INTERNATIONAL STANDARD

ISO
3443-3

First edition
1987-02-15

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION
ORGANISATION INTERNATIONALE DE NORMALISATION
МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ

Tolerances for building —

Part 3:
Procedures for selecting target size and predicting fit

Tolérances pour le bâtiment —

Partie 3: Procédés pour choisir la dimension recherchée et prévoir l'ajustement

Reference number
ISO 3443-3 : 1987 (E)

Foreword

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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 3443-3 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.

Printed in Switzerland

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Annexes

Tolerances for building —

Part 3:
Procedures for selecting target size and predicting fit

0 Introduction

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

It should be read in conjunction with parts 1 and 2 of ISO 3443, ISO 1803-1 and ISO 1803-2.

Parts 3 and 4 of ISO 3443 have been produced to meet the needs for internationally agreed methods of relating accuracy, tolerances and fit in the determination of sizes for components and construction (and, in part 4, joints). Two distinct needs are identified, though both share common ground.

There is thus a need to provide generally applicable expressions relating accuracy, tolerances and fit, that can be drawn upon either

a) to identify optimum target sizes for standard components where each type of component has a variety of applications, or

b) to identify appropriate limits of size for components, whether standard or not, for application in a specific building.

Both needs can be met by expression of substantially the same relationships between the factors affecting fit, and in principle either part might be pressed into service to meet either aim. In practice, however, each is structured to serve its particular purpose.

Joints in more than one dimension are however only considered in part 4 of ISO 3443.

This part of ISO 3443 is structured primarily to meet the aims in a) above. It provides procedures for selecting target sizes (formerly "work sizes") for components or *in situ* parts, such that joint clearances will be within their required limits with a known probability of success.[1] The procedures deal with the relationship between the following factors:

1) accuracy of components and *in situ* work;

2) sizes of components and *in situ* work;

3) joint clearances;

4) probability of fit;

and they can be used whether 2), 3) or 4) above is the unknown to be calculated. The procedures assume that values for 1) above have been established by measurement surveys and relate target sizes to coordinating sizes using the concepts of "extension" and "deduction". See 4.4 and 4.5.

The procedures also enable a target size to be calculated for any standard component, such that the component will have an optimal probability of fit in all its applications.

Worked examples are given in annex B.

Part 4 of ISO 3343 is structured primarily to meet the needs in b) above. It is therefore concerned primarily with the design of buildings in which components (including standard components) are used, and is aimed primarily at building designers who, as engineers, can be expected to be mathematically and statistically competent. It is to meet these aims that part 4 of ISO 3443 deals with

- methods for predicting deviations and specifying tolerances to obtain a particular desired total accuracy in an assembly;
- the effect of specified tolerances on expected size variability;
- the basis for optimization of tolerances for each particular assembly and its elements.

Part 4 of ISO 3443 presupposes calculations only for assemblies with elements of one dimension, such as beams and columns, for the sake of simplicity. However, tables for common cases with elements of two and three dimensions (panels, etc.) are given in the annex to part 4.

1 Scope

This part of ISO 3443 provides a basis for relating joint clearances and target sizes and for the prediction of fit within the context of dimensional coordination, including modular coordination.

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[1] This part deals with accuracy in terms of target size and limits of size (e.g. upper and lower limits of component size). Alternatively, accuracy can be defined in terms of permitted deviations in relation to a reference size — usually identical with the target size. See ISO 1803-1.

2 Field of application

This part of ISO 3443 is for use by component manufacturers when determining target sizes for standard components; it is also for use by building designers when determining target sizes for construction on site, assessing the applicability of standard components or determining target sizes for non-standard components. The applicability of the procedures is further described in 6.1 and 6.2.

