International Standard ISO 2859/2

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

Règles d'échantillonnage pour les contrôles par attributs — Partie 2: Plans d'échantillonnage pour les contrôles de lots isolés, indexés d'après la qualité limite (QL)

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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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

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

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 2859/1are 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" procedure[1] mentioned in sub-clause 12.6 of ISO 2859/1 to be implemented as a standard procedure.

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. <u>This procedure shall be used unless there is a specific instruction to use procedure B.</u>

b) **Procedure B**, to be used when the supplier regards the lot as one of 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. <u>The manufacturer will be concerned with all of his production, but the individual consumer only with the particular lot received.</u>

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 tables B1 to 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).

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

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.

Although the primary index to these tables 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 tables B1 to B10. Within each table the specified lot size and inspection level indicate the appropriate sample size (n) and acceptance number (Ac). 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 tables B1 to 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 $\geqslant 0{,}90$ 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 tables B1 to 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 $2{,}5\ \% \leqslant LQ < 4{,}0\ \%$.

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 %. 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.

4 Rules for acceptance and non-acceptance

4.1 Sampling

Once the sampling plan has been determined as in clause 3, the specified sample units shall now be drawn at random from the lot, and all units in the sample inspected.

4.2 Acceptance

If the number of nonconforming units, or the total number of nonconformities, found in the sample is equal to or less than the acceptance number (Ac) specified in the plan, the lot shall be accepted.

4.3 Nonconforming units

Notwithstanding that the lot is accepted, any nonconforming units found during inspection, whether forming part of the sample or not, shall be rejected.

4.4 Non-acceptance and resubmission

If the number of nonconforming units found in the sample is greater than the acceptance number (Ac), the lot is unacceptable. An unacceptable lot may not be resubmitted for inspection unless

a) the Responsible Authority agrees, and

b) all units in the lot have been re-examined or retested and all nonconforming units have been removed or replaced by good units or nonconformities have been corrected.

If the Responsible Authority agrees to the resubmission of an unacceptable lot, he shall determine the method of acceptance inspection to be applied (i.e. LQ and/or inspection level) and whether re-inspection shall include all types or classes of non-conformities or only those that caused the initial rejection.

5 Double and multiple sampling plans

Tables D3 and D4 provide the sample sizes and acceptance patterns for the double and multiple sampling plans in ISO 2859/1 equivalent to the single sampling plans given in tables B1 to B10. The sample size code agrees with that in ISO 2859/1 and the acceptance pattern code is the acceptance number in the corresponding single size plans. Since procedure A and procedure B plans have similar OC curves for non-zero acceptance numbers, these double and multiple plans can also be used in procedure A to replace the corresponding single sampling plan. The user is referred to 11.1.2 and 11.1.3 in ISO 2859/1 for the operation of these double and multiple sampling plans.

6 Examples illustrating how to use this part of ISO 2859

6.1 A consumer wishes to purchase prepacked sets of 10 screws to include in the self-assembly bookcase kits he plans to sell. While he prefers each set to contain exactly 10 screws, he can tolerate 1 % of packs with fewer screws but he does not want to risk accepting a much higher percentage of deficient packs. He plans to produce 5 000 kits in lots of 1 250.

The supplier agrees to use procedure A with nominal limiting quality 3,15 %. For lots of size 1 250, the selected plan has n = 125, Ac = 1.

The supplier offers to provide the packs needed for all 5 000 kits as a single lot. The new sampling plan has n = 200, Ac = 3.

The single lot requires proportionately fewer tested items and yet the sampling plan still provides a high probability of rejection for quality as poor as 3,15 %, while increasing the probability of acceptance for a lot of quality 1 % from 0,64 to 0,86.

6.2 The same consumer wishes to purchase the wooden components of his self-assembly bookcase kit as standard-size, plastic-faced chipboard panels. The supplier produces these panels as part of his regular production and regards the 7 500 panels needed for each lot of 1 250 kits as single lots in the general stream of supply to DIY shops. Scars to the plastic facing occur with probability 0,025 according to quality control checks. The consumer can tolerate some scarred panels since these can be detected and set aside during the processing to produce the bookcase kit, but he decides that if 5 % of the panels were scarred this would present problems during the processing.

The consumer and supplier agree that procedure B is appropriate and select nominal limiting quality 5,0 % with inspection level S-4. The parameters of the sampling plan for a lot size of 7 500 is n = 80, Ac = 1. With this plan the probability of acceptance with the current process average is less than 0,5. A lot which is unacceptable has to be 100 % inspected before use and this high probability of non-acceptance implies inspection costs larger than desirable.

Inspection level III would have provided a sampling plan with n = 315 and Ac = 10. The current process average would produce lots with a probability of acceptance greater than 0,80. A supplier with a better process average, say 1 %, would obtain a similar probability of acceptance with inspection level S-4. This illustrates the ability of better suppliers to work with smaller sample sizes whilst still meeting the same limiting quality criterion.

