



United States  
Department of  
Agriculture

Agricultural  
Marketing  
Service

Livestock  
and Seed  
Division

# United States Standards for Grades of Wool

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**Effective date December 21, 1968**

## United States Standards for Grades of Wool

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### **§31.0 Official grades**

The official grades of wool shall be those established in §§31.1 through 31.16: *Provided, however,* That the wool which qualifies for any of the grades in §§31.1 through 31.15 on the basis of its average fiber diameter shall be reduced in grade to the next coarser grade if its standard deviation in fiber diameter exceeds the maximum specified for the grade to which the average fiber diameter corresponds.

### **§31.1 Finer than grade 80's.**

Wool with an average fiber diameter of 17.69 microns or less and a standard deviation in fiber diameter of 3.59 microns or less.

### **§31.2 Grade 80's.**

Wool with an average fiber diameter of 17.70 to 19.14 microns, inclusive, and a standard deviation in fiber diameter of 4.09 microns or less.

### **§31.3 Grade 70's.**

Wool with an average fiber diameter of 19.15 to 20.59 microns, inclusive, and a standard deviation in fiber diameter of 4.59 microns or less.

### **§31.4 Grade 64's.**

Wool with an average fiber diameter of 20.60 to 22.04 microns, inclusive, and a standard deviation in fiber diameter of 5.19 microns or less.

### **§31.5 Grade 62's.**

Wool with an average fiber diameter of 22.05 to 23.49 microns, inclusive, and a standard deviation in fiber diameter of 5.89 microns or less.

### **§31.6 Grade 60's.**

Wool with an average fiber diameter of 23.50 to 24.94 microns, inclusive, and a standard deviation in fiber diameter of 6.49 microns or less.

### **§31.7 Grade 58's.**

Wool with an average fiber diameter of 24.95 to 26.39 microns, inclusive, and a standard deviation in fiber diameter of 7.09 microns or less.

### **§31.8 Grade 56's.**

Wool with an average fiber diameter of 26.40 to 27.84 microns, inclusive, and a standard deviation in fiber diameter of 7.59 microns or less.

**§31.9 Grade 54's.**

Wool with an average fiber diameter of 27.85 to 29.29 microns, inclusive, and a standard deviation in fiber diameter of 8.19 microns or less.

**§31.10 Grade 50's.**

Wool with an average fiber diameter of 29.30 to 30.99 microns, inclusive, and a standard deviation in fiber diameter of 8.69 microns or less.

**§31.11 Grade 48's.**

Wool with an average fiber diameter of 31.00 to 32.69 microns, inclusive, and a standard deviation in fiber diameter of 9.09 microns or less.

**§31.12 Grade 46's.**

Wool with an average fiber diameter of 32.70 to 34.39 microns, inclusive, and a standard deviation in fiber diameter of 9.59 microns or less.

**§31.13 Grade 44's.**

Wool with an average fiber diameter of 34.40 to 36.19 microns, inclusive, and a standard deviation in fiber diameter of 10.09 microns or less.

**§31.14 Grade 40's.**

Wool with an average fiber diameter of 36.20 to 38.09 microns, inclusive, and a standard deviation in fiber diameter of 10.69 microns or less.

**§31.15 Grade 36's.**

Wool with an average fiber diameter of 38.10 to 40.20 microns, inclusive, and a standard deviation in fiber diameter of 11.19 microns or less.

**§31.16 Coarser than grade 36's.**

Wool with an average fiber diameter of 40.21 microns or more.

**OFFICIAL STANDARDS OF THE UNITED STATES FOR GRADES OF WOOL TOP**

**§31.100 Official grades.**

The official grades of wool top shall be those established in §§31.101 through 31.116: *Provided, however,* That wool top which qualifies for any of the grades in §§31.101 through 31.116 on the basis of its average fiber diameter but fails to meet the fiber diameter dispersion requirements for that grade shall be assigned a dual grade designation. In such case, the first designation shall indicate the grade based on the average fiber diameter and the second designation shall be that of the next coarser grade and shall indicate merely that the fiber diameter dispersion does not meet the requirements specified for the grade corresponding to the average fiber diameter.

**§31.101 Finer than grade 80's.**

Wool top with an average fiber diameter of 18.09 microns or less and a fiber diameter dispersion that meets the following requirements:

- 25 microns and under-not less than 95 percent.
- 25.1 microns and over-not more than 5 percent.
- 30.1 microns and over-not more than 1 percent.

**§31.102 Grade 80's.**

Wool top with an average fiber diameter of 18.10 to 19.59 microns, inclusive, and a fiber diameter dispersion that meets the following requirements:

- 25 microns and under-not less than 91 percent.
- 25.1 microns and over-not more than 9 percent.
- 30.1 microns and over-not more than 1 percent.

**§31.103 Grade 70's.**

Wool top with an average fiber diameter of 19.60 to 21.09 microns, inclusive, and a fiber diameter dispersion that meets the following requirements:

- 25 microns and under-not less than 83 percent.
- 25.1 microns and over-not more than 17 percent.
- 30.1 microns and over-not more than 3 percent.

**§31.104 Grade 64's.**

Wool top with an average fiber diameter of 21.10 to 22.59 microns, inclusive, and a fiber diameter dispersion that meets the following requirements:

- 30 microns and under-not less than 92 percent.
- 30.1 microns and over-not more than 8 percent.
- 40.1 microns and over-not more than 1 percent.

**§31.105 Grade 62's.**

Wool top with an average fiber diameter of 22.60 to 24.09 microns, inclusive, and a fiber diameter dispersion that meets the following requirements:

- 30 microns and under-not less than 86 percent.
- 30.1 microns and over-not more than 14 percent.
- 40.1 microns and over-not more than 1.50 percent.

**§31.106 Grade 60's.**

Wool top with an average fiber diameter of 24.10 to 25.59 microns, inclusive, and a fiber diameter dispersion that meets the following requirements:

- 30 microns and under-not less than 80 percent.
- 30.1 microns and over-not more than 20 percent.
- 40.1 microns and over-not more than 2 percent.

