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Standard Test Methods for MOISTURE CONTENT OF WOOD[1]

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This method has been approved for use by agencies of the Department of Defense and for listing in the DoD Index of Specifications and Standards.

INTRODUCTION

The importance of moisture content control of lumber and other wood products for various uses cannot be overemphasized. Moisture content control in the processing and fabrication of consumer items of wood requires a rapid and reliable means of moisture determination. Four methods of wood moisture content determination are described herein: One, the electronical method, is non-destructive and practically instantaneous; the other three, namely the oven-drying method, a distillation method, and a hygrometric method, are destructive in that they require that the lot be sampled for specimens that are subsequently analyzed for moisture content.

1. Scope

1.1 These methods cover the determination of the moisture content of wood. The methods provide a means whereby producers, fabricators, processors, and users of wood and wood products can facilitate inspection for adherence to moisture quality-control specifications. The requirements, advantages, and limitations of the different methods are outlined.

1.2 The methods described are commonly used in research and by the producing industries to ascertain the amount of moisture present in specific specimens representing the lot or on samples tested with the electronic moisture meters. These different methods are not equally suitable for moisture content determinations in any given case; therefore, it is important to select the one that is best for the intended application and a specific method may be specified. If these methods are referenced without designation of the specific method to be used, it shall be assumed that all methods are equally acceptable and that the choice will be made by the party responsible for the moisture-content determination. The following guide to the advantages and limitations of the various methods will assist in making the proper choice:

1.2.1 *Method A—Oven-Drying Method*—The moisture content is calculated from weight values obtained before and after drying a representative specimen of wood in an oven. This has been the most universally accepted method for determining moisture content in research, in wood-seasoning operations such as air drying, predrying, and kilin drying, in moisture content control techniques in processing in wood-working factories. Its limitations are that it is a destructive test in that the samples representing the lot must be cut to produce the specimens; it takes several hours to make an accurate analysis; and accuracy is limited if the wood contains an appreciable amount of volatile extractives, or if the wood has been impreg-

[1] These methods are under the jurisdiction of ASTM Committee D-7 on Wood.

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nated with either volatile or nonvolatile chemicals.

1.2.2 *Method B—Electronic Moisture Meter Method*—Moisture content control often requires a rapid, nondestructive and reliable means of inspection for moisture content, and this requirement is met most conveniently by electronic moisture meters. Reliable results, however, can be obtained with moisture meters only when they are correctly used. A standard procedure should be established and accepted by users of these instruments and the method presented herein is intended to provide a uniform procedure for the use of electronic moisture meters for wood so that determinations made with them may be reliable and strictly comparable.

1.2.3 *Method C—Distillation Method*—The distillation method is destructive as is the oven-dry method. The procedure for selecting the specimen for analysis is the same as for the oven-drying method. The method is used when the wood contains volatiles other than water, such as pitch or oil-type preservatives, or has been impregnated with other chemicals that are soluble in toluene. The method generally consists of distilling the water from the fractured specimen along with a liquid that is immiscible with water such as toluene, catching the water in a trap and measuring its volume, and calculating the moisture content. The time required for the test method is often less than 2 h. This method also may be used to determine the quantity of any volatile material such as creosote in the wood specimen.

1.2.4 *Method D—Hygrometric Method*—The hygrometric method is also destructive as are the oven-drying and distillation methods. However, it is a fairly rapid method for obtaining moisture content estimates on wood samples that have been treated with preservatives or other chemicals. The method is limited to wood having a moisture content less than the fiber-saturation point.

2. Definitions and Description of Terms

2.1 *Moisture Content of Wood*—The moisture content of wood as determined by any of the methods described herein shall be expressed as a percentage of the oven-dry weight of the wood unless otherwise stipulated. The physical and mechanical properties of wood as they vary with changes in moisture content are generally reported as a function of moisture content expressed as a percentage of the oven-dry weight of the wood. Moisture content values may exceed 100 percent.

2.2 *unit*—one of a number of similar products, parts, specimens, etc., of wood.

2.3 *lot*—a specific quantity of similar wood units or collection of similar units from a common source; in wood moisture-inspection work, the quantity offered for inspection and acceptance at any one time. It may be a collection of mill items such as boards, dimension, dimension stock, or veneer, or semifinished parts or subassemblies such as furniture items, flooring, trusses, beams, or panels, that are inspected for moisture content during production, or a consignment of finished products to be sent out for service.

2.4 *sample*—a portion of material or a group of units taken from a larger quantity of material or collection of units, which serves to provide information that can be used as a basis for action on the larger quantity or on the production process.

2.5 *specimen*—a section, block, core, or other type of test piece cut from a sample or, in the case of nondestructive determinations, the area of a sample piece subjected to a moisture content analysis.

3. Sampling

3.1 The objective of sampling for moisture content specimens or for nondestructive electronic moisture meter tests is to obtain values that represent the lot. Three objectives are sought, namely: (*1*) an unbiased estimate of the population, or lot, mean; (*2*) an unbiased estimate of the variance; and (*3*) the estimates to be as accurate as possible for the time and money spent.

Method A—Oven-Drying Method

4. Apparatus

4.1 *Oven*—An oven that can be maintained at a temperature of 103 ± 2 C (217.4 ± 3.6 F) throughout the drying chamber for the time required to dry the specimen to constant weight. Ovens may require forced-air circulation to maintain uniform temperature. An accurate thermometer or pyrometer shall be used to check the temperature. For convenience, ovens will normally be thermostatically

controlled. Ovens shall be vented to allow the evaporated moisture to escape.

4.2 *Weighing Device*—A scale or balance that will weigh a specimen within accuracy of ±0.2 percent. The accuracy and sensitivity of the weighing apparatus shall be checked at least every year against standard weights. Knife edges shall be kept clean to assure accuracy. A torsion balance, Harvard trip balance, triple-beam balance, and automatic direct-reading balance are examples of suitable equipment.

5. Test Specimens

5.1 Specimens vary widely, depending on the type of material being analyzed and the anticipated use of the results. Specimens shall be selected that represent the lot. Unless otherwise specified, specimens shall be full cross sections no less than 25 mm (1 in.) along the grain, but longer as needed to provide a minimum volume of 33 cm^3 (2 $in.^3$). The section shall be cut with a sharp saw. All loosely attached slivers shall be removed from the section before it is weighed. Specimens from large items such as logs, poles, posts, piling, and timbers shall be (*1*) full cross sections, (*2*) representative sectors of such sections, (*3*) increment core borings, or (*4*) auger chips. When the latter two types of specimens are used on round items to represent the average moisture content of the sample, they shall be divided into zones and a weighted average moisture content determined arithmetically from the relative proportion of the cross section each zone represents. Because of the small volume of borings and auger chips, a more sensitive balance is required than would be required for specimens cut from lumber and other sawed items.

