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Standard Practice for Writing Specifications for Textiles[1]

This standard is issued under the fixed designation D 3777; 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 general methods for specifying textile product characteristics that may be measured or counted.

1.2 There are many different types of acceptance samplings plans. This practice describes five types. (See 1.5.)

1.3 This practice describes general methods for writing the sampling plans of the types named in 1.5 whose characteristics may be measured or counted. The requirements are described in terms of what the basic unit is and what limit constitutes a nonconforming item. Tables are provided from which appropriate sampling plans can be designed. Numerical examples illustrate the design of sampling plans and the construction of their consequent operating characteristic curves.

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

1.5 This practice includes the following sections:

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1.6 The annexes include:

Topic Title	Annex Number
Types of Sampling Plans:	
Single-Sample Fraction-Nonconforming Attribute Data	Annex A1
Single-Sample Nonconformances-per-Unit	Annex A2
Single-Sample by Variables to Control Fraction-Nonconforming with Standard Deviation Known	Annex A3
Single-Sample by Variables to Control Fraction-Nonconforming with Standard Deviation Unknown	Annex A4
Chain Sampling	Annex A5

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 123 Terminology Relating to Textiles

D 2906 Practice for Statements on Precision and Bias for Textiles

D 4271 Practice for Writing Statements on Sampling in Test Methods for Textiles

2.2 *Adjunct*

TEX-PAC[3]

NOTE 1—Tex-Pac is a group of PC programs on floppy disks, available through ASTM Headquarters, 100 Barr Harbor Drive, West Conshohocken, PA 19428, USA. The points on the operating characteristic (OC) curves described in the Annexes of this Standard can be calculated using programs in this adjunct.

2.3 *Other Standards:*

ANSI/ASQC Z1.4 Sampling Procedures and Tables for Inspection by Attributes[4]

MIL-STD-105D Sampling Procedures and Tables for Inspection by Attributes[5]

MIL-STD-414 Sampling Procedures and Tables for Inspection by Variables by Percent Defective[5]

Tables of the Binomial Probability Frequency Distribution (No. 6 Of the Applied Mathematics Series), National Institute of Standards and Technology (NIST)[6]

3. Terminology

3.1 *Definitions:*

[1] This practice is under the jurisdiction of ASTM Committee D13 on Textiles and is the direct responsibility of Subcommittee D13.93 on Statistics.

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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] PC programs on floppy disks are available through ASTM. For 3½ inch disk request PCN:12-429040-18, for a 5¼ inch disk request PCN:12-429041-18.

[4] American Society for Quality Control, 230 West Wells Street, Milwaukee, WI 53203.

[5] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

[6] Available from National Institute of Standards and Technology, NIST, Gaithersburg, MD 20899.

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3.1.1 *acceptable quality level, (AQL or p_1), n—in acceptance sampling*, the maximum fraction of nonconforming items at which the process average can be considered satisfactory; the process average at which the risk of rejection is called the producer's risk.

3.1.2 *acceptance number, (c), n—in acceptance sampling*, the maximum for the number of nonconforming items in a sample that allows the conclusion that the lot conforms to the specification.

3.1.3 *acceptance sampling*, *n*—sampling done to provide specimens for acceptance testing.

3.1.4 *acceptance testing*, *n*—testing done to decide if a material meets acceptance criteria.

3.1.5 *chain sampling*, *n—in acceptance sampling*, a sampling plan for which the decision to accept or reject a lot is based in part on the results of inspection of the lot and in part on the results of inspection of the immediately preceding lots.

3.1.6 *consumer's risk, (β), n—in acceptance sampling*, the probability of accepting a lot when the process average is at the limiting quality level.

3.1.7 *laboratory sample*, *n*—a portion of material taken to represent the lot sample, or the original material, and used in the laboratory as a source of test specimens.

3.1.8 *limiting quality level, (LQL or p_2), n—in acceptance sampling*, the fraction of nonconforming items at which the process average can be considered barely tolerable; the process average at which the risk of acceptance is called the consumer's risk. (Syn. *lot tolerance fraction nonconforming*.)

3.1.9 *lot*, *n—in acceptance sampling*, that part of a consignment or shipment consisting of material from one production lot.

3.1.10 *lot tolerance fraction nonconforming*, *n*—see *limiting quality level.*

3.1.11 *nonconforming*, *adj*—a description of a unit or a group of units that does not meet the unit or group tolerance.

3.1.12 *nonconformity*, *n*—an occurrence of failing to satisfy the requirements of the applicable specification; a condition that results in a nonconforming item.

