Designation: D2130 – 22

Standard Test Method for Diameter of Wool and Other Animal Fibers by Microprojection[1]

This standard is issued under the fixed designation D2130; 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 This test method covers a procedure, using the microprojector, for the determination of the average fiber diameter and the fiber diameter variation on wool and other animal fibers, such as mohair, cashmere, alpaca, camel's hair, etc. (Note 1) in their various forms.

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

NOTE 1—This test method may also be applied to any fibers having a round cross section and accordingly may be used many times for melt-spun man-made fibers such as polyamides, polyesters, and glass; also it may be applied to a limited number of polyacrylics and regenerated cellulose type fibers. The values given in Appendix X1 for density and correction factors, however, apply only to wool and should not be used for other fibers. For suitable values for the density of other fibers, see Table 5 in Test Methods D629, Quantitative Analysis of Textiles.

NOTE 2—In subsequent sections of this test method, the term "wool" also signifies mohair or other fibers if the circumstances are applicable.

NOTE 3—For fineness specifications for wool, wool top, mohair, mohair top, alpaca, and cashmere, refer to Specifications D3991 and D3992, Specification D2252, Test Method D2816.

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

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

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D123 Terminology Relating to Textiles

D584 Test Method for Wool Content of Raw Wool—Laboratory Scale

D629 Test Methods for Quantitative Analysis of Textiles

D1060 Practice for Core Sampling of Raw Wool in Packages for Determination of Percentage of Clean Wool Fiber Present

D1776 Practice for Conditioning and Testing Textiles

D2252 Specification for Fineness of Types of Alpaca

D2258 Practice for Sampling Yarn for Testing

D2816 Test Method for Cashmere Coarse-Hair Content in Cashmere

D2968 Test Method for Med and Kemp Fibers in Wool and Other Animal Fibers by Microprojection

D3992 Specifications for Fineness of Wool Top or Mohair Top and Assignment of Grade (Withdrawn 2021)[3]

D4845 Terminology Relating to Wool

E380 Practice for Use of the International System of Units (SI) (the Modernized Metric System) (Withdrawn 1997)[3]

2.2 *Other Standards:*

Federal Standard, Official Standard of the United States for Grades of Wool, Section 31.0, Measurement Method for Determining Grade of Wool, Section 31.204[4]

IWTO-8-66(E) Method of Determining Wool Fiber Diameter by the Projection Microscope[5]

3. Terminology

3.1 For all terminology related to D13.13, Wool and Felt, see Terminology D4845.

[1] This test method is under the jurisdiction of ASTM Committee D13 on Textiles and is the direct responsibility of Subcommittee D13.13 on Wool and Felt.

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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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] *Service and Regulatory Announcement*, No. 135, U. S. Department of Agriculture, C & MS, April 1966.

[5] International Wool Textile Organization, International Wool Secretariat, Raw Wool Services, Valley Drive, Ilkley, Yorkshire LS29 8PB, England.

3.1.1 The following terms are relevant to this standard: average fiber diameter, grade.

3.2 For definitions of all other textile terms see Terminology D123.

4. Summary of Test Method

4.1 This test method describes procedures for sampling various forms of wool and other animal fibers, the reduction of the sample to small test specimens, and the measurement, at high magnification, of the diameter of a number of fibers from the test specimens. From the observed data, computations are made to obtain the average fiber diameter, a measure of variation of fiber diameter and the percentage of medullated and kemp fibers, if present, as directed in Test Method D2968.

5. Significance and Use

5.1 This test method specifies a sampling and testing procedure for the measurement of average fiber diameter and variation in diameter of animal fibers as required in Test Method D2968.

5.2 Test Method D2130 for testing wool and other animal fibers for average fiber diameter is considered satisfactory for acceptance testing of commercial shipments since current estimates of between-laboratory precision are acceptable and the method has been used extensively in the trade for acceptance testing. In cases of disagreement arising from differences in values reported by the purchaser and the seller when using this method for acceptance testing, the statistical bias, if any, between the laboratory of the purchaser and the laboratory of the seller should be determined with each comparison being based on the testing of specimens randomly drawn from one sample of material of the type being evaluated.

6. Apparatus and Material

6.1 *Microprojector*[6]—The microscope shall be equipped with a fixed body tube, a focusable stage responsive to coarse and fine adjustments, a focusable substage with condenser and iris diaphragm, and a vertically installed adequate light source to give a precise magnification of 500×, that is, a 12.5× eyepiece and a 21×, 0.50 numerical aperture objective.

