INTERNATIONAL STANDARD

ISO 28593

First edition
2017-10

Acceptance sampling procedures by attributes — Accept-zero sampling system based on credit principle for controlling outgoing quality

Procédures d'échantillonnage par attributs pour acceptation — Système d'échantillonnage de tolérance zéro-défaut basé sur le principe de crédit pour le contrôle de la qualité à la sortie

Reference number
ISO 28593:2017(E)

ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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).

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).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

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

This first edition of ISO 28593 cancels and replaces ISO 18414:2006, of which it constitutes a minor revision to change the reference number from 18414 to 28593.

With the view to achieve a more consistent portfolio, TC 69/SC 5 has simultaneously renumbered the following standards, by means of minor revisions:

Old reference	New reference	Title
ISO 2859-10:2006	ISO 28590:2017	Sampling procedures for inspection by attributes — Introduction to the ISO 2859 series of standards for sampling for inspection by attributes
ISO 8422:2006	ISO 28591:2017	Sequential sampling plans for inspection by attributes
ISO 28801:2011	ISO 28592:2017	Double sampling plans by attributes with minimal sample sizes, indexed by producer's risk quality (PRQ) and consumer's risk quality (CRQ)
ISO 18414:2006	ISO 28593:2017	Acceptance sampling procedures by attributes — Accept-zero sampling system based on credit principle for controlling outgoing quality
ISO 21247:2005	ISO 28594:2017	Combined accept-zero sampling systems and process control procedures for product acceptance

ISO 14560:2004	ISO 28597:2017	Acceptance sampling procedures by attributes — Specified quality levels in nonconforming items per million
ISO 13448-1:2005	ISO 28598-1:2017	Acceptance sampling procedures based on the allocation of priorities principle (APP) — Part 1: Guidelines for the APP approach
ISO 13448-2:2004	ISO 28598-2:2017	Acceptance sampling procedures based on the allocation of priorities principle (APP) — Part 2: Coordinated single sampling plans for acceptance sampling by attributes

Cross references between the above listed documents have been corrected in the minor revisions.

A list of all documents in the new ISO 28590 - ISO 28599 series of International Standards can be found on the ISO website.

Acceptance sampling procedures by attributes — Accept-zero sampling system based on credit principle for controlling outgoing quality

1 Scope

1.1 This International Standard specifies a system of single sampling schemes for lot-by-lot inspection by attributes. All the sampling plans of the present system are of accept-zero form, i.e. no lot is accepted if the sample from it contains one or more nonconforming items. The schemes depend on a suitably-defined average outgoing quality limit (AOQL), the value of which is chosen by the user; no restrictions are placed on the choice of the value of the AOQL or on the sizes of successive lots in the series. The methodology ensures that the overall average quality reaching the customer or market-place will not exceed the AOQL in the long run.

1.2 The schemes are intended to induce a supplier, through the economic and psychological pressure of lot non-acceptance and consequent loss of accumulated credit, to attempt to maintain a nonconformity-free process, while assuring, by means of the lowest practicable sample sizes, that the long-term percentage of nonconforming items delivered to the customer or market-place does not exceed the AOQL. This objective is achieved by a progressive reduction in the sample size in response to good quality history.

1.3 The schemes are designed to be applied to a series of lots from each supplier. The credit principle provides:

a) automatic protection to the customer if a deterioration in quality is detected, by means of a total loss of accumulated credit and reversion to a relatively large sample size whenever a nonconforming item is found, and 100 % inspection of

   1) the first lot if it is not accepted, or

   2) any non-accepted lot that immediately follows a non-accepted lot;

b) an incentive to reduce sampling costs (by means of a progressive reduction in required sample size) if consistently good quality is achieved.

1.4 This International Standard is designed for use under the following conditions:

a) where the inspection procedure is to be applied to a series of lots of discrete items that are intended to be identical, and which are all supplied by one producer using one production process (If there are different producers or production processes, this International Standard is intended to be applied to each one separately.);

b) where one or more quality characteristics of these products are taken into consideration, which must all be classifiable as either conforming or nonconforming;

c) where the inspection error involved in classifying the state of a product's quality characteristic(s) is negligible;

d) where inspection is non-destructive.

This International Standard can be suitable for regulatory purposes, as control of the *expected* quality of items reaching the market-place is achieved with the smallest possible sample sizes, and long-term control of the *realized*, or *actual* quality level in the market-place is achieved with certainty, regardless of how long or short individual suppliers' series may be. This International Standard can be used by

suppliers/producers, buyers/consumers and regulatory agencies to provide control of the expected quality of the totality of accepted product of each type from each source.

