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ELECTRICITY METERING EQUIPMENT (AC) –
ACCEPTANCE INSPECTION –

Part 11: General acceptance inspection methods

SAUDI ARABIAN STANDARDS ORGANIZATION

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Foreword

The Saudi Arabian Standards Organization (SASO) has adopted the International standard No. IEC 62058-11/2008 “ELECTRICITY METERING EQUIPMENT (AC) – ACCEPTANCE INSPECTION – Part 11: General acceptance inspection methods.” The text of this international standard has been translated into Arabic so as to be approved as a Saudi standard without introducing any technical modification.
1 Scope

The general acceptance inspection methods specified in this part of IEC 62058 apply to newly manufactured electricity meters produced and supplied in lots of 50 and above.

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 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 2859-1:1999/Cor 1:2001

ISO 2859-2:1985, Sampling procedures for inspection by attributes – Part 2: Sampling plans indexed by limiting quality (LQ) for isolated lot inspection

ISO 2859-3:2005, Sampling procedures for inspection by attributes – Part 3: Skip-lot sampling procedures


ISO 3951-1:2005 Ed. 1, Sampling procedures for inspection by variables – Part 1: Specification for single sampling plans indexed by acceptance quality limit (AQL) for lot-by-lot inspection for a single quality characteristic and a single AQL

ISO 3951-2:2006 Ed. 1, Sampling procedures for inspection by variables – Part 2: General specification for single sampling plans indexed by acceptance quality limit (AQL) for lot-by-lot inspection of independent quality characteristics

ISO 5479:1997, Statistical interpretation of data – Tests for departure from the normal distribution

3 Terms and definitions

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

NOTE In this standard, the term “meter” means any kind of metering equipment in the Scope of TC 13, i.e. meters for active or reactive energy, time switches, ripple control receivers, etc. The term “customer” is used with the same meaning as “consumer” and the term “manufacturer” is used with the same meaning as the term “supplier”.

3.1.1 characteristic
distinguishing feature

NOTE 1 A characteristic can be inherent or assigned.

NOTE 2 A characteristic can be qualitative or quantitative.
[ISO 3534-2, 1.1.1 modified]

3.1.2 population
(reference) totality of items under consideration
[ISO 3534-2, 1.2.1. modified]

3.1.3 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, 1.2.4]

3.1.4 isolated lot
lot separated from the sequence of lots in which it was formed and not forming part of a current sequence
[ISO 3534-2, 1.2.5]

3.1.5 re-submitted lot
lot which previously has been designated as not acceptable and which is submitted again for inspection after having been further treated, tested, sorted, reprocessed, etc.
[ISO 3534-2, 1.2.9]

3.1.6 item
terms

3.1.7 nonconforming item
item with one or more nonconformities
[ISO 3534-2, 1.2.12]

3.1.8 defective item
item with one or more defects
3.1.9 sampling unit unit
one of the individual parts into which a population is divided
[ISO 3534-2, 1.2.14 modified]

3.1.10 nonconforming unit
unit with one or more nonconformities
[ISO 3534-2, 1.2.15]

3.1.11 sample
subset of a population made up of one or more sampling units
[ISO 3534-2, 1.2.17 modified]

3.1.12 sample size
number of sampling units in a sample

NOTE In a multistage sample, the sample size is the total number of sampling units at the conclusion of the final stage of sampling.
[ISO 3534-2, 1.2.26]

3.2 Types of sampling

3.2.1 sampling
act of drawing or constituting a sample
[ISO 3534-2, 1.3.1]

3.2.2 simple random sampling
sampling where a sample of \( n \) sampling units is taken from a population in such a way that all the possible combinations of \( n \) sampling units have the same probability of being taken
[ISO 3534-2, 1.3.4 modified]

3.2.3 acceptance sampling
sampling after which decisions are made to accept or not to accept a lot based on sample results
[ISO 3534-2, 1.3.17 modified]

3.3 Specifications, values and test results

3.3.1 specification limit
limiting value stated for a characteristic
[ISO 3534-2, 3.1.3]
3.3.2 upper specification limit

specification limit that defines the upper limiting value

[ISO 3534-2, 3.1.4]

3.3.3 lower specification limit

$L$
specification limit that defines the lower limiting value

[ISO 3534-2, 3.1.5]

3.3.4 single specification limit

specification limit where the decision criteria is applied only to one limit

[ISO 3534-2, 3.1.7]

3.3.5 combined double specification limit

specification limit where the decision criteria is applied collectively to the upper and lower limits

[ISO 3534-2, 3.1.8]

3.3.6 combined control

requirement when nonconformity beyond both the upper and the lower specification of a quality characteristic belongs to the same class, to which a single AQL is applied

[ISO 3951-2, 3.17, modified]

3.3.7 nonconformity

non-fulfilment of a requirement

NOTE See notes to "defect".

[ISO 3534-2, 3.1.11]

3.3.8 defect

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

NOTE 1 The distinction between the concepts defect and nonconformity 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 the information, such as operating or maintenance instructions, provided by the customer.

[ISO 3534-2, 3.1.12]

3.4 Types of inspection

3.4.1 conformity evaluation

systematic examination of the extent to which an item/entity fulfils specified requirements
3.4.2
inspection
corresponds to observation and judgement accompanied as appropriate by
measurement, testing or gauging

[ISO 3534-2, 4.1.2]

3.4.3
inspection by attributes
inspection 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

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, 4.1.3 modified]

3.4.4
inspection by variables
inspection by measuring the magnitude(s) of the characteristic(s) of an item

[ISO 3534-2, 4.1.4]

3.4.5
100 % inspection
inspection of selected characteristic(s) of every item in the group under consideration

[ISO 3534-2, 4.1.5]

3.4.6
sampling inspection
inspection of selected items in the group under consideration

[ISO 3534-2, 4.1.6]

3.4.7
acceptance sampling inspection
acceptance inspection where the acceptability is determined by means of sampling inspection

[ISO 3534-2, 4.1.8]

3.4.8
normal inspection
inspection which is used when there is no reason to think that the quality level achieved by
the process differs from a specified level

[ISO 3534-2, 4.1.10]

3.4.9
reduced inspection
inspection less severe than normal inspection, to which the latter is switched when inspection
results of a predetermined number of lots indicate that the quality level achieved by the
process is better than that specified

[ISO 3534-2, 4.1.11]
indicator that is used under normal inspection to determine whether the current inspection results are sufficient to allow for a switch to reduced inspection

[ISO 2859-1, 3.1.23]

3.4.11 tightened inspection
inspection more severe than normal inspection, to which the latter is switched when inspection results of a predetermined number of lots indicate that the quality level achieved by the process is poorer than that specified

[ISO 3534-2, 4.1.12]

3.4.12 isolated lot inspection
inspection of a unique lot or one separated from the sequence of lots in which it was produced or collected

[ISO 3534-2, 4.1.14]

3.4.13 lot-by-lot inspection
inspection of a product submitted in a series of lots

[ISO 3534-2, 4.1.15]

3.4.14 original inspection
inspection of a lot, or other amount, not previously inspected

NOTE This is in contrast, for example, to inspection of a lot which has previously been designated as not acceptable and which is submitted again for inspection after having been further sorted, reprocessed, etc.

[ISO 3534-2, 4.1.16]

3.4.15 acceptance inspection
inspection to determine whether a lot or other amount is acceptable

[ISO 3534-2, 4.1.17]

3.5 Types of acceptance sampling inspection

3.5.1 single acceptance sampling inspection
acceptance sampling inspection in which the decision, according to a defined rule, is based on the inspection results obtained from a single sample of predetermined size, n

[ISO 3534-2, 4.2.2]

3.5.2 double acceptance sampling inspection
multiple acceptance sampling inspection in which at most two samples are taken

NOTE The decisions are made according to defined rules.

[ISO 3534-2, 4.2.3]
acceptance sampling inspection in which some lots in a series are accepted without inspection, when the sampling results for a stated number of immediately preceding lots meet stated criteria

[ISO 3534-2, 4.2.5]

3.5.4 acceptance sampling inspection by variables
acceptance sampling inspection in which the acceptability of a process is determined statistically from measurements on specified quality characteristics of each item in a sample from a lot

NOTE Lots taken from an acceptable process are assumed to be acceptable.

[ISO 3534-2, 4.2.11]

3.5.5 acceptance sampling inspection by attributes
acceptance sampling inspection whereby the presence or absence of one or more specified characteristics of each item in a sample is observed to establish statistically the acceptability of a lot or process

[ISO 3534-2, 4.2.12]

3.6 Acceptance sampling inspection system aspects

3.6.1 acceptance sampling inspection system
collection of acceptance sampling plans or acceptance sampling schemes together with criteria by which appropriate plans or schemes may be chosen

[ISO 3534-2, 4.3.1]

3.6.2 acceptance sampling scheme
combination of acceptance sampling plans with switching rules for changing from one plan to another

[ISO 3534-2, 4.3.2]

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

[ISO 3534-2, 4.3.3]

3.6.4 switching rule
instruction within an acceptance sampling scheme for changing from one acceptance sampling plan to another of greater or lesser severity of sampling based on demonstrated quality history

NOTE Normal, tightened, reduced inspection or discontinuation of inspection are examples of severity of sampling.

[ISO 3534-2, 4.3.4]
3.6.5 inspection level
index of the relative amount of inspection of an acceptance sampling scheme, chosen in advance, and relating the sample size to the lot size

NOTE 1 A lower/higher inspection level can be selected if experience shows that a less/more discriminating operating characteristic curve will be appropriate.

NOTE 2 The term should not be confused with severity of sampling which concerns switching rules, which operate automatically.

[ISO 3534-2, 4.3.5]

3.6.6 severity of sampling
dergree of discrimination within an acceptance sampling scheme for changing from a normal to a reduced/tightened acceptance sampling plan if the quality of the submitted product or service improves/deteriorates

NOTE The term should not be confused with inspection level (4.3.5) which is independent of switching rules (4.3.4).

[ISO 3534-2, 4.3.6]

3.6.7 acceptance sampling procedure
operational requirements and/or instructions related to the use of a particular acceptance sampling plan

NOTE This covers the planned method of selection, withdrawal and preparation of sample(s) from a lot to yield knowledge of the characteristic(s) of the lot.

[ISO 3534-2, 4.3.7]

3.6.8 curtailed inspection
acceptance sampling procedure which contains a provision for stopping inspection when it becomes apparent that adequate data have been collected for a decision

[ISO 3534-2, 4.3.8]

3.6.9 sigma method
acceptance sampling inspection by variables using the presumed value of the process standard deviation

[ISO 3534-2, 4.3.9]

3.6.10 s method
acceptance sampling inspection by variables using the sample standard deviation

[ISO 3534-2, 4.3.10]

3.7 Acceptance criteria

3.7.1 rejection number
Re
smallest number of nonconformities or nonconforming items found in the sample by
acceptance sampling by attributes that requires the lot to be not accepted, as given in the acceptance sampling plan.

[ISO 3534-2, 4.4.1]

3.7.2 acceptance number

Ac

largest number of nonconformities or nonconforming items found in the sample by acceptance sampling by attributes that permits the acceptance of the lot, as given in the acceptance sampling plan.

[ISO 3534-2, 4.4.2]

3.7.3 acceptability constant

k

constant depending on the specified value of the acceptance quality limit and the sample size used in the criteria for accepting the lot in an acceptance sampling plan by variables.

NOTE Other acceptability constants are \( p^* \) and \( M \), where \( p^* \) is the maximum acceptable estimate of the process fraction nonconforming. \( M (=100p^*) \) is an alternative notation in use.

[ISO 3534-2, 4.4.4]

3.7.4 maximum sample standard deviation

MSSD

largest sample standard deviation for a given sample size code letter and acceptance quality limit for which it is possible to satisfy the acceptance criterion for a double specification limit when the process variability is unknown.

NOTE The MSSD depends on whether the double specification limits are combined, separate or complex and on the inspection severity (i.e. normal, tightened or reduced).

[ISO 3534-2, 4.4.7]

3.7.5 maximum process standard deviation

MPSD

largest process standard deviation for a given sample size code letter and AQL for which it is possible to satisfy the acceptance criterion for a double specification limit under all inspection severities (i.e. normal, tightened and reduced) when the process variability is known.

NOTE The MPSD depends on whether the double specification limits are combined, separate or complex, but does not depend on the inspection severity.

[ISO 3534-2, 4.4.8]

3.7.6 quality statistic

\( \bar{Q} \)

function of the specification limit, the sample mean and the sample or process standard deviation, used in assessing the acceptability of a lot.

NOTE For the case of a single specification limit, the lot may be sentenced on the result of comparing quality characteristic, \( \bar{Q} \), with the acceptability constant, \( k \)

[ISO 3534-2, 4.4.9]
3.7.7 upper quality statistic

The upper quality statistic, $Q_U$, is a function of the upper specification limit, the sample mean, and the sample or process standard deviation.

NOTE: For a single, upper specification limit, the lot is sentenced on the result of comparing the upper quality characteristic, $Q_U$, with the acceptability constant, $k$.

[ISO 3534-2, 4.4.10]

3.7.8 lower quality statistic

The lower quality statistic, $Q_L$, is a function of the lower specification limit, the sample mean, and the sample or process standard deviation.

NOTE: For a single, lower specification limit, the lot is sentenced on the result of comparing the lower quality characteristic, $Q_L$, with the acceptability constant, $k$.

[ISO 3534-2, 4.4.11]

3.8 Types of operating characteristic curves

3.8.1 operating characteristic curve

A curve showing the relationship between probability of acceptance of product and the incoming quality level for a given acceptance sampling plan.

[ISO 3534-2, 4.5.1]

3.8.2 isolated lot operating characteristic curve

type A curve

A curve applicable to isolated or individual lots, where the quality level relates to the lot.

[ISO 3534-2, 4.5.2]

3.8.3 lot sequence operating characteristic curve

type B curve

A curve applicable to a continuing series of lots from a given source, where the quality level relates to the process.

[ISO 3534-2, 4.5.4]

3.9 Terms relating to operating characteristics

3.9.1 probability of acceptance

$P_a$ probability that, when using a given acceptance sampling plan, a lot will be accepted when the lot or process is of a specific quality level.

[ISO 3534-2, 4.6.1]
3.9.2 consumer’s risk
\( \beta \)
probability of acceptance when the quality level has a value stated by the acceptance sampling plan as unsatisfactory

NOTE  Quality level could relate to fraction nonconforming and be unsatisfactory to the LQL.

[ISO 3534-2, 4.6.2]

3.9.3 probability of non-acceptance
probability that, when using a given acceptance sampling plan, a lot will not be accepted when the lot or process is of a specified quality level

[ISO 3534-2, 4.6.3]

3.9.4 producer’s risk
\( \alpha \)
probability of non-acceptance when the quality level has a value stated by the plan as acceptable

NOTE 1  Quality level could relate to fraction nonconforming and be acceptable to AQL.

NOTE 2  Interpretation of the producer’s risk requires knowledge of the stated quality level.

[ISO 3534-2, 4.6.4]

3.9.5 consumer’s risk point
CRP
point on the operating characteristic curve corresponding to a predetermined low probability of acceptance

NOTE 1  This low probability of acceptance is called the “consumer’s risk” and the corresponding lot quality determined by the CRP for that risk is called the “consumer’s risk quality” (CRQ).

NOTE 2  The type of operating characteristic curve needs to be specified.

[ISO 3534-2, 4.6.5]

3.9.6 producer’s risk point
PRP
point on the operating characteristic curve corresponding to a predetermined high probability of acceptance

NOTE  Interpretation of the producer’s risk point requires knowledge of the stated quality level.

[ISO 3534-2, 4.6.7]

3.9.7 slope of operating characteristic curve
slope of the line joining the producer’s risk point and the consumer’s risk point on an operating characteristic curve

NOTE  The nearer to vertical the slope of the line, the greater is the discriminatory power of the acceptance sampling plan.
3.9.8 consumer’s risk quality
CRQ
$\bar{Q}_{CR}$
quality level of a lot or process which, in the acceptance sampling plan, corresponds to a specified consumer’s risk

NOTE The specified consumer’s risk is usually 10%.
[ISO 3534-2, 4.6.9]

3.9.9 producer’s risk quality
PRQ
$\bar{Q}_{PR}$
quality level of a lot or process which, in the acceptance sampling plan, corresponds to a specified producer’s risk

NOTE 1 The type of operating characteristic curve needs to be specified.
NOTE 2 The specified producer’s risk is usually 5%.
[ISO 3534-2, 4.6.10]

3.9.10 discrimination ratio
ratio of quality levels consumer’s risk quality and producer’s risk quality
[ISO 3534-2, 4.6.12]

3.9.11 limiting quality
LQ
quality level, when a lot is considered in isolation, which, for the purposes of acceptance sampling inspection, is limited to a low probability of acceptance
[ISO 3534-2, 4.6.13]

3.9.12 limiting quality level
LQL
quality level which, for the purposes of acceptance sampling inspection, is the limit of an unsatisfactory process average when a continuing series of lots is considered
[ISO 3534-2, 4.6.14]

3.9.13 acceptance quality limit
AQL
worst tolerable quality level

NOTE 1 This concept only applies when an acceptance sampling scheme with rules for switching and for discontinuation, such as ISO 2859-1 and ISO 3951, is used.