6.2 *Stage Micrometer* ,[7]—calibrated in intervals of 0.01 mm for accurate setting and control of the magnification.

6.3 *Fiber Sectioning Apparatus:*

6.3.1 *Heavy-Duty Sectioning Device*[8]—An instrument comprised of a metal plate with slot and compressing key and equipped with a propulsion mechanism by which the fiber bundle may be extruded for sectioning. The instrument (Fig. 1) is designed to hold a sliver of top or equivalent bulk of fibers, yarn, or fabric.

6.3.2 *Safety Razor Blades*—Single-edge or double-edge blades (if used with blade holder).

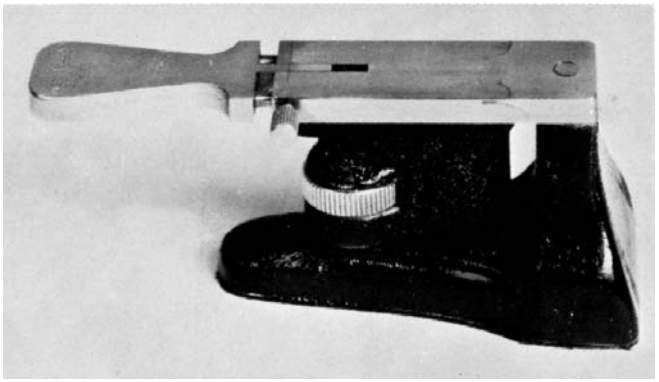


FIG. 1 Heavy-Duty Cross-Section Device

6.3.3 *FRL Fiber Cutter*[9]—A device comprised of two razor blades, a threaded pin and an assemblage that will hold the blades rigidly in position. The device (Fig. 2), which is operated by applying pressure vertically downward, cuts fibers approximately 250 µm (Note 4) in length.

NOTE 4—A description of the Swiss Fiber Cutting device described in earlier editions can be found in Part 25 of the *Annual Book of ASTM Standards*, issued in 1971 and previous volumes.

6.4 *Microscope Slides,* 1 in. by 3 in. (25 mm by 75 mm).

6.5 *Cover Glasses,* No. 1 thickness, ⅞ in. by 2 in. (22 mm by 50 mm).

6.6 *Mounting Medium*[10]—Colorless immersion oil with a refractive index of 1.480 ± 0.005 at 68 °F (20 °C), and a viscosity of 78.81 SUS at 100 °F (37.8 °C).

6.7 *Wedge Scale*[11]—Strips of heavy paper or Bristol board, imprinted with a wedge for use at a magnification of 500× (Fig. 3).

6.8 *Box for Compressing Loose Fibers*—A box 12 in. by 6 in. by 15 in. (300 mm by 150 mm by 375 mm) deep, inside dimensions, equipped with a floating top which has 16 randomly spaced holes 0.75 in. (20 mm) in diameter over its area. The wool may be firmly compressed by applying pressure on the top. The top is held in place by two rods extending through holes in the side of the box and over the top. The coring tube is thrust through the holes in the top to sample the wool.

6.9 *Pressure Coring Tube*[12]—A ½ in. (13 mm) inside-diameter metal tube, approximately 30 in. (760 mm) long, reamed and tapped on one end to hold a sharp ⅜ in. or ½ in. (10 mm or 13 mm) cutting tip. The tube is fitted with a "T" cross bar about 20 in. (500 mm) long.

6.10 *Core Extruder*—A 0.25 in. (6 mm) wood dowel or aluminum rod slightly longer than the coring tube to extrude wool from tube.

[6] Obtainable from R and B Instruments, Leeds, Wortly. Low Mills, 318 Whitehall Rd., Leeds L512 4RJ England.

[7] Obtainable from most scientific laboratory instrument supply companies.

[8] Obtainable from Joe Opheikens, 426 Adams, Ogden, UT 84404 and MICO Instruments, 1944 Main St. P.O. Box 451, Marshfield Hills, MA 02051-0451.

[9] Obtainable from Albany International Research Co., 1000 Providence Highway, Dedham, MA 02026.

[10] Obtainable from YoCOM-McColl Testing Laboratories, Inc., 540 West Elk Place, Denver, CO 80216.

[11] Obtainable from E. J. Powers Press, 201 South St., Boston, MA 02111 and Visual Inspection Products, 50 High St., Lynn, MA 01902.