**§31.107 Grade 58's**

Wool top with an average fiber diameter of 25.60 to 27.09 microns, inclusive, and a fiber diameter dispersion that meets the following requirements:

- 30 microns and under-not less than 72 percent.
- 30.1 microns and over-not more than 28 percent.
- 50.1 microns and over-not more than 1 percent.

**§31.108 Grade 56's**

Wool top with an average fiber diameter of 27.10 to 28.59 microns, inclusive, and a fiber diameter dispersion that meets the following requirements:

- 30 microns and under-not less than 62 percent.
- 30.1 microns and over-not more than 38 percent.
- 50.1 microns and over-not more than 1 percent.

**§31.109 Grade 54's.**

Wool top with an average fiber diameter of 28.60 to 30.09 microns, inclusive, and a fiber diameter dispersion that meets the following requirements:

- 30 microns and under-not less than 54 percent.
- 30.1 microns and over-not more than 46 percent.
- 50.1 microns and over-not more than 2 percent.

**§31.110 Grade 50's.**

Wool top with an average fiber diameter of 30.10 to 31.79 microns, inclusive, and a fiber diameter dispersion that meets the following requirements:

- 30 microns and under-not less than 44 percent.
- 30.1 microns and over-not more than 56 percent.
- 50.1 microns and over-not more than 2 percent.

**§31.111 Grade 48's.**

Wool top with an average fiber diameter of 31.80 to 33.49 microns, inclusive, and a fiber diameter dispersion that meets the following requirements:

- 40 microns and under-not less than 75 percent.
- 40.1 microns and over-not more than 25 percent.
- 60.1 microns and over-not more than 1 percent.

**§31.112 Grade 46's.**

Wool top with an average fiber diameter of 33.50 to 35.19 microns, inclusive, and a fiber diameter dispersion that meets the following requirements:

- 40 microns and under-not less than 68 percent.
- 40.1 microns and over-not more than 32 percent.
- 60.1 microns and over-not more than 1 percent.

**§31.113 Grade 44's.**

Wool top with an average fiber diameter of 35.20 to 37.09 microns, inclusive, and a fiber diameter dispersion that meets the following requirements:

- 40 microns and under-not less than 62 percent.
- 40.1 microns and over-not more than 38 percent.
- 60.1 microns and over-not more than 2 percent.

**§31.114 Grade 40's.**

Wool top with an average fiber diameter of 37.10 to 38.99 microns, inclusive, and a fiber diameter dispersion that meets the following requirements:

- 40 microns and under-not less than 54 percent.
- 40.1 microns and over-not more than 46 percent.
- 60.1 microns and over-not more than 3 percent.

**§31.115 Grade 36's.**

Wool top with an average fiber diameter of 39.00 to 41.29 microns, inclusive, and a fiber diameter dispersion that meets the following requirements:

- 40 microns and under-not less than 44 percent.
- 40.1 microns and over-not more than 56 percent.
- 60.1 microns and over-not more than 4 percent.

**§31.116 Coarser than grade 36's.**

Wool top with an average fiber diameter of 41.30 microns or over.

DEFINITIONS

**§31.200 Meaning of words.**

Words used in this part in the singular form shall be deemed to import the plural, and vice versa, as the case may demand.

**§31.201 Terms defined.**

For the purposes of this part, unless the context otherwise requires, the following terms shall be construed respectively to mean:

- (a) *Department.* The United States Department of Agriculture.
- (b) *Consumer and Marketing Service.* The Agricultural Marketing Service of the Department.
- (c) *Administrator.* The Administrator of the Agricultural Marketing Service, or any officer or employee of the Agricultural Marketing Service to whom authority has heretofore been delegated, or to whom authority may hereafter be delegated, to act in his stead.
- (d) *Division.* The Livestock Division of the Agricultural Marketing Service.
- (e) *Director.* The Director of the Division, or any officer or employee of the Division to whom authority has heretofore been delegated, or to whom authority may hereafter be delegated, to act in his stead.

(f) *Grade*. (1) With respect to wool, this term means a numerical designation of wool fineness based on average fiber diameter and variation of fiber diameter. It does not include characteristics such as length, crimp, strength, elasticity, luster, hand, and color--all of which affect the spinnability of wool and the properties of the yarn and fabric and which are usually referred to as "quality." Neither does it apply to wool by geographic origin, breed of sheep, manner of preparation for market, or a combination of characteristics which makes wool appropriate for a specific use. These characteristics are usually referred to as "type."

(2) With respect to wool top, this term means a numerical designation of wool top fineness based on average fiber diameter dispersion. It does not include characteristics such as length, crimp, strength, elasticity, luster, hand, and color--all of which affect the spinnability of wool and the properties of the yarn and fabric. The characteristics are usually referred to as "quality."

(g) *Wool*. The fiber from the fleece of sheep.

(h) *Wool top*. A continuous untwisted strand of scoured wool fibers from which the shorter fibers or noils have been removed by combing.

(i) *Fineness*. This term refers to fiber diameter.

(j) *Average fiber diameter*. The sum of the individual fiber diameter measurements divided by the number of fibers measured, as described in §31.204(a).

(k) *Micron*. A unit of linear measurement equal to 1/1000 millimeter or 1/25400 inch.

(l) *Grease wool*. Wool, as obtained from living sheep.

(m) *Scoured wool*. Wool from which the bulk of the impurities have been removed by washing in warm water, soap, and alkali or by an equivalent process.

(n) *Fleece*. The wool of one sheep obtained by shearing.

(o) *Skirted fleece*. A fleece from which the belly, britch, and stained portions have been removed.

(p) *Sorted wool*. Wool removed from various parts of fleeces and combined into different groups or sorts, each of which has closely similar fineness, length, and other qualities.

(q) *Pulled wool*. Wool obtained from the pelts of slaughtered sheep by pulling or similar means after subjecting the pelt to sweating, the use of a depilatory, or other auxiliary treatment to loosen the wool fibers from the skin.

(r) *Card sliver*. Wool that has been scoured and carded and formed into a continuous, untwisted strand of loosely assembled fibers.

(s) *Lot*. (1) With respect to wool, this term means the entire quantity of wool or card sliver constituting the subject of consideration or test.

