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Standard Test Method for Pile Thickness of Finished Multilevel Pile Yarn Floor Covering[1]

This standard is issued under the fixed designation D7241; 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 pile thickness of finished multilevel pile yarn floor covering using a thickness measuring instrument having a stationary surface (platen), a circular pressure foot under specified force, and capable of being moved vertically above the platen.

1.2 This test method is applicable only to finished multilevel loop pile constructions.

NOTE 1—Determination of pile thickness of multilevel pile yarn floor coverings was previously contained within Test Method D418. For user convenience, Subcommittee D13.21 subdivided Test Method D418 into separate standards of which this test method is one.

1.3 The values stated in ~~SI~~inch-pound units are to be regarded as ~~the~~ standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and ~~may be approximate.~~are not considered standard.

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

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D123 Terminology Relating to Textiles
D1776 Practice for Conditioning and Testing Textiles
D5684 Terminology Relating to Pile Floor Coverings
D5823 Test Method for Tuft Height of Pile Floor Coverings
E122 Practice for Calculating Sample Size to Estimate, With Specified Precision, the Average for a Characteristic of a Lot or Process

3. Terminology

3.1 For definitions of terms relating to Pile Floor Coverings, refer to the Terminology D5684.

3.2 The following terms are relevant to this standard: carpet, cut pile yarn floor covering, finished, finished pile yarn floor covering, floor covering, pile, pile thickness, pile yarn floor covering, pitch, primary backing, shorn pile stubble, stubble height, textile floor covering, tufted fabric.

3.3 For definitions of other terms related to textiles, refer to Terminology D123.

3.4 For discussion of terminology specific to this standard, see Annex A1.

4. Summary of Test Method

4.1 The thickness and mass are measured on each selected strip specimen in the unsheared condition and after removing approximately 25, 50, 75 % and all of the pile down to a stubble by shearing. The net pile thicknesses at the 25, 50, and 75 % levels are calculated by subtracting the stubble specimen thickness from the thicknesses measured at each of the other stages. The net pile masses are calculated by subtracting the mass of the stubble specimen from the four other weighings. The 25, 50, and 75 % net masses are expressed as a percent of the net pile mass of the unsheared specimen and the 25, 50, and 75 % net thicknesses

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

are plotted against these net mass percentages. A smooth curve is drawn through the three plotted points. The net pile thickness corresponding to 50 % net mass is read from the smooth curve and doubled to obtain the average pile thickness.

5. Significance and Use

5.1 The determination of pile thickness of multilevel pile yarn floor covering is useful in quality and cost control during manufacture of pile yarn floor covering. The appearance and performance may be affected by changes in pile thickness of pile yarn floor coverings. This test method is considered satisfactory for acceptance testing of commercial shipments because current estimates of between laboratory precision are acceptable, and this test method is commonly used in the trade for acceptance testing.

5.2 If there are differences of practical significance between reported test results for two laboratories (or more), comparative tests should be performed to determine if there is a statistical bias between them, using competent statistical assistance. As a minimum, use the samples for such comparative tests that are as homogenous as possible, drawn from the same lot of material as the samples that resulted in disparate results during initial testing and randomly assigned in equal numbers to each laboratory. The test results from the laboratories involved should be compared using a statistical test for unpaired data, 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 for that material must be adjusted in consideration of the known bias.

6. Sampling, Test Specimens, and Test Units

6.1 *Sampling Units:*

6.1.1 *Coated Floor Covering*—The basic sampling unit of coated floor covering is a shipping roll. The number of shipping rolls obtained from each production roll ranges from one to over ten.

6.1.2 *Lot Sample*—Take a lot sample as directed in Practice E122 when statistical knowledge of the product variability and test method precision is available, and a decision has been made on the maximum deviation that can be tolerated between the estimate to be made from the sample and the result that would be obtained by measuring every sampling unit of the lot. Otherwise the number of sampling units in a lot sample and the use of the test results obtained from the individual test samples shall be in accordance with the manufacturer's quality control program or with the specification agreed upon between the purchaser and the supplier.

6.1.3 *Laboratory Sampling Unit*—A laboratory sampling unit shall consist of a full width section of floor covering cut from one end of each roll in the lot sample and shall be at least ~~100 mm (4 in.)~~4 in. (100 mm) longer than the specimens required for the tests being conducted. Do not cut a laboratory sampling unit of coated floor covering from a seam end of a production roll.