7 Compatibility with ISO 2859/1

7.1 General

Within the probability constraints inherent in attribute sampling, the LQ indexed plans standardized in table A and tables B provide a rationalized selection from the existing AQL indexed plans of ISO 2859/1. Similar rules for acceptance and non-acceptance and the ISO 2859/1 lot size categories have also been retained for compatibility. Significant deviations are given in 7.2 and 7.3.

7.2 Procedure A (see table A)

For unique lots with a relatively high sample size/lot size ratio, it becomes necessary to use the hypergeometric distribution. Consequently, there are an additional 39 (Ac = 0) plans in table A for which operating characteristic (OC) curve data is given in table D2. The remaining 80 plans of table A have been taken from ISO 2859/1.

7.3 Procedure B (see tables B)

All the plans in tables B have been selected from ISO 2859/1 by using a sliding scale for the consumer's risk (usually below 10 %) at the specified limiting quality (LQ). ISO 2859/1 inspection levels are also included (see 3.5.2) but Ac = 0 plans have not been included in tables B, as table A can be used, if Ac = 0 plans are considered essential.

Table A — Single sampling plans indexed by limiting quality (LQ) (Procedure A)

Lot size		Limiting quality in percent (LQ)									
		0,5	0,8	1,25	2,0	3,15	5,0	8,0	12,5	20	32
16 to 25	*n* Ac	→	→	→	→	→	25 [1] 0	17 [1] 0	13 0	9 0	6 0
26 to 50	*n* Ac	→	→	→	50 [1] 0	50 [1] 0	28 [1] 0	22 0	15 0	10 0	6 0
51 to 90	*n* Ac	→	→	90 [1] 0	50 0	44 0	34 0	24 0	16 0	10 0	8 0
91 to 150	*n* Ac	→	150 [1] 0	90 0	80 0	55 0	38 0	26 0	18 0	13 0	13 1
151 to 280	*n* Ac	200 [1] 0	170 [1] 0	130 0	95 0	65 0	42 0	28 0	20 0	20 1	13 1
281 to 500	*n* Ac	280 0	220 0	155 0	105 0	80 0	50 0	32 0	32 1	20 1	20 3
501 to 1 200	*n* Ac	380 0	255 0	170 0	125 0	125 1	80 1	50 1	32 1	32 3	32 5
1 201 to 3 200	*n* Ac	430 0	280 0	200 0	200 1	125 1	125 3	80 3	50 3	50 5	50 10
3 201 to 10 000	*n* Ac	450 0	315 0	315 1	200 1	200 3	200 5	125 5	80 5	80 10	80 18
10 001 to 35 000	*n* Ac	500 0	500 1	315 1	315 3	315 5	315 10	200 10	125 10	125 18	80 18
35 001 to 150 000	*n* Ac	800 1	500 1	500 3	500 5	500 10	500 18	315 18	200 18	125 18	80 18
150 001 to 500 000	*n* Ac	800 1	800 3	800 5	800 10	800 18	500 18	315 18	200 18	125 18	80 18
> 500 000	*n* Ac	1 250 3	1 250 5	1 250 10	1 250 18	800 18	500 18	315 18	200 18	125 18	80 18

1) When *n* exceeds the lot size, use 100 % inspection with zero acceptance number.

→ Limiting quality implies less than one nonconforming item in the lot. Use first available plan for higher LQ.

Table B1 — Sampling plans for limiting quality 0,5 %

Lot sizes for inspection levels					ISO 2859/1 Single sampling plan (Normal inspection)			Code letter	Tabulated values of submitted quality accepted with designated probabilities[1] (quality as percent nonconforming)					Acceptance probabilities for limiting quality[2]	
S-1 to S-3	S-4	I	II	III	AQL	*n*	Ac		0,95	0,90	0,50	0,10	0,05	max.	min.
> 800[3]	> 800[3]	> 800[3]	801[3] to 500 000	801[3] to 150 000	0,065	800	1	P	0,044 4	0,066 5	0,210	0,486	0,593	0,091	0,000
			> 500 000	150 001 to 500 000	0,10	1 250	3	Q	0,109	0,140	0,294	0,534	0,620	0,129	0,129
				> 500 000	0,10	2 000	5	R	0,131	0,158	0,284	0,464	0,526	0,066	0,066