3 References

ISO 1791, *Modular co-ordination — Vocabulary.*

ISO 1803-1, *Tolerances for building — Vocabulary — Part 1: General terms.*

ISO 1803-2, *Tolerances for building — Vocabulary — Part 2: Derived terms.*

ISO 3443-1, *Tolerances for building — Part 1: Basic principles for evaluation and specification.*

ISO 3443-2, *Tolerances for building — Part 2: Statistical basis for predicting fit between components having a normal distribution of sizes.*

ISO 3443-4, *Tolerances for building — Part 4: Methods for predicting deviations of assemblies and the allocation of tolerances.*

4 Definitions

For the purposes of this part of ISO 3443, the definitions given in ISO 1791 and ISO 1803, and as follows, are applicable.

4.1 systematic deviation: Mean deviation of the type of space or component[1] considered (to be found by measurement of a representative sample of constructed spaces, or of components[1], of the type considered).

See ISO 3443-2.

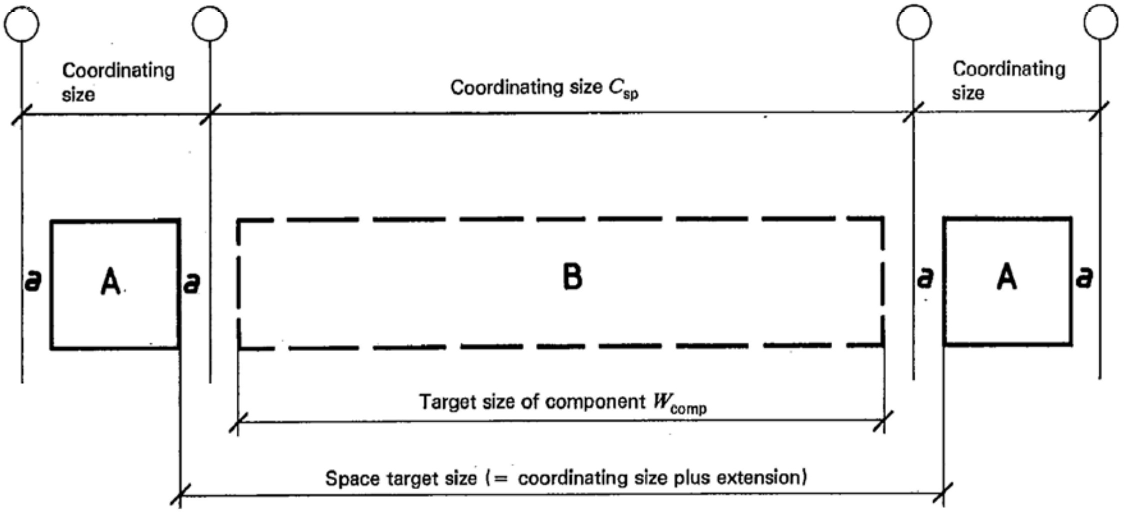
4.2 standard deviation: Positive square root of the mean of the squares of the deviations.

4.3 space target size: Intended size of an opening formed between two erected components[1].

NOTE — The size is equal to the sum of the coordinating size of the space and its extension.

4.4 extension: Amount by which the target size of a space exceeds its coordinating size (see figure 1).

4.5 deduction: Amount by which the target size of a component[1] is less than its coordinating size (see figure 1).



Extension = $a + a$ = Deduction for components "A"

The deduction, for the components "A" forming the space, provides the extension in the space and so produces a target size, for that space, that components "B" are to occupy.

Figure 1 — Illustration of extension and deduction

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[1] In certain cases, *in situ* work may be considered as if it were a component.

