

---

---

**Sampling procedures for inspection by  
attributes —**

Part 4:  
**Procedures for assessment of declared  
quality levels**

*Règles d'échantillonnage pour les contrôles par attributs —*

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

STANDARDSISO.COM : Click to view the full PDF of ISO 2859-4:2020



STANDARDSISO.COM : Click to view the full PDF of ISO 2859-4:2020



**COPYRIGHT PROTECTED DOCUMENT**

© ISO 2020

All rights reserved. Unless otherwise specified, or required in the context of its implementation, 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  
CP 401 • Ch. de Blandonnet 8  
CH-1214 Vernier, Geneva  
Phone: +41 22 749 01 11  
Email: [copyright@iso.org](mailto:copyright@iso.org)  
Website: [www.iso.org](http://www.iso.org)

Published in Switzerland

# Contents

	Page
Foreword.....	iv
Introduction.....	v
<b>1 Scope.....</b>	<b>1</b>
<b>2 Normative references.....</b>	<b>2</b>
<b>3 Terms, definitions, symbols and abbreviated terms.....</b>	<b>2</b>
3.1 Terms and definitions.....	2
3.2 Symbols and abbreviated terms.....	3
<b>4 Sampling and decision procedure.....</b>	<b>3</b>
4.1 Identifying a sampling plan.....	3
4.2 Drawing of samples.....	3
4.3 Decision objective.....	4
4.4 Decision by sampling.....	4
4.5 Disposition of nonconforming items.....	4
<b>5 Principles.....</b>	<b>4</b>
<b>6 Declared quality level (DQL).....</b>	<b>5</b>
<b>7 Sampling plans.....</b>	<b>5</b>
7.1 General.....	5
7.2 LQR level 0.....	6
7.3 LQR level I.....	7
7.4 LQR level II.....	7
7.5 LQR level III.....	8
<b>8 Further information.....</b>	<b>9</b>
8.1 Curves showing the approximate probability of contradiction.....	9
8.2 Tables indicating discriminatory ability.....	9
<b>Annex A (informative) Examples of use of the procedures.....</b>	<b>13</b>
<b>Annex B (informative) Quality ratio related to <math>\beta</math> 100 % acceptance probability.....</b>	<b>16</b>

## 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](http://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](http://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 of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

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

This third edition cancels and replaces the second edition (ISO 2859-4:2002), which has been technically revised.

The main changes compared to the previous edition are as follows:

- the scope has been widened from testing for the percentage of nonconforming items to testing for the percentage of nonconformities per item;
- the sampling and decision algorithm is more detailed and has been moved to an earlier position in the document, so as to facilitate the operational use of the document;
- an LQR level 0 has been introduced, which can be used when a large probability of erroneously contradicting a correctly declared quality level can be tolerated;
- an informative Annex B has been added to explain the mathematical-statistical background, and to provide tables on quality ratios.

A list of all parts in the ISO 2859 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at [www.iso.org/members.html](http://www.iso.org/members.html).

## Introduction

The procedures in this document differ in their scope from the procedures in ISO 2859-1 to ISO 2859-3. The acceptance sampling systems specified in ISO 2859-1 to ISO 2859-3 are intended to be used in bilateral agreements between two parties. The acceptance sampling procedures are supposed to be used as simple, pragmatic rules for deciding on product release by 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 2859-1, the two parties agree upon some acceptance quality limit (AQL) which is the worst tolerable process average when a continuing series of lots is submitted. The switching rules and the sampling schemes in ISO 2859-1 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. The procedures in ISO 2859-2, on the contrary, are designed to provide good protection against accepting individual lots of inferior quality (LQ), but at the expense of a possibly high risk of not accepting lots of qualities that both parties actually would consider to be acceptable.

The procedures in ISO 2859-1 to ISO 2859-3 are well suited for acceptance sampling purposes, but they should not be used in reviews, audits, systematic tests, 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 in a pragmatic attitude.

The procedures in this document have been developed as a response to the growing need for sampling procedures suitable for formal, systematic inspections such as reviews or audits or systematic tests. When performing such a formal inspection, it is necessary both for the inspecting authority and for the body subject to inspection to consider the risks of reaching an incorrect conclusion. These risks have to be accounted for explicitly in the design of review/auditing/testing procedures.

This document provides guidance and rules to assist the user in accounting for the risks of incorrect conclusions in an informed manner.

The rules in this document have been devised such that there is only an acceptably small 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 document 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 imbalance between the risks of reaching incorrect conclusions. For the levels I, II, and III, 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”.

**CAUTION — It should be noticed that, for sampling plans with very small sample sizes, one should be aware of the poor discriminatory power under such sample sizes by referring to the entries in [Tables B.1](#), [B.2](#), [B.3](#) and [B.4](#).**

[STANDARDSISO.COM](https://standardsiso.com) : Click to view the full PDF of ISO 2859-4:2020

# Sampling procedures for inspection by attributes —

## Part 4:

## Procedures for assessment of declared quality levels

### 1 Scope

This document establishes single sampling plans for conformance testing, i.e., for assessing whether the quality level of a relevant audit population (lot, process, inventory, file etc) conforms to a declared value. Sampling plans are provided corresponding to four levels of discriminatory ability. The limiting quality ratio (LQR) (see [Clause 4](#)) of each sampling plan is given for reference. For levels I-III, the sampling plans have been devised so as to obtain a risk no more than 5 % of contradicting a correct declared quality level. The risk of failing to contradict an incorrectly declared quality level which is related to the LQR is no more than 10 %. The sample sizes for level 0 are designed in a way that the LQR factors of the sampling plans are compatible with the LQR factors for level I.

