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Tolerances for building —

Part 7:
General principles for approval criteria, control of conformity with dimensional tolerance specifications and statistical control — Method 2 (Statistical control method)

Tolérances pour le bâtiment — Partie 7: Principes généraux pour les critères d'acceptation, le contrôle de conformité aux spécifications de tolérance dimensionnelle et le contrôle statistique — Méthode 2 (Méthode de contrôle statistique)

Foreword

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

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 3443-7 was prepared by Technical Committee ISO/TC 59, *Building construction*.

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

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Part 7:
General principles for approval criteria, control of conformity with dimensional tolerance specifications and statistical control — Method 2 (Statistical control method)

0   Introduction

The procedure and rules established in this part of ISO 3443 are not compulsory for any parties to an agreement. If the parties agree to follow this part of ISO 3443, they should therefore so indicate in the agreement on inspection.

This part of ISO 3443 forms one of a series of International Standards concerning tolerances for building and building components.

The principles for approval and the statistical methods recommended are, with only minor modifications, based on International Standards for statistical inspection.

Alternative methods of inspection (e.g. based on Bayesian statistics) are permitted when the statistical risks involved in the actual sampling plans are known by the parties.

A shorter and more generalized method, to be used when establishing approval criteria and controlling accuracy, and not applying specific statistical principles, is issued as method 1 in ISO 3443-6.[1]

1   Scope

This part of ISO 3443 specifies an operational procedure which can be used to determine acceptance of dimensional accuracy of components, and operations in the building industry to be used when the parties involved agree to refer to this part of ISO 3443. The procedure relates to the recognition of specified requirements, the criteria for acceptance and consequences of rejection, recommendations on the agreements and methods of measurement, and the planning and execution of inspection by statistical methods.

2   Field of application

This part of ISO 3443 applies to all types of forms, dimensions and positions within the building industry.

3   References

ISO 2859, *Sampling procedures and tables for inspection by attributes.*

ISO 2859/Add. 1, *General information on sampling inspection, and guide to the use of ISO 2859 tables.*

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

ISO 3443-6, *Tolerances for building — Part 6: General principles for approval criteria, control of conformity with dimensional tolerance specifications and statistical control — Method 1.*

ISO 3534, *Statistics — Vocabulary and symbols.*

ISO 3951, *Sampling procedures and charts for inspection by variables for percent defective.*

ISO 4464, *Tolerances for building — Relationship between the different types of deviations and tolerances used for specification.*

ISO 6284, *Tolerances for building — Indication of tolerances on building and civil engineering drawings.*

ISO 7077, *Measuring methods for building — General principles and procedures for the verification of dimensional compliance.*

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1)   Internationally, users are free to decide if they will use method 1 (the short method) or method 2 (the longer method).

4 Definitions

For the purposes of this part of ISO 3443, the following definitions apply.

4.1 tolerance specification: The set of expressions or their symbols, indicating the domain of acceptance of the characteristic indicated.

4.2 characteristic: A feature for which a tolerance has been specified; it can be a dimension, an angle, the shape of a surface, etc.

4.3 item (unit) of product or operation:

a) An actual or conventional object on which a set of observations may be made.

b) A defined quantity of material, on which a set of observations may be made.

c) An observed value, either qualitative (attributes) or quantitative (values).

NOTES

1 The item will normally be a component when checking manufacturing and erection tolerances, or a point when checking setting out tolerances, but it could also be individual dimensions, for instance in the case of checking earth-work or *in situ* cast concrete.

2 The item of product or operation is used as a counting item in determining lot size, sample size, number of conforming items, etc.

4.4 conformance with a tolerance specification: The case when the indicated characteristic, as measured according to the specified method under the specified conditions, is within the domain of acceptance.

4.5 Standardized statistical terms

Definitions of statistical terms standardized in other International Standards are shown in annex B.

5 Tolerances and specified requirements

5.1 Tolerance specifications

Tolerance specifications set the limits for such deviations from the ideal or basic specifications which the customer will accept unconditionally.

NOTE — The term tolerance is often used as a synonym for tolerance specification.

The expressions and symbols used in the tolerance specifications shall be clearly understandable, unambiguous and in accordance with International Standards wherever possible.

The expression can have one of the following forms.

a) D^{+A}_{-B} where $A + B = T$ (see figure 1).

This means that the indicated dimension X shall fulfil the following inequalities in order to be accepted:
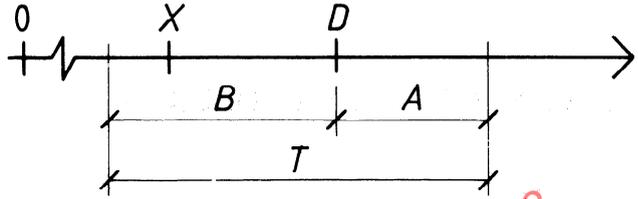
$$D - B \leqslant X \leqslant D + A$$

Figure 1

b) One-sided inequalities such as $X \leqslant T$ (see figure 2).
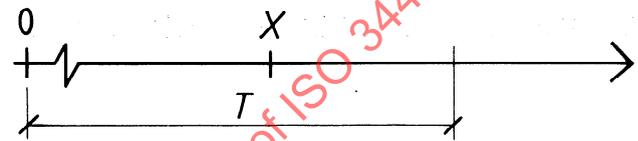

