Designation: D 2495 – 01

Standard Test Method for Moisture in Cotton by Oven-Drying[1]

This standard is issued under the fixed designation D 2495; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the determination of the amount of moisture in cotton by oven-drying and is applicable to raw cotton, cotton stock in process, and cotton waste.

1.2 This test method may also, by agreement, be used for determining moisture in blends of cotton with other fibers.

1.3 This test method offers alternative procedures for weighing the dried specimens, one procedure using an oven balance (9.3) and the other using a desiccator (9.4).

NOTE 1—For other methods of determination of moisture in textile materials refer to Test Method D 2654, which includes two options based on drying in an oven, and one option based on distillation with an immiscible solvent: Methods D 885, Test Method D 1576, Test Method D 2462.

1.4 The values stated in SI units are to be regarded as the standard. No other units are included in this standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 123 Terminology Relating to Textiles[2]

D 885 Test Methods for Tire Cords, Tire Cord Fabrics, and Industrial Filament Yarns Made from Manufactured Organic-Base Fibers[2]

D 1441 Practice for Sampling Cotton Fibers for Testing[2]

D 1576 Test Method for Moisture in Wool by Oven-Drying[2]

D 2462 Test Method for Moisture in Wool by Distillation with Toluene[2]

D 2654 Test Methods for Moisture in Textiles[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *cotton waste*, *n*—material removed from seed cotton, ginned lint, or stock in process by any cleaning or processing machinery and usually consisting of undesirable fibers or of a mixture of cotton fibers with foreign matter.

3.1.2 *ginned lint (cotton)*, *n*—cotton fibers that have been separated from their seeds by ginning but not subjected to any further processing after ginning.

3.1.2.1 *Discussion*—"Ginned lint" and "raw cotton" are synonymous; the same material that is called "ginned lint" at the ginnery (to distinguish it from seed cotton) is called "raw cotton" when it is received at a textile mill. "Lint cotton" may be either raw or processed.

3.1.3 *lint cotton*, *n*—loose cotton fibers in any form, either raw or processed, free of seeds and not bound together in yarn or fabric.

3.1.4 *moisture content*, *n*—the amount of water in a material determined under prescribed conditions and expressed as a percentage of the mass of the moist material; that is, the original mass comprising the dry substance plus any water present.

3.1.4.1 *Discussion*—The word "water" as used in these definitions refers to the compound technically defined as H_2O. The terms "water" and "moisture" are frequently used interchangeably in the literature and in the trade, but the term "moisture" is sometimes considered to include other volatile materials. Moisture content is also referred to as moisture on the "as is," "as received," or "wet" basis.

3.1.5 *moisture-free*, *adj*—the condition of a material that has been exposed in an atmosphere of desiccated air until there is no further significant change in its mass.

3.1.6 *moisture regain*, *n*—the amount of water in a material determined under prescribed conditions and expressed as a percentage of the mass of the water-free specimen. (see also *moisture content*)

3.1.6.1 *Discussion*—Equivalent expressions are "regain," moisture on the "moisture-free" or moisture on the "dry" basis, also moisture on the "oven-dry" basis. Moisture regain calculations are commonly based on the mass of a specimen which has been dried by heating in an oven. If the air in the oven contains moisture, the oven-dried specimen will contain some moisture even when it no longer undergoes a significant change in mass following additional drying under the same atmospheric conditions. In order to ensure that the specimen is moisture-free, it must be exposed to desiccated air until it shows no significant change in its mass; this procedure can be found in Test Method D 2654.

3.1.7 *oven-dry*, *adj*—the condition of a material that has been heated under prescribed conditions of temperature and

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[1] This test method is under the jurisdiction of ASTM Committee D13 on Textiles, and is the direct responsibility of Subcommittee D13.11 on Cotton Fibers.

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[2] *Annual Book of ASTM Standards,* Vol 07.01.

