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Sequential sampling plans for inspection by attributes

Plans d'échantillonnage progressif pour le contrôle par attributs

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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

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Foreword

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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).

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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 28591 cancels and replaces ISO 8422:2006, of which it constitutes a minor revision to change the reference number from 8422 to 28591.

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.

Introduction

In contemporary production processes, quality is often expected to reach such high levels that the number of nonconforming items is reported in parts per million (10^{-6}). Under such circumstances, popular acceptance sampling plans, such as those presented in ISO 2859-1, require prohibitively large sample sizes. To overcome this problem, users apply acceptance sampling plans with higher probabilities of wrong decisions or, in extreme situations, abandon the use of acceptance sampling procedures altogether. However, in many situations there is still a need to accept products of high quality using standardized statistical methods. In such cases, there is a need to apply statistical procedures that require the smallest possible sample sizes. Sequential sampling plans are the only statistical procedures that satisfy that need as, among all possible sampling plans having similar statistical properties, the sequential sampling plan has the smallest average sample size.

The principal advantage of sequential sampling plans is the reduction in the average sample size. The average sample size is the weighted average of all the sample sizes that may occur under a sampling plan for a given lot or process quality level. Like double and multiple sampling plans, the use of sequential sampling plans leads to a smaller average sample size than single sampling plans having the equivalent operating characteristic. However, the average savings are even greater when using a sequential sampling plan than when a double or multiple sampling plan is used. For lots of very good quality, the maximum savings for sequential sampling plans may reach 85 %, as compared to 37 % for double sampling plans and 75 % for multiple sampling plans. On the other hand, when using a double, multiple or sequential sampling plan, the actual number of items inspected for a particular lot may exceed the sample size, n_0, of the corresponding single sampling plan. For double and multiple sampling plans, there is an upper limit of 1,25 n_0 to the actual number of items to be inspected. For classical sequential sampling plans, there is no such limit, and the actual number of inspected items may exceed the corresponding single sample size, n_0, or be even as large as the lot size, N. For the sequential sampling plans in this International Standard, a curtailment rule has been introduced involving an upper limit n_t on the actual number of items to be inspected.

Other factors that should be taken into account include:

a) Simplicity

The rules of a sequential sampling plan are more easily misunderstood by inspectors than the simple rules for a single sampling plan.

b) Variability in the amount of inspection

As the actual number of items inspected for a particular lot is not known in advance, the use of sequential sampling plans brings about various organisational difficulties. For example, scheduling of inspection operations may be difficult.

c) Ease of drawing sample items

If drawing sample items at different times is expensive, the reduction in the average sample size by sequential sampling plans may be cancelled out by the increased sampling cost.

d) Duration of test

If the test of a single item is of long duration and a number of items can be tested simultaneously, sequential sampling plans are much more time-consuming than the corresponding single sampling plans.

e) Variability of quality within the lot

If the lot consists of two or more sublots from different sources and if there is likely to be a substantial difference between the qualities of the sublots, drawing of a representative sample under a sequential sampling plan is far more awkward than under the corresponding single sampling plan.

The advantages and disadvantages of double and multiple sampling plans always lie between those of single and sequential sampling plans. The balance between the advantage of a smaller average sample size and the above disadvantages leads to the conclusion that sequential sampling plans are suitable only when inspection of individual items is costly in comparison with inspection overheads.

The choice between single, double, multiple and sequential sampling plans shall be made before the inspection of a lot is started. During inspection of a lot, it is not permitted to switch from one type to another, because the operating characteristics of the plan may be drastically changed if the actual inspection results influence the choice of acceptability criteria.

Although use of sequential sampling plans is on average much more economical than the use of corresponding single sampling plans, acceptance or non-acceptance may occur at a very late stage due to the cumulative count of nonconforming items (or nonconformities) remaining between the acceptance number and the rejection number for a long time. When using the graphical method, this corresponds to the random progress of the step curve remaining in the indecision zone. Such a situation is most likely to occur when the lot or process quality level (in terms of percent nonconforming or in nonconformities per 100 items) is close to ($100g$), where g is the parameter giving the slope of the acceptance and rejection lines.

To improve upon this situation, the sample size curtailment value is set before the inspection of a lot is begins. If the cumulative sample size reaches the curtailment value n_t without determination of lot acceptability, inspection terminates and the acceptance and non-acceptance of the lot is then determined using the curtailment values of the acceptance and rejection numbers.

For sequential sampling plans in common use, curtailment usually represents a deviation from their intended usage, leading to a distortion of their operating characteristics. In this International Standard, however, the operating characteristics of the sequential sampling plans have been determined with curtailment taken into account, so curtailment is an integral component of the provided plans.