In contrast to the procedures in the other parts of the ISO 2859 series, the procedures in this document are not applicable to acceptance assessment of lots. Generally, this document mainly focuses on controlling type I error, which differs from the balancing of the risks in the procedures for acceptance sampling.

This document can 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 document are applicable, but not limited, to the inspection of a variety of targets such as:

- end items;
- components and raw materials;
- operations;
- materials in process;
- supplies in storage;
- maintenance operations;
- data or records;
- administrative procedures;
- accounting procedures or accounting entries;
- internal control procedures.

This document considers two types of quality models for discrete items and populations, as follows.

- i) The conforming-nonconforming model, where each item is classified as conforming or nonconforming, and where the quality indicator of a population of items is the proportion  $p$  of nonconforming items, or, equivalently, the percentage  $100 p$  of nonconforming items.

- ii) The nonconformities model, where the number of nonconformities is counted on each item, and where the quality indicator of a population of items is the average number  $\lambda$  of nonconformities found on items in the population, or, equivalently, the percentage  $100 \lambda$  of nonconformities on items in the population.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 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 9000, *Quality management systems — Fundamentals and vocabulary*

## 3 Terms, definitions, symbols and abbreviated terms

### 3.1 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

#### 3.1.1

##### **non-rejection number**

*c*

largest number of nonconforming items or nonconformities, respectively, found in the sample from the population under investigation that does not lead to contradiction of the declared quality level

#### 3.1.2

##### **quality ratio**

**QR**

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

#### 3.1.3

##### **limiting quality ratio**

**LQR**

value of the quality ratio that is limited to a small risk of failing to contradict an incorrect declared quality level

Note 1 to entry: In this document, the risk of failing to contradict an incorrect declared quality level is no more than 10 %.

#### 3.1.4

##### **audit population**

totality of items under audit inspection

#### 3.1.5

##### **audit population conformance**

state of the audit population fulfilling imposed requirements

### 3.2 Symbols and abbreviated terms

$c$	non-rejection number of a sampling plan
$d$	number of nonconforming items or, respectively, nonconformities in the sample
$n$	sample size of a sampling plan
DQL	declared quality level
LQR	limiting quality ratio
QR	quality ratio

## 4 Sampling and decision procedure

### 4.1 Identifying a sampling plan

A single sampling plan ( $n, c$ ) with sample size  $n$  and non-rejection number  $c$  is identified from [Table 1](#) by two characteristics:

- the DQL, ranging from 0,01 percent to 10,00 percent;
- the LQR level, ranging over 0, I, II, III.

Except a few exceptions for very small and very large DQL, the non-rejection numbers are constant under each LQR level, with  $c = 0$  under level 0,  $c = 1$  under level I,  $c = 2$  under level II, and  $c = 3$  under level III.

If the declared quality level is not one of the tabulated values, then the next higher tabulated value of DQL shall be used to select the plan.

**NOTE** This results in an LQR that is somewhat higher, and to a probability of falsely contradicting a correct declared quality level that is somewhat lower than the values given in [Tables 2 to 5](#) (see [8.2](#)).

**EXAMPLE** If an LQR level II is chosen with a DQL of 0,65 % nonconforming items, [Table 1](#) yields a sampling plan with a sample size  $n$  of 127, and a non-rejection number of nonconforming items  $c$  of 2, which provides an LQR of 6,45 (see [Table 4](#)).

### 4.2 Drawing of samples

The sample shall be selected by simple random sampling or, where appropriate, by stratified or other methods of random sampling from the entity.

When stratified sampling is used, the number of items from each stratum shall be selected in proportion to the size of strata of the entity under investigation. The sub-sample from each stratum shall be selected by simple random sampling from that stratum.

When sampling from a lot or a consignment, stratified sampling may be used with strata corresponding to identifiable sub-lots.

When sampling from a process, stratified sampling may be used with strata corresponding to identified sources of variation, for example tools, operators, shifts, etc.

If the sample size exceeds the size of the entity under investigation, then all items of the entity shall be inspected.

**EXAMPLE** If, in the example considered in 4.1, the entity under investigation is the computer records of administrative transactions during five business days, and the number of transactions each day are approximately equal, then the total sample of  $n = 127$  transactions are selected as five sub-samples, three consisting of 25 transactions and two consisting of 26 transactions, selected by simple random sampling from the transactions on each of the five days.

### 4.3 Decision objective

The audit population is considered as *conforming* if the population quality indicator (percentage of nonconforming units, or percentage of nonconformities per item, respectively) is smaller or equal to the DQL. Otherwise, the audit population is considered as *nonconforming*. The inspection objective shall decide on the conformance of the population by taking one of two mutually exclusive decisions: i) *rejection*, i.e., contradict the quality declaration expressed by the DQL and classify the population as nonconforming; ii) *non-rejection* or *acceptance*, i.e., do not contradict the quality declaration expressed by the DQL and classify the population as conforming.