[12] Obtainable from YoCOM-McColl Testing Laboratories, Inc., 540 W. Elk Place, Denver, CO 80216 and Aero Associates, Inc., 163 Merrimac St., Woburn, MA 01801.

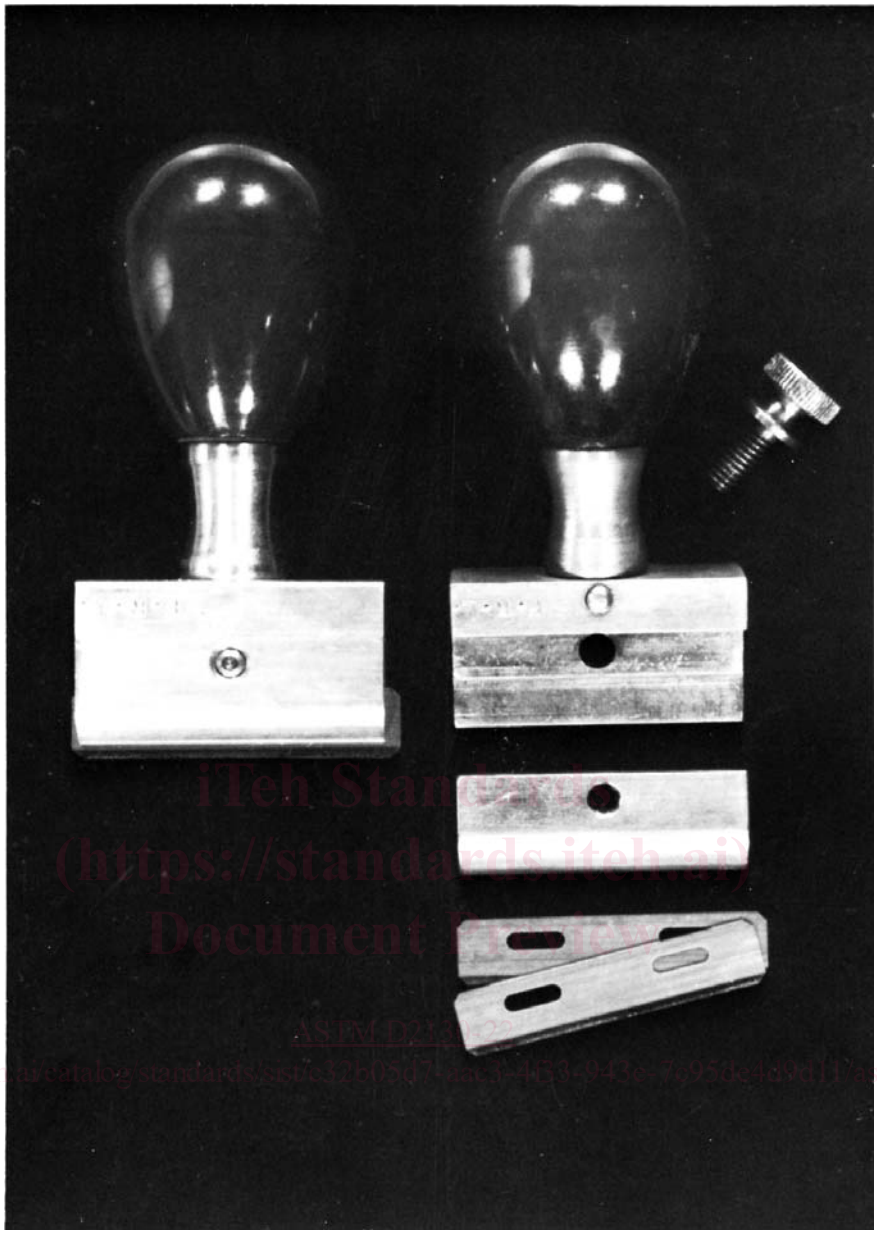


FIG. 2 FRL Fiber Cutter

7. Sampling

7.1 *Loose Fibers*—The method of obtaining a representative sample of wool will differ according to circumstances. The sampling procedures and major circumstances encountered are as follows:

7.1.1 *Lots of Packaged, Grease, Pulled, or Scoured Wool*—Take core samples as directed in Practice D1060. Clean or scour the raw wool sample as directed in Test Method D584. If a representative portion of the scoured wool core sample resulting from the test for clean wool fiber present is available, it may be used for fiber diameter determination. If core sampling is not feasible, take at random, by hand, at least 50 handfuls of wool from not less than 10 % of the packages. The aggregate mass of the sample shall be at least 3 lb (1.5 kg).