3.1.13 *operating characteristic curve, OC-curve*, *n—in acceptance sampling*, the curve which has as its abscissa an hypothesized lot average, and which has as its ordinate the probability of accepting the lot, when the plan is used. (See also *type A operating characteristic curve* and *type B operating characteristic curve.*)

3.1.14 *producer's risk, (α)*, *n*—the probability of rejecting a lot when the process average is at the acceptable quality level, the *AQL*.

3.1.15 *rejection number*, *n—in acceptance sampling*, the minimum number of nonconforming items in a sample that requires the conclusion that the lot does not conform to the specification.

3.1.16 *sample*, *n*—(*1*) a portion of a lot of material which is taken for testing or for record purposes; (*2*) a group of specimens used, or observations made, which provide information that can be used for making statistical inferences about the population(s) from which they were drawn.

3.1.17 *sampling unit*, *n*—an identifiable discrete unit or subunit of material that could be taken as part of a sample.

3.1.18 *single sampling*, *n—in acceptance sampling*, a sampling plan for which the decision to accept or reject a lot is based on a single sample.

3.1.19 *specification*, *n*—a precise statement of a set of requirements to be satisfied by a material, product, system, or service, that indicates the procedures for determining whether each of the requirements is satisfied.

3.1.20 *type A operating characteristic curve*, *n*—an operating characteristic curve which describes the operation of a sampling plan where the size of the lot being sampled is taken into consideration.

3.1.21 *type B operating characteristic curve*, *n*—an operating characteristic curve which describes the operation of a sampling plan where items are drawn at random from a theoretically infinite process.

3.1.22 For definitions of textile and statistical terms used in this practice refer to Terminology D 123.

4. Significance and Use

4.1 All purchase agreements should be based on a specification of the material to be purchased which is agreeable to both parties. The parties should have a common understanding of the quality of material described by the specification. This practice describes how to write such a specification.

4.2 All purchase agreements should contain a sampling plan to use to determine the disposition of lots of material. A specification is not complete without a sampling plan. This practice describes how to write sampling plans which, when used as part of a purchase agreement, will give the parties a common understanding of the quality of material described, the risks connected with the sampling and testing procedures, and the procedures to follow when a lot is rejected.

4.3 It should be clearly understood that no sampling plan, including 100 % inspection, can make certain that all accepted lots will have a certain quality. No matter what the quality level a vendor supplies, if the purchaser continues to receive shipments from the same vendor, a portion of the shipments will be accepted by the sampling plan. All a sampling plan can do is increase the probability of acceptance of good lots, and decrease the probability of acceptance of bad lots.

4.4 When inspection is inexpensive and not destructive, or when it is extremely important that all nonconforming items be detected, conformance to the specification may be determined by complete inspection of every item in the lot.

4.5 When neither of the situations described in 4.4 pertain, a sampling plan which involves less than 100 % inspection may be used. A plan should be chosen which will divide the cost of imperfect judgments caused by inspecting only a portion of the lot between producer and buyer. This practice describes some simple methods for preparing sampling plans. More complex sampling plans may be justified when the costs of inspection are high. Such plans may be found in Duncan,[7,8] MIL-STD-105D, and in MIL-STD-414. In any case, sampling

[7] Duncan, Acheson J., *Quality Control and Industrial Statistics*, Richard D. Irwin, Inc., Homewood, IL, 1974.

[8] Hahn, Gerald J., Schilling, Edward G., "An Introduction to the MIL-STD-105D Acceptance Sampling Scheme," *Standardization News*, American Society for Testing and Materials, September 1975, pp. 20–26.

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plans can be compared using their operating characteristic curves and their costs.

4.6 The operating characteristic curves in this practice are of the type B. That is, that the lots being inspected are assumed to be infinitely large. This assumption is convenient, and no significant error is introduced, if the lot size is 1000 or more items, or if the sample size is no more than 10 % of the lot size. In other cases the consumer's risk will be somewhat overstated.

5. Organizational Form for Specifications

5.1 The important parts of a specification are: designation number, title, scope, reference documents, terminology, requirements, sampling plan, test methods, and operating characteristic curve. See Part B of *Form and Style for ASTM Standards*[9] for further information regarding parts and their order of presentation.

6. Introductory Sections of Specifications

6.1 Write the sections on title, scope, referenced documents, and terminology in accordance with *Form and Style for ASTM Standards*.[9]

7. Requirements Section of Specification

7.1 State the requirements for a laboratory sampling unit. Requirements may be expressed as attributes or as variables. Tolerances may be one-sided or two-sided. It is recommended that the sections specifying the requirements are preceded by a center heading reading *Requirements.*

7.2 Table 1 illustrates the requirements and acceptance criteria for an attribute and a variables plan. This table is based on the examples in Annex A1 and Annex A3.