6. Procedure

6.1 *Initial Weighing*—Weigh each specimen immediately after cutting from the sample representing the lot or else protect it from a moisture change until weighed. Weigh each specimen to an accuracy of ±0.2 percent, for example, if the specimen weighs 250 g, obtain the weight to the nearest 0.5 g. Record the weight either on the specimen or on a data sheet that is numbered to correspond with the number on the specimen. If a delay between cutting the specimen and weighing cannot be avoided, place the specimen in a vapor-tight container or wrapper immediately upon cutting and allow it to remain in the container or wrapper until it can be weighed. Suitable wrappers can be made of aluminum foil or polyethylene film. The delay between cutting and weighing of the protected specimen shall be as short as possible, but in no case to exceed 2 h. Obtaining weights in grams rather than in grains or ounces simplifies calculations.

6.2 *Drying*—After they have been weighed, place the specimens in an oven when convenient and heat at 103 ± 2 C (217.4 ± 3.6 F) until they reach constant weight. Place the specimens in the oven in a manner that will allow free access of heated air to each. To test for constant weight, weigh the heaviest specimens at intervals of 2 h or more until they show no further weight loss within the accuracy of weighing required. Avoid drying for periods longer than necessary to achieve constant weight since prolonged distillation or oxidation of the wood will produce a weight loss reflecting a higher-than-actual moisture content. Newly cut specimens should not be placed in the oven with partially dried ones since the drier specimens will be retarded in drying.

NOTE 1—As a guide, an air-dry specimen about 50 by 100 mm (2 by 4 in.) in cross section and 25 mm (1 in.) along the grain will usually attain constant weight within 24 h at the specified temperature when dried in an electric oven having good forced-air circulation.

6.3 *Final Weighing*—Weigh each specimen immediately after it is removed from the oven upon attaining constant weight or store in a desiccator while awaiting weighing. The accuracy shall be the same as required for initial weighing.

7. Calculation

7.1 Calculate the moisture content as follows:

$$\text{Moisture content, percent} = [(A - B)/B] \times 100$$

or, for more convenient slide rule or computer calculation:

$$\text{Moisture content, percent} = ((A/B) - 1) \times 100$$

where:

A = original weight, and
B = oven-dry weight.

Example—A 25-mm (1-in.) specimen of lumber weighed 56.7 g. After oven-drying, the weight was 52.3 g.

Moisture content, percent
= [(56.7 − 52.3)/52.3] × 100
= (4.4/52.3) × 100 = 8.4 percent

NOTE 2—If wood has been treated with a water-borne nonvolatile chemical and if the weight of the retained chemical is known, the moisture content may be determined as follows:

Moisture content, percent = $[(A - B)/D] \times 100$

where $D = B$ − weight of retained chemical in sample.

METHOD B—ELECTRONIC MOISTURE METER METHOD

8. Scope

8.1 The range of moisture content in wood that can be measured reliably with electric moisture meters is limited to 0 to 30 percent when using dielectric-type meters, and 6 to 30 percent when using a resistance-type meter. The precision of the meters decreases near the limits of their useful range. This method is applicable only to those species of wood for which calibrations have been established. Species corrections are supplied by moisture meter manufacturers or may be developed from basic resistance-moisture content data (1), (2).[2]

8.2 The temperature of the lumber affects the readings of electric moisture meters (1); (3); (4). When available temperature corrections (Fig. 1) are used, reliable moisture content determinations may be obtained with a resistance-type meter over a wood temperature range from about −40 to +90 C (−40 to 200 F). Temperature corrections for the power-loss and capacitive admittance meters are most accurately made graphically (3), (Figs 2 and 3) but can be put into tabular form for some applications.

8.3 This method is applicable particularly to the manual inspection of wood and wood products using portable equipment, and is not generally applicable to such procedures as automatic inspection of moving material with permanently installed equipment.

9. Apparatus

9.1 *Resistance Meters*—Resistance measurements shall be made with commercial resistance-type moisture meters or electronic ohmmeters capable of measuring resistance from 10 kΩ to 1 tΩ (10^4 to 10^{12} ohms) to an accuracy of ±10 percent. No instrument shall be used that applies to the test specimen a d-c potential exceeding 45 V. No attempt shall be made to measure moisture content with an ohmmeter unless reliable data are available for calibration of the ohmmeter as a moisture meter.

9.2 *Electrodes* for resistance measurements shall be of the needle type. The needles shall be mounted on a fixture of high-quality moisture-resistant insulation, permitting driving the needles into the wood to the proper depth. Surface contact electrodes shall not be used with resistance-type meters. Because of the possibility that unknown moisture gradients exist in the wood, it is desirable to use electrode needles of the type that are covered, except for the tip, with an insulating coating. If for any reason insulated needles cannot be used, the wood shall be tested for surface moisture as described in 11.1.4. If the available electrode needles are too short to penetrate to the required depth, as specified in 11.1.5, substitute electrode needles such as uncoated nails or coated nails from whose tips the coating has been removed may be used. The diameter of the nails is not critical, but nails with a diameter near that of the regular electrode needles are preferred. Measurements on wood 6 mm (¼ in.) or less in thickness shall be made with an electrode consisting of approximately 6 to 12 short, fine needles.

9.3 *Dielectric-Type Meters* (Power-Loss and Capacitive-Admittance Type)—Dielectric-type moisture meters shall be equipped with an electrode suitable for the surface and thickness of the material. No attempt shall be made to use the dielectric meters for moisture measurements unless a reliable calibration, applicable to the species of wood and the type of electrode, is available for the meter being used.

10. Test Specimens

10.1 Specimens for moisture tests may be either whole pieces from the lot being inspected or smaller sections cut from such pieces. If whole pieces are used, readings shall be taken near the middle of the widest surface at least 500 mm (20 in.) from the end of the piece. If sections are cut, these shall be cut so that no less than 500 mm (20 in.) of the piece are discarded from either end, and the sections shall be large enough to contact the electrode

[2] Boldface numbers in parentheses refer to the list of references appended to this method.

completely with an amount to spare on all sides at least as large as the thickness of the specimen. The moisture content of small sections shall be measured soon after they are cut to prevent error from rapid end-grain drying. Readings shall be taken in areas free of defects such as splits, knots, and decay. When a dielectric meter is used, the surface of the specimen shall conform to the surface for which the available electrode was calibrated.

