

Sampling procedures for inspection by attributes —

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

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Committees responsible for this British Standard

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- British Clay plc
- Clay Pipe Development Association Limited
- Institute of Metal Finishing
- Institute of Quality Assurance
- Ministry of Defence
- Royal Statistical Society
- Society of Engineers Incorporated

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National foreword

This Part of BS 6001, having been prepared under the direction of the Quality, Management and Statistics Standards Policy Committee, supersedes BS 6001-2:1984, which is withdrawn.

This revision is identical with ISO 2859-2:1985 *Sampling procedures for inspection by attributes — Part 2: Sampling plans indexed by limiting quality (LQ) for isolated lot inspection*, published by the International Organization for Standardization (ISO). It follows the principles and procedures that were given in the 1984 edition of BS 6001-2.

In this edition there has been a rearrangement in the sequence of the tables. The illustrative examples, previously collected in an annex, have been brought into the main body of the text. Other changes are of a minor editorial nature.

BS 6001 is published in the following Parts.

- *Part 1: Specification for sampling plans indexed by acceptable quality level (AQL) for lot-by-lot inspection;*
- *Part 2: Specification for sampling plans indexed by limiting quality (LQ) for isolated lot inspection;*
- *Part 3: Specification for skip-lot procedures.*

The publication of this revision of Part 2 coincides with the publication of a revision of Part 3. It is envisaged that Part 0 will be published identical to ISO 2859-0, which is in preparation.

Additional information. In addition to the textual errors which have been found in the international text (see below), there are points in the text that will benefit from some commentary.

In **0.1**, paragraph 2, it is stated that acceptable quality level (AQL) is defined as a process average. This statement contradicts **5.1** of ISO 2859-1:1989 which asserts (paragraph 3) that the AQL should not be confused with the process average. For guidance see **3.6** of ISO 2859-1 where AQL is defined as the quality level which for the purpose of sampling inspection is the limit of a satisfactory process average.

Footnote 1 to **1.1** quotes from ISO 2859-1. In line 3 delete “Tables 6 and 7 give process levels” and substitute with “Tables VI and VII give percent nonconforming levels” in order to bring the quote up to date with the current edition of ISO 2859-1.

In **3.5.1**, paragraph 2, line 5, “ LQ_{10} ” introduces a notational convention which is not explained in the text. This symbol means the limiting quality level for which there is a 10 % chance of acceptance.

The statement in parentheses underneath the title of the OC curve plots in each of the Table B1 to Table B10 is not complete. Therefore “(Curves are identified by sample size code)” should be deleted and substituted with “(Curves are identified by the sample size code letter and acceptance number)”.

For consistency, the limiting quality in the title of Table B4 should be stated as 2,0 % rather than 2,00 %.

In Table D1 the purpose of the rectangular box may not be immediately clear. The sentence underneath the box should be deleted and substituted with “Each cell in the table has the above layout and shows the consumer’s risk (PLQ) and the producer’s risk point (p , P_a) as indicated”.

Cross-references

International Standard	Corresponding British Standard
ISO 2859	BS 6001 <i>Sampling procedures for inspection by attributes</i>
ISO 2859-0 ^a	Part 0 <i>Introduction to the BS 6001 attribute sampling system</i> ^a (Identical)

^a In preparation.

International Standard	Corresponding British Standard
ISO 2859-1:1989	Part 1:1991 <i>Specification for sampling plans indexed by acceptable quality level (AQL) for lot-by-lot inspection</i> (Identical)
ISO 2859-3:1991	Part 3:1993 <i>Specification for skip-lot procedures</i> ^a (Identical)

^a In preparation.

Textual errors. When adopting the text of the International Standard, the textual errors listed below were discovered. They have been marked in the text and have been reported to ISO in a proposal to amend the text of the International Standard.

In **0.1**, paragraph 1, first indented line, delete “General introduction” and substitute “Introduction to the ISO 2859 attribute sampling system”.

In **0.1**, paragraph 2, line 8, delete “reduction to test and inspection costs” and substitute “reduction in test and inspection costs”.

In **1.2**, item b), line 2, insert “a” between “one of” and “continuing series”.

In **3.3**, paragraph 2, line 2, delete “sampling size” and substitute “sample size”.

