Designation: E2555 – 21

An American National Standard

Standard Practice for Factors and Procedures for Applying the MIL-STD-105 Plans in Life and Reliability Inspection[1]

This standard is issued under the fixed designation E2555; 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 presents a procedure and related tables of factors for adapting Practice E2234 (equivalent to MIL-STD-105) sampling plans to acceptance sampling inspection when the item quality of interest is life length or reliability. Factors are provided for three alternative criteria for lot evaluation: mean life, hazard rate, and reliable life. Inspection of the sample is by attributes with testing truncated at the end of some prearranged period of time. The Weibull distribution, together with the exponential distribution as a special case, is used as the underlying statistical model.

1.2 A system of units is not specified by this practice.

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

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

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E456 Terminology Relating to Quality and Statistics

E2234 Practice for Sampling a Stream of Product by Attributes Indexed by AQL

2.2 *Other Documents:*

MIL-STD-105E Sampling Procedures and Tables for Inspection by Attributes[3]

3. Terminology

3.1 *Definitions:*

3.1.1 The terminology defined in Terminology E456 applies to this practice unless modified herein.

3.1.2 *acceptance quality limit (AQL), n*—quality limit that is the worst tolerable process average when a continuing series of lots is submitted for acceptance sampling. **E2234**

3.1.2.1 *Discussion*—This definition supersedes that given in MIL-STD-105E.

3.1.2.2 *Discussion*—A sampling plan and an AQL are chosen in accordance with the risk assumed. Use of a value of AQL for a certain defect or group of defects indicates that the sampling plan will accept the great majority of the lots or batches provided the process average level of percent defective (or defects per hundred units) in these lots or batches are no greater than the designated value of AQL. Thus, the AQL is a designated value of percent defective (or defects per hundred units) for which lots will be accepted most of the time by the sampling procedure being used. The sampling plans provided herein are so arranged that the probability of acceptance at the designated AQL value depends upon the sample size, being generally higher for large samples than for small ones, for a given AQL. The AQL alone does not identify the chances of accepting or rejecting individual lots or batches but more directly relates to what might be expected from a series of lots or batches, provided the steps indicated in this refer to the operating characteristic curve of the plan to determine the relative risks.

3.1.3 *consumer's risk, n*—probability that a lot having specified rejectable quality level will be accepted under a defined sampling plan.

[1] This practice is under the jurisdiction of ASTM Committee E11 on Quality and Statistics and is the direct responsibility of Subcommittee E11.40 on Reliability.

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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] MIL-STD-105E is also commonly referred to as "MIL-STD-105." It is virtually identical in content to its predecessor, MIL-STD-105D. These documents are out of print.

3.1.4 *double sampling plan, n*—a multiple sampling plan in which up to two samplings can be taken and evaluated to accept or reject a lot.

3.1.5 *hazard rate, n*—differential fraction of items failing at time t among those surviving up to time t, symbolized by $h(t)$.

3.1.5.1 *Discussion—h(t)* is also referred to as the instantaneous failure rate at time t. It is related to the probability density and cumulative distribution functions by $h(t) = f(t)/(1 - F(t))$.

3.1.6 *limiting quality level (LQL), n*—quality level having a specified consumer's risk for a given sampling plan.

3.1.7 *lot, n*—a definite quantity of a product or material accumulated under conditions that are considered uniform for sampling purposes.

3.1.7.1 *Discussion*—The lot for sampling may differ from a collection of units designated as a batch for other purposes, for example, production, shipment, and so forth.

3.1.8 *multiple sampling plan, n*—a sampling plan in which successive samples from a lot are drawn and after each sample is inspected a decision is made to accept the lot, reject the lot, or to take another sample, based on quality level of the combined samples.

3.1.8.1 *Discussion*—When the quality is much less or much more than the AQL, the decision can be made on the first sample, which is smaller than that of a single sampling plan with equivalent acceptance quality level. For samples that are close to the AQL in quality, additional samples are required and the total sample size will be larger than the corresponding single sampling plan.

3.1.9 *sample, n*—group of items, observations, test results, or portions of material taken from a large collection of items, observations, test results, or quantities of material that serves to provide information that may be used as a basis for making a decision concerning the larger collection. **E2234**

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *acceptance number, n*—the maximum number of failed items allowed in the sample for the lot to be accepted using a single or multiple sampling plan.

3.2.2 *mean life, n*—average time that items in the lot or population are expected to operate before failure.

3.2.2.1 *Discussion*—This metric is often referred to as mean time to failure (MTTF).

3.2.3 *rejection number, n*—the minimum number of failed items in the sample that will cause the lot to be rejected under a given sampling plan.

3.2.4 *reliable life (ρ_r), n*—life beyond which some specified proportion, r, of the items in the lot or population will survive.

3.2.5 *test truncation time (t), n*—amount of time sampled items are allowed to be tested.