### 4.4 Decision by sampling

Each of the  $n$  items in the sample shall be inspected, and the total number  $d$  of nonconforming items or, respectively, of the nonconformities on items in the sample shall be determined.

- If  $d$  is less than or equal to the non-rejection number  $c$ , the decision is *non-rejection*, i.e., the declared quality level is not contradicted.
- If  $d$  exceeds the non-rejection number  $c$ , the decision is *rejection*, i.e., the declared quality level is contradicted.

**EXAMPLE** Assume that, in the situation considered by the Example in 4.1, two or fewer nonconforming items are found in the sample of 127 items. Then the sample result does not contradict the DQL of 0,65 % nonconforming items. If three or more nonconforming items are found, the sample evidence contradicts the DQL.

### 4.5 Disposition of nonconforming items

Any nonconforming items or items exhibiting nonconformities found in the sample shall not be returned to the rest of the items unless the nonconforming items are brought to a conforming condition and applicable administrative rules are followed.

Examples for the use of the sampling and decision procedure in industrial practice are provided in [Annex A](#).

## 5 Principles

Any assessment procedure based on sampling is subject to *sampling risk*, i.e., the risk of taking an erroneous decision due to the limited information conveyed by a sample. In the present context, there are two types of erroneous conclusions on an audit population:

- a) rejection although the population is actually conforming, i.e., the population quality indicator (percentage of nonconforming units, or percentage of nonconformities per item, respectively) is actually smaller or equal to the DQL;
- b) non-rejection although the population is actually nonconforming, i.e., the population quality indicator (percentage of nonconforming units, or percentage of nonconformities per item, respectively) is actually exceeding the DQL.

The corresponding error risks are expressed by the respective error probabilities, namely a) the probability of rejecting an actually conforming population; b) the probability of not rejecting an actually nonconforming population. The latter two risks shall be balanced by the design of the sampling plans.

The sampling plans for the LQR levels I, II and III are, with few exceptions for large DQLs, devised such that the probability of contradicting an actually correct quality declaration is less than 5 %. For the LQR level 0, the probability of contradicting an actually correct quality declaration is bounded by 20 %. See [Tables 2](#) through [5](#) for the detailed values.

For the inspection authority, it is vital to have a small probability of not detecting an incorrectly declared quality level. The design of the sampling plans in this document focusses on the *limiting quality ratio* (LQR): when the actual quality level is  $LQR \times DQL$ , i.e., LQR times worse than the declared quality level DQL, the procedures in this document have a risk of less than 10 % of failing to contradict the declared quality level (corresponding to a 90 % probability of contradicting/rejecting the incorrect declared quality level).

The ideal LQR would be close to 1,00. The latter ideal case cannot be achieved with practically feasible sample sizes. This document considers four LQR levels 0, I, II and III. For all levels, the LQR values range between 4 and 13, roughly. The sample sizes for level 0 are set to make sure that level 0 has approximately the same LQR as level I at the same DQL value where the LQR ranges from 7,78 for the largest DQL up to 12,34 for the smallest DQL. Under the latter design, it is inevitable that under level 0 the probabilities of contradicting an actually correct quality declaration are considerably higher than under levels I, II, and III.

Technical details on the design of the sampling plans are provided in [Annex B](#).

## 6 Declared quality level (DQL)

The DQL together with the LQR level is used for indexing the sampling plans provided in this document. 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 2859-1.

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 quality characteristic, 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 document 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 document.**

## 7 Sampling plans

### 7.1 General

The master [Table 1](#) provides all single sampling plans ( $n, c$ ) for the four LQR levels, indexed in the DQL and the LQR level. Background on the choice of the LQR level and the properties of the corresponding sampling plans are provided in [7.2](#) through [7.5](#).

**Table 1 — Master table of sampling plans**

DQL (% nonconforming items or % nonconformities per item)	LQR Level 0		LQR Level I		LQR Level II		LQR Level III	
	<i>n</i>	<i>c</i>	<i>n</i>	<i>c</i>	<i>n</i>	<i>c</i>	<i>n</i>	<i>c</i>
0,010	1 866	0	3 153	1	←		←	
0,015	1 185	0	2 001	1	←		←	
0,025	743	0	1 255	1	3 154	2	←	
0,040	476	0	804	1	2 001	2	3 152	3
0,065	298	0	503	1	1 253	2	2 004	3
0,100	188	0	317	1	802	2	1 252	3
0,150	119	0	202	1	502	2	803	3
0,250	75	0	127	1	317	2	503	3
0,400	49	0	82	1	202	2	317	3
0,650	31	0	52	1	127	2	202	3
1,000	20	0	34	1	82	2	127	3
1,500	13	0	22	1	52	2	82	3
2,500	9	0	15	1	34	2	52	3
4,000	→		10	1	22	2	34	3
6,500	→		7	1	15	2	22	3
10,000	→		5	1	10	2	16	3

The plans are indexed by the declared quality level (DQL) of nonconforming product and the limiting quality ratio (LQR) levels.  
 “→” means: use the sampling plan to the right, which corresponds to a smaller limiting quality ratio  
 “←” means: use the sampling plan to the left, which corresponds to a higher limiting quality ratio

**7.2 LQR level 0**

Level 0 may be used when a large probability of erroneously contradicting a correct declared quality level may be tolerated. For level 0 sampling plans, the probabilities of erroneously contradicting a correct declared quality level in [Table 2](#) range in value from 16,3 % to 20,4 %, see [Table 2](#). For example, if the actual quality level equals the declared quality level 2,50 %, the probability of erroneously contradicting the declared quality level is 20,4 %.