In **3.3**, paragraph 3, line 1, delete “these tables” and substitute “this table”.

In **3.5.2**, lines 14 to 17, delete the sentence “For this reason, inspection level III provided by ISO 2859-1 has not been incorporated in this part of ISO 2859 for limiting qualities greater than 5 %.”

In **4.1**, line 2, insert “number of” between “specified” and “sample units”.

In the title of Table B1 delete “Sampling plans” and substitute “Single sampling plans”.

In Table D1, in the rectangle below the title, bottom right, delete “Probability of acceptance at quality (p)” and substitute “Probability of acceptance at quality p (P_a)”.

In Table D1, the column headed “1,25”, second cell from the bottom, top right entry, delete “0,060” and substitute “0,066”.

In Table D1, footnote 1, line 2, insert “point” between “producer’s risk” and “is”.

In Table D1, footnote 2, insert “this” between “of” and “limiting”; after “nonconforming” insert “items”.

In Table D2, line 1 of the text following the title, insert “no” between “there are” and “nonconforming” in the second sentence.

In Table D2, line 2 of the text following the title, delete “sample ($A_c = 0$), the” and substitute “sample ($A_c = 0$). The”.

In Table D5, in the column headed “Sample size”, delete “1 500” and substitute “500”.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 22, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

0 Introduction

0.1 General

ISO 2859 comprises four parts:

- *Part 0: General introduction;*
- *Part 1: Sampling plans indexed by acceptable quality level (AQL) for lot-by-lot inspection;*
- *Part 2: Sampling plans indexed by limiting quality (LQ) for isolated lot inspection;*
- *Part 3: Skip lot sampling plan.*

ISO 2859-1 sampling plans, indexed in terms of AQL, which is defined as a process average, were primarily designed for the assessment of a continuing series of lots. This enables switching rules to be employed which not only give protection to the consumer (by the switch to tightened inspection and discontinuation where necessary) but also provide an incentive to the producer (by the switch to reduced inspection) with a reduction to test and inspection costs (when consistently good quality is achieved). However, there is little doubt that in many industrial situations today the switching rules are not applied for a variety of reasons or excuses, not all of which may be valid:

- a) individual ISO 2859-1 plans are used alone but “AQL” protection is still claimed or AQL re-defined, to suit “so-called unique products”;
- b) “our industry... product is special so ISO 2859-1 standard plans need not apply to us”;
- c) production is intermittent (not continuous);
- d) production is from several different sources in varying quantities, i.e. “job lots”;
- e) purchases are from stock-holders — no source data available;
- f) lots are “small” (use of hypergeometric distribution required);
- g) lots are “isolated”;
- h) lots are re-submitted after initial rejection.

Consequently, in certain of the above cases consumer protection may need to be attained or measured by other methods. This part of ISO 2859 uses the limiting quality to measure consumer protection. It should be remembered, however, that prior information on the supplier’s quality assurance system and its effectiveness may play a major part in deciding whether or not to accept a single lot.

0.2 Objectives

In an attempt to reconcile the somewhat diverse requests for assistance made over the past few years by committees of international standardizing bodies representing various product sectors, this part of ISO 2859 was drawn up in accordance with the following principles:

- a) the new LQ plans can be easily integrated with the existing AQL plans in ISO 2859-1;
- b) the LQ indexing uses a preferred series of values that cannot be confused with the preferred series of AQL values;
- c) the five basic numbers associated with a single sampling plan, i.e. lot size, sample size, acceptance number, AQL (or quality accepted with probability 0,95) and LQ, appear in the same table, whenever possible.

0.3 Summary

The problems associated with acceptance sampling inspection involve defining unambiguously the criteria used to judge discrete individual items supplied in quantity, the quality level expected from the manufacturing process, the discrimination offered by the plans and the procedure to be followed when a lot is not accepted. Above all, however, it is necessary to design the sampling scheme so that it may easily be invoked in a purchasing contract. The plans in this part of ISO 2859 make maximum use of the established plans given in ISO 2859-1, so that sub-clause 12.6 of ISO 2859-1 (see 1.1) can be made directly operational, by providing a rationalized series of plans indexed in terms of limiting quality (LQ).

