

AMERICAN NATIONAL STANDARD

ASQ/ANSI Z1.4–2003 (R2018)

SAMPLING PROCEDURES AND TABLES FOR INSPECTION BY ATTRIBUTES

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AMERICAN NATIONAL STANDARD

Sampling Procedures and Tables for Inspection by Attributes

Prepared by
ASQ (ASC Z1) Subcommittee on the Application of Statistical Methods

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ABSTRACT

Sampling Procedures and Tables for Inspection by Attributes is an acceptance sampling system to be used with switching rules on a continuing stream of lots for AQL specified. It provides tightened, normal, and reduced plans to be applied for attributes inspection for percent nonconforming or nonconformities per 100 units.

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SAMPLING PROCEDURES AND TABLES FOR INSPECTION BY ATTRIBUTES

1. SCOPE

1.1 PURPOSE. This publication establishes sampling plans and procedures for inspection by attributes. When specified by the responsible authority, this publication shall be referenced in the specification, contract, inspection instructions, or other documents and the provisions set forth herein shall govern. The “responsible authority” shall be designated in one of the above documents, as agreed to by the purchaser and seller or producer and user.

1.2 APPLICATION. Sampling plans designated in this publication are applicable, but not limited, to inspection of the following:

- a. End items.
- b. Components and raw materials.
- c. Operations.
- d. Materials in process.
- e. Supplies in storage.
- f. Maintenance operations.
- g. Data or records.
- h. Administrative procedures.

These plans are intended primarily to be used for a continuing series of lots or batches. The plans may also be used for the inspection of isolated lots or batches, but, in this latter case, the user is cautioned to consult the operating characteristic curves to find a plan which will yield the desired protection (see 11.6).

1.3 INSPECTION. Inspection is the process of measuring, examining, testing, or otherwise comparing the unit of product (see 1.5) with the requirements.

1.4 INSPECTION BY ATTRIBUTES. Inspection by attributes is inspection whereby either the unit of product is classified simply as conforming or nonconforming, or

the number of nonconformities in the unit of products is counted, with respect to a given requirement or set of requirements.

1.5 UNIT OF PRODUCT. The unit of product is the unit inspected in order to determine its classification as conforming or nonconforming or to count the number of nonconformities. It may be a single article, a pair, a set, a length, an area, an operation, a volume, a component of an end 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.

2. DEFINITIONS AND TERMINOLOGY

The definitions and terminology employed in this standard are in accord with ISO 3534-2 (Terms, Symbols, and Definitions for Acceptance Sampling). The following two definitions are particularly important in applying the standard.

DEFECT: A departure of a quality characteristic from its intended level or state that occurs with a severity sufficient to cause an associated product or service not to satisfy intended normal, or foreseeable, usage requirements.

NONCONFORMITY: A departure of a quality characteristic from its intended level or state that occurs with severity sufficient to cause an associated product or service not to meet a specification requirement.

These acceptance sampling plans for attributes are given in terms of the percent or proportion of product in a lot or batch that depart from some requirement. The general terminology used within the document will be given in terms of percent of nonconforming units or number of nonconformities, since these terms are likely to constitute the most widely used criteria for acceptance sampling.

In the use of this standard it is helpful to distinguish between:

- a. an individual sampling plan—a specific plan that states the sample size or sizes to be used, and the associated acceptance criteria.

- b. a sampling scheme—a combination of sampling plans with switching rules and possibly a provision for discontinuance of inspection. In this standard the terms “sampling scheme” and “scheme performance” will be used in the restricted sense described in Sec. 11.1.
- c. a sampling system—a collection of sampling schemes. This standard is a sampling system indexed by lot-size ranges, inspection levels, and AQLs.

3. PERCENT NONCONFORMING AND NONCONFORMITIES PER HUNDRED UNITS

3.1 EXPRESSION OF NONCONFORMANCE. The extent of nonconformance of product shall be expressed either in terms of percent nonconforming or in terms of nonconformities per hundred units.

3.2 PERCENT NONCONFORMING. The percent nonconforming of any given quantity of units of product is one hundred times the number of nonconforming units divided by the total number of units of product, i.e.:

$$\text{Percent nonconforming} = \frac{\text{Number nonconforming}}{\text{Number of units inspected}} \times 100$$

3.3 NONCONFORMITIES PER HUNDRED UNITS. The number of nonconformities per hundred units of any given quantity of units of product is one hundred times the number of nonconformities contained therein (one or more nonconformities being possible in any unit of product) divided by the total number of units of product, i.e.:

$$\text{Nonconformities per hundred units} = \frac{\text{Number of nonconformities}}{\text{Number of units inspected}} \times 100$$

It is assumed that nonconformities occur randomly and with statistical independence within and between units.

4. ACCEPTANCE QUALITY LIMIT (AQL)

4.1 USE. The AQL together with the Sample Size Code Letter, is used for indexing the sampling plans provided herein.

4.2 DEFINITION. The AQL is the quality level that is the worst tolerable process average when a continuing series of lots is submitted for acceptance sampling.

Note: The use of the abbreviation AQL to mean Acceptable Quality Level is no longer recommended.

4.3 NOTE ON THE MEANING OF AQL. The concept of AQL only applies when an acceptance sampling scheme with rules for switching between normal, tightened and reduced inspection and discontinuance of sampling inspection is used. These rules are designed to encourage suppliers to have process averages consistently better than the AQL. If suppliers fail to do so, there is a high probability of being switched from normal inspection to tightened inspection where lot acceptance becomes more difficult. Once on tightened inspection, unless corrective action is taken to improve product quality, it is very likely that the rule requiring discontinuance of sampling inspection will be invoked.

Although individual lots with quality as bad as the AQL can be accepted with fairly high probability, the designation of an AQL does not suggest that this is necessarily a desirable quality level. The AQL is a parameter of the sampling scheme and should not be confused with a process average which describes the operating level of a manufacturing process. It is expected that the product quality level will be less than the AQL to avoid excessive non-accepted lots.

The sampling plans in this standard are so arranged that the probability of lot acceptance at the designated AQL depends upon sample size, being generally higher for large samples than for small samples for a given AQL. To determine the specific protection to the consumer at a given AQL, it is necessary to refer to the operating characteristic curves (which are provided in this standard) of the corresponding scheme and its constituent plans.