5 Symbols

C_{sp}	Space coordinating size
D	Deduction
E	Extension
E_{max}	Maximum extension
E_{min}	Minimum extension
J	Joint clearance (required by a chosen jointing technique)
J_{max}	Maximum joint clearance (required by a chosen jointing technique)
J_{min}	Minimum joint clearance (required by a chosen jointing technique)
j	Predicted joint clearance
j_{max}	Maximum predicted joint clearance
j_{min}	Minimum predicted joint clearance
μ	Systematic deviation
μ_{comp}	Systematic deviation of component[1]
μ_{sp}	Systematic deviation of space
n	The number of components occupying a constructed space
Q	Multiplier of the standard deviation corresponding to a selected probability of joint clearances being too large
q	Multiplier of the standard deviation corresponding to a selected probability of joint clearances being too small
r	The mean of correlation coefficients between the sizes of all possible pairs of components
σ_{comp}	The standard deviation of the total[2] dimensional variability, induced in manufacture of a component, along the axis considered
σ_{sp}	The standard deviation of the total[2] dimensional variability that is characteristic of the type of space, along the axis considered
W_{comp}	Target size of component[1]
W_{max}	Component size — upper target size limit[1]
W_{min}	Component size — lower target size limit[1]

6 Basis of procedures

Induced and inherent deviations[3] (see ISO 3443-1) potentially prevent the achievement, on site, of joint clearances that are within the working limits of a jointing technique.

The procedures recommended in this part of ISO 3443 enable selection of suitable target sizes for components and construction so that joints that are within their required clearance limits can be achieved. The procedures also enable selection of jointing techniques that have suitable clearance limits when some or all of the target sizes are predetermined (as when standard components are used).

In either application the procedures enable prediction of the probability that joints on site will be within their clearance limits. The procedures are designed to predict the chance of misfitting either the minimum or maximum joint clearance of which the chosen jointing technique is capable.

6.1 Assumptions

6.1.1 Deviations

Dimensional variability data are for the general case of each form of construction or component; that is, it is assumed that tolerances have not yet been applied and that deviations for both components and *in situ* work therefore follow normal distributions about a mean the value of which is influenced by systematic deviation. The values of mean and standard deviation which are required as a description of dimensional variability may be estimated from measurement surveys; alternatively, standard deviation may be estimated from tolerance specifications combined with acceptance criteria, it being then assumed that systematic deviation is zero.

6.1.2 Criteria for fit

Two factors, acting in conjunction, determine whether or not fit will be achieved. These factors are as follows:

a) the specified upper and lower limits of joint clearance;

b) the capability of the selected jointing technique to function satisfactorily within those limits.

In order to predict fit, this part of ISO 3443 requires that target sizes are to be derived from coordinating or modular sizes. The calculations make use of extension and deduction as a means of maintaining the relationship.

6.1.3 Assembly

It is assumed that those components that are erected first form spaces within which the remainder must fit with satisfactory joint clearances. It is recognized that not all building construction follows this sequence in practice but the assumption nonetheless provides a valid basis for calculation purposes.

When measurement surveys provide the accuracy data for the sizes of such constructed spaces, these data will automatically include the contributions of setting out and erection to the total variability of constructed spaces.

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[1] In certain cases, *in situ* work may be considered as if it were a component.

[2] i.e., embracing all constituent variables such as bow, twist, etc.

[3] Inherent deviations are dealt with in annex A.

It is also assumed that components which are to occupy constructed spaces can be adjusted in position to achieve joint clearances within their working limits. Alternatively, where physical adjustment of components would not be practical they, and the constructed space they are to occupy, can be measured prior to their insertion in the space concerned in order to derive an approximate uniform joint clearance to be aimed for in that assembly. It will then be clear prior to assembly whether or not the joint clearance that will be achieved will lie within the required limits of joint clearance.

As an alternative to the assumption that components can be adjusted (or measured to achieve the same end), a modification to deal with placing components in relation to a datum or grid is given in 7.6.

If two or more components in an assembly are butt-jointed, the group may be treated as if it were one component with a σ_{comp} value equal to the square root of the sum of the squares of σ_{comp} for each component.

6.1.4 Common basis of application

Provided the assumptions (in 6.1) apply, the procedures provide a common basis for

- selecting target sizes for standard components so that they can have the widest application, and for
- selecting, from standard components, those that are suitable for a specific application.

