BRITISH STANDARD

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Sampling procedures for inspection by attributes —

Part 5: Procedures for assessment of declared quality levels

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BSI
British Standards

National foreword

This British Standard reproduces verbatim ISO 2859-4:2002 and implements it as the UK national standard. It supersedes BS 6001-5:2000 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee SS/5, Acceptance sampling schemes, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

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

Cross-references

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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

Reference number
ISO 2859-4:2002(E)

Contents

Annex

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 3.

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 part of ISO 2859 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 2859-4 was prepared by Technical Committee ISO/TC 69, *Applications of statistical methods*, Subcommittee SC 5, *Acceptance sampling*.

This second edition cancels and replaces the first edition (ISO 2859-4:1999), which has been technically revised.

ISO 2859 consists of the following parts, under the general title *Sampling procedures for inspection by attributes*:

— *Part 0: Introduction to the ISO 2859 attribute sampling system*

— *Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

— *Part 2: Sampling plans indexed by limiting quality (LQ) for isolated lot inspection*

— *Part 3: Skip-lot sampling procedures*

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

Annex A of this part of ISO 2859 is for information only.

Introduction

The procedures in this part of ISO 2859 differ in their scope from the procedures in ISO 2859 Parts 1 to 3. The system of acceptance sampling procedures that are specified in ISO 2859 Parts 1 to 3 are intended to be used in bilateral agreements between two parties. The 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 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 possible high risk of not accepting lots of qualities that both parties actually would consider to be acceptable.

Procedures in ISO 2859 Parts 1 to 3 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 2859 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 2859 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 2859 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 2859 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 attributes —

Part 4:
Procedures for assessment of declared quality levels

1 Scope

This part of ISO 2859 establishes sampling plans and procedures 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 as to obtain a risk of less than 5 % 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.

In contrast to the procedures in the other parts of ISO 2859, the procedures in this part of ISO 2859 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 2859 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 2859 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;

— administrative procedures.

The procedures are primarily intended to be used when the quantity of interest is the number or fraction of nonconforming items for which the inspected items are classified as conforming or nonconforming.

With minor changes, the procedures may also be used when the quantity of interest is the number of nonconformities or number of nonconformities per item. The necessary changes are:

— replacement of “number of nonconforming items” by “number of nonconformities”;

— replacement of “percent nonconforming items” by “nonconformities per 100 items”.

In this case the values given in Tables 2 to 7 are only approximations.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 2859. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 2859 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 3534-1:1993, *Statistics — Vocabulary and symbols — Part 1: Probability and general statistical terms*

ISO 3534-2:1993, *Statistics — Vocabulary and symbols — Part 2: Statistical quality control*

ISO 9000:2000, *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 2859, the terms and definitions given in ISO 3534-1, ISO 3534-2 and ISO 9000 and the following apply.

3.1.1

limiting number of nonconforming items

L

largest number of nonconforming items (or nonconformities) found in the sample from the entity under investigation that does not lead to contradiction of the declared quality level

3.1.2

quality ratio

ratio of the actual 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 (10 % in this part of ISO 2859) 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 2859 are as follows:

DQL Declared quality level

L Limiting number of nonconforming items in the sample

LQR Limiting quality ratio

n Sample size

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 2859 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 procedures have been devised in such a way 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. Consequently, 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.

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 worse than the declared quality level, the procedures in this part of ISO 2859 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 2859 are given in 6.1.

The sampling plans provided in this part of ISO 2859 are indexed by the limiting quality ratio (LQR) level and the declared quality level (DQL) and are provided in Table 1.

Table 1 — Master table of sampling plans

DQL	LQR level I		LQR level II		LQR level III	
% nonconforming items	n	L	n	L	n	L
0,010	3 150	1	[b] ←		[b] ←	
0,015	2 000	1	[b] ←		[b] ←	
0,025	1 250	1	3 150	2	[b] ←	
0,040	800	1	2 000	2	3 150	3
0,065	500	1	1 250	2	2 000	3
0,100	315	1	800	2	1 250	3
0,150	200	1	500	2	800	3
0,250	125	1	315	2	500	3
0,400	80	1	200	2	315	3
0,65	50	1	125	2	200	3
1,0	32	1	80	2	125	3
1,5	20	1	50	2	80	3
2,5	13	1	32	2	50	3
4,0	[a] →		20	2	32	3
6,5	[a] →		13	2	20	3
10,0	[a] →		[a] →		13	3

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

[a] → Use the sampling plan to the right which corresponds to a smaller limiting quality ratio as no sampling plan exist for this level of the limiting quality ratio.