The AQL alone does not describe the protection to the consumer for individual lots or batches, but more directly relates to what is expected from a series of lots or batches provided the provisions of this standard are satisfied.

4.4 LIMITATION. The designation of an AQL shall not imply that the supplier has the right to knowingly supply any nonconforming unit of product.

4.5 SPECIFYING AQLs. The AQL to be used will be designated in the contract or by the responsible authority. Different AQLs may be designated for groups of nonconformities considered collectively, or for individual nonconformities. For example, Group A may include nonconformities of a type felt to be of the highest concern for the product or service and therefore be assigned a small AQL value; Group B may include nonconformities of the next higher degree of concern and therefore be assigned a larger AQL value than for Group A and smaller than that of Group C, etc. The classification into groups should be

appropriate to the quality requirements of the specific situation. An AQL for a group of nonconformities may be designated in addition to AQLs for individual nonconformities, or subgroups, within that group. AQL values of 10.0 or less may be expressed either in percent nonconforming or in nonconformities per hundred units; those over 10.0 shall be expressed in nonconformities per hundred units only.

4.6 PREFERRED AQLs. The values of AQLs given in these tables are known as preferred AQLs. If, for any product, an AQL be designated other than a preferred AQL, these tables are not applicable.

5. SUBMISSION OF PRODUCT

5.1 LOT OR BATCH. The term lot or batch shall mean “inspection lot” or “inspection batch,” i.e., a collection of units of product from which a sample is to be drawn and inspected to determine conformance with the acceptability criteria, and may differ from a collection of units designated as a lot or batch for other purposes (e.g., production, shipment, etc.).

5.2 FORMATION OF LOTS OR BATCHES. The product shall be assembled into identifiable lots, sublots, batches, or in such other manner as may be prescribed (see 5.4). Each lot or batch shall, as far as is practicable, consist of units of product of a single type, grade, class, size, and composition, manufactured under essentially the same conditions, and at essentially the same time.

5.3 LOT OR BATCH SIZE. The lot or batch size is the number of units of product in a lot or batch.

5.4 PRESENTATION OF LOTS OR BATCHES. The formation of the lots or batches, lot or batch size, and the manner in which each lot or batch is to be presented and identified by the supplier shall be designated or approved by the responsible authority. As necessary, the supplier shall provide adequate and suitable storage space for each lot or batch, equipment needed for proper identification and presentation, and personnel for all handling of product required for drawing of samples.

6. ACCEPTANCE AND NON-ACCEPTANCE

6.1 ACCEPTABILITY OF LOTS OR BATCHES. Acceptability of a lot or batch will be determined by the use of a sampling plan or plans associated with the designated AQL or AQLs.

In the use of this standard a statement that a lot is acceptable means simply that sample results satisfy the standard's

acceptance criteria. The acceptance of a lot is not intended to provide information about lot quality. If a stream of lots from a given process is inspected under an acceptance sampling scheme such as provided in this standard, some lots will be accepted and others will not. If all incoming lots are assumed to be at the same process average and if the nonconforming items that are discovered and replaced by conforming items during sample inspection are ignored, it will be found that both the set of accepted lots and the set of non-accepted lots will have the same long run average quality as the original set of lots submitted for inspection. Inspection of incoming lots whose quality levels vary around a fixed long run average quality level will divide the lots into a set of accepted lots and a set of non-accepted lots, but it will be found that the long run average quality of the accepted lots is only slightly better than the long run average quality of the non-accepted lots. Replacement of the nonconforming items that are discovered during sample inspection does not alter this finding because the samples are a small fraction of the lots.

The purpose of this standard is, through the economic and psychological pressure of lot non-acceptance, to induce a supplier to maintain a process average at least as good as the specified AQL while at the same time providing an upper limit on the consideration of the consumer's risk of accepting occasional poor lots. The standard is not intended as a procedure for estimating lot quality or for segregating lots.

In acceptance sampling, when sample data do not meet the acceptance criteria, it is often stated that the lot is to be “rejected.” In this connection, the words “to reject” generally are used. Rejection in an acceptance sampling sense means to decide that a batch, lot or quantity of product, material, or service has not been shown to satisfy the acceptance criteria based on the information obtained from the sample(s).

In acceptance sampling, the words “to reject” generally are used to mean “to not accept” without direct implication of product usability. Lots which are “rejected” may be scrapped, sorted (with or without nonconforming units being replaced), reworked, re-evaluated against more specific usability criteria, held for additional information, etc. Since the common language usage of “reject” often results in an inference of unsafe or unusable product, it is recommended that “not accept” be understood rather than “reject” in the use of this standard.

The word “non-acceptance” is used here for “rejection” when it refers to the result of following the procedure. Forms of the word “reject” are retained when they refer to actions the customer may take, as in “rejection number.”

6.2 NONCONFORMING UNITS. The right is reserved to reject any unit of product found nonconforming during inspection whether that unit of product forms a part of a sample or not, and whether the lot or batch as a whole is accepted or rejected. Rejected units may be repaired or corrected and resubmitted for inspection with the approval of, and in the manner specified by, the responsible authority.

6.3 SPECIAL RESERVATION FOR DESIGNATED NONCONFORMITIES. Since most acceptance sampling involves evaluation of more than one quality characteristic, and since these may differ in importance in terms of quality and/or economic effects, it is often desirable to classify the types of nonconformity according to agreed upon groupings. Specific assignment of types of nonconformities to each class is a function of agreement on specific sampling applications. In general, the function of such classification is to permit the use of a set of sampling plans having a common sample size, but different acceptance numbers for each class having a different AQL, such as in Tables II, III, and IV.

The supplier may be required at the discretion of the responsible authority to inspect every unit of the lot or batch for designated classes of nonconformities. The right is reserved to inspect every unit submitted by the supplier for specified nonconformities, and to reject the lot or batch immediately, when a nonconformity of this class is found. The right is reserved also to sample, for specified classes of nonconformities, lots or batches submitted by the supplier and to reject any lot or batch if a sample drawn therefrom is found to contain one or more of these nonconformities.

6.4 RESUBMITTED LOTS OR BATCHES. Lots or batches found unacceptable shall be resubmitted for reinspection only after all units are re-examined or re-tested and all nonconforming units are removed or nonconformities corrected. The responsible authority shall determine whether normal or tightened inspection shall be used on reinspection and whether reinspection shall include all types or classes of nonconformities or only the particular types or classes of nonconformities which caused initial rejection.