**Table 2 — LQR and probability of falsely contradicting a correct DQL — LQR level 0 plans**

DQL (% nonconforming items or % nonconformities per item)	<i>n</i>	<i>c</i>	LQR	Probability of falsely contradicting a correct DQL %, $\alpha$
0,010	1 866	0	12,34	17,0
0,015	1 185	0	12,95	16,3
0,025	743	0	12,40	17,0
0,040	476	0	12,09	17,3
0,065	298	0	11,89	17,6
0,10	188	0	12,25	17,1
0,15	119	0	12,90	16,4
0,25	75	0	12,28	17,1
0,40	49	0	11,75	17,8
0,65	31	0	11,43	18,3
1,0	20	0	11,51	18,2

Table 2 (continued)

DQL (% nonconforming items or % nonconformities per item)	$n$	$c$	LQR	Probability of falsely contradicting a correct DQL %, $\alpha$
1,5	13	0	11,81	17,8
2,5	9	0	10,23	20,4

EXAMPLE Suppose that the plan  $n = 20$ ,  $c = 0$ , corresponding to a DQL of 1,0 % nonconforming items, is used. For this plan, there is a 10 % risk of failing to contradict DQL when the actual quality level is 11,51 (LQR) times worse than the DQL, i.e. the actual quality level is 11,51 % nonconforming items.

If, on the contrary, the actual quality level had been the DQL, i.e. if the actual quality level is 1,0 % nonconforming items, then there is a risk of 18,2 % of falsely contradicting this correct DQL.

### 7.3 LQR level I

Level I may be used when a smaller sample size than levels II or III is desirable. For level I sampling plans, the limiting QR range in value from 7,78 to 12,96, see [Table 3](#).

Table 3 — LQR and probability of falsely contradicting a correct DQL — LQR level I plans

DQL (% nonconforming items or % nonconformities per item)	$n$	$c$	LQR	Probability of falsely contradicting a correct DQL %, $\alpha$
0,010	3 153	1	12,34	4,0
0,015	2 001	1	12,96	3,7
0,025	1 255	1	12,40	4,0
0,040	804	1	12,09	4,2
0,065	503	1	11,90	4,3
0,10	317	1	12,27	4,1
0,15	202	1	12,84	3,8
0,25	127	1	12,25	4,1
0,40	82	1	11,86	4,3
0,65	52	1	11,51	4,6
1,0	34	1	11,44	4,6
1,5	22	1	11,79	4,4
2,5	15	1	10,37	5,5
4,0	10	1	9,72	6,2
6,5	7	1	8,55	7,7
10,0	5	1	7,78	9,0

EXAMPLE Suppose that the plan  $n = 317$ ,  $c = 1$ , corresponding to a DQL of 0,10 %, is used. For this plan, there is a 10 % risk of failing to contradict the DQL when the actual quality level is 12,27 (LQR) times worse than the DQL, i.e. the actual quality level is 1,227 %. If, on the contrary, the actual quality level had been the DQL, i.e. if the actual quality level had been 0,1 %, then there is a risk of 4,1 % of falsely contradicting this correct DQL.

### 7.4 LQR 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 QR range in value from 5,32 to 7,07, see [Table 4](#).

**Table 4 — LQR and probability of falsely contradicting a correct DQL — LQR level II plans**

DQL (% nonconforming items or % nonconformities per item)	<i>n</i>	<i>c</i>	LQR	Probability of falsely contradicting a correct DQL %, $\alpha$
0,025	3 154	2	6,75	4,6
0,040	2 001	2	6,65	4,7
0,065	1 253	2	6,53	5,0
0,10	802	2	6,64	4,8
0,15	502	2	7,07	4,1
0,25	317	2	6,72	4,6
0,40	202	2	6,59	4,9
0,65	127	2	6,45	5,1
1,0	82	2	6,49	5,0
1,5	52	2	6,82	4,5
2,5	34	2	6,26	5,5
4,0	22	2	6,05	6,0
6,5	15	2	5,46	7,6
10,0	10	2	5,32	8,0

**EXAMPLE** Suppose the plan  $n = 802, c = 2$ , corresponding to a DQL of 0,1 % nonconforming items, is used. For this plan, there is a 10 % risk of failing to contradict DQL when the actual quality level is 6,64 (LQR) times worse than the DQL, i.e. the actual quality level is 0,664 % nonconforming items.

If, on the contrary, the actual quality level had been the DQL, i.e. if the actual quality level is 0,1 % nonconforming items, then there is a risk of 4,8 % of falsely contradicting this correct DQL.

