Designation: D2654 – 22

Standard Test Methods for Moisture in Textiles[1]

This standard is issued under the fixed designation D2654; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 These test methods cover measurement of moisture in textile materials as *(1)* moisture content or pick-up using ambient air for oven-drying, *(2)* moisture content or pick-up using standard atmosphere for testing textiles for oven-drying, *(3)* moisture content or pick-up at moisture equilibrium, and *(4)* moisture regain. These test methods are applicable to all fibers natural or man-made, and in all forms from fiber or filament to finished fabric, subject to the limitations set forth in 1.1.1 through 1.1.4. Blends of fibers shall also be tested by these methods.

1.1.1 *Procedure 1*—This oven-drying technique, using ambient air heated to 105 °C, shall be used in any situation in which a simple and convenient method for routine process control or when in-plant evaluation is needed to determine an approximation of the moisture content or pickup. It is not recommended for jute or grease wool, or for acceptance testing in commercial transactions.

1.1.2 *Procedure 2*—Oven-drying technique, using air from the standard atmosphere air for testing textiles that is heated to 105 °C and other refinements in technique, shall be used as a basis for commercial transactions for all materials for which it is known that no significant quantity of non-aqueous volatile matter is present on, or in, the material to be tested.

NOTE 1—The air supply for Procedure 2 has been changed from desiccated air to the air from the standard atmosphere for testing textiles because the latter is in common use and is prescribed in Test Method D494 for commercial mass of a shipment. By agreement, however, desiccated air may be used.

1.1.3 *Procedure 3*—This oven-drying technique uses specimens in moisture-equilibrium under specified conditions and an oven with an air supply of specified temperature and relative humidity heated to 105 °C, and other refinements in technique. The procedure is used to determine the moisture content or pickup of a material in equilibrium conditions, usually the standard atmosphere for testing textiles.

NOTE 2—The previous Procedure 3 for determining moisture using distillation with toluene has been dropped from this method because it is essentially the same as Test Method D2462 which is the preferred method for jute and grease wool in any circumstance. Test Method D2462 is the preferred method for any material in which it is known, or suspected, that a significant quantity of nonaqueous and non-water miscible volatile matter is present.

1.1.4 *Procedure 4*—This new technique is for determination of actual moisture regained by a material under specified conditions after the material has been extracted by a suitable procedure, if surface materials are present, and dried in vacuum at a low temperature

1.2 In Procedures 1, 2, and 3, alternative techniques are described for weighing oven-dried specimens: in the oven while hot, and outside the oven at room temperature.

1.3 The word *water* refers to the chemical compound H_20. The terms *water* and *moisture* are frequently used interchangeably in the literature and in the trade even when the "moisture" is known to contain other volatile materials. When the loss during oven exposure is not known to be all water, it shall be considered a "volatiles loss" rather than a "moisture loss" for technical accuracy.

1.4 Moisture calculations commonly involve the mass of a specimen that has been dried by heating in an oven. If the air in the oven contains moisture, the oven-dried specimen will contain moisture (in equilibrium with that in the oven air) even when it no longer shows a significant change in mass. Therefore, if a very precise measurement of the moisture present is required and oven drying is used, the mass must be exposed to desiccated air until it shows no further significant change in mass.

NOTE 3—Other ASTM Standards related to the determination of moisture of textile materials are Test Methods D1576, D2495, and D2118.

1.5 The values stated in SI units are to be regarded as standard. The values given in parentheses after SI units are provided for information only and are not considered standard.

[1] These test methods are under the jurisdiction of ASTM Committee D13 on Textiles and are the direct responsibility of Subcommittee D13.51 on Conditioning, Chemical and Thermal Properties.