Thus the procedures enable target sizes to be derived from coordinating sizes or modular sizes so as to enable dimensional or modular coordination to be implemented at their practical level.

The procedures can also be applied when designing a specific building using non-standard components but where generalized accuracy data (for example, for "precast concrete units", or for "timber windows") are available. In this case its basis matches the common design circumstance in which particular sources of components or construction are not yet identified.

6.2 Application limitations

The objective is to provide manufacturers, building designers and builders with working procedures for predicting the probability that satisfactory fit can be achieved with the chosen sizes of components, construction and joints. The procedures are not based on a complete and mathematically exact expression of the relationships concerned and the mathematical basis is further restricted to terms for which data are usually obtainable.

The variabilities in sizes of constructed spaces and of components are assumed to follow normal distributions even if there has been prior implementation of tolerances. Prior implementation of tolerances on constructed space sizes is not possible and their size distribution is thus undisturbed. Surveys demonstrate that constructed spaces are the predominant source of variability in assemblies. It is unlikely that prior implementation of tolerances on components would affect their size distribution noticeably, for reasons of manufacturing economics. However, the deviations of size within a batch of components may tend to be similar to each other, in which case the procedure in 7.6 should be used.

The variability considered along any one axis is the total effect of all its constituent variabilities (for example, bow, twist, surface irregularity, etc.).

Commonly, the user will wish to examine one axis only but the procedures can be applied to each of the three dimensional axes in turn.

7 Procedures[1]

7.1 Selecting a component target size when all components, and all joints, are of the same type

7.1.1 Risk of misfit

Decide on acceptable risks of misfit and read the values of Q and q, from figure 2, corresponding to the risk of the joint clearance being too large and too small respectively.

In choosing risks of misfit, the consequence of misfit must be considered. For example, if the cost of dealing with a misfit is too great the risk may have to be reduced.

7.1.2 Checking the jointing technique

Before calculating the minimum and maximum target sizes for components, ensure that the jointing technique can accommodate the range of variation in actual size of components and spaces.

Check that

$$(n + 1)(J_{max} - J_{min}) > (Q + q)\sqrt{n\sigma^2_{comp} + \sigma^2_{sp}}$$

7.1.3 Component size — lower target size limit

Calculate the lower limit of component target size W_{min} as follows:

$$W_{min} = \frac{C_{sp} + E + \mu_{sp}}{n} + \frac{Q\sqrt{n\sigma^2_{comp} + \sigma^2_{sp}}}{n} - \frac{(n + 1)J_{max}}{n} - \mu_{comp}$$

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[1] Worked examples of application are given in annex B.

7.1.4 Component size — upper target size limit

Calculate the upper limit of component target size W_{max} as follows:

$$W_{max} = \frac{C_{sp} + E + \mu_{sp}}{n} - \frac{q\sqrt{n\sigma^2_{comp} + \sigma^2_{sp}}}{n} - \frac{(n + 1)\,J_{min}}{n} - \mu_{comp}$$

7.1.5 Special case

In some cases $n\sigma^2_{comp}$ is so small compared with σ^2_{sp} that the second expression in 7.1.3 becomes approximately equal to $\frac{Q\sigma_{sp}}{n}$, and the second expression in 7.1.4 becomes approximately $\frac{q\sigma_{sp}}{n}$. If σ^2_{comp} is not known but $n\sigma^2_{comp}$ can safely be assumed to be small, the same approximation can be made.

7.1.6 Selecting the target size of the component from the range calculated in 7.1.3 and 7.1.4

Use the following procedure.

a) Select any target size which lies above the lower limit and below the upper limit; or

b) If the component, being a standard component, is to have other uses, repeat the procedure in 7.1.3 and 7.1.4 for other uses and select a target size common to all of the ranges so calculated. If a size common to all of the ranges cannot be found, it may be necessary to repeat one or more of the calculations, varying the risks of misfit on other values. For example, for some uses it may be possible to accept a greater risk of misfit.