(2) With respect to wool top, this term means the entire quantity of wool top constituting the subject of consideration or test.

(t) *Sample*. (1) With respect to wool, this term means a suitable amount of wool representing a lot, obtained as described in §31.204(a)(5).

(2) With respect to wool top, this term means four slivers of top obtained as described in §31.301(a)(4).

(u) *Test specimen*. (1) With respect to wool, this term means a representative portion of the sample obtained and prepared as described in §31.204(a)(6).

(2) With respect to wool top, this term means a sliver of wool top, at least 1 yard (0.91 meter) long, obtained as described in §31.301(a)(4).

(v) *Test.* (1) With respect to wool, this term means a determination by measurement of the average fiber diameter and the standard deviation of a sample of wool in accordance with the procedures provided in §31.204.

(2) With respect to wool top, this term means a determination by measurement of the average fiber diameter and the fiber diameter dispersion of a sample of wool top, in accordance with the procedures provided in §31.301.

(w) *Core sampling.* A method of coring a package of wool by means of special tools to obtain a representative sample of the wool according to the appropriate procedures described in §31.204(a)(5).

(x) *Hand sampling.* A method of drawing by hand many small handfuls of wool to obtain a representative sample of the wool according to the appropriate procedures described in §31.204(a)(5).

(y) *Major sort.* The wool of one grade that is greater by weight than any other grade in a fleece.

(z) *Standards.* The official standards of the United States for grades of wool and wool top.

(aa) *Standard samples.* Physical samples representative of the standards.

(bb) *Bulk sample.* A quantity of wool selected for use in the preparation of standards samples.

## METHODS FOR DETERMINING GRADE OF WOOL

### **§31.202 General.**

The official standards of the United States for grades of wool, as defined in §§31.1-31.16, shall be the basis of classification of wool by grade. Grade may be determined by inspection, usually by comparison of the fiber diameters of the wool being graded with the fiber diameters of samples representative of standards; or by measuring a prescribed number of fibers of a sample, calculating the average and standard deviation of fiber diameter and comparing the average and standard deviation with the diameter specifications for grades of wool. The provisions in §§31.203 through 31.204 prescribe methods for making such determinations. Both methods for determining grade shall be official; however, if the grade as determined by inspection differs from that determined by measurement, the grade determined by measurement shall prevail.

### **§31.203 Inspection method.**

Determination of the grade of wool by inspection frequently will be facilitated by comparing the fiber fineness of a sample of wool representative of the lot with the fiber fineness of valid standard wool samples representative of the official grades, in accordance with the procedure described in this section. A core sample is not satisfactory for determination of grade by the inspection method. When using the standard wool samples, the following procedures shall be followed:

(a) *Procedure for wools not in fleece form.* The fibers in the lot sample shall be compared with the fibers in the standard wool samples. The grade of the lot shall be designated as the grade corresponding to the standard wool sample which the lot sample most nearly matches in fineness.

(b) *Procedure for fleeces.* (1) For fleeces that have a major sort, the grade of the major sort shall be determined in accordance with the procedure specified in paragraph (a) of this section, and this shall be designated as the grade of the fleece.



(2) For fleeces that do not have a major sort, the grade of the entire fleece shall be determined in accordance with the procedure specified in paragraph (a) of this section.

### **§31.204 Measurement method.**

The determination of the grade of wool by measurement shall be by comparison of the measured average and standard deviation of fiber diameter with the specifications of the United States standards. This determination shall be made in accordance with the procedure for determining average and standard deviation of fiber diameter provided in paragraph (a) of this section and the procedure for designating grade provided in paragraph (b) of this section.

(a) *Procedure for determining average and standard deviation of fiber diameter--*

(1) *Scope.* The procedure set forth in this section shall be used in the determination of the average and standard deviation of fiber diameter of grease wool, scoured wool, pulled wool, or wool in the form of card sliver.

(2) *Principle of procedure.* The average and standard deviation of fiber diameter are determined by sectioning the fibers in a specimen to a designated short length, mounting the sections on a slide, projecting the magnified image onto a scale, and measuring the diameter of a specified minimum number of the fibers, randomly selected, as specified in this section.

(3) *Apparatus and material.* The following apparatus and material are needed and shall comply with the following provisions:

(i) *Microprojector.* The microscope shall be equipped with a fixed body tube a focusable stage responsive to coarse and fine adjustments, and a focusable substage with condenser and iris diaphragm. It shall be vertically installed with adequate light source, eyepiece, and objective to give a precise magnification of 500X as determined by use of a stage micrometer. A magnification of 500X can be obtained when the microscope is adjusted at a proper projection distance and equipped with a searchlight microprojector bulb, a 10 to 15X eyepiece, and a 20 to 21X objective of good quality with an aperture of approximately 0.50 centimeter.

(ii) *Stage micrometer.* Calibrated glass slide used for accurate setting and control of the magnification .

(iii) *Cross sectioning device, heavy duty.* An instrument approximately 2 inches in height, consisting essentially of a metal plate with a slot for holding a quantity of fibers, a key for compressing the fibers, and a tongue-propelling arrangement by which the fiber bundle may be extruded for sectioning.

(iv) *Microscope slides.* 1" x 3" (25 x 75 mm).

(v) *Cover glasses.* No. 1 thickness, 7/8" x 2" (22 x 50mm).

(vi) *Mounting medium.* Colorless mineral oil with a refractive index between 1.53 and 1.43, and of suitable viscosity.

(vii) *Wedge scales.* Strips of heavy paper or Bristol board, imprinted with a wedge for measurement of fiber diameter at a magnification of 500X. The wedge is usually divided into 2.5 micron intervals (cells).

(4) *Calibration.* The microscope shall be adjusted to give a magnification of 500X in the plane of the projected image. This may be accomplished by placing a stage micrometer on the stage of the microprojector and bringing the microscope into such adjustment that an interval of 0.0 mm on the stage micrometer will measure 100 mm when sharply focused in the center of the image

plane.