Figure 2

c) Specification, by mathematical or linguistic expressions, of the envelope for the permitted positions of the points of a line or a surface (see figure 3). See for instance the explanation of the box principle for a 3-dimensional component in ISO 4464.
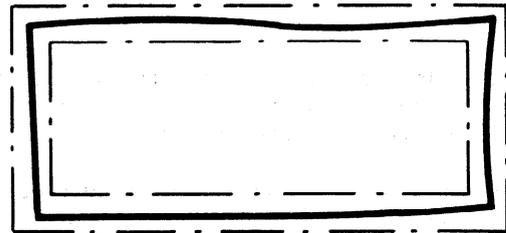

Figure 3

Tolerance specifications may include, directly or indirectly, the conditions under which the parameters are to be measured. For methods and instruments to be used, see ISO 7077.

5.2. Indication and recognition of tolerance specifications

5.2.1 Particular indication

The case when the tolerance specification is indicated directly on the building drawing or in the specification of work.

The rules and principles given in ISO 4464 and ISO 6284 should be followed, and a reference to these International Standards should appear on all drawings and specifications of work.

5.2.2 General indication

In cases where the tolerance specification is not indicated as in 5.2.1, general tolerance specifications, if any, shall be applied.

Such specifications shall appear, in order to be recognized, either in an agreement between the parties or as legal demands.

NOTE — Normally an agreement between the parties will have the form of an order or a sales contract. The general tolerance specifications may be stated therein, or they may be indicated by reference to other documents, for instance project descriptions, general product specifications, trade recommendations and national or International Standards.

5.2.3 No indication

If there are no tolerance specifications indicated, directly or indirectly, requirements in accordance with normal practices are assumed.

These requirements can only be controlled according to the rules in 7.5.

5.3 Recommendations on the use of tolerance specifications

It is generally recommended that only such tolerance specifications which will be controlled according to the agreement on inspection be indicated on the drawings and specifications of work, in order to maintain the respect for tolerance specifications.

However, in cases where requirements "in accordance with normal practice" are not evident, for instance in connection with new production or building techniques, it is recommended that tolerance specifications for all significant characteristics be indicated, even for those not intended for economic reasons to be controlled systematically.

6 Inspector responsible

An inspector responsible for undertaking the control of conformity with the tolerance specifications shall be designated in the inspection agreement.

The inspector responsible is normally a private person who is recognized by both parties as having the necessary knowledge and reliability to perform the important operations stated below and being impartial to a high degree in judgement, regardless of his employment.

The inspector responsible shall supervise or carry out the following:

a) authorization of sampling plans (confirming the proper sampling plan for the personnel who carry out the inspection);

b) formation of lots and drawing of samples;

c) checking the proper conditions and methods of measurement;

d) checking the calibration of the instruments and carrying out the measurements;

e) recording the measurements, physical conditions and other control data in an inspection journal. The inspection journal shall be presented to the parties on demand;

f) approval or rejection of items or lots according to the measurements.

The inspector responsible will further make necessary judgements during the inspection; for instance rejection of certain control measurements, the applicability, conditions of repair and resubmission of defective items, and the determination whether normal, tightened or reduced inspection shall be used. A record of these judgements shall be presented to the parties.

The competence of the inspector responsible shall be stated in the agreement on inspection. It is important in practice that his power to make judgements according to the procedures described in clause 8 be not too limited, as many negotiations between the parties will otherwise be necessary.

NOTE — The inspector responsible need not in principle be independent of both parties. It may be practical that he be employed by one of the parties, often the supplier, in order to have necessary facilities at easy disposal.

7 Approval criteria for items (units)

7.1 Definition of item

The term "item" shall be further specified in the agreement on inspection if it is not unambiguous, possibly by reference to other International Standards covering inspection in particular fields.

7.2 Conditions for remeasuring defective items

It is not permitted, except in the two cases indicated below, to make new measurements on defective items, even with more accurate instruments, in order to recheck the conformity with the tolerance specification. This procedure will otherwise introduce a systematic error in the control method in the form of higher acceptability than planned, since the number of measurements is guided according to the benefit of the supplier.

The two exceptions are as follows:

a) If it can be shown with high certainty that the outlying result of the measurement is due to severe errors in measuring, the responsible inspector may permit a new measurement on the same item.

b) In case of planned multiple stage control procedures, where it is shown that the resulting acceptability is equal to that of a single direct measurement of the characteristic.

Example: The characteristic in question is first measured with a simple or cheap method, which accordingly must have a systematic offset in the form of lower acceptability. In case of non-conformity a more comprehensive method of measurement is applied.

NOTE — An item which has been repaired and is submitted for reinspection according to the procedure described in 8.3 is not in this connection regarded as defective prior to the re-inspection.

7.3 Compulsory information about defective items

The supplier is not allowed to supply any item which to his knowledge is defective, without informing the responsible inspector.