7.1.2 *Major Sort*—Packaged grease wool in fleece form for which a diameter test is desired for only the major sort of the fleece, hand sample by drawing one or more handfuls of wool from the major sort portion of at least 50 fleeces taken at random from the lot. The aggregate mass of the sample shall be at least 3 lb (1.5 kg).

7.1.3 *Piles of Graded or Sorted Wool*—Sample piles of graded or sorted wool by taking from random locations in the pile at least 50 handfuls of wool, the aggregate mass of which

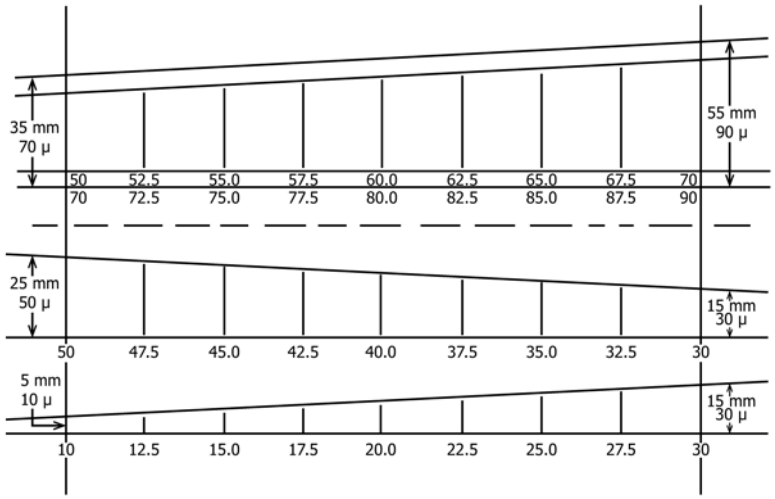


FIG. 3 Wedge Scale

shall be at least 3 lb (1.5 kg). If the wool is in fleece form and a test is desired for only the major sort, take the sample as directed in 7.1.2.

7.1.4 *Card Sliver*— Sample the wool card sliver by drawing at random from the lot, preferably during the carding operation, ten 2-ft (600 mm) lengths of sliver.

7.1.5 *Top*—Sample the top by drawing from each 20 000 lb (9072 kg) or fraction thereof, four sections of sliver, each of which shall be at least 1 yd (1 m) in length and taken from different balls of top selected at random. Take only one ball from any one bale or carton. For broken top, take an equivalent aggregate length of sliver at random.

7.2 *Yarns and Fabrics*—Take a yarn sample as directed in Practice D2258. Cut an approximately 3-yd (3 m) length of yarn sample into at least 20 sections of woolen-spun yarn, or 50 sections if worsted-spun yarn. For fabric, take two samples at least 2 in. by 2 in. (50 mm by 50 mm) from areas at least 2 in. from a selvage and at a sufficient distance apart to represent filling yarn taken from at least two different bobbins. Remove 20 (if woolen-spun) or 50 (if worsted-spun) warp yarns from each sample. Remove 10 (if woolen-spun) and 25 (if worsted-spun) filling yarns from each sample.

8. Test Specimens

8.1 *Grease Wool, Pulled Wool, Scoured Wool:*

8.1.1 *Sub-Coring*—Randomly pack the core or hand sample (see 7.1.1 – 7.1.3), into a suitable container (see 6.8) and compress to approximately 2 psi (14 kPa) by loading a weight of 150 lbf (667 N) on the floating top. By means of a ⅜ in. or ½ in. (10 mm or 13 mm) tube with sharp tip, extract a sufficient number of cores (at least five) to provide a test specimen of at least 20 g of scoured wool. Scour or otherwise clean the test specimen if it is grease wool or pulled wool as directed in Test Method D584.

8.1.2 *Gridding*—Core Test Residue—If the sample comprises an adequate amount of scoured wool resulting from the core testing of a lot for clean fiber content (see 7.1.1), divide the sample into 40 portions of approximately equal size. From each portion, draw at random at least 0.5 g. Mix or blend these 40 portions to form the test specimen. Test specimens from samples obtained by means of 1.25 in. (30 mm) and larger coring tubes may be carded for homogenization; but do not card those from coring tubes smaller than 1.25 in. (30 mm) since loss of fiber may occur.