**7.5 LQR 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 QR in Table 5 range in value from 4,18 to 5,55.

**Table 5 — LQR and probability of falsely contradicting a correct DQL — LQR level III plans**

DQL (% nonconforming items or % nonconformities per item)	<i>n</i>	<i>c</i>	LQR	Probability of falsely contradicting a correct DQL %, $\alpha$
0,040	3 152	3	5,30	3,9
0,065	2 004	3	5,13	4,3
0,10	1 252	3	5,34	3,8
0,15	803	3	5,55	3,4
0,25	503	3	5,31	3,9
0,40	317	3	5,27	4,0
0,65	202	3	5,09	4,4
1,0	127	3	5,26	4,0
1,5	82	3	5,43	3,6
2,5	52	3	5,14	4,3
4,0	34	3	4,91	4,9
6,5	22	3	4,67	5,7
10,0	16	3	4,18	7,9

**EXAMPLE** Suppose the plan  $n = 1\ 252$ ,  $c = 3$ , corresponding to a DQL of 0,1 % nonconforming items, is used. For this plan, there is a 10 % risk of failing to contradict DQL when the actual quality level is 5,34 (LQR) times worse than the DQL, i.e. if the actual quality level is 0,534 % nonconforming items.

If, on the contrary, the actual quality level had been the DQL, i.e. if the actual quality level is 0,1 % nonconforming items, then there is a risk of 3,8 % of falsely contradicting this correct DQL.

## 8 Further information

### 8.1 Curves showing the approximate probability of contradiction

The curves shown in [Figure 1](#) indicate the approximate probability that a sample result leads to contradiction of the DQL. The curves give the approximate probability of contradiction as a function of the QR.

The curves in [Figure 1](#) refer to situations where the DQL is one of the preferred values. For non-preferred values of DQL, the information in [Figure 1](#) does not apply.

### 8.2 Tables indicating discriminatory ability

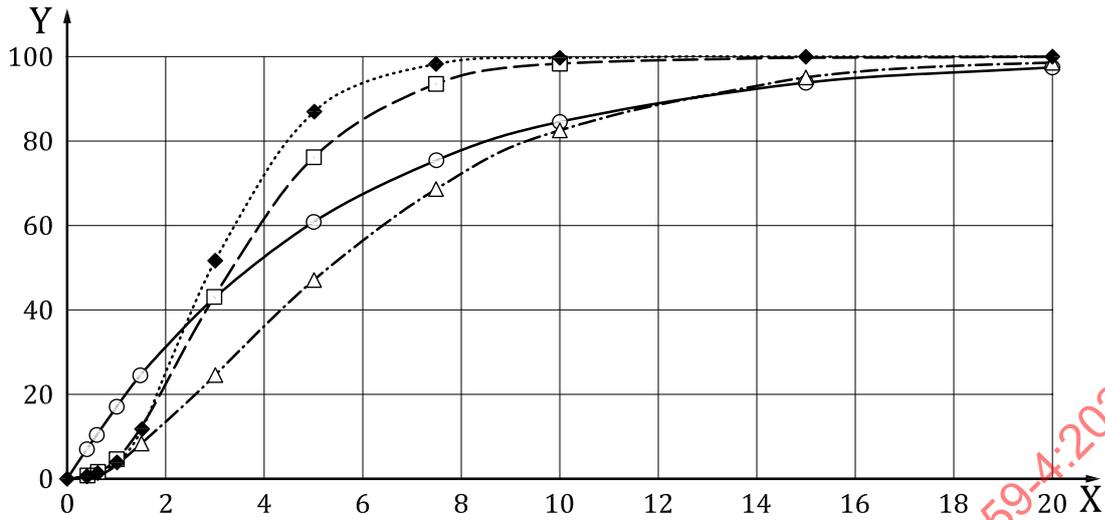
[Tables 6](#) through [9](#) provide additional information about the probabilities of contradicting incorrect DQL for different values of the QR.

For each individual sampling plan, [Tables 2](#) to [5](#) show the value of the limiting quality ratio (LQR) that corresponds to a nearly 10 % risk (20 % for [Table 2](#)) of failing to contradict the declared quality level. This LQR together with the information presented in [Tables 6](#) to [9](#) may be used to assess the discriminatory ability of each sampling plan.

[Tables 2](#) to [5](#) also show the probability that the sample result (falsely) contradict the DQL when the actual quality level is equal to the DQL.

The values in [Tables 2](#) to [9](#) have been determined under the assumption that the sample size is only a small fraction of the entity under investigation. The values in these tables are valid when the sample size is less than or equal to one tenth of the entity.

When the sample size is a larger fraction of the entity under investigation, the actual discriminatory ability is better than indicated by the values in [Tables 2](#) to [9](#). In particular, the actual LQR is smaller than the value indicated in [Tables 2](#) to [5](#) and, moreover, the actual probability of falsely contradicting a correct DQL is also smaller than that indicated in [Tables 2](#) to [5](#).