NOTE 2 Although individual lots with quality as bad as the acceptance quality limit can be accepted with fairly high probability, the designation of an acceptance quality limit does not suggest that this is a desirable quality level.
NOTE 3 Acceptance sampling schemes found in standards such as ISO 2859-1 with their rules for switching and discontinuation of sampling inspection are designed to encourage suppliers to have process averages consistently better than the acceptance quality limit. If suppliers fail to do so, there is a high probability of being switched from normal inspection to tightened inspection where lot acceptance becomes more difficult. Once on tightened inspection, unless action is taken to improve the process, it is very likely that the rule requiring discontinuation of sampling inspection pending such improvement will be invoked.

NOTE 4 The use of the abbreviation AQL to mean “acceptable quality level” is no longer recommended.
[ISO 3534-2, 4.6.15]

3.9.14 quality level
quality expressed as a rate of nonconforming units or rate of number of nonconformities
[ISO 3534-2, 4.6.16]

3.10 Outgoing quality concepts

3.10.1 average outgoing quality
AOQ
expected average quality level of outgoing product for a given value of incoming product quality

NOTE 1 Unless otherwise specified, the average outgoing quality is calculated over all accepted lots plus all non-accepted lots after the latter have been inspected 100 % and the nonconforming items replaced by conforming items.

NOTE 2 New concepts with new terms and definitions can be used depending on the circumstances under which nonconforming items removed in the 100 % inspection of non-accepted lots are replaced by conforming units.

NOTE 3 An approximation often used is: “Average outgoing quality = incoming process quality x probability of acceptance”. This formula is exact for accept-zero plans and overestimates otherwise.
[ISO 3534-2, 4.7.1]

3.10.2 average outgoing quality limit
AOQL
maximum AOQ over all possible values of incoming product quality level for a given acceptance sampling plan and rectification of all non-accepted lots unless specified otherwise
[ISO 3534-2, 4.7.2]

3.11 Other terms

3.11.1 percent nonconforming
(in a sample) one hundred times the number of nonconforming items in the sample divided by the sample size, viz:

\[
\frac{d}{n} \times 100
\]

where

\[d\] is the number of nonconforming items in the sample;
\[n\] is the sample size

[ISO 2859-1, 3.1.8]
(in a population or lot) one hundred times the number of nonconforming items in the population or lot divided by the population or lot size, viz:

\[ 100p = 100 \frac{D}{N} \]

where

- \( p \) is the proportion of nonconforming items;
- \( D \) is the number of nonconforming items in the population or lot;
- \( N \) is the population or lot size

[ISO 2859-1, 3.1.9 modified]

### 3.11.3 Process fraction nonconforming

rate at which nonconforming items are generated by a process, expressed as a proportion

[ISO 3951-1, 3.5]

### 3.11.4 Responsible authority

concept used to maintain the neutrality of this standard (primarily for specification purposes), irrespective of whether it is being invoked or applied by the first, second or third party

**NOTE** The responsible authority may be:

a) the quality department within a supplier’s organization (first party);
b) the purchaser or procurement organization (second party);
c) an independent verification or certification authority (third party).

[ISO 2859-1, 3.1.12]

### 4 Symbols and abbreviations

#### 4.1 Symbols

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \alpha )</td>
<td>producer’s risk</td>
</tr>
<tr>
<td>( Ac )</td>
<td>acceptance number</td>
</tr>
<tr>
<td>( \beta )</td>
<td>consumer’s risk</td>
</tr>
<tr>
<td>( d )</td>
<td>number of nonconforming items (or nonconformities) found in a sample from a lot</td>
</tr>
<tr>
<td>( D )</td>
<td>number of nonconforming items in a lot</td>
</tr>
<tr>
<td>( f_s )</td>
<td>factor, that relates the maximum sample standard deviation to the difference between ( U ) and ( L )</td>
</tr>
<tr>
<td>( f_a )</td>
<td>factor, that relates the maximum process standard deviation to the difference between ( U ) and ( L )</td>
</tr>
<tr>
<td>( k )</td>
<td>acceptability constant</td>
</tr>
<tr>
<td>( \mu )</td>
<td>process mean, population parameter</td>
</tr>
<tr>
<td>( n )</td>
<td>sample size</td>
</tr>
<tr>
<td>( N )</td>
<td>lot size</td>
</tr>
<tr>
<td>( L )</td>
<td>specification limit, lower</td>
</tr>
<tr>
<td>( P_a )</td>
<td>probability of acceptance</td>
</tr>
<tr>
<td>( \hat{p} )</td>
<td>estimate of the process fraction nonconforming</td>
</tr>
</tbody>
</table>
### Symbols

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \hat{p}_L )</td>
<td>estimate of the process fraction nonconforming below the lower specification limit</td>
</tr>
<tr>
<td>( \hat{p}_U )</td>
<td>estimate of the process fraction nonconforming above the upper specification limit</td>
</tr>
<tr>
<td>( p^* )</td>
<td>maximum acceptable value for the estimate of the process fraction nonconforming</td>
</tr>
<tr>
<td>( Q_{CR} )</td>
<td>consumer’s risk quality</td>
</tr>
<tr>
<td>( Q )</td>
<td>quality statistics</td>
</tr>
<tr>
<td>( Q_L )</td>
<td>quality statistics, lower</td>
</tr>
<tr>
<td>( Q_U )</td>
<td>quality statistics, upper</td>
</tr>
<tr>
<td>( Q_{PR} )</td>
<td>producer’s risk quality</td>
</tr>
<tr>
<td>( Re )</td>
<td>rejection number</td>
</tr>
<tr>
<td>( s )</td>
<td>sample standard deviation of the measured values of the quality characteristics (also an estimation of the standard deviation of the process)</td>
</tr>
<tr>
<td>( s_{max} )</td>
<td>maximum sample standard deviation (MSSD)</td>
</tr>
<tr>
<td>( \sigma )</td>
<td>standard deviation of a process that is under statistical control</td>
</tr>
<tr>
<td>( \sigma_{max} )</td>
<td>maximum process standard deviation (MPSD)</td>
</tr>
<tr>
<td>( U )</td>
<td>specification limit, upper</td>
</tr>
<tr>
<td>( x_j )</td>
<td>measured value of the quality characteristic for the ( j^{th} ) item of the sample</td>
</tr>
<tr>
<td>( \bar{x} )</td>
<td>arithmetic mean of the measured values of the quality characteristics in the sample, i.e.</td>
</tr>
</tbody>
</table>

\[
\bar{x} = \frac{\sum_{j=1}^{n} x_j}{n}
\]

### 4.2 Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOQ</td>
<td>average outgoing quality</td>
</tr>
<tr>
<td>AOQL</td>
<td>average outgoing quality limit</td>
</tr>
<tr>
<td>AQL</td>
<td>acceptance quality limit</td>
</tr>
<tr>
<td>CR</td>
<td>consumer’s risk</td>
</tr>
<tr>
<td>CRP</td>
<td>consumer’s risk point</td>
</tr>
<tr>
<td>CRQ</td>
<td>consumer’s risk quality</td>
</tr>
<tr>
<td>LQ</td>
<td>limiting quality</td>
</tr>
<tr>
<td>LQL</td>
<td>limiting quality level</td>
</tr>
<tr>
<td>MPSD</td>
<td>maximum process standard deviation</td>
</tr>
<tr>
<td>MSSD</td>
<td>maximum sample standard deviation</td>
</tr>
<tr>
<td>OC</td>
<td>operating characteristic</td>
</tr>
<tr>
<td>PR</td>
<td>producer’s risk</td>
</tr>
<tr>
<td>PRP</td>
<td>producer’s risk point</td>
</tr>
<tr>
<td>PRQ</td>
<td>producer’s risk quality</td>
</tr>
</tbody>
</table>
5.1 The objectives of acceptance inspection

When meters are offered for supply, both the manufacturer and the customer may use acceptance sampling procedures to satisfy themselves that the product is of acceptable quality. The manufacturer will be seeking to maintain a reputation for good quality and to reduce the likelihood of claims under warranty, but without incurring unnecessary production and supply costs. On the other hand, the customer will require adequate evidence, at minimum cost to himself, that the product he receives conforms to specification. Compared with, say, 100 % inspection, suitable sampling methods will often be beneficial in achieving these aims.

Several types of sampling systems, schemes and plans are available for these purposes. This standard makes a selection from relevant ISO standards, deemed to be appropriate for electricity metering equipment in the scope of IEC TC 13.

NOTE 1 If necessary, other sampling systems, schemes and plans may be selected from the relevant ISO standards.

The choice of sampling system, scheme or plan depends on a number of conditions and on the prevailing circumstances. In any supply situation, the first essential is that the manufacturer and the customer understand, and have agreed, the requirements and the basis for release and acceptance of the product, including any acceptance sampling methods to be used.

Lots that are not acceptable cause difficulties for both manufacturer and customer. The manufacturer incurs additional costs in rework, scrap, increased inspection, damage to reputation and possibly loss of sales. Delays in delivery and re-inspection costs are a burden to the customer. For these reasons, it is usually considered essential for the manufacturer to provide lots that have a very high probability of being accepted, i.e. 95 % or more. The manufacturer has to ensure that quality control of the production or delivery process provides lots of a quality sufficient to meet this objective. A basic principle of some acceptance sampling inspection schemes is to promote the production of lots of acceptable quality.

The primary purpose of these schemes is not to discriminate between acceptable and non-acceptable lots, i.e. to sort, but to keep production under control to yield an acceptable process average quality. Although all acceptance sampling plans are discriminatory to some degree, the process average quality (expressed in terms of percent nonconforming or number of nonconformities) should not be greater than half the acceptance quality limit in order to ensure a very high probability of acceptance.

NOTE 2 ISO/TR 8550-1 Clause 4 describes some abuses and uses of acceptance sampling.

5.2 Acceptance sampling plans, schemes and systems

An acceptance sampling plan is a set of rules by which a lot is to be inspected and its acceptability determined. The plan stipulates the number of items (units) in the sample, to be drawn randomly from a lot for inspection against the product specification. The lot is then sentenced as ‘acceptable’ or ‘not acceptable’ according to how the inspection results compare with the criteria of the acceptance sampling plan.

Sometimes, when a long series of lots is being inspected, a sampling procedure might call for a shift from one sampling plan to another, depending on the current and previous sample results. Sampling procedures that call for switching from one sampling plan to another, and possibly back again, are called sampling schemes. A sampling scheme might also call for discontinuation of inspection if product quality appears to remain poor. The customer may
A collection of sampling plans and related sampling schemes constitute a sampling system. The system is generally indexed in some way, for example by lot size, inspection level and acceptance quality limit.

5.3 Practical and economic advantages of using standard sampling plans

To those concerned with the writing of specifications, it is of benefit that statistically sound sampling procedures are provided. Because there are economies of scale for larger lots, sampling schemes presented in this standard relate sample size to lot size.

Apart from providing control over the methods of selection of the sample, this standard should normally be invoked because it specifies requirements that control the treatment of nonconformities found during inspection and the treatment of lots resubmitted after initial non-acceptance. Furthermore, most of these sampling systems contain built-in switching rules (e.g. from 'normal' to 'tightened' or to 'reduced' inspection) to adjust the sampling plan in the event of deterioration or improvement in quality.

Sampling involves risk and, quite naturally, all parties concerned attempt to minimize their share. Theoretically, these risks are functions of the sampling plan and the quality level agreed, without relation to the industry or the product. In practice, these risks are reduced by controlling the production process and improving the level of quality.

These risks cannot be eliminated, but they can be precisely calculated and economically assessed by the use of modern statistical techniques. Consequently, it is of benefit to all parties that statistically sound acceptance criteria be specified in product/process specifications and that, wherever possible, the generally applicable basic reference standards on sampling be utilized.

The motivation for acceptance sampling is primarily economic: inspection of a sample from a lot is the (usually small) price paid to achieve desirable quality in the accepted lots. This quality is achieved by two pressures:

- the purely statistical pressure of different probabilities of acceptance of good and bad quality lots; and
- when sequences of lots are purchased, the commercial pressure of frequent non-acceptance of lots and the switch to tightened inspection or discontinuation of inspection when quality is poor.

The problem associated with acceptance sampling inspection relates to defining unambiguously the criteria used to judge discrete individual items supplied in quantity, the criterion for acceptance of the lot, the quality level expected from the manufacturing process, the discrimination afforded by the sampling plans and the rules to be followed when a lot is not accepted. Above all, however, it is necessary to design the sampling scheme so that it can be invoked easily in a purchasing contract. The sampling plans presented in this standard enable this to be done efficiently.

5.4 Agreement between the parties

The parties involved in the process are the manufacturer, the customer and, as the case may be, a responsible authority.

Before selecting an acceptance method, a sampling system, scheme or plan, the parties should agree on the following:
the specification to which the meters are to conform. This is necessary because in all dealings between the parties there has to be an agreement on what constitutes a conforming item and what constitutes a nonconforming item. These requirements are fixed for various types of meters in the relevant parts of IEC 62058 series containing particular requirements for acceptance inspection;

- whether the acceptance of the product is to be determined by the acceptance of individual items or collectively by the acceptance of inspection lots of items (acceptance of individual items precludes sampling). Acceptance of individual items may be used when the number of meters is low;
- when the acceptance is to be on a lot basis, the agreement between supplier and recipient needs to include:
  - the criteria for item conformance;
  - the criteria for lot acceptance;
  - the criteria for non-acceptance of the lot; and
  - the acceptance sampling system, scheme or plan to be used.

The latter should be based on risk factors that are mutually acceptable to both producer and customer.

Having agreed on the acceptance sampling system, scheme or plan to use, the supplier knows, for various quality levels, the probability that his supply lots will be accepted. Likewise, the customer understands the protection provided by the sampling system, scheme or plan against acceptance of a poor quality product.

5.5 Selection of sampling schemes and sampling plans

This standard specifies the following methods for sampling inspection:

- lot-by-lot inspection by attributes;
- inspection of isolated lots by attributes;
- skip-lot inspection;
- lot-by-lot inspection by variables.

The selection process is shown on Figure 1.

In addition, 100 % inspection may be used for small lots or when sampling inspection has to be discontinued.
5.6 Considerations influencing a selection

5.6.1 Long and short production runs

The procedures described in Clauses 7, 9 and 10 are all intended for use primarily on a continuing series of lots of sufficient duration to allow the switching rules to be applied. This implies a 'long' production run.

Clause 8 comprises limiting quality (LQ) plans that can be used when the switching rules of Clause 7 are not applicable. These are primarily intended for use with single lots or lots of an 'isolated nature'. By implication, this embraces a 'short' series of inspection lots or a 'short' production run.

In order for a production run to qualify as 'long', one criterion is clearly that the switching rules have a reasonable chance of coming into effect if “the quality is unsatisfactory”.

Figure 1 – Selection procedure of sampling schemes and plans
In the absence of any other guidance, anything up to 10 consecutive inspection lots should be considered as a 'short run', and the plans in Clause 8 should be used. However, lots should not be subdivided arbitrarily in order to create a 'long run'.

The practical factor to consider is whether there is evidence that a stable process average has been established and still exists.

5.6.2 Lot-by-lot inspection

Lot-by-lot inspection is the inspection of product submitted in a series of lots.

If a sequence of lots is to be offered for acceptance at the time of production, the inspection results from the preceding lots can be available before the later lots are made. It is therefore possible that the inspection performed can beneficially influence the quality of subsequent production. The lots should be submitted and inspected in the same sequence as they are manufactured and inspection should be made promptly. Information obtained from a lot may indicate that the process appears to have deteriorated. The information obtained from several lots in sequence can be used to invoke a switching procedure, which requires the use of a more rigorous sampling procedure in the event that the process deteriorates. This is important because, in the long run, it provides the best protection a consumer has against poor quality.

If the quality remains poor, then under the more rigorous sampling practice more lots will be returned to the manufacturer for sorting. This tighter sampling increases the producer’s risk of having an acceptable lot judged unacceptaable. The identification of possible deterioration in product quality is a signal to initiate corrective action.

If the quality is very much better than that agreed upon, the customer may, with the permission of the responsible authority, elect to adopt reduced or skip-lot sampling.