10.2 The readings of electric moisture meters show some variability, even on specimens that are at the same moisture content, because properties of wood other than moisture content affect these readings. Dielectric meters are affected more than are resistance meters, so the readings of dielectric meters will generally show more variability than corresponding readings of resistance meters. Because of this variability, and because of natural variability in the moisture content of any quantity of lumber, reliable indications of the average moisture content of a given quantity of lumber can be obtained only if a sufficient sample is taken. For routine inspection of any lot of lumber, no fewer than 10 percent of the lot or 20 specimens whichever is greater, shall be tested when using a resistance meter. No fewer than 20 percent of the lot, or 20 specimens, whichever is greater, shall be tested when using a dielectric meter. Specimens shall be selected at random throughout the lot; the only deviation from random selection shall be that defective specimens and specimens that clearly do not represent the lot (different species, thickness, history, etc.) shall be discarded.

11. Procedure

11.1 *Using Resistance-Type Meter:*

11.1.1 Commercial instruments for measuring moisture content or high resistance usually are accompanied by detailed manuals of instructions. The importance of following these instructions carefully should be stressed. The procedures given here are general and do not supersede instructions provided by the instrument manufacturer. It is particularly important to apply the corrections for species and temperature when they are supplied by the manufacturer.

11.1.2 Test suitable specimens for moisture content according to the instructions for the particular meter being used. Use insulated needles if they can be obtained. Drive the needles into the wood oriented so the current flows parallel to the grain.

11.1.3 If the reading drifts toward lower moisture content, take the reading immediately after the needle electrodes are driven into the specimen.

11.1.4 When the meter is being used with uninsulated needles, note the moisture indication with the needle points just pricking the surface and as the needles are driven into the wood. If the meter reading with the needles just pricking the surface is as high as that with the needles penetrating one fourth of the specimen thickness, the specimen may have a wet surface and the accuracy of the reading is doubtful. If the meter reading increases progressively as the needles are driven deeper, the specimen does not have a wet surface and uninsulated needles will give correct indications.

11.1.5 Wood of rectangular cross-section that has been drying under reasonably constant equilibrium conditions generally has a moisture distribution across its thickness such that at a depth below the surface of one fourth to one fifth of the thickness the moisture content is equal to the average for the cross section. Correspondingly, for wood of circular cross section, the average moisture content occurs at a depth below the surface of about one sixth to one seventh of the diameter. Therefore to measure the average moisture content with a resistance-type meter, drive the electrode needles to a depth of about one fourth to one fifth of the thickness of specimens of rectangular cross section, and to about one sixth to one seventh of the diameter of cylindrical specimens. If the regular electrode needles are too short to reach the specified depth, use nails or other substitute electrodes. Drive the substitute electrodes to the proper depth and about the same distance apart as the needles on the standard electrode. The reading may then be obtained by touching the regular electrode needles to the exposed ends of the substitute electrode needles.

11.2 *Using Dielectric-Type Meters:*

11.2.1 The dielectric-type moisture meter causes an alternating electric field to penetrate into the specimen, the depth of this penetration depending principally on the design of the surface-contact electrode. The reading of the

dielectric meters tends to reflect the integrated or average effect of the material penetrated by the field, to a certain extent independent of the moisture distribution. The material nearest the electrode, however, does have a predominant effect on the meter reading because the field is strongest there and consequently inaccuracies can result when a steep moisture gradient exists. For example, temporary high surface moisture content, such as from rain, dew, or very high relative humidity, will result in erroneously high readings of average moisture content. Therefore, no attempt shall be made to use a dielectric moisture meters on material that has recently been exposed to such weather conditions.

11.2.2 It is desirable to take readings with dielectric meters on material more than 50 mm (2 in.) thick on both sides of the specimen and average the results. Large differences in the readings from opposite sides may be due to one surface being temporarily wet, in which case disregard the readings. Take dielectric readings on specimens 25 mm (1 in.) or less in thickness only with the specimen supported on a base of low-density, nonhygroscopic material, such as rigid polystyrene foam, about 30 mm thick. Alternatively, the specimen may be supported as its ends so that it is at least 25 mm (1 in.) away from other solid material and the reading made at the center of the specimen. Take readings on material 3 mm (⅛ in.) thick or less only with a special veneer electrode with the specimen supported on a low-density base, as above. Alternatively, the thin material may be stacked into a pile 13 to 25 mm (½ to 1 in.) in thickness and the reading obtained with a standard lumber electrode, provided that sufficient pressure is exerted to hold the layers in intimate contact, and the thinner stacks are supported on the low-density base as above. The reading in this latter case will be an approximate average of the various layers penetrated by the field, but again those layers nearest the electrode have a predominant effect. Thus, if the individual layers vary greatly in moisture content, the integrated reading of the stack may be considerably different from the true average of all the layers if the layers near the electrode happen to be at extreme levels of moisture content.

11.3 *Effect of Chemicals and Glue Lines*—Salts or other electrolytes, when present in wood in abnormal amounts, cause large errors in the readings of electronic moisture meters of all types (5). Do not attempt to determine the moisture content with electric meters of lumber that has been treated with salt preservatives or fire retardants, or that has been in prolonged contact with sea water, unless readings no greater than 8 percent moisture content are obtained, in which case the effect of the retained salts is negligible. Any effect of retained salts is to increase the readings, so electronic meters can still be used to establish upper limits of moisture content on salt-treated wood. Preservatives such as pentachlorophenol and creosote affect the readings of electronic meters only slightly, and usually no corrections are necessary. Moisture measurements with electronic meters on plywood may be subject to large error, depending upon the type of glue used in the plywood (6). In some cases it may be possible to establish a correction factor applicable over a narrow range of moisture to one type of plywood made from one species of wood and using one type of glue. More frequently, however, the readings will be so erratic because of the variable electrical properties of the glue that they will be useless. Generally, do not attempt to determine the moisture content of plywood with electronic meters unless it can be shown conclusively by independent tests that the moisture meter readings are accurate.

11.4 *Temperature Corrections*—If the temperature of the specimen is different from that of the material used for calibrating the meter, apply a temperature correction. This temperature correction may be obtained graphically (Figs. 1, 2, 3). As indicated, the amount of correction varies with the temperature and moisture content.

11.5 *Species Corrections*—If the species of wood being tested is other than that for which the moisture meter is directly calibrated, use a species correction supplied by the instrument manufacturer. Occasionally it may be necessary to obtain moisture meter readings on species for which a correction is not available. In such instances, report the type of meter and the species for which it was calibrated in addition to the observed meter readings.

NOTE 3—The errors in moisture content that are obtained without species correction may be as much as ±4 percent for a resistance-type meter but are

usually less than this, and may be as much or greater than ±10 percent for dielectric meters.