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1.6 *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.*

1.7 *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]

D123 Terminology Relating to Textiles
D494 Test Method for Acetone Extraction of Phenolic Molded or Laminated Products
D584 Test Method for Wool Content of Raw Wool—Laboratory Scale
D629 Test Methods for Quantitative Analysis of Textiles
D1441 Practice for Sampling Cotton Fibers for Testing
D1576 Test Method for Moisture in Wool by Oven-Drying
D1776/D1776M Practice for Conditioning and Testing Textiles
D1909 Standard Tables of Commercial Moisture Regains and Commercial Allowances for Textile Fibers
D2118 Practice for Assigning a Standard Commercial Moisture Content for Wool and its Products
D2258 Practice for Sampling Yarn for Testing
D2462 Test Method for Moisture in Wool by Distillation With Toluene
D2494 Test Method for Commercial Mass of a Shipment of Yarn or Manufactured Staple Fiber or Tow
D2495 Test Method for Moisture in Cotton by Oven-Drying
D2525 Practice for Sampling Wool for Moisture
D3333 Practice for Sampling Manufactured Staple Fibers, Sliver, or Tow for Testing

3. Terminology

3.1 *Definitions:*

3.1.1 *commercial moisture regain, n*—an arbitrary value formally adopted as the regain to be used with the oven-dried mass when making certain calculations. (Compare *moisture regain* and *standard moisture regain*.)

3.1.1.1 *Discussion*—The assigned *commercial moisture regain* value is usually higher than the experimental moisture regain value for the same material.

3.1.2 *dew point, n*—the temperature below which condensation of water vapor begins to take place when the atmosphere is cooled.

3.1.2.1 *Discussion*—As air is cooled, the amount of water vapor which it can hold decreases. If air is cooled sufficiently, the saturation water-vapor pressure becomes equal to the actual water-vapor pressure and any further cooling beyond this point will normally result in the condensation of moisture.

3.1.3 *hygrometer, n*—any instrument for measuring the humidity of the atmosphere.

3.1.4 *moisture, n—as used with textiles*, water absorbed, adsorbed or resorbed by a material. (See also *water*.)

3.1.5 *moisture as-is, n*—deprecated term. See *moisture content*.

3.1.6 *moisture as-received, n*—deprecated term. See *moisture content*.

3.1.7 *moisture content, n*—that part of the total mass of a material that is absorbed or adsorbed water, compared to the total mass. (Compare *moisture pick-up* and *moisture regain*.)

3.1.7.1 *Discussion*—Moisture content is usually expressed as a percentage and is calculated using the equation:

$$C = 100\,(A - D)/A$$

where:

C = moisture content, %,
A = mass of material before drying, and
D = mass of the dried material.

There is a relationship between *moisture content* and *moisture pick-up* since both shall be calculated from the same data. The difference is in the bases used for calculating the percentages, original versus dried material mass. The relationship between moisture content and moisture pick-up is shown by the equations:

$$C = 100\,P/(100 + P)$$
$$P = 100C/(100 - C)$$

where:

C = moisture content, %, and
P = moisture pick-up, %.

3.1.8 *moisture content, n—at moisture-equilibrium*, the moisture content of a material in equilibrium with air of known, or specified, temperature and relative humidity.

3.1.8.1 *Discussion*—A frequently prescribed condition for determining *moisture content at moisture-equilibrium* is use of a standard atmosphere, for example, 21 °C ± 2 °C (70 °F ± 4 °F) and 65 ± 5 % relative humidity, for textiles both in establishing the equilibrium and air supply for the drying oven.

3.1.9 *moisture content (dry-basis), n*—deprecated term. See *moisture pick-up*.

3.1.10 *moisture (dry-basis), n*—deprecated term. See *moisture pick-up*.

3.1.11 *moisture equilibrium, n*—the condition reached by a material when it no longer takes up moisture from or gives up moisture to the surrounding atmosphere. (Compare *moisture-free*.)

3.1.11.1 *Discussion*—The establishment of equilibrium between a material and the surrounding atmosphere is dependent upon the exposure time, the difference in moisture levels between the material and the atmosphere, and motion of the air about the material. The level at which the moisture in the textile reaches equilibrium depends upon the side from which

[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.

equilibrium is approached. Because of this difference equilibrium for textiles shall be approached from the dry (but not moisture-free) side which is faster. Equilibrium with air in motion is considered to be achieved when successive weighings at specified time intervals do not show a change in mass greater than the tolerance established for the material. If there is no established tolerance, consider 0.1 % of the mass after a 2-h exposure as satisfactory.