[3] Discontinued 1998; see *1997 Annual Book of ASTM Standards,* Vol 07.01.

humidity until there is no further significant change in its mass. (see *moisture regain*)

3.1.8 *percentage point, n*—a difference of 1 % of a base quantity.

3.1.8.1 *Discussion*—A phrase such as "a difference of *X* %" is ambiguous when referring to a difference in percentages. For example, a change in the moisture regain of a material from 5 to 7 % could be reported as an increase of 40 % of the initial moisture regain, or as an increase of two percentage points. The latter wording is recommended.

3.1.9 *raw cotton, n*—ginned lint that has not been subjected to any textile manufacturing process. (see also *ginned lint*)

3.1.10 *seed cotton, n*—cotton, as harvested and before ginning, consisting of seeds with the fibers attached and usually including measurable amounts of foreign matter.

3.1.11 *stock in process, n—in textiles*, staple fibers at any stage of manufacture between the opening of the bale and the completion of the spinning process.

3.2 For definitions of other textile terms used in this test method refer to Terminology D 123.

4. Summary of Test Method

4.1 Specimens are weighed, dried in an oven, and reweighed. The difference between the original mass and the oven-dry mass is calculated in percent, either as moisture content or moisture regain.

5. Significance and Use

5.1 This test method for testing the moisture content of cotton can be used for acceptance testing of commercial shipments of lint cotton provided the between-laboratory bias is known.

5.1.1 If there are differences or practical significance between reported test results for two laboratories, or more, comparative test should be performed to determine if there is a statistical bias, using competent statistical assistance. As a minimum, use test samples as homogeneous as possible, drawn from the material from which the disparate test results are obtained, and assigned randomly in equal numbers to each laboratory for testing. Other materials with established test values may be used for this purpose. Compare the test results from the two laboratories using a statitical test for unpaired data at a probability level chosen prior to the testing series. If a bias is found, either its cause must be found and corrected, or future test results must be adjusted in consideration of the known bias.

5.2 Information on the moisture content of cotton is desirable since the physical properties of cotton are significantly affected by its moisture content. High moisture content increases flexibility, toughness, elongation, and tensile strength. Too high a moisture content causes difficulty in processing due to the tendency of the stock to "lap-up" on drafting rolls. Low moisture, on the other hand, facilitates cleaning but increases the brittleness of the fiber and results in fiber breakage during ginning, cleaning, and mill processing. Low moisture also increases fly waste and may cause manufacturing difficulties due to static electricity.

5.3 Variations in the amount of moisture present affect the mass and hence the market value of a lot of material sold at a definite price per unit mass. Knowledge of the moisture content or regain can be accordingly an important financial consideration.

5.4 Moisture content variation affects lap, sliver, and roving linear density which in turn controls yarn number variation.

5.5 The mass of the oven-dry specimen used in this method is the mass observed after the specimen has been dried in an oven supplied with ambient air. The observed mass is accordingly subject to minor variations as discussed in 3.6.1. These variations, however, are believed to be without significance in commercial transactions.

6. Apparatus

6.1 *Oven*, thermostatically controlled at a temperature of 105 ± 2°C (220 ± 4°F) with fan-forced ventilation and preferably equipped with a balance that permits weighing the specimens without opening the oven. The air entering the oven must come from the standard atmosphere for testing textiles.

6.2 *Balance(s)*, of sufficient capacity to weigh the specimens in the containers that will be used and having a sensitivity of 0.01 g.

NOTE 2—Although all the weighing can be done on the oven balance, it is more convenient and the work can be completed more quickly if a separate balance is available for weighing the specimens before drying. Otherwise, the oven must be allowed to cool to room temperature before a new set of specimens can be weighed.

6.3 *Weighing Containers*, to be used when the specimens are weighed in the oven (see 9.1.1 and 9.2).

6.3.1 The weighing containers may be perforated metal baskets or shallow pans, of a size to fit the particular oven in which they are used. For specimens containing particles of foreign matter that are easily shaken out, use baskets made of or lined with wire screening fine enough to hold the trash, or line the lower part of the basket with metal foil, but this technique may prolong the drying period required.

