Designation: D2525 – 13

Standard Practice for Sampling Wool for Moisture[1]

This standard is issued under the fixed designation D2525; 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 practice covers the design of a sampling plan to be used to obtain samples for the determination of the moisture content of grease wool, scoured wool, carded wool, garnetted wool, wool top and intermediate products, and rovings.

1.2 Directions are given for the designation of sampling units, calculation of the number of sampling units required to achieve a preselected precision and confidence level or, alternatively, for calculating the confidence limits for the mean based on the variability of the sample tested.

NOTE 1—This practice for devising a sampling plan is intended for use in connection with Test Method D1576 or Test Method D2462. The sampling of raw wool for the determination of clean wool fiber present is covered in Practice D1060.

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 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

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

D1576 Test Method for Moisture in Wool by Oven-Drying

D2462 Test Method for Moisture in Wool by Distillation With Toluene

D4845 Terminology Relating to Wool

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

3.1.1 The following terms are relevant to this standard: laboratory sample, lot lot sample, sample, sampling unit, specimen.

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

4. Summary of Practice

4.1 Directions are given for subdividing a lot of material into potential sampling units and for providing each potential sampling unit with its own unique identification.

4.2 Directions are given for calculating the number of such sampling units required to give a preselected allowable variation at a stated probability level, or for calculating confidence limits for the sample mean obtained for a given size of sample.

4.3 Directions are given for deciding which particular sampling units should be chosen to constitute the required lot sample. These directions ensure that all potential sampling units have approximately the same chance of being selected for the lot sample.

5. Significance and Use

5.1 This recommended practice furnishes directions for the sampling of wool of the various forms indicated in Section 1, in order that correct probability statements may be made about the relationship between the sample mean and the population mean. If these statements are to be correct, certain conditions, which are stated, must hold.

5.2 This recommended practice requires that a deliberate act of randomization be performed so that all potential sampling units have approximately the same chance of being taken and no sampling unit is deprived of its chance of being taken.

5.3 In any case where insufficient information about the variability of the sampling units within the lot is available, directions are given for calculating confidence limits for the sample mean so that a correct probability statement can still be made.

[1] This practice is under the jurisdiction of the ASTM Committee D13 onTextiles 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.

6. Preliminary Conditions

6.1 If it is desired to calculate a sample size to achieve a preselected precision at a preselected level of confidence, knowledge of the variation of the moisture content is necessary.

6.1.1 The test method to be used must be the same method that was used to derive any prior information with respect to the variability of the moisture content.

6.1.2 The sampling unit must be the fundamental unit in terms of which the variance is expressed. In other words, if the sampling unit is chosen to be a 25-g handful of bulk material or a 4-yd (3.65-m) length of sliver, then the variance used must be the number that expresses the variability of these units, and the number of sampling units which is calculated will be the number of such units required. The sampling unit is not necessarily the same thing as a specimen.

6.1.3 The lot designated for sampling must be statistically homogeneous. This is equivalent to saying that the lot shall not be composed of a mixture of two or more parts, the moisture content of which is distributed sufficiently differently that if the moisture content of the entire lot were measured, a plot of the moisture content versus the number of sampling units would show a curve having more than one peak. (See Appendix X1.) If the test given in Appendix X1 leads to the conclusion that the lot cannot be considered to be statistically homogeneous, then it should be subdivided into groups that are homogeneous. The pattern of runs found may indicate what the subgroups should be.

6.1.4 The magnitude of the variation of moisture content within the homogeneous lot must be known. The magnitude of the variation is usually expressed as the standard deviation, although the range may also be used.

6.2 If insufficient knowledge is available to ensure meeting the above conditions, a sample of convenient size may be selected and confidence limits calculated for the mean using the information in the sample results. In this case, the only condition that applies is 6.1.3.

7. Procedure

7.1 Designate the form and size of the sampling unit, bearing in mind the conditions and precautions discussed in Sections 5 and 6. Whenever possible, make the size of the sampling unit and specimen the same.