1 Scope and field of application

1.1 Scope

This part of ISO 2859 establishes LQ sampling plans and procedures for inspection by attributes compatible with ISO 2859-1 that can be used when the switching rules given in ISO 2859-1 are not applied, for example, when lots are of an isolated nature.

The plans in this part of ISO 2859 are indexed by a preferred series of limiting qualities (LQ) with a consumer’s risk usually below 10 %, but always below 13 %. This method of indexing permits the “ad-hoc” procedure¹⁾ mentioned in sub-clause 12.6 of ISO 2859-1 to be implemented as a standard procedure.

¹⁾ ISO 2859-1 sub-clause 12.6.2, states: “If the lot or batch is of an isolated nature, it may be desirable to limit the selection of sampling plans to those, associated with a designated AQL value, that provide not less than a specified limiting quality protection. Sampling plans for this purpose can be selected by choosing a limiting quality (LQ) and a consumer’s risk to be associated with it. Tables 6 and 7 give process levels for which the probabilities of lot acceptance under various sampling plans are 10 % and 5 %, respectively.” This part of ISO 2859 establishes preferred values for the LQ and allows the consumer’s risk to vary as indicated above.

NOTE The plans in ISO 2859-1 are indexed by a preferred series of AQL values and inspection levels. During the inspection of a continuing series of lots the application of switching rules helps to ensure that the process average in that series of lots is kept below the specified AQL. Limiting quality does not have the same direct relationship with the process average (see 3.5.1).

1.2 Field of application

Alternative procedures are provided in this part of ISO 2859 to cater for two situations often met in practice:

- a) **Procedure A**, to be used when the supplier and consumer both wish to regard the lot in isolation. The tables are based on random sampling from finite lots for both consumer and producer risks. This procedure shall be used unless there is a specific instruction to use procedure B.
- b) **Procedure B**, to be used when the supplier regards the lot as one of²⁾ continuing series but the consumer considers the lot received in isolation. The tables are based on random sampling from a finite lot for consumer's risk at the limiting quality, but random sampling from a process for the producer's risk and the tabulated values of the operating characteristic (OC) curves. The plans used are a selection of the plans available in ISO 2859-1 so that a producer can maintain consistent procedures for customers whether or not they receive individual lots or a continuing series of lots. This procedure is suitable for inclusion in product standards or specifications that contain sampling clauses. The manufacturer will be concerned with all of his production, but the individual consumer only with the particular lot received.

2 Definitions

The definitions given in ISO 2859-1 shall apply.

3 Choice of sampling plan

3.1 Specifying a sampling plan

When reference is made to this part of ISO 2859 in a contract or specification, it is necessary to specify the procedure to be used (i.e. either A or B). In the absence of any reference to either procedure, then procedure A shall be used.

3.2 Choice of sampling procedure

Although procedure A is based on the hypergeometric distribution for sampling results, this distribution is well approximated by the binomial distribution for plans with non-zero acceptance numbers in procedure A. Hence the OC curves for these plans are well approximated by the tabulated performance of the same plans in procedure B. However, procedure A uses plans with acceptance number zero and with sample sizes based on the hypergeometric distribution of sampling results while procedure B excludes accept zero plans, replacing them with 100 % inspection.

The choice between the procedures is dominated by the attitude towards accept zero plans. Procedure A uses accept zero plans linking the sample size and the lot size by the hypergeometric distribution until the proposed plan corresponds to the accept zero plan in ISO 2859-1 corresponding to that limiting quality. Thereafter the progression of sampling size and acceptance number with lot size is based on the inspection levels available in ISO 2859-1. The overall effect of procedure A resembles inspection level II for limiting quality less than 8 % and level I for limiting quality greater than 8 % with 8 % being intermediate between these levels.

Procedure B provides greater flexibility in the choice of inspection levels. The tabulated OC curves are based on the probability of producing a nonconforming unit so they are approximately correct for small sampling fractions but as the sampling fraction increases the curves (and tables) underestimate the probability of acceptance for good quality and underestimate the probability of rejection for poor quality. For sufficiently small lots, procedure B requires 100 % inspection.