7. DRAWING OF SAMPLES

7.1 SAMPLE. A sample consists of one or more units of product drawn from a lot or batch, 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.

7.2 SAMPLING. When appropriate, the number of units in the sample shall be selected in proportion to the size of sublots or subbatches, or parts of the lot or batch, identified by some rational criterion. In so doing, the units from each part of the lot or batch shall be selected at random, as defined in ISO 3534-2.

7.3 TIME OF SAMPLING. Samples may be drawn after all the units comprising the lot or batch have been produced, or samples may be drawn during production of the lot or batch.

7.4 DOUBLE OR MULTIPLE SAMPLING. Where double or multiple sampling is to be used, each sample shall be selected over the entire lot or batch.

8. NORMAL, TIGHTENED AND REDUCED INSPECTION

8.1 INITIATION OF INSPECTION. Normal inspection will be used at the start of inspection unless otherwise directed by the responsible authority.

8.2 CONTINUATION OF INSPECTION. Normal, tightened or reduced inspection shall continue unchanged on successive lots or batches except where the switching procedures given below require change.

8.3 SWITCHING PROCEDURES.

8.3.1 NORMAL TO TIGHTENED. When normal inspection is in effect, tightened inspection shall be instituted when 2 out of 5 or fewer consecutive lots or batches have been non-acceptable on original inspection (i.e., ignoring resubmitted lots or batches for this procedure).

8.3.2 TIGHTENED TO NORMAL. When tightened inspection is in effect, normal inspection shall be instituted when 5 consecutive lots or batches have been considered acceptable on original inspection.

8.3.3 NORMAL TO REDUCED. When normal inspection is in effect, reduced inspection shall be instituted providing that all of the following conditions are satisfied.

- a. The preceding 10 lots or batches (or more, as indicated by the note to Table VIII) have been on normal inspection and all have been accepted on original inspection; and

- b. The total number of nonconforming units (or nonconformities) in the samples from the preceding 10 lots or batches (or such other number as was used for condition "a" above) is equal to or less than the applicable limit number given in Table VIII (see 8.5). If double or multiple sampling is in use, all samples inspected should be included, not "first" samples only; and
- c. Production is at a steady rate; and
- d. Reduced inspection is considered desirable by the responsible authority.

8.3.4 REDUCED TO NORMAL. When reduced inspection is in effect, normal inspection shall be instituted if any of the following occur on original inspection:

- a. A lot or batch is rejected; or
- b. A lot or batch is considered acceptable under the procedures for reduced inspection given in 10.1.4; or
- c. Production becomes irregular or delayed; or
- d. Other conditions warrant that normal inspection shall be instituted.

8.4 DISCONTINUATION OF INSPECTION. If the cumulative number of lots not accepted in a sequence of consecutive lots on tightened inspection reaches 5, the acceptance procedures of this standard shall be discontinued. Inspection under the provisions of this standard shall not be resumed until corrective action has been taken. Tightened inspection shall then be used as if 8.3.1 had been invoked.

8.5 LIMIT NUMBERS FOR REDUCED INSPECTION. When agreed upon by responsible authority for both parties to the inspection, that is, the supplier and the end item customer, the requirements of 8.3.3b may be dropped. This action will have little effect on the operating properties of the scheme.

8.6 SWITCHING SEQUENCE. A schematic diagram describing the sequence of application of the switching rules is shown in Figure 1.

9. SAMPLING PLANS

9.1 SAMPLING PLAN. A sampling plan indicates the number of units of product from each lot or batch which are

to be inspected (sample size or series of sample sizes) and the criteria for determining the acceptability of the lot or batch (acceptance and rejection numbers).

9.2 INSPECTION LEVEL. The inspection level determines the relationship between the lot or batch size and the sample size. The inspection level to be used for any particular requirement will be prescribed by the responsible authority. Three inspection levels: I, II and III are given in Table I for general use. Unless otherwise specified, Inspection Level II will be used. However, Inspection Level I may be specified when less discrimination is needed, or Level III may be specified for greater discrimination. Four additional special levels: S-1, S-2, S-3, and S-4, are given in the same table and may be used where relatively small sample sizes are necessary and large sampling risks can or must be tolerated.

NOTE: In the designation of inspection levels S-1 to S-4, care must be exercised to avoid AQLs inconsistent with these inspection levels.

9.3 CODE LETTERS. Sample sizes are designated by code letters. Table I shall be used to find the applicable code letter for the particular lot or batch size and the prescribed inspection level.

9.4 OBTAINING SAMPLING PLAN. The AQL and the code letter shall be used to obtain the sampling plan from Tables II, III, or IV. When no sampling plan is available for a given combination of AQL and code letter, the tables direct the user to a different letter. The sample size to be used is given by the new code letter, not by the original letter. If this procedure leads to different sample sizes for different classes of nonconformities, the code letter corresponding to the largest sample size derived may be used for all classes of nonconformities when designated or approved by the responsible authority. As an alternative to a single sampling plan with an acceptance number of 0, the plan with an acceptance number of 1 with its correspondingly larger sample size for a designated AQL (where available), may be used when designated or approved by the responsible authority.

9.5 TYPES OF SAMPLING PLANS. Three types of sampling plans: Single, Double and Multiple, are given in Tables II, III, and IV, respectively. When several types of plans are available for a given AQL and code letter, any one may be used. A decision as to type of plan, either single, double, or multiple, when available for a given AQL and code letter, will usually be based upon the comparison between the

administrative difficulty and the average sample sizes of the available plans. The average sample size of multiple plans is less than for double (except in the case corresponding to single acceptance number 1) and both of these are always less than a single sample size (see Table IX). Usually the administrative difficulty for single sampling and the cost per unit of the sample are less than for double or multiple.

10. DETERMINATION OF ACCEPTABILITY

10.1 PERCENT NONCONFORMING INSPECTION.

To determine acceptability of a lot or batch under percent nonconforming inspection, the applicable sampling plan shall be used in accordance with 10.1.1, 10.1.2, 10.1.3 and 10.1.4.

10.1.1 SINGLE SAMPLING PLAN. The number of sample units inspected shall be equal to the sample size given by the plan. If the number of nonconforming units found in the sample is equal to or less than the acceptance number, the lot or batch shall be considered acceptable. If the number of nonconforming units is equal to or greater than the rejection number, the lot or batch shall be considered not acceptable.