7.1.1 The designation of the sampling unit depends on the form of the material and on the method to be used for making measurements on the sample. The material to be sampled may exist in one of three basic forms: bulk material such as scoured wool or picked blends of wools, packaged material such as baled wool, or material put up in the form of packages within packages such as balls of top within cases or bales. The method of measurement may require a specimen as large as a whole package of material, or as small as a few grams of material.

7.1.2 Where the material to be sampled exists in some bulk form, such as scoured wool, or a blend that has been picked and stored in a bin, the designation of a sampling unit will depend upon the mechanics of drawing the sample. If hand sampling is the method employed, the sampling unit will be a handful of a certain specified size. Whenever possible, the size of a sampling unit should be made to coincide with the size of the specimen required by the method of measurement because the random variations observed in the test results are then directly applicable to the sampling units.

7.1.3 When the material to be sampled exists in the form of packages such as baled wool or packages within packages, such as balls of wool top in cases or bales, the sampling unit can be either an entire package or some portion of a package, depending upon the size of the specimen required.

7.2 Identify each potential sampling unit in the lot by numbering, coding, using geometrical coordinates, or by any other systematic means. It is important that by some means or other, all potential sampling units must be furnished with their own unique identification so that none is deprived of its chance of being sampled.

7.2.1 In designing a sampling plan, it is necessary to devise a method for assigning to every potential sampling unit in the lot a unique identification. This is a relatively simple task in those instances where the sampling units are discrete packages, such as might be the case with balls of top if an entire ball is to be the sampling unit.

7.2.2 With material in bulk form or with packaged material in which the sampling unit is to be only a portion of the package, it is not as easy to identify uniquely each potential sampling unit, and some method of approximating the ideal situation must be devised. See, for example, the instructions given in Practice D1060.

7.2.3 For materials in loose bulk form, considerable ingenuity and imagination may be required to effect a proper identification of the potential sampling units.

7.3 *Option 1*—This procedure is available for those instances where information is sufficient to enable the calculation of sample size required for a specified allowable variation and probability level.

7.3.1 If the allowable variation and probability level are not stated in the applicable material specification or otherwise established, determine for these factors values mutually agreeable to all parties interested in the test results.

7.3.2 Whenever the material being tested has been produced under statisically controlled conditions and records are available, or information is available from prior tests on the same lot, estimate the universe standard deviation from these data.

NOTE 2—In many instances only an estimation of the variation likely to be encountered in a lot is available, such as the limits beyond which values of moisture content are not likely to occur. Practice E122 includes formulas for estimating the standard deviation for different distributions based on the extreme range of values expected. Whenever there is no information available as to the form of the distribution, assuming a rectangular distribution will yield a relatively conservative estimate.

7.3.3 Based on values determined as directed in 7.3.1 and 7.3.2, calculate the number of sampling units required, using Eq 1 or Table 1:

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

TABLE 1 Number of Sampling Units Required to Achieve an Allowable Variation, *E*, at a Stated Probability Level, *P*, for Various Values of Universe Standard Deviation, σ

The listed values have been calculated by Eq 1.

Probability Level, *P*, ...		Allowable Variation to be Achieved, *E*					
		0.25	0.5	0.75	1.0	1.25	1.5
σ							
0.25	0.80	2	1	1	1	1	1
	0.90	3	1	1	1	1	1
	0.95	4	1	1	1	1	1
0.50	0.80	7	2	1	1	1	1
	0.90	11	3	2	1	1	1
	0.95	16	4	2	1	1	1
0.75	0.80	15	4	2	1	1	1
	0.90	25	7	3	2	1	1
	0.95	35	9	4	3	2	1
1.00	0.80	27	7	3	2	2	1
	0.90	44	11	5	3	2	2
	0.95	62	16	7	4	3	2
1.50	0.80	60	15	7	4	3	2
	0.90	97	25	11	7	4	3
	0.95	139	35	16	9	6	4
2.00	0.80	106	27	12	7	5	3
	0.90	174	44	20	11	7	5
	0.95	246	62	28	16	10	7
2.50	0.80	165	41	19	11	7	5
	0.90	271	68	31	17	11	8
	0.95	385	96	43	25	16	11
3.00	0.80	237	60	27	15	10	7
	0.90	390	98	44	25	16	11
	0.95	554	139	62	35	23	16

where:

n = number of sampling units required rounded to the next higher whole number when the calculated value of n is equal to or less than 50 and rounded to the next higher multiple of five when the calculated value of n is greater than 50,

t = constant depending on the desired probability level and equal to Student's t for infinite degrees of freedom and two-sided limits, for example,

