INTERNATIONAL STANDARD

ISO
3951-1

Sampling procedures for inspection by variables —

Part 1:
Specification for single sampling plans indexed by acceptance quality limit (AQL) for lot-by-lot inspection for a single quality characteristic and a single AQL

Règles d'échantillonnage pour les contrôles par mesures —

Partie 1: Spécifications pour les plans d'échantillonnage simples indexés d'après le niveau de qualité acceptable (NQA) pour le contrôle lot par lot pour une caractéristique de qualité unique et un NQA unique

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 3951-1 was prepared by Technical Committee ISO/TC 69, *Applications of statistical methods*, Subcommittee SC 5, *Acceptance sampling*.

This first edition of ISO 3951-1 cancels and replaces ISO 3951:1989, of which it constitutes a technical revision. The most significant differences between ISO 3951-1:2003 and ISO 3951:1989 are as follows.

— The acronym AQL now stands for Acceptance Quality Limit rather than Acceptable Quality Level, in order to reflect more accurately its function.

— The coverage of this part of ISO 3951 is constrained to a single, normally distributed variable with a single class of nonconformity. This part of ISO 3951 includes the case of combined control of double specification limits, but procedures for separate or complex control of double specification limits are deferred to ISO 3951-2. More general procedures that can be used for multiple characteristics and/or multiple AQLs are also given in ISO 3951-2.

— The plans have been modified so that their operating characteristic curves more closely match those of the plans in ISO 2859-1. The sample sizes for both the "s" method and the "σ" method are constant along rows of the master tables.

— All acceptability constants (see Annexes B, C, G and I) have been revised and tabulated to three decimal places for an extended range of AQLs corresponding to ISO 2859-1:1999.

— All tabulated values of operating characteristics have been recalculated and related directly to reduced inspection as well as to normal and tightened inspection.

— The annex containing the general statistical theory has been removed. It is planned ultimately to reintroduce this within a guidance document to sampling procedures for inspection by variables.

— Tables that are required for implementing the procedures have been relocated into annexes.

— The annex dealing with the "R" method has been eliminated, now that the availability of calculators with a standard deviation function key is so widespread. Data for acceptance sampling by variables is often substantially more expensive to acquire than data for sampling by attributes, and the "s" method makes more efficient use of this data.

ISO 3951 currently consists of the following parts, under the general title *Sampling procedures for inspection by variables*:

— *Part 1: Specification for single sampling plans indexed by acceptance quality limit (AQL) for lot-by-lot inspection for a single quality characteristic and a single AQL*

— *Part 2: General specification for single sampling plans indexed by acceptance quality limit (AQL) for lot-by-lot inspection of independent quality characteristics*

The following parts are under preparation:

— *Part 3: Double sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

— *Part 5: Sequential sampling plans indexed by acceptance quality limit (AQL) for inspection by variables*

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Introduction

This part of ISO 3951 specifies an acceptance sampling system of single sampling plans for inspection by variables. It is indexed in terms of the Acceptance Quality Limit (AQL), and is designed for users who have simple requirements. A more comprehensive and technical treatment is given in ISO 3951-2. This part of ISO 3951 is complementary to ISO 2859-1.

The objectives of the methods laid down in this part of ISO 3951 are to ensure that lots of an acceptable quality have a high probability of acceptance, and that the probability of not accepting inferior lots is as high as practicable. This is achieved by means of the switching rules, which provide:

a) automatic protection to the consumer (by means of a switch to tightened inspection or discontinuation of sampling inspection) should a deterioration in quality be detected;

b) an incentive (at the discretion of the responsible authority) to reduce inspection costs (by means of a switch to a smaller sample size) if consistently good quality is achieved.

In this part of ISO 3951, the acceptability of a lot is implicitly determined from an estimate of the percentage of nonconforming items in the process, based on a random sample of items from the lot.

This part of ISO 3951 is intended for application to a continuing series of lots of discrete products all supplied by one producer using one production process. If there are different producers or production processes, this part of ISO 3951 is applied to each one separately.

This part of ISO 3951 is intended for application to a single quality characteristic that is measurable on a continuous scale. For two or more such quality characteristics, see ISO 3951-2.

It is assumed in this part of ISO 3951 that measurement error is negligible. For information on allowing for measurement error, see Reference [17] in the Bibliography.

For double specification limits, this part of ISO 3951 treats combined control. For other types of control, see ISO 3951-2.

Inspection by variables for percent nonconforming items, as described in the present document, includes several possible modes, the combination of which leads to a presentation that may appear quite complex to the user:

— unknown standard deviation, or originally unknown then estimated with fair precision, or known since the start of inspection;

— a single specification limit, or combined control of double specification limits;

— normal inspection, tightened inspection or reduced inspection.