6.3.2 *Weighing Bottles or Weighing Cans*, with tight-fitting covers, for use with the desiccator procedure (9.1.2 and 9.4). To expedite drying, the diameter of each container should be greater than its height.

6.4 *Desiccator*, large enough to hold as many weighing containers as will be dried at one time. (For the desiccator procedure only, see 9.1.2 and 9.4.)

6.5 *Desiccant*—Calcium chloride is satisfactory, provided that it is redried or replaced as required for effective desiccation. Any other effective, noncaustic desiccant may be used. (For the desiccator procedure only, see 9.1.2 and 9.4.)

6.6 *Sample Containers*—Metal cans, glass jars, or plastic containers of approximately 1-L (1-qt) capacity with airtight covers are recommended for use when sampling cotton outside the laboratory.

NOTE 3—For very dry material, that must be weighed in the containers, lightweight containers are desirable. For damp cotton, which would rust tin-plated cans, the containers should be made of rustproof material (such as aluminum, glass, or plastic).

7. Sampling and Test Specimens

7.1 *Primary Sampling Unit*—Consider bales or other shipping containers to be the primary sampling unit.

7.2 *Laboratory Sample Unit*—As a laboratory sample unit

for acceptance testing, take at random from the primary sampling units as directed in Practice D 1441.

7.3 Since the purpose of this test method is to determine the moisture content of the cotton in the shipping containers in the lot sample, the laboratory sampling units are taken directly from the shipping container and placed directly into the sample container. Therefore, for this test method, laboratory sampling units will be used as specimens and the terms "laboratory sampling unit," "sample," and "specimen" can be used interchangeably.

7.4 *Sample Size*:

7.4.1 The recommended minimum size for a specimen of lint cotton or waste containing at least 50 % lint cotton is 5 g.

7.4.2 The recommended minimum size for a specimen of waste containing less than 50 % lint cotton is 10 g.

7.4.3 It is anticipated that only one specimen will be tested from each sample container. However, a 1-L (1-qt) container will hold ample material for testing more than one specimen. The container should be well filled with the material being sampled to minimize changes in moisture content caused by confined ambient air.

7.4.4 In identifying containers or specimens, do not use any material of variable moisture content. For example, do not place identifying tags or slips of paper inside the sample containers and do not paste labels on the outside if the specimens are to be weighed in the containers. Identify containers by etching, stamping, or by scratching numbers on them, or by marking with crayon, ink, or paint.

7.5 *Sample Collection*:

7.5.1 When sampling lint cotton as it passes through (*1*) lint cleaners or condensers in the ginnery, (*2*) opening and cleaning machinery in the mill, or (*3*) mechanical or pneumatic conveyors between machines, take the specimen as the material flows past the sampling location. Place it in the sample container without delay, and immediately close the container with a tightly fitting cover.

7.5.2 Sliver and roving are usually in approximate moisture equilibrium with the air in the mill. Take short sections from a number of strands as directed in 7.5.1 and place enough of them in the container so that the total mass is as specified in 7.4. Extreme haste is not necessary, but avoid handling the material more than necessary to minimize adsorption of moisture from the hands. Immediately after the sample has been placed in the container, close the latter with a tightly fitting cover.

7.5.3 To sample raw cotton in bales, cut out a section approximately 0.15 m (6 in.) wide across the bale and at least 0.15 m deep from the space between two bale ties. Immediately take the specimen (*1*) by taking the surface cotton from the bottom of the cavity, or (*2*) by pulling cotton from the face of the section that was nearest the inside of the bale.

7.5.4 When the material is far from moisture equilibrium with the surrounding air, seal the containers as quickly as possible and do not take time to adjust the specimen to an exact mass. If specimens are taken while the material is very dry (less than 2 %), the containers must not be opened before the first weighing.