5.6.3 Isolated lot inspection

Acceptance inspection may sometimes be performed on an isolated lot, just a few isolated lots, or on stored lots at a time when production has been finished. Under these circumstances, there is insufficient opportunity for the switching rules to be invoked and hence to influence the quality being offered.

If a single lot is delivered, then it is helpful to know whether a lot is one of many similar lots delivered to other customers and consists of material from a controlled process or not.

5.6.4 Attributes versus variables

Acceptance sampling standards generally describe procedures for inspection by attributes or for inspection by variables, so a key decision to make is which of these to use.

Inspection by attributes consists of examining an item, or characteristics of an item, and classifying the item as “conforming” or “nonconforming”. The criterion for lot acceptance is based on counting the number of nonconforming items found in a random sample. It shall be applied when a characteristic under inspection cannot be measured on a continuous scale. It shall also be applied if the characteristic can be measured on a continuous scale, but normality of the distribution of the values cannot be assumed.

Inspection by variables consists of selecting a random sample of a number of items and measuring characteristics so that information is available not only on whether a characteristic is within certain limits but on the actual value of the characteristic. The decision whether or not to accept a lot is made on the basis of calculations of the average and the variability of the measurements. It can be applied only if production of lots is continuous and if normality of the distribution of the variables can be assumed. For more information on normality, see ISO/TR 8550-3, Clause 3.
If certain assumptions are true, the variables method has the advantage of generally requiring a smaller sample size than the attributes method to attain a given degree of protection against incorrect decisions. In addition, it provides more information as to whether quality is being adversely affected by process mean, process variability or both.

The attributes method has the advantage that it is more robust, in the sense that it is not subject to assumptions of distributional shape, and that it is simpler to use. The larger sample sizes and consequential increased costs associated with using attribute sampling methods might be justifiable for these reasons. Furthermore, an attribute scheme might be understood and accepted more readily by inspection personnel. To avoid the assumption of normality and the attendant inability or difficulty in checking for this with ‘short runs’ or lots of an ‘isolated’ nature, sampling by attributes is recommended even to the extent of converting measurements to attributes.

5.6.5 Single and double sampling

For most single sampling plans, it is possible to find double sampling plans with an operating characteristic curve (see 5.9) close to that of a single sampling plan.

Choice between single sampling and double sampling depends on the balance between administrative difficulties taking a second sample and the advantages to be gained from the reduction of inspection costs.

In this standard, double sampling plans have been selected only for inspection by attributes.

5.6.6 ”s” method and “σ” method

If a process standard deviation, σ is unknown, it is estimated by the corresponding sample standard deviation, s. Acceptance sampling procedures based on s are referred to collectively as the ”s” method. Conversely, acceptance sampling procedures based on σ are referred to collectively as the ”σ” method.

Under the ”σ” method there is less uncertainty in the value of the quality statistic, which generally results in a lower sample size requirement, dramatically so in the case of large lots.

NOTE The process standard deviation, although never known exactly, might on occasion be known accurately enough for practical purposes.

See also 10.2.

5.7 Nonconformity and nonconforming items

For 100 % inspection and inspection by attributes, any failure to conform to a specified product characteristic, attribute or performance requirement represents a nonconformity. A nonconforming item may have one or more nonconformities. The qualification “nonconformity” does not necessarily imply that the unit of product cannot be used for the purpose intended.

The quality of a given quantity of meters is expressed in percent nonconforming.

5.8 Classification of nonconformities

This standard makes a distinction between critical and non-critical nonconformities.

For different types of meters, the classification of various nonconformities as critical and non-critical is specified in the relevant standards specifying particular requirements for acceptance testing.
For critical nonconformities, it would be desirable to establish that there are no nonconforming items in the lot, but this is possible only with 100 % inspection.

To allow sampling inspection, inspection by attributes with single sampling plans have been selected with the acceptance number equal to zero for all sample sizes. The larger the sample size, the smaller is the AQL demonstrated.

### 5.9 Operating characteristic (OC) curve

**NOTE** This subclause is based on 8.3 of ISO/TR 8550-1.

The operating characteristic (OC) curve is a curve that shows what any particular sampling plan can be expected to do in terms of accepting and not accepting lots; that is, it is a sort of 'efficiency curve'. An OC curve refers to a particular sampling plan. Each possible plan has its own curve.

In the case of sampling inspection by attributes and in the case of a long production run with stable process, the OC curves give the proportion of lots of a particular quality that will be accepted. In the case of isolated or individual lots, the OC curves show the probability of acceptance of the particular lot with a given quality.

In the case of sampling inspection by variables, the OC curves show the average percentage of lot accepted, but do not show probabilities of acceptance of particular lots. For a particular lot, it may happen that a rejected lot may be free of nonconforming items. Moreover, an individual lot with a given high fraction of nonconforming items may have a smaller actual probability of rejection than it can be shown by the OC curve for the whole process.

The OC curves of the sampling plans selected for the purposes of this standard are given in 7.6, 8.5 and 10.14 respectively.

### 5.10 Producer's risks (PR) and consumer's risk (CR)

Because samples constitute only a small part of the whole of an inspection lot, sampling involves risks for both the producer and the consumer. Occasionally, a 'good' lot might not be accepted because the sample inspected, though randomly selected, does not reflect the true quality of the lot. The risk of this happening is known as the 'producer's risk' (PR). Conversely, a 'poor quality' lot might pass inspection because of the limited data available in the sample. This eventuality is known as the 'consumer's risk' (CR).

The producer would require a high probability of acceptance if the quality were good, while the customer would want a low probability of acceptance if the quality were poor.

For the sampling plans selected for the purposes of this standard, 7.10 and 10.15 show the Consumer’s Risk Quality (CRQ) values at given values of CR, for lot-by-lot inspection by attributes and for inspection by variables respectively.

Similarly, 7.11 and 10.16 show the values of the producer’s risk.

The OC curves and the tables also show the effect of moving to tightened inspection: the producer's risk increases and the consumer's risk decreases.

Methods of reducing the risks for both parties are:

- to improve the quality of production; and
5.11 AQL, PRQ, LQ and CRQ

For the purposes of this standard, the AQL and the PRQ can be deemed synonymous. They are both indices of what quality can be tolerated for the purposes of sampling inspection, the difference being that the PRQ is associated with a specified small PR whereas the AQL denotes a quality level for which the (unspecified) PR will be small.

In analogy with the AQL and the PRQ, the LQ and the CRQ can be considered equivalent indices whose stipulated values express, for sampling purposes, a level of ‘objectionable’ quality that has only a small chance of acceptance.

The AQL and LQ values are used for indexing the sampling plans.

ISO 2859-1, ISO 2859-3 and ISO 3951-2 standards define a preferred series of AQL values. For non-critical nonconformities, this standard specifies AQL = 1.0 %.

Limitation: The designation of an AQL shall not imply that the supplier has the right to supply knowingly any nonconforming items of product.

Similarly, ISO 2859-2 defines a preferred series of LQ values. For non-critical nonconformities, this standard specifies LQ = 5.0 %.

NOTE Other standard levels for AQL and LQ may be agreed on between the parties involved. The appropriate sampling plans can be found in the relevant ISO standards.

5.12 Switching rules for normal, tightened and reduced inspection

When an AQL is specified, the ideal would be to have a system whereby lots could be always accepted when their quality was better than the AQL and always not accepted when worse than AQL. This ideal is not attainable by any sampling plan. To meet the requirements of both the producer and the customer, some compromise is needed.

The device adopted is to join normal inspection and tightened inspection together with rules for determining when to switch from one to the other and when to switch back again.

Normal inspection is used at the start of inspection. If at any time the sampling results indicate that the process average is probably worse than the AQL, then tightened inspection is instituted. If it appears that the quality has improved and it is probably better than AQL, normal inspection is reinstated. However, when tightened inspection does not in time stimulate the producer to improve the production process, sampling inspection shall be discontinued.

Tightened inspection and the discontinuation rule are integral and therefore obligatory procedures of this International Standard if the protection implied by the AQL is to be maintained.

Sometimes there is evidence that the product quality is consistently better than the AQL. When this happens and there is a reason to believe that good production will continue, reduced inspection sampling plans or the skip-lot sampling plans can be used. This practice is however optional (at the discretion of the responsible authority).

Details of the operation of the switching rules are given in 7.5 and 10.10 and are shown diagrammatically in Figure 2.
5.13 Inspection level

The inspection level is an index of the relative amount of inspection for a sampling scheme, and relates the sample size to the lot size and hence to the discrimination afforded between ‘good’ and ‘poor’ quality. ISO 2859-1 and ISO 3951-2 provide seven inspection levels.

Generally, inspection level II shall be used.

Inspection level III may be used to meet the requirements for selectivity at smaller lot sizes.

The inspection level that has been specified shall be kept unchanged when switching between normal, tightened and reduced inspection.
Sampling plans are identified by sample size code letters.

Knowing the requirements for the selectivity of the operating characteristic curves, the sample size code letter can be selected. From this, the inspection level and the lot size can be determined.

EXAMPLE

Inspection is carried out using lot-by-lot inspection by attributes, AQL = 1.0, single sampling plans.

The parties agree that the probability of acceptance shall be at least 95\% if the quality is as good as 1\% nonconforming, and the probability of acceptance shall be less than 10\% if the quality is as bad as 7\% nonconforming. From the OC curves shown in Figure 3 and Table 9, it is found that the first sample size code letter where these requirements are met is J. From Table 2, the lot size is 501 to 1 200 or higher with inspection level II and 281 to 500 or higher with inspection level III.

5.15 Place of inspection

In the case of lot-by-lot inspection, the feedback of the results to the manufacturing process is essential. Therefore, the inspection shall be carried out on the manufacturer's premises, but on test benches other than those on which the adjustments were made.

In the case of isolated lot inspection, the inspection shall be carried out by mutual agreement:

- on the manufacturer's premises, but on test benches other than those on which the adjustments were made; or
- on the customer's test benches; or
- on other agreed test benches.

5.16 Submission of product for acceptance inspection

The product shall be assembled into identifiable lots. Each lot shall, as far as is practicable, consist of items of a single type manufactured under uniform conditions at essentially the same time.

The formation of the lots, the lot size and the manner in which each lot shall be presented and identified by the manufacturer shall be designated or approved by, or according to, the customer or the responsible authority. As necessary, the manufacturer shall provide adequate and suitable storage space for each lot, equipment needed for proper identification and presentation, and personnel for all handling of product required for drawing of samples.

5.17 Drawing of samples

In acceptance sampling, a lot is sentenced on the quality of the sample. Hence, the sample needs to be representative of the lot. What is demanded is a random sample and not a biased one.

The selection of a random sample can be made using Table A.1 and the manufacturing numbers of the meters making up the lot.

EXAMPLE
A sample of size 8 is to be drawn from a lot of size 5000. The articles in the lot are labelled with numbers from 1 to 5000. Starting at the top of the first column of Table A.1, the articles to be drawn for the sample are numbers 110, 4148, 2403, 1828, 2267, 2985, 4313 and 4691 (the numbers 5327, 5373, 9244, etc., being ignored as corresponding articles would not be found in the lot).

The following should be noted with regard to the use of a table of random sampling numbers:

- it is incorrect to always start at the top of the first column. For each sample to be drawn, the best procedure is to start from an arbitrary point and work through the table either up or down columns or across rows;
- there is no need to read the numbers as having four figures. If the lot size were 1000 or fewer, the first three figures would be adequate, and would be read as 11, 532, 537, etc. Sometimes two figures are enough, sometimes more than four are required. As many or as few as desired may be combined.

5.18 Acceptability of lots

Acceptability of lots shall be determined by the use of a sampling plan or plans.

The parties shall agree how lots that are not accepted will be disposed of. Such lots may be scrapped, sorted (with or without nonconforming items being replaced), reworked, etc.

If the lot has been accepted, the right is reserved to not accept any item found nonconforming during inspection, whether the item formed part of a sample or not. Where required, meter(s) shall be opened and examined. Items found nonconforming may be reworked or replaced by conforming items and resubmitted for inspection upon the agreement of and in the manner agreed by the parties.

A lot shall not be resubmitted until all items are re-examined or retested and the customer is satisfied that all nonconforming items have been removed or replaced by conforming items, or all nonconformities have been corrected. The parties shall agree whether re-inspection shall include all characteristics or only the characteristic which caused initial non-acceptance. In the case of lot-by-lot inspection, the parties shall agree whether normal or tightened inspection shall be used.

6 100 % inspection

6.1 Application of the method

This method shall be applied:

- for small lots, for which sampling plans are either not available, or insufficiently discriminatory;
- for critical nonconformities, if sampling inspection using accept zero plans is not approved by the responsible authority;
- when the results of sampling inspection indicate that the required process quality is not reached. See 7.5.6 and 10.11;
- when the parties agree to use 100 % inspection.

6.2 Lot sizes and acceptance numbers

100 % inspection is done by attributes. The lot sizes and acceptance numbers are shown in Table 1.
### 6.3 Acceptance and non-acceptance

In addition to 5.18, the following applies.

The lot is accepted if:

- there are no items found with any critical nonconformity \((Ac = 0)\);
- the number of meters found with a non-critical nonconformity is equal to or less than the acceptance number \(Ac\); and
- the cumulated number of non-critical nonconformities is not more than twice the acceptance number \(Ac\).

Otherwise, the lot shall be considered unacceptable.

**EXAMPLE**

100 meters are tested. The results are the following:

- no meters with critical nonconformities are found;
- one meter is found exhibiting a non-critical nonconformity. This meter exhibits two non-critical nonconformities.

The lot is accepted.

If this meter had had three non-critical nonconformities, the lot would have to be rejected.

### 7 Lot-by-lot inspection by attributes

#### 7.1 Application of the method

Sampling schemes for lot-by-lot inspection by attributes described here are based on ISO 2859-1.

These schemes are intended to be used for a continuing series of lots, that is, a series long enough to allow the switching rules described in 7.5 to be applied. These rules provide:

- a protection to the consumer (by means of a switch to tightened inspection or discontinuation of sampling inspection) should a deterioration in quality be detected;
Reduced inspection may be replaced by skip-lot sampling when the requirements of Clause 9 are fulfilled.

For isolated lot inspection, see Clause 8.

7.2 Drawing of samples

Samples may be drawn after the lot has been produced, or during production of the lot. In either case, the samples shall be selected according to 5.17.

When double sampling is used, the second sample shall be selected from the remainder of the same lot.

7.3 Inspection level

Generally, inspection level II shall be used. Inspection level III provides greater discrimination and double sampling plans are available with smaller lots.

7.4 Sampling plans

7.4.1 Obtaining a sampling plan

The sampling plans shall be obtained from Table 2, single sampling or from Table 7, double sampling respectively.

NOTE If justified and agreed by the responsible authority, other sampling plans may be selected from ISO 2859-1.

When no sampling plan is available for a given sample size code letter, the tables direct the user to a different code letter. The sample size to be used is given by the new sample size code letter, not by the original code letter.

When more than one type of plan, either single or double, is available for a given sample size code letter either may be used. A decision as to the type of plan shall usually be based upon the comparison between the administrative difficulty and the average sample sizes of the available plans.

7.4.2 Single sampling plans

7.4.2.1 Non-critical nonconformities

Table 2 contains single sampling plans for non-critical nonconformities with AQL = 1.0, indexed by the sample size code letter, for normal, tightened and reduced inspection.
### Table 2 – Single sampling plans for normal, tightened and reduced inspection, AQL = 1,0

<table>
<thead>
<tr>
<th>Lot sizes for inspection levels</th>
<th>Sample size code letter</th>
<th>Sample size code letter</th>
<th>Normal inspection</th>
<th>Tightened inspection</th>
<th>Reduced inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td>II 51 to 90</td>
<td>E</td>
<td>13</td>
<td>0 1</td>
<td></td>
<td>5 0 1</td>
</tr>
<tr>
<td>91 to 150</td>
<td>F</td>
<td>20</td>
<td>0 1</td>
<td></td>
<td>8 0 1</td>
</tr>
<tr>
<td>151 to 280</td>
<td>G</td>
<td>32</td>
<td>0 1</td>
<td>13</td>
<td>5 0 1</td>
</tr>
<tr>
<td>281 to 500</td>
<td>H</td>
<td>50</td>
<td>1 2</td>
<td>20</td>
<td>5 0 1</td>
</tr>
<tr>
<td>501 to 1 200</td>
<td>J</td>
<td>80</td>
<td>2 3</td>
<td>32</td>
<td>1 2</td>
</tr>
<tr>
<td>1 201 to 3 200</td>
<td>K</td>
<td>125</td>
<td>3 4</td>
<td>50</td>
<td>2 3</td>
</tr>
<tr>
<td>-</td>
<td>L</td>
<td>200</td>
<td>5 6</td>
<td>80</td>
<td>3 4</td>
</tr>
</tbody>
</table>

### NOTES

The values are taken from Tables 1, 2-A, 2-B and 2-C of ISO 2859-1. If agreed by the responsible authority, higher lot sizes may be applied. The corresponding sampling plans can be selected from the tables referenced.

