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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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**Standard Practice for
Sampling of Plastics¹**

This standard is issued under the fixed designation D 1898; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This practice is primarily a statement of principles to guide purchasers of plastic materials purchased under specifications to prepare sampling plans that will describe sampling procedures and that will enable them to determine within practical limits whether or not the products meet the specifications.

1.2 The same principles may be used to guide the preparation of specifications in quantitative terms.

1.3 Some of the same principles may be used to determine the actual quality of a product, including its average and variation above and below that average, with respect to a particular property.

1.4 Since the design of probability sampling depends upon the ultimate use of the samples and the resulting data, consideration must be given to the intended inspection of the samples. Hence, the design of plans for examination and testing of samples for both their attributes and their variables is included.

1.5 This practice is intended for general guidance when little information is available on the variability of the material and of the method of inspection. In some cases, quality control chart methods may be substituted for the procedures herein. In any event, a statistician should be consulted if difficulty is encountered in applying the recommendations herein to the design of a specific sampling problem.

1.6 There is no intent to guide the *disposition* of material that is found to be off-specification by sampling and inspection; disposition is a contractual matter.

1.7 The following outline is presented to facilitate use of this practice:

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1.8 The values stated in SI units are to be regarded as the standard.

1.9 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems 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:*
E 122 Practice for Choice of Sample Size to Estimate the Average Quality of a Lot or Process²
- 2.2 *Military Standards:*³
MIL-STD-105 Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-414 Sampling Procedures and Tables for Inspection by Variables for Percent Defective

3. Significance and Use

3.1 The purpose of the sample may be as follows:

3.1.1 To estimate properties of a lot or shipment, such as the percentage of some constituent, the fraction of the items that fail to meet a specific requirement, the average weight or property of an item, or the quality or total weight of the shipment, or simple identity.

3.1.2 To dispose of the lot or shipment rationally, without the intermediate step of the formation of an estimate.

3.1.3 To define new materials in terms of their properties.

3.1.4 To provide material for evaluation of a test method.

4. General Philosophy

4.1 Sampling is a means employed to meet the problem of estimating the quality of a lot from the inspection of only part

² *Annual Book of ASTM Standard*, Vol 14.02.

³ Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

of the lot. When 100 % inspection (“screening”) of a lot is performed, sampling does not apply.

4.2 The inspection of the sample or portion according to a sampling plan results in an estimation of properties, hence, an uncertainty which can be expressed for a given sampling plan in terms of an operating characteristic curve. Each such curve, that is, for a given acceptable quality level, can be used to obtain two numerical quantities: α , the seller’s risk, and β , the purchaser’s risk. An example is given in Appendix X2.

4.3 The acceptable quality level (AQL) provides assurance to the producer that good material will seldom be rejected. There is a large probability that quality that is close to and slightly better than the AQL will be accepted (X2.2.1, Note X2.1). Consequently the seller is well protected against rejection of submitted lots of material from a process that is at the AQL or slightly above it. The operating characteristic curve is a graph of the risks that are taken in sampling inspection plotted as a function of incoming lot quality. Any of several units such as average, median, or coefficient of variation, can be used to establish the seller’s and purchaser’s risks. The unit most frequently used for this purpose is the arithmetic average.

4.4 An immediate question which arises in approaching the sampling of a given lot is that of selecting the number of units to be sampled, that is, defining the sampling plan. A sample of relatively small size will generally be adequate for a large lot. For a small lot, however, a relatively large sample is required for reliable estimation of properties. Such a sample is often uneconomical, and a compromise must then be found between the cost of an adequate sample and its inspection, and the risk entailed in the less certain information from a smaller sample. Actually, such a balance should always be sought in statistical practice so that the value of the information to be obtained from a given program is commensurate with the cost of obtaining the information. This practice includes in Appendix X2 and Appendix X3 some specific directions for choosing the number of units to be sampled. This has proved useful in extensive use in certain seller-purchaser relationships.

NOTE 1—Some detailed procedures for setting up the numerical features of a sampling plan for a particular characteristic of a material will also be found in Practice E 122.

