
**Sampling procedures for inspection
by variables —**

Part 2:

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

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Règles d'échantillonnage pour les contrôles par mesures —

*Partie 2: Spécification générale pour les plans d'échantillonnage
simples, indexés d'après la limite d'acceptation de qualité (LAQ), pour
les contrôles lot par lot des caractéristiques de qualité indépendantes*



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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 3951-2 was prepared by Technical Committee ISO/TC 69, *Applications of statistical methods*, Subcommittee SC 5, *Acceptance sampling*.

This first edition of ISO 3951-2, together with ISO 3951, cancels and replaces ISO 3951:1989, of which it constitutes a technical revision.

The most significant differences between ISO 3951-2:2006 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.
- ISO 3951-2:2006 not only covers the univariate procedures of ISO 3951:1989 but also includes separate and complex control of double specification limits and multivariate procedures for independent characteristics.
- The plans have been modified so that their operating characteristic curves match those of the plans in ISO 2859-1 more closely. The sample sizes for both the “*s*” method and the “ σ ” method are constant along rows of the master tables.
- The acceptability constants of Annexes B and C have been recalculated and tabulated to three decimal places for an extended range of AQLs corresponding to ISO 2859-1:1999. A new master table of Form *p** acceptability constants is provided as Annex G, tabulated to four significant figures.
- 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 statistical theory has been removed. It is planned ultimately to reintroduce this within a guidance document to sampling procedures for inspection by variables.
- Text and tables that are merely informative have been consigned to annexes wherever practicable.
- 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.

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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*
- *Part 5: Sequential sampling plans indexed by acceptance quality limit (AQL) for inspection by variables (known standard deviation)*

The following part is under preparation:

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

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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 of a technical nature, aimed at users who are already familiar with sampling by variables or who have complicated requirements. (An introductory treatment is given in ISO 3951-1.)

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) should consistently good quality be achieved.

In this part of ISO 3951, the acceptability of a lot is implicitly or explicitly 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 complementary to ISO 2859-1. When specified by the responsible authority, both ISO 3951-2 and ISO 2859-1 may be referenced in a product specification, contract, inspection instructions, or other documents, and the provisions set forth therein shall govern. The "responsible authority" shall be designated in one of the above documents.

It is assumed in this part of ISO 3951 that measurement uncertainty is negligible (see ISO 10576-1:2003). For further information on allowing for measurement uncertainty in sampling by variables, see Reference [16] in the Bibliography.

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

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 double specification limits with combined, separate or complex control;
- univariate or multivariate cases;
- 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 formulae for the estimation of the process fraction nonconforming, together with a highly accurate approximation for use when the process standard deviation is unknown.
- Annex L provides the statistical theory underlying the calculation of the consumer's risk qualities, together with tables showing these quality levels for normal, tightened and reduced inspection under the " s " and " σ " methods.
- Annex M provides similar information for the producer's risks.
- Annex N gives the general formula for the operating characteristic of the " σ " method.

Table 1 is intended to facilitate the use of this part of ISO 3951 by directing the user to the paragraphs and tables concerning any situation with which he may be confronted. Table 1 only deals with Clauses 15, 16, 17, 18, 19, 23, 24 and 25; in every case, it is necessary first of all to have read the other clauses.

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Table 1— Summary

Inspection type	Single specification limit			Double specification limits with combined control			
	“s” method			“σ” method			
	Clauses or sub-clauses	Tables	Clauses or sub-clauses	Tables	Clauses or sub-clauses	Tables	
Normal inspection	15.1, 15.2, 15.3, 16.2, 23.1	A.1, A.2, B.1	17.1, 17.2, 18, 19, 23.1	A.1, A.2, C.1	15.1, 15.4, 16.2, 23.1	A.1, A.2, D.1, F.1 (for $n = 3$), G.1	A.1, A.2, C.1, E.1
Switching between normal and tightened inspection	23.2, 23.3	B.1, B.2	23.2, 23.3	C.1, C.2	23.2, 23.3	D.1, D.2, G.1, G.2	E.1 G.1, G.2
Switching between normal and reduced inspection	23.4, 23.5	B.1, B.3 I.1	23.4, 23.5	C.1, C.3 I.1	23.4, 23.5	D.1, D.3, G.1, G.3 I.1	E.1 G.1, G.3 I.1
Switching between tightened and discontinued inspection	21, 24	B.2	24	C.2	21, 24	D.2, G.2	E.1 G.2
Switching between the “s” and “σ” methods	25 K.2.1 K.3, K.4, K.5	H.1	25 K.2.2	H.1	25 K.2.1 K.3, K.4, K.5	H.1	H.1