6.1.4 *Test Specimens*—A test specimen is a designated area cut from a laboratory sampling unit For laboratory sampling units ~~3000 mm (120 in.)~~120 in. (3000 mm) wide or wider, three test specimens are required for a test method, one at each edge no nearer to the edge than 5 % of the total floor covering width and one in the middle portion of the test sample. For laboratory sampling units at least ~~1500 mm (60 in.)~~60 in. (1500 mm) wide but less than ~~3000 mm (120 in.),~~120 in. (3000 mm), take two test specimens, one at each edge no nearer to the edge than 5 % of the total floor covering width. For laboratory sampling units less than ~~1500 mm (120 in.)~~120 in. (1500 mm) wide, take one test specimen from the middle.

6.2 Where it is known that systematic variations in a floor covering characteristic may occur in bands ~~460 mm (18 in.)~~18 in. (460 mm) or more in width, as with a modular pattern device having separate controls or adjustments for each module, take test specimens from the middle of each band.

6.3 When a full-width sample is not available, take specimens as directed in 6.1.4, and state in the report the width available and the number of test specimens taken.

7. Apparatus

7.1 *Balance,* capable of weighing to the nearest 0.01 g.

7.2 *Shear or Clipper,* capable of shearing close enough to the backing so as to leave a stubble of no more than ~~1.3 mm (0.05 in.).~~0.05 in. (1.3 mm).

7.2.1 Means for adjusting the height of the shear, such as shims or mechanical mount for a shearing head.

7.3 *Thickness Measuring Instrument:*

7.3.1 Having a stationary surface (plate) on which to place the specimen, and a presser foot capable of being moved vertically above the plate, at least ~~25 mm (1 in.)~~1 in. (25 mm) from the plate.

7.3.2 Having two interchangeable presser feet; one ~~25.40 ± 0.03 mm (1.000 ± 0.001 in.)~~1.000 ± 0.001 in. (25.4 ± 0.03 mm) diameter, the other ~~57.15 ± 0.03 mm (2.250 ± 0.001 in.)~~2.250 ± 0.001 in. (57.15 ± 0.03 mm) in diameter.

7.3.3 Having means for indicating the vertical distance between the presser foot and the plate to the nearest ~~0.03 mm (0.001 in.)~~0.001 in. (0.03 mm) and capable of developing and indicating a force up to ~~2.77 N (0.6 lbf)~~0.6 lbf (2.77 N) between the presser foot and the plate.

7.4 *Graph Paper,* with ~~2-mm (0.1-in.)~~0.1-in. (2-mm) divisions.

7.5 *Drafting Curves,* such as a set of French curves, flexible curve, or software capable of drawing the graph.

8. Preparation of Apparatus

8.1 Attach the presser foot loosely to the moveable stem or head of the instrument and bring the presser foot into firm contact with the plate. Tighten the presser foot on the stem, check the instrument zero by lowering the presser foot into contact with the plate until the indicated pressure increases to the pressure to be used in measuring the distance between the foot and the plate. The instrument must read 0 ± ~~0.03 mm (± 0.001 in.),~~ 0.001 in. (0 ± 0.03 mm), if the reading is not within this range a adjustment shall be made appropriate to the type of instrument being used. Verify the instrument with calibrated thickness blocks.

9. Conditioning

9.1 Condition the laboratory sampling unit or the test specimens in the standard atmosphere for testing textiles, that is ~~21~~70 ± ~~1°C (70~~2°F (21 ± ~~2°F)~~1°C) at 65 ± 2 % relative humidity, 12 h or until the mass changes no more than 0.1 % in 2 h as directed in Practice D1776.

10. Procedure

10.1 Select the number and location of the test specimens as directed in Section 6. Prepare the test specimens according to the procedure in Annex A2.

10.2 The test specimens shall comprise a full pattern repeat or a whole number multiple of a full pattern repeat in each direction but no less than ~~250 ± 3 mm (9.9 ± 0.1 in.)~~9.9 ± 0.1 in. (250 ± 3 mm) in the lengthwise direction by ~~320 ± 3 mm (12.5 ± 0.1 in.)~~12.5 ± 0.1 in. (320 ± 3 mm) in the widthwise direction. If the pattern repeat is not known and cannot be determined readily, use ~~457 mm~~ 18.0 by ~~457 ± 3 mm (18.0 by 18.0 ± 0.1 in)~~18.0 ± 0.1 in. (457 by 457 ± 3 mm) for the test specimen dimensions.

10.3 Select a strip specimen from each of the test specimens. The strip specimens shall be ~~250 ± 3 mm (9.9 ± 0.1 in.)~~9.9 ± 0.1 in. (250 ± 3 mm) in the lengthwise direction and ~~64 ± 3 mm (2.5 ± 0.1 in.)~~2.5 ± 0.1 in. (64 ± 3 mm) in the widthwise direction and should be conditioned as directed in Section 9.