(5) *Sampling*. The method of obtaining a sample representative of the fineness of a lot of grease wool, pulled wool, scoured wool, or card sliver will differ according to circumstances. Lots may be sampled either by coring or by hand. The sampling procedures, advisable are as follows:

(i) *Core sampling*. Core sampling of packaged scoured, pulled, or grease wool is advisable whenever feasible. Acceptable procedures and schedules for core sampling raw wool are described in current ASTM Standards on Textile Materials, Designation: D1060, "Standard Method of Core Sampling of Raw Wool Packages for Determination of Percentage of Clean Wool Fiber Present."<sup>1</sup> If a representative portion of the scoured wool core sample resulting from the test for clean wool fiber content is available it may be used for average and standard deviation of fiber diameter determinations if the procedures described in ASTM Designation: D584, "Standard Methods of Tests for Wool Content of Raw Wool,"<sup>1</sup> are followed.

(ii) *Hand sampling an individual fleece*. A sample shall consist of approximately 30 grams of wool. For fleeces having a major sort, the sample shall be drawn at random from this part of the fleece. For fleeces not having a major sort, the sample shall be drawn at random from all parts of the fleece.

(iii) *Hand sampling lots of fleece*. A sample shall consist of at least 3 pounds of wool. If the fleeces are packaged, the sample shall be drawn from at least 50 randomly selected fleeces from not less than 10 percent of randomly selected packages in the lot. If the fleeces are in piles, the sample shall be drawn from at least 50 fleeces selected from random locations throughout the pile. If there are less than 50 fleeces in the lot, all fleeces shall be sampled. Each fleece shall be sampled in accordance with the provisions in paragraph (a)(5) of this section.

(iv) *Hand sampling lots of scoured, pulled, and grease wool not in fleece form*. A sample shall consist of at least 3 pounds of wool. If the wool is packaged, the sample shall be drawn by taking a total of at least 50 handfuls of wool from not less than 10 percent of randomly selected packages in the lot. If the wool is in piles, the sample shall be drawn by taking from randomly locations throughout the pile at least 50 handfuls of wool.

(v) *Hand sampling card sliver*. Wool card sliver shall be sampled by drawing at random from the lot, preferably during the carding operation, ten 24-inch lengths of sliver.

(6) *Test specimens of grease wool, pulled wool, scoured wool, and card sliver*. The method of obtaining a test specimen representative of a sample drawing in accordance with the procedures of paragraph (a)(5) of this section will differ according to circumstances. The methods advisable are as follows:

(i) *Obtaining test specimen from core test residue*. The test specimen shall be obtained from one or more aliquot portions of the scoured wool remaining after core testing of a lot for clean fiber content by using the following procedures: The sample shall be divided into 40 portions of approximately equal size. From each portion, a sufficient quantity of fibers shall be drawn at random to provide an aggregate test specimen of 20 grams. These fibers shall be mixed or blended to form the test specimen. For best blending results, test specimens from samples

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<sup>1</sup>Copies of D1060 and D584 may be purchased from the American Society for Testing and Materials , 1916 Race Street, Philadelphia, PA, 19103.

obtained by means of 1 1/4-inch and larger coring tubes should be machine blended. However, samples drawn with smaller tubes should not be machine blended since loss of fiber may occur. The machine blending of test specimens may be accomplished by carding the specimen 3 times, breaking the web and feeding at right angles after the first and second passes; or by gilling the specimens 15 times, breaking and combining the pieces of sliver to maintain a convenient length.

(ii) *Obtaining test specimens from other samples (except card sliver)*. Test specimens may be obtained by hand sampling or core sampling as described herein:

(a) *Hand sampling*. Samples shall be divided into 40 portions of approximately equal size. From each portion, a sufficient quantity of fiber to provide a test specimen of 20 grams shall be drawn at random. Test specimens of grease wool and pulled wool shall be scoured or otherwise cleaned. Clean specimens, except those from samples of wool with fibers less than 1 1/4 inches in length, shall be further homogenized, preferably by machine blending, following the procedures described in paragraph (a)(6) of this section.

(b) *Core sampling*. The sample shall be compressed in a suitable container by means of a 3/8"-inch or a 1/2-inch coring tube with sharp tip, a sufficient number of cores shall be extracted to provide a test specimen of 20 grams of scoured wool. Test specimens of grease wool or pulled wool shall be scoured or otherwise cleaned.

Note: An example of a suitable container would be a box 12 inches by 10 inches by 6 inches deep, equipped with a floating top which has 16 randomly spaced holes three-fourth inch 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.

(iii) *Obtaining test specimens from card sliver samples*. Portions shall be stripped from each of the ten 24-inch pieces of sliver obtained in accordance with paragraph (a)(5)(v) of this section. These pieces shall be combined to form a composite sliver about 2 feet in length. This will constitute the test specimen.

(7) *Test condition*. Precondition all test specimens to approximate equilibrium in an atmosphere of 5 to 25 percent relative humidity at a temperature less than 122° F. (50° C). Then condition them for at least 4 hours in the standard atmosphere for testing, 65 percent relative humidity  $\pm 2$  percent at 70° F.  $\pm 2$ ° F. (21°  $\pm 1.1$ ° C.) in temperature.

(8) *Preparation of slides--(i) Filling cross section device*. For specimen in sliver form, the specimen shall be placed in the slot of the cross section device, far enough from either end of the sliver to assure sectioning at an undisturbed area. It shall be compacted firmly with the compression key, and the latter secured with the set screw. For specimen not in sliver form, from the bulk of the test specimen, small quantities of fibers shall be drawn at random, packing the slot to the required level. The specimen shall be compacted firmly with the compression key, and the latter secured with the set screw.

(ii) *Preliminary section*. The gripped fibers shall be cut off at the upper and lower surfaces of the plate. The fiber bundle shall be extruded to the extent of approximately 0.50 mm in order to take up slack in the fibers and the propulsion mechanism. The projecting fibers shall be moistened with a few drops of mineral oil. This projecting fiber bundle shall be cut off with a razor blade flush with the upper surface of the fiber holder plate, and the section discarded.