Table 1 (continued)

Inspection type	Double specification limits with separate control			Double specification limits with complex control		
	“ s ” method		“ σ ” method	“ s ” method		“ σ ” method
	Clauses or sub-clauses	Tables	Clauses or sub-clauses	Tables	Clauses or sub-clauses	Tables
Normal inspection	15.1, 15.4, 16.2, 23.1	A.1, A.2, D.1, F.1 (for $n = 3$), G.1	17.1, 17.2, 17.3, 18, 19, 23.1	A.1, A.2, C.1, E.2	15.1, 15.5, 16.2, 23.1	A.1, A.2, D.1, F (for $n = 3$), G.1
Switching between normal and tightened inspection	23.2, 23.3	D.1, D.2 G.1, G.2	23.2, 23.3	E.1 G.1, G.2	23.2, 23.3	D.1, D.2 G.1, G.2
Switching between normal and reduced inspection	23.4, 23.5	D.1, D.3 G.1, G.3 I.1	23.4, 23.5	E.2 G.1, G.3 I.1	23.4, 23.5	D.1, D.3 G.1, G.3 I.1
Switching between tightened and discontinued inspection	21, 24	D.2 G.2	24	E.1 G.2	21, 24	D.2 G.2
Switching between the “ s ” and “ σ ” methods	25 K.2.1 K.3, K.4, K.5	H.1	25 K.2.2	H.1	25 K.2.1 K.3, K.4, K.5	25 K.2.2 H.1

Sampling procedures for inspection by variables —

Part 2:

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

1 Scope

This part of ISO 3951 specifies an acceptance sampling system of single sampling plans for inspection by variables, indexed in terms of the Acceptance Quality Limit (AQL).

This part of ISO 3951 is primarily designed for use 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. If there are different producers or production processes, apply this part of ISO 3951 to each one separately;
- b) where the quality characteristics of the items of product are measurable on a continuous scale;
- c) where the measurement error is negligible (i.e. with a standard deviation no more than 10 % of the corresponding process standard deviation);
- d) where production is stable (under statistical control) and the quality characteristics are distributed, at least to a close approximation, according to normal distributions;
- e) where, in the case of multiple quality characteristics, the characteristics are independent of one another, at least approximately;
- f) where a contract or standard defines an upper specification limit U , a lower specification limit L , or both on each of the quality characteristics.

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 2859-1:1999, *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 general statistical terms*

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

ISO 9000, *Quality management systems — Fundamentals and vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 3534-1, ISO 3534-2, ISO 2859-1 and ISO 9000 apply, except where redefined below. References are given in square brackets for definitions that have been repeated here for convenience.

3.1

inspection by variables

inspection by measuring the magnitude(s) of a characteristic(s) 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 inspection where the acceptability is determined by means of **sampling inspection** (3.2)

[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 specified quality characteristics 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

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3.6

acceptance quality limit

AQL

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

NOTE See Clause 5.

3.7

quality level

quality expressed as a rate of occurrence of nonconforming items

3.8

consumer's risk quality

CRQ

quality level (3.7) of a process which, in the acceptance sampling plan, corresponds to a specified consumer's risk

NOTE 1 In this part of ISO 3951, the quality level is the process fraction nonconforming.

NOTE 2 In this part of ISO 3951, the consumer's risk quality is such that the consumer's risk is 10 %.

3.9

producer's risk

PR

probability of non-acceptance when the **quality level** (3.7) has a value stated by the plan as acceptable

NOTE Quality level relates to the **process fraction nonconforming** (3.5) and acceptable relates to the **AQL** (3.6).

3.10**nonconformity**

non-fulfilment of a requirement

[ISO 9000]

NOTE Nonconformity will generally be classified by its degree of seriousness, such as:

- **Class A.** Nonconformity of a type considered to be of the highest concern for the product or service. Such types of nonconformity will typically be assigned very small AQL values.
- **Class B.** Nonconformity of a type considered to have the next lower degree of concern; this is typically assigned a larger AQL value than that in Class A and smaller than that in Class C if a third class exists, and so on.

