INTERNATIONAL STANDARD

ISO 3951-4

First edition
2011-08-15

Sampling procedures for inspection by variables —

Part 4: Procedures for assessment of declared quality levels

Règles d'échantillonnage pour les contrôles par mesures —

Partie 4: Procédures pour l'évaluation des niveaux déclarés de qualité

Reference number
ISO 3951-4:2011(E)

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

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 3951-4 was prepared by Technical Committee ISO/TC 69, *Application of statistical methods*, Subcommittee SC 5, *Acceptance sampling*.

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)*

Introduction

The procedures in this part of ISO 3951 differ in their scope from the procedures in ISO 3951 Parts 1, 2, 3 and 5. The acceptance sampling procedures that are specified in ISO 3951 Parts 1, 2, 3 and 5 are intended to be used in bilateral agreements between two parties. Those acceptance sampling procedures are intended to be used as simple, pragmatic rules for releasing product after inspection of only a limited sample of a consignment, and therefore the procedures do not make reference (either explicitly or implicitly) to any formally declared quality level.

Under acceptance sampling, there is no sharp borderline between quality levels that should be considered acceptable and qualities that should be rejected by the procedure. For the procedures in ISO 3951 Parts 1, 2, 3 and 5, the two parties agree upon some limiting quality level (AQL) which is the worst tolerable process average when a continuing series of lots is submitted. The switching rules and the sampling schemes in those four standards are designed to encourage the suppliers to have process averages consistently better than the AQL selected. In order to keep sample sizes moderate, the protection against accepting individual lots of inferior quality may be less than that provided by sampling plans targeted for sentencing individual lots.

Procedures in ISO 3951 Parts 1, 2, 3 and 5 are well suited for acceptance sampling purposes, but they should not be used in reviews, audits, etc. to verify a quality that has been declared for some entity. The main reason is that the procedures have been indexed in terms of quality levels that are relevant solely for the pragmatic purposes of acceptance sampling, and the various risks have been balanced accordingly.

The procedures in this part of ISO 3951 have been developed as a response to the growing need for sampling procedures suitable for formal, systematic inspections such as reviews or audits. When performing such a formal inspection, it is necessary for the authority to consider the risk of reaching an incorrect conclusion, and to take this risk into account in planning and executing the review/audit/testing, etc.

This part of ISO 3951 provides guidance and rules to assist the user in taking this risk into account in an informed manner.

The rules in this part of ISO 3951 have been devised such that there is only a small, limited risk of contradicting the declared quality level when in fact the actual level conforms to the declared level.

If it were also desired that there should be a similarly small risk of not contradicting the declared quality level when in fact the actual quality level does not conform to the declared quality level, then it would be necessary to investigate a rather large sample. Therefore, in order to obtain the benefit of a moderate sample size, the procedures in this part of ISO 3951 have been devised in such a way that they allow a somewhat higher risk of failing to contradict the declared quality level when in fact the actual quality level does not conform to the declared quality level.

The wording of the result of the assessment should reflect this unbalance between the risks of reaching incorrect conclusions.

When the sample result contradicts the declared quality level, *there is strong evidence of nonconformance to the declared quality level.*

When the sample result does not contradict the declared quality level, this should be understood as “we have not, in this limited sample, found strong evidence of nonconformance to the declared quality level”.

Sampling procedures for inspection by variables —

Part 4: Procedures for assessment of declared quality levels

1 Scope

This part of ISO 3951 establishes sampling plans and procedures by variables that can be used to assess whether the quality level of an entity (lot, process, etc.) conforms to a declared value. The sampling plans have been devised so that their operating characteristic curves match those of the corresponding attributes plans in ISO 2859-4 as closely as possible, so that the choice between using sampling by attributes and sampling by variables is not influenced by attempts to increase the chance of accepting an incorrectly declared quality level. In this part of ISO 3951, there is a risk of between 1,4 % and 8,2 % of contradicting a correct declared quality level. The risk is 10 % of failing to contradict an incorrect declared quality level which is related to the limiting quality ratio (see Clause 4). Sampling plans are provided corresponding to three levels of discriminatory ability, and for the cases of unknown and known process standard deviation.

In contrast to the procedures in the other parts of ISO 3951, the procedures in this part of ISO 3951 are not applicable to acceptance assessment of lots. Generally, the balancing of the risks of reaching incorrect conclusions in assessment procedures will differ from the balancing in the procedures for acceptance sampling.

This part of ISO 3951 may be used for various forms of quality inspection in situations where objective evidence of conformity to some declared quality level is to be provided by means of inspection of a sample. The procedures are applicable to entities such as lots, process output, etc. that allow random samples of individual items to be taken from the entity.

