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AnAmerican National Standard

Standard Practice for Sampling a Stream of Product by Variables Indexed by AQL[1]

This standard is issued under the fixed designation E2762; 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 *Purpose*—This practice establishes lot or batch sampling plans and procedures for inspection by variables using MIL-STD-414 as a basis for sampling a steady stream of lots indexed by AQL.

1.2 This practice provides the sampling plans of MIL-STD-414 in ASTM format for use by ASTM committees and others. It recognizes the continuing usage of MIL-STD-414 in industries supported by ASTM. Most of the original text in MIL-STD-414 is preserved in Sections 6-9 of this practice.

1.3 The values stated in inch-pound units are to be regarded as standard. No other units of measurement are included in this standard.

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.*

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

E2586 Practice for Calculating and Using Basic Statistics

2.2 *Other Standards:*[3]

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

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

3. Terminology

3.1 *Definitions:*

3.1.1 For a more extensive list of terms in E11 standards, see Terminology E456.

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 and MIL-STD-414.

3.1.3 *classification of defects, n*—the enumeration of possible defects of the unit of product classified according to their seriousness, that is, critical, major, or minor defect. **E2234**

3.1.4 *critical defect, n*—a defect that judgment and experience indicate would result in hazardous or unsafe conditions for individuals using, maintaining, or depending upon the product, or a defect that judgment and experience indicate is likely to prevent performance of the function of a major end item. **E2234**

3.1.5 *defect, n*—any nonconformance of the unit of product with specified requirements. **E2234**

3.1.6 *inspection, n*—the process of measuring, examining, testing, or otherwise comparing the unit of product with the requirements. **E2234**

3.1.7 *inspection by variables, n*—inspection wherein the unit of product is measured on a continuous scale with respect to a given requirement or set of requirements.

3.1.8 *inspection lot, n*—a collection of units of product produced under conditions that are considered uniform and from which a sample is drawn and inspected. **E2234**

3.1.9 *major defect, n*—a defect, other than critical, that is likely to result in failure, or to reduce materially the usability of the unit of product for its intended purpose. **E2234**

3.1.10 *minor defect, n*—a defect that is not likely to reduce materially the usability of the unit of product for its intended purpose, or is a departure from established standards having little bearing on the effective use or operation of the unit. **E2234**

3.1.11 *operating characteristic, n*—probability of acceptance using a specified acceptance sampling plan, as a function of parameters describing quality of the lot. **E2234**

[1] This practice is under the jurisdiction of ASTM Committee E11 on Quality and Statistics and is the direct responsibility of Subcommittee E11.30 on Statistical Quality Control.

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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] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://dodssp.daps.dla.mil.

3.1.12 *sample, n*—a group of observations, test results, taken from a large collection of observations, test results, which serves to provide information that may be used as a basis for making a decision concerning the larger collection. **E2586**

3.1.12.1 *Discussion*—A sample consists of one or more units of product drawn from an inspection lot, the units of the sample being selected at random without regard to their quality. The number of units of product in the sample is the sample size.

4. Summary of Practice

4.1 The main body of this practice is divided into four sections. Section 6 (Section A in MIL-STD-414) describes general procedures of the sampling plans. Sections 7 and 8 (Sections B and C in MIL-STD-414) describe specific procedures and applications of the sampling plans when variability is unknown. In Section 7 (Section B in MIL-STD-414) the estimate of lot standard deviation is used as the basis for an estimate of the unknown variability, and in Section 8 (Section C in MIL-STD-414) the average range of the sample is used. Section 9 (Section D in MIL-STD-414) describes the plans when variability is known.

4.2 Each of Sections 7, 8, and 9 is divided into three parts: (I) Sampling Plans for the Single Specification Limit Case, (II) Sampling Plans for the Double Specification Limit Case, and (III) Procedures for Estimation of Process Average and Criteria for Tightened and Reduced Inspection. For the single specification limit case, the acceptability criterion is given in two forms: Form 1 and Form 2. Either of the forms may be used, since they are identical as to sample size and decision for lot acceptability or rejectability. In deciding whether to use Form 1 or Form 2, the following point should be borne in mind. Form 1 provides the lot acceptability criterion without estimating lot percent defective. The Form 2 lot acceptability criterion requires estimates of lot percent defective. These estimates also are required for estimation of the process average.

4.3 Operating Characteristic Curves in Table A-3 (see Fig. A1.3) show the relationship between quality and percent of lots expected to be acceptable for the quality characteristic inspected. As stated, these Operating Characteristic Curves are based on the assumption that measurements are selected at random from a normal distribution.

4.4 The corresponding sampling plans in Sections 7, 8, and 9 were matched as closely as possible under a system of fixed sample size with respect to their Operating Characteristic Curves. Operating Characteristic Curves in Table A-3 (see Fig. A1.3) have been computed for the sampling plans based on the estimate of lot standard deviation of unknown variability. They are equally applicable for sampling plans based on the average range of the sample of unknown variability and those based on known variability.

4.5 Certain characteristics concerning the sampling plans in Sections 7 and 8 and those in Section 9 should be noted. Plans based on the estimate of unknown variability require fewer sample units for comparable assurance when the estimate of lot standard deviation is used than when the average range of the sample is used; on the other hand, plans using the average range of the sample require simpler computations. Plans using known variability require considerably fewer sample units for comparable assurance than either of the plans when variability is unknown; however, the requirement of variability is a stringent one. The user is advised to consult his technical agency before applying sampling plans using known variability.

4.6 Table B-8 (see Fig. A1.11) provides values of the factor F to compute the maximum standard deviation MSD. The MSD serves as a guide for the magnitude of the estimate of lot standard deviation when using plans for the double specification limit case, based on the estimate of lot standard deviation of unknown variability. Similarly, Table C-8 (see Fig. A1.19) provides values of the factor f to compute the maximum average range MAR. The MAR serves as a guide for the magnitude of the average range of the sample when using plans for the double specification limit case, based on the average range of the sample of unknown variability. The estimate of lot standard deviation or average range of the sample, if it is less than the MSD or MAR respectively, helps to insure, but does not guarantee, lot acceptability.

4.7 All symbols and their definitions are given in Annex A1 for their applicable section. An illustration of the computations and procedures used in the sampling plans is given in the examples of Parts I and II of the applicable section. The computations involve simple arithmetic operations such as addition, subtraction, multiplication, and division of numbers, or at most, the taking of a square root of a number. The user should become familiar with the general procedures of Section 6, and refer to the applicable section for detailed instructions regarding specific procedures, computations, and tables for the sampling plans.

5. Significance and Use

5.1 This practice was prepared to meet a growing need for the use of standard sampling plans for inspection by variables in customer procurement, supply and storage, and maintenance inspection operations. The variables sampling plans apply to a single quality characteristic which can be measured on a continuous scale, and for which quality is expressed in terms of percent defective. The theory underlying the development of the variables sampling plans, including the operating characteristic curves, assumes that measurements of the quality characteristic are independent, identically distributed normal random variables.

5.2 In comparison with attributes sampling plans, variables sampling plans have the advantage of usually resulting in considerable savings in sample size for comparable assurance as to the correctness of decisions in judging a single quality characteristic, or for the same sample size, greater assurance is obtained using variables plans. Attributes sampling plans have the advantage of greater simplicity, of being applicable to either single or multiple quality characteristics, and of requiring no knowledge about the distribution of the continuous measurements of any of the quality characteristics.

5.3 It is important to note that variables sampling plans are not to be used indiscriminately, simply because it is possible to

obtain variables measurement data. In considering applications where the normality or independence assumptions may be questioned, the user is advised to consult his technical agency to determine the feasibility of application.