The number of classes and the assignment into a class should be appropriate to the quality requirements of the specific situation.

3.11**nonconforming unit**

unit with one or more nonconformities

[ISO 3534-2]

3.12**"s" method acceptance sampling plan****s method**

acceptance sampling plan by variables using the sample standard deviation

[ISO 3534-2]

NOTE See Clause 15.

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3.13**"σ" method acceptance sampling plan****sigma method**

acceptance sampling plan by variables using the presumed value of the process standard deviation(s)

[ISO 3534-2]

NOTE See Clause 16.

3.14**specification limit**

limiting value stated for a characteristic

[ISO 3534-2]

3.15**lower specification limit**

specification limit (3.14) that defines the lower limiting value

NOTE The preferred symbol for the lower specification limit is *L*.

[ISO 3534-2]

3.16
upper specification limit

specification limit (3.14) that defines the upper limiting value

NOTE The preferred symbol for the upper specification limit is U .

[ISO 3534-2]

3.17
combined control

requirement when **nonconformity** (3.10) beyond both the **upper** and the **lower specification limits** (3.16, 3.15) of a quality characteristic belongs to the same class, to which a single AQL is applied

NOTE 1 See 5.3, 15.3.2 and 17.3.

NOTE 2 The use of a combined **AQL** (3.6) requirement implies that nonconformities beyond either **specification limit** (3.14) are believed to be of equal, or at least roughly equal, importance to the lack of integrity of the product.

3.18
separate control

requirement when nonconformity beyond the **upper** and the **lower specification limits** (3.16, 3.15) of a quality characteristic belongs to different classes, to which separate **AQLs** (3.6) are applied

NOTE See 5.3, 15.3.3 and 17.2.

3.19
complex control

requirement when nonconformity beyond the **upper specification limit** (3.16) and the **lower specification limits** (3.15) of a quality characteristic belongs to one class, and nonconformity beyond either the upper specification limit or the lower specification limit belongs to a different class, with separate **AQLs** (3.6) being applied to the two classes

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NOTE See 5.3, 15.3.4 and 17.3.

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3.20
acceptability constant

k, p^*

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 plan by variables

[ISO 3534-2]

NOTE See 15.2 and 16.2.

3.21
quality statistic

Q

function of the **specification limit** (3.14), the sample mean, and the sample or process standard deviation, used in assessing the acceptability of a lot (see 4.1, symbols Q_L and Q_U)

[ISO 3534-2]

NOTE 1 For the case of a single specification limit, the lot may be sentenced on the result of comparing Q with the **acceptability constant** (3.20) k .

NOTE 2 See 15.2 and 16.2.

3.22**lower quality statistic**

function of the **lower specification limit** (3.15), the sample mean, and the sample or process standard deviation

[ISO 3534-2]

NOTE 1 For a single, lower specification limit, the lot is sentenced on the result of comparing Q_L with the **acceptability constant** (3.20) k .

NOTE 2 See Clause 4, 15.2 and 16.2.

3.23**upper quality statistic**

function of the **upper specification limit** (3.16), the sample mean, and the sample or process standard deviation

[ISO 3534-2]

NOTE 1 For a single, upper specification limit, the lot is sentenced on the result of comparing Q_U with the **acceptability constant** (3.20) k .

NOTE 2 See Clause 4, 15.2 and 16.2.

3.24**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 double **specification limits** (3.14) with a combined **AQL** (3.6) requirement and unknown process variability

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NOTE See 15.3.

3.25**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 double **specification limits** with a combined **AQL** (3.6) requirement under tightened inspection with known process variability

NOTE See 17.2 and 17.3.

3.26**switching rule**

instruction within an acceptance sampling scheme for changing from one acceptance sampling plan to another of greater or lesser severity of sampling based on demonstrated quality history

[ISO 3534-2]

NOTE 1 Normal, tightened or reduced inspection, or discontinuation of inspection, are examples of "greater or lesser severity".

NOTE 2 See Clauses 6 and 23.

3.27**measurement**

set of operations having the object of determining a value of a quantity

[ISO 3534-2]