In case of statistical inspection of lots, an item which is designated as defective by the supplier is not part of the lot while the lot is controlled for the characteristics for which the item is known to be non-conforming. Accordingly this item cannot be drawn as a part of the sample nor be accepted together with the lot for these characteristics.

Items designated as defective by the supplier are treated as other defective items and will follow the procedures described in 8.3.

7.4 Acceptance and the time of delivery of items

Conforming items are unconditionally accepted for the characteristics in question.

Defective items may be accepted in accordance with the procedures described in clause 8.

Items may also be accepted, without inspection, as parts of an accepted lot.

An item is not accepted until it is accepted for all characteristics on which, according to the agreement of inspection, control is required.

If the time of delivery of some items is limited by agreement between the parties, it shall be stated in the agreement whether the time of delivery is defined as before or after acceptance of the items.

7.5 Extraordinary inspection and rejection

The consumer may, at his own expense, inspect any item for conformity to any requirement and tolerance specification, including those on which control is not required according to the agreement of inspection, and reject the item in case of non-conformity (see 5.2.3 and 9.5.4.3).

The consumer cannot in this way reject items for characteristics which have earlier been found conforming or which have been accepted conditionally according to 8.2 and 10.2.

This extra inspection may be organized and supervised by the responsible inspector or performed by another surveyor recognized by the supplier.

Items found non-conforming as a result of this extra inspection follow the regular procedure for defective items stated in clause 8. The time of delivery of the items will, however, not be changed in this case.

If this extra inspection is performed after the regular inspection according to the agreement on inspection, the consumer is to prove with a high certainty that the defective item must also have been defective at that time or at the reference time.

NOTE — This extraordinary inspection is instituted to protect the consumer against severe and unexpected defects in the items. If 100 % inspection of a certain characteristic was not economically justified when the control was planned, it will only pay off for the consumer to use this procedure in very special cases.

8 Procedures for defective items

8.1 Judgement of applicability

If an item is non-conforming with respect to a characteristic, the applicability of the item shall be evaluated.

This judgement and other judgements in the procedures described in this clause are most efficiently made by the responsible inspector if he is empowered so to do according to the agreement of the inspection. Otherwise the judgements shall be based on mutual consent of both parties.

One of the parties may require any judgement by the responsible inspector to be negotiated between the parties.

The judgements may be supported by more comprehensive measurements of the item, but care shall be taken to avoid thereby having a two-stage control method with a systematic error as cited in 7.2.

8.2 Item applicable

In this case the item is accepted in accordance with the conditions stated in the agreement of inspection. Examples of the main features in such conditions are:

a) compensation to the consumer;

b) the extra cost involved by using the defective item is estimated and distributed between the parties;

c) the increased risk of misfits caused by the defective item is estimated, and the supplier participates accordingly at a certain rate in the actual and documented extra costs, if any, involved in the fitting of this item or possibly other items depending on it.

The supplier may choose to follow the procedure in 8.3.

8.3 Item not applicable

If the item is judged to be not applicable, for instance because the deviation is very large, the item is rejected.

The item may be repaired according to specifications stated by the responsible inspector, or by mutual consent. After being repaired, the item may not be resubmitted in a new inspection lot: it shall be presented for special inspection in order to be accepted.

If not repaired, the item shall be replaced by a new item. This new item shall be presented for special inspection for all characteristics.

9 Approval criteria for lots

9.1 General, approval of individual items and of inspection lots

A lot is a group of items compiled primarily for the purpose of inspection.

The criteria for approval of lots are based on the approval of individual items. The rules and procedures valid for approval or rejection of items as described in clauses 7 and 8 are, therefore, also valid for such individual items in the lot as are inspected.

The definitions of the terms used in this part of ISO 3443 relating to inspection and approval of lots are in accordance with ISO 3534. Some of these definitions are given in annex B.

The characteristics to be controlled, and the methods of inspection and approval of the lots shall be stated in the agreement on inspection.

9.2 Determination of the key parameters of inspection

The methods of inspection are determined on a high level between the parties through key parameters, for instance AQL, LQ (for definitions, see annex B), lot size and "100 % inspection", as described in the following clauses and annex D.

These parameters, and the switching procedures given in 9.5.1 if necessary, govern the economy and the risks involved in the statistical inspection.

It is possible to specify different parameters for different characteristics to be controlled.

The actual values of the key parameters are stipulated in one or more of the following ways:

 a) stated in standards or trade recommendations;

 b) according to negotiations, common practice or common sense;

 c) optimized, for instance mathematically by taking into account the costs of inspection, production, and using defective items, etc.

The choice of AQL is restricted to preferred values if International Standards of statistical inspection are to be used. The preferred values are listed in annex A.

9.3 Critical defects

When negotiating the key parameters of the inspection, some defects may be designated as critical.

This means either that the lot is 100 % inspected for these defects or that the consumer will get special protection against items with such defects through the specified key parameters plus the provision of extraordinary rejection of the lot if one defective item is found, even by accident. (See 9.5.3.2 and 9.5.4.4.)

Designating defects as critical should be limited to such characteristics where this intensive control and rigorous protection of the consumer are explicitly justified.