4.5 In the early stages of experience with a material, the required sample quantity for an isolated lot is generally calculated while considering the lot as an entity. Considerable advantage is often gained in evaluating a series of shipments of similar material by regarding their manufacture as a whole. This is generally done after there is some assurance that the manufacturing process is under control, as by the application of control chart methods.⁴

4.6 If the sampling plan is to be designed to help establish whether a lot meets the requirements of a material specification, it is imperative that the specification be formulated carefully.⁵

5. Sampling for Attributes

5.1 The quality of plastic materials or products is judged in

⁴ See the *ASTM Manual on Quality Control of Materials, STP 15-C*, Am. Soc. Testing Mats. (1951).

⁵ See *Form and Style for ASTM Standards*, available from ASTM Headquarters.

part by the frequency of occurrence of their attributes, that is, properties or conditions which may or may not be present in a given sample. Examples include visual defects, contamination, and success or failure in meeting dimensional or test specifications. Probability sampling should be employed to assess the actual frequency, provided that a small number of undesirable attributes can be tolerated.

NOTE 2—If the presence of a given attribute is unacceptable, all the lot must be inspected, and statistical techniques do not apply.

5.2 The quality of a lot with respect to attributes is evaluated by inspection. The sampling plans for such an evaluation are conveniently expressed in tabular and graphic forms (Appendix X2). The selection of AQL’s for a given material is traditionally a contractual matter. Factors in determining the number of samples to be taken from a lot include the size of the lot and the degree and level of inspection.

5.3 Attributes may be evaluated by examination or by testing.

5.4 *Sampling for Examination* presents fewer problems. Examination generally is nondestructive and hence less costly. Contamination of molding powder, bubbles in sheets, fisheyes in film, warp and twist in extruded shapes, and dimensions by go and no-go gages fall in this category. Because of their subjective nature, it is difficult to put firm numbers on visual defects and contamination for a plastics material specification. Once the specification has been established, however, a sufficient number of samples for a good statistical evaluation of a lot can generally be examined at reasonable cost.

5.5 *Sampling for Physical and Chemical Tests* must be planned while keeping in mind that the tests are often time-consuming and destructive of the sample. The cost tends to limit the number of tests that will be performed. Tests include the determination of particle size and of moisture of molding powder, measurement of properties such as tensile strength, hardness, and deflection temperature, and measurements of color and transparency. For many of these tests, specimens must be cut or molded. The manipulations and calculations may require considerable time for each sample.

5.6 The definition of the sampling unit is important, since it affects the size of the sample. The conception of the sampling unit should also take into account the intended use of the material. For instance, a single bubble may seriously impair the usefulness of a large sheet of glazing material that is to be used in its entirety in military aircraft. If the sheet is to be cut into 152-mm (6-in.) portholes, however, more defects could presumably be tolerated because they can be marked and then avoided in the cutting.

6. Sampling for Variables

6.1 The ultimate object of sampling for variables is to estimate the average value of a property of the material that can be measured on a continuous scale and the variability of the property, with a desired degree of confidence. Such a procedure can be used to obtain data for establishing a specification, as well as for comparing a new lot with a specification.

6.2 In working against a specification for a variable, the concept of AQL is useful because it reduces to tabular and graphic forms the choice of sample size (that is the number of

units from the lot to be drawn into the sample) that is necessary in order to minimize the risk of accepting substandard material.

6.3 In both inspection for attributes by means of tests, and in inspection for variables, values measured in tests are the ultimate bases for judgment of quality, that is, both types of inspection are intended to ensure that the percent defective is less than a certain value. The difference lies in that, in the first instance, the individual test results, or perhaps an average for each sampling unit, are used in deciding acceptance or rejection. In inspection for variables, however, the range (spread) of the group of measurements is also important. The estimated standard deviation, derived from the measurements, is multiplied by a factor from tables, and the resulting product is then subtracted from the average. The corrected average is used for comparison with a minimum specification value. (When the specification is a maximum limit, the product is added to the average.) This means, as one result, that a lot of product having a relatively poor average value, but a narrow range of values for a certain property, may be accepted as meeting a specification, while another lot having a better average but greater variation may be unacceptable. This puts a premium on consistent performance, which is probably more economical in the long run for everyone concerned.