3.1.12 *moisture-free, adj—in textiles*, a descriptive term for a material that *(1)* has been exposed to a flow of desiccated air at a specified temperature until there is no further significant change in mass, or *(2)* has been treated by a distillation process using a suitable solvent. (Syn. *zero moisture*.) (Compare *moisture equilibrium*.)

3.1.12.1 *Discussion*—Moisture determinations frequently involve the change in mass of an oven-dried specimen. If the air in the oven contains moisture, the oven-dried specimen will also contain some moisture even though it no longer shows a significant change in mass. This is due to the establishment of moisture equilibrium under the existing conditions. To ensure that the specimen is actually *moisture free*, it must be exposed to desiccated air until it shows no further significant change in mass. Although heating textiles in desiccated air to temperatures as high as 110 °C increases the rate of moisture loss without changing the final equilibrium mass of the moisture-free textile, heating also increases the possibility of removing other matter. The distillation process shall be substituted provided the textile does not contain any distillable, water-soluble matter.

3.1.13 *moisture pick-up, n*—the mass of absorbed and adsorbed water that is held by a material, compared to the mass of the dried material. (Compare *moisture content* and *moisture regain*.)

3.1.13.1 *Discussion—Moisture pick-up* is usually expressed as a percentage based on the dried mass of the material and is calculated using the equation:

$$P = 100\ (A - D)/D$$

where:

P = moisture pick-up, %,
A = mass of material before drying, and
D = mass of the dried material.

(See equations in 3.1.7 for relationship between *moisture pick-up* and *moisture content*.) Since *moisture pick-up*, like *moisture content*, involves the "as-is, where-is" (from a location with unknown temperature and humidity conditions) state of the material, it is generally unknown if the loss in mass on drying is caused by the loss of any materials other than water.

3.1.14 *moisture pick-up, n—at moisture-equilibrium*, the moisture pick-up of a material in equilibrium with air of known, or specified, temperature and relative humidity.

3.1.14.1 *Discussion*—A frequently prescribed condition for determining moisture content at moisture-equilibrium is use of a standard atmosphere, for example, 21 °C ± 1 °C (70 °F ± 2 °F) and 65 ± 2 % relative humidity, for textiles, both in establishing the equilibrium and as air supply for the drying oven.

3.1.15 *moisture regain, n*—the amount of water resorbed by a dried material at specified equilibrium conditions of temperature and humidity, compared to the mass of the dried material. (See *standard moisture regain*.) (Compare *commercial moisture regain*, *moisture content*, and *moisture pick-up*.)

3.1.15.1 *Discussion—Moisture regain* is usually expressed as a percentage and is calculated using the equation:

$$R = 100\ (B - D)/D$$

where:

R = moisture regain, %,
B = mass of material in moisture-equilibrium at specified conditions, and
D = mass of the material dried under specified conditions.

Since most surface matter can be extracted without appreciably affecting the textile material, or the textile material can be produced without surface matter (except natural fibers), anything removed by drying or distillation after *moisture-equilibrium* is established is water. This is a key difference between *moisture regain* and *moisture pick-up*, which have been traditionally, but incorrectly, used synonymously.

3.1.16 *moisture, wet-basis, n*—deprecated term. See *moisture content*.

3.1.17 *oven-dried, adj*—a descriptive term for a material that has been heated under prescribed conditions of temperature and humidity until there is no further significant change in the mass of the material.

3.1.17.1 *Discussion*—An oven-dried material retains a small amount of moisture which is dependent upon the temperature and relative humidity of the air supplied to the oven. An oven-dried material will only be *moisture-free* if the air supplied to the oven has been desiccated.

3.1.18 *resorption, n*—the process by which a material that has given up another material by desorption takes up some more of the material given up.

3.1.19 *standard atmosphere for testing, n—in textiles*, an atmosphere for testing in which the air is maintained at a relative humidity of 65 ± 5 % and at a temperature of 21 °C ± 2 °C (70 °F ± 4 °F).