5.4 *Application*—Sampling plans designated in this publication are applicable, but not limited, to inspection of the following: *(1)* end items, *(2)* components and raw materials, *(3)* operations or services, *(4)* materials in process, *(5)* supplies in storage, *(6)* maintenance operations, *(7)* data or records, and *(8)* administrative procedures.

6. General Description of Sampling Plans

6.1 *Scope:*

6.1.1 *Purpose*—This practice establishes sampling plans and procedures for inspection by variables for use in customer procurement, supply and storage, and maintenance inspection operations. When applicable this practice shall be referenced in the specification, contract, or inspection instructions, and the provisions set forth herein shall govern.

6.1.2 *Inspection*—Inspection is the process of measuring, examining, testing, gaging, or otherwise comparing the "unit of product" (see 6.1.4) with the applicable requirements.

6.1.3 *Inspection by Variables*—Inspection by variables is inspection wherein a specified quality characteristic (see 6.1.5) on a unit of product is measured on a continuous scale, such as pounds, inches, feet per second, etc., and a measurement is recorded.

6.1.4 *Unit of Product*—The unit of product is the entity of product inspected in order to determine its measurable quality characteristic. This may be a single article, a pair, a set, a component of a product, or the end product itself. The unit of product may or may not be the same as the unit of purchase, supply, production, or shipment.

6.1.5 *Quality Characteristic*—The quality characteristic for variables inspection is that characteristic of a unit of product that is actually measured to determine conformance with a given requirement.

6.1.6 *Specification Limits*—The specification limit(s) is the requirement that a quality characteristic should meet. This requirement may be expressed as an upper specification limit; or a lower specification limit, called herein a single specification limit; or both upper and lower specification limits, called herein a double specification limit.

6.1.7 *Sampling Plans*—A sampling plan is a procedure which specifies the number of units of product from a lot which are to be inspected, and the criterion for acceptability of the lot. Sampling plans designated in this practice are applicable to the inspection of a single quality characteristic of a unit of product. These plans may be used whether procurement inspection is performed at the plant of a prime contractor, subcontractor or vendor, or at destination, and also may be used when appropriate in supply and storage, and maintenance inspection operations.

6.2 *Classification of Defects:*

6.2.1 *Method of Classifying Defects*—A classification of defects is the enumeration of defects of the unit of product classified according to their importance. A defect is a deviation of the unit of product from requirements of the specifications, drawings, purchase descriptions, and any changes thereto in the contract or order. Defects normally belong to one of the following classes; however, defects may be placed in other classes.

6.2.1.1 *Critical Defects*—A critical defect is one that judgment and experience indicate could result in hazardous or unsafe conditions for individuals using or maintaining the product; or, for major end items units of product, such as ships, aircraft, or tanks, a defect that could prevent performance of their tactical function.

6.2.1.2 *Major Defects*—A major defect is a defect, other than critical, that could result in failure, or materially reduce the usability of the unit of product for its intended purpose.

6.2.1.3 *Minor Defects*—A minor defect is one that does not materially reduce the usability of the unit of product for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit.

6.3 *Percent Defective:*

6.3.1 *Expression of Nonconformance*—The extent of nonconformance of product that shall be expressed in terms of percent defective.

6.3.2 *Percent Defective*—The percent defective for a quality characteristic of a given lot of product is the number of units of product defective for that characteristic divided by the total number of units of product and multiplied by one hundred. Expressed as an equation:

$$\text{Percent defective} = \frac{\text{number of defectives} \times 100}{\text{number of units}} \quad (1)$$

6.4 *Acceptance Quality Level:*

6.4.1 *Acceptance Quality Level*—The acceptance quality level (AQL) is a nominal value expressed in terms of percent defective specified for a single quality characteristic. Certain numerical values of AQL ranging from 0.04 to 15.00 percent are shown in Table A-1 (see Fig. A1.1). When a range of AQL values is specified, it shall be treated as if it were equal to the value of AQL for which sampling plans are furnished and which is included within the AQL range. When the specified AQL is a particular value other than those for which sampling plans are furnished, the AQL, which is to be used in applying the provisions of this practice, shall be as shown in Table A-1 (see Fig. A1.1).

6.4.1.1 The term "acceptable" was changed to "acceptance" after publication of MIL-STD-105E, so where possible this term has been edited in the case of direct references to the AQL value. The notable exceptions are the original tables in Annex A1 which show the original wording as they appeared in MIL-STD-105E.

6.4.2 *Specifying AQL's*—The particular AQL value to be used for a single quality characteristic of a given product must be specified. In the case of a double specification limit, either an AQL value is specified for the total percent defective outside of both upper and lower specification limits, or two AQL values are specified, one for the upper limit and another for the lower limit.

6.5 *Submittal of Product:*

6.5.1 *Lot*—The term "lot" shall mean "inspection lot," that is, a collection of units of product from which a sample is drawn and inspected to determine compliance with the acceptability criterion.

6.5.1.1 *Formation of Lots*—Each lot shall, as far as is practicable, consist of units of product of a single type, grade, class, size, or composition manufactured under essentially the same conditions.

6.5.2 *Lot Size*—The lot size is the number of units of product in a lot, and may differ from the quantity designated in the contract or order as a lot for production, shipment, or other purposes.

6.6 *Lot Acceptability:*

6.6.1 *Acceptability Criterion*—The acceptability of a lot of material submitted for inspection shall be determined by use of one of the sampling plans associated with a specified value of the AQL(s). This practice provides sampling plans based on known and unknown variability. In the latter case, two alternative methods are provided, one based on the estimate of lot standard deviation and the other on the average range of the sample. These are referred to as the standard deviation method and the range method. For the case of a single specification limit, the acceptability criterion is given in two forms. These are identified as Form 1 and Form 2.

6.6.2 *Choice of Sampling Plans*—Sampling plans and procedures are provided in Section 7 if variability is unknown and the standard deviation method is used, in Section 8 if variability is unknown and the range method is used, and in Section 9 if variability is known. Unless otherwise specified, unknown variability, standard deviation method sampling plans, and the acceptability criterion of Form 2 (for the single specification limit case) shall be used.

6.7 *Sample Selection:*

6.7.1 *Determination of Sample Size*—The sample size is the number of units of product drawn from a lot. Relative sample sizes are designated by code letters. The sample size code letter depends on the inspection level and the lot size. There are five inspection levels: I, II, III, IV, and V. Unless otherwise specified, inspection level IV shall be used. The sample size code letter applicable to the specified inspection level and for lots of given size shall be obtained from Table A-2 (see Fig. A1.2).

NOTE 1—*Special Reservation for Critical Characteristics*—The customer reserves the right to inspect every unit submitted by the supplier for critical characteristics, and to reject the remainder of the lot immediately after a defect is found. The customer also reserves the right to sample for critical defects every lot submitted by the supplier, and to reject any lot if a sample drawn there from is found to contain one or more critical defects.

6.7.2 *Drawing of Samples*—A sample is one or more units of product drawn from a lot. Units of the sample shall be selected without regard to their quality.

6.8 *Estimation of Process Average and Severity of Inspection:*

6.8.1 Procedures for estimating the process average and criteria for tightened and reduced inspection based on the inspection results of preceding lots are provided in Part III of Sections 7, 8, and 9.

6.9 *Special Procedure for Application of Mixed Variables-Attributes Sampling Plans:*

6.9.1 *Applicability*—A mixed variables and attributes sampling plan may be used under either of the two following conditions:

NOTE 2—No Operating Characteristic Curves are provided for the mixed variables-attribute sampling plans herein and that those in Table A-1 (see Fig. A1.1) are not applicable.

6.9.1.1 *Condition A*—Ample evidence exists that the product submitted for inspection is selected by the supplier to meet the specification limit(s) by a screening process from a larger quantity of product which is not being produced within the specification limit(s).

6.9.1.2 *Condition B*—Other conditions exist that warrant the use of a variables-attributes sampling plan.