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 3534-2, *Statistics — Vocabulary and symbols — Part 2: Applied statistics*

3 Terms and definitions

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

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

— ISO Online browsing platform: available at http://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
credit
K
<acceptance sampling> total number of items accepted in a sequence of accepted lots since a lot in the sequence was non-accepted, or since the start of inspection if all previous inspected lots have been accepted

3.2
average outgoing quality
AOQ
<acceptance sampling> long-term average quality level of outgoing product for a given value of incoming product quality

Note 1 to entry: In this International Standard, the average outgoing quality (AOQ) is calculated over all accepted lots together with the conforming items found after 100 % inspection of lots that are non-accepted when the credit, *K*, is zero.

3.3
average outgoing quality limit
AOQL
a
<acceptance sampling> maximum AOQ over all possible values of incoming product quality level for a given acceptance sampling scheme

4 Symbols and abbreviated terms

The symbols and abbreviations used in this International Standard are as follows:

AOQ average outgoing quality, in percent nonconforming items

AOQL average outgoing quality limit, in percent nonconforming items

a specified value of the AOQL, expressed in proportion of nonconforming items

d number of nonconforming items in the sample

K credit (an integer)

K_{max} upper limit (if any) to the usable credit

n sample size

N lot size

5 Average outgoing quality limit

When the quality of lots submitted for inspection is very good, almost all the lots are accepted and enter the market-place unchanged. The average outgoing quality (AOQ) of items to the market-place is therefore a low percentage nonconforming.

When the quality of lots submitted for inspection is very poor, most of the lots are non-accepted and 100 % inspected. In this case, most of the items are subjected to inspection and only the conforming items accepted, so the AOQ of items to the market-place is again a low percentage nonconforming, albeit at a relatively high average inspection cost per item reaching the market-place.

As quality moves between these extremes, the AOQ increases, reaches a limit, and thereafter decreases. The upper limit to the average outgoing percentage nonconforming is called the average outgoing quality limit (AOQL). No sampling scheme obtained by use of this standard has an expected (or long-term) AOQ in excess of the specified AOQL.

For an isolated lot or a short series of lots, there is a chance of the actual AOQ exceeding the AOQL. This chance depends on the length of the series, the lot sizes (which are not necessarily constant) within the series, and the quality levels in these lots, and tends to zero as the number of lots in the series increases.

CAUTION — It follows that plans from this International Standard are unsuitable for guaranteeing an upper limit to the *realized* (as against *expected*) process fraction nonconforming for isolated lots or short series of lots.

As sample sizes by their nature are constrained to be integers, the sampling schemes resulting from the application of this International Standard tend to be slightly on the conservative side, resulting in an AOQL slightly smaller than that specified.

The average outgoing quality after a long sequence of lot submissions only approaches the AOQL under the most adverse sequence of lot qualities. In practice, this is unlikely to occur, providing another reason for the AOQ to tend to be generally somewhat better than the specified AOQL.

NOTE The sampling procedure results only in the lot being unchanged or in the removal of its nonconforming items. Hence, if the submitted lot quality is consistently much better than the AOQL, then the AOQ will also be much better than the AOQL.

6 Credit principle

The unifying concept behind the sampling schemes in this International Standard is the credit principle. It is assumed that a supplier submits for inspection a continuing sequence of lots of items. Each lot may be of any size.

NOTE For short series of lots or for an isolated lot, the AOQL protection is still valid, in the sense that the *expected* outgoing quality will still be no worse than the AOQL. However, the *realized* average outgoing quality may well be worse than the AOQL, although the chance of this happening decreases as the series gets longer. Moreover, the supplier does not benefit to the same extent from an accumulation of credit and the resulting reduction in inspection costs.

At the start of inspection, the credit is set to zero. The appropriate sample size for each lot is determined from a formula involving the AOQL, the lot size and the credit. A random sample of this size is selected and inspected. If the first lot fails to meet the acceptance criterion, the credit remains at zero. Otherwise, the credit is increased by the lot size. The process is repeated with successive lots, with credit increasing by the size of accepted lots until a lot is non-accepted, at which point the credit is reset to zero and a new sequence is started.

By this means, a supplier who submits lots of consistently high quality is rewarded by smaller sample sizes and therefore lower inspection costs, while the required AOQL is still guaranteed.

Where items are supplied by a number of suppliers, this International Standard shall be applied to the lots from each supplier separately. Suppliers shall therefore have their own individual credit records.