3.1.19.1 *Discussion*—Special conditions of humidity and temperature are sometimes prescribed for the testing of certain textiles for specific service predictions; resistance to water or biological action, etc. When international testing is involved, a standard temperature of 20 °C ± 2 °C, or, by agreement, 27 °C ± 2 °C is involved. A standard temperature of 20 °C ± 2 °C shall be used.

3.1.20 *standard condition, n—for glass textiles*, that condition reached by the material when in moisture equilibrium with a standard atmosphere having a relative humidity of 65 % at 21 °C (70 °F). A tolerance of ±2 % is permitted in relative humidity and ±2 °F (1 °C) in temperature.

3.1.21 *standard condition for physical testing, n*—the condition reached by a specimen or sample when, after being preconditioned in the standard atmosphere for preconditioning, it has been brought to moisture equilibrium for testing in the standard atmosphere for testing.

3.1.22 *standard moisture regain, n*—the moisture regain of a material at equilibrium with the standard atmosphere for testing textiles. (See *moisture regain*.)

3.1.23 *volatiles, n*—materials readily vaporizable at relatively low temperatures.

3.1.23.1 *Discussion*—When the nature of the loss in mass on heating is not known to be water only; the lost matter shall be called "volatiles" with subsequent modification of these moisture content and pick-up terms.

3.1.24 *water, n*—the chemical compound, H_20. Syn. *moisture*.

3.1.25 *zero-moisture, adj*—See *moisture-free*, the preferred term.

3.1.26 For definitions of other textile terms used in these test methods, refer to Terminology D123.

4. Summary of Test Methods

4.1 Procedures 1 and 2, for moisture content and pick-up, are based on drying in ovens which have different air supplies. Procedure 3, for moisture-equilibrium content or pick-up, uses air from the standard atmosphere for testing textiles for conditioning and drying. Procedure 4, for moisture regain, is based on suitable removal of surface materials, if any, oven drying, and resorption by conditioning. More detailed summaries are given in 7.1, 14.1, 22.1, and 29.1.

5. Significance and Use

5.1 Test Methods D2654, Procedure 1, is used in the trade as a basis for rejecting abnormally wet material, but it is not recommended for routine acceptance testing of commercial shipment. Procedure 2 is used by the trade and is recommended for acceptance testing of commercial shipments except as stated in Note 1 . Procedure 3 is used to determine the moisture in a material in a given moisture-equilibrium situation and is not used for acceptance testing of commercial shipments. Procedure 4 is for research and development and is recommended for determining the standard moisture regain of a material although there will usually be a bias between buyer and producer data because the produce is usually able to obtain material without surface material, mostly finishes.

5.1.1 In case of a dispute arising from differences in reported test results when using Test Method D2654 for acceptance testing of commercial shipments, the purchaser and the supplier shall conduct comparative tests to determine if there is a statistical bias between their laboratories. Competent statistical assistance is recommended for the investigation of bias. As a minimum, the two parties shall take a group of test specimens that are as homogeneous as possible and that are from a lot of material of the type in question. The test specimens shall then be randomly assigned in equal numbers to each laboratory for testing. The average results from the two laboratories shall be compared using student's l-test for unpaired data and an acceptable probability level chosen by the two parties before the testing is begun. If a bias is found, either its cause must be found and corrected or the purchaser and the supplier must agree to interpret future test results in the light of the known bias.

5.2 The measurement of moisture is important for several reasons, including the following:

5.2.1 Large quantities of fibers and manufactured textile products containing some water are bought and sold on the basis of mass. The value of a particular commodity varies over a significant range with a variation in the amount of water it contains.

5.2.2 Besides the effect of the moisture present when the material is received, the moisture present at the time of testing and subsequent handling and processing can be quite important.

5.2.2.1 Some textile fibers, particularly cellulosic fibers and wool, have physical properties that vary significantly with the amount of moisture present, such as tensile strength, crimp, torsional rigidity, etc.

5.2.2.2 Optimum conditions for processing, such as in carding, include moisture as an important parameter.

5.2.2.3 Control of blends during processing is sometimes critically dependent on the moisture present in the components.

5.2.2.4 Production of textile products to meet specifications for mass per unit area of fabric and the linear density of yarn depends on control of moisture.