(iii) *Final section*. The fiber bundle shall again be extruded, approximately 0.25 mm. The

fiber bundle shall be moistened with a few drops of mineral oil, blotting off the excess. The projecting fibers shall be cut off with a sharp razor blade flush with the holder plate. The fiber pieces should adhere to the razor blade.

(iv) *Mounting the fibers.* A few drops of mineral oil shall be placed on a clean glass slide. With a dissecting needle, the fiber pieces shall be scraped from the razor blade onto the slide. The fibers shall be thoroughly dispersed in the oil with the dissecting needle and the slide completed with a cover glass. Sufficient oil should be used in the preparation of the slide to insure 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, a portion of the mixture, after thorough dispersion of the fibers, may be wiped away with a piece of tissue or cloth.

(v) *Finished slide.* The slide shall be placed on the stage of the microprojector, cover glass toward the objective. The measurement courses shall be planned across the slide so that the far, near, and intermediate areas will be reached. Slides shall be measured the day they are prepared.

(9) *Measurement of fibers.* Starting at the upper left corner on the slide, the midlength portion of the fiber to be measured shall be brought into sharp focus on the wedge scale. Fiber edges appear as fine lines without borders when they are uniformly in focus. It is unusual, however, for both edges of the fiber to be in focus at the same time. If both edges of the fiber are not uniformly in focus, adjustment shall be made so that one edge of the fiber is in focus and the other shows as a bright line. To record the measurement, it is necessary to mark the point where the wedge corresponds with the fiber image as determined by (i) the fine lines of both edges when they are uniformly in focus, or (ii) 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. The slide shall be traversed and successive fibers measured in the planned courses, measuring only those fibers whose midpoints come within the field--a circle 4 inches in diameter, centrally located in the projected area. Fibers shorter than 150 microns in length, and those having distorted images shall be excluded from measurement. The marks on the wedge indicating the diameter of fibers measured are counted and combined into cells for calculation as indicated in §31.204(a)(12).

(10) *Nature of test.* A test shall comprise the measurement of the test specimen by two operators, each operator following independently the procedures of paragraph (a)(8) of this section.

(11) *Number of fibers.* The minimum number of fibers required for each test shall be the number for the respective grade as prescribed in the procedure for designating grade (paragraph (b) of this section), each operator measuring approximately one-half the required number of fibers. The prescribed minimum number of fibers per test should result in confidence limits of the mean ranging from approximately  $\pm 0.4$  to  $\pm 0.5$  micron at a probability level of 95 percent, when wools of average uniformity in fiber fineness are measured.

(12) *Calculation and report.* The measurements of both operators shall be combined and the following calculations made by using the applicable formulae shown below:

- (i) Total number of measurements ( $n$ )
- (ii) The average diameter of fiber ( $X$ );  $X=A+mE$
- (iii) The standard deviation ( $y$ );  $y=m\sqrt{E_2-E_1^2}$

In the formula stated above:

$A$ =Midpoint of cell containing the smallest measurement

$m$ =Cell interval

$$E_1=(\Sigma fx/n)$$

$$E_2=(\Sigma fx^2/n)$$

$\Sigma$ =Summation

$f$ =Observed frequency

$x$ =Deviation in cells from  $A$

An example of the calculations is set forth below:

**EXAMPLE OF CALCULATIONS: AVERAGE FIBER DIAMETER AND STANDARD DEVIATION**

Cell No.	Cell Boundary	A	Deviation in cells from A, x	Observed frequency f	fx	fx <sup>2</sup>
5.....	10.0-12.5	11.25	0	1	0	0
6.....	12.5-15.0	.....	1	12	12	12
7.....	15.0-17.5	.....	2	53	106	212
8.....	17.5-20.0	.....	3	113	339	1,017
9.....	20.0-22.5	.....	4	132	528	2,112
10.....	22.5-25.0	.....	5	141	705	3,525
11.....	25.0-27.5	.....	6	111	666	3,996
12.....	27.5-30.0	.....	7	79	553	3,871
13.....	30.0-32.5	.....	8	63	504	4,032
14.....	32.5-35.0	.....	9	44	396	3564
15.....	35.0-37.5	.....	10	28	280	2800
16.....	37.5-40.0	.....	11	7	77	847
17.....	40.0-42.5	.....	12	6	72	864
18.....	42.5-45.0	.....	13	5	65	845
19.....	45.0-47.5	.....	14	3	42	588
20.....	47.5-50.0	.....	15	0	0	0
21.....	50.0-52.5	.....	16	2	32	512
Total .....	.....	.....	.....	800	4,377	28,797

Number of measurements ( $n$ )=800

$A$  (midpoint of cell containing smallest diameter measurement) =11.25 microns

$m$  (cell interval)=2.5 microns

$$E_1=(\Sigma fx/n)=(4377/800)5.4712 \text{ and}$$

$$E_2=(\Sigma fx^2/n)=(28,797/800)=35.9962$$

Average diameter,  $X=A+mE_1=11.25+2.5(5.4712)=24.93$  microns\*

Standard deviation,  $\sigma=m\sqrt{E_2-E_1^2}=2.5\sqrt{35.9962-29.9340}=2.5(2.4622)=6.16$  microns\*

\* Round off the calculated values of average fiber diameter and of standard deviation to two decimal places as follows: If the figure in the third decimal place is 4 or less, retain the figure in the second decimal place unchanged; otherwise, increase the figure in the second decimal place by 1.

(b) *Procedure for designating grade.* For grade determination by measurement, the minimum number of fibers to be measured per test based on the average fiber diameter limits of the various grades is set forth below.

