BS ISO 3951-1:2013



BSI Standards Publication

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

bsi.

...making excellence a habit.™

National foreword

This British Standard is the UK implementation of ISO 3951-1:2013. It supersedes BS 6002-1:2007 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee SS/5, Acceptance sampling schemes.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2013. Published by BSI Standards Limited 2013

ISBN 978 0 580 75507 1

ICS 03.120.30

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 September 2013.

Amendments issued since publication

Date	Text affected

BS ISO 3951-1:2013

INTERNATIONAL STANDARD

ISO 3951-1

Second edition
2013-09-01

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

Reference number
ISO 3951-1:2013(E)

© ISO 2013



COPYRIGHT PROTECTED DOCUMENT

© ISO 2013

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

Foreword ... **vi**

Introduction ... **vii**

1 Scope ... **1**

2 Normative references ... **1**

3 Terms and definitions ... **2**

4 Symbols ... **5**

5 Acceptance quality limit (AQL) ... **6**
5.1 Concept ... 6
5.2 Use ... 7
5.3 Specifying AQLs ... 7
5.4 Preferred AQLs ... 7
5.5 Caution ... 7
5.6 Limitation ... 7

6 Switching rules for normal, tightened, and reduced inspection ... **7**

7 Relation to ISO 2859-1 ... **8**
7.1 Similarities ... 8
7.2 Differences ... 8

8 Consumer protection ... **9**
8.1 Use of individual plans ... 9
8.2 Consumer's risk quality (CRQ) tables ... 9
8.3 Producer's risk tables ... 9
8.4 Operating characteristic (OC) curves ... 9

9 Allowing for measurement uncertainty ... **10**

10 Planning ... **10**

11 Choice between variables and attributes ... **10**

12 Choice between the *s*-method and σ-method ... **11**

13 Choice of inspection level and AQL ... **11**

14 Choice of sampling scheme ... **11**
14.1 Standard plans ... 11
14.2 Special plans ... 12

15 Preliminary operations ... **12**

16 Standard procedures for the *s*-method ... **13**
16.1 Obtaining a plan, sampling, and preliminary calculations ... 13
16.2 Acceptability criteria for single specification limits ... 13
16.3 Graphical method for a single specification limit ... 15
16.4 Acceptability criterion for combined control of double specification limits ... 15

17 Standard procedures for the σ-method ... **21**
17.1 Obtaining a plan, sampling, and preliminary calculations ... 21
17.2 Acceptability criteria for a single specification limit ... 21
17.3 Acceptability criterion for combined control of double specification limits ... 22

18 Procedure during continuing inspection ... **23**

19 Normality and outliers ... **24**
19.1 Normality ... 24
19.2 Outliers ... 24

20 Records ... **24**

© ISO 2013 – All rights reserved

20.1 Control charts 24
20.2 Lots that are not accepted 24

21 Operation of switching rules 24

22 Discontinuation and resumption of inspection 25

23 Switching between the *s*-method and *σ*-method 25
23.1 Estimating the process standard deviation 25
23.2 State of statistical control 26
23.3 Switching from the ***s***-method to the ***σ***-method 26
23.4 Switching from the ***σ***-method to the ***s***-method 26

24 Charts B to R — Operating characteristic curves and tabulated values for single sampling plans, normal inspection: *s*-method 28
24.1 Operating characteristic curves and tabulated values for sample size code letter B: ***s***-method 28
24.2 Operating characteristic curves and tabulated values for sample size code letter C: ***s***-method 29
24.3 Operating characteristic curves and tabulated values for sample size code letter D: ***s***-method 30
24.4 Operating characteristic curves and tabulated values for sample size code letter E: ***s***-method 31
24.5 Operating characteristic curves and tabulated values for sample size code letter F: ***s***-method 32
24.6 Operating characteristic curves and tabulated values for sample size code letter G: ***s***-method 33
24.7 Operating characteristic curves and tabulated values for sample size code letter H: ***s***-method 34
24.8 Operating characteristic curves and tabulated values for sample size code letter J: ***s***-method 35
24.9 Operating characteristic curves and tabulated values for sample size code letter K: ***s***-method 36
24.10 Operating characteristic curves and tabulated values for sample size code letter L: ***s***-method 37
24.11 Operating characteristic curves and tabulated values for sample size code letter M: ***s***-method 38
24.12 Operating characteristic curves and tabulated values for sample size code letter N: ***s***-method 39
24.13 Operating characteristic curves and tabulated values for sample size code letter P: ***s***-method 40
24.14 Operating characteristic curves and tabulated values for sample size code letter Q: ***s***-method 41
24.15 Operating characteristic curves and tabulated values for sample size code letter R: ***s***-method 42