Sequential sampling plans for inspection by attributes are also provided in ISO 2859-5. However, the design principle of those plans is fundamentally different from that of this International Standard. The sampling plans in ISO 2859-5 are designed to supplement the ISO 2859-1 acceptance sampling system for inspection by attributes. Thus, they should be used for the inspection of a continuing series of lots, that is, a series long enough to permit the switching rules of the ISO 2859 system to function. The application of the switching rules is the only means of providing enhanced protection to the consumer (by means of tightened sampling inspection criteria or discontinuation of sampling inspection) when the sequential sampling plans from ISO 2859-5 are used. However, in certain circumstances, there is a strong need to have both the producer's and the consumer's risks under strict control. Such circumstances occur, for example, when sampling is performed for regulatory reasons, to demonstrate the quality of the production processes or to test hypotheses. In such cases, individual sampling plans selected from the ISO 2859-5 sampling scheme may be inappropriate. The sampling plans from this International Standard have been designed in order to meet these specific requirements.

Sequential sampling plans for inspection by attributes

1 Scope

This International Standard specifies sequential sampling plans and procedures for inspection by attributes of discrete items.

The plans are indexed in terms of the producer's risk point and the consumer's risk point. Therefore, they can be used not only for the purposes of acceptance sampling, but for a more general purpose of the verification of simple statistical hypotheses for proportions.

The purpose of this International Standard is to provide procedures for sequential assessment of inspection results that may be used to induce the supplier, through the economic and psychological pressure of non-acceptance of lots of inferior quality, to supply lots of a quality having a high probability of acceptance. At the same time, the consumer is protected by a prescribed upper limit to the probability of accepting lots of poor quality.

This International Standard provides sampling plans that are applicable, but not limited, to inspection in different fields, such as:

— end items,

— components and raw materials,

— operations,

— materials in process,

— supplies in storage,

— maintenance operations,

— data or records, and

— administrative procedures.

This International Standard contains sampling plans for inspection by attributes of discrete items. The sampling plans may be used when the extent of nonconformity is expressed either in terms of proportion (or percent) nonconforming items or in terms of nonconformities per item (per 100 items).

The sampling plans are based on the assumption that nonconformities occur randomly and with statistical independence. There may be good reasons to suspect that one nonconformity in an item could be caused by a condition also likely to cause others. If so, it would be better to consider the items just as conforming or not, and ignore multiple nonconformities.

The sampling plans from this International Standard should primarily be used for the analysis of samples taken from processes. For example, they may be used for the acceptance sampling of lots taken from a process that is under statistical control. However, they may also be used for the acceptance sampling of an isolated lot when its size is large, and the expected fraction nonconforming is small (significantly smaller than 10 %).

In the case of the acceptance sampling of continuing series of lots, the system of sequential sampling plans indexed by acceptance quality limit (AQL) for lot-by-lot inspection published in ISO 2859-5 should be applied.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3534-1, *Statistics — Vocabulary and symbols — Part 1: General statistical terms and terms used in probability*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 3534-1 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
inspection
conformity evaluation by observation and judgement accompanied as appropriate by measurement, testing or gauging

[SOURCE: ISO 3534-2:2006, 4.1.2]

3.2
inspection by attributes
inspection (3.1) by noting the presence, or absence, of one or more particular characteristic(s) in each of the items in the group under consideration, and counting how many items do, or do not, possess the characteristic(s), or how many such events occur in the item, group or opportunity space

Note 1 to entry: When inspection is performed by simply noting whether the item is nonconforming or not, the inspection is termed inspection for nonconforming items. When inspection is performed by noting the number of nonconformities on each unit, the inspection is termed inspection for number of nonconformities.

[SOURCE: ISO 3534-2:2006, 4.1.3]

3.3
item
entity
anything that can be described and considered separately

EXAMPLE A discrete physical item; a defined amount of bulk material; a service, activity, person, system or some combination thereof.

[SOURCE: ISO 3534-2:2006, 1.2.11]

3.4
nonconformity
non-fulfilment of a requirement

[SOURCE: ISO 3534-2:2006, 3.1.11]

Note 1 to entry: See notes to 3.5.

3.5
defect
non-fulfilment of a requirement related to an intended or specified use

Note 1 to entry: The distinction between the concepts defect and *nonconformity* (3.4) is important as it has legal connotations, particularly those associated with product liability issues. Consequently the term “defect” should be used with extreme caution.

Note 2 to entry: The intended use by the customer can be affected by the nature of information, such as operating or maintenance instructions, provided by the customer.