5.2.2.5 Quantitative analysis of fiber mixtures requires information on moisture present. (See Test Methods D629.)

5.3 Between Procedures 1 and 2, the choice for use is dependent primarily on the degree of accuracy required in the result. They are oven-drying procedures and have the virtue of simplicity and economy, with Procedure 1 having the added feature of not requiring a special drying atmosphere for the oven. Both are subject to certain limitations, however, that are avoided by toluene distillation (Note 2).

5.3.1 Because Procedure 1 uses ambient air and Procedure 2 uses air from the standard atmosphere for testing textiles, the mass of the oven-dry specimen is somewhat greater than it would be if the air were without water. This is due to the establishment of moisture-equilibrium between the moisture in the air supply and the moisture in the specimen. The error is usually slight, but in the case of wool dried at 105 °C with the use of ambient air that is hot and humid, the residual moisture in the oven-dry specimen can be as high as 1 % or more (see Tables 1 and 2 of Test Method D584). When the temperature and relative humidity of the ambient air are known, the amount of moisture retained by a specimen of wool, cotton, silk, viscose rayon, cuprammonium rayon, or acetate shall be estimated data.[3] An additional source of potential error in oven-drying is the loss of volatile matter other than water when such material is present.

5.4 It is sometimes possible, and preferable, when sampling a material for the determination of moisture to select sampling units of a size which coincide with the size required by the method for a test specimen. In these instances, the mass shall be determined immediately, and if the mass of the oven-dry material is to be determined, no intermediate steps are necessary. However, in other instances, it will be necessary to

[3] Toner, R. K., Bowen, C. F., and Whitwell, J. C., "Equilibrium Moisture Relations for Textile Fibers," *Textile Research Journal*, Vol 17, No. I, January 1947, p 7.

perform some intermediate manipulation with the material, such as compositing or subsampling. For such instances to circumvent the problem of moisture loss or gain after sampling, provisions are made in these methods to stabilize the material in the working laboratory atmosphere, and equations are provided with correction terms to relate the measured moisture to the amount which existed at the time when the sample was taken.

5.5 While moisture regain is not a frequently tested property, it has an importance, once established. Commercial moisture regains (see Table 1 in D1909) are values adopted for use in determining commercial mass and fiber blends which meet government regulations. These values are usually slightly higher than experimental standard moisture regain values or an average for a class which has a range.

5.6 The measurement of moisture regain of a fiber is affected by any surface material present, the procedure (technique, solvent) used to remove the material, the dryness achieved and the atmosphere (temperature, humidity) in which the dry material is conditioned.

6. Conditioning

6.1 Samples and specimens for Procedures 1, 2, and 4 must not be either conditioned or preconditioned for testing.

6.2 Samples for Procedure 3 are preconditioned as directed in Practice D1776/D1776M and conditioned at prescribed conditions of temperature and humidity, or in the standard atmosphere for testing textiles

PROCEDURE 1 – MOISTURE CONTENT AND PICKUP USING OVEN WITH AMBIENT AIR

7. Summary of Test Method

7.1 A specimen is collected and weighed to prevent moisture loss, dried in an oven supplied with ambient air heated to 105 °C , until the loss in mass is minimal and reweighed. The total mass lost is assumed to be moisture and is expressed either as percent moisture content, or percent moisture pick-up. The results are subject to some variations as discussed in 1.3 and 1.4. These variations are considered to be without significance in control operations.

8. Apparatus

8.1 *Sampling Containers* that can be sealed. Mason jars have been found to be satisfactory if the sample size is not too large. For larger samples, bags of various plastic materials shall be suitable if the wall thickness is sufficient to provide a good moisture barrier. For example, polyethylene having a thickness of approximately 0.1 mm (at least 4 mils) has been found satisfactory.

8.2 *Oven,* ventilated and thermostatically controlled in the 105 ± 2 °C temperature range throughout the enclosure. The oven shall be of either the forced draft or convection type. Equip with the ambient air supply.