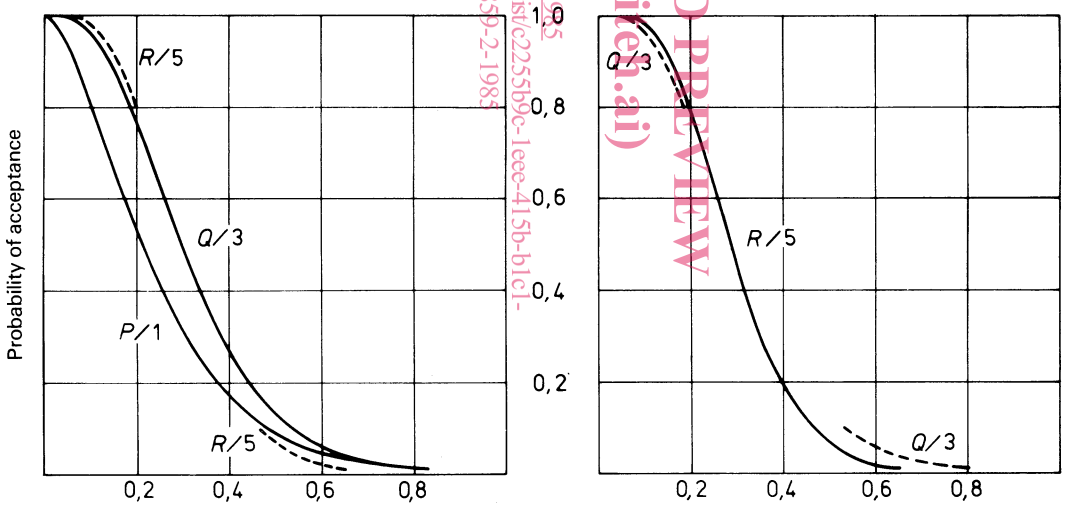
1) Probability calculated by the Poisson approximation.

2) The exact acceptance probabilities calculated from the hypergeometric distribution vary with lot size, the maximum and minimum values attained for permitted lot sizes are given for each plan.

3) For fewer than 801 in the lot, 100 % inspect the lot.

Operating characteristic curves for single sampling plans

(Curves are identified by sample size code)



Quality of submitted lots (percent nonconforming)

Table B2 — Single sampling plans for limiting quality 0,8 %

Lot sizes for inspection levels					ISO 2859/1 Single sampling plan (Normal inspection)			Code letter	Tabulated values of submitted quality accepted with designated probabilities[1] (quality as percent nonconforming)					Acceptance probabilities for limiting quality[2]	
S-1 to S-3	S-4	I	II	III	AQL	*n*	Ac		0,95	0,90	0,50	0,10	0,05	max.	min.
> 500[3]	> 500[3]	501[3] to 500 000	501[3] to 150 000	501[3] to 35 000	0,1	500	1	N	0,071	0,106	0,336	0,778	0,949	0,091	0,000
		> 500 000	150 001 to 500 000	35 001 to 150 000	0,15	800	3	P	0,171	0,218	0,459	0,835	0,969	0,118	0,115
			> 500 000	> 150 000	0,15	1 250	5	Q	0,209	0,252	0,454	0,742	0,841	0,066	0,066

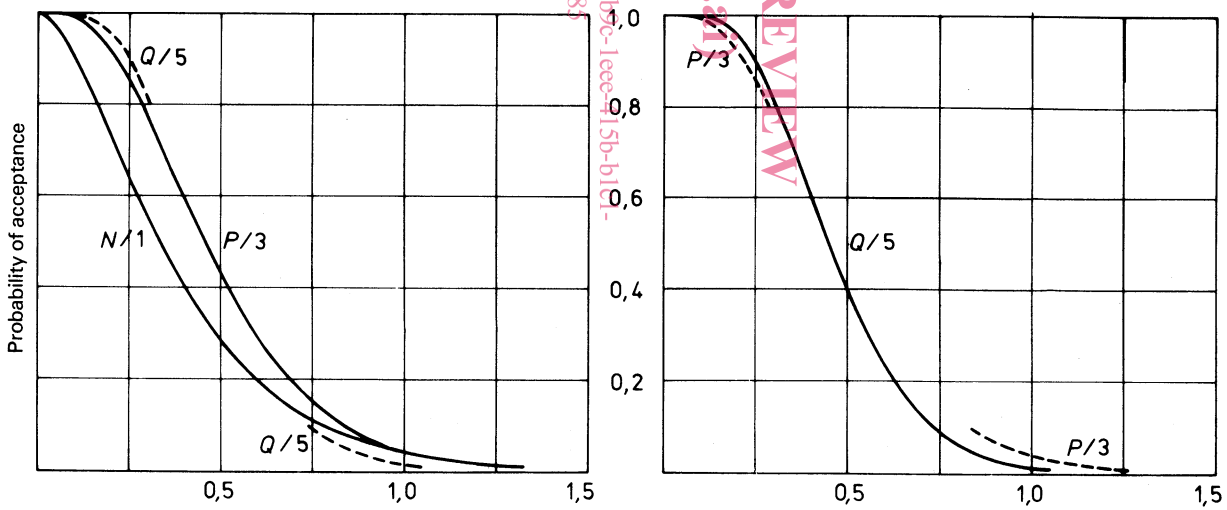
1) Probability calculated by the Poisson approximation.

2) The exact acceptance probabilities calculated from the hypergeometric distribution vary with lot size, the maximum and minimum values attained for permitted lot sizes are given for each plan.

3) For fewer than 501 in the lot, 100 % inspect the lot.

Operating characteristic curves for single sampling plans

(Curves are identified by sample size code)



Quality of submitted lots (percent nonconforming)