3.2.6 *Weibull distribution, n*—probability distribution having cumulative distribution:

$$\text{function } F(t) = 1 - \exp\left(-\left(\frac{t-\gamma}{\eta}\right)^{\beta}\right),\ t>\gamma \text{ and probability density}$$

$$\text{function } f(t) = \frac{\beta}{\eta}\left(\frac{t-\gamma}{\eta}\right)^{\beta-1}\exp\left(-\left(\frac{t-\gamma}{\eta}\right)^{\beta}\right)$$

3.2.6.1 *Discussion*—The Weibull distribution is widely used for modeling product life. It can take a wide variety of shapes and also the characteristics of other types of distributions based on the value of its parameters. γ is called the location, minimum life, or threshold parameter and defines the lower limit of the distribution (Fig. 1). η is called the scale or characteristic life parameter and is equal to the 63.2 percentile

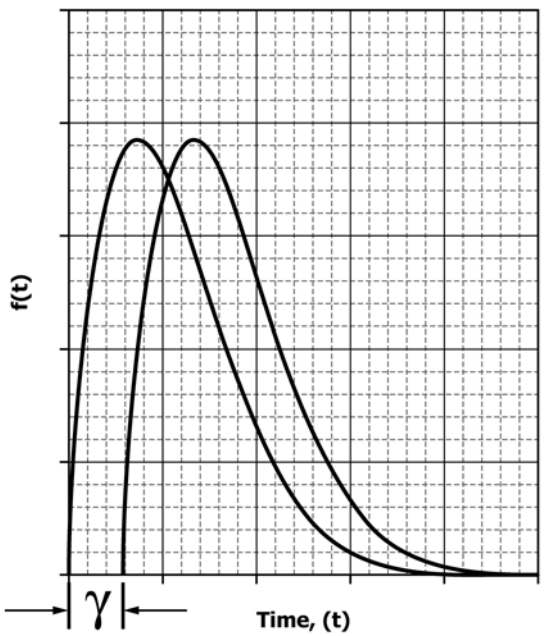

FIG. 1 Effect of the Parameter γ on the Weibull Probability Density Function, *f(t)*

of the distribution, minus γ (Fig. 2). β is the shape parameter (Fig. 3). The exponential distribution is the special case where γ = 0 and β = 1.

4. Significance and Use

4.1 The procedure and tables presented in this practice are based on the use of the Weibull distribution in acceptance sampling inspection. Details of this work, together with tables of sampling plans of other forms, have been published previously. See Refs **(1-3)**.[4] Since the basic computations required have already been made, it has been quite easy to provide these new factors. No changes in method or details of application have been made over those described in the publications referenced above. For this reason, the text portion of this report has been briefly written. Readers interested in further details are referred to these previous publications. Other sources of material on the underlying theory and approach are also available **(4-7)**.

4.2 The procedure to be used is essentially the same as the one normally used for attribute sampling inspection. The only difference is that sample items are tested for life or survival instead of for some other property. For single sampling, the following are the required steps:

4.2.1 Using the tables of factors provided in Annex A1, select a suitable sampling inspection plan from those tabulated in Practice E2234.

4.2.2 Draw at random a sample of items of the size specified by the selected Practice E2234 plan.

4.2.3 Place the sample of items on life test for the specified period of time, *t*.

4.2.4 Determine the number of sample items that failed during the test period.

4.2.5 Compare the number of items that failed with the number allowed under the selected Practice E2234 plan.

4.2.6 If the number that failed is equal to or less than the acceptable number, accept the lot; if the number failing exceeds the acceptable number, reject the lot.

4.3 Both the sample sizes and the acceptance numbers used are those specified by Practice E2234 plans. It will be assumed in the section on examples that single sampling plans will be used. However, the matching double sampling and multiple sampling plans provided in MIL-STD-105 can be used if desired. The corresponding sample sizes and acceptance and rejection numbers are used in the usual way. The specified test truncation time, *t*, must be used for all samples.

4.4 The probability of acceptance for a lot under this procedure depends only on the probability of a sample item failing before the end of the test truncation time, *t*. For this reason, the actual life at failure need not be determined; only the number of items failing is of interest. Life requirements and test time specifications need not necessarily be measured in chronological terms such as minutes or hours. For example, the life measure may be cycles of operation, revolutions, or miles of travel.

4.5 The underlying life distribution assumed in this standard is the Weibull distribution (note that the exponential distribution is a special case of the Weibull). The Weibull model has three parameters. One parameter is a scale or characteristic life parameter. For these plans and procedures, the value for this parameter need not be known; the techniques used are independent of its magnitude. A second parameter is a location or "guaranteed life" parameter. In these plans and procedures, it is assumed that this parameter has a value of zero and that there is some risk of item failure right from the start of life. If this is not the case for some applications, a simple modification in procedure is available. The third parameter, and the one of

[4] The boldface numbers in parentheses refer to the list of references at the end of this standard.

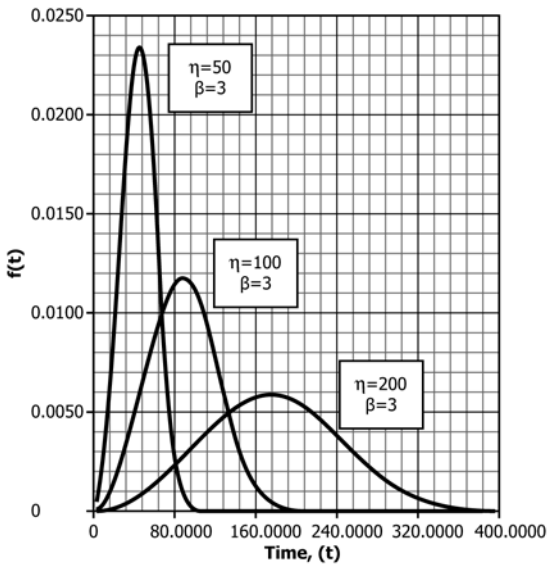

FIG. 2 Effect of the Parameter η on the Weibull Probability Density Function, *f(t)*