11.6 *Precautions in Using Electronic Moisture Meters:*

11.6.1 Prolonged exposure of moisture meters to environments of very high humidity, or moving the meter from a cold location to a warm location, can cause surface films of moisture to form on nonconducting parts of the instrument. These surface films temporarily destroy the value of insulators and strongly affect the meter operation. With the resistance meter, moisture films can seriously affect the meter calibration, particularly on low moisture ranges, even though initial balance may be obtainable. This situation usually can be recognized by a large inconsistency between scales or ranges of the meter, but, on the other hand, the error from these moisture films may be unnoticed. With the dielectric meters, if the initial balance or adjustment can be attained with the adjustment control, the effect of those moisture films is largely compensated and reasonably accurate measurements can still be made. The effect of the moisture films is quite variable, however, and when using the dielectric meters in humid weather the initial balance should be checked frequently. Generally, use of moisture meters of any type should be avoided if possible during very humid weather, but if their use is necessary, the meter should be stored in a warm dry location and used in the humid environment only for short periods of time. Particular care is necessary under these conditions to keep the electrode of resistance meters dry.

11.6.2 Occasionally resistance-type moisture meters are used with permanently installed nail or needle electrodes to monitor the moisture content of wood from a remote location. While there is conflicting evidence concerning the value of such a procedure, it should be recognized that large errors may exist in readings so taken, particularly where the wood is at a moisture content of 20 percent or higher. Apparently, the resistance of the interface between the electrode and the wood increases with time until, after an hour or more, it is so high that indications higher than 15 or 20 percent may not be obtained even on green wood. On the other hand, when the wood is at a moisture content below about 15 percent, the error becomes smaller and usually is negligible on wood at 10 percent moisture content or lower, even if the electrodes have been installed for weeks.

METHOD C—DISTILLATION METHOD

12. Apparatus

12.1 *Extraction Flask*—A 500-ml flask and thimble holder, as shown in Fig. 4. The flask and holder may be combined in one unit.

12.2 *Condenser*—A water-cooled condenser of the cold-finger type, as shown in Fig. 2, or of the straight-tube, Liebig type.

12.3 *Water Trap*—A glass tube preferably having an inside diameter of 9.0 to 10.0 mm and sealed at one end. If a trap with stopcock is used, the stopcock shall be securely held in place by means of a wire. The graduated portion of the tube shall have a capacity of 10 ml. The smallest graduation should be not greater than 0.1 ml with the major divisions marked 1 to 10. The water trap should be chemically clean so that the shape of the meniscus at the end of the test is the same as at the beginning. (The trap may be coated with a silicone resin to give a uniform meniscus. To coat the trap, first clean it with sulfuric acid-chromic acid mixture. Rinse the clean trap with a silicone resin[3] and, after draining for a few minutes, bake for 1 h at approximately 200 C.)

12.4 *Extraction Cup*—Either a Wiley siphon cup of suitable size or a basket made of approximately 45-mesh, stainless steel gauze and having the approximate dimensions of 42 mm (1 11/16 in.) in outside diameter and 127 mm (5 in.) in length. The siphon cup is recommended for borings from heavily treated piling. When a siphon cup is used, the loss of wood particles should be prevented either by placing a conical screen at the bottom of the siphon cup or by putting the chips or borings in a wire gauze basket which is then placed inside the siphon cup.

12.5 *Hot Plate.*

12.6 *Weighing Bottle*—The weighing bottle shall have a ground glass stopper and be of sufficient size to contain the wire extraction cup or Wiley siphon described in 12.4.

12.7 *Rod*—A rod approximately 3 mm (⅛ in.) in diameter made of some material to which

[3] Dow-Corning 1107 has been found satisfactory for this purpose.

bon resin.

12.8 *Oven*—See 4.1. The oven shall be maintained at a temperature of 103 ± 2 C (217.4 ± 3.6 F).

12.9 *Desiccator.*

12.10 *Balance*—The balance shall have a sensitivity of 0.01 g.

12.11 *Swedish Increment Borer.*

13. Reagents and Materials

13.1 *Desiccant*—Calcium chloride, silica gel, etc.

13.2 *Toluene*—The toluene shall be of the grade known as industrial pure, boiling within 2 C.

14. Preparation of Apparatus

14.1 Place about 200 ml of toluene and 1 to 2 ml of distilled water in the extraction flask. Assemble the apparatus on the hot plate, apply heat, and reflux for about 30 min. Allow the contents of the water trap to cool to room temperature, then using the rod, transfer any water adhering to the walls of the condenser or to the walls of the water trap to the water layer in the trap. Read and record the volume of water in the trap to the nearest 0.01 ml. This procedure may be dispensed with if at the start of the determination the flask, water trap, and inner walls of the condenser are carefully dried and dry toluene may be used for the extraction.

14.2 Before using the increment borer to take a sample for moisture or preservative determination, calibrate the borer. Take 20 borings from material of like species. Measure each boring at its mid-point to the nearest 0.025 mm (0.001 in.), once in the transverse grain direction and once in the longitudinal grain direction. Average these two measurements and square the result. Calculate the sum of the 20 squares and divide the total by 20. Calculate the square root of the quotient to the nearest 0.025 mm (0.001 in.). Use this result as the calibrated diameter of the borer.

15. Procedure

15.1 Weigh the wire extraction basket or the Wiley siphon and the weighing bottle separately to the nearest 0.01 g. Place the basket or siphon in the weighing bottle.

15.2 When using the Swedish increment borer, take a minimum of 20 borings from the lot of wood to be sampled. As each boring is taken carefully cut and measure the desired portion for assay. Place each boring section in the extraction basket or Wiley siphon as it is cut. Stopper the weighing bottle at all times except when actually placing or removing borings from it. When a specimen other than an increment boring is used, it should be composed of fragments that are no more than 6 mm (¼ in.) along the grain, and of cross-sectional dimensions convenient to fit the extraction container. Mix the fragments quickly in a suitable container and then transfer a portion of about 25 g into the extraction basket.

15.3 Weigh the bottle, container, and contents to the nearest 0.01 g. Transfer the container and contents to the extraction section of the apparatus. Weigh the empty, stoppered weighing bottle to the nearest 0.01 g without removing any condensate from it. The difference between this weight and the original tared weight of the weighing bottle represents the first portion of water in the sample.

15.4 Apply heat to the extraction apparatus and reflux the toluene at a rate of at least 1 drop/s from the tip of the condenser. With freshly creosoted wood continue the refluxing for at least 2 h. Use an extraction of at least 5 h for wood freshly treated with creosote-coal tar solutions. After the appropriate reflux period, allow the contents of the trap to cool to room temperature. By means of the rod, transfer any water adhering to the walls of the condenser or to the walls of the water trap to the water layer in the trap, then read and record the volume of water in the trap to the nearest 0.01 ml. The difference between this reading and the first reading (14.1) represents the second and final portion of water in the sample.

15.5 While the extraction is in process, clean the weighing bottle by rinsing with acetone, dry in the oven, cool in the desiccator, then reweigh and place back in the desiccator.