7.1.7 Calculating target sizes of components when used together with presized components

When some of the components occupying a space have predetermined target sizes, modify 7.1.3 and 7.1.4 so that the first expression

$$\frac{C_{sp} + E + \mu_{sp}}{n}$$

becomes

$$\frac{C_{sp} + E + \mu_{sp} - \Sigma W_d}{n - n_d}$$

where

ΣW_d is the sum of all the predetermined target sizes;

n_d is the number of components with predetermined target sizes.

7.2 Calculating a target size for a space to contain standard (i.e. presized) components

7.2.1 Risk of misfit

Decide on acceptable values of misfit and read the value of Q and q, from figure 2, corresponding to the risks of the joint clearance being too large and too small respectively.

7.2.2 Calculation of maximum extension

Calculate the maximum extension E_{max} (i.e. the greatest amount by which the space target size can be bigger than its coordinating size for the chosen risk of misfit) as follows:

$$E_{max} = n(W_{comp} + \mu_{comp}) + (n + 1)J_{max} - Q\sqrt{n\sigma^2_{comp} + \sigma^2_{sp}} - \mu_{sp} - C_{sp}$$

7.2.3 Calculation of minimum extension

Calculate the minimum extension E_{min} (i.e. the least amount by which the space target size must be bigger than its coordinating size for the chosen risk of misfit) as follows:

$$E_{min} = n(W_{comp} + \mu_{comp}) + (n + 1)J_{min} + q\sqrt{n\sigma^2_{comp} + \sigma^2_{sp}} - \mu_{sp} - C_{sp}$$

7.2.4 Calculation of deduction

Any extension value selected from the range calculated in 7.2.2 and 7.2.3, added to the coordinating size of the space, gives a target size for the space such that the chosen risk of misfit is not exceeded. The selected value of extension is then used as the deduction for each of the components forming the space (see figure 1).

7.3 Selecting a jointing technique when using components with a predetermined target size (for example standard components)

7.3.1 Risk of misfit

Decide on acceptable risks of misfit and read the values of Q and q, from figure 2, corresponding to the risks of the joint clearance being too large and too small respectively.

7.3.2 Minimum predicted joint clearance

Calculate the minimum clearance predicted clearance j_{min} which the jointing technique needs to accommodate, as follows:

$$j_{min} = \frac{C_{sp} + E + \mu_{sp}}{n + 1} - \frac{n(W_{comp} + \mu_{comp})}{n + 1} - \frac{q\sqrt{n\sigma^2_{comp} + \sigma^2_{sp}}}{n + 1}$$