10.3.1 Determine the total mass of all the strip specimens to the nearest 0.01 g and record as M_o, where the subscript zero indicates the strip specimens are unsheared.

10.4 *Total Thickness:*

10.4.1 Attach the ~~57.15 mm (2.250 in.)~~2.250 in. (57.15 mm) presser foot as directed in 8.1. For each strip specimen, raise the presser foot and center the specimen, pile face up, on the plate under the foot. Lower the presser foot slowly (take about 5 s to apply full load) onto the pile surface until a pressure of ~~689 ± 21 Pa (0.100 ± 0.003 psi)~~0.100 ± 0.003 psi (689 ± 21 Pa) is exerted on the specimen. Read the distance between the presser foot and the plate to the nearest ~~0.03 mm (0.001 in.), determine~~0.001 in. (0.03 mm). Determine the total thickness in three different areas for each strip specimen and record the average as the total thickness, T_o.

10.5 *Estimation of Shearing Levels:*

10.5.1 Obtain an approximate stubble specimen thickness by shearing the pile down to a stubble measuring approximately ~~1.3 mm (0.05 in.).~~0.05 in. (1.3 mm).

10.5.2 Attach the ~~25.40 mm (1.000 in.)~~1.000 in. (25.40 mm) diameter presser foot loosely to the stem and bring the presser foot into firm contact with the plate. Tighten the presser foot on the stem. Check the instrument zero as directed in 8.1. Verify the instrument with calibrated thickness blocks.

10.5.3 For each stubble specimen, raise the presser foot and center the specimen, stubble side up, on the plate. Lower the presser foot onto the stubble surface until a pressure of ~~5170 ± 69 Pa (0.75 ± 0.01 psi)~~0.75 ± 0.01 psi (5170 ± 69 Pa) is exerted on the stubble specimen. Read the distance between the presser foot and the plate to the nearest ~~0.03 mm (0.01 in.), determine~~0.01 in. (0.03 mm). Determine the stubble thickness in three different areas of the strip specimen and record the average as the stubble thickness h.

10.5.4 Obtain an approximate total pile thickness using Eq 1:

$$Z = T_o - h \tag{1}$$

where:

~~Z = total pile thickness, mm (in.),~~
~~T_o = average total thickness, mm (in.), and~~
~~h = average stubble thickness, mm (in.).~~

Z = total pile thickness, in. (mm),
T_o = average total thickness, in. (mm), and
h = average stubble thickness, in. (mm).

10.5.5 Calculate target thicknesses to the nearest ~~0.03 mm (0.001 in.)~~0.001 in. (0.03 mm) for removing 25, 50, and 75 % of the pile using Eq 2-4:

$$T_{25} = 0.75Z + H \tag{2}$$

$$T_{50} = 0.5Z + H \quad (3)$$

$$T_{75} = 0.25Z + H \quad (4)$$

where:

~~T_{25}, T_{50}, T_{75} = target shearing thickness for 25, 50, and 75 % shearing, mm (in.),~~
~~Z = total thickness, $T_o - h$, mm (in.) and~~
~~h = stubble thickness, approximate thickness of backing material plus stubble, mm (in.).~~

T_{25}, T_{50}, T_{75} = target shearing thickness for 25, 50, and 75 % shearing, in. (mm),
Z = total thickness, $T_o - h$, in. (mm) and
h = stubble thickness, approximate thickness of backing material plus stubble, in. (mm).

10.6 *25 % Shearing:*

10.6.1 Shear each strip specimen to a thickness of approximately t_{25}. Remove all loose fibers from the specimens.

10.6.2 Attach the ~~57.15 mm (2.250 in.)~~2.250 in. (57.15 mm) presser foot loosely to the moveable stem of the instrument and bring the presser foot into firm contact with the plate. Tighten the presser foot on the stem. Check the instrument zero as directed in 8.1. Verify the instrument with calibrated thickness blocks.

10.6.3 Measure the 25 % sheared strip specimen thickness at three different locations, average the measurements for all strip specimens and record the average as T_1, to the nearest ~~0.03 mm (0.001 in.).~~0.001 in. (0.03 mm).

10.6.4 Determine the total mass of all the 25 % sheared strip specimens and record to the nearest 0.01 g as M_1.

10.7 *50 % Shearing:*

10.7.1 Shear each strip specimen to a thickness of approximately t_{50}. Remove all loose fibers from the specimens. Measure the 50 % sheared strip specimen thickness at three different locations, average the measurements for all strip specimens and record the average as T_2, to the nearest ~~0.03 mm (0.001 in.).~~0.001 in. (0.03 mm).