6.9.2 *Definitions:*

6.9.2.1 *Inspection by Attributes*—Inspection by attributes is inspection wherein the unit of product is classified simply as defective or nondefective with respect to a given requirement or set of requirements.

6.9.2.2 *Mixed Variables*—Attributes Inspection. Mixed variables-attributes inspection is inspection of a sample by attributes, in addition to inspection by variables already made of a previous sample, before a decision as to acceptability or rejectability of a lot can be made.

6.9.3 *Selection of Sampling Plans*—The mixed variables-attributes sampling plan shall be selected in accordance with the following:

6.9.3.1 Select the variables sampling plan in accordance with Section 7, 8, or 9.

6.9.3.2 Select the attributes sampling plan from Practice E2234, 6.9, using a single sampling plan and tightened inspection. The same AQL value(s) shall be used for the attributes sampling plan as used for the variables plan of 6.9.3.1. (Additional sample items may be drawn, as necessary, to satisfy the requirements for sample size of the attributes sampling plan. Count as a defective each sample item falling outside of specification limit(s).)

6.9.4 *Determination of Acceptability*—A lot meets the acceptability criterion if one of the following conditions is satisfied:

6.9.4.1 *Condition A*—The lot complies with the appropriate variables acceptability criterion of Section 7, 8, or 9.

6.9.4.2 *Condition B*—The lot complies with the acceptability criterion of Practice E2234, 6.10.

6.9.4.3 If Condition A is not satisfied, proceed in accordance with the attributes sampling plan to meet Condition B.

6.9.4.4 If Condition B is not satisfied, the lot does not meet the acceptability criterion.

6.9.5 *Severity of Inspection*—The procedures for severity of inspection referred to in 6.8 are not applicable for mixed variables-attributes inspection.

NOTE 3—When customer drawings, specifications, or other data are used for any purpose other than in connection with a definitely related customer procurement operation, the customer thereby incurs no responsibility or any obligation whatsoever; and the fact that the customer may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or

corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

7. Variability Unknown—Standard Deviation Method

Part I–Single Specification Limit

7.1 *Sampling Plan for Single Specification Limit*—This part of the practice describes the procedures for use with plans for a single specification limit when variability of the lot with respect to the quality characteristic is unknown and the standard deviation method is used. The acceptability criterion is given in two equivalent forms. These are identified as Form 1 and Form 2.

7.1.1 *Use of Sampling Plans*—To determine whether the lot meets the acceptability criterion with respect to a particular quality characteristic and AQL value, the applicable sampling plan shall be used in accordance with the provisions of Section 6, General Description of Sampling Plans, and those in this part of the practice.

7.1.2 *Drawing of Samples*—All samples shall be drawn in accordance with 6.7.2.

7.1.3 *Determination of Sample Size Code Letter*—The sample size code letter shall be selected from Table A-2 (see Fig. A1.2) in accordance with 6.7.1.

7.2 *Selecting the Sampling Plan When Form 1 is Used:*

7.2.1 *Master Sampling Tables*—The master sampling tables for plans based on variability unknown for a single specification limit when using the standard deviation method are Tables B-1 and B-2 (see Figs. A1.4 and A1.5). Table B-1 is used for normal and tightened inspection and Table B-2 for reduced inspection.

7.2.2 *Obtaining the Sampling Plan*—The sampling plan consists of a sample size and an associated acceptability constant.[4] The sampling plan is obtained from Master Table B-1 or B-2 (see Figs. A1.4 and A1.5).

7.2.2.1 *Sample Size*—The sample size n is shown in the master table corresponding to each sample size code letter.

7.2.2.2 *Acceptability Constant*—The acceptability constant, *k*, corresponding to the sample size mentioned in 7.2.2.1, is indicated in the column of the master table corresponding to the applicable AQL value. Table B-1 (see Fig. A1.4) is entered from the top for normal inspection and from the bottom for tightened inspection. Sampling plans for reduced inspection are provided in Table B-2 (see Fig. A1.5).

7.3 *Lot-by-lot Acceptability Procedures When Form 1 is Used* (see Example 7-1 (Fig. 1) for a complete example of this procedure):

7.3.1 *Acceptability Criterion*—The degree of conformance of a quality characteristic with respect to a single specification limit shall be judged by the quantity $(U - \bar{X})/s$ or $(\bar{X} - L)/s$.

7.3.2 *Computation*—The following quantity shall be computed: $(U - \bar{X})/s$ or $(\bar{X} - L)/s$ depending on whether the specification limit is an upper or lower limit,

where:

U = the upper specification limit,
L = the lower specification limit,
$\bar{X}$ = the sample mean, and
s = the estimate of lot standard deviation.

7.3.3 *Acceptability Criterion*—Compare the quantity $(U - \bar{X})/s$ or $(\bar{X} - L)/s$ with the acceptability constant k. If $(U - \bar{X})/s$ or $(\bar{X} - L)/s$ is equal to or greater than k, the lot meets the acceptability criterion; if $(U - \bar{X})/s$ or $(\bar{X} - L)/s$ is less than k or negative, then the lot does not meet the acceptability criterion.

7.4 *Summary for Operation of Sampling Plan When Form 1 is Used:*

7.4.1 The following steps summarize the procedures to be followed:

(1) Determine the sample size code letter from Table A-2 (see Fig. A1.2) by using the lot size and inspection level.

(2) Obtain plan from Master Table B-1 or B-2 (see Figs. A1.4 and A1.5) by selecting the sample size n and the acceptability constant k.

(3) Select at random the sample of n units from the lot; inspect and record the measurement of the quality characteristic for each unit of the sample.

(4) Compute the sample mean $\bar{X}$ and estimate of lot standard deviation s, and also compute the quantity $U - \bar{X})/s$ for an upper specification limit U or the quantity $\bar{X} - L)/s$ for a lower specification limit L.

(5) If the quantity $(U - \bar{X})/s$ or $(\bar{X} - L)/s$ is equal to or greater than k, the lot meets the acceptability criterion; if $(U - \bar{X})/s$ or $(\bar{X} - L)/s$ is less than k or negative, then the lot does not meet the acceptability criterion.

7.5 *Selecting the Sampling Plans When Form 2 is Used:*

7.5.1 *Master Sampling Tables*—The master sampling tables for plans based on variability unknown for a single specification limit when using the standard deviation method are Tables B-3 and B-4 (see Figs. A1.6 and A1.7) of Part II. Table B-3 is used for normal and tightened inspection and Table B-4 for reduced inspection.

7.5.2 *Obtaining the Sampling Plan*—The sampling plan consists of a sample size and an associated maximum allowable percent defective. The sampling plan is obtained from Master Table B-3 or B-4 (see Figs. A1.6 and A1.7).

7.5.2.1 *Sample Size*—The sample size n is shown in the master table corresponding to each sample size code letter.

7.5.2.2 *Maximum Allowable Percent Defective*—The maximum allowable percent defective M for sample estimates corresponding to the sample size mentioned in 7.5.2.1 is indicated in the column of the master table corresponding to the applicable AQL value. Table B-3 (see Fig. A1.6) is entered from the top for normal inspection and from the bottom for tightened inspection. Sampling plans for reduced inspection are provided in Table B-4 (see Fig. A1.7).

7.6 *Lot-by-lot Acceptability Procedures When Form 2 is Used* (see Example 7-2 (Fig. 2) for a complete example of this procedure):

7.6.1 *Acceptability Criterion*—The degree of conformance of a quality characteristic with respect to a single specification limit shall be judged by the percent of nonconforming product

[4] See Section 7 Definitions in Annex A1 for definitions of all symbols used in the sampling plans based on variability unknown-standard deviation method.