[b] ← 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.

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 2859. 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 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 2859.

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 10,7 to 13,0. For example, if the declared quality level is 0,10 % nonconforming items, and the actual quality level is 12,3 times worse than this declared quality level, then the risk is 10 % for failing to contradict the declared quality level (see Table 2).

Table 2 — Limiting quality ratio (LQR) and probability of falsely contradicting a correct declared quality level (DQL) — LQR level I plans

DQL % nonconforming items	n	L	**LQR**	**Probability of falsely contradicting a correct DQL** %
0,010	3 150	1	12,3	4,0
0,015	2 000	1	13,0	3,7
0,025	1 250	1	12,4	4,0
0,040	800	1	12,1	4,1
0,065	500	1	11,9	4,3
0,10	315	1	12,3	4,0
0,15	200	1	12,9	3,7
0,25	125	1	12,3	4,0
0,40	80	1	11,9	4,1
0,65	50	1	11,6	4,2
1,0	32	1	11,6	4,1
1,50	20	1	12,1	3,6
2,5	13	1	10,7	4,1
EXAMPLE Suppose the plan, $n = 315$, $L = 1$, corresponding to a declared quality level (DQL) of 0,1 % nonconforming items, is used. For this plan, there is a 10 % risk of failing to contradict this DQL when the actual quality level is 12,3 (LQR) times worse than the declared quality level, i.e. if the actual quality level is 1,23 % 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 4,0 % 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 5,54 to 7,07. For example, if the declared quality level is 0,10 % nonconforming items, and the actual quality level is 6,64 times worse than this declared quality level, then the risk is 10 % for failing to contradict the declared quality level (see Table 3).

Table 3 — Limiting quality ratio (LQR) and probability of falsely contradicting a correct declared quality level (DQL) — LQR level II plans

DQL % nonconforming items	n	L	**LQR**	**Probability of falsely contradicting a correct DQL** %
0,025	3 150	2	6,75	4,6
0,040	2 000	2	6,65	4,7
0,065	1 250	2	6,54	4,9
0,10	800	2	6,64	4,7
0,15	500	2	7,07	4,0
0,25	315	2	6,72	4,5
0,40	200	2	6,60	4,7
0,65	125	2	6,46	4,9
1,0	80	2	6,52	4,7
1,5	50	2	6,86	3,9
2,5	32	2	6,31	4,5
4,0	20	2	6,12	4,4
6,5	13	2	5,54	4,8
EXAMPLE Suppose the plan, $n = 800$, $L = 2$, corresponding to a declared quality level (DQL) of 0,1 % nonconforming items, is used. For this plan, there is a 10 % risk of failing to contradict this DQL when the actual quality level is 6,64 (LQR) times worse than the declared quality level, i.e. if 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 4,7 % 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 4,44 to 5,55. For example, if the declared quality level is 0,10 % nonconforming items, and the actual quality level is 5,34 times worse than this declared quality level, then the risk is 10 % for failing to contradict the declared quality level (see Table 4).

6.2 Selection of a sampling plan

Given the chosen DQL and LQR levels, use Table 1 to select a single sampling plan.

EXAMPLE For example, if 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 125, and a limiting number of nonconforming items L of 2 which provides a LQR of 6,46 (see Table 3).

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 will result in a limiting quality ratio that is somewhat higher and a probability of falsely contradicting a correct declared quality level that is somewhat lower than the values given in Tables 2 to 4 (see 8.2).