15.6 Remove the extraction container and contents from the extraction flask and place under a hood for 15 min; then place in the oven preheated to 125 C. Dry for 2 ± 0.5 h.

15.7 When the container and borings have dried for the prescribed period, transfer to the weighing bottle. Cool the uncovered weighing bottle and contents to room temperature in a

desiccator; then weigh with cover to the nearest 0.01 g. Calculate and record the weight of dry extracted wood.

16. Calculations

16.1 Calculate the moisture content as follows:

$$\text{Moisture content, percent of extracted wood} = [(W_1 + W_2)/W_3] \times 100$$

where:

W_1 = first portion of water, g (15.3),
W_2 = water measured in trap, ml (15.4), and
W_3 = final weight of bottle plus container plus contents minus final tared weight of bottle minus tared weight of container, g. This is the weight of the dry extracted wood.

16.2 Should the weight of the preservative in the sample, volume of the sample, and retention be desired, the following equations shall be used:

$$\text{Weight of preservative in sample, g} = W_4 - W_3 - W_2 - W_1$$

$$\text{Weight of preservative in sample, lb} = (W_4 - W_3 - W_2 - W_1)/453.6$$

where:

W_4 = original weight of bottle plus container plus content minus original tared weight of bottle minus tared weight of container, g,
W_3 = final weight of bottle plus container plus contents minus final tared weight of bottle minus tared weight of container, g,
W_2 = water measured in trap, ml, and
W_1 = first portion of water, 15.3, g.

$$\text{Volume of sample, ft}^3 = L\pi R^2/1728$$

where:

L = total length of borings, mm (in.), and
R = calibrated diameter of borings.

$$\text{Content of preservative, lb/ft}^3 = W/V$$

where:

W = weight of preservative, lb, and
V = volume of sample, ft^3.

Method D—Hygrometric Method

17. Apparatus

17.1 *Bottles*—Wide-mouth glass bottles of about 500-cm^3 capacity. The wood specimens are placed in the bottle and the sensing element of an electric hygrometer inserted and held in position over the wood specimens by means of a rubber stopper which has been bored and cut to accommodate the cord connecting the sensing element with the indicating meter.

17.2 *Electric Hygrometer* (*Fig. 5*)—An electric hygrometer that indicates relative humidity over the range from 20 to 90 percent. The instrument calibrated scale or scales should enable reading to 1 percent relative humidity. Temperature correction charts or curves shall be provided by the instrument manufacturer.

18. Test Specimens

18.1 The specimen to be tested should weigh approximately 10 g and should be cut into slices that are about 1.5 to 3 mm ($\frac{1}{16}$ to $\frac{10}{8}$ in.) along the grain. The slices shall be immediately placed in the bottle, which is then sealed by the rubber stopper. If a delay between obtaining the specimen and cutting for test cannot be avoided, the specimen shall be placed in a vapor-tight container or wrapper immediately after it is obtained and remain in the container or wrapper until it can be cut up and placed in the bottle. Suitable wrappers can be made of aluminum foil or polyethylene film. As with the oven-drying method, Method A, the delay between obtaining and cutting the protected specimen for test shall be as small as possible.

19. Procedure

19.1 *Obtaining Equilibrium Relative Humidity*—Place the bottle containing the cut up wood specimen and sensing element of the electric hygrometer where the temperature is fairly constant and can be readily determined. Take readings on the meter at frequent intervals until equilibrium is registered. The time to reach equilibrium will vary from 5 to 30 min depending upon the species of wood, moisture content, and chemicals in the wood. When equilibrium is indicated, record the relative humidity and temperature in degrees Celsius (Fahrenheit).

19.2 *Temperature Correction*—Correct the hygrometer reading of relative humidity for temperature using charts or curves provided by the instrument maker. Figure 6 is an example of such a correction curve. For example, if the hygrometer reading is 62 percent and the

temperature is 16°C (60°F), the correction (Fig. 4) is +3 percent relative humidity, and the corrected reading is 65 percent relative humidity.

19.3 *Estimating Wood Moisture Content*—Estimate the moisture content of the wood specimen by reference to wood equilibrium moisture content charts such as shown in Fig. 7. For example, if the corrected equilibrium relative humidity is 65 percent and the temperature is 16°C (60°F), the estimated moisture content of the wood specimen in the bottle is 12 percent.

REFERENCES

(1) James, W. L. "Electric Moisture Meters for Wood," *Forest Products Laboratory*, FPLIA, No. 08, July 1963.

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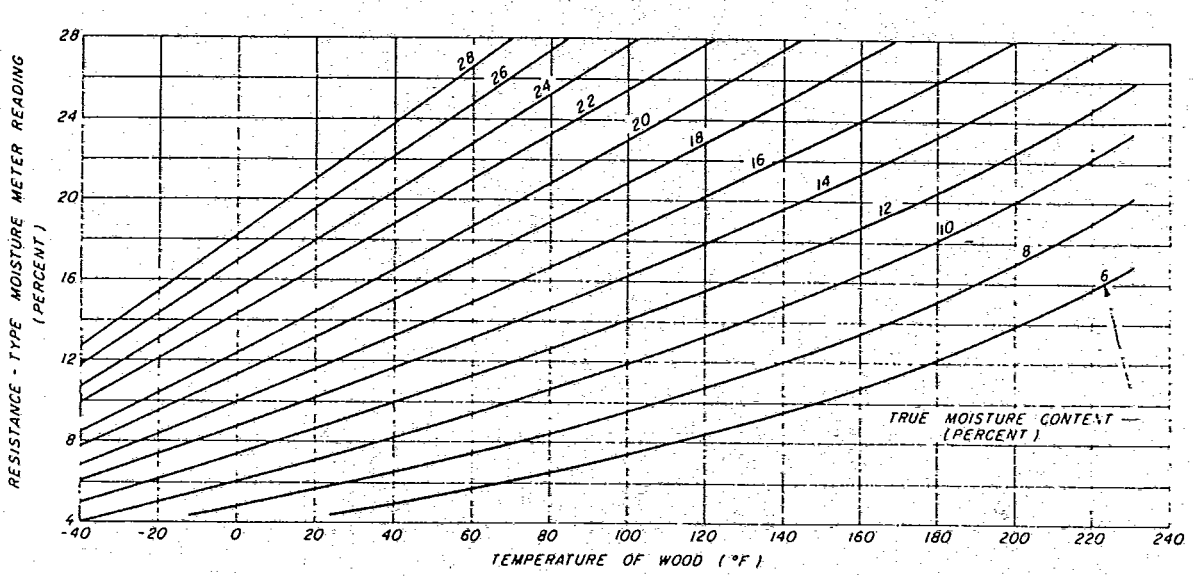
(3) James, W. L. "Effect of Temperature on the Readings of Electric Moisture Meters," *Forest Products Journal*, FPJOA, Vol 18, No. 10, October 1968.