10.7.2 Determine the total mass of all the 50 % sheared strip specimens and record to the nearest 0.01 g as M_2.

10.8 *75 % Shearing:*

10.8.1 Shear each strip specimen to a thickness of approximately T_{75}. Remove all loose fibers from the specimens. Measure the 75 % sheared strip specimen thickness at three different locations, average the measurements for all strip specimens and record the average as T_3, to the nearest ~~0.03 mm (0.01 in.).~~0.001 in. (0.03 mm).

10.8.2 Determine the total mass of all the 75 % sheared strip specimens and record to the nearest 0.01 g as M_3.

10.9 *Stubble Shearing:*

10.9.1 Shear each strip specimen as close to the back as possible (approximately ~~1.3 mm (0.05 in.).~~0.05 in. (1.3 mm)). Remove all loose fibers from the specimens.

10.9.2 Attach the ~~25.40 mm (1.000 in.)~~1.000 in. (25.40 mm) diameter presser foot loosely to the stem and bring the presser foot into firm contact with the plate. Tighten the presser foot on the stem. Check the instrument as directed in 8.1.

10.9.3 Measure the stubble specimen thickness at three different locations, average the measurement for all strip specimens and record the average as T_4 to the nearest ~~0.03 mm (0.01 in.).~~0.001 in. (0.03 mm).

10.9.4 Determine the total mass of all the stubble specimens and record to the nearest 0.01 g as M_4.

11. Calculation or Interpretation of Results

11.1 A test result is the average of the measurements made on a set of test specimens described in Section 10. In this method, directions are given only for obtaining a test result from a laboratory sampling unit. The value representative of the lot being sampled will be the average of the test results from each laboratory-sampling unit.

11.2 *Net Pile Thickness*—Calculate the net average pile thickness for all specimens at shearing levels using Eq 5.

$$D_k = T_k - T_4 \quad (5)$$

where:

~~D_k = net average pile thickness of all strip specimens at the indicated *(k)* shearing level, mm (in.),~~
~~T_k = average strip specimen thickness at shearing level, *k*, mm (in.), and~~
~~T_4 = average stubble specimen thickness, mm. (in.).~~

D_k = net average pile thickness of all strip specimens at the indicated *(k)* shearing level, in. (mm),
T_k = average strip specimen thickness at shearing level, *k*, in. (mm), and
T_4 = average stubble specimen thickness, in. (mm).

11.3 *Net Pile Masses*—Calculate the net total pile mass at each shearing level using Eq 6:

$$N_k = M_k - M_4 \quad (6)$$

where:

N_k = net total pile mass of all strip specimens at shearing level k, g,
M_k = total mass of all strip specimens at shearing level k, g, and
M_4 = total mass of all stubble specimens, g.

11.4 *Net Pile Masses in Percent*—Calculate the net total pile masses as a percent of the unsheared net total pile mass at shearing levels 1, 2 and 3 (25, 50, and 75 % respectively) using Eq 7:

$$M_k = 100N_k/N_o \tag{7}$$

where:

M_k = net total pile mass at shearing level k as a percent of N_o , and
N_o = net total pile mass of all unsheared strip specimens, g.

11.5 *Average Pile Thickness:*

11.5.1 Plot D_1, D_2, and D_3 versus M_1, M_2, and M_3, where D_1 = net pile thickness at 25 % target thickness, D_2 = net pile thickness at 50 % target thickness, D_3 = net pile thickness at 75 % target thickness, M_1 = net pile mass at 25 % target thickness, M_2 = net pile mass at 50 % target thickness, M_3 = net pile mass at 75 % target thickness respectively, on graph paper or with a software program. Draw a smooth curve through the three points. An example of the graph is illustrated in Appendix X1.

11.5.2 Read the net average pile thickness at M = 50 % and double the value to obtain the average pile thickness. Record to the nearest ~~0.03 mm (0.001 in.).~~0.001 in. (0.03 mm).

12. Report

12.1 State the test sample was tested as directed in Test Method D7241 for determining the pile thickness of multilevel pile yarn floor covering. Describe the material or product sampled and the method of sampling used.

12.2 Report the average pile thickness.

13. Precision and Bias

13.1 *Summary*—In comparing two averages, the differences should not exceed the single-operator precision values shown in Tables 1 and 2 for the respective number of tests in 95 out of 100 cases when all the observations are taken by the same well-trained operator using the same piece of equipment and specimens randomly drawn from the sample of material. Larger differences are likely to occur under all other circumstances.