8.3 *Balance,* having a capacity adequate for weighing specimens and containers and a sensitivity for weighing to within 0.1 % of the specimen mass. The balance may can be an integral part of the drying oven.

8.4 *Weighing Containers:*

8.4.1 For weighing in oven-perforated metal baskets or shallow pans, of a size to fit the particular oven in which they are used. For specimens containing particles that are easily shaken out, use baskets made of or lined with wire screening fine enough to hold the particles, or

8.4.2 For weighing outside oven-containers that can be sealed to prevent moisture changes.

8.5 *Desiccator,* large enough to hold one or more weighing containers (for the alternative in which the specimens are weighed outside the oven).

8.6 *Desiccant,* any suitable non-caustic desiccant shall be used provided it is dried or replaced as required for effective desiccation. Anhydrous calcium sulfate is recommended.

9. Sampling

9.1 *Lot Sample*—Take a lot sample as directed in the applicable material specifications, or as agreed upon between the parties interested in the test results. In the absence of any specifications or agreement, take a lot sample as directed in Practices D1441, D2258, D2525, and D3333, or Test Method D2494, depending on the type of material being sampled.

NOTE 4—A realistic specification or other agreement between the purchaser and the supplier requires taking into account the variability between shipping containers, laboratory samples within shipping containers, and specimens within a laboratory sample to provide a sampling plan which has a meaningful producer's risk, consumer's risk, acceptable quality level, and lot tolerance fraction defective at the level specified for the property being tested.

9.2 *Laboratory Sample:*

9.2.1 Take laboratory samples as directed in Practices D1441, D2258, D3333, or Test Method D2494, depending on the type of material being tested (see Note 4). Laboratory samples must be taken quickly and sealed immediately to avoid changes in moisture prior to testing.

9.2.2 Because time delay and temperature exposure in transit shall be factors, it is advisable to weigh the container without and with the material, recording the weights. These weights shall be checked for abnormal changes before testing starts.

9.3 *Test Specimens*—Take two specimens from each laboratory sample. Specimen mass is dependent upon the oven-drying container size, but each should shall be at least 10 g. If blending is not involved, it is preferable to take the test specimens at the source, weighing the container without and with the specimen and recording the weights. Specimens must be taken quickly and sealed immediately to avoid moisture changes.

10. Procedure

10.1 *Tare Masses:*

10.1.1 To save the time required to reweigh the empty baskets or containers after each use, adjustment to equal mass within ±0.005 g by grinding or filing is recommended.

10.1.2 Identify baskets/containers by numbers and record their masses.

10.1.3 The basket/containers must be kept clean and their masses checked regularly (at least weekly).

10.2 *Weighing the Specimen:*

10.2.1 Open the sample container and quickly remove and weigh a 10 g representative specimen if specimen-sized portions were not obtained at the time of sampling.

10.2.2 Record the as-is mass of the specimen (mass A). If container is used, record the mass of the container and specimen (mass G), and the mass of the empty container (mass T).

10.3 Dry and weigh the specimens as directed in 10.4 using an oven with a balance as an integral part, or in 10.5 using an oven and a balance.

NOTE 5—Whether or not the specimen is in a container during the drying process, the specimen must be well exposed to freely moving air.

10.4 *Using an Oven Balance:*

10.4.1 Place the specimen in a basket in the oven and dry at 105 °C ± 2 °C until the change in mass between successive weighings is within 0.01 % when spaced 2 h apart. Before making a weighing, turn off the air current in a forced draft type oven and block off natural air currents present.

10.4.2 Weigh the specimen and basket to the nearest 0.005 g.

10.5 *Using an Outside Balance:*

10.5.1 Place the specimen, container, and cover in the oven, at 105 °C ± 2 °C. Dry until the change in mass between successive weighings is within 0.01 % when the successive drying periods are 2 h ± 5 min duration.

10.5.2 In executing the weighings, transfer the container with specimen and cover to a desiccator. While the specimen and container is cooling, the container is uncovered.

NOTE 6—It is necessary to close containers during transfer depending on the distance between the oven and desiccator. A partial vacuum develops while closed hot containers are cooling, especially if containers are glass. This vacuum will impart a buoyancy to the container decreasing its apparent mass if not released. Therefore, leave the covers off while the containers are in the desiccator.