The sample sizes are the same for normal and tightened inspection.

- **Ac** = Acceptance number
- **Re** = Rejection number
- Sampling plan not available. Use the first sampling plan below the arrow.
- Sampling plan not available. Use the first sampling plan above the arrow.

### EXAMPLE 1

The lot size is 80. The agreed inspection level is II; the sample size code letter is E. A sampling plan is available for normal inspection and reduced inspection, but for tightened inspection, the table directs the user to code letter F. This gives the following sampling scheme:

<table>
<thead>
<tr>
<th>Code letter</th>
<th>Normal inspection</th>
<th>Tightened inspection</th>
<th>Reduced inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size n</td>
<td>E 13</td>
<td>F 20</td>
<td>E 5</td>
</tr>
<tr>
<td>Acceptance number Ac</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Rejection number Re</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

In this case, the acceptance number is the same for all three plans. Tightening is achieved by increasing the sample size. For reduced inspection, the sample size is decreased.

### EXAMPLE 2

The lot size is 400. The agreed inspection level is II; the sample size code letter is H. A sampling plan is available for normal inspection, but for tightened and reduced inspection, the table directs the user to code letter J. This gives the following sampling scheme:
Table 4 – Example with lot size = 400, inspection level II

<table>
<thead>
<tr>
<th>Code letter</th>
<th>Normal inspection</th>
<th>Tightened inspection</th>
<th>Reduced inspection (optional)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code letter</td>
<td>Normal inspection</td>
<td>Tightened inspection</td>
<td>Reduced inspection (optional)</td>
</tr>
<tr>
<td>Sample size</td>
<td>H</td>
<td>J</td>
<td>J</td>
</tr>
<tr>
<td>Acceptance</td>
<td>50</td>
<td>80</td>
<td>32</td>
</tr>
<tr>
<td>number Ac</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Rejection</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Again, the acceptance number is the same for all three plans. Tightening is achieved by increasing the sample size. For reduced inspection, the sample size is decreased.

EXAMPLE 3

The lot size is 800. The agreed inspection level is III, the sample size code letter is K. A sampling plan is available for normal, tightened and reduced inspection alike with the same code letter. This gives the following sampling scheme:

Table 5 – Example with lot size = 800, inspection level III

<table>
<thead>
<tr>
<th>Code letter (from Table 2)</th>
<th>Normal inspection</th>
<th>Tightened inspection</th>
<th>Reduced inspection (optional)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code letter</td>
<td>Normal inspection</td>
<td>Tightened inspection</td>
<td>Reduced inspection (optional)</td>
</tr>
<tr>
<td>Sample size</td>
<td>K</td>
<td>K</td>
<td>K</td>
</tr>
<tr>
<td>Acceptance number Ac</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Rejection number Re</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

For tightened inspection, the sample size is kept the same, but the acceptance number is decreased. For reduced inspection, both the sample size and the acceptance number are decreased.

7.4.2.2 Critical nonconformities

For critical nonconformities, sampling plans with acceptance number 0 have been selected. The sampling plans are shown in Table 6.
Table 6 – Single sampling plans for critical nonconformities **Ac = 0**

<table>
<thead>
<tr>
<th>Lot sizes for inspection levels</th>
<th>Sample size code letter</th>
<th>Normal inspection</th>
<th>Tightened inspection</th>
<th>Reduced inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sample size n</td>
<td>AQL</td>
<td>Sample size n</td>
<td>AQL</td>
</tr>
<tr>
<td>II 51 to 90</td>
<td>E</td>
<td>13, 1,0</td>
<td>20</td>
<td>8</td>
</tr>
<tr>
<td>91 to 150</td>
<td>F</td>
<td>20, 0,65</td>
<td>32</td>
<td>13</td>
</tr>
<tr>
<td>151 to 280</td>
<td>G</td>
<td>32, 0,40</td>
<td>50</td>
<td>20</td>
</tr>
<tr>
<td>281 to 500</td>
<td>H</td>
<td>50, 0,25</td>
<td>80</td>
<td>32</td>
</tr>
<tr>
<td>501 to 1200</td>
<td>J</td>
<td>80, 0,15</td>
<td>125</td>
<td>50</td>
</tr>
<tr>
<td>1201 to 3200</td>
<td>K</td>
<td>125, 0,1</td>
<td>200</td>
<td>80</td>
</tr>
<tr>
<td>-</td>
<td>L</td>
<td>200, 0,065</td>
<td>315</td>
<td>125</td>
</tr>
</tbody>
</table>

**NOTE 1** The values are taken from Tables 1, 2-A, 2-B and 2-C of ISO 2859-1. If agreed by the responsible authority, higher lot sizes may be applied. The corresponding sampling plans can be selected from the tables referenced.

**NOTE 2** For inspection to **AQL = 1,0** the plans corresponding to sample size code letter **F** and **G** for normal inspection are not available, but they are available with **Ac = 0**.

The sample sizes for normal inspection are the same as for non-critical nonconformities. For tightened inspection, the sample size is increased, for reduced inspection it is decreased by one step.

As it can be seen, the value of AQL demonstrated decreases from the value 1,0 belonging to sample size code letter **E** as the sample size increases, until it reaches a very low value at high sample sizes.

Therefore, these accept zero plans may be used with low sample sizes only upon agreement of the responsible authority. Otherwise, 100 % inspection shall be performed.

### 7.4.3 Double sampling plans

Table 7 contains double sampling plans for non-critical nonconformities with **AQL = 1,0**, indexed by the sample size code letter, for normal, tightened and reduced inspection.
for normal, tightened and reduced inspection, 
AQL = 1,0

<table>
<thead>
<tr>
<th>Lot sizes for inspection levels</th>
<th>Sample size code letter</th>
<th>Sample size n</th>
<th>Cumulative sample size</th>
<th>Normal inspection</th>
<th>Tightened inspection</th>
<th>Reduced inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td>III</td>
<td>Ac</td>
<td>Re</td>
<td>Ac</td>
<td>Re</td>
<td>Ac</td>
</tr>
<tr>
<td>281 to 500</td>
<td>H</td>
<td>1st</td>
<td>32</td>
<td>0</td>
<td>2</td>
<td>δ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2nd</td>
<td>32</td>
<td>1</td>
<td>2</td>
<td>δ</td>
</tr>
<tr>
<td>501 to 1 200</td>
<td>J</td>
<td>1st</td>
<td>50</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2nd</td>
<td>50</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>1 201 to 3 200</td>
<td>K</td>
<td>1st</td>
<td>80</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2nd</td>
<td>80</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>1 201 to 3 200</td>
<td>L</td>
<td>1st</td>
<td>125</td>
<td>2</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2nd</td>
<td>125</td>
<td>3</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

NOTE 1 The values are taken from Tables 1, 3-A, 3-B and 3-C of ISO 2859-1. If agreed by the responsible authority, higher lot sizes may be applied. The corresponding sampling plans can be selected from the tables referenced.

NOTE 2 Sampling plans below code letter H are not available.

NOTE 3 The sample sizes are the same for normal and tightened inspection.

NOTE 4 Ac = Acceptance number
Re = Rejection number

δ Sampling plan not available. Use the first sampling plan below the arrow.

7.4.4 Determination of acceptability

In addition to 5.18, the following applies:

7.4.4.1 Single sampling plans

The number of sample items inspected shall be equal to the sample size given by the plan. If the number of nonconforming items found in the sample is equal to or less than the acceptance number, the lot shall be considered acceptable. If the number of nonconforming items is equal to or greater than the rejection number, the lot shall be considered not acceptable.

Important: The acceptance number refers to items in the sample. If there are several characteristics inspected, it may happen that some items in the sample exhibit several nonconformities. As long as the number of nonconforming items is less than the acceptance number, the lot is acceptable. If nonconformities exhibit themselves on different items, so that the number of nonconforming items exceeds the acceptance number, then the lot is not acceptable.

EXAMPLE

A lot of 400 units is tested for three non-critical characteristics, using inspection level II. The sampling plan, from Table 2, is as follows:

- sample size code letter is H;
- sample size is 50;
If there is only one nonconforming item found, the lot is accepted, even if this item exhibits two or three nonconformities. However, if there are two items found with one nonconformity each, the lot is rejected.

### 7.4.4.2 Double sampling plans

The number of sample items first inspected shall be equal to the first sample size given by the plan. If the number of nonconforming items found in the first sample is equal to or less than the first acceptance number, the lot shall be considered acceptable. If the number of nonconforming items found in the first sample is equal to or greater than the first rejection number, the lot shall be considered not acceptable.

If the number of nonconforming items found in the first sample is between the first acceptance and rejection numbers, a second sample of the size given by the plan shall be inspected. The number of nonconforming items found in the first and second samples shall be accumulated. If the cumulative number of nonconforming items is equal to or less than the second acceptance number, the lot shall be considered acceptable. If the cumulative number of nonconforming items is equal to or greater than the second rejection number, the lot shall be considered not acceptable.

### 7.4.4.3 Curtailment of inspection

As inspection of the items in the sample proceeds, the action to be taken may become more and more evident. It may happen that the decision on accepting or rejecting the lot can be taken before finishing the inspection of all items. If inspection is stopped as soon as the final decision can be predicted with certainty, then the inspection is said to be curtailed.

Although there are obvious costs savings to be gained, this practice would lead to loss of information regarding the process average.

Therefore, curtailed inspection in single sampling is not allowed.

In the case of double sampling, the process average may be estimated by the percent nonconforming in the first sample from each lot or by the overall percent nonconforming in a number of first samples. When double sampling plans are used, it is common practice to curtail sampling in the second sample, as these data are not utilized for the estimation of the process average.

### 7.5 Normal, tightened and reduced inspection (see also 5.12)

#### 7.5.1 Start and continuation of inspection

Normal inspection shall be carried out at the start of inspection, unless otherwise agreed.

Normal, tightened or reduced inspection shall continue unchanged on successive lots, except where the switching procedures require the severity of inspection to be changed. The switching procedures shall be applied to critical and non-critical nonconformities independently.

#### 7.5.2 Normal to tightened

When normal inspection is being carried out, tightened inspection shall be implemented as soon as two out of five (or fewer than five) consecutive lots have been unacceptable on original inspection (that is, ignoring resubmitted lots for this procedure).
NOTE
Tightened inspection is achieved either by increasing the sample size or by reducing the acceptance number, depending on the sampling plan. See the examples shown in 7.4.2.1.

7.5.3 Tightened to normal

When tightened inspection is being carried out, normal inspection shall be re-instated when five consecutive lots have been considered acceptable on original inspection.

7.5.4 Normal to reduced

7.5.4.1 General

When normal inspection is carried out, reduced inspection shall be implemented provided that all of the following conditions are satisfied:

- the current value of the switching score is at least 30;
- production is at a steady rate; and
- reduced inspection is considered desirable by the parties.

7.5.4.2 Switching score

The calculation of the switching score shall be initiated at the start of normal inspection unless otherwise specified by the responsible authority.

The switching score shall be set at zero at the start and updated following the inspection of each subsequent lot on original normal inspection.

a) Single sampling plans:

- when the acceptance number is 2 or more, add 3 to the switching score if the lot would have been accepted if the AQL had been one step higher; otherwise reset the switching score to zero;
  
  NOTE As for the purposes of this standard AQL = 1.0 has been selected, an “AQL of one step higher” means AQL = 0.65.

- when the acceptance number is 0 or 1, add 2 to the switching score if the lot is accepted; otherwise reset the switching score to zero.

b) Double sampling plans:

- when a double sampling plan is used, add 3 to the switching score if the lot is accepted after the first sample; otherwise reset the switching score to zero.

The calculation of switching scores is shown in Table 8.
### Calculation of switching scores

#### Single sampling plans

<table>
<thead>
<tr>
<th>Sample size code letter</th>
<th>Ac and Re for AQL = 1,0</th>
<th>Condition to earn switching score (Ac and Re acc. to AQL = 0,65)</th>
<th>Switching score earned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ac</td>
<td>Re</td>
<td>Ac</td>
<td>Re</td>
</tr>
<tr>
<td>E</td>
<td>0</td>
<td>1</td>
<td>Accept lot</td>
</tr>
<tr>
<td>F</td>
<td>9</td>
<td>Accept lot</td>
<td>2</td>
</tr>
<tr>
<td>G</td>
<td>9</td>
<td>Accept lot</td>
<td>2</td>
</tr>
<tr>
<td>H</td>
<td>1</td>
<td>2</td>
<td>Accept lot</td>
</tr>
<tr>
<td>J</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>K</td>
<td>3</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>L</td>
<td>5</td>
<td>6</td>
<td>3</td>
</tr>
</tbody>
</table>

#### Double sampling plans

<table>
<thead>
<tr>
<th>Double sampling plans</th>
<th>Accept lot after first sample</th>
<th>3</th>
</tr>
</thead>
</table>

**7.5.5 Reduced to normal**

When reduced inspection is being carried out, normal inspection shall be re-instated if any of the following occur on original inspection:

a) a lot is not accepted; or  
b) production becomes irregular or delayed; or  
c) other conditions warrant that normal inspection shall be re-instated.

**7.5.6 Discontinuation and resumption of inspection**

If the cumulative number of lots not accepted in a sequence of consecutive lots on original tightened inspection reaches 5, the acceptance procedures of this Clause 7 shall be discontinued. Sampling inspection shall not be resumed until action has been taken by the supplier to improve the quality of the submitted product and the responsible authority has agreed that this action is likely to be effective. Tightened inspection shall then be used as if 7.5.2 had been invoked.

**7.6 Operating characteristic (OC) curves**

The operating characteristic curves for AQL = 1,0, normal and tightened inspection, shown in Figure 3 and Figure 4, indicate the percentage of lots, which may be expected to be accepted under the given plan. The curves shown are for single sampling plans; curves for double sampling plans are matched as closely as practicable.

Table 9 shows the tabulated values of OC curves, i.e. the quality of submitted product corresponding to selected values of probabilities of acceptance for normal and tightened inspection.
Figure 3 – OC curves for AQL = 1.0, single sampling plans, normal inspection

Figure 4 – OC curves for AQL = 1.0, single sampling plans, tightened inspection
### Table 10 – Tabulated values of OC curves for single sampling, AQL = 1.0 plans

<table>
<thead>
<tr>
<th>Code letter</th>
<th>E</th>
<th>F</th>
<th>H</th>
<th>J</th>
<th>K</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td>P_a (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>99</td>
<td>0.0773</td>
<td>0.0502</td>
<td>0.300</td>
<td>0.550</td>
<td>0.187</td>
<td>0.664</td>
</tr>
<tr>
<td>95</td>
<td>0.394</td>
<td>0.256</td>
<td>0.715</td>
<td>1.03</td>
<td>0.446</td>
<td>1.10</td>
</tr>
<tr>
<td>90</td>
<td>0.807</td>
<td>0.525</td>
<td>1.07</td>
<td>1.39</td>
<td>0.667</td>
<td>1.40</td>
</tr>
<tr>
<td>75</td>
<td>2.19</td>
<td>1.43</td>
<td>1.92</td>
<td>2.16</td>
<td>1.20</td>
<td>2.03</td>
</tr>
<tr>
<td>50</td>
<td>5.19</td>
<td>5.41</td>
<td>3.33</td>
<td>3.33</td>
<td>2.09</td>
<td>2.93</td>
</tr>
<tr>
<td>25</td>
<td>10.1</td>
<td>6.70</td>
<td>5.29</td>
<td>4.84</td>
<td>3.33</td>
<td>4.05</td>
</tr>
<tr>
<td>10</td>
<td>16.2</td>
<td>10.9</td>
<td>7.56</td>
<td>6.52</td>
<td>4.78</td>
<td>5.27</td>
</tr>
<tr>
<td>5</td>
<td>20.6</td>
<td>13.9</td>
<td>9.14</td>
<td>7.66</td>
<td>5.79</td>
<td>6.09</td>
</tr>
<tr>
<td>1</td>
<td>29.8</td>
<td>20.6</td>
<td>12.6</td>
<td>10.1</td>
<td>8.01</td>
<td>7.81</td>
</tr>
</tbody>
</table>

#### NOTE
The values are taken from Tables 10-E, 10-F, 10-H, 10-J, 10-K and 10-L of ISO 2859-1.

Figure 5 shows the OC curves for Ac = 0, normal inspection, single sampling plans, and Table 10 shows the tabulated values.
### Table 10 – Tabulated values of OC curves for single sampling, normal inspection, accept zero sampling plans

<table>
<thead>
<tr>
<th>Sample size code letter</th>
<th>AQL</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>J</th>
<th>K</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1,0</td>
<td>0,65</td>
<td>0,40</td>
<td>0,25</td>
<td>0,15</td>
<td>0,10</td>
<td>0,065</td>
<td></td>
</tr>
<tr>
<td>$\bar{p}_r$ (in percent nonconforming)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>99</td>
<td>0,0773</td>
<td>0,0502</td>
<td>0,0314</td>
<td>0,0201</td>
<td>0,0126</td>
<td>0,00804</td>
<td>0,00503</td>
<td></td>
</tr>
<tr>
<td>95</td>
<td>0,394</td>
<td>0,256</td>
<td>0,160</td>
<td>0,103</td>
<td>0,0641</td>
<td>0,0410</td>
<td>0,0256</td>
<td></td>
</tr>
<tr>
<td>90</td>
<td>0,807</td>
<td>0,525</td>
<td>0,329</td>
<td>0,210</td>
<td>0,132</td>
<td>0,0843</td>
<td>0,0527</td>
<td></td>
</tr>
<tr>
<td>75</td>
<td>2,19</td>
<td>1,43</td>
<td>0,895</td>
<td>0,574</td>
<td>0,359</td>
<td>0,230</td>
<td>0,144</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>5,19</td>
<td>3,41</td>
<td>2,14</td>
<td>1,38</td>
<td>0,863</td>
<td>0,553</td>
<td>0,346</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>10,1</td>
<td>6,70</td>
<td>4,24</td>
<td>2,73</td>
<td>1,72</td>
<td>1,10</td>
<td>0,691</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>16,2</td>
<td>10,9</td>
<td>6,94</td>
<td>4,50</td>
<td>2,84</td>
<td>1,83</td>
<td>1,14</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>20,6</td>
<td>13,9</td>
<td>8,94</td>
<td>5,82</td>
<td>3,68</td>
<td>2,37</td>
<td>1,49</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>29,8</td>
<td>20,6</td>
<td>13,4</td>
<td>8,80</td>
<td>5,59</td>
<td>3,62</td>
<td>2,28</td>
<td></td>
</tr>
</tbody>
</table>

NOTE: The values are taken from Tables 10-E to 10-L of ISO 2859-1.