In order not to create disrespect for "non-critical" tolerance specifications, the designation as critical should not appear in the tolerance specifications, but in the agreement of inspection.

9.4 Approval by 100 % inspection

When all items are inspected, there is no statistical uncertainty and no expense for organizing the statistical methods.

For this reason, 100 % inspection is often preferable to statistical inspection designed with very low AQL, for instance when controlling critical defects.

100 % inspection may also be advantageous in the case of very small lots where a high inspection rate is otherwise necessary in order to get reasonably large samples.

The items are accepted or rejected individually according to the rules stated in clauses 7 and 8.

9.5 Approval by representative samples (statistical inspection)

9.5.1 Normal, tightened and reduced inspection

9.5.1.1 General, switching procedures

International Standards on statistical inspection are intended primarily to be used for a continuing series of lots. However, in the case of inspecting a small number of lots, the methods will still work if they are coupled with sufficient costs for the supplier when lots are rejected. (See ISO 2859-2.)

For a continuing or quasi-continuing series of lots, the switching procedures are applicable. According to this concept, the inspection and criteria for acceptance of the lots are to some extent guided by the results of the inspection of earlier lots.

In this way the inspection level is reduced when the supplier continues to submit lots with a percent defective appreciably lower than the AQL, thus reducing the inspection costs. This is beneficial because the supplier will still have an almost 100 % probability of acceptance of the lots.

If, however, the supplier continues to submit lots with a quality approximately at AQL, the inspection is tightened in order to raise the protection of the consumer. The probability of acceptance of lots with a percent defective equal to AQL is thus considerably reduced.

The rules standardized in this part of ISO 3443 for using normal, tightened and reduced inspection are those stated in ISO 2859[1], clause 8, with the following modification to clause 8.4:

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1) Cross-references to a specific clause in ISO 2859 apply to the first edition published in 1974.

In the event that ten consecutive lots remain on tightened inspection (or such other number as may be designated by the inspector responsible), the statistical inspection should be discontinued and replaced by 100 % inspection pending action to improve the quality of the items submitted.

9.5.1.2 Isolated lots

Statistical inspection of single lots or a short series of lots (under 5) shall always be with normal inspection. The absence of possible tightened inspection should be compensated by higher costs charged to the supplier for rejected lots. (See ISO 2859-2.)

9.5.1.3 Large projects or quasi-continuing series of lots

If the number of lots comprised by the agreement on inspection is more than 5, or if the consumer receives lots for more building projects consecutively from the same supplier, the production may be regarded as a quasi-continuing series of lots and the switching procedures may be applied.

9.5.1.4 Supplier affiliated to a control organization

The statistical inspection of the products from a supplier may be supervised and guided by an independent organization, for instance a trade association or a public institute.

Such an organization is able to accumulate the knowledge about the products and the individual supplier's production process and to follow periodic changes. It is thus possible to make full use of the switching procedures.

9.5.2 Specification of statistical inspection

The procedure for the execution of the statistical determination of acceptability is called a sampling procedure. It contains detailed information about the formation of lots, sample sizes and criteria for acceptance or rejection of the lots according to the measurements of the items in the samples.

The sampling procedure shall be specified in the agreement of inspection.

On the basis of the key parameters specified according to 9.5.3 and of the knowledge of the products, any control engineer is able to design a sampling procedure following the procedures described in clause 14 and in ISO 2859.

In cases where the economic losses caused by defective items in a reasonable number are acceptable under the consumer's budget, the important factor for him is usually the average percent defective items he receives. For such cases the AQL procedure as described in 9.5.3.1 is relevant.

In cases where non-conformances to the tolerance specification will be disastrous to the consumer's budget or to the safety of the building project or important functions of it, the procedures for critical defects, as described in 9.5.3.2, are relevant.

If the losses for the supplier in case of rejection are small, for instance if he can destroy or sell to others the rejected lots, submitting new lots to the original consumer, the procedure given in 9.5.3.1 may not give sufficient protection to the consumer. In such cases, the sampling procedure may be determined by other key parameters or combinations of parameters, for instance by specifying both AQL and LQ. Corresponding sampling procedures may be designed following the procedures given in clause 14 and ISO 2859.

9.5.3 Key parameters and the protection of the parties

9.5.3.1 Regular tolerance specifications

For inspecting non-critical tolerance specifications, the key parameters to be determined are AQL and the approximate lot size. Inspection level II is used unless the use of another inspection level is justified (see 14.5).

The inspection cost per item is higher for small lots than for large ones, as the recommended sample size is approximately proportional to the square root of the lot size. Dividing the total population of items into more and smaller inspection lots gives, however, a better map of the variations and makes more logical or production-relevant groupings of the items possible.

The protection of the supplier is ensured in such a way that if he submits lots continuously with a percent defective items equal to AQL, he will have a probability of acceptance of approximatively 90 % to 99 %.

The protection of the consumer is ensured by the costs of rejection which is charged to the supplier. This cost multiplied by the probability of rejection of unacceptable lots should be so large that it will be expedient for the supplier to keep his production quality well within the agreed limits.