Table 4 — Limiting quality ratio (LQR), and probability of falsely contradicting a correct declared quality level (DQL) — LQR level III plans

DQL % nonconforming items	n	L	LQR	Probability of falsely contradicting a correct DQL %
0,040	3 150	3	5,30	3,9
0,065	2 000	3	5,13	4,3
0,10	1 250	3	5,34	3,8
0,15	800	3	5,55	3,4
0,25	500	3	5,32	3,8
0,40	315	3	5,27	3,9
0,65	200	3	5,09	4,3
1,0	125	3	5,27	3,7
1,5	80	3	5,44	3,3
2,5	50	3	5,15	3,6
4,0	32	3	4,92	3,8
6,5	20	3	4,68	3,7
10,0	13	3	4,44	3,4

EXAMPLE Suppose the plan, $n = 1\,250$, $L = 3$, corresponding to a declared quality level (DQL) of 0,1 % nonconforming items, is used. For this plan, there is a 10 % risk of failing to contradict this DQL when the actual quality level is 5,34 (LQR) times worse than the declared quality level, 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.

7 Operating a sampling plan

7.1 Sample selection

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 6.2, 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 $n = 1\,25$ transactions shall be selected as five subsamples, each consisting of 25 transactions selected by simple random sampling from the transactions on each of the five days.

7.2 Rules for contradicting a declared quality level

The number of sample items inspected shall be equal to the sample size given by the plan.

— If the number of nonconforming items found in the sample is less than or equal to the limiting number (L), the declared quality level has not been contradicted.

— If the number of nonconforming items found in the sample is greater than the limiting number (L), the declared quality level has been contradicted.

EXAMPLE If, in the example considered in 6.2, two or fewer nonconforming items are found in the sample of 125, 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.

If the sample size equals or exceeds the size of the entity under investigation, then the DQL shall be verified by comparing it to the actual quality level determined by inspecting all items in the entity.

7.3 Disposition of nonconforming items

Any nonconforming items 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.

8 Further information

8.1 Curves showing approximate probability of contradiction

The curves shown in Figure 1 indicate the approximate probability that a sample result will lead to contradiction of the declared quality level. The curves give the approximate probability of contradiction as a function of the quality ratio.

The curves in Figure 1 refer to situations where the declared quality level 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 5 to 7 provide additional information about the probabilities of contradicting incorrect declared quality levels for different values of the quality ratio.

For each individual sampling plan, Tables 2 to 4 show the value of the limiting quality ratio (LQR) that corresponds to a 10 % risk of failing to contradict the declared quality level. This LQR together with the information presented in Tables 5 to 7 may be used to assess the discriminatory ability of each sampling plan.

Tables 2 to 4 also show the probability that the sample result (falsely) will contradict the declared quality level when the actual quality level is equal to the DQL.

The values in Tables 2 to 7 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 1/10 of the entity.

When the sample size is a larger fraction of the entity under investigation, the actual discriminatory ability will be better than indicated by the values in Tables 2 to 7. In particular, the actual limiting quality ratio will be smaller than the value indicated in Tables 2 to 4, and moreover, the actual probability of falsely contradicting a correct DQL will also be smaller than that indicated in Tables 2 to 4.