7.5.5 When sampling material over a period of time (for example, in ginning or other processing experiments that are not conducted under controlled atmospheric conditions), take at least three specimens from each lot: one near the beginning of the test, one at about the middle, and one at the end. If the experiment runs for more than 2 h, take additional specimens so that the time interval between specimens does not exceed 1 h. If atmospheric conditions are changing rapidly, it may be necessary to sample as often as every 15 min.

7.5.6 When the material to be tested comprises a number of bales of raw cotton, or a number of finished units of stock in process, such as picker laps, cans of sliver, or bobbins of roving all sampled at one time, take one or more specimens from each such unit if the number of units is not greater than the number of specimens required (see Section 9). Otherwise, take one specimen from each of the required number of units drawn at random from the entire quantity to be represented by the specimens.

7.5.7 When sampling stock in process from a group of machines, take one or more specimens from each machine if the number of machines is not greater than the number of specimens required (see Section 9). Otherwise, take one specimen from each of the required number of machines selected at random. If the machines, such as drawing frames, combers, or roving frames, have two to six points at which stock is delivered, take approximately equal portions from each delivery point. If there are more than six delivery points per machine, take approximately equal portions from each of at least five delivery points.

7.6 *Number of Specimens*:

7.6.1 Unless otherwise agreed upon, as when specified in an applicable material specification, take a number of specimens such that the user may expect at the 95 % probability level that the test result is not more than 0.50 percentage points above or below the true average (that is, a theoretical average obtained from an infinite number of observations). Determine the number of specimens as follows.

7.6.1.1 *Reliable Estimate of s*—When there is a reliable estimate of s based upon extensive past records for similar material tested in the user's laboratory as directed in this method, calculate the number of specimens using Eq 1:

$$n = (t^2 \times s^2)/E^2 = 15.4 \times s^2 \quad (1)$$

where:

n = number of specimens (rounded upward to a whole number),

s = reliable estimate of the standard deviation of individual observations on similar materials in the user's laboratory under conditions of single-operator precision,

t = 1.960, the value of Student's t for infinite degrees of freedom, for two-sided limits, and a 95 % probability level ($t^2 = 3.842$),

E = 0.50 percentage points, the value of the allowable variation of the test result, and

15.4 = a value calculated from t^2/E^2.

7.6.2 *No Reliable Estimate of s*—When there is no reliable estimate of s for the user's laboratory, Eq 1 should not be used directly. Instead, specify the fixed numbers of specimens shown in Table 1. These numbers of specimens are calculated

TABLE 1 Specimens Required Under Conditions of Unknown Variability in User's Laboratory, Percentage Points

Names of the Properties	Number of Specimens	Basis[A]
Moisture in lint cotton oven balance procedure	3	s = 0.378
Moisture in lint cotton desiccator procedure	2	s = 0.309

[A] The values of s in Table 1 are somewhat larger than will usually be found in practice (see 7.6.2).

using values of s that are listed in Table 1 and which are somewhat larger values of s than are usually found in practice. When a reliable estimate of s for the user's laboratory becomes available, Eq 1 will usually require fewer specimens than are listed in Table 1.

8. Conditioning

8.1 Since the purpose of this method is to determine the moisture content of the material at a specified time or under prevailing conditions, do not precondition or condition the specimens after they are taken.

9. Procedure

9.1 *Alternative Weighing Procedures*:

9.1.1 *Oven-Balance Procedure*—An oven with a built-in balance is usually preferred for speed and convenience. The precision of such equipment is adequate for most test purposes, the error in weighing being less than the usual sampling error. When the equipment is in good condition and the procedure is carried out exactly as specified, moisture content or moisture regain may be determined within ±0.5 percentage points at the 95 % probability level.

9.1.2 *Desiccator Procedure*—When an oven with a built-in balance is not available, or when maximum precision is required, specimens may be weighed after cooling in a desiccator. This procedure takes much more time, but the moisture content or moisture regain may be determined within ±0.3 percentage point at the 95 % probability level. However, unless the specimens are truly representative of the material and are taken under conditions that prevent any change in moisture content during sampling, the desiccator procedure may not give any more accurate information as to the moisture content or moisture regain of the material sampled than does the oven-balance procedure.