Probability Level, %	t	t^2
90	1.645	2.706
95	1.960	3.842
99	2.576	6.636

s = standard deviation of individual observations, in units of the property being evaluated, and

E = allowable variation of the test results expressed in units of the property being evaluated, which in some cases may be a percentage.

NOTE 3—The arbitrarily chosen value for E refers to the allowable variation in a test result based on observations still to be carried out under conditions of single-operator precision.

7.3.4 Using a table of random numbers or any satisfactory objective randomizing procedure, decide which particular potential sampling units will make up the sample of the size calculated in 7.3.3.

7.3.5 Acquire these particular sampling units by the method required by the designation done in 7.1, using special care to avoid gain or loss of moisture by the sampling unit in the process of being taken. Weigh these sampling units as rapidly as possible as they are selected.

7.4 *Option 2*—This procedure is available for those instances where enough information to apply Option 1 is not obtainable or for those instances where all parties interested in the results of the test agree to accept whatever precision may result from an agreed upon fixed sample size and probability in order to reduce the cost of testing.

7.4.1 Decide, by agreement between the parties interested in the test results, on the number of sampling units to be taken and the confidence level desired.

7.4.2 Proceed as directed in 7.3.4 and 7.3.5.

7.4.3 After performing the tests, calculate the confidence limits for the sample mean by Eq 2:

$$\text{Confidence limits} = \pm ts/\sqrt{n} \tag{2}$$

where:

n = number of sampling units in the sample,

t = value of Student's t for $n - 1$ degrees of freedom, two-sided limits, and the specification probability level,[3] and

s = sample standard deviation, defined by Eq 3:

$$s = \left[\sum_i (x_i - \bar{x})^2/(n-1)\right]^{1/2} \tag{3}$$

NOTE 4—The x_i in the above equation are individual values for sampling units when the sampling unit and the specimen are the same size. When, however, more than one specimen is measured per sampling unit, the x_i will be averages of those specimens belonging to a particular sampling unit. $\bar{x}$ is, of course, the grand average of all values.

7.5 Having obtained a lot sample, there are alternative ways of acquiring specimens from it depending on the type of information needed.

7.5.1 *Option 1 has been exercised and no information is needed about variability:*

The entire lot sample is the laboratory sample. Condition the specimen in accordance with Test Method D1576.

7.5.2 *Option 1 has been exercised and information about variability is wanted, or Option 2 has been exercised:*

Example 1: The sampling unit is greater than or equal to the specimen size—Each sampling unit is a laboratory sample. Condition each laboratory sample in accordance with Test Method D1576.

Example 2: The sampling unit is less than the size of specimen required—Combine enough sampling units to give a weight of material equal to or greater than the required specimen size. Divide the entire bulk sample into such groups, making all groups as nearly as possible the same size. Each such group is a laboratory sample. Condition each laboratory sample in accordance with Test Method D1576.

7.6 Proceed from this point as directed in the applicable test method.

8. Report

8.1 State that the specimens were obtained as directed in Practice D2525.

9. Keywords

9.1 moisture content; sampling; statistics; wool

[3] See, for instance, Hoel, P. G., *Introduction to Mathematical Statistics,* John Wiley & Sons Inc., New York, NY.1962, pp. 402–403.

APPENDIX

(Nonmandatory Information)

X1. SAMPLING

TABLE X1.1 Critical Length of Longest Run for *n* Observations

Number of observations	10	20	30	40	50
Critical number (α = 0.05)	5	7	8	9	10
Critical number (α = 0.01)		8	9	10	11

TABLE X1.2 Critical Number of Runs, *u* , for Values of *n*

$n_a = n_b$	5	10	15	20	25	30	40	50	60	70
$u_{0.05}$	3	6	11	15	19	24	33	42	51	60
$u_{0.95}$	8	15	20	26	32	37	48	59	70	81
$u_{0.025}$	2	6	10	14	18	22	31	40	49	58
$u_{0.975}$	9	15	21	27	33	39	50	61	72	83

X1.1 Section 6.1.3 requires the assumption of statistical homogeneity in the lot being sampled, but in many cases it will not be possible to know, *a priori*, that this assumption is valid. A simple test is described herein which may be applied to the data after the test has been performed to check whether this assumption is likely to be valid.