Fourteen annexes are provided. Annexes A to I provide the tables needed to support the procedures. Annex J indicates how the sample standard deviation, "s", and the presumed known value of the process standard deviation, "σ", should be determined. Annex K provides the statistical theory underlying the calculation of the consumer's risks, together with tables showing these risks for normal, tightened and reduced inspection as well as for the "s" and "σ" methods. Annex L provides similar information for the producer's risks. Annex M gives the general formula for the operating characteristic of the "σ" method. Annex N provides the statistical theory underlying the estimation of the process fraction nonconforming under the "s" method for sample sizes 3 and 4, which for technical reasons are treated differently from the other sample sizes in this part of ISO 3951.

Table 1 is intended to facilitate the use of this part of ISO 3951 by directing users to the paragraphs and tables concerning any situation with which they may be confronted. Table 1 only deals with Clauses 15, 16, 20, 21 and 22; in every case, it is necessary to have first read the other clauses.

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Table 1 — Summary table

Inspection type	Single specification limit						Double specification limits with combined control					
	"s" method			"σ" method			"s" method			"σ" method		
	Clauses or subclauses	Tables	Charts	Clauses or subclauses	Tables	Charts	Clauses or subclauses	Tables	Charts	Clauses or subclauses	Tables	Charts
Normal inspection	15.1, 15.2, 15.3 and 20.1	A.1, A.2, B.1, B to R	B to R	16.1, 16.2 and 20.1	A.1, A.2, C.1, B to R *	B to R *	15.1, 15.4 and 20.1	A.1, A.2, D.1, F (for $n=3$), G (for $n=3$ or 4), B to R*	s-D to s-R, B to R *	16.1, 16.3 and 20.1	A.1, A.2, C.1, E, B to R *	B to R *
Switching between normal and tightened inspection	20.2, 20.3	B.1, B.2	B to R	20.2, 20.3	C.1, C.2, B to R *	B to R *	20.2, 20.3	D.1, D.2	s-D to s-R, B to R *	20.2, 20.3	C.1, C.2, E	B to R *
Switching between normal and reduced inspection	20.4, 20.5	B.1, B.3	B to R	20.4, 20.5	C.1, C.3, B to R *	B to R *	20.4, 20.5	D.1, D.3	s-D to s-R, B to R *	20.4, 20.5	E	B to R *
Switching between tightened and discontinued inspection	21	B.2	B to R	21	C.2	B to R *	21	D.2	s-D to s-R, B to R *	21	E	B to R *
Switching between the "s" and "σ" methods	22	Annex K		22	Annex K		22	Annex K		22	Annex K	

* But see 8.4.

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Sampling procedures for inspection by variables —

Part 1:
Specification for single sampling plans indexed by acceptance quality limit (AQL) for lot-by-lot inspection for a single quality characteristic and a single AQL

CAUTION —The procedures in this part of ISO 3951 are not suitable for application to lots that have been screened previously for nonconforming items.

1   Scope

This part of ISO 3951 specifies an acceptance sampling system of single sampling plans for inspection by variables, in which the acceptability of a lot is implicitly determined from an estimate of the percentage of nonconforming items in the process, based on a random sample of items from the lot.

This part of ISO 3951 is primarily designed for application under the following conditions:

a)   where the inspection procedure is to be applied to a continuing series of lots of discrete products all supplied by one producer using one production process;

b)   where only a single quality characteristic x of these products is taken into consideration, which must be measurable on a continuous scale;

c)   where the measurement error is negligible, i.e. with a standard deviation no more than 10 % of the process standard deviation;

d)   where production is stable (under statistical control) and the quality characteristic x is distributed according to a normal distribution or a close approximation to the normal distribution;

e)   where a contract or standard defines an upper specification limit U, a lower specification limit L, or both; an item is qualified as conforming if and only if its measured quality characteristic x satisfies the appropriate one of the following inequalities:

1) $x \geqslant L$ (i.e. the lower specification limit is not violated);

2) $x \leqslant U$ (i.e. the upper specification limit is not violated);

3) $x \geqslant L$ and $x \leqslant U$ (i.e. neither the lower nor the upper specification limit is violated).

Inequalities 1) and 2) are called cases with a single specification limit, and 3) a case with double specification limits.

If double specification limits apply, it is assumed in this part of ISO 3951 that conformance to both specification limits is equally important to the integrity of the product; in such cases it is appropriate to apply a single AQL to the combined percentage of product outside the two specification limits. This is referred to as combined control.

2   Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2859-1, *Sampling procedures for inspection by attributes — Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

ISO 3534-1, *Statistics — Vocabulary and symbols — Part 1: Probability and statistical terms*

ISO 3534-2, *Statistics — Vocabulary and symbols — Part 2: Applied statistics*

3   Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 2859-1, ISO 3534-1, and ISO 3534-2 apply.

3.1
inspection by variables
inspection by measuring the magnitude of a characteristic of an item

[ISO 3534-2]

3.2
sampling inspection
inspection of selected items in the group under consideration

[ISO 3534-2]

3.3
acceptance sampling inspection
acceptance sampling
sampling inspection (3.2) to determine whether or not to accept a lot or other amount of product, material or service

[ISO 3534-2]

3.4
acceptance sampling inspection by variables
acceptance sampling inspection (3.3) in which the acceptability of the process is determined statistically from measurements on a specified quality characteristic of each item in a sample from a lot

3.5
process fraction nonconforming
rate at which nonconforming items are generated by a process, expressed as a proportion

3.6
acceptance quality limit (AQL)
worst tolerable **process fraction nonconforming** (3.5) when a continuing series of lots is submitted for **acceptance sampling** (3.3)

NOTE   See Clause 5.