6.4 In setting up a plan for sampling for variables, it must be remembered that it is generally easier to attain a desired degree of assurance for the average value than for its standard deviation. This can easily be demonstrated by an experiment which involves drawing numbers truly at random from a bowl. In general, it takes a very few trials in order to establish a reasonable value for the average number. It takes many more samples to arrive at a good estimate of the standard deviation of the average. This would be equally true for a plastic molding powder that happened to be quite heterogeneous with respect to some property, for example, if the moisture content varied from one particle to another. If random sampling were achieved, a good idea of the average moisture could be obtained from a few samples. It would require considerably more to establish the actual variability.

6.5 Detailed plans for sampling for variables, suggested for wide applicability, will be found in Appendix X3.

7. Means and Standard Deviations

7.1 In evaluating the results of measurements of a variable property of a material, several calculations should be made. It is common practice to perform a series of measurements on the material and to calculate the arithmetic mean or average of the series, $\bar{X}$, for comparison with the specification.

7.2 Even in the most careful measurements, a certain amount of variability or dispersion will be encountered. This must also be reported in order to allow meaningful comparisons of the values. For the purpose of this practice, the most useful numerical expression of this variability is an estimate of the standard deviation, s , of the individual values, calculated as follows:

$$s = \sqrt{(\sum(X_i - \bar{X})^2)/(n - 1)} \quad (1)$$

where:

s = estimated standard deviation,

X_i = value of a single observation,

$\bar{X}$ = arithmetic means of a set of observations, and

n = number of observations in the set.

The reliability of the mean can now be estimated.

7.3 The condition of the average and the standard deviation can also lead to an estimation of the “confidence limits” of the average, provided that only random errors influence the measurements. In order to achieve narrow confidence limits, a large number of determinations must be made. This is seldom realized in practice because of economic considerations of the cost of repeated measurements. Hence, it becomes necessary to report also the numbers of measurements made in arriving at the stated average. Then, confidence limits can be calculated from tables of Student’s “ t ” values.

7.4 Sampling may be designed simply to obtain such information as the above on a new material or test method. This information is then applied to make decisions on the quality of subsequent lots of the material.

8. Comparison of Sampling Plans

8.1 Table 1 shows the sample sizes (number of units of product or specimens) and the qualities of lots (in percent defective) that would be accepted 90 and 10 % of the time under three methods of inspection. Inspection Method A is inspection by means of attributes under Military Standard MIL-STD-105 at Inspection Level II. Method B is inspection by means of variables, with variability unknown, under Military Standard MIL-STD-414 at Inspection Level IV. Method C is inspection by means of variables, with variability known, under Military Standard MIL-STD-414 at Inspection Level IV. The plans shown are for lot sizes of 500 and 10 000 units subjected to “normal” single inspection under AQL’s of 1.0 and 6.5 % defective. Table 1 is presented to show the following:

8.1.1 Smaller sample sizes are needed for the same degree of discrimination for Method B than for Method A, and for

TABLE 1 Comparison of Sampling Plans
(Sample size and quality of lots accepted.)

Lot Size Units	Code Letter	Number of Units Sampled								
		Method A (II)			Method B (IV)			Method C (IV)		
		(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)
AQL = 1.0% Defective										
500	H	50	(1.07)	(9.53)	25	(1.2)	(8.0)	9	(1.2)	(8.0)
10 000	L	200	(1.58)	(4.64)	75	(1.3)	(4.2)	25	(1.3)	(4.2)
AQL = 6.5 % Defective										
500	H	50	(7.56)	(2.4)	25	(7.2)	(21.0)	15	(7.2)	(21.0)
10 000	L	200	(9.34)	(14.1)	75	(7.5)	(14.7)	42	(7.5)	(14.7)

Example—Using Method A at AQL = 1.0 on a lot size of 500, a sample size (a) of 50 is required. Under this plan, 90 % of lots containing 1.07 % (b) defective material would be accepted, but only 10 % of lots containing 9.53 % (c) defective material would be accepted.