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Acceptance sampling plans and procedures for the inspection of bulk materials

Plans et procédures d'échantillonnage pour acceptation pour le contrôle de matériaux en vrac

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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. 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 3.

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 International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 10725 was prepared by Technical Committee ISO/TC 69, *Applications of statistical methods*, Subcommittee SC 3, *Application of statistical methods in standardization*.

Annexes A and B form a normative part of this International Standard. Annexes C and D are for information only.

Introduction

The application of statistical methods in the field of sampling of bulk materials has been developed since the late 1940s, principally for large quantities of raw materials, such as coals or iron ores, where major interest was to obtain an accurate estimate of the lot mean with reasonable cost, so as to adjust the price and process duly when necessary.

Recently, the need for acceptance sampling of bulk materials has increased especially for industrial products, such as powder chemicals or plastic beads, where the determination of acceptability of a lot is more important than to acquire an accurate estimate of the lot mean. This International Standard has been developed for the former purpose.

The subject of this International Standard is situated on the border line between ISO/TC69/SC 3 dealing with bulk sampling and ISO/TC 69/SC 5 dealing with acceptance sampling, and some SC 5 experts have assisted in the drafting.

Acceptance sampling plans and procedures for the inspection of bulk materials

1 Scope

This International Standard specifies acceptance sampling plans by the determination of variables and use of acceptance inspection procedures for bulk materials. These sampling plans comply with specific operating characteristic curves at reasonable cost.

This International Standard is applicable to the inspection where the lot mean of a single quality characteristic is the principal factor in the determination of lot acceptability, but it also gives special procedures for multiple quality characteristics. This International Standard is applicable to the cases where the values of standard deviations at individual stages of sampling are known or are imprecise.

This International Standard is applicable to various kinds of bulk materials, but is not always applicable to minerals such as iron ores, coals, crude petroleum, etc., where accurate estimation of the lot mean is more important than the determination of lot acceptability.

For special cases when standard procedures are not always adequate and the measurement standard deviation is dominant, this International Standard specifies special acceptance sampling plans and procedures, such as in the case for liquids.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

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.*

ISO 3534-1:1993, *Statistics — Vocabulary and symbols — Part 1: Probability and general statistical terms.*

ISO 3534-2:1993, *Statistics — Vocabulary and symbols — Part 2: Statistical quality control.*

ISO 5725-1:1994, *Accuracy (trueness and precision) of measurement methods and results — Part 1: General principles and definitions.*

ISO 11648-1:—[1)], *Statistical aspects of sampling from bulk materials — Part 1: General principles*.

1) To be published.

3 Terms and definitions

For the purposes of this International Standard, the terms and definitions given in ISO 2859-1, ISO 3534-1, ISO 3534-2, ISO 5725-1 and the following apply.

3.1
acceptance sampling
sampling inspection in which decisions are made to accept or not to accept a lot based on the results of a sample or samples selected from that lot

3.2
acceptance inspection
inspection to determine whether an item or lot delivered or offered for delivery is acceptable

3.3
sampling system
collection of sampling plans, together with criteria by which appropriate sampling plans may be chosen

3.4
sampling plan
combination of sample size and associated acceptability criteria

3.5
sample size
total number of tests or measurements and elements thereof

NOTE 1 In this International Standard, the sample size is, for example, the number of sampling increments in a composite sample, the number of composite samples per lot, the number of test samples prepared from a composite sample, the number of measurements per test sample. The number of measurements is the same as the number of test portions.

NOTE 2 In this International Standard, this term should not be used for sample amount such as the volume or mass of a sampling increment.

3.6
acceptability criteria
criteria or element of the criteria (for instance an acceptance value) for the determination of lot acceptability, i.e. to accept or not to accept a lot

3.7
acceptance quality limit
when a continuing series of lots is considered, a level of the lot mean which for the purposes of sampling inspection is the limit of the satisfactory process average

3.8
non-acceptance quality limit
when a continuing series of lots is considered, a level of the lot mean which for the purposes of sampling inspection is the limit of the unsatisfactory process average

3.9
one-sided specification limit
specification limit of either a lower or an upper limit for the lot mean

3.10
two-sided specification limits
specification limits of both lower and upper limits for the lot mean

3.11
bulk material
amount of material within which component parts are not initially readily distinguishable on the macroscopic level

NOTE This International Standard excludes paper rolls, wire coils, iron scrap or similar materials, because it is difficult to apply the specified sampling procedures.