7.7 Process average

The process average can be estimated by the average percent nonconforming found in the samples of product submitted by the manufacturer for original inspection, provided that inspection was not curtailed. When double or multiple sampling is used, only first sample results shall be included in the process average estimation.

7.8 Average outgoing quality (AOQ)

The average outgoing quality is the long-term average quality of outgoing product for a given value of incoming product quality, including all accepted lots, plus all lots which are not accepted, after such lots have been effectively 100 % inspected and all nonconforming items replaced by conforming items.

7.9 Average outgoing quality limit (AOQL)

The AOQL is the maximum of the average outgoing qualities for all possible qualities submitted for a given acceptance sampling plan. AOQL values are given in Table 11 for AQL = 1,0, single sampling plans for normal inspection and tightened inspection for and in Table 12 for Ac = 0 sampling plans.

NOTE: For a detailed explanation of the concept of AOQL see ISO/TR 8550-1, 8.7.
### Table 11 – Average Outgoing Quality Limit (AOQL) at AQL = 1,0

<table>
<thead>
<tr>
<th>Lot sizes for inspection levels</th>
<th>Sample size code letter</th>
<th>Sample size ( n )</th>
<th>AOQL percent nonconforming</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>51 to 90</td>
<td>-</td>
<td>E</td>
<td>13</td>
</tr>
<tr>
<td>91 to 150</td>
<td>51 to 90</td>
<td>F</td>
<td>20</td>
</tr>
<tr>
<td>151 to 280</td>
<td>91 to 150</td>
<td>G</td>
<td>32</td>
</tr>
<tr>
<td>281 to 500</td>
<td>151 to 280</td>
<td>H</td>
<td>50</td>
</tr>
<tr>
<td>501 to 1 200</td>
<td>281 to 500</td>
<td>J</td>
<td>80</td>
</tr>
<tr>
<td>1 201 to 3 200</td>
<td>501 to 1 200</td>
<td>K</td>
<td>125</td>
</tr>
<tr>
<td>-</td>
<td>1 201 to 3 200</td>
<td>L</td>
<td>200</td>
</tr>
</tbody>
</table>

**NOTE** The values of this table are taken from Table 8-A and 8-B of ISO 2859-1.

### Table 12 – Average Outgoing Quality Limit (AOQL) for Ac = 0 sampling plans, normal inspection

<table>
<thead>
<tr>
<th>Lot sizes for inspection levels</th>
<th>Sample size code letter</th>
<th>Sample size ( n )</th>
<th>AOQL percent nonconforming</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>51 to 90</td>
<td>-</td>
<td>E</td>
<td>13</td>
</tr>
<tr>
<td>91 to 150</td>
<td>51 to 90</td>
<td>F</td>
<td>20</td>
</tr>
<tr>
<td>151 to 280</td>
<td>91 to 150</td>
<td>G</td>
<td>32</td>
</tr>
<tr>
<td>281 to 500</td>
<td>151 to 280</td>
<td>H</td>
<td>50</td>
</tr>
<tr>
<td>501 to 1 200</td>
<td>281 to 500</td>
<td>J</td>
<td>80</td>
</tr>
<tr>
<td>1 201 to 3 200</td>
<td>501 to 1 200</td>
<td>K</td>
<td>125</td>
</tr>
<tr>
<td>-</td>
<td>1 201 to 3 200</td>
<td>L</td>
<td>200</td>
</tr>
</tbody>
</table>

**NOTE** The values of this table are taken from Table 8-A of ISO 2859-1.

### 7.10 Consumer’s risk (CR)

If the series of lots is not long enough to allow the switching rules to be applied, it may be desirable to limit the selection of sampling plans to those that give consumer’s risk quality not more than a specified limiting quality protection. Sampling plans for this purpose can be selected by choosing a consumer’s risk quality (CRQ) and a consumer’s risk (probability of lot acceptance) to be associated with it.

Table 13 gives the values of consumer’s risk quality (CRQ) for sampling plans with AQL = 1,0 for a consumer’s risk of 10 % and 5 % respectively. For individual lots with quality levels less than or equal to the tabulated values, the probabilities of lot acceptance are equal to or less than 10 % or 5 % respectively. When there is a reason for protecting against a specified limiting quality in a lot, these tables may be useful for fixing minimum sample sizes to be associated with the AQL and inspection level specified for inspection of the series of lots.

**EXAMPLE**

The responsible authority specifies that the consumer’s risk shall be not more than 5 % if the quality is 7 % nonconforming. This gives the following minimum lot sizes and inspection levels:

- lot size 1 201 – 3 200 with inspection level II, code letter K;
lot size 501–1200 with inspection level III, code letter K.
Table 13 – Consumer’s risk quality (CRQ): AQL = 1.0 plans

<table>
<thead>
<tr>
<th>Lot sizes for inspection levels</th>
<th>Sample size code letter</th>
<th>CRQ percent nonconforming</th>
<th>Sample size n, normal and tightened</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td>III</td>
<td>CRQ percent nonconforming</td>
<td>Sample size n, normal and tightened</td>
</tr>
<tr>
<td>51 to 90</td>
<td>-</td>
<td>E 13</td>
<td>16,2</td>
</tr>
<tr>
<td>91 to 90</td>
<td>F</td>
<td>20</td>
<td>-</td>
</tr>
<tr>
<td>151 to 280</td>
<td>G</td>
<td>32</td>
<td>-</td>
</tr>
<tr>
<td>281 to 500</td>
<td>H</td>
<td>50</td>
<td>7,56</td>
</tr>
<tr>
<td>501 to 1 200</td>
<td>J</td>
<td>80</td>
<td>6,52</td>
</tr>
<tr>
<td>1 201 to 3 200</td>
<td>K</td>
<td>125</td>
<td>5,27</td>
</tr>
<tr>
<td>1 201 to 3 200</td>
<td>L</td>
<td>200</td>
<td>4,59</td>
</tr>
</tbody>
</table>

NOTE 1: The values are taken from Tables 6-A, 6-B, 6-C, and 10-C to 10-L of ISO 2859-1.

NOTE 2: The sample sizes are the same for normal and tightened inspection.

Table 14 gives the values of consumer’s risk quality (CRQ) for sampling plans with Ac = 0 for a consumer’s risk of 10 % (CRQ10) and 5 % (CRQ5) respectively.

Table 14 – Consumer’s risk quality (CRQ): Accept zero plans

<table>
<thead>
<tr>
<th>Lot sizes for inspection levels</th>
<th>Sample size code letter</th>
<th>CRQ percent nonconforming</th>
<th>Sample size n, normal and tightened</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td>III</td>
<td>CRQ percent nonconforming</td>
<td>Sample size n, normal and tightened</td>
</tr>
<tr>
<td>51 to 90</td>
<td>-</td>
<td>E 13</td>
<td>16,2</td>
</tr>
<tr>
<td>91 to 90</td>
<td>F</td>
<td>20</td>
<td>10,9</td>
</tr>
<tr>
<td>151 to 280</td>
<td>G</td>
<td>32</td>
<td>6,94</td>
</tr>
<tr>
<td>281 to 500</td>
<td>H</td>
<td>50</td>
<td>4,50</td>
</tr>
<tr>
<td>501 to 1 200</td>
<td>J</td>
<td>80</td>
<td>2,84</td>
</tr>
<tr>
<td>1 201 to 3 200</td>
<td>K</td>
<td>125</td>
<td>1,83</td>
</tr>
<tr>
<td>1 201 to 3 200</td>
<td>L</td>
<td>200</td>
<td>1,14</td>
</tr>
</tbody>
</table>

NOTE: The values are taken from Tables 6-A, 6-B, 6-C and 10-D to 10-L of ISO 2859-1.
Clause 8 gives details of the procedure for selecting sampling plans for lots in isolation.

### 7.11 Producer’s risk (PR)

Table 15 gives the probability of rejection for lots of AQL quality (producer’s risk, PR) on normal, tightened and reduced inspection respectively.

#### Table 15 – Producer’s risk (PR): AQL = 1,0

<table>
<thead>
<tr>
<th>Lot sizes for inspection levels</th>
<th>Sample size code letter</th>
<th>Normal inspection</th>
<th>Tightened inspection</th>
<th>Reduced inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td>II</td>
<td>Sample size n</td>
<td>PR %</td>
<td>Sample size n</td>
</tr>
<tr>
<td>51 to 90</td>
<td>-</td>
<td>E</td>
<td>13</td>
<td>12,2</td>
</tr>
<tr>
<td>91 to 150</td>
<td>51 to 90</td>
<td>F</td>
<td>20</td>
<td>-</td>
</tr>
<tr>
<td>151 to 280</td>
<td>91 to 150</td>
<td>G</td>
<td>32</td>
<td>-</td>
</tr>
<tr>
<td>281 to 500</td>
<td>151 to 280</td>
<td>H</td>
<td>50</td>
<td>8,94</td>
</tr>
<tr>
<td>501 to 1 200</td>
<td>281 to 500</td>
<td>J</td>
<td>80</td>
<td>4,66</td>
</tr>
<tr>
<td>1 201 to 3 200</td>
<td>501 to 1 200</td>
<td>K</td>
<td>125</td>
<td>3,74</td>
</tr>
<tr>
<td>-</td>
<td>1 201 to 3 200</td>
<td>L</td>
<td>200</td>
<td>1,60</td>
</tr>
</tbody>
</table>

**NOTE** The values are taken from Tables 5-A, 5-B and 5-C of ISO 2859-1.

Table 16 gives the probability of rejection of lots of AQL quality (producer’s risk) for accept zero plans on normal, tightened and reduced inspection respectively.

#### Table 16 – Producer’s risk (PR): Accept zero plans

<table>
<thead>
<tr>
<th>Lot sizes for inspection levels</th>
<th>Sample size code letter</th>
<th>Normal inspection</th>
<th>Tightened inspection</th>
<th>Reduced inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td>II</td>
<td>Sample size n</td>
<td>PR %</td>
<td>Sample size n</td>
</tr>
<tr>
<td>51 to 90</td>
<td>-</td>
<td>E</td>
<td>13</td>
<td>12,2</td>
</tr>
<tr>
<td>91 to 150</td>
<td>51 to 90</td>
<td>F</td>
<td>20</td>
<td>12,2</td>
</tr>
<tr>
<td>151 to 280</td>
<td>91 to 150</td>
<td>G</td>
<td>32</td>
<td>12,0</td>
</tr>
<tr>
<td>281 to 500</td>
<td>151 to 280</td>
<td>H</td>
<td>50</td>
<td>11,8</td>
</tr>
<tr>
<td>501 to 1 200</td>
<td>281 to 500</td>
<td>J</td>
<td>80</td>
<td>11,3</td>
</tr>
<tr>
<td>1 201 to 3 200</td>
<td>501 to 1 200</td>
<td>K</td>
<td>125</td>
<td>11,8</td>
</tr>
<tr>
<td>-</td>
<td>1 201 to 3 200</td>
<td>L</td>
<td>200</td>
<td>12,2</td>
</tr>
</tbody>
</table>

**NOTE** The values are taken from Tables 5-A, 5-B and 5-C of ISO 2859-1.
8.1 Application of the method

Sampling schemes for isolated lot inspection by attributes described here are based on ISO 2859-2.

The procedures specified here can be applied when the switching rules given in 7.5 are not applicable; for example, when the lots are of an isolated nature.

Whereas with lot-by-lot inspection customer protection is achieved by applying a sampling scheme ensuring that the process quality is kept below AQL, with isolated inspection it is achieved by applying sampling plans ensuring that the probability of accepting a lot with a quality equal to the Limiting Quality is very low (usually below 10%).

8.2 Procedures specified

8.2.1 Procedure A

Procedure A is to be used, when the manufacturer and the customer both wish to regard the lot in isolation. The sampling plans are based on random sampling from finite lots for both manufacturer and customer risk. If accept zero plans are required – as in the case of critical nonconformities – only this procedure can be used.

8.2.2 Procedure B

Procedure B is to be used when the manufacturer regards the lot as one of a continuing series, but the customer considers the lot received in isolation. The manufacturer will be concerned with all of its production, but the individual customer only with the particular lot received. The sampling plans are based on random sampling from finite lots 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 OC curves.

Wherever possible, the plans used are a selection of the plans available in Clause 7, so that a producer can maintain consistent procedures for customers whether or not they receive individual lots or a continuing series of lots.

Accept zero plans are not available. Therefore, for critical nonconformities, 100 % inspection has to be applied. For small lots, procedure B also requires 100 % inspection.

8.3 Limiting quality

For non-critical nonconformities, the limiting quality value shall be LQ = 5.0.

8.4 Procedure A

The sampling plans are given in Table 17. Each cell in the rightmost column of the table shows the consumer’s risk (PLQ) and the producer’s risk point \((p, P_a)\).

The following small table identifies the contents of the sampling plan cells in Table 17 and Table 18.
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SASO IEC
62058
11/2010

<table>
<thead>
<tr>
<th>Sample size / Acceptance number Ac (n/Ac)</th>
<th>Probability of acceptance ( P_a ) at the limiting quality (PLQ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent nonconforming ( (p) )</td>
<td>Probability of acceptance ( (P_a) ) at quality ( (p) )</td>
</tr>
</tbody>
</table>

*The stated probability of acceptance is the maximum for lots of limiting quality in the size range and the minimum for lots with percent nonconforming \( p \). The producer’s risk is \( (p, P_a) \), the consumer’s risk point is \( (LQ, PLQ) \).

### Table 17 – Sampling plans for non-critical nonconformities, procedure A, LQ = 5,0

<table>
<thead>
<tr>
<th>Lot size</th>
<th>LQ</th>
<th>Sampling plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>51 to 90</td>
<td>34/0</td>
<td>0,103</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1,0</td>
</tr>
<tr>
<td>91 to 150</td>
<td>38/0</td>
<td>0,103</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1,0</td>
</tr>
<tr>
<td>151 to 280</td>
<td>42/0</td>
<td>0,097</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1,0</td>
</tr>
<tr>
<td>281 to 500</td>
<td>50/0</td>
<td>0,067</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1,0</td>
</tr>
<tr>
<td>501 to 1,200</td>
<td>80/1</td>
<td>0,079</td>
</tr>
<tr>
<td></td>
<td>0,417</td>
<td>0,96</td>
</tr>
<tr>
<td>1,201 to 3,200</td>
<td>125/3</td>
<td>0,119</td>
</tr>
<tr>
<td></td>
<td>1,13</td>
<td>0,95</td>
</tr>
</tbody>
</table>

**NOTE** The values are taken from Table D1 of ISO 2859-2. If agreed by the responsible authority, higher lot sizes may be applied. The corresponding sampling plans can be selected from the tables referenced.