8.1.3 *Gridding and Machine Blending*—For samples other than those specified in 8.1.1 and 8.1.2, divide the sample into 40 portions of approximately equal size. From each portion draw at random a sufficient quantity of fiber to provide a test specimen of 20 g. Scour or otherwise clean the test specimen, of grease or pulled wool. Homogenize the clean specimen by carding 3 times, breaking the web, and feeding at right angles after the first and second passes; or by gilling 15 times, breaking, and combining the pieces of silver as required to maintain a convenient length.

8.2 *Card Sliver*—Strip off portions of each of the ten 2-ft (600 mm) lengths of sliver (see 7.1.4). Combine these portions to form a composite sliver about 2 ft in length. This constitutes the test specimen.

8.3 *Top*—Each of the four sections of sliver comprising the sample (see 7.1.5) constitutes a test specimen.

8.4 *Yarn*—The yarn sections (see 7.2) constitute the test specimen.

8.5 *Fabric*—The undisturbed piece of fabric or the teased out yarns of the fabric (see 7.2) constitute the test specimen.

9. Calibration of Microprojector

9.1 Adjust the microprojector to produce a magnification of 500× in the plane of the projected image. Do this by placing a stage micrometer on the stage of the microprojector and bringing the microscope into such adjustment that the lines of the micrometer are sharply focused in the center of the image plane. An interval of 0.20 mm on the stage micrometer will then measure 100 mm on the image plane, or 0.01 mm on the micrometer will measure 5 mm on the image plane. All measurements must be made with the specimen in a plane at the same distance from the stage as the lines on the stage micrometer.

10. Conditioning

10.1 Precondition all test specimens to approximate equilibrium in an atmosphere having a relative humidity of 10 to 25 % and a temperature of not over 122 °F (50 °C), then condition the samples for at least 4 h in the standard atmosphere for testing textiles, 65 ± 2 % relative humidity and 70 °F ± 2 °F (21 °C ± 1 °C), as directed in Practice D1776.

11. Test Provisions

11.1 Separate observations shall be made by two operators.

11.2 Each operator shall independently prepare at least one slide for each test specimen.

12. Preparation of Slides by Use of Heavy-Duty Cross-Section Device

12.1 *Compacting Specimen:*

12.1.1 *Sliver Specimen*—At an area of the sliver, estimated to be a full fiber length or more from the end, place the specimen in the slot of the metal plate, compress with the key, and secure with the set screw.

12.1.2 *Bulk Specimen*—Draw small quantities of fiber at random, pack the assemblage of fibers into the slot, compress and secure as directed in 12.1.1.

12.1.3 *Yarn Specimen*—Pack the assemblage of yarn pieces into the slot, compress, and secure as directed in 12.1.1.

12.1.4 *Fabric Specimen*—Pack the assemblage of warp or filling yarn pieces or diagonal cuts of fabric into the slot, compress, and secure as directed in 12.1.1. If it is known that warp and filling yarns are identical, make a diagonal cut in each of the fabric samples. Segregate the warp and filling yarns when of different or unknown composition and when necessary to determine diameter and dispersion for each.

12.2 *Preliminary Sectioning of Specimen*—Cut off the gripped fibers at the upper and under surfaces of the plate. Extrude the fiber bundle about 0.50 mm to take up slack in the fibers and the propulsion mechanism. Moisten the projecting fibers with a few drops of mounting medium. With a sharp razor blade, cut off this projecting fiber bundle flush with the upper surface of the fiber-holding plate, and discard the section.

12.3 *Final Sectioning of Specimen*—Again extrude the fiber bundle approximately 0.25 mm (250 µm). With the razor blade, cut off the projecting fibers flush with the plate, leaving the fiber pieces adhering to the razor blade.

12.4 *Mounting the Fibers on the Slide*—Place a few drops of mounting medium on a clean glass slide. With a dissecting needle, scrape the fiber pieces from the blade onto the slide. Thoroughly disperse the fibers in the oil with the dissecting needle (Fig. 4), and cover the specimen with a cover glass.

NOTE 5—Use sufficient oil in the preparation of the slide to ensure thorough distribution of the fibers, but an excess must be avoided, as practically no oil should be permitted to flow out or be squeezed out beyond the borders of the cover glass. If the number of fibers is too great to permit proper distribution on the slide, or if an excess of oil has been used, wipe away a portion of the mixture after thorough dispersion of the fibers.