[SOURCE: ISO 3534-2:2006, 3.1.12]

3.6
nonconforming item
item (3.3) with one or more *nonconformities* (3.4)

[SOURCE: ISO 3534-2:2006, 1.2.12]

3.7
percent nonconforming
⟨in a sample⟩ one hundred times the number of *nonconforming items* (3.6) in the *sample* (3.13) divided by the *sample size* (3.14), viz:

$$100 \times \frac{d}{n}$$

where

d is the number of nonconforming items in the sample;

n is the sample size

[SOURCE: ISO 2859-1:1999, 3.1.8]

3.8
percent nonconforming
⟨in a population or lot⟩ one hundred times the number of *nonconforming items* (3.6) in the population or *lot* (3.11) divided by the population or *lot size* (3.12), viz:

$$100 \times p_{\mathrm{ni}} = 100 \times \frac{D_{\mathrm{ni}}}{N}$$

where

p_{ni} is the proportion of nonconforming items;

D_{ni} is the number of nonconforming items in the population or lot;

N is the population or lot size

Note 1 to entry: Adapted from ISO 2859-1:1999, 3.1.9.

Note 2 to entry: In this International Standard, the terms *percent nonconforming* (3.7 and 3.8) or *nonconformities per 100 items* (3.9 and 3.10) are mainly used in place of the theoretical terms “proportion of nonconforming items” and “nonconformities per item” because the former terms are the most widely used.

3.9
nonconformities per 100 items
⟨in a sample⟩ one hundred times the number of *nonconformities* (3.4) in the *sample* (3.13) divided by the *sample size* (3.14), viz:

$$100 \times \frac{d}{n}$$

where

d is the number of nonconformities in the sample;

n is the sample size

[SOURCE: ISO 2859-1:1999, 3.1.10]

3.10
nonconformities per 100 items
⟨in a population or lot⟩ 100 times the number of *nonconformities* (3.4) in the population or *lot* (3.11) divided by the population or *lot size* (3.12), viz:

$$100 \times p_{\mathrm{nt}} = 100 \times \frac{D_{\mathrm{nt}}}{N}$$

where

p_{nt} is the number of nonconformities per item;

D_{nt} is the number of nonconformities in the population or lot;

N is the population or lot size

Note 1 to entry: Adapted from ISO 2859-1:1999, 3.1.11.

Note 2 to entry: An item may contain one or more nonconformities.

3.11
lot
definite part of a population constituted under essentially the same conditions as the population with respect to the sampling purpose

Note 1 to entry: The sampling purpose can, for example, be to determine lot acceptability, or to estimate the mean value of a particular characteristic.

[SOURCE: ISO 3534-2:2006, 1.2.4]

3.12
lot size
number of *items* (3.3) in a *lot* (3.11)

[SOURCE: ISO 2859-1:1999, 3.1.14]

3.13
sample
subset of a population made up of one or more sampling units

[SOURCE: ISO 3534-2:2006, 1.2.17]

3.14
sample size
number of sampling units in a *sample* (3.13)

[SOURCE: ISO 3534-2:2006, 1.2.26]

3.15
acceptance sampling plan
plan which states the *sample size*(s) (3.14) to be used and the associated criteria for lot acceptance

[SOURCE: ISO 3534-2:2006, 4.3.3]

3.16
consumer's risk quality
Q_{CR}
⟨acceptance sampling⟩ quality level of a *lot* (3.11) or process which, in the *acceptance sampling plan* (3.15), corresponds to a specified consumer's risk

[SOURCE: ISO 3534-2:2006, 4.6.9]

Note 1 to entry: The specified consumer's risk is usually 10 %.

3.17
producer's risk quality
Q_{PR}
⟨acceptance sampling⟩ quality level of a *lot* (3.11) or process which, in the *acceptance sampling plan* (3.15), corresponds to a specified producer's risk

[SOURCE: ISO 3534-2:2006, 4.6.10]

Note 1 to entry: The specified producer's risk is usually 5 %.

3.18
count
when inspection by attributes is performed, the result of the inspection of each sample item

Note 1 to entry: In the case of the inspection for nonconforming items, the count is set to 1 if the sample item is nonconforming. In the case of the inspection for nonconformities, the count is set to the number of nonconformities found in the sample item.

3.19
cumulative count
when a sequential sampling plan is used, the sum of the counts during inspection, counting from the start of the inspection of the lot up to, and including, the sample item last inspected

3.20
cumulative sample size
when a sequential sampling plan is used, the total number of sample items during inspection, counting from the start of the inspection of the lot up to, and including, the sample item last inspected

3.21
acceptance value
⟨for sequential sampling⟩ value used in the graphical method for determination of acceptance of the lot, that is derived from the specified parameters of the sampling plan and the cumulative sample size

3.22
acceptance number
⟨for sequential sampling⟩ number used in the numerical method for determination of acceptance of the lot, that is obtained by rounding the acceptance value down to the nearest integer