10.1.2 DOUBLE SAMPLE PLAN. The number of sample units first inspected shall be equal to the first sample size given by the plan. If the number of nonconforming units found in the first sample is equal to or less than the first acceptable number, the lot or batch shall be considered acceptable. If the number of nonconforming units found in the first sample is equal to or greater than the first rejection number, the lot or batch shall be considered not acceptable. If the number of nonconforming units found in the first sample is between the first acceptance and rejection numbers, a second sample of the size given by the plan shall be inspected. The number of nonconforming units found in the first and second samples shall be accumulated. If the cumulative number of nonconforming units is equal to or less than the second acceptance number, the lot or batch shall be considered acceptable. If the cumulative number of nonconforming units is equal to or greater than the second rejection number, the lot or batch shall be considered not acceptable.

10.1.3 MULTIPLE SAMPLE PLAN. Under multiple sampling, the procedure shall be similar to that specified in 10.1.2, except that the number of successive samples required to reach a decision might be more than two.

10.1.4 SPECIAL PROCEDURE FOR REDUCED INSPECTION. Under reduced inspection, the sampling

procedure may terminate without making a decision. In these circumstances, the lot or batch will be considered acceptable, but normal inspection will be reinstated starting with the next lot or batch (see 8.3.4(b)).

10.2 NONCONFORMITIES PER HUNDRED UNITS INSPECTION. To determine the acceptability of a lot or batch under Nonconformities per Hundred Units inspection, the procedure specified for Percent Nonconforming inspection above shall be used, except that the word “nonconformities” shall be substituted for “nonconforming units.”

11. SUPPLEMENTARY INFORMATION

11.1 OPERATING CHARACTERISTIC CURVES.

Operating characteristic curves and other measures of performance presented in this standard are of two types. Those for the individual plans that represent the elements of the schemes are presented in Tables V, VI, VII, IX, and X. Analogous curves and other measures of overall scheme performance when the switching rules are used are given in Tables XI, XII, XIII, XIV, and XV. Scheme performance is defined as the composite proportion of lots accepted at a stated percent nonconforming when the switching rules are applied. The term scheme performance is used here in a very restrictive sense. It refers to how the ASQ/ANSI Z1.4 scheme of switching rules would operate at a given process level under the assumption that the process stays at that level even after switching to tightened inspection or discontinuation of inspection. This gives a conservative “worst case” description of the performance of the scheme for use as a baseline in the sense that if the psychological and economic pressures associated with the switching rules are considered, the protection of the scheme may be somewhat better than that shown.

Operating characteristic curves are given in Table X for individual sampling plans for normal and tightened inspection. The operating characteristic curve for unqualified acceptance under reduced inspection can be found by using the AQL index of the normal plan with the sample size(s) and acceptance number(s) of the reduced plan. The curves shown are for single sampling; curves for double and multiple sampling are matched as closely as practicable. The O.C. curves shown for AQLs greater than 10.0 are based on the Poisson distribution and apply for nonconformities per hundred units inspection; those for AQLs of 10.0 or less and sample sizes of 80 or less are based on the binomial distribution and apply for percent nonconforming inspection; those for AQLs of 10.0 or less and sample sizes larger than 80 are based on the Poisson distribution and apply either for

nonconformities per hundred units inspection, or for percent nonconforming inspection (the Poisson distribution being an adequate approximation to the binomial distribution under these conditions). Tabulated values corresponding to selected values of probabilities of acceptance (P_a in percent) are given for each of the curves shown, and, in addition, are indexed for tightened inspection, and also show values for nonconformities per hundred units for AQLs of 10.0 or less and sample sizes of 80 or less.

The operating characteristic curves for scheme performance shown in Table XV indicate the percentage of lots or batches which may be expected to be accepted under use of the switching rules with the various sampling plans for a given process quality subject to the restrictions stated above. The operating characteristic curves of scheme performance are based on the use of limit numbers in switching to reduced inspection and are approximately correct when the limit numbers for reduced inspection are not used under Option 8.5. The curves also assume a return to tightened inspection when inspection is resumed after discontinuation has been imposed. This is also true of average outgoing quality limit and average sample size for ASQ/ANSI Z1.4 scheme performance.

Note that the operating characteristic curve for scheme performance is approximately that of the normal plan for low levels of percent nonconforming and that the tightened plan for high levels of percent nonconforming. Use of the reduced plan increases scheme probability of acceptance only for extremely low levels of percent nonconforming.

11.2 PROCESS AVERAGE. The process average is the average percent nonconforming or average number of nonconformities per hundred units (whichever is applicable) of product submitted by the supplier for original inspection. Original inspection is the first inspection of a particular quantity of product as distinguished from the inspection of product which has been resubmitted after prior rejection. When double or multiple sampling is used, only first sample results shall be included in the process average calculation.

11.3 AVERAGE OUTGOING QUALITY (AOQ). The AOQ is the average quality of outgoing product including all accepted lots or batches, plus all lots or batches which are not accepted after such lots or batches have been effectively 100 percent inspected and all nonconforming units replaced by conforming units.

11.4 AVERAGE OUTGOING QUALITY LIMIT (AOQL). The AOQL is the maximum of the AOQs for all

possible incoming qualities for a given acceptance sampling plan. AOQL values are given in Table V-A for each of the single sampling plans for normal inspection and in Table V-B for each of the single sampling plans for tightened inspections. AOQL values for ASQ/ANSI Z1.4 scheme performance are given in Table XI subject to the restrictions of 11.1. They show the average outgoing quality limits for scheme performance when using single sampling. AOQL will be slightly higher when the limit numbers for reduced inspection are not used under Option 8.5.

11.5 AVERAGE SAMPLE SIZE CURVES. Average sample size curves for double and multiple sampling as compared to the single sampling plan for each acceptance number are in Table IX. These show the average sample sizes which may be expected to occur under the various sampling plans for a given process quality level. The curves assume no curtailment of inspection and are approximate to the extent that they are based upon the Poisson distribution, and that the sample sizes at each stage for double and multiple sampling are assumed to be $0.631n$ and $0.25n$ respectively, where n is the equivalent single sample size. Average sample size tables for ASQ/ANSI Z1.4 scheme performance are given in Table XIV. They show the average sample size for scheme performance when using single sampling.