Both procedures treat the limiting quality (LQ) as the actual percent nonconforming units in the submitted lots and the probability of acceptance at this limiting quality can be found in Table D1 for procedure A and Table B1 to Table B10 for procedure B. Procedure B is indicated as the appropriate procedure if the manufacturer is concerned with a continuing series of lots; whether or not these go to the same consumer. Procedure A is indicated as the appropriate procedure when the lot is a single lot and shall be used if accept zero plans are required to be part of the sampling scheme.

3.3 Procedure A (use Table A)

A plan is identified by the lot size and the limiting quality (LQ).

²⁾ See national foreword for details of textual error.

With the specified lot size and limiting quality as indexing values, the sampling size³⁾ (n) and acceptance number (A_c) are, given in Table A.

Although the primary index to these tables³⁾ is the limiting quality (LQ), the producer/supplier needs guidance on the quality level required if lots are to have a high probability of acceptance. Information on the producer's risk point is contained in Table D1. Information on the probability of acceptance of relatively good lots by accept zero plans is given in Table D2.

3.4 Procedure B (use Tables B)

A plan is identified by the lot size, limiting quality (LQ) and the inspection level (unless otherwise specified, level II shall be used).

The specified limiting quality is used to select the appropriate table from Table B1 to Table B10. Within each table the specified lot size and inspection level indicate the appropriate sample size (n) and acceptance number (A_c). Although the primary index to the table is the limiting quality (LQ), the producer/supplier needs guidance on the quality level required if lots are to have a high probability of acceptance. Each table gives information on the equivalent AQL and details of the OC curves. The OC curves are indexed by the sample size code letter used in ISO 2859-1 and the acceptance number.

The OC curves given under Table B1 to Table B10 are based on the Poisson/binomial distribution; the actual operating characteristic will be more discriminating than these curves by accepting with greater probability when the indicated probability is $\geq 0,90$ and with a smaller probability when the indicated probability is $< 0,10$.

3.5 Choice of parameters for the sampling procedures

3.5.1 Limiting quality (LQ)

Unlike the AQL, which provides a guide for the producer on the level or quality he needs to produce so that he can satisfy the acceptance criteria (sampling clause) most of the time, the limiting quality does not provide a reliable guide for the consumer as to the true quality of the accepted lots. For this reason the limiting quality should be chosen realistically at a minimum of three times the desired quality.

This enables the producer/supplier to provide lots of the desired quality and still have a reasonable probability of acceptance for the submitted lots, at least for acceptance numbers 3, 5, 10 and 18. For acceptance number 1 plans the lots have to have a quality better than LQ_{10} and for acceptance number zero plans the lots have to be perfect or nearly perfect before the probability of acceptance rises to 0,95 or greater. The limiting values are restricted to a set of preferred values and the plans are intended to be used with these preferred values. If these plans are introduced where a non-standard limiting quality is already specified, the plans should be entered with the preferred value (LQ) corresponding to the interval containing the non-standard value (L) listed in column 4 of Table C. Columns 2 and 3 of Table C contain information on the consumer's risk qualities (CRQ) found in Table B1 to Table B10 for consumer's risks of 10 % and 5 %.

Example:

The limiting quality has previously been set at 3,5 %. This is not a preferred value and the tables shall be entered by using the nominal limiting quality $LQ = 3,15$ %, since 3,5 % lies in the range $2,5 \% \leq LQ < 4,0 \%$.

3.5.2 Inspection level

In the ISO 2859-1 procedures, increased sample size corresponds to a greater protection for the consumer. In this part of ISO 2859, consumer protection is held approximately constant and the effect of increasing sample size is to permit the supplier greater latitude in the permitted process averages. If the consumer is satisfied by the protection provided against an occasional poor lot by the nominal limiting quality, then the inspection level is primarily of interest to the supplier, especially if the costs of the sampling inspection are borne by him. A process average well below the limiting quality (better quality) would allow the use of smaller sample sizes. Conversely, if the consumer is concerned with actual rather than limiting quality, or if he pays for the sampling costs, then greater inspection levels are not necessarily advantageous. For this reason, inspection level III provided by ISO 2859-1 has not been incorporated in this part of ISO 2859 for limiting qualities greater than 5 %.³⁾ When sample sizes have to be kept small and other considerations are secondary, specifying level S-2 has the effect of providing a fixed sample size for all lot sizes, the sample size depending only on the limiting quality.

³⁾ See national foreword for details of textual error.