3.12
sampling increment
amount of bulk material taken in one action by a sampling device

3.13
composite sample
aggregation of two or more sampling increments taken from a lot for inspection of the lot

3.14
test sample
sample, as prepared for testing or analysis, the whole amount or a part of it being used for testing or analysis at one time

3.15
test portion
part of a test sample which is used for testing or for analysis at one time

3.16
acceptance value
limiting value of sample average that permits lot acceptance

3.17
discrimination interval
interval between the acceptance quality limit and the non-acceptance quality limit

3.18
limiting interval
minimum interval between upper and lower acceptance quality limits, when two-sided specification limits are specified

3.19
relative standard deviation
ratio of a standard deviation relative to the discrimination interval

3.20
repeatability
precision under repeatability conditions, i.e. where independent test results are obtained with the same method on identical test items in the same laboratory, by the same operator using the same equipment within short intervals of time

3.21
intermediate precision measurement
precision under intermediate precision conditions, i.e. where test results are obtained with the same method on identical test items in the same laboratory, under some different operating conditions (time, calibration, operator and equipment)

4 Symbols and abbreviated terms

The symbol and the abbreviated terms used in this International Standard are as follows:

C varying cost per lot

C_I sum of costs proportional to total number of sampling increments

C_M sum of costs proportional to total number of measurements

C_T sum of costs proportional to the total number of test samples

c_I cost of drawing a sampling increment

c_M cost of a measurement

c_T cost of preparing a test sample

c_{TM} cost of treating a test sample (= $c_T + n_M c_M$)

D discrimination interval

D_N narrow discrimination interval for multiple characteristics

d_I relative standard deviation between sampling increments (= σ_I/D)

d_T relative test sample standard deviation (= σ_T/D)

d_O relative overall standard deviation (= σ_O/D)

f_D correction factor for multiple characteristics

f_U factor for obtaining upper control limit

G number of lots used for re-estimation of standard deviations

J number of quality characteristics

K_p the upper p-fractile of the standardized normal distribution
(Examples of p are α, β and P_a. For α = 0,05, K_α = 1,644 85. For β = 0,10, K_β,=1,281 55, etc.)

L_{CL} lower control limit

L_{SL} lower specification limit for the lot mean

m lot mean

m_A acceptance quality limit for the lot mean

m_R non-acceptance quality limit for the lot mean

n_I number of sampling increments per composite sample

n_M number of measurements per test sample

n_T number of test samples per composite sample

P_a probability of acceptance

Q_{CR} consumer’s risk quality

Q_{PR} producer’s risk quality

R_C cost ratio (= c_{TM}/c_I)

s_c composite sample standard deviation

s_{cT} combined sample standard deviation

s_{M}	measurement standard deviation
s_{T}	test sample standard deviation
$t_p(\nu)$	the lower p-fractile of the t-distribution with ν degrees of freedom
U_{SL}	upper specification limit for the lot mean
U_{CL}	upper control limit
x_{ijk}	measured value for the k-th test portion from j-th test sample from the i-th composite sample
$\overline{x}_{...}$	sample grand average
$\overline{x}_L$	lower acceptance value
$\overline{x}_U$	upper acceptance value
α	producer's risk
α^*	individual producer's risk
β	consumer's risk
β^*	individual consumer's risk
γ	constant for obtaining the acceptance value
Δ	interval between the upper and lower acceptance quality limits
δ	constant for obtaining the limiting interval
ν	degrees of freedom of a standard deviation
ν_{E}	degrees of freedom of an estimate standard deviation
σ_{c}	composite sample standard deviation
σ_{E}	estimate standard deviation for a lot mean
σ_{M}	measurement standard deviation
σ_{O}	overall standard deviation
σ_{T}	test sample standard deviation ($\sigma_{\mathrm{T}}^2 = \sigma_{\mathrm{P}}^2 + \sigma_{\mathrm{M}}^2 / n_{\mathrm{M}}$)
σ_{I}^2	variance component between sampling increments
σ_{M}^2	variance component between measurements
σ_{P}^2	variance component between test samples (variance for test sample preparation).

NOTE 1 The symbols accompanied by a subscript, "L" or "U", denote that they are for the lower or upper specification limit, respectively.

NOTE 2 The symbol σ is used for a population standard deviation, while the symbol s is used for a sample value.

5 Sampling plans

5.1 General

At the beginning of the acceptance sampling, the following items should be established for satisfactory inspection of a lot of bulk material.

5.2 Applicability

5.2.1 Lot mean

This International Standard is applicable when the lot mean of a single quality characteristic is the principal factor in the determination of lot acceptability.

When the material is homogenized through further processing in the consumer's plant, the consumer may be principally interested in the lot mean.

If two or more quality characteristics are specified for a material, then the procedures given in annex A shall be applied. Annex A also provides optional procedures for multiple characteristics to prevent an increase in both the producer's risk and the consumer's risk.