**Key**  
 X quality ratio  
 Y probability of contradicting a DQL (%)  
 —○— level 0  
 - -△- - level 1  
 - -□- - level 2  
 .....◆..... level 3

**Figure 1 — Curves showing the approximate probability of contradicting a DQL for different values of the quality ratio**

If the DQL used is not one of the preferred DQLs, then the next higher preferred DQL shall be used to select the sampling plan. This results in a change to the balance of risks. On one hand, the risk of falsely contradicting a correct DQL is less than that given in Tables 2 to 5. On the other hand, the actual LQR is higher than the tabulated value of LQR for the preferred DQL.

The actual  $LQR_a$ , is given by the formula:

$$LQR_a = LQR \times \frac{DQL}{DQL_a}$$

where

- LQR is the preferred limiting quality ratio;
- DQL is the preferred declared quality level;
- $DQL_a$  is the actual, non-preferred declared quality level.

The quality level corresponding to a 10 % risk of failing to contradict the actual (i.e. non-preferred) DQL remains as given by the sampling plan and is determined as this preferred DQL times its tabulated LQR.

Tables 6 to 9 can still be applied to non-preferred DQLs with the understanding that the actual quality level is the QR given in Tables 6 to 9, times the preferred DQL used (see the example below).

**EXAMPLE** Suppose a DQL of 0,125 % nonconforming items is to be assessed at a LQR level II. As this is a non-preferred DQL, and the next higher preferred DQL is 0,15 %, Table 1 indicates that the sampling plan  $n = 502$ ,  $c = 2$  is to be used.

From Table 4, it can be concluded that there is less than 4,1 % risk of falsely contradicting the (non-preferred) DQL of 0,125 % nonconforming items. Furthermore, there is a 10 % risk of failing to

contradict the non-preferred DQL when the actual quality level is 7,07 times 0,15 %, i.e. 1,06 %. For the non-preferred DQL, the actual LQR is  $7,07 \times (0,15/0,125) = 8,48$ . In other words, there is a 10 % risk of failing to contradict the non-preferred DQL when the actual quality level is 8,48 times higher ( $8,48 \times 0,125$  % being equal to 1,06 %).

Using [Table 8](#), for a QR of 5,0 and the preferred DQL of 0,15 % (corresponding to an actual quality level of  $5,0 \times 0,15$  % = 0,75 %), the probability of contradicting the non-preferred DQL of 0,15 % is 72,5 %. [Table 8](#) can similarly be used to find the probability of contradicting the non-preferred DQL for seven other values of the QR.

**Table 6 — Probability (%) of contradicting a DQL for different values of the QR — LQR level 0 plans**

QR	DQL (% nonconforming items or % nonconformities per item)												
	0,010	0,015	0,025	0,040	0,065	0,10	0,15	0,25	0,40	0,65	1,0	1,5	2,5
0,4	7,2	6,9	7,2	7,3	7,5	7,2	6,9	7,2	7,5	7,8	7,7	7,5	8,6
0,6	10,6	10,1	10,5	10,8	11,0	10,7	10,2	10,6	11,1	11,4	11,3	11,1	12,7
1,0	17,0	16,3	17,0	17,3	17,6	17,1	16,4	17,1	17,8	18,3	18,2	17,8	20,4
1,5	24,4	23,4	24,3	24,8	25,2	24,6	23,5	24,5	25,5	26,1	25,9	25,4	28,6
3,0	42,9	41,3	42,7	43,5	44,1	43,1	41,5	43,0	44,5	45,4	45,1	44,3	49,1
5,0	60,7	58,9	60,5	61,4	62,0	60,9	59,0	60,8	62,5	63,5	63,2	62,3	67,5
7,5	75,3	73,6	75,2	76,0	76,6	75,6	73,8	75,5	77,0	77,9	77,7	76,8	81,5
10,0	84,5	83,1	84,4	85,1	85,6	84,7	83,2	84,7	85,9	86,7	86,5	85,8	89,5
15,0	93,9	93,0	93,8	94,3	94,5	94,0	93,1	94,0	94,7	95,1	95,0	94,6	96,6
20,0	97,6	97,1	97,6	97,8	97,9	97,7	97,2	97,6	98,0	98,2	98,2	98,0	98,9

EXAMPLE Suppose the plan corresponding to a DQL of 0,10 % nonconforming items is used. For a QR of 10 (the actual quality level is 10 times the DQL, i.e. 1,0 % nonconforming items), there is a probability of 84,7 % that this sampling plan indicate contradiction of the DQL.