7.3 Tabulate the key parameters, specifying the OC-curves of sampling plans in a table similar to Table 2. Table 2 is based on the examples of Annex A1 and Annex A3.

8. Sampling

8.1 Follow the directions of Practice D 4271 in describing how sampling is to be done.

9. Test Methods

9.1 Specify a test method for every property for which requirements are indicated. List the test methods for the properties in exactly the same order that they are listed in the sections and tables on requirements. It is recommended that the sections specifying the test methods to be used are preceded by a center heading reading *Test Methods*.

9.2 Specify a test method in one of two ways:

[9] Available from ASTM Headquarters.

TABLE 1 Requirements of Acceptance Criteria[A]

Requirement	Test Method	Lot Acceptance Criteria
No separation of components	D XXXX	accept if nonconforming units < 2 in sample of 36 units
Tenacity, min = 1200 mN/tex $\sigma' = 324$	D YYY	accept if $\bar{X}$ > 1779.9 mN/tex, for sample of 22 items

[A] $\bar{X}$ = observed average.

TABLE 2 Basis for Acceptance Sampling Plan

Property	Fraction of Lot Out of Specification		Risk Factors	
	Acceptable Quality Level	Limiting Quality Level	Producer's	Consumer's
Component separation	0.01	0.11	0.05	0.10
Tenacity	0.015	0.07	0.04	0.075

9.2.1 Use the preferred option of stating that the property will be tested as directed in an existing test method which is listed in the section on referenced documents. If it is necessary to make minor changes in the test method, add a section on precision and bias as follows: "The precision and bias of this test method are not changed significantly by the minor changes specified above." (See Practice D 2906.)

9.2.2 If the less desirable option of writing a test method within the specification is used, the test method cannot be referenced in another specification. In addition, the test method must include sections on scope, significance and use, procedure, and precision and bias as required by Part A of *Form and Style for ASTM Standards*.[9] For practical purposes, this option is no easier than writing a separate test method and contains serious drawbacks.

9.3 If neither a measurement nor a count can be made on a unit of the sample, state in writing what is to be done and how conformance is to be decided. If appropriate, specify that physical samples of satisfactory and unsatisfactory materials are to be exchanged by the producer and the buyer.

9.4 In case of a dispute arising from differences in reported test results follow the procedure described in the applicable test method.

10. Sampling Plans

10.1 *Single-Sample Fraction-Nonconforming Attribute Data*—Attribute inspections are summarized in terms of fraction of units not conforming. Simple two-point plans are based on two selected points on the operating characteristic curve. Single-sample plans base the decision to accept or reject the lot being sampled on one sample only. The plans in this standard are based on the binomial frequency distribution. They do not take into account inspections made on prior lots from the same vendor. The calculation of such plans is described in Annex A1.

10.2 *Single-Sample Nonconformances-Per-Item*—A single-sample nonconformance-per-unit plan consists of one sample of size n and an acceptance number c. If the sample has a total number of instances of nonconformances less than or equal to c, accept the lot; otherwise reject it. The calculation of such plans is described in Annex A2.

10.2.1 For such plans, it is assumed that the number of nonconformances per unit are distributed in the form of a Poisson distribution with mean equal to μ'.

10.3 *Single-Sample by Variables to Control Fraction-nonconforming with Standard Deviation Known*—Variables inspections are based on the assumption that the normal distribution is a suitable model for the data. Simple two-point plans are based on two selected points on the operating characteristic curve. They do not take into account results of inspections made on prior lots from the same vendor. Single-sample plans base the decision to accept or reject the lot being

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basis of one sample. The calculation of plans with such data with the standard deviation known and with one sided limits is described in Annex A3.

10.4 *Single-Sample by Variables to Control Fraction-nonconforming with Standard Deviation Unknown*—Variables inspections are based on the assumption that the normal distribution is a suitable model for the data. Simple two-point plans are based on two selected points on the operating characteristic curve. They do not take into account results of inspections made on prior lots from the same vendor. Single-sample plans base the decision to accept or reject the lot on the basis of one sample. The calculation of plans with such data and with two-sided limits is described in Annex A4.

10.5 *Chain Sampling*—Chain sampling takes into account the results of prior inspections made on lots of material from the same vendor. The calculation of a chain sampling plan is described in Annex A5.