MEASUREMENT SCHEDULE FOR DESIGNATING  
GRADES OF WOOL

Grade	Minimum number of fiber diameter measurements	Limits for average fiber diameter (microns)	Limit for standard deviation, maximum (microns)
Finer than 80's	400	Under 17.70 . . . .	3.59
80-s . . . . .	400	17.70 to 19.14 . . . .	4.09
70's . . . . .	400	19.15 to 20.59 . . . .	4.59
64's . . . . .	600	20.60 to 22.04 . . . .	5.19
62's . . . . .	800	22.05 to 23.49 . . . .	5.89
60's . . . . .	800	23.50 to 24.94 . . . .	6.49
58's . . . . .	1,000	24.95 to 26.39 . . . .	7.09
56's . . . . .	1,200	26.40 to 27.84 . . . .	7.59
54's . . . . .	1,400	27.85 to 29.29 . . . .	8.19
50's . . . . .	1,600	29.30 to 30.99 . . . .	8.69
48's . . . . .	1,800	31.00 to 32.69 . . . .	9.09
46's . . . . .	2,000	32.70 to 34.39 . . . .	9.59
44's . . . . .	2,200	34.40 to 36.19 . . . .	10.09
40's . . . . .	2,400	36.20 to 38.09 . . . .	10.69
36's . . . . .	2,600	38.10 to 40.20 . . . .	11.19
Coarser than 36's	2,600	Over 40.20 . . . .	. . . . .

(1) *Grade designation.* That grade shall be assigned to a sample of wool which correspond, in the measurement schedule for designating grades of wool, to the measured average and standard deviation of fiber diameter, provided this is determined in accordance with the procedure set forth in paragraph (a) of this section. Example: Measured average fiber diameter equals 27.25 microns; number of fiber diameter measurements equal 1200; standard deviation equals 6.72 microns; grade designation equals 56's. If the measured standard deviation exceeds the maximum specified for the grade to which the measured average fiber diameter corresponds, assign to the wool the next coarser grade. Example: Measured average fiber diameter equals 27.25 microns; number of fiber diameter measurements equal 1200; standard deviation equals 7.80 microns; grade designation equals 54's. Example: Measured average fiber diameter equals 27.25 microns; number of fiber diameter measurements equals 1200; standard deviation equals 8.50 microns; grade designation equals 54's.

(2) *Interpretation.* Since all the wool in a lot may not be of the same grade, the grade determined by measurement represents only the average grade of the entire lot. It should not be construed to represent the grade of any component part of the lot selected on as nonrandom basis.

## METHODS FOR DETERMINING GRADE OF WOOL TOP

### § 31.300 General.

The official standards of the United States for grades of wool top as defined in §§31.000 through 31.116 shall be the basis for determining the grade of wool top. The provisions in §§31.301 through 31.302 prescribe two methods for making such determinations--by measurement and by inspection. Both methods for determining grade shall be official; however, if the grade as determined by inspection differs from that determined by measurement, the grade determined by measurement shall prevail.

### § 31.301 Measurement method.

The determination of the grade of wool top by measurement shall be by comparison of the measured average fiber diameter and fiber diameter dispersion with the specifications of the U.S. standards. This determination shall be made in accordance with the procedure for determining average fiber diameter and fiber diameter dispersion provided in paragraph (a) of this section and the procedure for designating grade provided in paragraph (b) of this section.

(a) *Procedure for determining average fiber diameter and fiber diameter dispersion--(1) Principle of procedure.* The average fiber diameter and fiber diameter dispersion are determined by sectioning the fibers in a sample to a designated short length, mounting the sections of fibers on a slide, projecting the magnified image onto a scale, and measuring the diameter of a minimum number of fibers, as specified in this section.

(2) *Apparatus and material.* The following apparatus and material are needed and shall comply with the following provisions:

(i) *Microprojector.* The microscope shall be equipped with a fixed body tube, a focusable stage responsive to a course and fine adjustment, and a focusable substage with condenser and iris diaphragm. It shall be vertically installed with adequate light source, eyepiece, and objective to give a precise magnification of 500 x as determined by use of a stage micrometer. A magnification of 500 x can be obtained when the microscope is adjusted at a proper projection distance and equipped with a searchlight microprojector bulb, a 10-15 x eyepiece, and a 20-21 x objective of good quality with an aperture of approximately 0.50 centimeter.

(ii) *Stage micrometer.* Calibrated glass slide used for accurate setting and control of the magnification.

(iii) *Cross-sectioning device, heavy duty.* An instrument approximately 5 cm. (2 inches) in height, consisting essentially of a metal plate with slot for holding a quantity of fibers, a key for compressing the fibers, and a tongue-propelling arrangement by which the fiber bundle may be extruded for sectioning.

(iv) *Microscope slides.* 25 x 75 mm. 1" x 3").

(v) *Cover glasses.* No. 1 thickness, 22 x 50 mm. (7/8" x 2")

(vi) *Mounting medium.* Colorless mineral oil with a refractive index between 1.53 and 1.43 and of suitable viscosity.

(vii) *Wedge scales.* Strips of heavy paper or Bristol board imprinted with a wedge for use at a magnification of 500 x 0. The wedge is usually divided into 2.5 micron intervals.

(3) *Calibration.* The microscope shall be adjusted to give a magnification of 500 x in the plane of the projected image. This may be accomplished by placing a stage micrometer on the stage of the microprojector and bringing the microscope into such adjustment that an interval of 0.20 mm. on the

stage micrometer will measure 100 mm. when sharply focused in the center of the image plane.

(4) *Sampling.* Sample the lot of top by drawing from each 20,000 pounds (9,072 kilograms), or fraction thereof, four sections of sliver (test specimen) each of which shall be at least 1 yard (0.91 meter) in length and taken from different balls of top selected at random. Take one ball only from any one bale or carton. For broken top take an equivalent aggregate length of sliver at random. The four test specimens shall constitute a sample.

(5) *Test condition.* Precondition all samples to approximate equilibrium in an atmosphere of 5-25 percent relative humidity at a temperature less than 50° C. (122° F.). Then condition them for at least 4 hours in the standard atmosphere for testing--65±2 percent relative humidity at 21±1.1° C. (70°±2° F.).

(6) *Preparation of slides--(i) Filling cross-section device.* Each sliver (test specimen) of top making up the sample shall be placed individually in the slot of the cross-section device far enough from either end of the sliver to assure sectioning at an undisturbed area. The sliver shall be compacted firmly with the compression key and the later secured with the set screw.

(ii) *Preliminary section.* The gripped fibers shall be cut off at the upper and lower surfaces of the plate. The fiber bundle shall be extruded to the extent of approximately 0.50 mm. in order to take up slack in the fibers and the propulsion mechanism. The projecting fibers shall be moistened with a few drops of mineral oil. This projecting fiber bundle shall be cut off with a razor blade flush with the upper surface of the fiber holder plate and the section discarded.