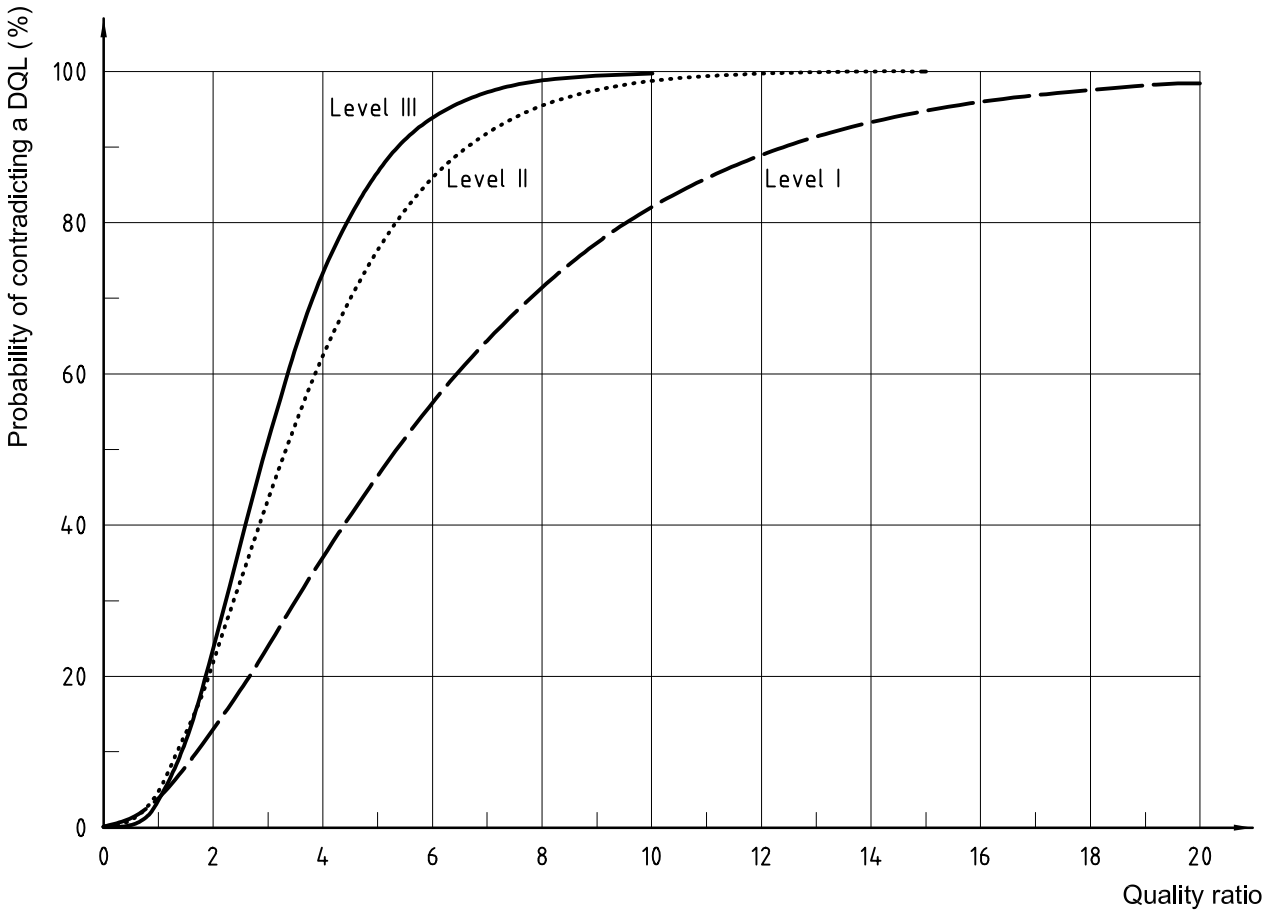

Figure 1 — Curves showing the approximate probability of contradicting a DQL for different values of the quality ratio

The values in Tables 2 to 7 refer to situations where the DQL used is one of the preferred values of DQL. 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 declared DQL will be less than that given in Tables 2 to 4. On the other hand, the actual LQR will be higher than the tabulated value of LQR for the preferred DQL.

The actual LQR, R_{a}, is given by the formula:

$$R_{\mathrm{a}} = R \times \frac{p}{p_{\mathrm{a}}}$$

where

R is the preferred limiting quality ratio;

p is the preferred declared quality level;

p_{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 5 to 7 can still be applied to non-preferred DQLs with the understanding that the actual quality level is the quality ratio, given in Tables 2 to 4, 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 $n = 500$, $L = 2$ is to be used.

From Table 3, it can be concluded that there is less than a 4 % risk of falsely contradicting the (non-preferred) DQL of 0,125 % nonconforming items. Furthermore, there will be 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 will be 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 6, for a quality ratio 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 72,4 %. Table 6 can similarly be used to find the probability of contradicting the non-preferred DQL for seven other values of the quality ratio.