The sampling plans provided in this part of ISO 3951 are applicable, but not limited, to inspection of a variety of products such as

- end items,
- components and raw materials,
- operations,
- materials in process,
- supplies in storage,
- maintenance operations,
- data or records, and
- administrative procedures.

The procedures are intended to be used when the quality characteristics are measurable variables that are independent and normally distributed, and where the quantity of interest is the fraction of items that are nonconforming.

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 2859-4:2002, *Sampling procedures for inspection by attributes — Part 4: Procedures for assessment of declared quality levels*

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 3951-2: 2006, *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*

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

3 Terms, definitions, symbols and abbreviations

3.1 Terms and definitions

For the purposes of this part of ISO 3951, the terms and definitions given in ISO 3534-1, ISO 3534-2, ISO 3951-2 and ISO 9000 and the following apply.

3.1.1
quality ratio
ratio of the actual to the declared quality level of the entity under investigation

3.1.2
limiting quality ratio
LQR
value of the quality ratio that is limited to a small risk (10 % in this part of ISO 3951) of failing to contradict an incorrect declared quality level

3.2 Symbols and abbreviated terms

The symbols and abbreviated terms used in this part of ISO 3951 are as follows:

$B_v(.)$ Distribution function of the symmetric beta distribution with both parameters equal to v

$B(v,v)$ Beta function with both arguments equal to v, i.e. $B(v,v)=\Gamma(v)\Gamma(v)/\Gamma(v)$ where $\Gamma(v)$ is the gamma function (see below)

D Declared quality level (as a symbol)

DQL Declared Quality Level (as an acronym)

k_s Form k acceptability constant under the "s" method, used when the sample standard deviation is unknown

k_σ Form k acceptability constant under the "σ" method, used when the process standard deviation is presumed to be known

L	Lower specification limit (as a subscript, denotes the value at L)
LQR	Limiting Quality Ratio (as an acronym)
m	Number of quality characteristics, all assumed to be independent and normally distributed
n_s	Sample size under the "s" method
n_σ	Sample size under the "σ" method
OC	Operating Characteristic
p	Process fraction nonconforming in the entity
$\hat{p}$	Estimate of the fraction nonconforming in the entity
$\hat{p}_c$	Estimate of the combined fraction nonconforming at both specification limits, i.e. $\hat{p}_c = \hat{p}_L + \hat{p}_U$
p^*	Form p^* acceptability constant (for both the "s" and "σ" methods)
Q	Quality statistic (see 7.2.2 and 7.3.2)
s	Sample standard deviation
U	Upper specification limit (as a subscript, denotes the value at U)
$\bar{x}$	Sample mean
$\Phi(.)$	Standard normal distribution function
$\Gamma(v)$	Gamma function, defined by $\Gamma(v) = \int_0^\infty t^{v-1} \exp(-t) dt$ for $v > 0$
σ	Process standard deviation

4 Principles

In any assessment procedure based on sampling, there will be an inherent uncertainty due to possible sampling fluctuations. The procedures in this part of ISO 3951 have been conceived so as to lead to contradiction of the declared quality level only when there is sufficient evidence to support a conclusion that the actual quality is poorer than the declared quality level.

The plans have been devised in such a way that their operating characteristic curves match those of the corresponding attributes plans ISO 2859-4 as closely as possible. Details of the matching method are given in Annex A. The attributes plans of ISO 2859-4 were selected such that when the actual quality level is equal to or better than the declared quality level, the risk is less than 5 % of contradicting the declared value. It follows that when the actual quality level is worse than the declared quality level, there is a risk that the procedures will fail to contradict an incorrect declared quality level. Owing to the fact that the match between corresponding OC curves in ISO 2859-4 and ISO 3951-4 is imperfect, the corresponding risk in this part of ISO 3951 varies around 5 %.

This risk depends on the value of the quality ratio, i.e. the ratio between the actual and the declared quality level. The limiting quality ratio, LQR, is introduced to denote the highest quality ratio considered tolerable. When the actual quality level is LQR times the declared quality level, the procedures in this part of ISO 3951 have a risk of 10 % of failing to contradict the declared quality level (corresponding to a 90 % probability of contradicting the incorrect declared quality level).

Three LQR levels I, II and III are considered; details of the three LQR levels provided in this part of ISO 3951 are given in 6.1. Sampling plans are provided for both the case where the process standard deviation is unknown (the "s" method) and the case where it is known (the "σ" method). (See ISO 3951-2 for details on the implementation of sampling by variables plans.)

The sampling plans provided in this part of ISO 3951 are indexed by the limiting quality ratio (LQR) level and the declared quality level (DQL) and are provided in Table 1.