(iii) *Final section.* The fiber bundle shall again be extruded, approximately 0.25 mm., the equivalent of 250 microns. The fiber bundle shall be moistened with a few drops of mineral oil and the excess blotted off. The projecting fibers shall be cut off with a sharp razor blade flush with the holder plate. The fiber pieces should adhere to the razor blade.

(iv) *Mounting the fibers.* A few drops of mineral oil shall be placed on a clean glass slide. With a dissecting needle the fiber pieces shall be scraped from the razor blade onto the slide. The fibers shall be thoroughly dispersed in the oil with the dissecting needle and the slide completed with a cover glass. Sufficient oil should be used in the preparation of the slide to insure 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, a portion of the mixture, after thorough dispersion of the fibers, may be wiped away with a piece of tissue or cloth.

(v) *Finished slide.* The slide shall be placed on the stage of the microprojector, cover glass toward the objective. The measurement courses shall be planned across the slide so that the far, near, and intermediate areas will be reached. Slides shall be measured the day they are prepared.

(7) *Measurement of fibers.* The midlength portion of the fiber to be measured shall be brought into sharp focus on the wedge scale. Fiber edges appear as fine lines without borders when they are uniformly in focus. It is unusual, however, for both edges of the fiber to be in focus at the same time. If both edges of the fiber are not uniformly in focus, adjustment shall be made so that one edge of the fiber is in focus and the other shows as a bright line. The measurements of 100 fibers are recorded on one wedge by marking on the wedge scale the point where the wedge corresponds with the fiber image as determined by (i) the fine lines of both edges when they are uniformly in focus or (ii) 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. The slide shall be traversed and successive fibers measured in the planned courses, with only those fibers being measure whose midpoints come within the field--a circle 4 inches in diameter, centrally located in the projected area. Fibers shorter than 200 microns or longer than 300 microns and those having distorted images shall be excluded from measurement. The marks on the wedge



indicating the diameter of fibers measured are counted and combined into class intervals for calculation as indicated in paragraph (a)(10) of this section. Occasionally a fiber diameter will be less or greater than the extreme limits of the wedge scale. When this occurs, the image of the fiber is projected onto the border of the wedge scale and lines are drawn on the scale at the edges of the fiber image. The distance between the lines is later measured with a metric ruler to obtain the correct average diameter of the fiber. In using the metric scale in this manner, 1 mm. is equal to 2 microns at a magnification of 500 x.

(8) *Nature of test.* One test shall consist of the measurement by two operators of the same four slivers (test specimens) of top. The measurement of both operators shall be combined for calculation of average fiber diameter and fiber diameter dispersion.

(9) *Number of slides and fibers.* Each operator shall make a slide from each test specimen for a total of four slides per operator. The number of fibers to be measured per slide shall be determined by dividing the total number of fibers to be measured per test by 8 (the total number of slides prepared per test). The minimum number of fiber measurements required for each test shall be the number for the respective grade as prescribed in the measurement schedule for designating grades of wool top set forth in paragraph (c) of this section. Each operator shall measure approximately one-half the required number of fibers. In lots that are assigned a dual grade designation, the minimum number of fibers measured shall be that specified for the coarser of the two grades.

(10) *Calculations.* From the observations recorded on the wedge scales, compute the total number of measurements (n), the distribution of fiber diameter frequencies, and the average diameter of fiber (X).

(i) The average diameter of fiber (X) shall be determined by the following formula:  $X=A+mE_j$ . In this formula--

A=Class interval midpoint

m=Class interval

$E_j=\Sigma fx/n$ , where

$\Sigma$ =Summation

f=Observed frequency

x=Deviation in class intervals from A

n=Total number of measurements

An example of the calculations is set forth below, based on an arbitrary selection of a class interval midpoint of 6.25 microns:

**EXAMPLE OF CALCULATIONS: AVERAGE FIBER DIAMETER  
AND FIBER DIAMETER DISPERSION**

Class Interval	A	Deviation in class intervals from A x	Observed frequency f	fx	Cumulative frequency	Cumulative percent
5.0 to 7.5.....	6.25	0	0	0	0	0
7.5 to 10.0.....	.....	1	0	0	0	0
10.0 to 12.5 .....	.....	2	1	2	1	.12
12.5 to 15.0 .....	.....	3	12	36	13	1.62
15.0 to 17.5 .....	.....	4	53	212	66	8.25
17.5 to 20.0 .....	.....	5	113	565	179	22.38
20.0 to 22.5.....	.....	6	132	792	311	38.88
22.5 to 25.0.....	.....	7	141	987	452	56.50
25.0 to 27.5 .....	.....	8	111	888	563	70.38
27.5 to 30.0 .....	.....	9	79	711	642	80.25
30.0 to 32.5 .....	.....	10	63	630	705	88.13
32.5 to 35.0 .....	.....	11	44	484	749	93.63
35.0 to 37.5 .....	.....	12	28	336	777	97.10
37.5 to 40.0.....	.....	13	7	91	784	98.05
40.0 to 42.5 .....	.....	14	6	84	790	98.78
42.5 to 45.0 .....	.....	15	5	75	795	99.35
45.0 to 47.5.....	.....	16	3	48	798	99.75
47.5 to 50.0 .....	.....	17	0	0	798	99.70
50.0 to 52.5 .....	.....	18	2	36	800	100.70
Total.....	.....	.....	800	5,977	.....	.....

Number of measurements (n)=800

A (class interval midpoint)=6.25 microns

m (class interval)=2.5 microns

$$(E_1=(\Sigma fx/n)=(5977/800)=7.47$$

Average diameter,  $X=A+mE_1=6.25+2.5(7.47)=24.93$  microns<sup>1</sup>

<sup>1</sup> Round off the calculated values of average fiber diameter to two decimal places as follows: If the figure in the third decimal place is 4 or less, retain the figure in the second decimal place unchanged; otherwise, increase the figure in the second decimal place by 1.