Table 5 — Probability (%) of contracting a DQL for different values of the quality ratio — LQR level I plans

Quality ratio	Declared quality level (DQL) % nonconforming items												
	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
1,0	4,0	3,7	4,0	4,1	4,3	4,0	3,7	4,0	4,1	4,2	4,1	3,6	4,1
1,5	8,2	7,5	8,1	8,4	8,6	8,2	7,5	8,1	8,4	8,6	8,3	7,4	8,3
3,0	24,4	22,8	24,1	25,0	25,5	24,4	22,7	24,1	24,9	25,5	24,9	22,7	25,4
5,0	46,7	44,2	46,3	47,5	48,3	46,7	44,3	46,4	47,7	48,6	48,0	44,9	49,6
7,5	68,3	65,8	67,9	69,2	70,0	68,4	65,9	68,2	69,6	70,7	70,3	67,5	73,1
10,0	82,2	80,1	81,9	82,9	83,6	82,4	80,3	82,2	83,5	84,5	84,4	82,4	87,3
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	98,0
20,0	98,7	98,3	98,6	98,8	98,9	98,7	98,4	98,8	99,0	99,2	99,3	99,2	99,8
EXAMPLE Suppose the plan corresponding to a declared quality level of 0,10 % nonconforming items is used. For a quality ratio of 10 (the actual quality level is 10 times the declared quality level, i.e. 1,0 % nonconforming items) then there is a probability of 82,4 % that this sampling plan will indicate contradiction of the declared quality level.													

Table 6 — Probability (%) of contradicting a DQL for different values of the quality ratio — LQR level II plans

Quality ratio	Declared quality level (DQL) % nonconforming items												
	0,025	0,040	0,065	0,10	0,15	0,25	0,40	0,65	1,0	1,5	2,5	4,0	6,5
1,0	4,6	4,7	4,9	4,7	4,0	4,5	4,7	4,9	4,7	3,9	4,5	4,4	4,8
1,5	11,6	12,0	12,5	12,0	10,4	11,6	12,0	12,4	11,9	10,3	11,7	11,5	12,6
2,0	21,0	21,7	22,3	21,7	19,1	21,0	21,6	22,2	21,6	18,9	21,4	21,2	23,4
3,0	42,0	43,0	44,0	43,0	39,1	42,1	43,1	44,1	43,2	39,2	43,4	43,7	48,0
4,0	61,0	62,0	63,1	62,1	57,7	61,1	62,2	63,4	62,5	58,4	63,3	64,2	69,7
5,0	75,3	76,2	77,1	76,3	72,4	75,4	76,5	77,6	76,9	73,4	78,1	79,4	84,7
7,5	93,4	93,8	94,3	93,9	92,0	93,5	94,1	94,6	94,5	93,1	95,5	96,5	98,6
10,0	98,5	98,6	98,8	98,7	98,0	98,6	98,8	98,9	98,9	98,6	99,3	99,6	100,0
EXAMPLE Suppose the plan corresponding to a declared quality level of 0,15 % nonconforming items is used. For a quality ratio of 5 (the actual quality level is 5 times the declared quality level, i.e. 0,75 % nonconforming items) then there is a probability of 72,4 % that this sampling plan will indicate contradiction of the declared quality level.													

Table 7 — Probability (%) of contradicting a DQL for different values of the quality ratio — LQR level III plans

Quality ratio	Declared quality level (DQL) % nonconforming items												
	0,040	0,065	0,10	0,15	0,25	0,40	0,65	1,0	1,5	2,5	4,0	6,50	10,0
1,0	3,9	4,3	3,8	3,4	3,8	3,9	4,3	3,7	3,3	3,6	3,8	3,7	3,4
1,5	12,4	13,4	12,1	10,8	12,1	12,3	13,3	12,0	10,6	11,7	12,3	12,4	11,8
2,0	24,7	26,4	24,2	22,1	24,2	24,6	26,3	24,1	21,9	24,0	25,1	25,7	25,3
3,0	52,3	54,7	51,6	48,5	51,7	52,3	54,9	51,9	48,8	52,2	54,6	56,6	57,9
4,0	74,1	76,2	73,6	70,7	73,6	74,3	76,6	74,1	71,4	75,0	77,6	80,4	83,1
5,0	87,4	88,9	87,0	85,0	87,1	87,6	89,2	87,6	85,9	88,6	90,7	93,0	95,4
6,0	94,3	95,2	94,1	92,9	94,2	94,5	95,5	94,6	93,7	95,4	96,7	98,0	99,2
8,0	99,0	99,2	99,0	98,7	99,0	99,1	99,3	99,2	99,0	99,4	99,7	99,9	100,0