7 Treatment of non-accepted lots

If a supplier continually submits lots with quality worse than the specified AOQL, then eventually such a lot will be submitted from which a sample is selected that satisfies the acceptance criterion. If the previous non-accepted lots are all scrapped without any further inspection, then this lot will be the first lot to enter the market-place and the required AOQL is at once exceeded. Clearly, such a procedure does not provide the required level of consumer protection.

This problem is overcome in this International Standard by requiring that a lot shall be 100 % inspected if it is non-accepted when the credit is zero, and that all conforming items found in the lot shall be allowed to enter the market-place. This feature enables schemes to be devised that provide the required consumer protection. Moreover, this protection is provided by means of remarkably small sample sizes (see Annex A).

100 % inspection may be relatively expensive if the items are of low value and the lot is large. For such items, the supplier is advised to first submit reasonably small lots when the credit is zero, in order to eliminate the possibility of having to subject large lots to 100 % inspection. However, small lots have relatively large sample sizes as compared to large lots.

On the other hand, items may be quite valuable. In that case, the supplier may prefer non-accepted lots to be 100 % inspected when the credit exceeds zero, so that all the conforming items in the lot can be placed in the market.

NOTE The supplier may demand this course of action, as the AOQL consumer protection is not thereby compromised.

8 Sampling plans

For a given value a of the required AOQL, the sampling plan for the next lot is automatically determined by a, by the size, N, of the lot and by the current value, K, of the credit. No tables are needed, the appropriate sample size, n, being determined from a simple inequality. The required sampling plan is then a sample of size n with lot acceptance criterion:

— accept if $d = 0$;

— do not accept otherwise,

where d is the number of nonconforming items in the sample.

9 Preliminary operations

The credit, K, shall initially be set to zero.

At the outset, the treatment of a lot that is non-accepted when the credit exceeds zero shall be agreed between the supplier and the consumer. The lot shall either be returned without further sampling, in which case the supplier and consumer shall also agree on the disposition of conforming and nonconforming items found in the sample; or it shall be 100 % inspected, in which case the supplier and consumer shall agree on the disposition of any conforming or nonconforming items found in the lot.

NOTE 1 At the discretion of the responsible authority, an upper limit K_{max} may be imposed on the usable credit. This has the effect of limiting the extent to which a long history of excellent quality can hide a temporary deterioration in quality.

NOTE 2 The overall long-term AOQL is guaranteed without the need to impose an upper limit on the usable credit.

10 Standard procedure

All attributes sampling plans in this International Standard consist of a sample size together with an acceptance number of zero. The procedures shall be carried out as follows.

a) For the specified value of the AOQL (a), for the accumulated credit K and for the lot size N, the sample size shall be determined as

$$n = \frac{N}{(K+N)a+1}, \text{ rounded up to a whole number.} \quad (1)$$

b) A random sample of size n shall be selected from the lot, and the quality characteristics on each item in the sample shall be inspected. If none of the items in the sample are outside specification, the lot is accepted and the credit is increased by N; otherwise, the lot is non-accepted.

c) In the case of lot non-acceptance:

   1) If the current credit is zero, the lot shall be subjected to 100 % inspection and all conforming items accepted. Furthermore, the credit remains at zero.

   2) If the current credit is not zero, then it is by agreement between the supplier and the consumer whether the lot is 100 % inspected, scrapped or returned to the supplier. The credit is then reset to zero. The disposition of conforming items found in sampling or 100 % inspection shall be agreed between the supplier and the consumer.

d) For subsequent lots of similar items from the same supplier, the procedure shall be repeated from a).

NOTE 1 In certain circumstances, it may be considered undesirable to allow excellent quality from more than a specified number of consecutive months, or from more than a specified number of consecutive lots, to influence the sample size from the current lot. Such influence can be eliminated by imposing an upper limit K_{max} on the usable credit, where the value of $K_{max}$is chosen to be the typical total number of items produced by that supplier during x months or in y lots. Equation (1) then becomes

$$n = \frac{N}{[\min(K, K_{max}) + N]a+1}, \text{rounded up to a whole number.}$$

where min(K, K_{max}) is the smaller of K and K_{max}.

NOTE 2 Imposing an upper limit on the usable credit tends to result in larger minimum sample sizes for any given lot size. This is a more stringent requirement that effectively results in a reduction of the AOQL, but the extent of this reduction is difficult to assess in general.

NOTE 3 Imposing an upper limit on the usable credit is therefore not part of the standard procedure, because the properties of the resulting method are not so well understood. However, the use of such a limit on the credit can be tolerated if it is appreciated that the nominal AOQL is reduced by an unknown amount.

A flow chart of the standard procedure is given in Figure 1.