9.5.3.2 Protection against critical defects

For inspecting critical characteristics the same procedure as described in 9.5.3.1 can be followed, i.e. specifying a very small AQL.

However, there is no protection of the consumer against accepting lots occasionally with a percent defective appreciably higher than the AQL.

Alternatively, an LQ could be specified.

This necessary sample size will, however, often be very high compared to the lot size, still without giving full protection to the consumer, and it is therefore generally recommended that lots are 100 % inspected for critical defects.

9.5.4 Acceptance and rejection

9.5.4.1 Separate approval of different characteristics

The lot is accepted or rejected separately for the different characteristics which are to be controlled.

For statistical inspection of lots a single characteristic need not be attached to one single tolerance specification. One characteristic could fundamentally be defined, such as pos-

itional deviations of inserts, which may comprise several dimensions and their respective tolerance specifications. In this case defects may be counted instead of defective items.

The grouping of tolerance specifications to major characteristics should, however, not go too far. In practice some tolerance specifications will be easy to comply with, while others are more difficult, and the supplier might therefore systematically compensate a high rate of non-conformity to some tolerance specifications with low rates of non-conformity to others.

The various characteristics to be controlled shall be defined in detail in the agreement of inspection if they are not immediately obvious and unambiguous, possibly by reference to other International Standards covering inspection in particular fields.

9.5.4.2 Regular procedures

Acceptability is determined by executing the sampling plan and comparing the measurements of the items in the samples with the demands of the sampling plan. This statistical experiment with the lot has three possible outcomes:

  a) Lot accepted.

  b) Lot rejected. In this case the procedures in clause 10 are followed.

  c) Lot neither accepted nor rejected. This outcome is possible under reduced inspection according to the switching procedures. In this case the lot is accepted, but normal inspection will be reinstated, starting with the next lot.

Rejected lots to be 100 % inspected in accordance with the procedure described in 10.1 are accepted when all items have been accepted individually.

Rejected lots may also be accepted under certain conditions according to the procedure described in 10.2.

A lot is not accepted until it is accepted for all characteristics on which, according to the agreement of inspection, control is required.

9.5.4.3 Conditions for extended statistical inspection

In no case is it permissible to re-examine rejected lots by drawing new samples in the hope of achieving acceptance.

The specified sampling plan, being of the single or multiple stage type, is designed to have a given probability of acceptance at a given percent defective items according to the key parameters agreed. Any further chances for the lot to be accepted increase this probability of acceptance at a higher percent defective.

The possibility of inspecting more items in rejected lots is given in 10.2. This is only for the purpose of getting a better judgement of the actual percent defective items, not to redetermine the acceptability of the lot.

At his own discretion, the inspector responsible may, if according to the agreement on inspection he is competent to do so, draw more samples from accepted lots and inspected lots

and inspect them for critical defects, if he suspects that the lot contains items with critical defects.

The consumer may instruct the inspector responsible to inspect any item for critical as well as non-critical defects at the expense of the consumer. For non-critical specifications, the result of this extra inspection cannot change the status of the lot being accepted or rejected (see 7.5).

9.5.4.4 Extraordinary rejection of lots

If any item with a critical defect is found during extended inspection or even by accident, the lot is rejected for that characteristic.

9.5.4.5 Procedures for defective items in the lot

Items known by the supplier to be defective prior to the inspection follow the rules stated in 7.3.

All defective items that may be found in the lot, whether parts of planned samples or not, follow the procedures stated in clause 8.

10 Procedures for rejected lots

10.1 100 % inspected lot

The regular procedure is to inspect all the items in the lot for the characteristic in question.

Defective items found follow the procedures stated in clause 8, except in the case where a defective item is replaced by a new one.

This new item shall be presented for special inspection only for the non-conforming characteristics of the original item. The remaining inspection of the new item may be done statistically as a part of another lot.

The procedure stated here ensures that when a lot is rejected for a certain characteristic, all defective items will be found and be repaired or replaced, or possibly accepted by the consumer on satisfactory conditions.

10.2 Conditional acceptance

As an alternative to inspecting a rejected lot 100 %, it may be accepted by mutual consent on certain conditions.

Examples of main features in such conditions are fundamentally the same as in the conditions for accepting applicable defective items, in 8.2.

Accepting a rejected lot normally means, however, that the number of defective items and the severity of the non-conformity have to be guessed or estimated. The estimate may be supported by inspecting more items in the lot.

It must be pointed out that by applying this procedure the consumer is only protected (see 9.5.3.1) if the compensation is appreciably higher than his expected losses due to defects in the rejected lots.

For this reason it is recommended that the availability or not of the procedure given here is stated in the agreement of inspection. If the procedure should be available, detailed rules for estimating the defectiveness of the lot and for specifying the conditions of acceptance should also appear in the agreement of inspection.

10.3 Lot replaced by a new lot

The new lot shall be presented for routine inspection according to the sampling procedure.

As the protection of the consumer in this case may be low, the availability or not of this procedure shall be stated in the agreement on inspection.

11 Approval by the quality control of the supplier

The routine quality control function, which guides the production process at the supplier's end could be used for the approval of the products. In this case the production process, rather than the individual items or lots, is approved.

