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## 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

*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*

[Revision of first edition (ISO 3951-2:2006) and ISO 3951-2:2006/Amd.1:2009]

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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, *Application of statistical methods*, Subcommittee SC 5, *Acceptance sampling schemes*.

This edition cancels and replaces (ISO 3951-2:2005), which has been technically revised.

ISO 3951 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 - Single quality characteristic and single AQL*
- Part 2: *General specification for single sampling plans indexed by acceptance quality limit (AQL) for lot-by-lot inspection*
- Part 3: *Double sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*
- Part 4: *Procedures for assessment of declared quality levels*
- Part 5: *Sequential sampling plans indexed by acceptance quality limit (AQL) for inspection by variables (known standard deviation)*

The most significant differences between ISO 3951-2:2011 and ISO 3951-2:2006 are that

- procedures have been introduced to accommodate measurement uncertainty;
- many of the sampling plans have been adjusted to improve the match between their operating characteristic curves and the operating characteristic curves of the corresponding plans for single sampling by attributes in ISO 2859-1.

Sixteen annexes are provided. Annexes A to J provide the tables needed to support the procedures. Annex K indicates how the sample standard deviation,  $s$ , and the presumed known value of the process standard deviation,  $\sigma$ , should be determined. Annex L 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 M provides formulae for the consumer's risk qualities, together with tables showing these quality levels for normal, tightened and reduced inspection under the  $s$ -method and  $\sigma$ -method. Annex N provides similar information for the producer's risks. Annex O gives the general formula for the operating characteristic of the  $\sigma$ -method. Annex P provides procedures for accommodating measurement uncertainty.

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## Introduction

This International Standard 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. (A more introductory treatment is given in ISO 3951-1.)

The objectives of the methods laid down in this International Standard 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 International Standard, the acceptability of a lot is either 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.

ISO 3951-2 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, ISO 3951-2 is applied to each one separately.

ISO 3951-2 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.

**Caution The procedures in this International Standard 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;
- three inspection severities, namely normal inspection, tightened inspection or reduced inspection.

The summary tables given below are intended to facilitate the use of the standard by directing the user to the paragraphs and tables concerning any situation with which he may be confronted. The tables only deal with Clauses 15, 16, 17, 18, 19, 23, 24 and 25; in every case, it is necessary first of all to have read all the preceding clauses.

Summary table

|   | Single specification limit             |                 |                          |                 | Double specification limits with combined control |                                   |                          |                        |
|---|--|-----------------|--------------------------|-----------------|---|-----------------------------------|--------------------------|------------------------|
|   | "s" method                             |                 | "σ" method               |                 | "s" method  |                                   | "σ" method               |                        |
|   | Clauses or sub-clauses                 | Tables          | Clauses or sub-clauses   | Tables          | Clauses or sub-clauses                            | Tables                            | Clauses or sub-clauses   | Tables                 |
| Normal inspection                                       | 16.1, 16.2, 16.3, 17.1, 17.2, 20, 24.1 | A.1, B.1        | 18.1, 18.2, 19, 20, 24.1 | A.1, C.1        | 16.1, 16.3, 17.1, 17.2, 20, 24.1<br>Annex L       | A.1, D.1, H.1 (for $n = 3$ ), I.1 | 18.1, 18.3, 19, 20, 24.1 | A.1, C.1, E.1          |
| Switching between normal and tightened inspection       | 24.2, 24.3                             | B.1, B.2        | 24.2, 24.3               | C.1, C.2        | 24.2, 24.3  | D.1, D.2<br>F.1, F.2              | 24.2, 24.3               | E.1, E.2<br>G.1, G.2   |
| Switching between normal and reduced inspection         | 24.4, 24.5                             | B.1, B.3<br>J.1 | 24.4, 24.5               | C.1, C.3<br>J.1 | 24.4, 24.5  | D.1, D.3<br>F.1, F.3<br>J.1       | 24.4, 24.5               | E.1<br>G.1, G.3<br>J.1 |
| Switching between tightened and discontinued inspection | 22, 25                                 | B.2             | 25                       | C.2             | 22, 25  | D.2<br>F.2                        | 25                       | E.2<br>G.1             |
| Switching between the "s" and "σ" methods               | 25                                     | I.1             | 26                       | I.1, K.2        | 26<br>L.2.1<br>L.3, L.4, L.5                      | I.1                               | 26<br>L.2.2              | I.1, K.2               |