11.6 LIMITING QUALITY PROTECTION.

11.6.1 USE OF INDIVIDUAL PLANS. This standard is intended to be used as a system employing tightened, normal, and reduced inspection on a continuing series of lots to achieve consumer protection while assuring the producer that acceptance will occur most of the time if quality is better than the AQL.

11.6.2 IMPORTANCE OF SWITCHING RULES. Occasionally specific individual plans are selected from the standard and used without the switching rules. This is not the intended application of the ASQ/ANSI Z1.4 system and its use in this way should not be referred to as inspection under ASQ/ANSI Z1.4. When employed in this way, this document simply represents a repository for a collection of individual plans indexed by AQL. The operating characteristics and other measures of a plan so chosen must be assessed individually for that plan from the tables provided.

11.6.3 LIMITING QUALITY TABLES. If the lot or batch is of an isolated nature, it is desirable to limit the selection of sampling plans to those, associated with a designated AQL value, that provide not less than a specified

limiting quality protection. Sampling plans for this purpose can be selected by choosing a Limiting Quality (LQ) and a consumer's risk to be associated with it. Limiting Quality is the percentage of nonconforming units (or nonconformities) in a batch or lot for which for purposes of acceptance sampling, the consumer wishes the probability of acceptance to be restricted to a specified low value.

Tables VI and VII give process levels for which the probabilities of lot acceptance under various sampling plans are 10 percent and 5 percent respectively. If a different value of consumer's risk is required, the O.C. curves and their tabulated values may be used. For individual lots with percents nonconforming or nonconformities per 100 units equal to the specified Limiting Quality (LQ) values, the probabilities of lot acceptance are less than 10 percent in the case of plans listed in Table VI and less than 5 percent in the case of plans listed in Table VII. When there is reason for avoiding more than a limiting percentage of nonconforming units (or nonconformities) in a lot or batch, Tables VI and VII may be useful for fixing minimum sample sizes to be associated

with the AQL and Inspection Level specified for the inspection of a series of lots or batches. For example, if an LQ of 5 percent is desired for individual lots with an associated P_a of 10 percent or less, then if an AQL of 1.5 percent is designated for inspection of a series of lots or batches. Table VI indicates that the minimum sample size must be that given by Code Letter M.

Where there is interest in a limiting *process level*, Tables XII and XIII, which give LQ values and ASQ/ANSI Z1.4 scheme performance may be used in a similar way to fix minimum sample sizes.

In the case of an isolated lot, it is preferable for the customer to adapt a sampling plan with a small consumer's risk. The ideal method of calculating the sample size and risk is by use of the hypergeometric probability function. ASQC Q3-1988 contains sampling plans that have been calculated on this basis and therefore provide a more accurate set of tables for these situations.

Switching Rules for ASQ/ANSI Z1.4 System

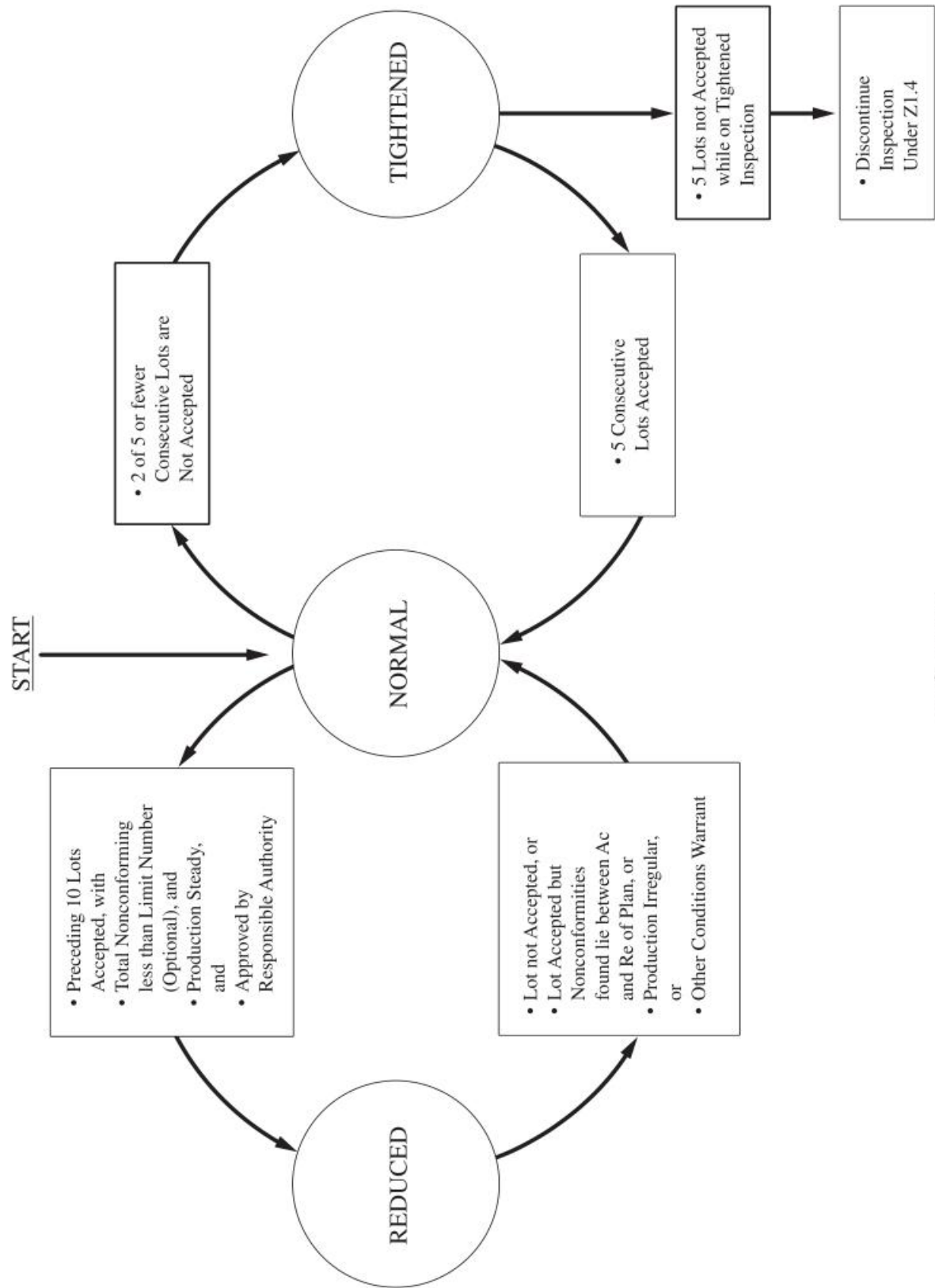


FIGURE 1

**SWITCHING
RULES**

Table I—Sample size code letters

(See 9.2 and 9.3)