According to this procedure the quality control is to be supervised by the consumer or an independent organization, and if the defined quality statistics or parameters of the control method are within the limits agreed upon within a certain time interval, the production in a certain period is approved.

The methods of control and approval could be similar to the methods given in this part of ISO 3443, i.e. inspection of the finished products or items — in which case the procedure is similar to that in 9.5.1.4. It is, however, generally recommended in the field of quality control that every step or logical group of steps in the production process be controlled immediately afterwards in order to achieve a faster and more explicit feedback.

No further standardization or recommendations referring to the procedure indicated here are given in this part of ISO 3443, but it is strongly emphasized that the most cost-effective way of using the sums laid down for inspecting the products is to utilize the measurements not only for acceptance or rejection, but to get, in addition, better guidance of the production process in order to minimize the number of defective items produced.

12 Agreement on inspection

12.1 General

This matter is only treated here by listing the various items to be considered when making an agreement on inspection.

It is generally recommended that national institutes or trade organizations make standard agreements on inspection based on the principles in International Standards and in accordance with local conditions, possibly in the form of norms which could be referenced together with International Standards in

the agreement between the parties. This will ensure uniformity and minimize clerical work.

12.2 Contents of an agreement on inspection

An agreement on inspection shall contain the following information:

a) definition of the parties and the products in question;

b) reference to general tolerance specifications and definitions of the physical conditions under which the tolerance specifications shall apply;

c) definition of the characteristics to be controlled and which are specified as critical;

d) reference to the specifications of the method of measurement;

e) general reference to the rules stated in this International Standard and stated in other standards covering relevant fields of application;

f) designation of the inspector responsible and definition of his field of competence;

g) specification of the form and content of the inspection journal. As a general rule the original readings of the instruments, i.e. before any corrections due to deviating reference conditions or according to the calibrations, should appear and possibly a complete recording of the calibration checking procedures. Further the conditions of filing and availability of the journal to other companies or organizations should be defined;

h) a clause stating how possible disagreements are settled, e.g. by arbitration;

i) place and time of the inspection. The items should be inspected at such an early stage that possible rejection will not delay the building project or incur unnecessary costs;

j) the inspectors who will carry out the measurements, etc.;

k) distribution of the costs for the original inspection and the additional inspection in case of rejection. It is generally recommended that all inspection costs caused by rejection be paid by the supplier, and that the supplier as well benefits from any savings caused by the reduced inspection according to the switching procedures and multiple sampling;

l) definition of the term item if necessary and specification of the formation of lots and drawing of samples;

m) sampling procedure for statistical inspection. If the switching procedures are applied, the rules shall be indicated;

n) rules for conditional acceptance of applicable defective items (see 8.2);

o) the availability or not of conditional acceptance of rejected lots; see 10.2. If available, detailed rules shall also appear;

p) the availability or not of replacing a rejected lot with a new lot (see 10.3);

q) indication, as necessary, of the time of delivery (see 7.4);

r) rules for co-operation with a supervising organization, as necessary (see 9.5.1.4 and clause 11);

s) a list of surveyors recognized for extraordinary inspection, as necessary (see 7.5).

13 Method of measurement

13.1 General

The main objective here is to point out some important factors to be considered in connection with setting up of agreements on inspection and specification of the methods of control.

Detailed standardization of methods of measurement are found in other International Standards covering particular fields of application within the building industry. These methods are in general not compulsory.

If the method of measurement, and the physical conditions under which the measurements shall be performed, are not completely defined in the tolerance specifications, this shall be done in other documents and referenced in the agreement on inspection.

13.2 Accuracy demands

The control shall be carried out in such a way that the inaccuracies of the method of measurement are insignificant for the acceptance or rejection of the items, at a reasonable level, in accordance with the economic factors involved.

If nothing else can be shown to be better, it is recommended that the tolerances of the resulting systematic error and the resulting standard deviation of the random errors are below one in five and one in ten respectively of the tolerance width for the characteristic in question. In case of one-sided tolerance intervals, the interval of the normal variability of the production process could be used analogously for the calculation of the limit of the errors.

Accordingly, the specification of the method of measurement shall include an error analysis and the accuracy demands of the instruments and operation. For this reason, it is most convenient to specify a standardized method of measurement.

13.3 Reference conditions

The reference conditions are the specified time of control and the specified physical conditions of the items during the measurements, such as temperature, moisture content and support.

The reference time is normally the time of delivery, but for practical reasons the control measurements are often carried out at a different time.

Deformations caused by different conditions, e.g. temperature and support, and by creep and shrinkage may be important compared to the variabilities of the production and should be observed.

When measuring at a different time and under different physical conditions than those specified, it may be necessary to make a conversion to the reference conditions, taking into account the change of temperature, shrinkage, and elastic and plastic deformations, etc.

14 Techniques of statistical inspection

14.1 General

The objective of this clause is to give basic information about statistical inspection and the choice of proper sampling plans.

Control engineers and personnel designated as inspectors responsible are recommended to be familiar with International Standards for statistical inspection listed in clause 3.