5 Declared quality level (DQL)

The DQL together with the LQR level is used for indexing the sampling plans provided in this part of ISO 3951. The values of DQL in the tables are known as preferred DQLs. The series of preferred DQL values correspond to the series of preferred AQLs for inspection for nonconforming items given in ISO 3951-1.

There shall be a sound basis for the DQL used. The DQL shall not be deliberately overstated or understated.

When a DQL is designated for a certain type of nonconformity, it indicates that the supplier has good reason to believe that the quality is not worse than this designated value.

CAUTION — When the DQL is estimated from a sample taken from the entity of interest, the procedures in this International Standard shall not be used. Such a verification of an estimate from a sample requires that the sample size and inspection result be taken into account in order to incorporate the uncertainty associated with the estimate. This uncertainty affects the assessment of the risks of making incorrect conclusions on the actual status of the entity of interest. Such verification usually requires larger sample sizes than those used in the procedures described in this part of ISO 3951.

Table 1 — Master table of sampling plans

DQL	LQR Level I					LQR Level II					LQR Level III				
in % nonconforming items	n_s	k_s	n_σ	k_σ	100 p^*	n_s	k_s	n_σ	k_σ	100 p^*	n_s	k_s	n_σ	k_σ	100 p^*
0,010	132	3,286	23	3,277	0,040 31	←					←				
0,015	117	3,156	21	3,143	0,064 05	←					←				
0,025	101	3,016	20	3,003	0,103 0	179	3,148	33	3,140	0,071 38	←				
0,040	86	2,879	19	2,867	0,161 4	158	3,012	31	3,003	0,113 6	258	3,187	46	3,181	0,065 03
0,065	73	2,728	17	2,710	0,260 4	132	2,867	29	2,858	0,181 7	223	3,051	44	3,045	0,103 5
0,10	60	2,573	16	2,556	0,415 6	112	2,723	27	2,712	0,285 4	189	2,912	40	2,905	0,163 2
0,15	50	2,412	15	2,393	0,662 1	93	2,565	25	2,553	0,458 7	160	2,762	37	2,754	0,261 8
0,25	40	2,237	13	2,211	1,070	76	2,400	23	2,387	0,732 7	134	2,614	34	2,604	0,410 3
0,40	31	2,061	12	2,033	1,685	61	2,230	20	2,212	1,162	110	2,449	31	2,438	0,659 8
0,65	24	1,863	11	1,830	2,747	48	2,043	18	2,021	1,876	89	2,279	28	2,266	1,052
1,0	18	1,659	9	1,611	4,376	37	1,853	16	1,827	2,962	70	2,101	26	2,087	1,667
1,5	13	1,426	8	1,367	7,199	27	1,636	14	1,604	4,802	54	1,904	23	1,886	2,688
2,5	9	1,189	7	1,114	11,44	20	1,411	12	1,370	7,626	41	1,702	20	1,680	4,238
4,0	6	0,887	6	0,786	19,45	13	1,195	8	1,127	11,42	30	1,471	17	1,442	6,857
6,5	4	0,536	3	0,379	32,13	9	0,869	8	0,801	19,60	21	1,227	14	1,190	10,85
10	3	0,044	2	0,021	48,79	6	0,497	4	0,402	32,11	14	0,935	9	0,877	17,61

The plans are indexed by the declared quality level (DQL) of nonconforming product and limiting quality ratio (LQR) levels.

← Use the sampling plan to the left, which corresponds to a higher limiting quality ratio as no sampling plan exists for this level of the limiting quality ratio.

6 Sampling plans

6.1 LQR (limiting quality ratio) levels

6.1.1 Level I

Level I may be used when a smaller sample size is desirable. For Level I sampling plans, the limiting quality ratios range in value from 7,6 to 14,1. For example, if the declared quality level is 1,0 % nonconforming items, and the actual quality level is 12,2 times this declared quality level, then the risk is 10 % of failing to contradict the declared quality level (see Table 2).

Table 2 — Level I plans, limiting quality ratios (LQRs) and probabilities of falsely contradicting correctly declared quality levels (DQLs)