25 Charts s-D to s-R — Acceptance curves for combined control of double specification limits: *s*-method 43

Annex A (normative) **Table for determining the sample size code letter 56**

Annex B (normative) **Form *k* for single sampling plans: *s*-method 57**

Annex C (normative) **Form *k* for single sampling plans: *σ*-method 60**

Annex D (normative) **Values of f_s for maximum sample standard deviation (MSSD) 63**

Annex E (normative) **Values of f_σ for maximum process standard deviation (MPSD) 66**

Annex F (normative) **Estimating the process fraction nonconforming for sample size 3: *s*-method 67**

Annex G (normative) **Single sampling plans of Form *p**** 70

Annex H (normative) **Values of c_U for upper control limit on the sample standard deviation 71**

 © ISO 2013 – All rights reserved

Annex I (normative) **Supplementary acceptability constants for qualifying towards reduced inspection** **72**

Annex J (normative) **Procedures for obtaining *s* and *σ*** **73**

Annex K (informative) **Consumer's risk qualities** **75**

Annex L (informative) **Producer's risks** **79**

Annex M (informative) **Operating characteristics for the *σ*-method** **83**

Annex N (informative) **Estimating the process fraction nonconforming for sample sizes 3 and 4: *s*-method** **84**

Annex O (normative) **Accommodating measurement variability** **87**

Bibliography **92**

© ISO 2013 – All rights reserved

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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 69, *Application of statistical methods,* SC 5, *Acceptance sampling.*

This second edition cancels and replaces the first edition (ISO 3951-1:2006), of which it constitutes a minor revision with the following changes:

— 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.

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 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 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)*

© ISO 2013 – All rights reserved

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 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 the following:

a) an 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 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 the body of this part of ISO 3951 that measurement error is negligible (see ISO 10576-1:2003). For information on allowing for measurement error, see Annex O, which was derived from Reference [20] in the Bibliography.

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

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

Inspection by variables for percent nonconforming items, as described in this part of ISO 3951, 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.

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

© ISO 2013 – All rights reserved

Table 1 — Summary table

Inspection	Single specification limit						Double specification limits with combined control					
	s–method			*σ*–method			*s*–method			*σ*–method		
	Clauses or sub-clauses	Tables/ Annexes	Charts	Clauses or sub-clauses	Tables/ Annexes	Charts	Clauses or sub-clauses	Tables/ Annexes	Charts	Clauses or sub-clauses	Tables/ Annexes	Charts
Normal inspection	16.1, 16.2, 16.3, 21.1	A.1, B.1, B to R	B to R	17.1, 17.2, 21.1	A.1, C.1, B to R[a]	B to R[a]	16.1, 16.4, 21.1	A.1, D.1, F.1 (for $n = 3$), G.1 (for $n = 3$ or 4), B to R[a]	*s*-D to *s*-R, B to R[a]	17.1, 17.3 and 21.1	A.1, C.1, E.1, B to R[a]	B to R[a]
Switching between normal and tightened inspection	21.2, 21.3	B.1, B.2	B to R	21.2, 21.3	C.1, C.2	B to R[a]	21.2, 21.3	D.1, D.2	*s*-D to *s*-R, B to R[a]	21.2, 21.3	C.1, C.2, E.1	B to R[a]
Switching between normal and reduced inspection	21.4, 21.5	B.1, B.3	B to R	21.4, 21.5	C.1, C.3, I	B to R[a]	21.4, 21.5	D.1, D.3, G.1 (for $n = 3$ or 4)	*s*-D to *s*-R, B to R[a]	21.4, 21.5	C.1, C.3, E.1	B to R[a]
Switching between tightened and dis- contin-ued inspec-tion	22	B.2	B to R	22	C.2	B to R[a]	22	D.2	*s*-D to *s*-R, B to R[a]	22	E.1	B to R[a]
Switching between the *s*-method and σ-method	23	Annex J		23	Annex J		23	Annex J		23	Annex E, Annex J	

[a] But see 8.4.

Fifteen 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 risk qualities, together with tables showing these quality levels for normal, tightened, and reduced inspection as well as for the *s*–method and *σ*–method. 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. Annex O provides procedures for accommodating measurement uncertainty.

© ISO 2013 – All rights reserved

INTERNATIONAL STANDARD **ISO 3951-1:2013(E)**

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

1 Scope

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;

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 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;

d) where a contract or standard defines a lower specification limit, L, an upper specification limit, U, 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) $x \geq L$ (i.e. the lower specification limit is not violated);

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

   3) $x \geq L$ and $x \leq U$ (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.

Where 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 a product outside the two specification limits. This is referred to as combined control.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 isolated lot inspection*

ISO 3534-1, *Statistics — Vocabulary and symbols — Part 1: General statistical terms and terms used in probability*

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

© ISO 2013 – All rights reserved