EXAMPLE Suppose that the AOQL is 1,5 % and the first lot submitted in a sequence is of size N = 201. Testing is non-destructive. The credit K is zero, so the appropriate sample size n is found from Equation (1) to be

$$n = \frac{N}{(K+N)a+1} = \frac{201}{(0+201)\times 0{,}015+1} = \frac{201}{3{,}015+1} = 50{,}06 \text{ rounded up,}$$

i.e. n = 51.

Fifty-one items are selected at random from the lot and inspected. None are found to be nonconforming, so the credit is increased to K = 201.

Suppose that the second lot in the sequence is of size N = 192. From Equation (1) it is seen that the second sample size is

$$n = \frac{N}{(K+N)a+1} = \frac{192}{(201+192)\times 0{,}015+1} = \frac{192}{5{,}895+1} = 27{,}84 \text{ rounded up,}$$

i.e. n = 28.

Accordingly, a random sample of 28 items is selected from the second lot and inspected. One nonconforming item is found in the sample. The lot is therefore considered to be non-acceptable, and the credit K is reset to zero. As the credit was greater than zero when the sample size for this lot was determined, it is not necessary for the purpose of guaranteeing the AOQL to subject the lot to 100 % inspection. By prior agreement between the supplier and the consumer, all conforming items found in the sample are accepted by the consumer, the remaining items being returned to the supplier with any nonconforming items found in the sample identified. Thus, the consumer accepts 27 items from the second lot, and returns the other 165 to the supplier with the nonconforming item identified.

If the sample from the second lot had yielded no nonconforming items, then the credit would have increased from K = 201 to K = 201 + 192 = 393.

11 Procedure during continuing inspection

Schemes conforming to this International Standard can only operate effectively if the automatic switching rules [see Clause 10 a), b) and c)] are obeyed and the credit is correctly updated. Comprehensive records shall be kept to ensure that these requirements are being met.

NOTE The keeping and monitoring of records is a subsidiary activity that can provide the supplier with useful information. However, the ultimate decision on the acceptability of an individual lot is governed by the procedures given in Clause 10.

12 Discontinuation of inspection

Acceptance sampling standards for lot-by-lot inspection generally provide for discontinuation of inspection if quality is consistently poor (see, for example, ISO 2859-1). This International Standard neither has nor requires this provision, because the long-term AOQL is guaranteed without it. With consistently poor quality, lots are frequently non-accepted at credit zero, requiring 100 % inspection during which conforming items are accepted. The costs of this high level of inspection tend to provide a sufficient incentive to the supplier to improve quality.