(b) *Procedure for designating grade.* A grade shall be assigned to a lot of wool top which corresponds to the average fiber diameter and fiber diameter dispersion requirements specified in §§31.100 through 31.116 and paragraph (c) of this section.

(1) *Single grade designation.* If the measured average diameter and fiber diameter dispersion correspond to a single grade, that shall be the grade assigned to the sample.

Example: Average fiber diameter--28.10 microns.

Fiber diameter dispersion:

30 microns and under--64 percent.

30.1 microns and over--36 percent.

50.1 microns and over--1 percent.

Grade designation--56s.

(2) *Dual grade designation.* If the fiber diameter dispersion does not meet the requirements for the grade to which the average fiber diameter corresponds, the wool top shall be assigned a dual grade designation, the second designation being one grade coarser than the grade to which the average fiber diameter corresponds.

Example: Average fiber diameter--28.10 microns.

Fiber diameter dispersion:

30 microns and under--61 percent.

30.1 microns and over--39 percent.

50.1 microns and over--2 percent.

Grade designation--56s-54s.

(c) *Measurement schedule for designating grades of wool top.*

Grade	Finer than 80s	80s	70s	64s	62s	60s	58s	56s	54s	50s	48s	46s	44s	40s	36s	Coarser than 36s
Average fiber diameter range, microns:																
Minimum.....	.....	18.10	19.60	21.10	22.60	24.10	25.60	27.10	28.60	30.10	31.80	33.50	35.20	37.10	39.00	41.30
Maximum.....	18.09	19.59	21.09	22.59	24.09	25.59	27.09	28.59	30.09	31.79	33.49	35.19	37.09	38.99	41.29	.....
Fiber diameter dispersion, percent: <sup>1</sup>																
25 microns and under, minimum.....	95	91	83	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
30 microns and under, minimum.....	.....	.....	.....	92	86	80	72	62	54	44	.....	.....	.....	.....	.....	.....
40 microns and under, minimum.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	75	68	62	54	44	.....
25.1 microns and over, maximum.....	5	9	17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
30.1 microns and over, maximum.....	1	1	3	8	14	20	28	38	46	56	.....	.....	.....	.....	.....	.....
40.1 microns and over, maximum.....	.....	.....	.....	1	1.5	2	.....	.....	.....	.....	25	32	38	46	56	.....
50.1 microns and over, maximum.....	.....	.....	.....	.....	.....	.....	1	1	2	2	.....	.....	.....	.....	.....	.....
60.1 microns and over, maximum.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	2	3	4	.....
Number of fibers required per test <sup>2</sup>	400	400	400	600	800	800	1,000	1,200	1,400	1,600	1,800	2,000	2,200	2,400	2,600	2,600

<sup>1</sup>The second maximum percent shown for any grade is a part of, and not in addition to, the first maximum percent. In each grade, the minimum percent and the first maximum percent total 100 percent.

<sup>2</sup>Research has shown that when wools of average uniformity in fiber diameter are measured, the prescribed number of fibers to measure per test will result in confidence limits of the mean ranging from approximately  $\pm 0.4$  to  $\pm 0.5$  micron at a probability of 95 percent.

**§ 31.302 Inspection method.**

The grade of wool top also may be determined by inspection. This usually will be facilitated by comparing the fibers in the sample of wool top to be graded with fibers in the wool top samples certified by the U. S. Department of Agriculture as representative of the official grades. When using the certified samples to determine the grade of wool top, the grade assigned shall be that of the certified sample which most nearly matches the wool top being graded.

SAMPLES REPRESENTATIVE OF OFFICIAL GRADE STANDARDS OF THE  
UNITED STATES FOR WOOL AND WOOL TOP.

**§31.400 Standard samples for wool and wool top grades; method of obtaining.**

Samples certified as representative of the official standards of the United States for grades of wool and wool top will be furnished as follows, subject to other conditions of this section, upon filing of an approved application and prepayment of costs thereof as fixed in §§31.401 and 31.402. The certification will be issued by the United States Department of Agriculture and will be signed by the Director of the Livestock Division or other official duly authorized by him.

(a) Samples representative of each of the standard grades of wool:

- (1) Complete set: Grades 80's through 36's. Fourteen samples, each of approximately 1/8 pound grease wool, or
- (2) Individual sample: Individual samples of approximately 1/8 pound of grease wool.

NOTE: A sample consists of wool randomly selected from a bulk sample. The measured average and standard deviation of fiber diameter of the bulk sample are within the limits corresponding to the grade of the standard sample as set forth in §§31.2 through 31.15.

(b) Samples representative of each of the standard grades of wool top:

- (1) Complete set: Grades 80's through 36's. Fourteen samples, each of approximately 3 ounces wool top, or
- (2) Individual sample: Individual samples of approximately 3 ounces of wool top, representing a standard grade.

(c) Each application for standard samples of wool or wool top shall be upon an application form furnished or approved by the Agricultural Marketing Service, shall be signed by the applicant, and shall be accompanied by certified check, draft, post office money order, or express money order, payable to the "Agricultural Marketing Service,," in an amount to cover the cost of the samples requested, and shall incorporate the following agreement:

- (1) That no samples representative of the official wool or wool top standards shall be considered or used as representing such standards after cancellation in accordance with this section.
- (2) That the said standard samples shall be subject to inspection by the Secretary or by any duly authorized officer or agent of the Department of Agriculture during usual business hours of the person having custody of the samples.
- (3) That the certificate covering any of the samples representative of the standards may be revoked and canceled by the Director of the Livestock Division if it is found upon such inspection that the said samples are not representative of the official standards.

**§31.401 Cost of standard samples for wool grades.**

(a) Complete set: \$22 each, delivered to any destination within the United States and \$24 each, delivered to any destination outside the United States.

(b) Individual sample: \$2 each, delivered to any destination within the United States and \$2.50 each, delivered to any destination outside the United States.

**§31.402 Cost of standard samples for wool top grades.**

(a) Complete set: \$42 each, delivered to any destination within the United States and \$44 each, delivered to any destination outside the United States.

(b) Individual sample: \$3 each, delivered to any destination within the United States and \$3.50 each, delivered to any destination outside the United States.