DQL in % nonconforming items	"s" method				"σ" method				100 p^*
	n_s	k_s	LQR	Probability of falsely contradicting a correct DQL in %	n_σ	k_σ	LQR	Probability of falsely contradicting a correct DQL in %	
0,010	132	3,286	13,6	2,5	23	3,277	13,1	1,7	0,040 31
0,015	117	3,156	14,1	2,1	21	3,143	14,0	1,5	0,064 05
0,025	101	3,016	13,5	2,4	20	3,003	13,2	1,6	0,103 0
0,040	86	2,879	13,2	2,6	19	2,867	12,6	1,7	0,161 4
0,065	73	2,728	12,9	2,7	17	2,710	12,6	1,8	0,260 4
0,10	60	2,573	13,3	2,7	16	2,556	12,7	1,6	0,415 6
0,15	50	2,412	13,7	2,3	15	2,393	13,1	1,3	0,662 1
0,25	40	2,237	13,1	2,7	13	2,211	12,7	1,6	1,070
0,40	31	2,061	12,7	3,1	12	2,033	12,0	1,6	1,685
0,65	24	1,863	12,2	3,2	11	1,830	11,5	1,5	2,747
1,0	18	1,659	12,2	3,2	9	1,611	11,8	1,6	4,376
1,5	13	1,426	12,5	2,9	8	1,367	12,0	1,2	7,199
2,5	9	1,189	11,1	3,6	7	1,114	10,6	1,3	11,44
4,0	6	0,887	10,3	3,4	6	0,786	9,9	0,91	19,45
6,5	4	0,536	8,9	3,1	3	0,379	9,9	2,5	32,13
10	3	0,044	7,6	1,6	2	0,021	8,1	3,7	48,79

EXAMPLE Suppose the "s" method plan $n_s = 60$, $k_s = 2{,}573$ is used, corresponding to a declared quality level (DQL) of 0,10 % nonconforming items. For this plan, there is a risk of 10,0 % of failing to contradict this DQL when the actual quality level is 13,3 (LQR) times the declared quality level, i.e. if the actual quality level is 1,33 % nonconforming items.

If, on the contrary, the actual quality level had been the DQL, i.e. if the actual quality level is 0,10 % nonconforming items, then there is a risk of 2,7 % of falsely contradicting this correct DQL.

6.1.2 Level II

Level II is the standard level that shall be used unless specific conditions warrant the use of another level. For Level II sampling plans, the limiting quality ratios range in value from 5,34 to 7,48. For example, if the declared quality level is 0,10 % nonconforming items, and the actual quality level is 7,05 times the declared quality level, then the risk of failing to contradict the declared quality level under the "s" method is 10,0 % (see Table 3).

Table 3 — Level II plans, limiting quality ratios (LQRs) and probabilities of falsely contradicting correctly declared quality levels (DQLs)

DQL in % nonconforming items	"s" method				"σ" method				100 p *
	n_s	k_s	LQR	Probability of falsely contradicting a correct DQL in %	n_σ	k_σ	LQR	Probability of falsely contradicting a correct DQL in %	
0,025	179	3,148	7,22	3,4	33	3,140	7,07	2,5	0,0713 8
0,040	158	3,012	7,06	3,4	31	3,003	6,95	2,6	0,113 6
0,065	132	2,867	6,97	3,7	29	2,858	6,76	2,7	0,181 7
0,10	112	2,723	7,05	3,6	27	2,712	6,84	2,5	0,285 4
0,15	93	2,565	7,48	3,0	25	2,553	7,21	1,9	0,458 7
0,25	76	2,400	7,10	3,5	23	2,387	6,80	2,2	0,732 7
0,40	61	2,230	6,95	3,8	20	2,212	6,77	2,5	1,162
0,65	48	2,043	6,76	4,0	18	2,021	6,59	2,5	1,876
1,0	37	1,853	6,78	3,9	16	1,827	6,60	2,3	2,962
1,5	27	1,636	7,14	3,4	14	1,604	6,90	1,7	4,802
2,5	20	1,411	6,48	3,9	12	1,370	6,35	2,0	7,626
4,0	13	1,195	6,04	5,9	8	1,127	6,25	3,9	11,42
6,5	9	0,869	5,66	4,6	8	0,801	5,60	2,2	19,60
10	6	0,497	5,34	3,2	4	0,402	5,94	3,9	32,11

EXAMPLE Suppose the "s" method plan $n_s = 112$, $k_s = 2{,}723$ is used, corresponding to a declared quality level (DQL) of 0,10 % nonconforming items. For this plan, there is a risk of 10,0 % of failing to contradict this DQL when the actual quality level is 7,05 (LQR) times the declared quality level, i.e. if the actual quality level is 0,705 % nonconforming items.

If, on the contrary, the actual quality level is equal to the DQL, i.e. if the actual quality level is 0,10 % nonconforming items, then there is a risk of 3,6 % of falsely contradicting this correct DQL.

6.1.3 Level III

Level III is for situations where a smaller LQR is desired, at the expense of a larger sample size. For Level III sampling plans, the limiting quality ratios range in value from 4,72 to 5,97. For example, if the declared quality level is 0,10 % nonconforming items and the actual quality level is 5,30 times this declared quality level, i.e. 0,530 %, then under the "σ" method there is a risk of 10 % of failing to contradict the declared quality level (see Table 4).