**EXAMPLE**

A lot consisting of 200 items is inspected for non-critical nonconformities.

- The sampling plan is: sample size \( n = 42 \), \( Ac = 0 \).
- The probability of acceptance at \( LQ = 5,0 \) is 9.7 %.
- If the percent nonconforming is 0 %, then the probability of acceptance is 100 %.
<table>
<thead>
<tr>
<th>Lot size</th>
<th>LQ</th>
<th>Sampling plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>51 to 90</td>
<td>5.0</td>
<td>34/0,103</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1,0</td>
</tr>
<tr>
<td>91 to 150</td>
<td>5.0</td>
<td>38/0,103</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1,0</td>
</tr>
<tr>
<td>151 to 280</td>
<td>5.0</td>
<td>42/0,097</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1,0</td>
</tr>
<tr>
<td>281 to 500</td>
<td>3.15</td>
<td>80/0,061</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1,0</td>
</tr>
<tr>
<td>501 to 1200</td>
<td>2.0</td>
<td>125/0,069</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1,0</td>
</tr>
<tr>
<td>1201 to 3200</td>
<td>1.25</td>
<td>200/0,074</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1,0</td>
</tr>
</tbody>
</table>

NOTE The values are taken from Table D1 of ISO 2859-2. If agreed by the responsible authority, higher lot sizes may be applied. The corresponding sampling plans can be selected from the tables referenced.

The probability of acceptance of relatively good lots by accept zero plans is given in Table 19. If a sample size of \( n \) is drawn from a lot containing \( R \) nonconforming items, the probability of acceptance for the lot \( (P_a) \) is shown for the minimum and maximum lot sizes in the lot size range and for the various sampling plans \( "n / 0" \).

Table 19 – Probability of acceptance for accept zero plans

<table>
<thead>
<tr>
<th>Limiting quality (LQ)</th>
<th>5.0</th>
<th>5.0</th>
<th>3.15</th>
<th>2.0</th>
<th>1.25</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>34/0</td>
<td>38/0</td>
<td>42/0</td>
<td>281</td>
<td>500</td>
</tr>
<tr>
<td>Sampling plan ( n / 0 )</td>
<td>51</td>
<td>90</td>
<td>91</td>
<td>150</td>
<td>280</td>
</tr>
<tr>
<td>( R ) ( P_a ) ( P_0 ) ( P_1 )</td>
<td>501</td>
<td>1200</td>
<td>1201</td>
<td>3200</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>1</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>2</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>3</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>4</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>5</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>6</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>7</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

NOTE The values are taken from Table D2 of ISO 2859-2.
A lot consisting of 150 items is inspected for critical nonconformities.

- the sampling plan is sample size 38, $Ac = 0$;
- if there is 1 nonconforming item, the probability of acceptance is 75%.

### 8.5 Procedure B

Whereas in the procedures specified in Clause 7, increased inspection level with resulting increased sample size corresponds to greater protection for the customer, in isolated lot inspection consumer protection is provided by the limiting quality. The effect of increasing sample size is to permit the supplier greater latitude in the permitted process average. 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 the interest of 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 the sampling costs, then greater inspection levels are not necessarily advantageous.

For these reasons, two different inspection levels and two different equivalent AQL values are given in Table 20. The sample size code letter and the tabulated values of the OC curves are also given.
Single sampling plans for non-critical nonconformities, procedure B, LQ = 5,0

<table>
<thead>
<tr>
<th>AQL</th>
<th>n</th>
<th>Ac</th>
<th>0.95</th>
<th>0.90</th>
<th>0.50</th>
<th>0.10</th>
<th>0.05</th>
<th>Max.</th>
<th>Min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>65</td>
<td>80</td>
<td>1</td>
<td>0.444</td>
<td>0.666</td>
<td>2.09</td>
<td>4.78</td>
<td>5.80</td>
<td>0.086</td>
<td>0.000</td>
</tr>
<tr>
<td>1.0</td>
<td>125</td>
<td>3</td>
<td>1.09</td>
<td>1.40</td>
<td>2.94</td>
<td>5.35</td>
<td>6.20</td>
<td>0.124</td>
<td>0.092</td>
</tr>
<tr>
<td>1.0</td>
<td>200</td>
<td>5</td>
<td>1.31</td>
<td>1.58</td>
<td>2.84</td>
<td>4.64</td>
<td>5.26</td>
<td>0.062</td>
<td>0.048</td>
</tr>
</tbody>
</table>

NOTE The values are taken from Table B6 of ISO 2859-2. If agreed by the responsible authority, higher lot sizes may be applied. The corresponding sampling plans can be selected from the tables referenced.

* The exact acceptance probabilities vary with the lot size, the maximum and minimum values attained for permitted lot sizes are given for each plan.

Figure 6 – Operating characteristic curves for single sampling plans for non-critical nonconformities, procedure B

IEC 1511/08
The lot size is 800, the process average is 1.5%. If inspection level II is chosen, the sampling plan is code letter J, \( n = 80 \), Ac = 1. With this plan, the probability of acceptance is only 64%. With inspection level III, the sampling plan is code letter K, \( n = 125 \), Ac = 3. The probability of acceptance increases to 87%. If the lot size is increased to 1 600, and inspection level III is chosen, the sampling plan is code letter L, \( n = 200 \), Ac = 5. The probability of acceptance increases to 92%. In all three cases, the limiting quality value is the same.

The sampling plans for double sampling are given in Table 21 and Table 22.

### Table 21 – Equivalent sample sizes for single and double sampling

| Type of sampling plan | Sample size code letter \(^a\) and cumulative sample sizes in accordance with Clause 7 |
|-----------------------|-------------------------------------------------------------------------------------------------
|                       | J  | K  | L  |
| Single                | 80 | 125 | 200 |
| Double \(^1\)st       | 50 | 80  | 125 |
| Double \(^2\)nd       | 100 | 160 | 250 |

NOTE The values are taken from Table D3 of ISO 2859-2.

\(^a\) For double sampling plans, the tabulated entries are the cumulative sample sizes. In each case, the second stage of sampling takes a fresh sample equal in size to that taken in the first stage. This sample is aggregated with the samples from previous stages and the combined sample is then tested by the criterion in Table 22.

### Table 22 – Equivalent acceptance numbers for single and double sampling

<table>
<thead>
<tr>
<th>Type of sampling plan</th>
<th>Approximate relative sample sizes at each stage(^a)</th>
<th>Acceptance number codes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Single</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Double (^1)st</td>
<td>0.63</td>
<td>0</td>
</tr>
<tr>
<td>Double (^2)nd</td>
<td>0.63</td>
<td>1</td>
</tr>
<tr>
<td>Discrimination ratio</td>
<td>10.9</td>
<td>4.89</td>
</tr>
<tr>
<td>Probability of acceptance at AQL (Procedure B)</td>
<td>0.91</td>
<td>0.96</td>
</tr>
</tbody>
</table>

NOTE The values are taken from Table D4 of ISO 2859-2.

\(^a\) These relative samples are approximate only. The exact values are given in Table 21.

### 8.6 Rules for acceptance and non-acceptance

In addition to 5.18, the following applies:

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

The procedures described here are based on ISO 2859-3 and shall be used together with the procedures described in Clause 7.

These procedures are intended only for a continuing series of lots and shall not be used for isolated lots. All lots in the series are expected to be of a similar quality and there should be reason to believe that the lots not inspected are of the same quality as those inspected.

These procedures are to be used only for characteristics inspected by attributes as designated in Clause 7.

The skip-lot procedures can only be implemented if the procedures specified in Clause 7 are in use on normal or reduced inspection, or a combination of normal and reduced inspection at general inspection at inspection levels II or III.

Double sampling plans may only be used during the qualification phase associated with normal inspection. It is strongly recommended that single sampling plans with an acceptance number of zero not be used. Skip-lot inspection may be used in the place of reduced inspection if it is more cost-effective.

It is essential that skip-lot procedures are not applied to the inspection of critical product characteristics.

9.2 Manufacturer qualification

The requirements for supplier qualification are as follows:

- the supplier shall have implemented and maintained a documented system for controlling product quality and design changes. It is assumed that the system includes inspection by the supplier of each lot produced and the recording of inspection results;
- the supplier shall have instituted a system that is capable of detecting and correcting shifts in quality levels and monitoring process changes that may adversely affect quality. The supplier's personnel responsible for the application of the system shall demonstrate a clear understanding of the applicable standards, systems and procedures to be followed;
- the supplier shall not have experienced any change that might adversely affect quality.

9.3 Product qualification

Generic requirements for the product qualification are as follows:

- the product shall be of stable design;
- the product shall not have any critical classes of nonconforming items or nonconformities;

NOTE If the product has critical nonconformities, the procedures described here should be applicable only for the non-critical nonconformities.

- the product shall have been on normal or reduced inspection or a combination of normal and reduced inspection (see Clause 7) during the qualification period. A product that has been on tightened inspection at any time during the qualification period is ineligible for skip-lot inspection;
- the product shall have been produced on an essentially continuous basis for a specified production period at a specified production frequency.

Both the minimum production period and the minimum production frequency should be specified, based on the agreement between the supplier and the responsible authority.
If no minimum production period is specified, the period shall be 6 months. Whenever production is held pending sample approval, only the time period after approval and resumption of production shall be included.

If no minimum production frequency is specified, the minimum production frequency shall be once per month, or at least one lot shall be submitted each month.

Products of a similar nature shipped to other parties may be considered in the determination of "essentially continuous", if agreed to by both the supplier and the responsible authority:

- the product quality shall have been maintained at the AQL or better for a period of stability mutually agreed to by both the supplier and the responsible authority. If no period is specified, the period shall be 6 months.

9.4 Detailed procedures

Further details for qualification for skip-lot inspection, determining the skip-lot frequency (from 1 in 2 to 1 in 6), lot selection, interrupt, re-qualification and disqualification procedures are described in ISO 2859-3.

10 Lot-by-lot inspection by variables

10.1 Application of the method

Inspection by variables described here is based on ISO 3951-2, designed primarily for use under the following conditions:

- where the inspection procedure is to be applied to a continuing series of lots of discrete products all supplied by one producer using one production process. If there are different producers or production processes, apply these procedures to each one separately;
- where the quality characteristics of the items of product are measurable on a continuous scale;
- where the measurement error is negligible (i.e. with a standard deviation no more than 10 % of the corresponding process standard deviation);
- where production is stable (under statistical control) and the quality characteristics are distributed, at least to a close approximation, according to normal distributions;
- where, in the case of multiple quality characteristics, the characteristics are independent of one another, at least approximately;
- where a contract or standard defines both an upper specification limit $U$, and a lower specification limit $L$ on each of the quality characteristics and nonconformity beyond both limits is equally important (combined control).

The procedures selected from ISO 3951-2 are the following:

- standard multivariate “s” method procedures for independent quality characteristics;
- standard multivariate “σ” method procedures for independent quality characteristics.

NOTE If justified, other procedures, inspection levels and AQL values available in ISO 3951-2 may be selected.

10.2 Choice between the “s” and the “σ” methods

The “σ” method is the most economical in terms of sample size but, before this method may be employed, the value of $σ$ has to be established.

Initially, it will be necessary to begin with the “s” method but, subject to the agreement of the responsible authority and provided the quality remains satisfactory, the standard switching rules will permit a switch to reduced inspection and the use of a smaller sample size.
under control and lots continue to be accepted, will it be economical to change to the \( \sigma \) method? Table 23 may help in the decision.
10.3 Standard plans

The standard procedure can be used only when the production of lots is continuing.

This standard procedure, with its semi-automatic steps from lot size to sample size, using inspection level II and beginning with the “s” method, has been found in practice to produce workable sampling schemes; but it rests on the assumption that the order of priority is first the AQL, second the sample size, and last, the limiting quality.

NOTE 1 Inspection level III may be used to obtain better selectivity.

The acceptability of this system is due to the fact that the consumer is protected by the switching rules (see 10.10, 10.11 and 10.12), which quickly increase the severity of inspection and finally terminate inspection altogether if the quality of the process remains worse than the AQL.

NOTE 2 It is pointed out that the limiting quality is the quality, which, if offered for inspection, would have a 10 % probability of acceptance. The actual risk taken by the consumer varies according to the probability that goods of such a low quality are offered for inspection.

10.4 Preliminary operations

Before starting inspection by variables,

a) Check that production is considered to be continuing and that the distribution of the quality characteristics can be considered to be normal and independent.

NOTE 1 For tests for departure from normality, see ISO 5479.

NOTE 2 If lots have been screened for nonconforming items prior to acceptance sampling, then the distribution will have been truncated and inspection by variables will not be applicable.

b) Check whether the “s” method is to be used initially or whether the process standard deviation is stable and known, in which case the “σ” method should be used.

10.5 Standard multivariate “s” method procedures for independent quality characteristics with combined control

10.5.1 General methodology

The general methodology for dealing with \( m \) independent quality characteristics \( x_1, x_2, \ldots, x_m \) is as follows. Denoting the estimated process fraction nonconforming for the \( i^{th} \) quality characteristic by \( \hat{F}_i \), the estimated process fraction nonconforming is given by
\( - \bar{E}_1 (1 - \bar{E}_2) \ldots (1 - \bar{E}_m) \)

i.e. one minus the product of the estimated process fractions conforming.

and where \( \bar{E}_i = \bar{E}_{Li} + \bar{E}_{Mi} \)

with

\[
\bar{E}_L = B_{(n-2)/2} \left[ \frac{1}{2} \left( 1 - \frac{\bar{x} - L}{s} \frac{\sqrt{n}}{n-1} \right) \right],
\]

\[
\bar{E}_U = B_{(n-2)/2} \left[ \frac{1}{2} \left( 1 - \frac{U - \bar{x}}{s} \frac{\sqrt{n}}{n-1} \right) \right],
\]

in which \( B_{(n-2)/2} \ldots \) represents the distribution function of the symmetric beta distribution with both parameters being equal to \( (n-2)/2 \).

For details, see K.2.1 of ISO 3951-2.

Values of the distribution function of the symmetric beta distribution can be obtained from tables or by using computer programs. Alternatively, an approximate procedure and simplified exact formulas are available. These are described in 10.5.4 and 10.5.5.

If \( \bar{E}_1, \bar{E}_2, \ldots, \bar{E}_m \) are all small, say no greater than 0.01, then \( \bar{E} \) is approximately equal to the sum of the individual estimates, i.e. \( \bar{E} \approx \bar{E}_1 + \bar{E}_2 + \ldots + \bar{E}_m \).

The lot is accepted if

\[ \bar{E} \leq p^* \]

and not accepted otherwise, where \( p^* \) is the Form \( p^* \) acceptability constant given in Table 24 for the applicable sample size code letter and normal inspection, tightened inspection or reduced inspection as appropriate.

10.5.2 Sampling plans

The sampling plans, the values of the standardized MSSD \( f_i \), and the acceptability constants \( p^* \) can be obtained from Table 24.
### Table 24 - Sampling plans for the “s” method

<table>
<thead>
<tr>
<th>Lot sizes for</th>
<th>Sample size code letter</th>
<th>Sample size $n$ normal and tightened</th>
<th>Normal inspection</th>
<th>Tightened inspection</th>
<th>Reduced inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td>III</td>
<td></td>
<td>$f_i$</td>
<td>100 $p^*$</td>
<td>$f_i$</td>
</tr>
<tr>
<td>51 to 90</td>
<td>-</td>
<td>E</td>
<td>9</td>
<td>0.274</td>
<td>4,196</td>
</tr>
<tr>
<td>91 to 150</td>
<td>51 to 90</td>
<td>F</td>
<td>13</td>
<td>0.257</td>
<td>3,605</td>
</tr>
<tr>
<td>151 to 280</td>
<td>91 to 150</td>
<td>G</td>
<td>18</td>
<td>0.248</td>
<td>3,323</td>
</tr>
<tr>
<td>281 to 500</td>
<td>151 to 280</td>
<td>H</td>
<td>25</td>
<td>0.240</td>
<td>3,010</td>
</tr>
<tr>
<td>501 to 1,200</td>
<td>281 to 500</td>
<td>J</td>
<td>35</td>
<td>0.235</td>
<td>2,880</td>
</tr>
<tr>
<td>1,201 to 3,200</td>
<td>501 to 1,200</td>
<td>K</td>
<td>50</td>
<td>0.232</td>
<td>2,800</td>
</tr>
<tr>
<td>-</td>
<td>1,201 to 3,200</td>
<td>L</td>
<td>70</td>
<td>0.230</td>
<td>2,725</td>
</tr>
</tbody>
</table>

**NOTE 1** The values are taken from Tables A.1, A.2, D.1, D.2, D.3, G.1, G.2 and G.3 of ISO 3951-2. If agreed by the responsible authority, higher lot sizes may be applied. The corresponding sampling plans can be selected from the tables referenced.