EXAMPLE 7-1

Example of Calculations
Single Specification Limit-Form 1
Variability Unknown - Standard Deviation Method

Example The maximum temperature of operation for a certain device is specified as 209°F. A lot of 40 items is submitted for inspection. Inspection Level IV, normal inspection, with AQL = 1% is to be used. From Tables A-2 and B-1 it is seen that a sample of size 5 is required. Suppose the measurements obtained are as follows: 197°, 188°, 184°, 205°, and 201°; and compliance with the acceptability criterion is to be determined.

Line	Information Needed	Value Obtained	Explanation
1	Sample Size: n	5	
2	Sum of Measurements: $\sum X$	975	
3	Sum of Squared Measurements: $\sum X^2$	190,435	
4	Correction Factor (CF): $\left(\sum X\right)^2/n$	190,125	$(975)^2/5$
5	Corrected Sum of Squares (SS): $\sum X^2$ - CF	310	190,435 - 190,125
6	Variance (V): SS/(n-1)	77.5	310/4
7	Estimate of Lot Standard Deviation s: $\sqrt{V}$	8.81	$\sqrt{77.5}$
8	Sample Mean $\bar{X}$: $\sum X/n$	195	975/5
9	Specification Limit (Upper): U	209	
10	The quantity: $\left(U-\bar{X}\right)/s$	1.59	(209 - 195)/8.81
11	Acceptability Constant: k	1.53	See Table B-1
12	Acceptability Criterion: Compare $\left(U-\bar{X}\right)/s$ with k	1.59> 1.53	See Section 7.3.3

The lot meets the acceptability criterion, since $\left(U-\bar{X}\right)/s$ is greater than k.

NOTE: If a single lower specification limit L is given, then compute the quantity $\left(\bar{X}-L\right)/s$ in line 10 and compare it with k; the lot meets the acceptability criterion, if $\left(\bar{X}-L\right)/s$ is equal to or greater than k.

FIG. 1 Example 7-1

outside the upper or lower specification limit. The percentage of nonconforming product is estimated by entering Table B-5 (see Fig. A1.8) with the quality index and the sample size.

7.6.2 *Computation of Quality Index*—The Quality index $Q_U = (U - \bar{X})/s$ shall be computed if the specification limit is an upper limit U, or $Q_L = (\bar{X} - L)/s$ if it is a lower limit L. The quantities, $\bar{X}$ and s, are the sample mean and estimate of lot standard deviation, respectively.

7.6.3 *Estimate of Percent Defective in Lot*—The quality of a lot shall be expressed by p_U, the estimated percent defective in the lot above the upper specification limit, or by p_L, the estimated percent defective below the lower specification limit. The estimated percent defective p_U or p_L is obtained by entering Table B-5 (see Fig. A1.8) with Q_U or Q_L and the appropriate sample size.

7.6.4 *Acceptability Criterion*—Compare the estimated lot percent defective p_U or p_L with the maximum allowable percent defective M. If p_U or p_L is equal to or less than M, the lot meets the acceptability criterion; if p_U or p_L is greater than M or if Q_U or Q_L is negative, then the lot does not meet the acceptability criterion.

7.7 *Summary for Operation of Sampling Plan When Form 2 is Used:*

7.7.1 The following steps summarize the procedures to be followed:

(1) Determine the sample size code letter from Table A-2 (see Fig. A1.2) by using the lot size and the inspection level.

(2) Obtain plan from Master Table B-3 or B-4 (see Figs. A1.6 and A1.7) by selecting the sample size n and the maximum allowable percent defective M.

(3) Select at random the sample of n units from the lot; inspect and record the measurement of the quality characteristic on each unit of the sample.

EXAMPLE 7-2

Example of Calculations
Single Specification Limit-Form 2
Variability Unknown - Standard Deviation Method

Example The maximum temperature of operation for a certain device is specified as 209°F. A lot of 40 items is submitted for inspection. Inspection Level IV, normal inspection, with AQL =1 % is to be used. From Tables A-2 and B-1 it is seen that a sample of size 5 is required. Suppose the measurements obtained are as follows: 197°, 188°,184°,205°, and 201°; and compliance with the acceptability criterion is to be determined.

Line	Information Needed	Value Obtained	Explanation
1	Sample Size: n	5	
2	Sum of Measurements: $\sum X$	975	
3	Sum of Squared Measurements: $\sum X^2$	190 435	
4	Correction Factor (CF): $\left(\sum X\right)^2/n$	190 125	$(975)^2/5$
5	Corrected Sum of Squares (SS): $\sum X^2$ - CF	310	190 435 – 190 125
6	Variance (V): SS/(n-1)	77.5	310/4
7	Estimate of Lot Standard Deviation s: $\sqrt{V}$	8.81	$\sqrt{77.5}$
8	Sample Mean $\bar{X}$: $\sum X/n$	195	975/5
9	Specification Limit (Upper): U	209	
10	Quality Index: $Q_U = \left(U - \bar{X}\right)/s$	1.59	(209 - 195)/8.81
11	Est. of Lot Percent Def.: p_U	2.19 %	See Table B-5
12	Max. Allowable Percent Def.: M	3.32 %	See Table B-3
13	Acceptability Criterion: Compare p_U with M	2.19 % < 3.32 %	See Section 7.6.4

The lot meets the acceptability criterion, since p_U is less than M.

NOTE: If a single lower specification limit L is given, then compute the quality index $Q_L = \left(\bar{X} - L\right)/s$ in line 10 and obtain the estimate of lot percent defective p_L. Compare p_L with M; the lot meets the acceptability criterion, if p_L is equal to or less than M.

FIG. 2 Example 7-2

(4) Compute the sample mean $\bar{X}$ and the estimate of lot standard deviation s.

(5) Compute the quality index $Q_U = (U - \bar{X})/s$ if an upper specification limit U is specified, or $Q_L = (\bar{X} - L)/s$ if a lower specification limit L is specified.

(6) Determine the estimated lot percent defective p_U or p_L from Table B-5 (see Fig. A1.8).

(7) If the estimated lot percent defective p_U or p_L is equal to or less than the maximum allowable percent defective M, the lot meets the acceptability criterion; if p_U or p_L is greater than M or if Q_U or Q_L is negative, then the lot does not meet the acceptability criterion.

Part II–Double Specification Limit

7.8 *Sampling Plan for Double Specification Limit*—This part of the practice describes the procedures for use with plans for a double specification limit when variability of the lot with respect to the quality characteristic is unknown and the standard deviation method is used.

7.8.1 *Use of Sampling Plans*—To determine whether the lot meets the acceptability criterion with respect to a particular quality characteristic and AQL value(s) the applicable sampling plan shall be used in accordance with the provisions of Section 6, General Description of Sampling Plans, and those in this part of the practice.

7.9 *Selecting the Sampling Plan*—A sampling plan for each AQL value shall be selected from Table B-3 or B-4 (see Figs. A1.6 and A1.7) as follows:

7.9.1 *Determination of Sample Size Code Letter*—The sample size code letter shall be selected from Table A-2 (see Fig. A1.2) in accordance with 6.7.1.

7.9.2 *Master Sampling Tables*—The master sampling tables for plans based on variability unknown for a double specification limit when using the standard deviation method are Tables B-3 and B-4 (see Figs. A1.6 and A1.7). Table B-3 is used for normal and tightened inspection and Table B-4 for reduced inspection.

7.9.3 *Obtaining Sampling Plan*—A sampling plan consists of a sample size and the associated maximum allowable percent defective(s). The sampling plan to be applied in inspection shall be obtained from Master Table B-3 or B-4 (see Figs. A1.6 and A1.7).

7.9.3.1 *Sample Size*—The sample size n is shown in the master tables corresponding to each sample size code letter.