10.5.1 According to Duncan,[6] for chain sampling plans to be used properly all of the following conditions should be met:

10.5.1.1 The lot should be one of a series in a continuing supply;

10.5.1.2 Lots should normally be expected to be of essentially the same quality;

10.5.1.3 The consumer should have no reason to believe that the lot currently sampled is poorer than the immediately preceding ones, and

10.5.1.4 The consumer must have confidence in the supplier and have confidence that the supplier would not take advantage of a good record to slip in a bad lot now and then when it would have the best chance of being accepted.

10.5.2 In addition to the information about chain sampling given here and in Annex A5, additional information can be found in Stephens.[10]

11. Operating Characteristic Curve

11.1 The operating characteristic curve of a sampling plan describes how the plan will behave. The abscissa of the curve is an hypothesized condition of the lot being sampled. Its ordinate is the probability that the lot will be accepted, if that condition is true. Tabulate the parameters of the operating characteristic curve in a table similar to Table 2. Tabulate and draw the OC-curve and incorporate it into the specification. Table 2 is based on the examples in the annexes.

11.2 In the case of chain sampling plans, the hypothesized condition of lots is assumed to remain the same over the period of sampling.

11.3 Every sampling plan has an operating characteristic curve. The annexes describe how to calculate such curves. With the help of someone versed in statistics, calculate the curve for other plans not in the annexes.

11.4 Every OC-curve discussed in this practice is of the type B.

11.5 In the interest of conserving space, no plots of operating characteristic curves are shown.

12. Keywords

12.1 sampling plans; specifications; statistics; writing specifications

[10] Stephens, Kenneth S., *Vol 2: How to Perform Continuous Sampling*, American Society for Quality Control, Milwaukee, WI 53203.

ANNEXES

(Mandatory Information)

A1. SINGLE-SAMPLE FRACTION-NONCONFORMING ATTRIBUTE DATA

A1.1 *Design of Plan*—To design a two-point sampling plan for attribute data, perform the following steps:

A1.1.1 Based on the objectives of the sampling plan, select the two points (*AQL*, 1-α) and (*LQL*, β) on the operating characteristic curve, where *AQL* is the acceptance quality level and is denoted by p_1, and where *LQL* is the limiting quality level and is denoted by p_2.

A1.1.2 Calculate the ratio: p_2/p_1

A1.1.3 From the appropriate columns of Table A1.1, obtain the acceptance number, *c*, and the value, np_1, corresponding to the number in the body of the table just equal to or greater than the ratio p_2/p_1.

A1.1.4 Determine the sample size, $n = np_1/p_1$, where np_1 is obtained from Table A1.1. Round *n*up to the nearest whole number.

A1.2 *Operating Characteristic Curve*—Points on the operating characteristic curve are (*E/n*, *P(A)*) where *E* and *P(A)* are from Table A1.2. *E* is the entry in the body of the table corresponding to *c* and *P(A)*.

A1.3 *Numerical Example:*

A1.3.1 A lot consists of 1000 rolls of fabric. The requirement is that there be no separation of fabric in any roll. It is desired to design a sampling plan which will have the following parameters:

A1.3.1.1 The acceptable quality level, $p_1 = 0.01$,

A1.3.1.2 The producer's risk, $\alpha = 0.05$,

A1.3.1.3 The lot tolerance fraction defective, $p_2 = 0.08$, and

A1.3.1.4 The consumer's risk, $\beta = 0.10$.

A1.3.2 The value of $p_2/p_1 = 8$.

A1.3.3 In the $\alpha = 0.05$ and $\beta = 0.10$ column of Table A1.1, the number just greater than the ratio calculated in A1.3.2 is 10.946. Corresponding to this ratio the acceptance number, $c = 1$, and $np_1 = 0.355$.

A1.3.4 As directed in A1.1.4, the sample size, $n = np_1/p_1 = 0.355/0.01 = 35.5 = 36$.

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TABLE A1.1 Single-Sampling Two-Point Sampling Plan for Attributes—$(p_2/p_1)^{A,B}$