Lot or batch size	Special inspection levels				General inspection levels		
	S-1	S-2	S-3	S-4	I	II	III
2 to 8	A	A	A	A	A	A	B
9 to 15	A	A	A	A	A	B	C
16 to 25	A	A	B	B	B	C	D
26 to 50	A	B	B	C	C	D	E
51 to 90	B	B	C	C	C	E	F
91 to 150	B	B	C	D	D	F	G
151 to 280	B	C	D	E	E	G	H
281 to 500	B	C	D	E	F	H	J
501 to 1200	C	C	E	F	G	J	K
1201 to 3200	C	D	E	G	H	K	L
3201 to 10000	C	D	F	G	J	L	M
10001 to 35000	C	D	F	H	K	M	N
35001 to 150000	D	E	G	J	L	N	P
150001 to 500000	D	E	G	J	M	P	Q
500001 and over	D	E	H	K	N	Q	R

**SINGLE
TIGHTENED
PLANS**

Table II-B—Single sampling plans for tightened inspection (Master table)

(See 9.4 and 9.5)

Sample size code letter	Acceptance Quality Limits (tightened inspection)																
	0.010	0.015	0.025	0.040	0.065	0.10	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10	15
A	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
B	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
C	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
D	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
E	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
F	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
G	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
H	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
J	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
K	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
L	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
M	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
N	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
P	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
Q	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
R	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
S	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re

↓ = Use first sampling plan below arrow. If sample size equals or exceeds lot or batch size, do 100 percent inspection.
↑ = Use first sampling plan above arrow.
Ac = Acceptance number.
Re = Rejection number.

APPENDIX B

Symbol	Read	Definitions	Definition
n		Sample size for a single lot.	
\bar{X}	X bar	Sample mean. Arithmetic mean of sample measurements from a single lot.	$\bar{X} = \frac{\sum X}{n}$
s		Estimate of lot standard deviation. Standard deviation of sample measurements from a single lot. (See Examples in Section B.)	$s = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n - 1}}$
U		Upper specification limit.	
L		Lower specification limit.	
k		The acceptability constant given in Tables B-1 and B-2.	
Q _U	Q sub U	Quality index for use with Table B-5.	
Q _L	Q sub L	Quality index for use with Table B-5.	
p _U	p sub U	Sample estimate of the lot percent nonconforming above U from Table B-5.	
p _L	p sub L	Sample estimate of the lot percent nonconforming below L from Table B-5.	
p		Total sample estimate of the lot percent nonconforming $p = p_U + p_L$.	
M		Maximum allowable percent nonconforming for sample estimates given in Tables B-3 and B-4.	
M _U	M sub U	Maximum allowable percent nonconforming above U given in Tables B-3 and B-4. (For use when different AQL values for U and L are specified.)	
M _L	M sub L	Maximum allowable percent nonconforming below L given in Tables B-3 and B-4. (For use when different AQL values for U and L are specified.)	
\bar{p}	p bar	Sample estimate of the process percent nonconforming, i.e., the estimated process average.	
\bar{p}_U	p bar sub U	The estimated process average for an upper specification limit.	
\bar{p}_L	p bar sub L	The estimated process average for a lower specification limit.	
F		A factor used in determining the maximum standard deviation (MSD). The F values are given in Table B-6.	
>	Greater than	Greater than.	
<	Less than	Less than.	
\sum	Sum of	Sum of.	
T		AQL symbol denoting plan used exclusively on tightened inspection (provides identification of appropriate OC curve).	

SECTION C

VARIABILITY UNKNOWN—RANGE METHOD

Part I SINGLE SPECIFICATION LIMIT

C1. SAMPLING PLAN FOR SINGLE SPECIFICATION LIMIT

This part of the standard 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.

C1.1 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 A, General Description of the Sampling Plans, and those in this part of the Standard.

C1.2 Drawing of Samples. All samples shall be drawn in accordance with paragraph A7.2.

C1.3 Determination of Sample Size Code Letter. The sample size code letter shall be selected from Table A-2 in accordance with paragraph A7.1.

C2. SELECTING THE SAMPLE PLAN WHEN FORM 1 IS USED

C2.1 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. Table C-1 is used for normal and tightened inspection and Table C-2 for reduced inspection.

C2.2 Obtaining the Sample Plan. The sampling plan consists of a sample size and an associated acceptability constant.¹ The sampling plan is obtained from Master Table C-1 or C-2.

C2.2.1 Sample Size. The sample size n is shown in the master table corresponding to each sample size code letter.

C2.2.2 Acceptability Constant. The acceptability constant k , corresponding to the sample size mentioned in paragraph C2.2.1, is indicated in the column of the master table corresponding to the applicable AQL value. Table C-1 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.

C3. LOT-BY-LOT ACCEPTABILITY PROCEDURES WHEN FORM 1 IS USED²

C3.1 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 $(\bar{X} - L)/\bar{R}$.

C3.2 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 is the upper specification limit,
 L is the lower specification limit,
 \bar{X} is the sample mean, and
 \bar{R} is the average range of the sample.

In this standard, \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 and the sample range is used as \bar{R} . 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.

¹See Appendix C for definitions of all symbols used in the sampling plans based on variability unknown—range method.

²See Example C-1 for a complete example of this procedure.

C3.3 Acceptability Criteria. 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.

C4. SUMMARY FOR OPERATION OF SAMPLING PLAN WHEN FORM 1 IS USED

The following steps summarize the procedures to be followed:

- (1) Determine the sample size code letter from Table A-2 by using the lot size and the inspection level.
- (2) Obtain plan from Master Table C-1 or C-2 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.

C5. SELECTING THE SAMPLING PLAN WHEN FORM 2 IS USED

C5.1 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 of Part II. Table C-3 is used for normal and tightened inspection and Table C-4 for reduced inspection.

C5.2 Obtaining the Sampling Plan. The sampling plan consists of a sample size and an associated maximum allowable percent nonconforming. The sampling plan is obtained from Master Table C-3 or C-4.