**NOTE 2** The symbol $\delta$ means that there is no suitable plan in this area; use the first sampling plan below the arrow.

**NOTE 3** The MSSD is obtained by multiplying the standardized MSSD $f_i$ by the difference between the upper specification limit $U$ and the lower specification limit $L$, i.e. $\text{MSSD} = s_{\text{max}} = (U - L) f_i$.

The above MSSDs indicate the greatest allowable magnitudes of the sample standard deviation under normal, tightened or reduced inspection when using plans for combined control of double specification limits when the process variability is unknown. If the sample standard deviation is less than the MSSD, then there is a possibility, but not a certainty, that the lot will be accepted.

### 10.5.3 Description of the procedure

Take a random sample of size $n$, measure the characteristic $x_i$, and then calculate $\bar{x}_i$, the sample mean, and $s_i$, the estimate of the process standard deviation. For calculation of $\bar{x}$ and $s$ see Annex B.

Following this, find the value of $f_i$ from Table 24.

With this, for each characteristic, calculate the value of MSSD:

$$\text{MSSD}_i = s_{\text{max}} = (U_i - L_i) f_i$$

Then compare $s_i$ with $s_{\text{max}}$. If $s_i$ is greater than $s_{\text{max}}$, then the lot may be rejected without further calculation.

Otherwise, for each characteristic, calculate the quality statistics:

$$Q_{ui} = \frac{U_i - \bar{x}_i}{s_i}$$

and
Calculate \( \hat{p} \) as described in 10.5.1.

If \( \hat{p} \) does not exceed the maximum allowable value \( p^* \) given in Table 24, the lot is considered to be acceptable, otherwise, the lot is considered to be not acceptable.

### 10.5.4 Simplified exact formula for the “s” method with sample size 4

As described in ISO 3951-2, Clause K.5, a simplified formula is available in this case.

Calculate

\[
\tilde{E}_{L_i} = \begin{cases} 
0 & \text{if } Q_{L_i} > 1.5 \\
0.5 - Q_{L_i}/3 & \text{if } -1.5 \leq Q_{L_i} \leq 1.5 \\
1 & \text{if } Q_{L_i} < -1.5
\end{cases}
\]

and

\[
\tilde{E}_{U_i} = \begin{cases} 
0 & \text{if } Q_{U_i} > 1.5 \\
0.5 - Q_{U_i}/3 & \text{if } -1.5 \leq Q_{U_i} \leq 1.5 \\
1 & \text{if } Q_{U_i} < -1.5
\end{cases}
\]

Add the two estimates to obtain \( \hat{p} = \hat{p}_{L_i} + \hat{p}_{U_i} \) then calculate

\[
\hat{p} = 1 - (1 - \hat{p}_1)(1 - \hat{p}_2)\ldots(1 - \hat{p}_m)
\]

If \( \hat{p} \) does not exceed the maximum allowable value \( p^* \) given in Table 24, the lot is considered to be acceptable, otherwise, the lot is considered to be not acceptable.

### 10.5.5 Approximate procedure for the “s” method for \( n \geq 5 \)

This method is described in ISO 3951-2 Clause K.3 as follows:

For each characteristic, using the value of \( Q_{U_i} \), calculate

\[
x_{U_i} = \frac{1}{2} \left[ 1 - Q_{U_i} \sqrt{n} / (n - 1) \right]
\]

If \( x_{U_i} \leq 0 \) then \( \hat{p}_{U_i} = 0 \); if \( x_{U_i} \geq 1 \) then \( \hat{p}_{U_i} = 1 \).

NOTE ISO 3951-2:2006 is being amended to add this missing step above.

Otherwise, using the value of \( x_{U_i} \), calculate
\[ w_U = y_U^2 - 3 \]

if \( w_U \geq 0 \), set \( t_U = \frac{12(n-1)y_U}{12(n-1) + w_U} \), otherwise set \( t_U = \frac{12(n-2)y_U}{12(n-2) + w_U} \)

Look up \( \hat{p}_U = \Phi(t_U) \) in tables of the standard normal distribution function.

Repeat the same process for \( Q_L \).

NOTE The same formulas above can be used, replacing the indices \( U \) to \( L \).

Add the two estimates to obtain \( \hat{p}_1 = \hat{p}_L + \hat{p}_U \)

Repeat the same process for each characteristic then calculate

\[ \hat{p} = 1 - (1 - \hat{p}_1)(1 - \hat{p}_2)...(1 - \hat{p}_m) \]

If \( \hat{p} \) does not exceed the maximum allowable value \( p^* \) given in Table 24, the lot is considered to be acceptable, otherwise, the lot is considered to be not acceptable.

NOTE The approximate method is typically very accurate.

EXAMPLE Determination of acceptability

Three-phase electricity meters of class 2,0 are manufactured in lots of 100. The inspection method selected is inspection by variables, normal inspection, "s" method.

<table>
<thead>
<tr>
<th>Information needed</th>
<th>Value obtained</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size ( n ) (from Table 24)</td>
<td>13</td>
</tr>
<tr>
<td>Measured values at ( I_b ), ( \cos \varphi = 1 )</td>
<td>(-0.07, -0.09, 0.01, 0.00, -0.15, 0.17, 0.11, -0.15 )</td>
</tr>
</tbody>
</table>
Sample size \( n \) (from Table 24)

\[
\bar{x} = \frac{\sum_{j=1}^{n} x_j}{n}
\]

Sample mean \( \bar{x} = \frac{\sum_{j=1}^{n} x_j}{n} \)

Sample standard deviation \( s = \sqrt{\frac{\sum_{j=1}^{n} (x_j - \bar{x})^2}{n-1}} \)

Upper specification limit, \( U \)
Lower specification limit, \( L \)

Value of MSSD (from Table 24)

\[
Q_U = \frac{U - \bar{x}}{s}
\]

\[
x_U = \frac{1}{2} \left[ 1 - Q_U \sqrt{n} / (n-1) \right]
\]

\[
Q_L = \frac{\bar{x} - L}{s}
\]

\[
x_L = \frac{1}{2} \left[ 1 - Q_L \sqrt{n} / (n-1) \right]
\]

\[\hat{p} = p_U + p_L\]

The lot is acceptable for this characteristic.

The acceptability of the lot has to be determined in the same way for each characteristic then for all characteristics as described in 10.5.4.

Let us suppose now that the same meters tested are class 0.2 S meters.

**Information needed**

**Value obtained**

\[\text{Sample size } n \text{ (from Table 24)}\]

\[\text{Measured values at } I_b, \cos \varphi = 1\]

\[
\bar{x} = \frac{\sum_{j=1}^{n} x_j}{n}
\]

\[
\sqrt{\frac{\sum_{j=1}^{n} (x_j - \bar{x})^2}{n-1}} = 0.087924793
\]

\[\text{Upper specification limit, } U\]

\[\text{Lower specification limit, } L\]

\[\text{Value of MSSD (from Table 24)}\]

\[\frac{U - \bar{x}}{s} = 2.633369423\]

\[-0.031538462\]

\[\]
\[ x_U = \frac{1}{2} \left[ 1 - Q_U \sqrt{n} / (n - 1) \right] \]
\[ a_u (\text{from Table 25}) \]
\[ y_U = a_u \ln[y_U / (1 - x_U)] \]
\[ w_U = y_U^2 - 3 \]
\[ \text{as } w_u > 0, \quad t_U = \frac{12(n - 1)y_U}{12(n - 1) + w_U} \]
\[ F_U = \Phi(t_U) \]
\[ Q_L = \frac{x - L}{s} \]
\[ x_L = \frac{1}{2} \left[ 1 - Q_L \sqrt{n} / (n - 1) \right] \]
\[ a_u (\text{from Table 25}) \]
\[ y_L = a_u \ln[y_L / (1 - x_L)] \]
\[ w_L = y_L^2 - 3 \]
\[ \text{as } w_u > 0, \quad t_U = \frac{12(n - 1)y_U}{12(n - 1) + w_U} \]
\[ \hat{p}_U = \Phi(t_U) \]
\[ \hat{p} = p_U + p_L \]
\[ p^* \text{ (from Table 24)} \]

The lot for this characteristic is acceptable.

The acceptability has to be determined in the same way for each characteristic then for all characteristics as described in 10.5.4.

10.6 Standard multivariate “σ” method procedures for independent quality characteristics with combined control

10.6.1 General methodology

The general methodology under the “σ” method is similar to that for the multivariate “s” method.

The only difference from the multivariate “s” method is that the process fraction nonconforming for each characteristic is estimated as:

\[ \hat{p}_L = \Phi\left(-Q_L \sqrt{\frac{n}{n - 1}}\right) = \Phi\left(L - \frac{x - \bar{x}}{\sigma} \sqrt{\frac{n}{n - 1}}\right), \]

\[ \hat{p}_U = \Phi\left(-Q_U \sqrt{\frac{n}{n - 1}}\right) = \Phi\left(\frac{\bar{x} - U}{\sigma} \sqrt{\frac{n}{n - 1}}\right), \]

where \( \Phi \) is the distribution function of the standard normal distribution.
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\[
\frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} e^{-t^2/2} dt
\]

See ISO 3951-2, K2.2.

10.6.2 Sampling plans

The sampling plans, the values of the standardized MPSD \( f_s \) and the acceptability constants \( p^* \) can be obtained from Table 26.

Table 26 – Sampling plans for the “\( \sigma \)" method

<table>
<thead>
<tr>
<th>Lot sizes for inspection level II</th>
<th>Sample size code letter</th>
<th>Sample size ( n ) normal and tightened</th>
<th>Normal inspection</th>
<th>Tightened inspection</th>
<th>Reduced inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td></td>
<td></td>
<td>( f_s )</td>
<td>( 100 \ p^* )</td>
<td></td>
</tr>
<tr>
<td>51 to 90</td>
<td>-</td>
<td>E</td>
<td>6</td>
<td>4,196</td>
<td>3</td>
</tr>
<tr>
<td>91 to 150</td>
<td>51 to 90</td>
<td>F</td>
<td>8</td>
<td>3,605</td>
<td>4</td>
</tr>
<tr>
<td>151 to 280</td>
<td>91 to 150</td>
<td>G</td>
<td>10</td>
<td>3,323</td>
<td>6</td>
</tr>
<tr>
<td>281 to 500</td>
<td>151 to 280</td>
<td>H</td>
<td>12</td>
<td>3,010</td>
<td>8</td>
</tr>
<tr>
<td>501 to 1200</td>
<td>281 to 500</td>
<td>J</td>
<td>15</td>
<td>2,880</td>
<td>10</td>
</tr>
<tr>
<td>1 201 to 3 200</td>
<td>501 to 1 200</td>
<td>K</td>
<td>18</td>
<td>2,800</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>1 201 to 3 200</td>
<td>L</td>
<td>21</td>
<td>2,725</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| NOTE 1 The values are taken from Tables A.1, A.2, E.1, G.1, G.2 and G.3 of ISO 3951-2. If agreed by the responsible authority, higher lot sizes may be applied. The corresponding sampling plans can be selected from the tables referenced.  
NOTE 2 The symbol \( \emptyset \) means that there is no suitable plan in this area; use the first sampling plan below the arrow.  
NOTE 3 The MPSD is obtained by multiplying the standardized MPSD \( f_s \) by the difference between the upper specification limit \( U \) and the lower specification limit \( L \), i.e. MPSD = \( \sigma_{i\ max} \cdot (U - L) f_s \). The MPSD indicates the greatest allowable magnitude of the process standard deviation when using plans for combined control of double specification limits when the process variability is known. If the process standard deviation is less than the MPSD, then there is a possibility, but not a certainty, that the lot will be accepted.

10.6.3 Description of the procedure

Before sampling, take the value of the factor \( f_s \) from Table 26.

a) Calculate, for each characteristic, the maximum allowable value of the process standard deviation, using the formula

\[
MPSD_i = \sigma_{i\ max} = (U_i - L_i)f_s
\]

b) Compare the value of the process standard deviation \( \sigma_i \) with \( \sigma_{i\ max} \). If \( \sigma_i \) exceeds \( \sigma_{i\ max} \), the process is unacceptable and sampling inspection is pointless until it is demonstrated that the process variability has been adequately reduced.

c) If \( \sigma_i \leq \sigma_{i\ max} \) then, for the given lot size and applicable inspection severity, determine the acceptability constant \( p^* \) from Table 26.
Select a random sample of size \( n \) from the lot and, for each characteristic, calculate the sample mean \( \bar{x}_i \).

e) Using the method given in 10.6.1, calculate \( \hat{p}_U, \hat{p}_L, \hat{p} \) and finally \( \hat{p} \).

The lot is acceptable if \( \hat{p} \leq p^* \).

### 10.7 Procedure during continuing inspection

As a variables sampling inspection plan can only operate efficiently if:
- the characteristic being inspected is normally distributed;
- records are kept;
- the switching rules are obeyed,

it is necessary to ensure that these requirements are being met.

### 10.8 Normality and outliers

#### 10.8.1 Normality

The responsible authority should have checked for normality before sampling began. In case of doubt, a statistician should advise whether the distribution appears suitable for sampling by variables, or whether use should be made of the tests for departure from normality such as those given in ISO 5479. Normality should be reconfirmed periodically, particularly if there is a significant change of any kind in production, for example in personnel, design, materials or production method.

#### 10.8.2 Outliers

An outlier (or an outlying observation) is one that appears to deviate markedly from other observations in the sample in which it occurs. A single outlier, even when it lies within specification limits, will produce an increase in variability and change the mean and may consequently lead to non-acceptance of the lot. (See, for example ISO 5725-2.) When outliers are detected, the disposition of the lot should be a matter for negotiation between the manufacturer and the purchaser.

### 10.9 Records

#### 10.9.1 Control charts

One of the advantages of inspection by variables is that trends in the quality level of the product can be detected and a warning given before an unacceptable standard is reached, but this is only possible if adequate records are kept.

Whatever the method used, "s" or "\( \sigma \)”, records should be kept of the values of \( \bar{x} \) and \( s \), preferably in the form of control charts. (See ISO 7870-1 and ISO 8258.)

This procedure should be applied especially with the “\( \bar{\sigma} \)” method in order to verify that the values of \( s \) obtained from the samples fall within the limits of the prescribed value of \( \sigma \).

The value of the MSSD, given in Table 24 should be plotted on the \( s \) control chart, as an indication of an unacceptable value.

NOTE: Control charts are used to detect trends. The ultimate decision as to the acceptability of an individual lot is governed by the procedures given in 10.5 and 10.6.
Particular care shall be taken to record all lots that are not accepted and to see that switching rules are implemented. Any lot not accepted by the sampling plan shall not be resubmitted either in whole or in part without the permission of the responsible authority.

10.10 Normal, tightened and reduced inspection (see also 5.12)

The standard switching rules are as follows:

a) Normal inspection is used at the start of inspection (unless otherwise designated) and shall continue to be used during the course of inspection until tightened inspection becomes necessary or reduced inspection is allowed.

b) Tightened inspection shall be instituted when two lots on original normal inspection are not accepted within any five or fewer successive lots.

Tightened inspection is achieved by decreasing the values of the acceptability constant $p^*$. The values are tabulated in Table 24 for the "$s$" method and in Table 26 for the "$\sigma$" method. For neither method is there a change in the size of the sample in switching from normal to tightened inspection, unless the tables indicate, with a downward arrow, that an increase in sample size is necessary.

c) Tightened inspection shall be relaxed when five successive lots on original inspection have been accepted on tightened inspection; then normal inspection shall be reinstated.

d) Reduced inspection may be instituted after ten successive lots have been accepted under normal inspection, provided that

1) these lots would have been acceptable if the AQL had been one step tighter.
   
   As for the purposes of this standard AQL = 1.0 has been selected, an "AQL of one step higher" means AQL = 0.65. The values of $p^*$ for this case are given in Table 27.