c	Values of p_2/p_1 for: $\alpha = 0.05$, $\beta = 0.10$	$\alpha = 0.05$, $\beta = 0.05$	$\alpha = 0.05$, $\beta = 0.01$	np_1	c	Values of p_2/p_1 for: $\alpha = 0.01$, $\beta = 0.10$	$\alpha = 0.01$, $\beta = 0.05$	$\alpha = 0.01$, $\beta = 0.01$	np_1
0	44.890	58.404	89.781	0.052	0	229.105	298.073	458.210	0.010
1	10.946	13.349	18.681	0.355	1	26.184	31.933	44.686	0.149
2	6.509	7.699	10.280	0.818	2	12.206	14.439	19.278	0.436
3	4.890	5.675	7.352	1.366	3	8.115	9.418	12.202	0.823
4	4.057	4.646	5.890	1.970	4	6.249	7.156	9.072	1.279
5	3.549	4.023	5.017	2.613	5	5.195	5.889	7.343	1.785
6	3.206	3.604	4.435	3.286	6	4.520	5.082	6.253	2.330
7	2.957	3.303	4.019	3.981	7	4.050	4.524	5.506	2.906
8	2.768	3.074	3.707	4.695	8	3.705	4.115	4.962	3.507
9	2.618	2.895	3.462	5.426	9	3.440	3.803	4.548	4.130
10	2.497	2.750	3.265	6.169	10	3.229	3.555	4.222	4.771
11	2.397	2.630	3.104	6.924	11	3.058	3.354	3.959	5.428
12	2.312	2.528	2.968	7.690	12	2.915	3.188	3.742	6.099
13	2.240	2.442	2.852	8.484	13	2.795	3.047	3.559	6.782
14	2.177	2.367	2.752	9.246	14	2.692	2.927	3.403	7.477
15	2.122	2.302	2.665	10.035	15	2.603	2.823	3.269	8.181
16	2.073	2.244	2.588	10.831	16	2.524	2.732	3.151	8.895
17	2.029	2.192	2.520	11.633	17	2.455	2.652	3.048	9.616
18	1.990	2.145	2.458	12.442	18	2.393	2.580	2.956	10.346
19	1.954	2.103	2.403	13.254	19	2.337	2.516	2.874	11.082
20	1.922	2.065	2.352	14.072	20	2.287	2.458	2.799	11.825
21	1.892	2.030	2.307	14.894	21	2.241	2.405	2.733	12.574
22	1.865	1.999	2.265	15.719	22	2.200	2.357	2.671	13.329
23	1.840	1.969	2.226	16.548	23	2.162	2.313	2.615	14.088
24	1.817	1.942	2.191	17.382	24	2.126	2.272	2.564	14.853
25	1.795	1.917	2.158	18.218	25	2.094	2.235	2.516	15.623
26	1.775	1.893	2.127	19.058	26	2.064	2.200	2.472	16.397
27	1.757	1.871	2.098	19.900	27	2.035	2.168	2.431	17.175
28	1.739	1.850	2.071	20.746	28	2.009	2.138	2.393	17.957
29	1.723	1.831	2.046	21.594	29	1.985	2.110	2.358	18.742
30	1.707	1.813	2.023	22.444	30	1.962	2.083	2.324	19.532
31	1.692	1.796	2.001	23.298	31	1.940	2.059	2.293	20.324
32	1.679	1.780	1.980	24.152	32	1.920	2.035	2.264	21.120
33	1.665	1.764	1.960	25.010	33	1.900	2.013	2.236	21.919
34	1.653	1.750	1.941	25.870	34	1.882	1.992	2.210	22.721
35	1.641	1.736	1.923	26.731	35	1.865	1.973	2.185	23.525
36	1.630	1.723	1.906	27.594	36	1.848	1.954	2.162	24.333
37	1.619	1.710	1.890	28.460	37	1.833	1.936	2.139	25.143
38	1.609	1.698	1.875	29.327	38	1.818	1.920	2.118	25.955
39	1.599	1.687	1.860	30.196	39	1.804	1.903	2.098	26.770
40	1.590	1.676	1.846	31.066	40	1.790	1.887	2.079	27.587
41	1.581	1.666	1.833	31.938	41	1.777	1.873	2.060	28.406
42	1.572	1.656	1.820	32.812	42	1.765	1.859	2.043	29.228
43	1.564	1.646	1.807	33.686	43	1.753	1.845	2.026	30.051
44	1.556	1.637	1.796	34.563	44	1.742	1.832	2.010	30.877
45	1.548	1.628	1.784	35.441	45	1.731	1.820	1.994	31.704
46	1.541	1.619	1.773	36.320	46	1.720	1.808	1.980	32.534
47	1.534	1.611	1.763	37.200	47	1.710	1.796	1.965	33.365
48	1.527	1.603	1.752	38.082	48	1.701	1.785	1.952	34.198
49	1.521	1.596	1.743	38.965	49	1.691	1.775	1.938	35.032

[A] Cameron, J. M., *Quality Progress*, September 1974, p. 17.
[B] c = acceptance number,
p_2/p_1 = ratio of *LQL* and *AQL*,
α = producer's risk, and
β = consumer's risk.

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