C5.2.1 Sample Size. The sample size n is shown in the master table corresponding to each sample size code letter.

C5.2.2 Maximum Allowable Percent Nonconforming. The maximum allowable percent nonconforming M for sample estimates corresponding to the sample size mentioned in paragraphs C5.2.1 is indicated in the column of the master table corresponding to the applicable AQL value. Table C-3 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.

C6. LOT-BY-LOT ACCEPTABILITY PROCEDURES WHEN FORM 2 IS USED³

C6.1 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 with the quality index and the sample size.

C6.2 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 paragraph C3.2. The factor c is provided in Master Tables C-3 and C-4 corresponding to the sample size code letter.

C6.3 Estimate of Percent Nonconforming in Lot. The quality of a lot shall be expressed by p_U , the estimated percent nonconforming in the lot above the upper specification limit, or by p_L , the estimated percent nonconforming below the lower specification limit. The estimated percent nonconforming p_U or p_L is obtained by entering Table C-5 with Q_U or Q_L and the appropriate sample size.

C6.4 Acceptability Criterion. Compare the estimated lot percent nonconforming p_U or p_L with the maximum allowable percent nonconforming 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.

³See Example C-2 for a complete example of this procedure.

C7. SUMMARY OF OPERATION OF SAMPLING PLAN WHEN FORM 2 IS USED

The following steps summarize the procedures to be followed:

- (1) Determine the sample size code letter from Table A-2 by using the lot size and the inspection level.
- (2) Obtain plan from Master Table C-3 or C-4 by selecting the sample size n , the factor c , and the maximum allowable percent nonconforming 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 nonconforming p_L or p_U from Table C-5.
- (7) If the estimated lot percent nonconforming p_L or p_U is equal to or less than the maximum allowable percent nonconforming M , the lot meets the acceptability criterion; if p_L or p_U is greater than M or if Q_U or Q_L is negative, then the lot does not meet the acceptability criterion.

EXAMPLE C-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 II, normal inspection, with AQL = .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, 627, 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}): $\sum R/\text{no. of subgroups}$	37	(39 + 35)/2
5	Specification Limit (Lower): L	620	
6	The quantity: $(\bar{X} - L)/\bar{R}$.730	(647 - 620)/37
7	Acceptability Constant: k	.811	See Table C-1
8	Acceptability Criterion: Compare $(\bar{X} - L)/\bar{R}$ with k	.730 < .811	See Para. C3.3

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 .

EXAMPLE C-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 II, normal inspection, with AQL = .4% is to be used. From Tables A-2 and C-1 it is seen that a sample of size 10 is required. Suppose the values of the sample resistances in the order reading from left to right are as follows:

643, 651, 619, 627, 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} : $\sum R/\text{no. of subgroups}$	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 Ncf.: p_L	2.54%	See Table C-5
9	Max. Allowable Percent Ncf.: M	1.14%	See Table C-3
10	Acceptability Criterion: Compare p_L with M	2.54% > 1.14%	See Para. C6.4

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 nonconforming p_U . Compare p_U with M ; the lot meets the acceptability criterion, if p_U is equal to or less than M .

Range Method

Table C-2
Master Table for Reduced Inspection for Plans Based on Variability Unknown
 (Single Specification Limit—Form 1)

Sample Size Code Letter	Sample Size	Acceptance Quality Limits											
		.10	.15	.25	.40	.65	1.00	1.50	2.50	4.00	6.50	10.00	
B	3	k	k	k	k	k	k	k	.587	.502	.401	.296	.178
	3								.587	.502	.401	.296	.178
D	3								.587	.502	.401	.296	.178
E	3								.587	.502	.401	.296	.178
F	4								.525	.450	.364	.276	.176
G	5								.498	.431	.352	.272	.184
H	7								.465	.405	.336	.266	.189
I	10								.579	.507	.424	.341	.252
J	15								.610	.536	.452	.368	.276
K	25								.647	.571	.484	.398	.305
L	30								.654	.577	.490	.403	.310
M	35								.658	.581	.494	.406	.313
N	60								.689	.610	.521	.432	.336
P	85								.701	.621	.530	.441	.345

All AQL values are in percent nonconforming.

↓ Use first sampling plan below arrow; that is, both sample size as well as k value. When sample size equals or exceeds lot size, every item in the lot must be inspected.

C11.3 Percent Nonconforming in the Lot. The quality of a lot shall be expressed in terms of the lot percent nonconforming. 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 estimate p_L and p_U shall be determined by entering Table C-5, respectively with Q_L and Q_U and the sample size. The estimate p shall be determined by adding the corresponding estimated percents nonconforming p_L and p_U found in the table.

C12. ACCEPTABILITY CRITERION AND SUMMARY FOR OPERATION OF SAMPLING PLANS

C12.1 One AQL Value for Both Upper and Lower Specification Limit Combined.

C12.1.1 Acceptability Criterion.⁴ Compare the estimated lot percent nonconforming $p = p_U + p_L$ with the maximum allowable percent nonconforming 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.

C12.1.2 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 by using the lot size and the inspection level.
- (2) Select plan from Master Table C-3 or C-4. Obtain the sample size n , the factor c , and the maximum allowable percent nonconforming 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 average range of the sample \bar{R} .

⁴See Example C-3 for a complete example of this procedure.

⁵See Example C-4 for a complete example of this procedure.

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

(6) Determine the estimated lot percent nonconforming $p = p_U + p_L$ from Table C-5.

(7) If the estimated lot percent nonconforming p is equal to or less than the maximum allowable percent nonconforming 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.

C12.2 Different AQL Values for Upper and Lower Specification Limit.

C12.2.1 Acceptability Criteria.⁵ Compare the estimated lot percent nonconforming p_L and p_U with the corresponding maximum allowable percents nonconforming 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.

C12.2.2 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 by using the lot size and inspection level.
- (2) Select the sampling plan from Master Table C-3 or C-4. Obtain the sample size n , the factor c , and the maximum allowable percent nonconforming M_U and M_L , corresponding to 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.

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

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

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

(7) If all three of the following conditions:

- (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 ,

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.