10.5.3 When 'the container and specimen have cooled to room temperature, put the cover on and weigh to the nearest 0.005 g.

10.5.4 Return the container and specimen to the oven. Uncover and repeat the 2-h drying, cooling, and weighing at intervals until the change in mass between two successive weighings is less than 0.01 %.

10.5.5 Record the dry mass of the specimen and container (mass B) and the mass of the empty container (mass T).

11. Calculation

11.1 Calculate the original mass of the specimen.

11.1.1 If the specimen was weighed as received in the sealed container, calculate the original as-is mass of the specimen, using Eq 1:

$$A = G - T \tag{1}$$

where:

A = mass of as-is specimen, g,
G = mass of as-received specimen and basket/container, g, and
T = tare mass of empty basket/container, g.

11.2 Calculate the mass of the oven-dry specimen, using Eq 2:

$$D = B - T \tag{2}$$

where:

D = mass of oven-dried specimen, g,
B = mass of oven-dried specimen in basket/container, g, and
T = tare mass of empty weighing basket/container, g.

11.3 Calculate the moisture content, or the moisture pick-up, of each specimen to the nearest 0.01 %, using Eq 3 or Eq 4, where A and D are defined in 11.1 and 11.2.

$$\text{Moisture content, \%} = 100\,(A - D)/A \tag{3}$$

$$\text{Moisture pick-up, \%} = 100\,(A - D)/D \tag{4}$$

11.4 Calculate the average percent moisture content, or percent moisture pick-up, for each laboratory sample and the lot.

11.5 Calculate the standard deviation, coefficient of variation, or both, for the lot, if requested.

12. Report

12.1 State that the specimens were tested as directed in Procedure 1 of Test Methods D2654. Describe the material or product sampled and the method of sampling used.

12.2 Report the following information:

12.2.1 Average percent moisture content, or percent moisture pick-up, for the laboratory sample and the lot,

12.2.2 The standard deviation, coefficient of variation, or both, for the lot, if calculated, and

12.2.3 Whether the test was made using an oven balance or an outside balance.

13. Precision and Bias[4]

13.1 *Interlaboratory Test Data*—An interlaboratory test was conducted in 1963 in which four laboratories each tested twelve specimens of a single material. Each laboratory used a single operator. All 48 specimens came from the same sample of material. The components of variance for moisture results using Procedure J, expressed as standard deviations and calculated on the basis of moisture content are:

$$\text{Within-laboratory component} - 0.20\ \%$$

$$\text{Between-laboratory component} - 0.45\ \%$$

NOTE 7—The square roots of the components of variance are being reported to express the variability in the appropriate units of measure rather than as the square of those units of measure

13.2 *Precision*—For the components of variance reported in 13.1, two averages of observed values should shall be considered significantly different at the 95 % probability level if the difference equals or exceeds the critical differences listed in Table 1.

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D13-1013. Contact ASTM Customer Service at service@astm.org.

TABLE 1 Moisture Critical Differences Using Procedure 1

Critical Differences, Percentage Points for the Number of Observations Conditions Noted[A]		
In Each Average	Within-laboratory Precision	Between-laboratory Precision
1	0.55	1.36
2	0.39	1.31
5	0.25	1.27
10	0.18	1.26

[A] The critical differences were calculated using $z = 1.960$.

NOTE 8—The values in Table 1 for the critical differences constitute a general statement particularly with respect to between-laboratory precision. Before a meaningful statement can be made about two specific laboratories however, the amount of statistical bias, if any, between the two laboratories must be established, with each comparison being based on recent data obtained on randomized specimens from one sample of the material to be tested.

NOTE 9—The measurements for this interlaboratory test were performed by laboratories having personnel with better than average skill and extensive experience. The prediction made about critical differences may prove to be optimistic and, therefore, should be used with caution.

13.3 *Bias*—Procedure 1 of Test Method D2654 for measuring moisture in textiles by oven-drying using ambient air, is biased by the variability of, and presence of, moisture in the ambient air supplied to the oven. (See 5.3.1.) Data are also affected by any surface materials which might trap moisture or volatilize below or at the drying temperature.

