temperature probes). Care shall be taken to not distort the original specimen condition with these additional steps.

6.4.4 *Determination of Corrections*—To establish a correction that reflects the influence of the measured variables, the principles of Test Methods D4444, section 6.2.4, shall be followed.

6.5 *Report*—Useful application of field test calibration is conditional upon the relevance of the test sample. Consequently, accurate reporting of the wood and process variables (see 6.3 and 6.4) is critical. The report shall follow the practice of Test Methods D4444, section 6.2.5.

6.5.1 Field samples often contain uncertainties with respect to exact species or species mixtures, temperature at the point of electrode measurement, in-exact moisture gradients, and other specimen variables. Where these non-uniformities and uncertainties cannot be measured or corrected, their presence shall be noted in the report and quantified where possible.

APPENDIXES

(Nonmandatory Information)

X1. COMMENTARY

INTRODUCTION

The purpose of this appendix is to supply auxiliary information on the basis for and practice of this practice. It is organized with paragraphs that correspond by section number to those in the mandatory text; text paragraphs needing no explanation are not listed. This concept permits changes at any time in order to keep the practice current and to improve its usefulness.

This is a practice standard; thus, it describes and standardizes, to the degree possible, the calibration and measurement practices that occur outside the environment of the testing laboratory.

TABLE X1.1

Section	Comments
1.1	The principal concepts of this practice, as first incorporated in Practice D2016 in 1965 and then in subsequent editions of this practice, addressed only meters based on the change of wood conductance or dielectric properties with moisture content. Specific electrode configurations were anticipated, based on early commercial use. Meters were classified as “resistance-type” and “dielectric-type”; no provisions were made other electrode configurations or measurement technologies. Meters are now classified as “conductance” rather than “resistance-type,” and “capacitive-admittance” rather than “dielectric-type” to better reflect current understanding of the underlying physics of their function. The current practice makes no distinction between meter measurement technologies for standardization and calibration requirements. Provision for unique characteristics of measurement technologies is accommodated in Appendix X1 – Appendix X3. The use of “field” to describe calibrations and measurement issues denotes conditions that cannot be controlled as in a laboratory, yet the conditions are very commonly the environment in which the meters are used.
1.1.1	This practice targets use outside of the laboratory where controlled conditions are not usually possible. In addition, most commercial wood products are not “clear” and straight-grain and are heterogenous in other characteristics. Sampling is necessarily tied to commercial product descriptions.
1.1.2	Requiring calibration under Test Methods D4444 ensures prior technical evaluation of a meter, with an associated report describing performance under controlled conditions. Although the intended use may not adhere to these same conditions, the performance in the laboratory establishes the minimum performance criteria for field use as well as reference points on sensitivity to variables such as species, density, temperature, etc.
3.2	This practice is designed to apply to meters using technologies other than the two technologies included in the section. Conductance and capacitive-admittance meters are included because they provide the generic descriptions of principal, current commercial meters. Individual characteristics of commercial meters are not intended to be covered in these generic descriptions. As other meter technologies are developed, more generic descriptions should be added to this section.
4.1.1	Much of the content of this practice was incorporated in previous versions and drafts of Test Methods D4444, and some earlier in Practice D2016. The mixing of test methods and practices in one standard is not desirable; thus, this practice attempts to capture the critical elements of the many and varied commercial applications of hand-held meters while Test Methods D4444 concentrates on the base-line laboratory test methods. Specific issues of meter technology in use are covered in more detail in Appendix X2.