(4) Bramhall, G. and Salamon, M., "Combined Species-Temperature Correction Tables for Moisture Meters," Report VP-X-103, *Eastern Forest Products Laboratory*, FPLPA, Canadian Forestry Service.

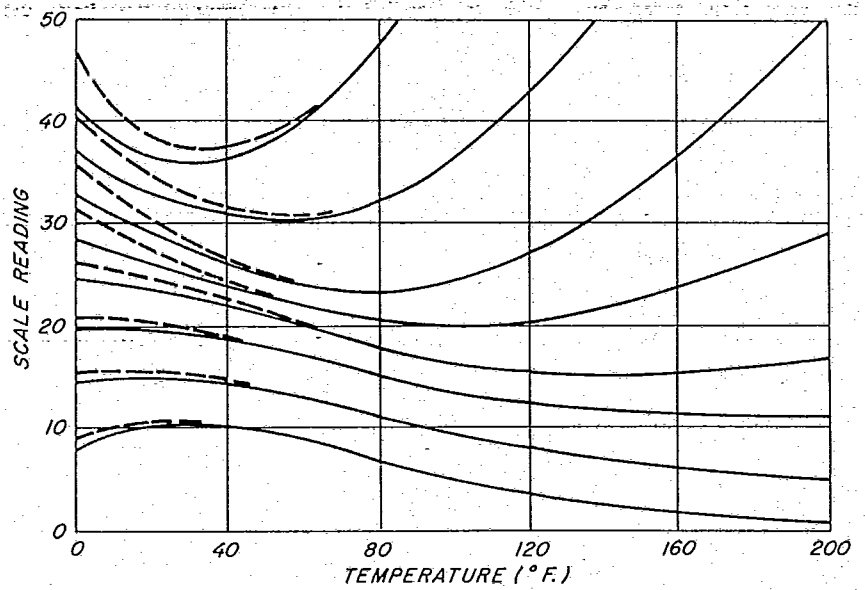
(5) James, W. L. "Effects of Wood Preservatives on Electric Moisture Meter Readings," U.S. Forest Service Research Note, *Forest Product Laboratory*, FPLIA, Report No. 0106, August 1965.

(6) Bell, E., and Krueger, N. "Effect of Plywood Glue Lines on the Accuracy of Moisture Meter Indications," *Forest Products Research Society*, FPNOA, Reprint No. 68 1949.



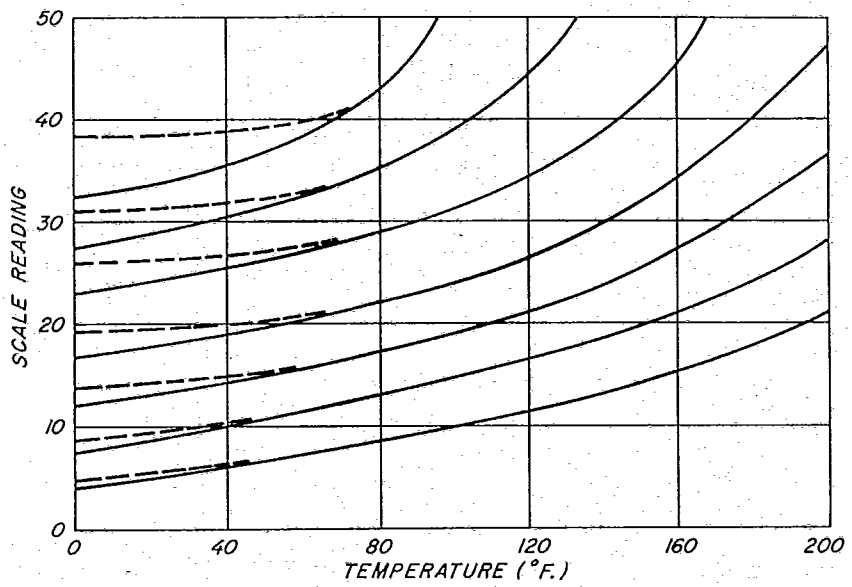
NOTE—Find meter reading on vertical left margin, follow horizontally to vertical line corresponding to the temperature of the wood, interpolate true moisture from family of curves. Example: if meter indicated 18 percent on wood at 120° F., true moisture content would be 14%. This chart is based on a calibration temperature of 70° F. For other calibration temperatures near 70° F., adequate corrections can be obtained simply by shifting the temperature scale so that the true calibration temperature coincides with 70° on the percent scale. For example, for meters calibrated at 80° F., add 10° to each point on the temperature scale (shift the scale 10° toward the left), and use the chart as before.

FIG. 1 Temperature Corrections for Reading of Resistance-Type Moisture Meters.



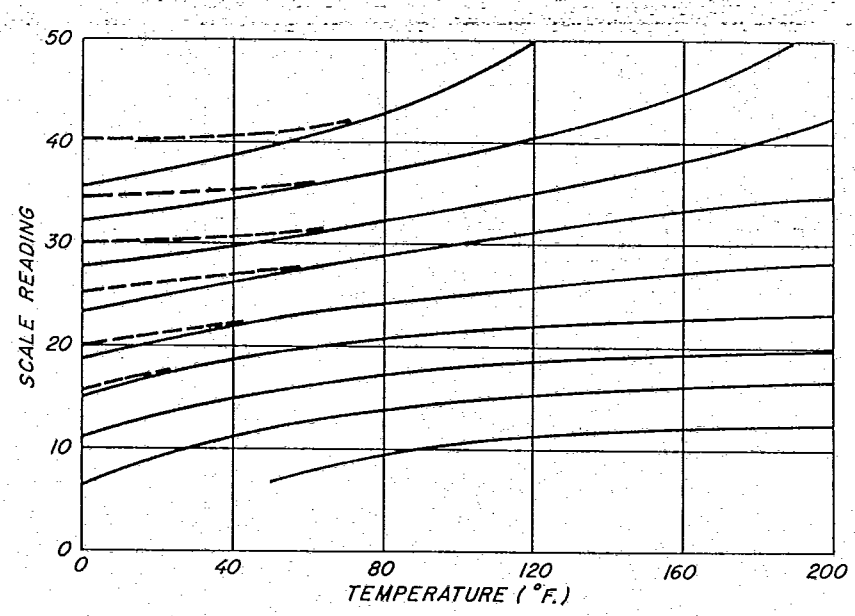
NOTE—Find the temperature of the wood on the horizontal coordinate, go straight up to the vertical coordinate corresponding to the meter reading, and follow the curves to the vertical line at the calibration temperature (usually 80°F) of the meter. The vertical coordinate at the calibration temperature is the corrected meter reading, which then is converted to moisture content using the usual tables. The solid lines indicate the correction when the meter itself is at the calibration temperature; the dashed portions when the meter is at the same temperature as the wood.