**Table 7 — Probability (%) of contradicting a DQL for different values of the QR — LQR level I plans**

QR	DQL (% nonconforming items or % nonconformities per item)												
	0,010	0,015	0,025	0,040	0,065	0,10	0,15	0,25	0,40	0,65	1,0	1,5	2,5
0,4	0,7	0,7	0,7	0,8	0,8	0,7	0,7	0,7	0,8	0,8	0,8	0,8	1,0
0,6	1,6	1,4	1,6	1,6	1,7	1,6	1,5	1,6	1,7	1,8	1,8	1,7	2,1
1,0	4,0	3,7	4,0	4,2	4,3	4,1	3,7	4,1	4,3	4,5	4,5	4,3	5,3
1,5	8,2	7,5	8,1	8,5	8,7	8,3	7,7	8,3	8,7	9,2	9,2	8,7	10,7
3,0	24,4	22,8	24,3	25,1	25,7	24,6	23,1	24,7	25,8	26,9	27,2	26,0	31,0
5,0	46,7	44,2	46,5	47,8	48,6	47,0	44,7	47,1	48,8	50,4	50,7	49,1	55,9
7,5	68,4	65,8	68,1	69,4	70,3	68,7	66,3	68,7	70,4	72,0	72,3	70,8	77,1
10,0	82,3	80,1	82,0	83,1	83,8	82,5	80,5	82,6	83,9	85,1	85,3	84,1	88,8
15,0	94,9	93,9	94,8	95,3	95,6	95,0	94,1	95,1	95,7	96,2	96,3	95,8	97,6
20,0	98,7	98,3	98,6	98,8	98,9	98,7	98,4	98,7	98,9	99,1	99,1	99,0	99,5

EXAMPLE Suppose the plan corresponding to a DQL of 0,10 % nonconforming items is used. For a QR of 10 (the actual quality level is 10 times the DQL, i.e. 1,0 % nonconforming items), there is a probability of 82,5 % that this sampling plan indicate contradiction of the DQL.

**Table 8 — Probability (%) of contradicting a DQL for different values of the QR — LQR level II plans**

QR	DQL (% nonconforming items or % nonconformities per item)												
	0,01	0,015	0,025	0,04	0,065	0,1	0,15	0,25	0,4	0,65	1	1,5	2,5
0,4	0,7	0,7	0,4	0,4	0,5	0,4	0,4	0,4	0,4	0,5	0,4	0,4	0,5
0,6	1,6	1,4	1,2	1,3	1,4	1,3	1,1	1,3	1,3	1,4	1,3	1,2	1,4
1,0	4,0	3,7	4,6	4,7	4,9	4,8	4,1	4,6	4,8	5,1	4,9	4,3	5,3
1,5	8,2	7,5	11,7	12,1	12,5	12,1	10,5	11,8	12,3	12,8	12,6	11,2	13,4
3,0	24,4	22,8	42,1	43,1	44,2	43,2	39,3	42,4	43,7	45,0	44,6	41,5	46,9
5,0	46,7	44,2	75,3	76,2	77,2	76,3	72,5	75,6	76,8	78,0	77,6	74,7	79,6
7,5	68,4	65,8	93,4	93,8	94,3	93,9	92,0	93,5	94,1	94,6	94,4	93,1	95,3
10,0	82,3	80,1	98,5	98,6	98,8	98,6	98,0	98,5	98,7	98,9	98,8	98,4	99,1
15,0	94,9	93,9	99,9	99,9	100,0	99,9	99,9	99,9	100,0	100,0	100,0	99,9	100,0
20,0	98,7	98,3	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0

EXAMPLE Suppose the plan corresponding to a DQL of 0,15 % nonconforming items is used. For a QR of 5 (the actual quality level is 5 times the declared quality level, i.e. 0,75 % nonconforming items), there is a probability of 72,5 % of this sampling plan indicating a contradiction of the DQL.

**Table 9 — Probability (%) of contradicting a DQL for different values of the QR — LQR level III plans**

QR	DQL (% nonconforming items or % nonconformities per item)												
	0,010	0,015	0,025	0,040	0,065	0,10	0,15	0,25	0,40	0,65	1,0	1,5	2,5
0,4	0,7	0,7	0,4	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2
0,6	1,6	1,4	1,2	0,8	0,8	0,7	0,6	0,7	0,8	0,8	0,7	0,7	0,8
1,0	4,0	3,7	4,6	3,9	4,3	3,8	3,4	3,9	4,0	4,4	3,9	3,5	4,1
1,5	8,2	7,5	11,7	12,4	13,5	12,1	11,0	12,3	12,5	13,7	12,5	11,4	13,0
3,0	24,4	22,8	42,1	52,3	54,8	51,7	48,8	52,1	52,7	55,5	52,9	50,4	54,7
5,0	46,7	44,2	75,3	87,4	88,9	87,1	85,1	87,3	87,7	89,3	87,7	86,2	88,8
7,5	68,4	65,8	93,4	98,5	98,8	98,4	97,9	98,4	98,5	98,8	98,5	98,2	98,8
10,0	82,3	80,1	98,5	99,9	99,9	99,8	99,8	99,9	99,9	99,9	99,9	99,8	99,9
15,0	94,9	93,9	99,9	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
20,0	98,7	98,3	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0

EXAMPLE Suppose the plan corresponding to a DQL of 0,25 % nonconforming items is used. For a QR of 3 (the actual quality level is 3 times the DQL, i.e. 0,75 % nonconforming items) there is a probability of 52,1 % of this sampling plan indicating a contradiction of the DQL.

## Annex A (informative)

### Examples of use of the procedures

#### A.1 Example 1

During the audit of a sales department, it is revealed that the invoicing process is a source of substantial financial losses. The auditors estimate the percentage of invoices that were processed incorrectly (errors, delays, etc.) as equal to 5 % of the invoices. Management decides to introduce a special training programme with the aim to reduce this percentage to 1 % incorrectly processed invoices. Once the programme is completed, management decides to assess its effectiveness.