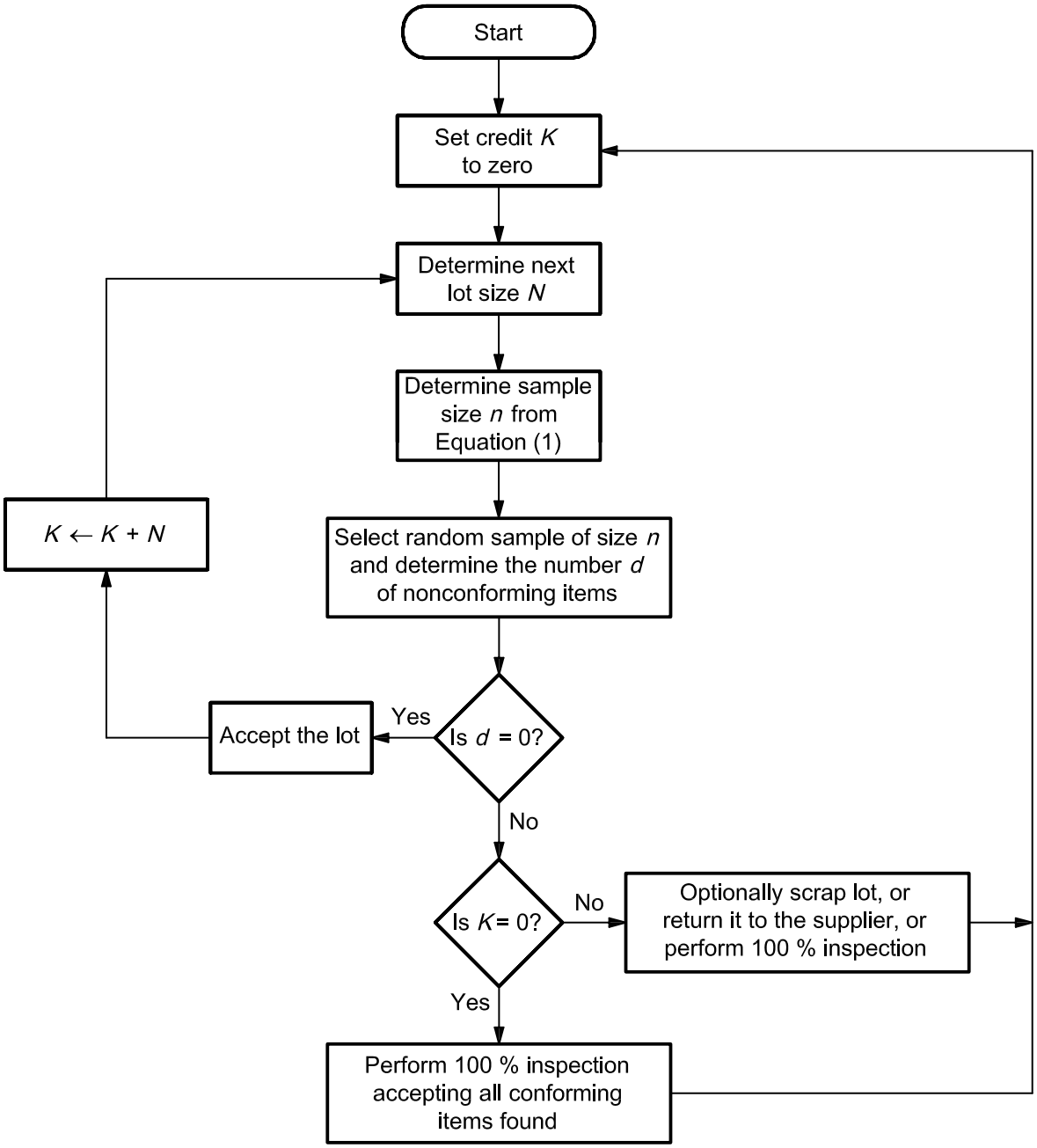

Figure 1 — Flow chart showing the standard acceptance procedure

Annex A
(informative)

Examples of sample sizes required for credit-based accept-zero plans

The largest required sample size for a given AOQL may be obtained from Equation (1) in Clause 10. The smallest lot size for which this sample size becomes necessary may also be determined; it occurs when the credit is zero, i.e. when inspection begins, or for the lot immediately following a non-acceptance lot. Table A.1 provides this information for selected AOQLs.

Table A.1 — Examples of largest required sample sizes and corresponding lot sizes at selected AOQLs

AOQL (%)	Largest sample size required	Applies to all lots of size greater than
0,1	1 000	999 000
0,2	500	249 500
0,5	200	39 800
1,0	100	9 900
2,0	50	2 450
5,0	20	380
10,0	10	90

For example, when the AOQL is 1 %, the largest sample size that could possibly be required is 100, the smallest lot size for which this sample size is necessary is 9 901, occurring when credit is zero.

As credit accumulates, the required sample sizes rapidly become smaller, at least initially. Examples of this sample size reduction are given in Table A.2 for sequences of lots of constant size and for an AOQL of 1 %.

Table A.2 — Examples of sample size reduction at AOQL 1% for sequences of lots of constant size

Lot number	Each lot is of size 50		Each lot is of size 500		Each lot is of size 5 000		Each lot is of size 50 000		Lot disposition
	Credit, K	Sample size, n	Credit, K	Sample size, n	Credit, K	Sample size, n	Credit, K	Sample size, n	
1	0	34	0	84	0	99	0	100	Accept
2	50	25	500	46	5 000	50	50 000	50	Accept
3	100	20	1 000	32	10 000	34	100 000	34	Accept
4	150	17	1 500	24	15 000	25	150 000	25	Accept
5	200	15	2 000	20	20 000	20	200 000	20	Non-accept
6	0	34	0	84	0	99	0	100	Accept

NOTE In the examples in Table A.2, for simplicity, the lot size is kept constant in the series of lots. In practice, there are no restrictions on the lot sizes in a series.

Bibliography

Baillie D.H., & Klaassen C.A.J. Credit-based accept-zero sampling schemes for the control of outgoing quality. In: *Frontiers in Intelligent Statistical Quality Control* ***6***. Physica-Verlag, Heidelberg, 2001, pp. 25–35.

ISO 2859-1:1999, *Sampling procedures for inspection by attributes — Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

Klaassen C.A.J. A Bonus-Malus system in statistical sampling for testing jewelry on fineness. In: *Proc. IPMI Seminar on Precious Metal Sampling and Analysis, San Antonio, Texas.* Allentown, Pennsylvania: International Precious Metals Institute

ICS 03.120.30

Price based on 9 pages