FIG. 2 Temperature Correction Chart for Dielectric Moisture Meters. Operating at approximately 10 MHz frequency employed in dielectric-type meters produced commercially in the United States and Canada during 1973.



NOTE—Find the temperature of the wood on the horizontal coordinate, go straight up to the vertical coordinate corresponding to the meter reading, and follow the curves to the vertical line at the calibration temperature (usually 80°F) of the meter. The vertical coordinate at the calibration temperature is the corrected meter reading, which then is converted to moisture content using the usual tables. The solid lines indicate the correction when the meter itself is at the calibration temperature; the dashed portions when the meter is at the same temperature as the wood.

FIG. 3a Approximate Temperature Correction Chart for Capacitive-Admittance Moisture Meters with Calibration of 15 or Less. Operating at approximately 1 MHz (Frequency employed in all capacity—admittance meters produced commercially in the United States and Canada during 1973.



NOTE—Find the temperature of the wood on the horizontal coordinate, go straight up to the vertical coordinate corresponding to the meter reading, and follow the curves to the vertical line at the calibration temperature (usually 80° F) of the meter. The vertical coordinate at the calibration temperature is the corrected meter reading, which then is converted to moisture content using the usual tables. The solid lines indicate the correction when the meter itself is at the calibration temperature; the dashed portions when the meter is at the same temperature as the wood.

FIG. 3b Approximate Temperature Corrections for Capacitive-Admittance Moisture Meters With Calibration Setting of 20 or Above.

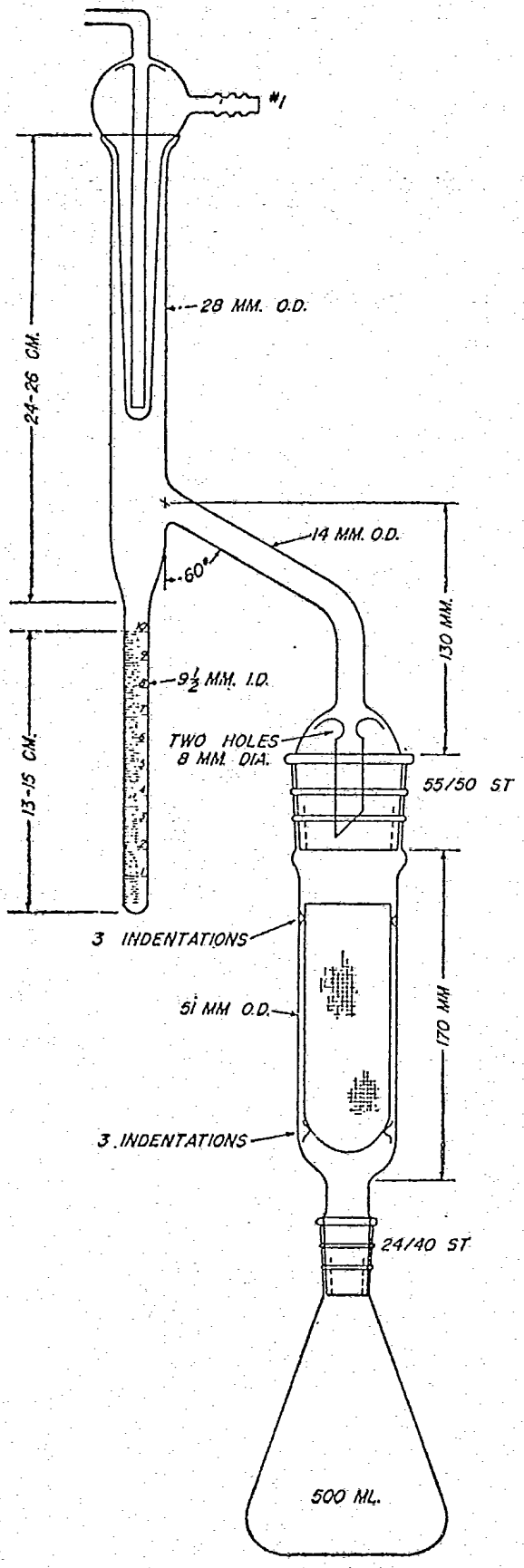


FIG. 4 Extraction Apparatus, Method C.

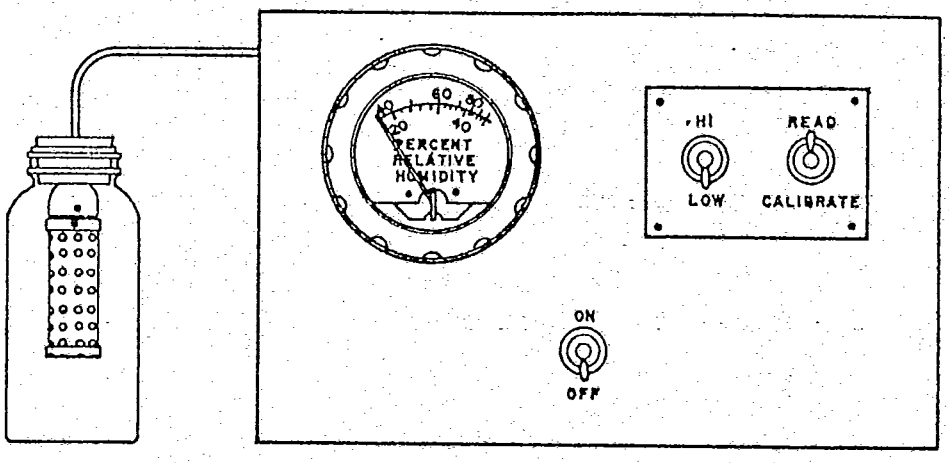


FIG. 5 Electric Hygrometer, Method D.