Management decides to use this document to evaluate the effectiveness of the special training programme by selecting a declared quality level (DQL) of 1 %. Management also wants a small probability of the positive evaluation of the training programme in the case of no reduction of the percentage of incorrectly processed invoices. Therefore, level III of the LQR that assures good discrimination between quality levels of 1 % and 5 % is chosen. From [Table 1](#), it is found that, for LQR level III and the DQL of 1 %, the sampling plan has a sample size of  $n = 127$  and a non-rejection number of nonconforming items of  $c = 3$ . This plan is proposed for the internal audit usage. A sample of  $n = 127$  invoices should be verified. If no more than three invoices in that sample are found to be processed incorrectly, the training programme can be considered successful. From [Table 5](#), it is found that for this plan there is a risk of 4,0 % of contradicting a correctly declared quality level (1 % incorrectly processed invoices), and a risk of 10 % of failing to contradict when the actual quality level is 5,26 % incorrectly processed invoices [i.e. the actual quality level is 5,26 (the LQR) times worse than the DQL]. For additional information of the discriminatory ability of this sampling plan, refer to [Table 9](#).

#### A.2 Example 2

To increase the efficiency of the quality management system, the employees of an industrial plant are encouraged to inform management about the problems that may negatively influence the quality of production. A closed-loop quality control system is introduced in order to assure that all the problems indicated by the employees are thoroughly investigated by the quality management of this plant. It is assumed that the system can be considered as effective when no more than 2,5 % of previously identified problems remain without a solution. After one year, management decides to investigate the efficiency of the system taking into account not only formal aspects but also complexity of the problems indicated by the employees. This requirement forces management to investigate only a limited number of cases, therefore it is decided to select LQR level I with a system DQL of 2,5 % of the problems remaining without a solution. From [Table 1](#), it is found that, for LQR level I and the DQL of 2,5 %, the sampling plan has a sample size of  $n = 15$  and a non-rejection number of nonconforming items of  $c = 1$ .

Therefore, the management decides to investigate 15 cases, and to consider the quality control system as effective if no more than one case is without at least a prescribed solution.

From [Table 3](#), it is found that, for this plan, there is a risk of 5,5 % of contradicting a correctly declared quality level (2,5 % problems without a solution), and a risk of 10 % of failing to contradict when the actual quality level is 25,925 % problems without a solution [i.e., the actual quality level is 10,37 (the LQR) times worse than the DQL].

For additional information of the discriminatory ability of this sampling plan, refer to [Table 7](#).

### A.3 Example 3

A company produces a certain product in a regular production. The manufacturing organization performs 100 % inspection on outgoing lots. All nonconforming items found during inspection are replaced by conforming items.

The inspection efficiency,  $E$ , of the final inspection is estimated independently on an ongoing basis as a long time moving average. The inspection efficiency indicates the fraction of nonconforming items detected among the nonconforming items submitted. Inspection errors arising from wrongly classifying conforming items as nonconforming are rather unlikely and therefore such errors are not taken into account.

At the end of each week, the manufacturing organization reports the “outgoing quality rating” for that week as:

$$Q_{\text{out}} = Q_{\text{fwi}} \times \frac{1-E}{E}$$

where

$Q_{\text{out}}$  is the outgoing quality rating, expressed in percent nonconforming items;

$Q_{\text{fwi}}$  is the quality found by the final inspection of that week's production, expressed in percent nonconforming items;

$E$  denotes the inspection efficiency (in fraction nonconforming items detected among nonconforming items submitted).

Assume that the current value of the inspection efficiency,  $E$ , is equal to 0,9 corresponding to 90 % of the nonconforming items being detected.

Assume further that final inspection of this week's production of 20 000 items found (and replaced) 1 082 nonconforming items.

The quality found after final inspection,  $Q_{\text{fwi}}$ , expressed as a percentage, is:

$$Q_{\text{fwi}} = \frac{1082}{20000} \times 100, \text{ or } 5,41 \text{ \% nonconforming items,}$$

and, adjusting for the inspection efficiency, the manufacturing organization reports the outgoing quality rating for this week as:

$$Q_{\text{out}} = 5,41 \times \frac{1-0,9}{0,9}, \text{ or } 0,6 \text{ \% nonconforming items.}$$

The internal audit team desires to validate this value.

As the declared quality level, 0,6 % nonconforming items, is not one of the preferred values, the next higher preferred value of DQL, namely DQL = 0,65 % nonconforming items, is used. From [Table 1](#) and for LQR level II, the sampling plan has a sample size of  $n = 127$  and a non-rejection number of nonconforming items of  $c = 2$ .

In the audit, a sample of 127 items is selected from the outgoing lots. If no more than 2 nonconforming items are found in the sample, the rating is not contradicted, and the rating may be maintained.

For the following determination of the discriminatory ability of the sampling plan  $n = 127$  and  $c = 2$  for the non-preferred DQL = 0,6 %, refer to [8.2](#).

From [Table 4](#), the probability of contradicting a correct DQL of 0,6 % nonconforming items is less than 5,1 %. There is 10 % risk of failing to contradict the DQL of 0,6 % when the actual quality level is the