EXAMPLE Suppose the plan corresponding to a declared quality level of 0,25 % nonconforming items is used. For a quality ratio of 4 (the actual quality level is 4 times the declared quality level, i.e. 1,0 % nonconforming items) then there is a probability of 73,6 % that this sampling plan will indicate contradiction of the declared quality level.

Annex A
(informative)

Examples of use of the procedures

A.1 Example 1

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

Management decides to use this part of ISO 2859 to evaluate the effectiveness of the special training program 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 % has been chosen. From Table 1, it is found that, for LQR level III and the declared quality level DQL $=$ 1 %, the sampling plan has a sample size of $n = 125$ and a limiting number of nonconforming items of $L = 3$. This plan was proposed for the internal audit usage. A sample of $n = 125$ 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 4, it is found that for this plan there is a risk of 3,7 % of contradicting a correct declared quality level (1 % incorrectly processed invoices), and a risk of 10 % of failing to contradict when the actual quality level is 5,27 % incorrectly processed invoices [i.e. the actual quality level is 5,27 (the LQR) times worse than the declared quality level]. For additional information of the discriminatory ability of this sampling plan, refer to Table 7.

A.2 Example 2

To increase the efficiency of the quality management system the employees of an industrial plant are encouraged to inform the management about the problems that may negatively influence the quality of production. A closed-loop quality control system has been 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 decided 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 forced the management to investigate only a limited number of cases, therefore it is decided to select LQR level I with a system declared quality level (DQL) of 2,5 % of the problems remaining without a solution. From Table 1, it is found that, for LQR level I and the declared quality level DQL $=$ 2,5 %, the sampling plan has a sample size of $n = 13$ and a limiting number of nonconforming items of $L = 1$.

Therefore, the management decided to investigate 13 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 2, it is found that for this plan there is a risk of 4,1 % of contradicting a correct declared quality level (2,5 % problems without a solution), and a risk of 10 % of failing to contradict when the actual quality level is 26,75 % problems without a solution [i.e., the actual quality level is 10,7 (the LQR) times worse than the declared quality level]. For additional information of the discriminatory ability of this sampling plan, refer to Table 5.

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_{out} is the outgoing quality rating, expressed in percent nonconforming items;

Q_{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_{fwi}, expressed as a percentage, is

$$Q_{\text{fwi}} = \frac{1\,082}{20\,000} \times 100$$

or 5,41 % nonconforming items

and, adjusting for the inspection efficiency, the manufacturing organization will report the outgoing quality rating for this week as

$$Q_{\text{out}} = 5{,}41 \times \frac{1 - 0{,}9}{0{,}9}$$

or 0,6 % 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 $n = 125$ and a limiting number of nonconforming items of $L = 2$.

In the audit a sample of 125 items is selected from the outgoing lots. If no more than 2 nonconforming items are found in the sample, the rating has not been contradicted, and the rating may be maintained.

For the following determination of the discriminatory ability of the sampling plan $n = 125$ and $L = 2$ for the non-preferred DQL $=$ 0,6 %, refer to 8.2.

From Table 3, the probability of contradicting a correct DQL of 0,6 % nonconforming items is less than 4,9 %. There is a 10 % risk of failing to contradict the DQL of 0,6 % when the actual quality level is the preferred DQL (0,65 %) times the LQR (6,46), i.e. 4,2 %. For the DQL of 0,6 % nonconforming items, the actual LQR is $6{,}46 \times (0{,}65/0{,}6) = 7{,}0$.

From Table 6 for a quality ratio of 5,0 and the preferred DQL of 0,65 % (actual quality level of $5{,}0 \times 0{,}65\ \% = 3{,}25\ \%$), the probability of contradicting the DQL of 0,6 % nonconforming items is 77,6 %.

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