X1.2 Order the data in a natural sequence. In most instances, bags, bales, cartons, or cases will be numbered serially in the order in which they were packed for identification purposes. Arranging the data in an order corresponding to such a serial numbering will yield such a natural sequence.

X1.3 Find the median value for the data and check each item that has a value greater than the median value. Replace each checked item with the letter *a* and each unchecked item with the letter *b*. A sequence of *i* identical letters that is preceded or followed by a different letter or no letter is called a run of length *i*.

X1.4 Two simple nonparametric tests may be applied to the data derived in X1.3.[4,5] One such test calls for the number of runs to be counted. A table of critical values then enables one to judge whether there are too many or too few runs to be able to assert at a given confidence level that that lot is statistically homogeneous. A related but different test is to determine the length of the longest run. Critical values of this quantity have also been calculated which help one to judge whether the lot is sufficiently homogeneous.

X1.5 Table X1.2 is a table that gives the critical number of runs, *u*, for specified numbers of *a*'s (or *b*'s). The number of *a*'s (n_a) or *b*'s (n_b) is half the total number of observations. To assert statistical homogeneity at a confidence level of 0.90, the number of runs, *u*, must be greater than the critical number $u_{0.05}$ and less than the critical number $u_{0.95}$. To assert statistical homogeneity at a confidence level of 0.95, the number of runs, *u*, must be greater than the critical number $u_{0.025}$ and less than the critical number $u_{0.975}$.

X1.6 Table X1.1 is a table that gives the critical length of the longest run in a sequence which might occur by chance as often as if the data were statistically homogeneous. If a run occurred whose length was greater, it can be taken as evidence, at the stated probability level, of a lack of statistical homogeneity.

[4] Hoel, P.G., *Introduction to Mathematical Statistics*, John Wiley and Sons, Inc., New York, NY, Section 13.3.

[5] Wilson, Jr., E. B., *An Introduction to Scientific Research*, McGraw-Hill Book Co., New York, NY, 1952 p. 266.

REFERENCES

The following references may be found to be useful for anyone who encounters a peculiar sampling problem which has not been anticipated in this practice:

(1) *Symposium on Application of Statistics*, ASTM STP 103, Am. Soc. Testing Mats., 1949.

(2) "Symposium on Usefulness and Limitations of Samples," *Proceedings*, Am. Soc. Testing Mats., Vol 48, p. 857.

(3) *Symposium on Bulk Sampling*, ASTM STP 114, Am. Soc. Testing Mats., 1951.

(4) Wilks, S. S., "Sampling and its Uncertainties, *Proceedings*, Am. Soc. Testing Mats., Vol 48, 1948, pp. 859–875.

(5) Tanner, Louis, and Deming, W. E., "Some Problems in the Sampling of Bulk Materials," *Proceedings*, Am. Soc. Testing Mats., Vol 49, 1949, pp. 1181–1186.

(6) Dodge, H. F., "Interpretation of Engineering Data, Some Observations," 1954 Edgar Marburg Lecture, *Proceedings*, Am. Soc. Testing Mats., Vol 54, 1954, p. 603.

(7) Hoel, P. G., *Introduction to Mathematical Statistics*, John Wiley & Sons Inc., New York, NY, 1962.

(8) *ASTM Manual on Quality Control of Materials* , ASTM STP 15-C, Am. Soc. Testing Mats., 1951.

(9) Wilson, Jr., E. B., *An Introduction to Scientific Research*, McGraw-Hill Book Co., New York, NY, 1952.

(10) Cochran, W. G., *Sampling Techniques*, John Wiley & Sons, New York, NY, 1977.