PROCEDURE 2-MOISTURE CONTENT AND PICK-UP USING OVEN WITH AIR FROM THE STANDARD ATMOSPHERE FOR TESTING TEXTILES

14. Summary of Test Method

14.1 A specimen is collected and weighed to prevent moisture loss dried at l05 °C in an oven, supplied with air from the standard atmosphere for testing textiles until the loss in mass is minimal, and reweighed. The total mass lost is assumed to be moisture and is expressed either as percent moisture con tent, or percent moisture pick-up. The results are subject to some variations as discussed in 1.3 and 1.4.

15. Apparatus

15.1 *Sampling Containers,* see 8.1.

15.2 *Ventilated Drying Oven,* maintained at a temperature of 105 °C ± 2 °C throughout the enclosure. The specimen shall not be subject to direct radiation from the heating elements. The oven shall be supplied with a current of air at a rate sufficient to change the air in the enclosure at least once every 4 min. The air supplied to the oven shall conform to 15.3 and shall pass freely through the specimens. The oven shall be combined with a balance, in which case, facilities shall be provided for shutting off the flow of air during the weighing.

15.3 *Air for oven,* maintained at 21 °C ± 1 °C and 65 ± 2 % relative humidity which are the requirements for the standard atmosphere for testing textiles.

15.4 *Balance,* see 8.3.

15.5 *Weighing Containers,* see 8.4

15.6 *Desiccator,* see 8.5.

15.7 *Desiccant,* see 8.6.

16. Sampling, Selection, and Number of Specimens

16.1 Take lot samples, laboratory samples and test specimens as directed in Section 9, except weigh laboratory samples, or test specimens, as directed in 16.2 and 16.3. The size of the test specimen required is determined by the particular oven-drying apparatus used. Use extreme care to prevent gain or loss of moisture during the sampling operation and in the transfer of material to the laboratory sample container.

16.2 *When Blending Is Required*—Weigh each of the laboratory samples in its tared container immediately after sampling. Subtract the tare mass of the container to obtain the as-received sampling mass (mass *L*). Note that for Procedure 2, the instructions given in Section 17 are to be applied to the laboratory sample before the 'test specimens are selected.

16.3 *When Blending Is Not Required*—Take the two test specimens quickly, put each in a tared container, seal and weigh immediately at the time of sampling (mass *A*).

17. Conditioning and Stability

17.1 When blending is required, condition the previously weighed laboratory sample(s) according to Practice D1776/D1776M, subsection 8.3.

NOTE 10—Preconditioning is not required. Since the purpose of conditioning in Procedure 2 is to stabilize the sample and eliminate changes in moisture while the specimens are being prepared and weighed, an atmosphere of exactly 65 % (±5) relative humidity as directed in Practice D1776/D1776M is not a critical requirement.

17.2 Weigh the moisture-stabilized, conditioned laboratory sample(s) to the nearest 0.005 g and record the net mass(es) (mass S). The "stabilized" mass and the, "as sampled" mass is used to convert the observed moisture present in the stabilized test specimen (19.2) to the moisture present at time of sampling (as-received moisture).

18. Procedure

18.1 *Moisture-Drying Time Curves:*

18.1.1 Different materials have different drying curves depending on the degree of exposure of all parts of a specimen to the drying atmosphere and the level of moisture present in the material. Using specimens of a relatively moist material, make several preliminary runs, measuring the mass lost versus the time of drying for use in plotting a mass-time curve. If weighings are performed outside the oven after cooling the specimens, use longer time intervals than would be required if the specimens were being weighed hot in the oven. Use unequal intervals of drying time to avoid achieving a false equilibrium.

18.1.2 Plot the curves and find the time at which at least 98 % of the mass loss ultimately achieved has occurred for the slowest specimen.

18.1.3 Use 20 % of this cycle as the time interval for additional drying between successive weighings.

18.2 If test specimen-sized portions were obtained and weighed (mass *A*) at the time of sampling, reweigh the