9.2 *Procedure for Weighing the Original Specimens*:

9.2.1 Two procedures are equally acceptable in most cases, but that described in 9.2.2 is mandatory for specimens that may contain less than 2 % moisture.

9.2.2 Because very dry cotton may absorb as much as 0.7 % moisture from the standard atmosphere during the first 30 s after the container is opened, weigh the specimen and container before the latter is opened and transfer the entire specimen to an oven basket, weighing bottle or can. Weigh the empty container to the nearest 0.01 g and calculate the mass of the specimen to the nearest 0.01 g using Eq 2 (see 10.1).

NOTE 4—To save the time required to reweigh the empty containers or baskets after each use, they may be adjusted to equal mass within ±0.005 g by grinding or filing. Or, they may be identified by numbers and their masses recorded. If this is done, the containers must be kept clean and their masses should be checked regularly to make sure they have not changed.

9.2.3 Since cotton containing at least 2 % moisture will not change more rapidly than 0.1 %/min during exposure to air at ordinary temperatures and humidities, it is permissible, and often more convenient, to open the container and weigh the specimen directly on the balance pan to the nearest 0.01 g.

9.3 *Drying Procedure Using an Oven Balance*:

9.3.1 Place the specimen and basket in the oven and dry at 105 ± 2°C (220 ± 4°F) as directed in 9.3.1.1 or 9.3.1.2.

9.3.1.1 Dry seed cotton or waste containing less than 50 % lint for at least 5 h or until the change in mass between successive weighings at intervals of at least 1 h is less than 0.1 % of the specimen mass.

NOTE 5—When the specimens have been dried for the length of time specified in 9.3.1.1, 9.3.1.2, 9.4.1.1, or 9.4.1.2, it may be assumed that constant mass has been reached, and reweighing is not necessary. Some time may be saved by drying for half the specified period and then weighing at the specified intervals until the change during the last interval is less than 0.1 %.

9.3.1.2 Dry lint cotton or waste containing at least 50 % lint for at least 1 h or until the change in mass between successive weighings at intervals of at least 15 min is less than 0.1 % of the specimen mass.

9.3.2 After each specified time interval, stop the fan and weigh the specimen and basket to the nearest 0.01 g. Weigh the empty basket to the nearest 0.01 g (Note 4).

9.4 *Drying Procedure Using a Desiccator*:

9.4.1 Place the specimen and container in the oven, uncover the container, and dry at 105 ± 2°C (220 ± 4°F) as directed in 9.4.1.1 or 9.4.1.2.

9.4.1.1 Dry seed cotton or waste containing less than 50 % lint for at least 12 h or until the change in mass between successive weighings at intervals of at least 1 h is less than 0.1 % of the specimen mass (Note 5).

9.4.1.2 Dry lint cotton or waste containing at least 50 % lint for at least 8 h or until the change in mass between successive weighings at intervals of at least 1 h is less than 0.1 % of the specimen mass (Note 5).

9.4.2 Close the weighing can or weighing bottle while it is still in the oven, then transfer the closed container to a desiccator and cover the desiccator. Two or three times while the specimen and container are cooling, uncover the desiccator, raise the cover of the container slightly for a moment to equalize the air pressure, and replace the cover on the desiccator (Note 6). When the container and specimen have cooled to room temperature, weigh them to the nearest 0.01 g. Return the container and specimen to the oven, uncover, and repeat the drying, cooling, and weighing at the intervals specified in 9.4.1.1 or 9.4.1.2 until the change in mass between two successive weighings is less than 0.1 % of the specimen mass. Record the final mass and the mass of the empty container (Note 4).