13.2 *Interlaboratory Test Data*—An interlaboratory test was run in 2000 in which randomly drawn samples of three materials were tested in each of three laboratories. One operator in each laboratory each tested two specimens of each material using Test Method D7241. One of the two specimens was tested on one day and one specimen was tested on a second day. Analysis of the data was conducted using standard statistical practice. The components of variance for Pile Thickness expressed as standard deviations were calculated to the values listed in Table 1. The material; types were:

A. 100 % Nylon 35 oz. 5/32 Gauge Enhanced Pattern Loop
B. 100 % Olefin 39 oz. 5/32 Gauge Pattern Loop
C. 100 % Olefin 40 oz. 5/32 Gauge Pattern Loop

13.3 *Precision*—For the components of variance reported in Table 1, two averages of observed values should be considered significantly different at the 95 % probability level if the difference equals the critical difference listed in Table 2. There were sufficient differences related to the material type and structure to warrant listing the components of variance and the critical differences separately.

NOTE 2—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 specimens taken from a lot of material to the type being evaluated so as to be as nearly homogeneous as possible and then randomly assigned in equal numbers to each of the laboratories.

13.4 *Bias*—The value of pile thickness can only be defined in terms of a test method. Within this limitation, Test Method D7241 has no known bias.

TABLE 1 Components of Variance Expressed as Standard Deviations[A]

Variance Component	Single Material Comparisons for Multilevel Loop Pile Carpets
Within Laboratory	0.010
Between Laboratory	0.016

[A] The square roots of the components of variance are being reported to express the variability in appropriate units of measure rather than as the squares of those units of measure.

TABLE 2 Critical Differences for Two Averages for the Conditions Noted, 95 % Probability Level, Pile Thickness in Inches for Multilevel Loop Pile Carpet

Number of Determinations	Single Material Comparisons Within Laboratory Precision CD	Between Laboratory Precision CD
1	0.0281	0.0527
2	0.0199	0.0488
3	0.0162	0.0474
5	0.0126	0.0463

14. Keywords

14.1 carpet; multilevel; pile thickness; pile yarn floor covering

ANNEXES

(Mandatory Information)

A1. CLARIFICATION OF PILE HEIGHT, PILE THICKNESS, AND TUFT HEIGHT

A1.1 Confusion sometimes arises in specifying and testing pile yarn floor coverings due to the similarity of the terminology describing these distinctly different methods of measuring the height of the pile in relation to the backing. Each method has a specific purpose and yields different data. They cannot be compared or interchanged. Problems occur when specifications are written using pile height and the testing laboratory reports pile thickness or tuft height, which may be appropriate for the particular product. Measuring pile thickness or tuft height of a typical loop pile carpet by either procedure will yield a difference in the range of 30 to 40 % from the pile height measurement.

A1.2 *Pile Height*is typically used generically by the layman and by manufacturing personnel in setting machinery. Pile height is measured by inserting a small graduated ruler into the pile down to the backing and reading the overall height of the pile. This procedure is subject to significant variability between technicians and is therefore used only for rough field work and in machinery settings during the manufacturing process and shall not be used for acceptance testing.

A1.3 *Pile Thickness*is a technical term used to describe the measurement of thickness of pile yarn which can be sheared from the backing of a carpet. Pile thickness is the preferred procedure for precision measurement of ~~loop pile carpets and of~~ level pile carpets, whether loop, cut and loop or cut pile carpets with a tuft height of less than ~~6 mm (0.25 in.).~~0.25 in. (6 mm). Although it is more complex, it is very repeatable between different technicians and laboratories. It involves the use of a thickness-measuring instrument, which measures thickness of materials between a platen and a circular foot of specified area under a specified force. In measuring carpet with this device, the total thickness of pile and backing is measured, the pile sheared away, and the backing only measured. Pile thickness is the difference between the two values. The procedure is complicated by remaining stubble, which cannot be sheared.

A1.4 *Tuft Height*,as described in this test method, is a laboratory procedure typically used for cut pile constructions, which is very repeatable. Ten tufts are severed from the backing with a cutting device, placed into a V-shaped groove in a specimen holder, covered with a clear plate, and measured with a precision scale. Tuft height is not applicable to cut pile constructions with tuft heights less than ~~6 mm (0.25 in.)~~0.25 in. (6 mm) due to the problems associated with mounting a tuft of this length in the grooved specimen holder. For this construction, pile thickness shall be performed. Refer to Test Method D5823.