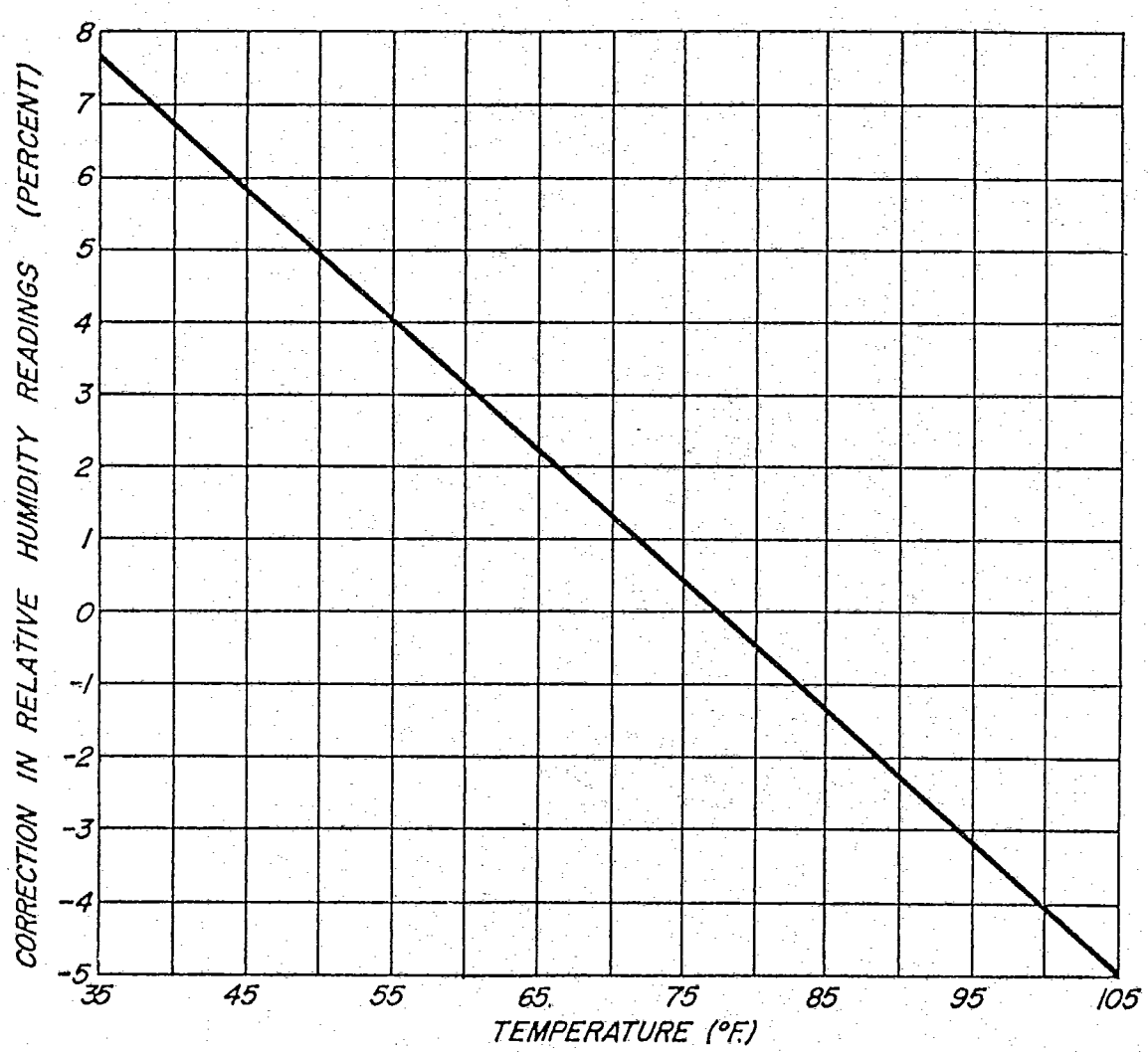


FIG. 6 Example of Temperature-Correction Chart for Electric Hygrometer (Method D).

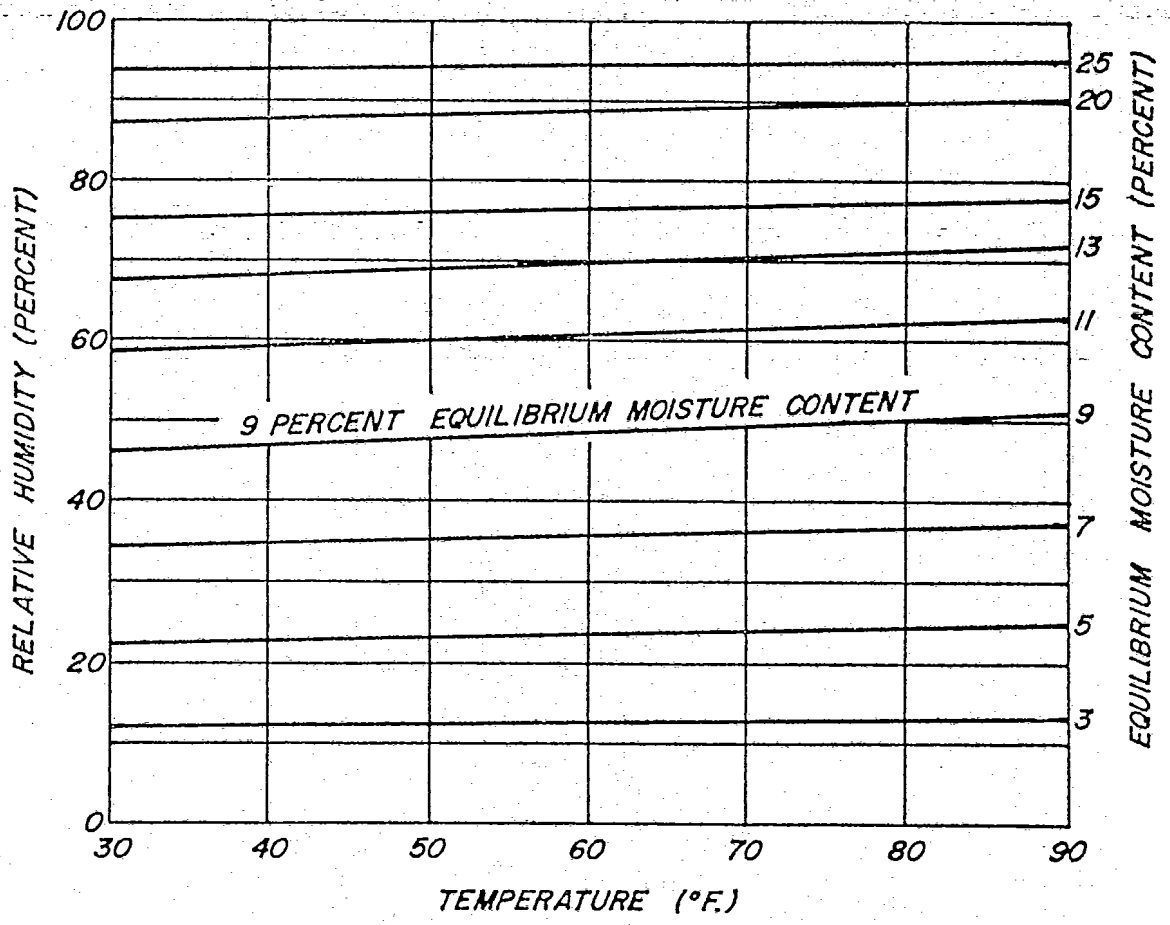


FIG. 7 Equilibrium Moisture Content of Wood as a Function of Relative Humidity and Temperature.

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