TABLE 2 Components of Variance as Standard Deviations, Percentage Points

Names of the Properties	Single-Operator Component	Between Laboratory Component
Moisture in lint cotton oven balance procedure	0.270	0.900
Moisture in lint cotton desiccator procedure	0.221	0.854

TABLE 3 Critical Differences,[A] Percentage Points for the Conditions Note

Names of the Properties	Number of Observations in Each Average	Single-Operator Precision	Between Laboratory Precision
Moisture in lint cotton oven balance procedure	1	0.748	2.60
	2	0.529	2.55
	4	0.374	2.52
	10	0.237	2.51
Moisture in lint cotton desiccator procedure	1	0.612	2.44
	2	0.433	2.41
	4	0.306	2.39
	10	0.194	2.37

[A] The critical differences were calculated using $t = 1.960$, which is based on infinite degrees of freedom.

NOTE 6—Opening the container is necessary only when using weighing bottles with ground-glass stoppers, or other airtight containers. If the containers are not opened, the partial vacuum created inside the bottle may make it impossible to open the bottle without breakage. A vacuum also imparts buoyancy to the container and decreases the apparent mass. With weighing cans that are not completely airtight, the air of the desiccator is able to leak in and equalize the pressure.

10. Calculation

10.1 If the specimen was weighed as received in a sealed container, calculate the original mass of the specimen using Eq 2:

$$M = G - C \tag{2}$$

where:
M = mass of specimen as received, g,
G = gross mass, specimen and container, g, and
C = mass of empty container, g.

10.2 Calculate the oven-dry mass of the specimen using Eq 3:

$$D = B - T \tag{3}$$

where:
D = oven-dry mass of specimen, g (see 4.5),
B = mass of specimen and basket or weighing bottle, g, and
T = mass of empty weighing container, g.

10.3 Calculate the moisture content using Eq 4:

$$\text{Moisture content, \%} = [(M - D)/M] \times 100 \tag{4}$$

10.4 Calculate the moisture regain using Eq 5:

$$\text{Moisture regain, \%} = [(M - D)/D] \times 100 \tag{5}$$

10.5 Calculate the moisture content or regain of each specimen to the nearest 0.1 %, the average of less than five specimens to the nearest 0.1 %, or the average of five or more specimens to the nearest 0.01 %.

10.6 Moisture regain may be calculated from moisture content using Eq 6, and moisture content may be calculated from moisture regain using Eq 7:

$$R = [C/(100 - C)] \times 100 \tag{6}$$

$$C = [R/(100 + R)] \times 100 \tag{7}$$

where:
R = moisture regain, and
C = moisture content.

11. Report

11.1 State that the specimens were tested as directed in ASTM Test Method D 2495. Describe the material or product sampled and the method of sampling used.

11.2 Report the following information:

11.2.1 The average moisture content or moisture regain in percent to the number of decimal places specified in 10.5, and

11.2.2 Whether the specimens were tested using an oven balance or a desiccator.

12. Precision and Bias

12.1 *Interlaboratory Test Data*[4]—An interlaboratory test was carried out in 1969 using samples of lint cotton that were randomly drawn from the same stock. Six laboratories each used one operator who tested five specimens of lint cotton for moisture using the oven balance procedure. Two of the laboratories also used one operator who tested five specimens of lint cotton for moisture using the desiccator procedure. The components of variance, expressed as standard deviations, are listed in Table 2.

12.2 *Precision*—For the components of variance in Table 2, two averages of observed values should be considered significantly different at the 95 % probability level if the difference equals or exceeds the critical differences tabulated in Table 3.

NOTE 7—The tabulated values of the critical differences should be considered to be a general statement, particularly with respect to between-laboratory precision. Before a meaningful statement can be made about two specific laboratories, the amount of statistical bias, if any, between them must be established, with each comparison being based on recent data obtained on randomized specimens from one sample of the material to be tested.

12.3 *Bias*—Test Method D 2495 for testing the moisture content of cotton by oven drying is used as a referee method although it has a small bias due to the use of ambient air (see Test Method D 2654).

13. Keywords

13.1 cotton; moisture content

[4] ASTM Research Report No. RR D-13-1001. A copy is available from ASTM Headquarters, 100 Barr Harbor Drive, West Conshohocken, PA 19428.