INTERNATIONAL STANDARD

ISO 8422

Second edition
2006-10-01

Sequential sampling plans for inspection by attributes

Plans d'échantillonnage progressif pour le contrôle par attributs

Reference number
ISO 8422:2006(E)

PDF disclaimer

This PDF file may contain embedded typefaces. In accordance with Adobe's licensing policy, this file may be printed or viewed but shall not be edited unless the typefaces which are embedded are licensed to and installed on the computer performing the editing. In downloading this file, parties accept therein the responsibility of not infringing Adobe's licensing policy. The ISO Central Secretariat accepts no liability in this area.

Adobe is a trademark of Adobe Systems Incorporated.

Details of the software products used to create this PDF file can be found in the General Info relative to the file; the PDF-creation parameters were optimized for printing. Every care has been taken to ensure that the file is suitable for use by ISO member bodies. In the unlikely event that a problem relating to it is found, please inform the Central Secretariat at the address given below.

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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 document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 8422 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 8422:1991), of which it constitutes a technical revision. It also incorporates the Technical Corrigendum ISO 8422:1991/Cor.1:1993. The following improvements have been introduced:

— preferred values of producer's risk quality and consumer's risk quality have been changed and their series have been extended,

— values of the parameters h_A, h_R and g have been recalculated in order to provide plans that exactly meet stated requirements,

— consumer's risk quality values in percent nonconforming are separated from those in nonconformities per 100 items both in the master tables and in Table A.1, which contains the average sample sizes for sequential sampling plans.

The revised version of Annex A of ISO 8422:1991 has been published as ISO 2859-5.

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 referenced documents are indispensable for the application 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. References are given in square brackets for definitions that have been repeated here for convenience.

3.1
inspection
conformity evaluation by observation and judgement accompanied as appropriate by measurement, testing or gauging

[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 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.

[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.

[ISO 3534-2:2006, 1.2.11]

3.4
nonconformity
non-fulfilment of a requirement

[ISO 3534-2:2006, 3.1.11]

NOTE See notes to 3.5.

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

NOTE 1 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 The intended use by the customer can be affected by the nature of information, such as operating or maintenance instructions, provided by the customer.

[ISO 3534-2:2006, 3.1.12]

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

[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

[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 Adapted from ISO 2859-1:1999, 3.1.9.

NOTE 2 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

[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:

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

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 Adapted from ISO 2859-1:1999, 3.1.11.

NOTE 2 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 The sampling purpose can, for example, be to determine lot acceptability, or to estimate the mean value of a particular characteristic.

[ISO 3534-2:2006, 1.2.4]

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

[ISO 2859-1:1999, 3.1.14]

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

[ISO 3534-2:2006, 1.2.17]

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

[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

[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

[ISO 3534-2:2006, 4.6.9]

NOTE 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

[ISO 3534-2:2006, 4.6.10]

NOTE 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 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

3.23
rejection value
⟨for sequential sampling⟩ value used in the graphical method for determination of non-acceptance of the lot, that is derived from the specified parameters of the sampling plan and the cumulative sample size

3.24
rejection number
⟨for sequential sampling⟩ number used in the numerical method for determination of non-acceptance of the lot, that is obtained by rounding the rejection value up to the nearest integer

3.25
acceptability table
table used for the lot acceptability determination in the numerical method

3.26
acceptability chart
chart used for the lot acceptability determination in the graphical method, consisting of the following three zones:

— acceptance zone;

— rejection zone;

— indecision zone;

the borders being acceptance, rejection and curtailment lines.

4 Symbols and abbreviated terms

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

A acceptance value (for sequential sampling plan)

Ac acceptance number

Ac_0 acceptance number for a corresponding single sampling plan

Ac_t acceptance number at curtailment (curtailment value)

d count

D cumulative count

g parameter giving the slope of the acceptance and rejection lines

h_A parameter giving the intercept of the acceptance line

h_R parameter giving the intercept of the rejection line

n_0 sample size for a corresponding single sampling plan

n_cum cumulative sample size

n_t cumulative sample size at curtailment (curtailment value)

$\overline{P}$ process average

p_x quality level for which the probability of acceptance is x, where x is a fraction

P_a probability of acceptance (in percent)

Q_{CR} consumer's risk quality (in percent nonconforming items or in nonconformities per hundred items)

Q_{PR} producer's risk quality (in percent nonconforming items or in nonconformities per hundred items)

R rejection value (for sequential sampling plan)

Re rejection number

Re_0 rejection number for a corresponding single sampling plan

Re_t rejection number at curtailment (curtailment value)

NOTE $\mathrm{Re}_t = \mathrm{Ac}_t + 1$

α producer's risk

β consumer's risk

5 Principles of sequential sampling plans for inspection by attributes

Under a sequential sampling plan by attributes, sample items are drawn at random and inspected one by one, and the cumulative count (the total number of nonconforming items or nonconformities) is obtained. After the inspection of each item, the cumulative count is compared with the acceptability criteria in order to assess whether there is sufficient information to decide about the lot at that stage of the inspection.

If, at a given stage, the cumulative count is such that the risk of accepting a lot of unsatisfactory quality level is sufficiently low, the lot is considered acceptable and the inspection is terminated.

If, on the other hand, the cumulative count is such that the risk of non-acceptance of a lot of satisfactory quality level is sufficiently low, the lot is considered not acceptable and the inspection is terminated.

If the cumulative count does not allow either of the above decisions to be taken, then an additional item is sampled and inspected. The process is continued until sufficient sample information has been accumulated to warrant a decision that the lot is acceptable or not acceptable.

6 Selection of a sampling plan

6.1 Producer's risk point and consumer's risk point

The general method described in 6.1 and 6.2 is used when the requirements of the sequential sampling plan are specified in terms of two points on the operating characteristic curve of the plan. The point corresponding to the higher probability of acceptance shall be designated the *producer's risk point*; the other shall be designated the *consumer's risk point.*

The first step when designing a sequential sampling plan is to choose these two points, if they have not already been dictated by circumstances. For this purpose, the following combination is often used:

— a producer's risk of $\alpha \leqslant 0{,}05$ and the corresponding producer's risk quality (Q_{PR}), and