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EXAMPLE C-3

Example of Calculations

Double Specification Limit

Variability Unknown—Average Range Method

One AQL Value for Both Upper and Lower Specification Limit Combined

Example: The specifications for electrical resistance of a certain electrical component are 650 ± 30 ohms. A lot of 100 items is submitted for inspection. Inspection Level II, normal inspection, with AQL = .4% is to be used. From Tables A-2 and C-3 it is seen that a sample of size 10 is required. Suppose the values of the sample resistance in the order reading from left to right are as follows:

643, 651, 619, 627, 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} : $\sum R/\text{no. of subgroups}$	37	(39 + 35)/2
5	Factor c	2.405	See Table C-3
6	Upper Specification Limit: U	680	
7	Lower Specification Limit: L	620	
8	Quality Index: $Q_U = (U - \bar{X})c/\bar{R}$	2.15	(680 - 647)2.405/37
9	Quality Index: $Q_L = (\bar{X} - L)c/\bar{R}$	1.76	(647 - 620)2.405/37
10	Est. of Lot Percent Ncf. above U : p_U	0.35%	See Table C-5
11	Est. of Lot Percent Ncf. below L : p_L	2.54%	See Table C-5
12	Total Est. Percent Ncf. in Lot: $p = p_U + p_L$	2.89%	0.35% + 2.54%
13	Max. Allowable Percent Ncf.: M	1.14%	See Table C-3
14	Acceptability Criterion: Compare $p = p_U + p_L$ with M	2.89% > 1.14%	See Para. C12.1.2(7)

The lot does not meet the acceptability criterion, since $p = p_U + p_L$ is greater than M .

EXAMPLE C-4

Example of Calculations

Double Specification Limit

Variability Unknown—Average Range Method

Different AQL Value for Upper and Lower Specification Limits

Example: The specifications for electrical resistance of a certain electrical component are 650 ± 30 ohms. A lot of 100 items is submitted for inspection. Inspection Level II, normal inspection, with AQL = 2.5% for the upper and AQL = 1% for the lower specification limit is to be used. From Tables A-2 and C-3 it is seen that a sample of size 10 is required. Suppose the values of the sample resistances in the order reading from left to right are as follows:

643, 651, 619, 627, 658, ($R_1 = 658 - 619 = 39$)
 670, 673, 641, 638, 650, ($R_2 = 673 - 638 = 35$)

and compliance with the acceptability criteria 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} : $\sum R/\text{no. of subgroups}$	37	(39 + 35)/2
5	Factor c	2.405	See Table C-3
6	Upper Specification Limit: U	680	
7	Lower Specification Limit: L	620	
8	Quality Index: $Q_U = (U - \bar{X})c/\bar{R}$	2.15	(680 - 647)2.405/37
9	Quality Index: $Q_L = (\bar{X} - L)c/\bar{R}$	1.76	(647 - 620)2.405/37
10	Est. of Lot Percent Ncf. above U : p_U	0.35%	See Table C-5
11	Est. of Lot Percent Ncf. below L : p_L	2.54%	See Table C-5
12	Total Est. Percent Ncf. in Lot: $p = p_U + p_L$	2.89%	0.35% + 2.54%
13	Max. Allowable Percent Ncf. above U : M_U	7.42%	See Table C-3
14	Max. Allowable Percent Ncf. below L : M_L	3.23%	See Table C-3
15	Acceptability Criteria: (a) Compare p_U with M_U	$0.35\% < 7.42\%$	See Para. C12.2.2(7)(a)
	(b) Compare p_L with M_L	$2.54\% < 3.23\%$	See Para. C12.2.2(7)(b)
	(c) Compare p with M_U	$2.89\% < 7.42\%$	See Para. C12.2.2(7)(c)

The lot meets the acceptability criteria, since 15(a), (b), and (c) are satisfied; i.e., $p_U < M_U$, $p_L < M_L$, and $p < M_U$.

Table C-3 Range Method
Master Table for Normal and Tightened Inspection for Plans Based on Variability Unknown
(Double Specification Limit and Form 2—Single Specification Limit)

Sample Size Code Letter	Sample Size	c factor	Acceptance Quality Limits (normal inspection)											
			T	.10	.15	.25	.40	.65	1.00	1.50	2.50	4.00	6.50	10.00
			M	M	M	M	M	M	M	M	M	M	M	M
B	3	0.910	↓	↓	↓	↓	↓	↓	↓	↓	7.59	18.86	26.94	33.69
C	4	2.234	↓	↓	↓	↓	↓	↓	1.53	5.50	10.92	16.45	22.86	29.45
D	5	2.474	↓	↓	↓	↓	↓	1.42	3.44	5.93	9.90	14.47	20.27	26.59
E	7	2.830	↓	↓	↓	.28	.89	1.99	3.46	5.32	8.47	12.35	17.54	23.50
F	10	2.405	↓	↓	.23	.58	1.14	2.05	3.23	4.77	7.42	10.79	15.49	21.06
G	15	2.379	.136	.253	.430	.786	1.30	2.10	3.11	4.44	6.76	9.76	14.09	19.30
H	25	2.358	.214	.336	.506	.827	1.27	1.95	2.82	3.96	5.98	8.65	12.59	17.48
I	30	2.353	.240	.366	.537	.856	1.29	1.96	2.81	3.92	5.88	8.50	12.36	17.19
J	40	2.346	.252	.375	.539	.842	1.25	1.88	2.69	3.73	5.61	8.11	11.84	16.55
K	60	2.339	.244	.356	.504	.781	1.16	1.74	2.47	3.44	5.17	7.54	11.10	15.64
L	85	2.335	.242	.350	.493	.755	1.12	1.67	2.37	3.30	4.97	7.27	10.73	15.17
M	115	2.333	.230	.333	.468	.718	1.06	1.58	2.25	3.14	4.76	6.99	10.37	14.74
N	175	2.331	.210	.303	.427	.655	.972	1.46	2.08	2.93	4.47	6.60	9.89	14.15
P	230	2.330	.215	.308	.432	.661	.976	1.47	2.08	2.92	4.46	6.57	9.84	14.10
			.10	.15	.25	.40	.65	1.00	1.50	2.50	4.00	6.50	10.00	
Acceptance Quality Limits (tightened inspection)														

All AQL values are in percent nonconforming. T denotes plan used exclusively on tightened inspection and provides symbol for identification of appropriate OC curve.

↓ Use first sampling plan below arrow; that is, both sample size as well as M value. When sample size equals or exceeds lot size, every item in the lot must be inspected.

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