This International Standard is based on the assumption that the lot mean is kept unchanged during acceptance sampling for the lot, or that the expected values of the physical average and the arithmetic mean are equal. Special care is necessary for some unstable characteristics, such as moisture of particulate material. There may be some exceptional cases where this assumption is not true, such as shown in the following example.

EXAMPLE CMC (carboxymethyl cellulose) powder is used as an additive to cement, and in this application one of its most important characteristics is the viscosity of the aqueous solution. If two samples, of equal mass, one having a high value of viscosity and the other a low value, are blended, the viscosity of the blended sample will always be lower than the arithmetic mean of the original two sample values. This International Standard is not applicable to such cases.

5.2.2 Standard deviations

This International Standard is based on the assumption that the values of the individual standard deviation of the specified quality characteristic is known and stable. Guidelines to judge the stability of the individual standard deviation are as follows:

a) in the standard procedure, if both s_c and s_T control charts have no out-of-control point, and if no other evidence gives doubt about the stability, one can deem that all standard deviations are stable. If σ_M is large and unstable, then this fact will probably be detected by the s_T control chart. If σ_M is sufficiently small, its instability can be neglected, because its precise estimate is unnecessary;

b) in the special procedure in annex B , if the s_T control chart has no out-of-control point, and if no other evidence gives doubt about the stability, all standard deviations can be deemed to be stable. In this case, the instability of σ_I and σ_T can be neglected, because their precise estimates are unnecessary.

However, at the start of acceptance sampling, the precise value and/or the stability of the individual standard deviation may not be sufficiently known. Furthermore, minor and temporary deviation from the stability guidelines given above may occur during application of this acceptance sampling system. In such cases, the procedures for imprecise standard deviations are applicable, where assumed values of standard deviations of the specified quality characteristic are used.

If relevant values of standard deviations are not available at all, this International Standard is not applicable.

5.2.3 Inspection lots

These sampling plans are intended to be used primarily for a continuing series of lots. However, if the requirements for standard deviations are satisfied, these plans may also be used for isolated lots.

5.3 Standardized sampling procedures

5.3.1 General

This International Standard contains the following procedures for inspection of an individual lot:

a) increment sampling;

b) constitution of composite samples;

c) preparation of test samples; and

d) measurements.

Figure 1 illustrates the schematic flow of the above procedures. In order to avoid overcrowding Figure 1, the numbers of unused test samples and test portions drawn are far smaller than the usual values, respectively (see C.2.7).

Representative sampling shall be used throughout the above-mentioned procedures. For example, it is required that individual composite sample can represent the whole lot. In order to obtain reliable results, it is important to specify instructions or standardized procedures. It is recommended that reference be made to ISO 11648-1 beforehand, so that reasonable sampling procedures may be specified.

5.3.2 Increment sampling (see Figure 1)

Take sampling increments of $2n_\mathrm{I}$ from a lot. It is recommended that dynamic sampling be used, where sampling increments are taken from a moving lot. However, the use of static sampling is allowed, where the lot stands still.

It is also recommended that an appropriate sampling device be used. When the material contains coarse lumps, the volume of individual sampling increments should be sufficiently large that representative samples may be obtained.

5.3.3 Constitution of composite samples (see Figure 1)

Pool sampling increments of n_I together and form two composite samples. In this International Standard, two composite samples have been adopted. Each composite sample shall be representive of the whole lot. This requirement may be attained by carrying out systematic duplicate sampling, described as follows:

Among $2n_\mathrm{I}$ sampling increments numbered in order, pool those with odd numbers (1, 3, …, $2n_\mathrm{I} - 1$) to form composite sample No. 1, and those with even numbers (2, 4, …., $2n_\mathrm{I}$) to form composite sample No. 2.

5.3.4 Preparation of test samples (see Figure 1)

Prepare n_T test samples from each of the two composite samples. Establish the procedure for test sample preparation beforehand, taking into account the nature of the material to be inspected.

When the material contains coarse lumps, make sure the procedure of the test sample preparation includes one or more stages of particle size reduction (such as crushing and grinding), homogenization (such as mixing) and sample division. The procedure should specify the mass of the test sample and, if necessary, the particle size of the test sample. When the material is liquid, test samples may be taken directly from the composite sample, after sufficient stirring.

NOTE If an adequate procedure for test sample preparation is chosen, then a variance component between test samples, σ_T^2, can be far smaller than the variance component between sampling increments, σ_I^2. On the other hand, economical considerations are also important. For example, grinding of lumps is effective in reducing σ_T^2, but fine grinding of the total amount of composite sample is frequently too expensive.