3.7
quality level
quality expressed as a rate of occurrence of nonconforming units

3.8
limiting quality
LQ
quality level (3.7), when a lot is considered in isolation, which, for the purposes of **acceptance sampling inspection** (3.3), is limited to a low probability of acceptance

[ISO 3534-2]

NOTE 1   In this part of ISO 3951, the probability of acceptance is limited to 10 %.

NOTE 2   See 13.1.

3.9
nonconformity
nonfulfilment of a requirement

[ISO 9000]

3.10
nonconforming unit
unit with one or more nonconformities

[ISO 3534-2]

3.11
"s" method acceptance sampling plan
acceptance sampling (3.3) plan by variables using the sample standard deviation

[ISO 3534-2]

NOTE   See Clause 15.

3.12
"σ" method acceptance sampling plan
acceptance sampling (3.3) plan by variables using the presumed value of the process standard deviation

[ISO 3534-2]

NOTE   See Clause 16.

3.13
specification limit
conformance boundary specified for a characteristic

[ISO 3534-2]

3.14
lower specification limit
L
specification limit [3.13] that defines the lower conformance boundary

[ISO 3534-2]

3.15
upper specification limit
U
specification limit (3.13) that defines the upper conformance boundary

[ISO 3534-2]

3.16
combined control
requirement when both upper and lower limits are specified for the quality characteristic and an **AQL** (3.6) is given that applies to the combined percent nonconforming beyond the two limits

NOTE 1   See 5.3.

NOTE 2   The use of combined control implies that nonconformity beyond either **specification limit** (3.13) is believed to be of equal, or at least roughly equal, importance to the lack of integrity of the product.

3.17
acceptability constant
k
constant depending on the specified value of the **acceptance quality limit** (3.6) and the sample size, used in the criteria for accepting the lot in an **acceptance sampling** (3.3) plan by variables

[ISO 3534-2]

NOTE   See 15.2 and 16.2.

3.18
quality statistic
Q
function of the **specification limit** (3.13), the sample mean, and the sample or process standard deviation, used in assessing the acceptability of a lot

[ISO 3534-2]

NOTE 1   For the case of a single **specification limit** (3.13), the lot may be sentenced on the result of comparing Q with the **acceptability constant** (3.17) k.

NOTE 2   See 15.2 and 16.2.

3.19
lower quality statistic
Q_L
function of the **lower specification limit** (3.14), the sample mean, and the sample or process standard deviation

NOTE 1   For a single lower **specification limit** (3.14), the lot is sentenced on the result of comparing Q_L with the **acceptability constant** (3.17) k.

[ISO 3534-2]

NOTE 2   See Clause 4, 15.2 and 16.2.

3.20
upper quality statistic
Q_U
function of the **upper specification limit** (3.15), the sample mean, and the sample or process standard deviation

NOTE 1   For a single **upper specification limit** (3.15) the lot is sentenced on the result of comparing Q_U with the **acceptability constant** (3.17) k.

[ISO 3534-2]

NOTE 2   See Clause 4, 15.2 and 16.2.

3.21
maximum sample standard deviation
MSSD

s_{max}

largest sample standard deviation for a given sample-size code letter and **acceptance quality limit** (3.6) for which it is possible to satisfy the acceptance criterion for the combined control of double **specification limits** (3.13) when the process variability is unknown

NOTE   See 15.4.

3.22
maximum process standard deviation
MPSD

σ_{max}

largest process standard deviation for a given sample-size code letter and **acceptance quality limit** (3.6) for which it is possible to satisfy the acceptance criterion for the combined control of double **specification limits** (3.13) under tightened inspection when the process variability is known

NOTE   See 16.3.

3.23
switching rule
instruction within an **acceptance sampling** (3.3) scheme for changing from one **acceptance sampling** (3.3) plan to another of greater or lesser severity based on demonstrated quality history

[ISO 3534-2]

NOTE 1   See Clause 20.

NOTE 2   Normal, tightened or reduced inspection, or discontinuation of inspection, are examples of "greater or lesser severity".

3.24
measurement
Set of operations to determine the value of some quantity

[ISO 3534-2]

4   Symbols

c_U factor for determining the upper control limit for the sample standard deviation (see Annex H)

f_s factor that relates the maximum sample standard deviation to the difference between U and L (see Annex D)

f_σ factor that relates the maximum process standard deviation under tightened inspection to the difference between U and L (see Annex E)

k acceptability constant for the "s" method or Annex C for the "σ" method (see Annex B)

L lower specification limit (as a suffix to a variable, denotes its value at L)

μ process mean

N lot size (number of items in a lot)

n sample size (number of items in a sample)