Knowledge of ISO 3951 is mandatory when inspecting by variables, as the somewhat comprehensive information and material necessary for this is not duplicated here.

Further information is given in ISO 2859/Add. 1.

14.2 Choice between inspection by attributes and variables

The definitions of the two different methods of inspection are given in annex B.

In ISO 3951 several points to be considered when choosing between inspection by attributes and variables are listed.

The following points should especially be considered:

a) Variables sampling has an advantage when the inspection process is expensive, as the necessary sample size to get a given discrimination between lots of good and poor quality is smaller for inspection by variables than by attributes. The gain is, however, small for small sizes.

b) Inspection by variables gives more information about the quality of the production process and the possible changes.

c) The use of inspection by variables is limited to lots and characteristics where the distribution of the variable to be controlled is known to be rather close to the Normal Probability Function. Otherwise the effective AQL and the protection of the parties are unknown.

d) Inspection by variables can be applied only for characteristics which can be represented by one single numerical value. It is often difficult to define such quantities in cases of, for instance, form tolerance specifications. Further, each characteristic has to be considered separately, while several characteristics could be grouped when they are inspected by attributes.

It may very well be advantageous that some characteristics are inspected by attributes while other characteristics in the same lot are inspected by variables.

14.3 Formation of inspection lots

The items to be inspected are grouped in lots according to the rules stated in the agreement on inspection. The lots shall be clearly defined after formation.

A lot may comprise the total production in a certain period of time from one supplier to one consumer. Larger lots draw lesser inspection costs per item.

It should be emphasized, however, that a better discrimination between lots of good and poor quality is obtained by dividing the total production into lots of some homogeneity. For instance, the lots could comprise the items from the different production sections at the supplier, or the items from the different moulds or other equipment, or the items from the different teams of workers or operators.

14.4 Switching procedures

The user of this part of ISO 3443 is referred to ISO 2859 when the switching procedures are applicable according to 9.5.1.1.

The fundamental principles are briefly summed up here for general information.

Normal, tightened or reduced inspection shall continue unchanged for each characteristic on successive lots except where the switching procedures require a change. The switching procedures shall be applied to each characteristic independently.

Switch from normal to tightened inspection takes place when two out of five or fewer consecutive lots have been rejected.

Switch from tightened to normal inspection takes place when five consecutive lots have been accepted.

Switch from normal to reduced inspection may take place when the preceding ten lots (or more in certain cases) have been accepted on normal inspection and none have been rejected. Further, the total number of defective items in these lots is limited, and the production should be at a steady rate.

Switch from reduced to normal inspection takes place if one of the following occurs: a lot is rejected, a lot is neither accepted nor rejected (see 9.5.4.2), production becomes irregular or delayed, etc.

14.5 Inspection level

The inspection level determines the relationship between the lot size and the sample size.

Normally level II is used, but if greater discrimination between lots of good and poor quality is justified, level III may be specified. If lower inspection costs at the expense of the descrimination is justified, level I or some of the special levels may be specified.

If the concept of LQ is used, the sample size is determined independently of the lot size and the inspection level.

14.6 Selection of proper sampling plan

14.6.1 General

The aim of this clause is to make it possible to select sampling plans in accordance with the key parameters if they are specified as recommended in 9.5.3. In the most common cases, full support is given here. Otherwise a quick entry to the tables and diagrams in ISO 2859 and ISO 3951 is given.

Frequently both AQL and LQ are specified, or two points of the desired OC-curve are defined. Proper sampling plans could be chosen after consulting the OC-curves in the respective International Standards.

14.6.2 AQL and lot size specified

14.6.2.1 Inspection by attributes and the key parameters within the domain of table 1

If the inspection level is II and the values of AQL and lot size are within the respective intervals covered by table 1, the proper sampling plan can be chosen directly from table 1.

For the specified AQL and lot size the proper sample size, acceptance, number and rejection number are given.

14.6.2.2 Inspection by attributes and the key parameters outside the domain of table 1

The user is referred to ISO 2859.

The lot size and inspection level in table 1 are transformed into a code letter for sample size. This code letter and the specified AQL are the entries to the master tables for sampling plans (tables II-A to IV-C).

Different master tables are given for normal, tightened and reduced inspection. Where the inspection cost per item is high compared to the cost of organizing the inspection, multiple or double sampling plans should be chosen wherever possible.

14.6.2.3 Inspection by variables

The user is referred to ISO 3951. The lot size and inspection level in table I-A are transformed into a code letter. This code letter and the specified AQL are the entries in the tables and diagrams in section three to the proper sample size and the proper value of k in case of a single-sided tolerance specification or the proper acceptance curve for double-sided tolerance specification.

14.6.3 LQ specified, critical defects

14.6.3.1 Inspection by attributes

The specified LQ is the entry in table 2 to get the proper sample size. Note that the values of LQ, when expressed in terms of percent defective items, are different from the value when expressed in defects per 100 items.

If the specified LQ is not equal to one of the values in table 2, the nearest value is chosen. If the indicated sample size is near to or larger than the lot size, 100 % inspection is specified.