7.9.3.2 *Maximum Allowable Percent Defective*—The maximum allowable percent defective for sample estimates of percent defective for the lower, upper, or both specification limits combined, corresponding to the sample size mentioned in 7.9.3.1, is shown in the column of the master table corresponding to the applicable AQL value(s). If different AQL's are assigned to each specification limit, designate the maximum allowable percent defective by M_L for the lower limit, and by M_U for the upper limit. If one AQL is assigned to both limits combined, designate the maximum allowable percent defective by M. Table B-3 (see Fig. A1.6) is entered from the top for normal inspection and from the bottom for tightened inspection. Sampling plans for reduced inspection are provided in Table B-4 (see Fig. A1.7).

7.10 *Drawing of Samples:*

7.10.1 Samples shall be selected in accordance with 6.7.2.

7.11 *Lot-by-lot Acceptability Procedures:*

7.11.1 *Acceptability Criterion*—The degree of conformance of a quality characteristic with respect to a double specification limit shall be judged by the percent of nonconforming product. The percentage of nonconforming product is estimated by entering Table B-5 (see Fig. A1.8) with the quality index and the sample size.

7.11.2 *Computation of Quality Indices*—The quality indices $Q_U = (U - \bar{X})/s$ and $Q_L = (\bar{X} - L)/s$ shall be computed,

where:

U = the upper specification limit,
L = the lower specification limit,
$\bar{X}$ = the sample mean, and
s = the estimate of lot standard deviation.

7.11.3 *Percent Defective in the Lot*—The quality of a lot shall be expressed in terms of the lot percent defective. Its estimate will be designated by p_L, p_U, or p. The estimate p_U indicates conformance with respect to the upper specification limit, p_L with respect to the lower specification limit, and p for both specification limits combined. The estimates p_L and p_U shall be determined by entering Table B-5 (see Fig. A1.8), respectively, with Q_L and Q_U and the sample size. The estimate p shall be determined by adding the corresponding estimated percent defectives p_L and p_U found in the table.

7.12 *Acceptability Criterion and Summary for Operation of Sampling Plans:*

7.12.1 *One AQL Value for both Upper and Lower Specification Limit Combined:*

7.12.1.1 *Acceptability Criterion* (see Example 7-3 (Fig. 3) for a complete example of this procedure): Compare the estimated lot percent defective $p = p_U + p_L$ with the maximum allowable percent defective M. If p is equal to or less than M, the lot meets the acceptability criterion; if p is greater than M or if either Q_U or Q_L or both are negative, then the lot does not meet the acceptability criterion.

7.12.1.2 *Summary for Operation of Sampling Plan*—In cases where a single AQL value is established for the upper and lower specification limit combined for a single quality characteristic, the following steps summarize the procedures to be used:

(1) Determine the sample size code letter from Table A-2 (see Fig. A1.2) by using the lot size and the inspection level.

(2) Select plan from Master Table B-3 or B-4 (see Figs. A1.6 and A1.7). Obtain the sample size n and the maximum allowable percent defective M.

(3) Select at random the sample of n units from the lot; inspect and record the measurement of the quality characteristic on each unit of the sample.

(4) Compute the sample mean $\bar{X}$ and estimate of lot standard deviation s.

(5) Compute the quality indices $Q_U = (U - \bar{X})/s$ and $Q_L = (\bar{X} - L)/s$.

(6) Determine the estimated lot percent defective $p = p_U + p_L$ from Table B-5 (see Fig. A1.8).

(7) If the estimated lot percent defective p is equal to or less than the maximum allowable percent defective M, the lot meets the acceptability criterion; if p is greater than M or if either Q_U or Q_L or both are negative, then the lot does not meet the acceptability criterion.

7.12.2 *Different AQL Values for Upper and Lower Specification Limit:*

7.12.2.1 *Acceptability Criteria* (see Example 7-4 (Fig. 4) for a complete example of this procedure)—Compare the estimated lot percent defectives p_L and p_U with the corresponding maximum allowable percent defectives M_L and M_U; also compare $p = p_L + p_U$ with the larger of M_L and M_U. If p_L is equal to or less than M_L, p_U is equal to or less than M_U, and p is equal to or less than the larger of M_L and M_U, the lot meets the acceptability criteria; otherwise, the lot does not meet the acceptability criteria. If either Q_L or Q_U or both are negative, then the lot does not meet the acceptability criteria.

7.12.2.2 *Summary for Operation of Sampling Plan*—In cases where a different AQL value is established for the upper and lower specification limit for a single quality characteristic, the following steps summarize the procedures to be used:

(1) Determine the sample size code letter from Table A-2 (see Fig. A1.2) by using the lot size and inspection level.

(2) Select the sampling plan from Master Table B-3 or B-4 (see Figs. A1.6 and A1.7). Obtain the sample size n and the maximum allowable percent defectives M_U and M_L, corresponding to the AQL values for the upper and lower specification limits, respectively.

(3) Select at random the sample of n units from the lot; inspect and record the measurement of the quality characteristic on each unit in the sample.

EXAMPLE 7-3

Example of Calculations
Double Specification Limit
Variability Unknown - Standard Deviation Method
One AQL Value for both Upper and Lower Specification Limit Combined

Example The minimum temperature of operation for a certain device is specified as 180°F. The maximum temperature is 209°F. A lot of 40 items is submitted for inspection. Inspection Level IV, normal inspection, with AQL = 1 % is to be used. From Tables A-2 and B-3 it is seen that a sample of size 5 is required. Suppose the measurements obtained are as follows: 197°, 188°, 184°, 205°, and 201°; and compliance with the acceptability criterion is to be determined.

Line	Information Needed	Value Obtained	Explanation
1	Sample Size: n	5	
2	Sum of Measurements: $\sum X$	975	
3	Sum of Squared Measurements: $\sum X^2$	190 435	
4	Correction Factor (CF): $\left(\sum X\right)^2/n$	190 125	$(975)^2/5$
5	Corrected Sum of Squares (SS): $\sum X^2$ - CF	310	190 435 – 190 125
6	Variance (V): SS/(n-1)	77.5	310/4
7	Estimate of Lot Standard Deviation s: $\sqrt{V}$	8.81	$\sqrt{77.5}$
8	Sample Mean $\bar{X}$: $\sum X/n$	195	975/5
9	Upper Specification Limit: U	209	
10	Lower Specification Limit: L	180	
11	Quality Index: $Q_U = \left(U - \bar{X}\right)/s$	1.59	(209 - 195)/8.81
12	Quality Index: $Q_L = \left(\bar{X} - L\right)/s$	1.70	(195-180)/8.81
13	Est. of Lot Percent Def. Above U: p_U	2.19 %	See Table B-5
14	Est. of Lot Percent Def. Below L: p_L	0.66 %	See Table B-5
15	Total Est. Percent Def. in Lot: $p = p_U + p_L$	2.85 %	2.19 % + 0.66 %
16	Max. Allowable Percent Def.: M	3.32 %	See Table B-3
17	Acceptability Criterion: Compare $p = p_U + p_L$ with M	2.85 % < 3.32 %	See Sec. 7.12.1.2(7)

The lot meets the acceptability criterion, since $p = p_U + p_L$ is less than M.

FIG. 3 Example 7-3

(4) Compute the sample mean $\bar{X}$ and estimate a lot standard deviation s.

(5) Compute the quality indices $Q_U = (U - \bar{X})/s$ and $Q_L = (\bar{X} - L)/s$.

(6) Determine the estimated lot percent defectives p_U and p_L, corresponding to the percent defectives above the upper and below the lower specification limits. Also determine the combined percent defective $p = p_U + p_L$.

(7) If all three of the following conditions are satisfied, the lot meets the acceptability criteria; otherwise the lot does not meet the acceptability criteria. If either Q_L or Q_U or both are negative, then the lot does not meet the acceptability criteria.