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Summary table (concluded)

|   | 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                            | Clauses or sub-clauses   | Tables             |
| Normal inspection                                       | 16.1, 16.3.3, 17.1, 17.2, 20, 24.1, Annex L       | A.1, D.1, H.1 (for $n = 3$ ), I.1 | 18.1, 18.2, 18.3, 19, 20, 24.1 | A.1, C.1, E.1      | 16.1, 16.3.4, 17.1, 17.2, 20, 24.1, Annex L      | A.1, D.1, H.1 (for $n = 3$ ), I.1 | 18.1, 18.3, 19, 20, 24.1 | A.1, C.1, E.1      |
| Switching between normal and tightened inspection       | 24.2, 24.3  | D.1, D.2, F.1, F.2                | 24.2, 24.3                     | E.1, E.2, G.2      | 24.2, 24.3                                       | D.1, D.2, F.1, F.2                | 24.2, 24.3               | E.1, E.2, G.3      |
| Switching between normal and reduced inspection         | 24.4, 24.5  | D.1, D.3, F.1, F.3, J.1           | 24.4, 24.5                     | E.1, E.3, G.2, J.1 | 24.4, 24.5                                       | D.1, D.3, F.1, F.3, J.1           | 24.4, 24.5               | E.1, E.3, G.3, J.1 |
| Switching between tightened and discontinued inspection | 22, 25  | D.2, F.2                          | 25                             | E.2, G.2           | 22, 25   | D.2, F.2                          | 25                       | E.2, G.3           |
| Switching between the "s" and "σ" methods               | 26, L.2.1, L.3, L.4, L.5                          | I.1                               | 26, L.2.2                      | I.1, K.2           | 26, L.2.1, L.3, L.4, L.5                         | I.1                               | 26, L.2.2                | I.1, K.2           |

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# 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 International Standard 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, this International Standard shall be applied 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). However, procedures are also provided in clause 9 and Annex P for accommodating measurement error when it has a non-negligible 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, or almost independent, of one another;

f) where a contract or standard defines a **lower specification limit  $L$** , an **upper specification limit  $U$** , or **both** on each of the quality characteristics. If there is only one quality characteristic, an item is qualified as conforming if its measured quality characteristic  $x$  satisfies the appropriate one of the following inequalities:

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

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

(iii)  $x \geq L$  and  $x \leq U$  (i.e. neither the lower nor the upper specification limit is violated).

If there are two or more, say  $m$ , quality characteristics, then, designating the lower and upper limits for the  $i^{\text{th}}$  quality characteristic by  $L_i$  and  $U_i$  respectively, an item of product is qualified

as nonconforming if one or more of its  $m$  measured quality characteristics  $x_i$  fails to satisfy the appropriate one of the following inequalities:

(iv)  $x_i \geq L_i$ ;

(v)  $x_i \leq U_i$ ;

(vi)  $x_i \geq L_i$  and  $x_i \leq U_i$ .

Inequalities (i), (ii), (iv) and (v) are called cases with a **single specification limit**, while

(iii) and (vi) are called cases with **double specification limits**. For double specification limits a further distinction is made between combined control, separate control and complex control. If there is only one quality characteristic, then:

combined control is where a single AQL applies to nonconformity beyond both limits;

separate control is where separate AQLs apply to nonconformity beyond each of the limits;

complex control is where one AQL applies to nonconformity beyond the limit that is of greater seriousness, and a larger AQL applies to the total nonconformity beyond both limits.

If there are two or more quality characteristics, this generalises as follows:

combined control is where nonconformity beyond both limits on a variable belongs to the same class, to which a single AQL applies;

separate control is where nonconformity beyond the two limits on a variable belongs to separate classes, to each of which a single AQL applies;

complex control is where nonconformity beyond the limit that is of greater seriousness belongs to one class to which a single AQL applies, and the total nonconformity beyond both limits belongs to another class to which a larger AQL applies.

Note that, in the case of two or more quality characteristics, nonconformity on more than one quality characteristic may belong to the same class.

## 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 2859-2, *Sampling procedures for inspection by attributes - Part 2: Sampling plans indexed by limiting quality (LQ) for lot-by-lot inspection*

ISO 3951-1:2004, *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*

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

ISO 3534-2, *Statistics - Vocabulary and symbols - Part 2: Statistical quality control*

### 3 Terms and definitions

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

#### 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 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

#### 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) (see Clause 5)