14.6.3.2 Inspection by variables

The user is referred to ISO 3951. Successively for each code letter the OC-curve, which has the least AQL, is considered. The OC-curve among those having the quality with 10 % probability of acceptance nearest to the specified LQ is chosen.

The k -value or the s -acceptance curve for this code letter and AQL together with the proper sample size are specified for the sampling plan.

14.7 Sampling

The number of items in the sample is the sample size.

It is very important to ensure that the set of items in the sample is representative of the lot. Two methods are recommended:

14.7.1 Simple random sampling

This is best carried out by giving the items numbers, and drawing the sample by means of a table of random numbers. The numbering of the items may be purely mental, for instance the number may indicate the position of the item in the store or on the site or be the chronological production sequence number.

14.7.2 Stratified sampling

The lot is divided into sub-lots according to some logical criterion such as items deriving from the same production equipment or team of operators. The sample is drawn by taking a sub-sample from each sub-lot proportionate in size to the size of the sub-lot. The sub-samples are drawn by simple random sampling.

When using double or multiple sampling plans, special attention shall be paid to ensuring that each sample is representative of the entire lot.

More information about the technique of drawing samples including a table of random numbers is given in ISO 2859/Add 1., table 1.

Annex A

Tables for statistical inspection

A.1 Sampling plans

Table 1 — Sampling plans for specified AQL and lot size: inspection by attributes

Lot size	Code letter in ISO 2859	AQL 4			AQL 6,5			AQL 10		
		Sample size n	Ac	Re	Sample size n	Ac	Re	Sample size n	Ac	Re
2 to 8	A	3	0	1	2	0	1	5	1	2
9 to 15	B	3	0	1	2	0	1	5	1	2
16 to 25	C	3	0	1	8	1	2	5	1	2
26 to 50	D	13	1	2	8	1	2	8	2	3
51 to 90	E	13	1	2	13	2	3	13	3	4
91 to 150	F	20	2	3	20	3	4	20	5	6
151 to 280	G	32	3	4	32	5	6	32	7	8
281 to 500	H	50	5	6	50	7	8	50	10	11

Ac = acceptance number
Re = rejection number

The table is based on tables in ISO 2859.
Inspection level II, normal inspection.

NOTE — The OC-curves of the sampling plans with acceptance number 0 have non-favourable shapes (see ISO 2859). It might be better to select the plans with acceptance number 1, although they have larger sample sizes.

Control procedure is as follows:

a) A number of items equal to the sample size is drawn at random and inspected.

b) If the number of defective items or number of defects is less than or equal to the acceptance number, the lot is accepted. Otherwise the lot is rejected.

A.2 Limiting quality

Table 2 — Limiting quality (in per cent defective items or defects per hundred) for which the probability of acceptance is 10 %

LQ		Sample size
Per cent defective	Defects per 100 items	n
37	46	5
25	29	8
16	18	13
11	12	20
6,9	7,2	32
4,5	4,6	50
2,8	2,9	80
1,8	1,8	125
1,2	1,2	200
0,73	0,73	315
0,46	0,46	500

Values from ISO 2859.

Inspection by attributes.

Acceptance number = 0

Rejection number = 1

Control procedure is as follows:

a) A number of items equal to the sample size is drawn at random and inspected.

b) If no defects are found, the lot is accepted. If one or more defects are found, the lot is rejected.

A.3 Preferred AQL values

Table 3 — Preferred AQL values in the tables of ISO 2859 for inspection by attributes

AQL	Sample size n
0,01	10
0,015	15
0,025	25
0,04	40
0,065	65
0,1	100
0,15	150
0,25	250
0,4	400
0,65	650
1	1 000
1,5	
2,5	
4	
6,5	

The values for AQL are in percent defective items, max. 10 %, or in defects per 100 items.

The available interval depends on the sample size and is smaller in ISO 3951 for inspection by variables.

Annex B

Definition of statistical terms

For the purposes of this part of ISO 3443, the following definitions, which are taken from ISO 3534, apply.

B.1 process average: The quality of a production estimated from successive samples taken from lots in the original inspection.

B.2 acceptable quality level: A quality level which in a sampling plan corresponds to a specified but relatively high probability of acceptance.

It is the maximum percent defective (or the maximum number of defects per hundred units) that, for purposes of sampling inspection can be considered satisfactory as a process average.

NOTE — The abbreviation AQL is used in this part of ISO 3443.

B.3 defect: Any non-conformance of an item with specified requirements.

B.4 defective (item): An item containing one or more defects.

B.5 limiting quality: In a sampling plan, a quality level which corresponds to a specified and relatively low probability of acceptance. It is the limiting lot quality characteristic that the consumer is willing to accept with a low probability that a lot of this quality would occur.

When expressed as percent defective, it may be referred to as lot tolerance percent defective.

NOTE — The abbreviation LQ is used in this part of ISO 3443.

B.6 inspection by attributes: A method which consists in taking note, for every item of a population or of a sample taken from this population, of the presence or absence of a certain qualitative characteristic (attribute) and in counting how many items have or do not have this characteristic.

B.7 inspection by variables: A method which consists in measuring a quantitative characteristic for each item of a population or of a sample taken from this population.

Annex C

Hierarchic table of contents