(a) p_U is equal to or less than M_U

(b) p_L is equal to or less than M_L

(c) p is equal to or less than the larger of M_L and M_U

Part III–Estimation of Process Average and Criteria for Reduced and Tightened Inspection

7.13 *Estimation of Process Average*—The average percent defective, based upon a group of lots submitted for original

EXAMPLE 7-4

Example of Calculations
Double Specification Limit
Variability Unknown - Standard Deviation Method
Different AQL Values for Upper and Lower Specification Limits

Example The minimum temperature of operation for a certain device is specified as 180°F. The maximum temperature is 209°F. A lot of 40 items is submitted for inspection. Inspection Level IV, normal inspection, with AQL = 1% for the upper and AQL = 2.5 % for the lower specification limit is to be used. From Tables A-2 and B-3 it is seen that a sample of size 5 is required. Suppose the measurements obtained are as follows: 197°, 188°, 184°, 205°, and 201°; and compliance with the acceptability criterion is to be determined.

Line	Information Needed	Value Obtained	Explanation
1	Sample Size: n	5	
2	Sum of Measurements: $\sum X$	975	
3	Sum of Squared Measurements: $\sum X^2$	190 435	
4	Correction Factor (CF): $\left(\sum X\right)^2/n$	190 125	$(975)^2/5$
5	Corrected Sum of Squares (SS): $\sum X^2$ - CF	310	190 435 – 190 125
6	Variance (V): SS/(n-1)	77.5	310/4
7	Estimate of Lot Standard Deviation s: $\sqrt{V}$	8.81	$\sqrt{77.5}$
8	Sample Mean $\bar{X}$: $\sum X/n$	195	975/5
9	Upper Specification Limit: U	209	
10	Lower Specification Limit: L	180	
11	Quality Index: $Q_U = \left(U - \bar{X}\right)/s$	1.59	(209 – 195)/8.81
12	Quality Index: $Q_L = \left(\bar{X} - L\right)/s$	1.70	(195 – 180)/8.81
13	Est. of Lot Percent Def. above U: p_U	2.19 %	See Table B-5
14	Est. of Lot Percent Def. below L: p_L	0.66 %	See Table B-5
15	Total Est. Percent Def. in Lot: $p = p_U + p_L$	2.85 %	2.19 % + 0.66 %
16	Max. Allowable Percent Def. Above U: M_U	3.32 %	See Table B-3
17	Max. Allowable Percent Def. Below L: M_L	9.80 %	See Table B-3
18	Acceptability Criterion:		
	(a) Compare p_U with M_U	2.19 % < 3.32 %	See Sec. 7.12.2.2(*7*)(*a*)
	(b) Compare p_L with M_L	0.66 % < 9.80 %	See Sec. 7.12.2.2(*7*)(*b*)
	(c) Compare p with M_L	2.85 % < 9.80 %	See Sec. 7.12.2.2(*7*)(*c*)

The lot meets the acceptability criteria, since 18(a), (b), and (c) are satisfied; that is, $p_U < M_U$, $p_L < M_L$ and $p < M_L$.

FIG. 4 Example 7-4

inspection, is called the process average. Original inspection is the first inspection of a particular quantity of product submitted for acceptability as distinguished from the inspection of product which has been resubmitted after prior rejection. The process average shall be estimated from the results of inspection of samples drawn from a specified number of preceding lots for the purpose of determining severity of inspection during the course of a contract in accordance with 7.14.3. Any lot shall be included only once in estimating the process average. The estimate of the process average is designated by $\bar{p}_U$ when computed with respect to an upper specification limit, by $\bar{p}_L$ when computed with respect to a lower specification limit, and by $\bar{p}$ when computed with respect to a double specification limit.

7.13.1 *Abnormal Results*—The results of inspection of product manufactured under conditions not typical of usual production shall be excluded from the estimated process average.

7.13.2 *Computation of the Estimated Process Average*—The estimated process average is the arithmetic mean of the estimated lot percent defectives computed from the sampling inspection results of the preceding ten (10) lots or as may be otherwise designated. In order to estimate the lot percent defective, the quality indices Q_U and/or Q_L shall be computed for each lot. These are: $Q_U = (U - \bar{X})/s$ and $Q_L = (\bar{X} - L)/s$. (See 7.11.2.)

7.13.2.1 *Single Specification Limit*[5]—The estimated lot percent defective shall be determined from Table B-5 (see Fig. A1.8) for the plans based on known variability. The quality index Q_U shall be used for the case of an upper specification limit, or Q_L for the case of a lower specification limit. Table B-5 is entered with Q_U or Q_L and the corresponding estimated lot percent defective p_U or p_L, respectively, is read from the table. The estimated process average $\bar{p}_U$ is the arithmetic mean of the individual estimated lot percent defectives p_U's. Similarly, the estimated process average $\bar{p}_L$ is the arithmetic mean of the individual estimated lot percent defectives p_L's.

7.13.2.2 *Double Specification Limit*—The estimated lot percent defective shall be determined from Table B-5 (see Fig. A1.8) for the plans based on variability known. The quality indices Q_U and Q_L shall be computed. Table B-5 is entered separately with Q_U and Q_L and the corresponding p_U and p_L are read from the table. The estimated lot percent defective is $p = p_U + p_L$. The estimated process average $\bar{p}$ is the arithmetic mean of the individual estimated lot percent defectives p's.

7.13.2.3 *Special Case*—If the quality index Q_U or Q_L is a negative number, then Table B-5 (see Fig. A1.8) is entered by disregarding the negative sign. However, in this case, the estimated lot percent defective above the upper limit or below the lower limit is obtained by subtracting the percentage found in the table from 100 %.[6]

7.14 *Normal, Tightened, and Reduced Inspection*—This practice establishes sampling plans for normal, tightened, and reduced inspection.

7.14.1 *At Start of Inspection*—Normal inspection shall be used at the start of inspection unless otherwise designated.

7.14.2 *During Inspection*—During the course of inspection, normal inspection shall be used when inspection conditions are such that tightened or reduced inspection is not required in accordance with 7.14.3 and 7.14.4.

7.14.3 *Tightened Inspection*—Tightened inspection shall be instituted when the estimated process average computed from the preceding ten (10) lots (or such other number of lots designated) in accordance with 7.13.2 is greater than the AQL, and when more than a certain number T of these lots have estimates of the percent defective exceeding the AQL. The T-values are given in Table B-6 (see Fig. A1.9) for the process average computed from 5, 10, or 15 lots.[7] Normal inspection shall be reinstated if the estimated process average of lots under tightened inspection is equal to or less than the AQL.

7.14.4 *Reduced Inspection*—Reduced inspection may be instituted provided that all of the following conditions are satisfied:

7.14.4.1 *Condition A*—The preceding ten (10) lots (or such other number of lots designated) have been under normal inspection and none has been rejected.

7.14.4.2 *Condition B*—The estimated percent defective for each of these preceding lots is less than the applicable lower limit shown in Table B-7 (see Fig. A1.10); or for certain sampling plans, the estimated lot percent defective is equal to zero for a specified number of consecutive lots (see Table B-7).

7.14.4.3 *Condition C*—Production is at a steady rate.

7.14.4.4 Normal inspection shall be reinstated if any one of the following conditions occurs under reduced inspection:

7.14.4.5 *Condition D*—A lot is rejected.

7.14.4.6 *Condition E*—The estimated process average is greater than the AQL.

7.14.4.7 *Condition F*—Production becomes irregular or delayed.

7.14.4.8 *Condition G*—Other conditions as may warrant that normal inspection should be reinstated.

7.14.5 *Sampling Plans for Tightened or Reduced Inspection*—Sampling plans for tightened and reduced inspection are provided in Section 7, Parts I and II.

8. Variability Unknown—Range Method

Part I–Single Specification Limit

8.1 *Sampling Plan for Single Specification Limit*—This part of the practice describes the procedures for use with plans for a single specification limit when variability of the lot with respect to the quality characteristic is unknown and the range method is used. The acceptability criterion is given in two equivalent forms. These are identified as Form 1 and Form 2.