   **Table 27 – Supplementary acceptability constants for qualifying towards reduced inspection**

<table>
<thead>
<tr>
<th>Sample size code letter</th>
<th>Form $p^*$ acceptability constant for AQL = 0.65</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>2.840</td>
</tr>
<tr>
<td>F</td>
<td>2.578</td>
</tr>
<tr>
<td>G</td>
<td>2.275</td>
</tr>
<tr>
<td>H</td>
<td>2.084</td>
</tr>
<tr>
<td>J</td>
<td>1.880</td>
</tr>
<tr>
<td>K</td>
<td>1.840</td>
</tr>
<tr>
<td>L</td>
<td>1.750</td>
</tr>
</tbody>
</table>

2) production is in statistical control;

3) reduced inspection is considered desirable by the responsible authority;

Reduced inspection is conducted on a much smaller sample than normal inspection and the values of the acceptability constant $p^*$ are increased. The values of $n$ and $p^*$ for reduced inspection are given in Table 24 for the "$s$" method and in Table 26 for the "$\sigma$" method.

e) Reduced inspection shall cease and normal inspection be reinstated if any of the following occur on original inspection:

   - a lot is not accepted;
   - production becomes irregular or delayed;
10.11 Discontinuation and resumption of inspection

If the cumulative number of lots not accepted in a sequence of consecutive lots on original tightened inspection reaches 5, the acceptance procedures of this standard shall be discontinued.

Inspection under the provisions of this standard shall not be resumed until action has been taken by the supplier to improve the quality of the submitted product or service. Tightened inspection shall then be used as if 10.10 b) had been invoked.

10.12 Switching between the “s” and “σ” methods

10.12.1 Estimating the process standard deviation

While this part of the standard describing inspection by variables is being used, the weighted root mean square of the values of \( s \) shall be calculated periodically as estimates of the process standard deviation \( \sigma \), for both the “s” and the “σ” methods. (See Clause B.2.) The value of \( \sigma \) shall be estimated at five-lot intervals, unless the responsible authority specifies another interval. The estimate shall be based on the preceding 10 lots, unless the responsible authority specifies another number of lots.

10.12.2 State of statistical control

Calculate the upper control limit for each of the 10 lots (or other number of lots specified by the responsible authority) from the expression \( c_U \sigma \), where \( c_U \) is a factor which depends on the sample size \( n \) and is given in Table 28. If none of the sample standard deviations, \( s_i \), exceeds the corresponding control limit, then the process may be considered to be in a state of statistical control; otherwise the process shall be considered to be out of statistical control.

**NOTE 1** If the sample sizes from the lots are all equal, then the value of \( c_U \sigma \) is common to all the lots.

**NOTE 2** If the sample sizes from each lot vary, it is not necessary to calculate \( c_U \sigma \) for those lots for which the sample standard deviation, \( s_i \), is less than or equal to \( \sigma \).

**NOTE 3** The values of \( c_U \) are such that, in a stable process with constant standard deviation \( \sigma \), in ten consecutive lots the probability of one or more sample standard deviations exceeding its \( c_U \sigma \) is 5%. Thus, the probability of a false alarm is constrained to 5%.

**Table 28 – Values of \( c_U \) for upper control limit on the sample standard deviation**

<table>
<thead>
<tr>
<th>Sample size ( n )</th>
<th>Factor ( c_U )</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2.297</td>
</tr>
<tr>
<td>4</td>
<td>2.065</td>
</tr>
<tr>
<td>6</td>
<td>1.827</td>
</tr>
<tr>
<td>8</td>
<td>1.700</td>
</tr>
<tr>
<td>9</td>
<td>1.654</td>
</tr>
<tr>
<td>10</td>
<td>1.617</td>
</tr>
<tr>
<td>12</td>
<td>1.558</td>
</tr>
<tr>
<td>13</td>
<td>1.534</td>
</tr>
<tr>
<td>15</td>
<td>1.494</td>
</tr>
<tr>
<td>18</td>
<td>1.448</td>
</tr>
<tr>
<td>25</td>
<td>1.377</td>
</tr>
<tr>
<td>35</td>
<td>1.316</td>
</tr>
</tbody>
</table>
10.12.3 Switching from the “s” method to the “σ” method

If the process is considered to be in a state of statistical control under the “s” method, then the “σ” method may be instituted using the latest value of σ.

NOTE This switch is made at the discretion of the responsible authority.

10.12.4 Switching from the “σ” method to the “s” method

It is recommended that a control chart for s be kept even under the “σ” method. As soon as there is any doubt that the process remains in statistical control, inspection shall be switched to the “s” method.

10.13 Consumer protection

This Clause 10 of this standard is intended to be used as a system employing tightened, normal and reduced inspection on a continuing series of lots to provide consumer protection while assuring the producer that acceptance will be very likely to occur if quality is better than the AQL.

10.14 Operating characteristic curves

The tables for consumer’s risk quality and producer’s risk provide information about only two points on the operating characteristic curves. The degree of consumer protection provided by an individual sampling plan at any process quality level may, however, be judged from its operating characteristic (OC) curve. OC curves for the normal inspection “s” method sampling plans of this part are given in the three figures and tables below for normal, tightened and reduced inspection. These should be consulted when choosing a sampling plan. The values are taken from ISO 3951-1 Charts C to L.

These OC curves and tables apply to a single specification limit under the “s” method. Most of them also provide a good approximation to the “σ” method, and to the case of combined control of double specification limits, particularly for the larger sample sizes. If more accurate OC values are required for the “σ” method, refer to ISO 3951-2, Annex N.
Figure 7 – OC curves for normal inspection, AQL = 1.0
### OC curves for normal inspection, AQL = 1,0

#### Sample size code letter

<table>
<thead>
<tr>
<th>$P_a$</th>
<th>Sample size code letter</th>
</tr>
</thead>
<tbody>
<tr>
<td>$%$</td>
<td>E</td>
</tr>
<tr>
<td>99</td>
<td>0,24</td>
</tr>
<tr>
<td>95</td>
<td>0,74</td>
</tr>
<tr>
<td>90</td>
<td>1,26</td>
</tr>
<tr>
<td>75</td>
<td>2,81</td>
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<tr>
<td>50</td>
<td>6,00</td>
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<tr>
<td>25</td>
<td>11,32</td>
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</tr>
<tr>
<td>5</td>
<td>23,24</td>
</tr>
<tr>
<td>1</td>
<td>34,16</td>
</tr>
</tbody>
</table>

**Figure 8 – OC curves for tightened inspection, AQL = 1,0**
## Tabulated values of OC curves for tightened inspection, AQL = 1,0

<table>
<thead>
<tr>
<th>Sample size code letter</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>J</th>
<th>K</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td>$p_a$ ( in percent nonconforming)</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td></td>
</tr>
<tr>
<td>99</td>
<td>-</td>
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<td>0,22</td>
<td>0,28</td>
<td>0,33</td>
<td>0,42</td>
<td>0,50</td>
</tr>
<tr>
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<td>-</td>
<td>0,51</td>
<td>0,53</td>
<td>0,58</td>
<td>0,61</td>
<td>0,70</td>
<td>0,76</td>
</tr>
<tr>
<td>90</td>
<td>-</td>
<td>0,84</td>
<td>0,82</td>
<td>0,83</td>
<td>0,83</td>
<td>0,90</td>
<td>0,94</td>
</tr>
<tr>
<td>75</td>
<td>-</td>
<td>1,79</td>
<td>1,58</td>
<td>1,46</td>
<td>1,35</td>
<td>1,36</td>
<td>1,33</td>
</tr>
<tr>
<td>50</td>
<td>-</td>
<td>3,72</td>
<td>3,03</td>
<td>2,60</td>
<td>2,22</td>
<td>2,07</td>
<td>1,91</td>
</tr>
<tr>
<td>25</td>
<td>-</td>
<td>7,00</td>
<td>5,40</td>
<td>4,34</td>
<td>3,51</td>
<td>3,07</td>
<td>2,68</td>
</tr>
<tr>
<td>10</td>
<td>-</td>
<td>11,40</td>
<td>8,51</td>
<td>6,58</td>
<td>5,12</td>
<td>4,25</td>
<td>3,58</td>
</tr>
<tr>
<td>5</td>
<td>-</td>
<td>14,75</td>
<td>10,89</td>
<td>8,27</td>
<td>6,31</td>
<td>5,12</td>
<td>4,21</td>
</tr>
<tr>
<td>1</td>
<td>-</td>
<td>22,46</td>
<td>16,42</td>
<td>12,21</td>
<td>9,07</td>
<td>7,08</td>
<td>5,64</td>
</tr>
</tbody>
</table>

### Figure 9 – OC curves for reduced inspection, AQL = 1,0
### OC curves for reduced inspection, AQL = 1,0

<table>
<thead>
<tr>
<th>Sample size code letter</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>J</th>
<th>K</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_s$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$p$ ( in percent nonconforming)</td>
<td>1.0%</td>
<td>0.89</td>
<td>0.69</td>
<td>0.56</td>
<td>0.41</td>
<td>0.36</td>
<td>0.34</td>
</tr>
<tr>
<td>99</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>95</td>
<td>1.13</td>
<td>1.27</td>
<td>1.38</td>
<td>1.57</td>
<td>1.74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>90</td>
<td>2.09</td>
<td>1.94</td>
<td>1.83</td>
<td>1.79</td>
<td>1.74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>75</td>
<td>3.22</td>
<td>3.27</td>
<td>3.28</td>
<td>3.39</td>
<td>3.77</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>4.75</td>
<td>5.14</td>
<td>5.55</td>
<td>6.35</td>
<td>7.51</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>6.79</td>
<td>7.23</td>
<td>7.84</td>
<td>8.65</td>
<td>9.53</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>9.11</td>
<td>9.76</td>
<td>10.15</td>
<td>10.73</td>
<td>10.73</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>14.29</td>
<td>14.11</td>
<td>13.84</td>
<td>13.57</td>
<td>13.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>14.29</td>
<td>14.11</td>
<td>13.84</td>
<td>13.57</td>
<td>13.30</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### 10.15 Consumer's risk (CR)

If the series of lots is not long enough to allow the switching rules to be applied, it may be desirable to limit the selection of sampling plans to those, associated with a designated AQL value (in the case of this standard 1,0), that give consumer’s risk quality not more than the specified limiting quality protection. Sampling plans for this purpose can be selected by choosing a consumer's risk quality (CRQ) and a consumer's risk to be associated with it.

Table 32 gives values of consumer’s risk quality (CRQ) levels for the “s” method corresponding to a consumer’s risk of 10 % and 5 % respectively.

Table 33 gives values of consumer’s risk quality (CRQ) levels for the “$a$” method corresponding to a consumer’s risk of 10 % and 5 % respectively.

However, the application of inspection by variables to isolated lots is deprecated, as the theory of sampling by variables applies to a process. For isolated lots, it is appropriate and more efficient to use plans for sampling by attributes, described in Clause 8.
### Table 32 – Consumer's risk quality (CRQ): “s” method

<table>
<thead>
<tr>
<th>Lot sizes for inspection levels</th>
<th>Sample size code letter</th>
<th>Normal inspection</th>
<th>Tightened inspection</th>
<th>Reduced inspection</th>
<th>Sample size n</th>
<th>CRQ %</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td></td>
<td>CR %</td>
<td>10</td>
<td>5</td>
<td>CR %</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sample size n</td>
<td>CRQ %</td>
<td>Sample size n</td>
<td>CRQ %</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td></td>
<td>51 to 90</td>
<td>4</td>
<td>41,32</td>
<td>50,30</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>91 to 150</td>
<td>6</td>
<td>29,28</td>
<td>36,40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>151 to 280</td>
<td>9</td>
<td>20,66</td>
<td>25,84</td>
<td></td>
</tr>
<tr>
<td></td>
<td>G</td>
<td>281 to 500</td>
<td>13</td>
<td>15,91</td>
<td>19,70</td>
<td></td>
</tr>
<tr>
<td></td>
<td>H</td>
<td>501 to 1200</td>
<td>8</td>
<td>12,8</td>
<td>15,64</td>
<td></td>
</tr>
<tr>
<td></td>
<td>J</td>
<td>1,201 to 3,200</td>
<td>10</td>
<td>10,76</td>
<td>12,91</td>
<td></td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>51 to 90</td>
<td>25</td>
<td>15,91</td>
<td>19,70</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>91 to 150</td>
<td>35</td>
<td>12,8</td>
<td>15,64</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>151 to 280</td>
<td>40</td>
<td>10,76</td>
<td>12,91</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>281 to 500</td>
<td>55</td>
<td>8,57</td>
<td>10,76</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>501 to 1200</td>
<td>65</td>
<td>6,31</td>
<td>8,57</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1,201 to 3,200</td>
<td>75</td>
<td>4,21</td>
<td>6,31</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>51 to 90</td>
<td>85</td>
<td>3,58</td>
<td>4,21</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>91 to 150</td>
<td>95</td>
<td>2,92</td>
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<td></td>
<td></td>
<td>151 to 280</td>
<td>105</td>
<td>1,54</td>
<td>2,92</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>281 to 500</td>
<td>115</td>
<td>0,98</td>
<td>1,54</td>
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</tr>
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<td></td>
<td></td>
<td>501 to 1200</td>
<td>125</td>
<td>0,43</td>
<td>0,98</td>
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</tr>
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<td></td>
<td>1,201 to 3,200</td>
<td>135</td>
<td>0,25</td>
<td>0,43</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE 1** The values are taken from Tables L.1, L3 and L.5 of ISO 3951-2 and Charts C to L of ISO 3951-1.

**NOTE 2** The sample sizes are the same for normal and tightened inspection.

### Table 33 – Consumer’s risk quality (CRQ): “σ” method

<table>
<thead>
<tr>
<th>Lot sizes for inspection levels</th>
<th>Sample size code letter</th>
<th>Normal inspection</th>
<th>Tightened inspection</th>
<th>Reduced inspection</th>
<th>Sample size n</th>
<th>CRQ %</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td></td>
<td>CR %</td>
<td>10</td>
<td>5</td>
<td>CR %</td>
<td>10</td>
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<tr>
<td></td>
<td></td>
<td>Sample size n</td>
<td>CRQ %</td>
<td>Sample size n</td>
<td>CRQ %</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td></td>
<td>51 to 90</td>
<td>3</td>
<td>40,1</td>
<td>50,30</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>91 to 150</td>
<td>4</td>
<td>29,28</td>
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**NOTE 1** The values are taken from Tables L.2, L.4 and L.6 of ISO 3951-2.

**NOTE 2** The sample sizes are the same for normal and tightened inspection.

**NOTE 3** CRQ values for CR = 5 % are not given in ISO 3951-2. As the OC curves given for the “s” method provide a good approximation for the “σ” method, the values given in Table 32 can be used.

See also ISO 3951-2, Annex L.
With code letter G, under normal inspection using the "s" method, the CRQ for CR = 10 % is 10.43 %. It means that if the process quality is as bad as 10.43 % non-conforming, then the consumer’s risk that a lot is accepted is 10 %.

### 10.16 Producer’ risk (PR)

Table 34 and Table 35 give the probability of non-acceptance under the "s" and "σ" methods respectively for lots produced when the process fraction nonconforming equals the AQL. This probability is called the producer’s risk (PR).

#### Table 34 – Producer’s risk (PR): “s” method

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<th>Reduced inspection</th>
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**NOTE** The values are taken from Tables M.1, M.3 and M.5 of ISO 3951-2.

#### Table 35 – Producer’s risk (PR): “σ” method

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**NOTE** The values are taken from Tables M.2, M.4 and M.6 of ISO 3951-2.
With code letter G, under normal inspection using the “s” method, the PR is 6.6%. It means that if the process quality is 1.0% non-conforming, then the producer’s risk that a lot is not accepted is 6.6%.

Note the increase of the PR under tightened inspection.
Annex A
(normative)

Random numbers

Table A.1 – Random numbers

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Annex B
(normative)

Procedure for obtaining $s$ or $\sigma$

B.1 Procedure for obtaining $s$

The estimate from a sample of the standard deviation of a population is generally denoted by the symbol $s$. Its value may be obtained from the mathematical formula

$$s = \sqrt{\frac{\sum_{j=1}^{n} (x_j - \bar{x})^2}{n-1}}$$

where

$x_j$ is the value of the quality characteristic of the $j$th item in a sample of size $n$; and

$\bar{x}$ is the mean value of the $x_j$, i.e.

$$\bar{x} = \frac{\sum_{j=1}^{n} x_j}{n}$$

For details, see ISO 3951-2, Clause J.1.

NOTE In ISO 3951-2:2006 the above formula is erroneous. An amendment has been initiated.

B.2 Procedure for obtaining $\sigma$

If it appears from the control chart that the value of $s$ is in control, $\sigma$ may be presumed to be the weighted root mean square value of $s$ given by the following formula:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{m} (n_i - 1)s_i^2}{\sum_{i=1}^{m} (n_i - 1)}}$$

where

$m$ is the number of lots;

$n_i$ is the sample size from the $i$th lot;

$s_i$ is the sample size standard deviation of the $i$th lot;

If the sample sizes from each of the lots are equal, then the above formula reduces to

$$\sigma = \sqrt{\frac{\sum_{i=1}^{m} s_i^2}{m}}$$
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