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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)

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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)

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Foreword

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

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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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)

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.*

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:

$$D - B \leqslant X \leqslant D + A$$

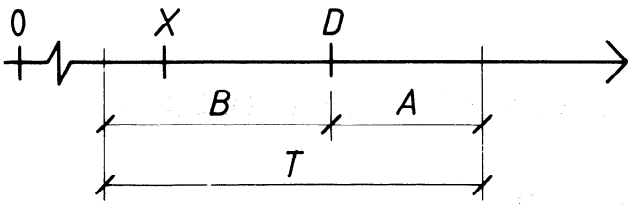

Figure 1

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

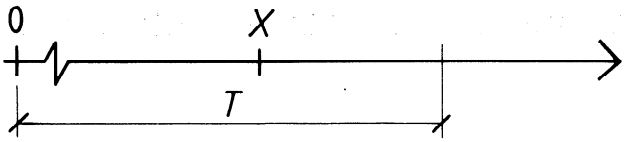

Figure 2

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.

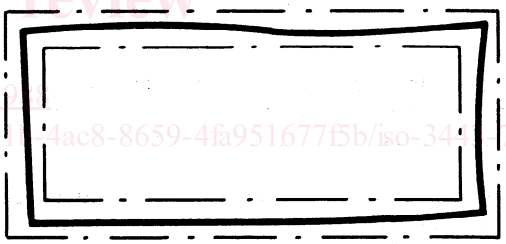

Figure 3

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 re-inspection according to the procedure described in 8.3 is not in this connection regarded as defective prior to the re-inspection.

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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.

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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:

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.

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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-