8.1.1 *Use of Sampling Plans*—To determine whether the lot meets the acceptability criterion with respect to a particular quality characteristic and AQL value, the applicable sampling plan shall be used in accordance with the provisions of Section 6, General Description of Sampling Plans, and those in this part of the practice.

8.1.2 *Drawing of Samples*—All samples shall be drawn in accordance with 6.7.2.

8.1.3 *Determination of Sample Size Code Letter*—The sample size code letter shall be selected from Table A-2 (see Fig. A1.2) in accordance with 6.7.1.

8.2 *Selecting the Sampling Plan When Form 1 is Used:*

8.2.1 *Master Sampling Tables*—The master sampling tables for plans based on variability unknown for a single specification limit when using the range method are Tables C-1 and C-2 (see Figs. A1.12 and A1.13). Table C-1 is used for normal and tightened inspection and Table C-2 for reduced inspection.

[5] When Form 1–Single Specification Limit is used for the acceptability criterion, the estimate of lot percent defective p_U or p_L is not obtained; in order to estimate the process average, it is necessary to complete 7.6.1 and 7.6.3 of Form 2.

[6] For example, if $Q_U = -0.50$ and $Q_L = 1.60$, using sample size 50, then $p_U = 100\ \% - 30.93\ \% = 69.07\ \%$, $p_L = 5.33\ \%$ and $p = 69.07\ \% + 5.33\ \% = 74.40\ \%$.

[7] If the sample size code letter is not the same for all samples used, the entry in Table B-6 (see Fig. A1.9) is determined by the sample size code letter corresponding to the smallest sample size used in any of the lots included in the estimation of the process average.

8.2.2 *Obtaining the Sampling Plan*—The sampling plan consists of a sample size and an associated acceptability constant.[8] The sampling plan is obtained from Master Table C-1 or C-2 (see Figs. A1.12 and A1.13).

8.2.2.1 *Sample Size*—The sample size n is shown in the master table corresponding to each sample size code letter.

8.2.2.2 *Acceptability Constant*—The acceptability constant k, corresponding to the sample size mentioned in 8.2.2.1, is indicated in the column of the master table corresponding to the applicable AQL value. Table C-1 (see Fig. A1.12) is entered from the top for normal inspection and from the bottom for tightened inspection. Sampling plans for reduced inspection are provided in Table C-2 (see Fig. A1.13).

8.3 *Lot-by-lot Acceptability Procedures When Form 1 is Used* (see Example 8-1 (Fig. 5) for a complete example of this procedure):

[8] See Section 8 Definitions in Annex A1 for definitions of all symbols used in the sampling plans based on variability unknown-range method.

8.3.1 *Acceptability Criterion*—The degree of conformance of a quality characteristic with respect to a single specification limit shall be judged by the quantity $(U - \bar{X})/\bar{R}$ or $(\bar{X} - L)/\bar{R}$.

8.3.2 *Computation*—The following quantity shall be computed: $(U - \bar{X})/\bar{R}$ or $(\bar{X} - L)/\bar{R}$, depending on whether the specification limit is an upper or a lower limit,

where:

U = the upper specification limit,
L = the lower specification limit,
$\bar{X}$ = the sample mean, and
$\bar{R}$ = the average range of the sample.

8.3.2.1 In this practice, $\bar{R}$ is the average range of subgroup ranges. Each of the subgroups consists of 5 measurements, except for those plans with sample size 3, 4, or 7 in which case the subgroup size is the same as the sample size. In computing $\bar{R}$, the order of the sample measurements as made must be retained. Subgroups of consecutive measurements must be formed and the range of each subgroup obtained. $\bar{R}$ is the average of the individual subgroup ranges.

EXAMPLE 8-1

Example of Calculations
Single Specification Limit-Form 1
Variability Unknown – Range Method

Example The lower specification limit for electrical resistance of a certain electrical component is 620 ohms. A lot of 100 items is submitted for inspection. Inspection Level IV, normal inspection, with AQL = 0.4 % is to be used. From Tables A-2 and C-1 it is seen that a sample of size 10 is required. Suppose that values of the sample resistances in the order reading from left to right are as follows:

643, 651, 619, 6Z7, 658, (R_1 = 658 – 619 = 39)
670, 673, 641, 638, 650, (R_2 = 673 – 638 = 35)

and compliance with the acceptability criterion is to be determined.

Line	Information Needed	Value Obtained	Explanation
1	Sample Size: n	10	
2	Sum of Measurements: $\sum X$	6470	
3	Sample Mean $\bar{X}$: $\sum X/n$	647	6470/10
4	Average Range $\bar{R}$: $\sum R$/no. of subgroups	37	(39+35)/2
5	Specification Limit (Lower): L	620	
6	The quantity: $(\bar{X} - L)/\bar{R}$	0.730	(647-620)/37
7	Acceptability Constant: k	0.811	See Table C-1
8	Acceptability Criterion: Compare $(\bar{X} - L)/\bar{R}$ with k	0.730 < 0.811	See Section 8.3.3

The lot does not meet the acceptability criterion, since $(\bar{X} - L)/\bar{R}$ is less than k.

NOTE: If a single upper specification limit U is given, then compute the quantity $(U - \bar{X})/\bar{R}$ in line 6 and compare it with k; the lot meets the acceptability criterion, if $(U - \bar{X})/\bar{R}$ is equal to or greater than k.

FIG. 5 Example 8-1

8.3.3 *Acceptability Criterion*—Compare the quantity $(U - \bar{X})/\bar{R}$ or $(\bar{X} - L)/\bar{R}$ with the acceptability constant k. If $(U - \bar{X})/\bar{R}$ or $(\bar{X} - L)/\bar{R}$ is equal to or greater than k, the lot meets the acceptability criterion; if $(U - \bar{X})/\bar{R}$ or $(\bar{X} - L)/\bar{R}$ is less than k or negative, then the lot does not meet the acceptability criterion.

8.4 *Summary for Operation of Sampling Plan When Form 1 is Used:*

8.4.1 The following steps summarize the procedures to be followed:

(1) Determine the sample size code letter from Table A-2 (see Fig. A1.2) by using the lot size and the inspection level.

(2) Obtain plan from Master Table C-1 or C-2 (see Figs. A1.12 and A1.13) by selecting the sample size n and the acceptability constant k.

(3) Select at random the sample of n units from the lot; inspect and record the measurement of the quality characteristic for each unit of the sample.

(4) Compute the sample mean $\bar{X}$ and the average range of the sample $\bar{R}$, and also compute the quantity $(U - \bar{X})/\bar{R}$ for an upper specification limit U or the quantity $(\bar{X} - L)/\bar{R}$ for a lower specification limit L.

(5) If the quantity $(U - \bar{X})/\bar{R}$ or $(\bar{X} - L)/\bar{R}$ is equal to or greater than k, the lot meets the acceptability criterion; if $(U - \bar{X})/\bar{R}$ or $(\bar{X} - L)/\bar{R}$ is less than k or negative, then the lot does not meet the acceptability criterion.

8.5 *Selecting the Sampling Plan When Form 2 is Used:*

8.5.1 *Master Sampling Tables*—The master sampling tables for plans based on variability unknown for a single specification limit when using the range method are Tables C-3 and C-4 (see Figs. A1.14 and A1.15) of Part II. Table C-3 is used for normal and tightened inspection and Table C-4 for reduced inspection.

8.5.2 *Obtaining the Sampling Plan*—The sampling plan consists of a sample size and an associated maximum allowable percent defective. The sampling plan is obtained from Master Table C-3 or C-4 (see Figs. A1.14 and A1.15).

8.5.2.1 *Sample Size*—The sample size n is shown in the master table corresponding to each sample size code letter.