13. Preparation of Slides by Use of the FRL Fiber Cutter

13.1 *Cutting Specimens:*

13.1.1 *Fabric*—Using the equipment described in 6.3.3, with the razor blades in alignment and firmly secured, force the blades vertically downward into the warp fringe close to the edge of the fabric. Repeat the operation for the filling yarns. If the warp and filling yarns are the same, the cut may be made diagonally, sectioning the warp and filling yarns of the fabric at the same time. Make a duplicate cut at the opposite side of the fabric. The individual cuts should include between 1500 and 2000 fibers, approximately 250 µm long.

13.1.2 *Yarns and Other Fiber Assemblies*—Cut the prepared woolen or worsted yarn specimens with the pieces arrayed as a unit, or other specimens of yarn, roving, and the like, in a manner similar to the procedure described in 13.1.1.

13.2 *Release of Cut Sections*—Release the top plate of the device, then remove the blades, holding the ends between the

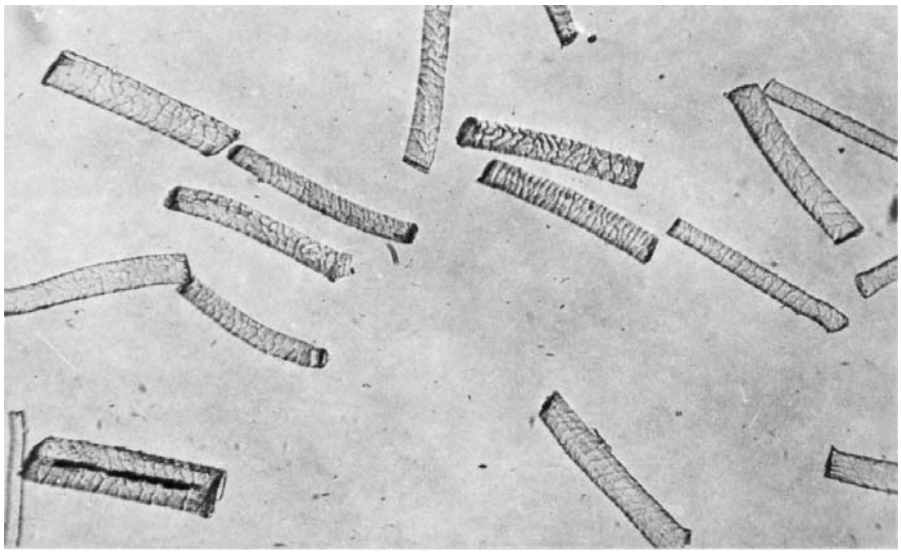


FIG. 4 Dispersion of Fibers on Slide

thumb and forefinger of one hand. By careful separation of the blades, the fiber sections will adhere to the edge of either blade.

13.3 *Mounting the Fibers on the Slide*—See 12.4.

14. Procedure

14.1 Measure fibers the same day a slide is prepared.

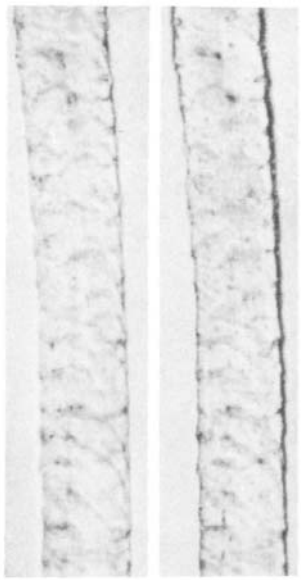
14.2 Place the finished (prepared) slide on the microprojector stage with the cover glass toward the objective (see 9.1).

14.3 Plan the viewing traverses across the slide to ensure that all portions under the glass are selected (sampled) for fiber measurement.

14.4 To measure a fiber, bring the midlength area into sharp focus on the wedge scale. When correctly focused the fiber edges appear as fine lines, not as pronounced dark borders (Fig. 5). However, the two edges of the fiber may not be in focus at the same time. If both edges of the fiber are not uniformly in focus, adjust the focus so that one edge of the fiber appears as a fine line and the other edge shows as a bright line. Fiber image width is regarded as the distance between the fine lines of both edges when they are uniformly in focus, or the fine line of one edge and the inner side of the bright line at the other edge when they are not uniformly in focus.

14.4.1 At the midlength area of the fiber, measure the width of the image by marking the wedge at the point where the width of the wedge scale coincides with the width of the fiber image (Fig. 6). Position the wedge scale so the taper of the scale is opposite any taper in the fiber image.