8.5.2.2 *Maximum Allowable Percent Defective*—The maximum allowable percent defective M for sample estimates corresponding to the sample size mentioned in 8.5.2.1 is indicated in the column of the master table corresponding to the applicable AQL value. Table C-3 (see Fig. A1.14) is entered from the top for normal inspection and from the bottom for tightened inspection. Sampling plans for reduced inspection are provided in Table C-4 (see Fig. A1.15).

8.6 *Lot-by-lot Acceptability Procedures When Form 2 is Used* (see Example 8-2 (Fig. 6) for a complete example of this procedure):

8.6.1 *Acceptability Criterion*—The degree of conformance of a quality characteristic with respect to a single specification limit shall be judged by the percent of nonconforming product outside the upper or lower specification limit. The percentage of nonconforming product is estimated by entering Table C-5 (see Fig. A1.16) with the quality index and the sample size.

8.6.2 *Computation of Quality Index*—The quality index $Q_U = (U - \bar{X})c/\bar{R}$ shall be computed if the specification limit is an upper limit U, or $Q_L = (\bar{X} - L)c/\bar{R}$ if it is a lower limit L. The quantities, $\bar{X}$ and $\bar{R}$, are the sample mean and average range of the sample, respectively. The computation of $\bar{R}$ is explained in 8.3.2. The factor c is provided in Master Tables C-3 and C-4 (see Figs. A1.14 and A1.15) corresponding to the sample size code letter.

8.6.3 *Estimate of Percent Defective in Lot*—The quality of a lot shall be expressed by p_U, the estimated percent defective in the lot above the upper specification limit, or by p_L, the estimated percent defective below the lower specification limit. The estimated percent defective p_U or p_L is obtained by entering Table C-5 (see Fig. A1.16) with Q_U or Q_L and the appropriate sample size.

8.6.4 *Acceptability Criterion*—Compare the estimated lot percent defective p_U or p_L with the maximum allowable percent defective M. If p_U or p_L is equal to or less than M, the lot meets the acceptability criterion; if p_U or p_L is greater than M or if Q_U or Q_L is negative, then the lot does not meet the acceptability criterion.

8.7 *Summary of Operation of Sampling Plan When Form 2 is Used:*

8.7.1 The following steps summarize the procedures to be followed:

(1) Determine the sample size code letter from Table A-2 (see Fig. A1.2) by using the lot size and the inspection level.

(2) Obtain plan from Master Table C-3 or C-4 (see Figs. A1.14 and A1.15) by selecting the sample size n, the factor c, and the maximum allowable percent defective M.

(3) Select at random the sample of n units from the lot; inspect and record the measurement of the quality characteristic on each unit of the sample.

(4) Compute the sample mean $\bar{X}$ and the average range of the sample $\bar{R}$.

(5) Compute the quality index $Q_U = (U - \bar{X})c/\bar{R}$ if the upper specification limit U is specified, or $Q_L = (\bar{X} - L)c/\bar{R}$ if the lower specification limit L is specified.

(6) Determine the estimated lot percent defective p_U or p_L from Table C-5 (see Fig. A1.16).

(7) If the estimated lot percent defective p_U or p_L is equal to or leas than the maximum allowable percent defective M, the lot meets the acceptability criterion; if p_U or p_L is greater than M or if Q_U or Q_L is negative, then the lot does not meet the acceptability criterion.

Part II–Double Specification Limit

8.8 *Sampling Plan for Double Specification Limit*—This part of the practice describes the procedures for use with plans for a double specification limit when variability of the lot with respect to the quality characteristic is unknown and the range method is used.

8.8.1 *Use of Sampling Plans*—To determine whether the lot meets the acceptability criterion with respect to a particular quality characteristic and AQL value(s), the applicable sampling plan shall be used in accordance with the provisions of Section 6, General Description of Sampling Plans, and those in this part of the practice.

EXAMPLE 8-2

Example of Calculations
Single Specification Limit-Form 2
Variability Unknown – Range Method

Example The lower specification limit for electrical resistance of a certain electrical component is 620 ohms. A lot of 100 items is submitted for inspection. Inspection Level IV, normal inspection, with AQL = 0.4 % is to be used. From Tables A-2 and C-l it is seen that a sample of size 10 is required. Suppose that values of the sample resistances in the order reading from left to right are as follows:

643, 651, 619, 6Z7, 658, (R_1 = 658 - 619 = 39)
670, 673, 641, 638, 650, (R_2 = 673 - 638 = 35)

and compliance with the acceptability criterion is to be determined.

Line	Information Needed	Value Obtained	Explanation
1	Sample Size: n	10	
2	Sum of Measurements: $\sum X$	6470	
3	Sample Mean $\bar{X}$: $\sum X/n$	647	6470/10
4	Average Range $\bar{R}$: $\sum R/$no. of subgroups	37	(39 + 35)/2
5	Factor c	2.405	See Table C-3
6	Specification Limit (Lower): L	620	
7	Quality Index: $Q_L = (\bar{X} - L)c/\bar{R}$	1.76	(647 - 620)2.405/37
8	Est. of Lot Percent Def.: p_L	2.54 %	See Table C-5
9	Max. Allowable Percent Def.: M	1.14 %	See Table C-3
10	Acceptability Criterion: Compare p_L with M	2.54 % > 1.14 %	See Section 8.6.4

The lot does not meet the acceptability criterion, since p_L is greater than M.

NOTE: If a single upper specification limit U is given, then compute the quality index $Q_U = (U - \bar{X})c/\bar{R}$ in line 7 and obtain the estimate of lot percent defective p_U. Compare p_U with M; the lot meets the acceptability criterion, if p_U is equal to or less than M.

FIG. 6 Example 8-2

8.9 *Selecting the Sampling Plan*—A sampling plan for each AQL value shall be selected from Table C-3 or C-4 (see Figs. A1.14 and A1.15) as follows:

8.9.1 *Determination of Sample Size Code Letter*—The sample size code letter shall be selected from Table A-2 (see Fig. A1.2) in accordance with 6.7.1.

8.9.2 *Master Sampling Tables*—The master sampling tables for plans based on variability unknown for a double specification limit when using the range method are Tables C-3 and C-4 (see Figs. A1.14 and A1.15). Table C-3 is used for normal and tightened inspection and Table C-4 for reduced inspection.

8.9.3 *Obtaining Sampling Plan*—A sampling plan consists of a sample size and the associated maximum allowable percent defective(s). The sampling plan to be applied in inspection shall be obtained from Master Table C-3 or C-4 (see Figs. A1.14 and A1.15).

8.9.3.1 *Sample Size*—The sample size n is shown in the master tables corresponding to each sample size code letter.

8.9.3.2 *Maximum Allowable Percent Defective*—The maximum allowable percent defective for sample estimates of percent defective for the lower, upper, or both specification limits combined, corresponding to the sample size mentioned in 8.9.3.1, is shown in the column of the master table corresponding to the applicable AQL value(s). If different AQL's are assigned to each specification limit, designate the maximum allowable percent defective by M_L for the lower limit, and by M_U for the upper limit. If one AQL is assigned to both limits combined, designate the maximum allowable percent defective by M. Table C-3 (see Fig. A1.14) is entered from the top for normal inspection and from the bottom for tightened inspection. Sampling plans for reduced inspection are provided in Table C-4 (see Fig. A1.15).

8.10 *Drawing of Samples:*

8.10.1 Samples shall be selected in accordance with 6.7.2.

8.11 *Lot-by-lot Acceptability Procedures:*

8.11.1 *Acceptability Criterion*—The degree of conformance of a quality characteristic with respect to a double specification limit shall be judged by the percent of nonconforming product. The percentage of nonconforming product is estimated by entering Table C-5 (see Fig. A1.16) with the quality index and the sample size.