14.5 In the planned traverses, measure all fibers whose midlength area comes within the field of a 4 in. (100 mm) diameter circle, centrally located in the projected area. Kemp and med fibers which come within the field of measurement are to be measured for fiber diameter. Exclude from measurement



(*a*) Correct (*b*) Incorrect

FIG. 5 Correctly and Incorrectly Focused Fiber

FIG. 6 Point to Mark Wedge Scale: Where Wedge and Fiber Image Coincide

fiber images shorter than 100 mm (200 µm fiber) or longer than 150 mm (300 µm fiber) and those having a distorted image. If the width of a fiber image is less than or greater than the limits of the wedge scale, project the fiber image onto the border of the wedge scale and draw lines which coincide with the edges of the midlength area. Measure the distance between the lines in millimetres and convert to micrometres; 1 mm is equal to 2 µm at a magnification of 500x.

15. Number of Fibers

15.1 The number of fibers to be measured depends on the variability of the fiber diameters and the required or desired precision of the average. Calculate the number by using Eq 1:

$$n = (t\sigma/E)^2 \quad (1)$$

where:

n = number of fibers to be measured,
σ = standard deviation of fiber diameters,
E = allowable variation of the mean, µm, and
t = 1.960, the value of Student's t for infinite degrees of freedom, two-sided limits, and a 95 % probability level, ($t^2 = 3.842$).

15.2 Estimates of standard deviation for the various grades of wool and wool top, mohair and mohair top, and alpaca are given in Tables A1.1-A1.3, together with the calculated number of fibers required for various confidence intervals of the mean at a statistical probability of 0.95.

16. Calculation

16.1 From the observations determined with the wedge scales calculate the pertinent information as shown in the example (Table A1.4).

17. Report

17.1 State that the specimens were tested as directed in ASTM Test Method D2130 and state the type and number of samples taken and the kind of material that was tested.

17.2 Report the following information:
17.2.1 The average fiber diameter ($\bar{X}$) in µm.
17.2.2 The fiber diameter distribution, where applicable.
17.2.3 The standard deviation of fiber diameters, in µm.
17.2.4 The coefficient of variation of fiber diameters, %, v.
17.2.5 The 95 % confidence limits for the lot mean.

18. Precision and Bias

18.1 *Precision*—Estimates of standard deviation for the various grades of wool and wool top, mohair and mohair top, and alpaca are given in Tables A1.1-A1.3, together with the calculated number of fibers required for various confidence intervals of the mean at a 95 % probability level.

18.2 *Bias*—The procedure in Test Method D2130 for measuring the diameter of wool fibers by microprojection is widely accepted in the trade as having no known bias and is generally used as a referee method.

19. Keywords

19.1 animal fibers (except wool); diameter; wool

ANNEX

(Mandatory Information)

A1. DATA FOR PRECISION OF MEASUREMENTS AND EXAMPLES OF CALCULATIONS

A1.1 The estimates of standard deviation for the various grades of wool for determination of the number of fibers to measure at selected confidence limits and examples of calculations listed in 15.1 and 15.2 are given in Tables A1.1-A1.4.

TABLE A1.1 Wool and Wool Top:[A] Number of Fibers to be Measured for Selected Confidence Limits of Mean in Micrometres, µm at a 95 % Probability Level, for Selected Standard Deviation Values

Wool or Wool Top Grade	Typical Average Standard Deviation, µm	Number of Fibers to be Measured for 95 % Confidence Limits of Lot Means		
		±0.2 µm	± 0.4 µm	± 0.5 µm
Finer than 80s	4.00	1 537	384	246
80s	4.00	1 537	384	246
80s	4.40	1 859	465	298
70s	5.00	2 401	600	385
64s	5.60	3 014	753	482
62s	6.10	3 574	893	572
60s	6.70	4 311	1 079	690
58s	7.20	4 979	1 245	796
56s	7.80	5 845	1 461	935
54s	8.00	6 146	1 537	983
50s	8.90	7 604	1 902	1 217
48s	9.00	7 779	1 945	1 245
46s	9.40	8 319	2 121	1 358
44s	9.90	9 413	2 353	1 506
40s	10.10	9 797	2 449	1 567
36s				
Coarser than 36s	—	—	—	—

[A] ASTM Research Report No. RR:D13-1024. A copy is available from ASTM Headquarters.