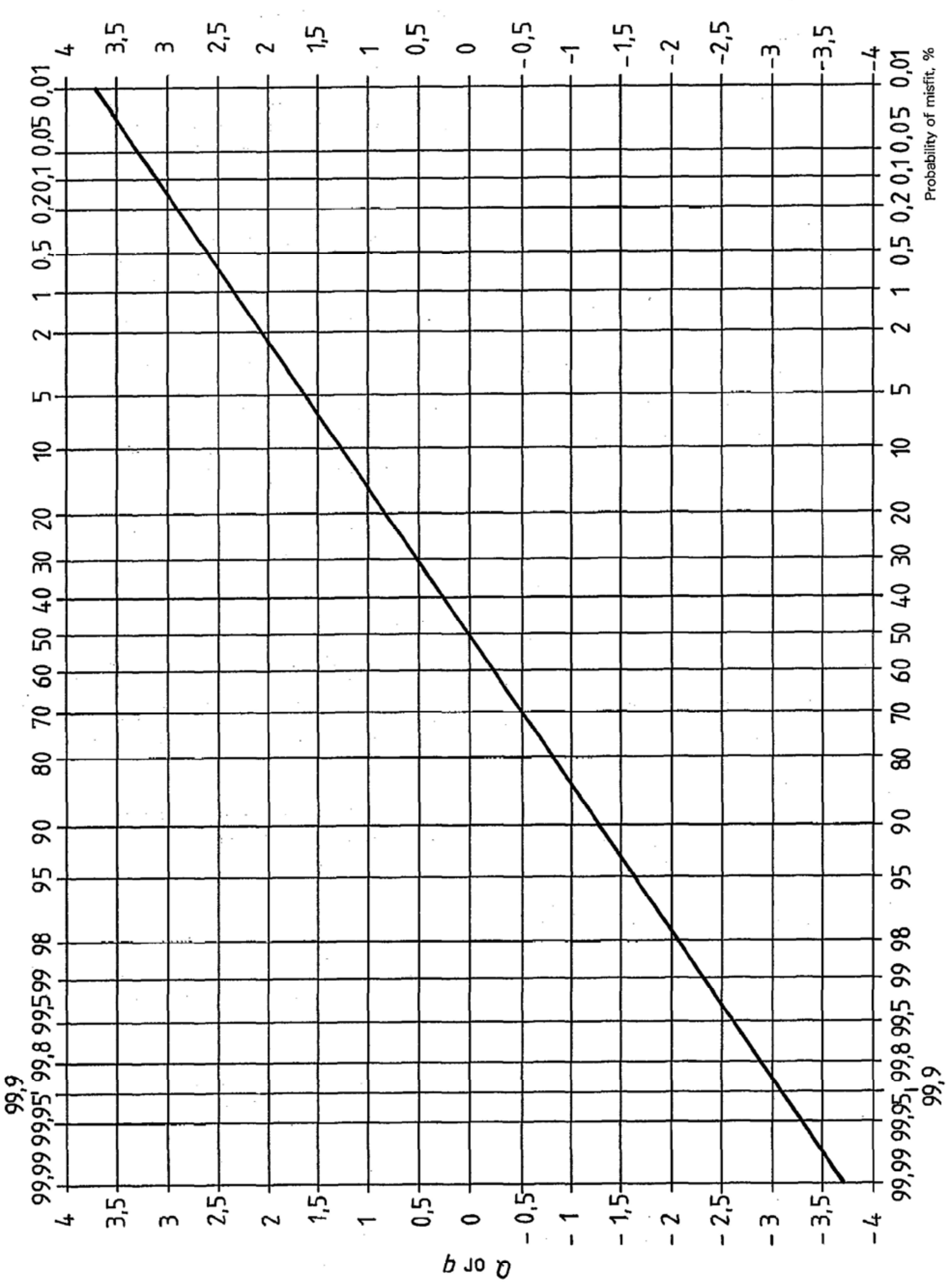

Figure 2 — *Q* and *q* relate to the probabilities of "joints too large" and "joints too small" respectively

7.3.3 Maximum predicted joint clearance

Calculate the maximum predicted clearance $j_{\max}$ which the jointing technique needs to accommodate, as follows:

$$j_{\max} = \frac{C_{\mathrm{sp}} + E + \mu_{\mathrm{sp}}}{n + 1} - \frac{n(W_{\mathrm{comp}} + \mu_{\mathrm{comp}})}{n + 1} + \frac{Q\sqrt{n\sigma^2_{\mathrm{comp}} + \sigma^2_{\mathrm{sp}}}}{n + 1}$$

7.3.4 Special case

As specified in 7.1.5, the third expressions in 7.3.2 and 7.3.3 may be approximately equal to

$$\frac{q\sigma_{\mathrm{sp}}}{n + 1} \text{ and } \frac{Q\sigma_{\mathrm{sp}}}{n + 1} \text{ respectively.}$$

7.3.5 Selecting the jointing technique

The jointing technique, or battery of techniques, selected must be capable of accommodating the whole range of clearances between the maximum and the minimum, and therefore $J_{\min}$ must be less than the calculated minimum joint clearance in 7.3.2 and $J_{\max}$ must be greater than the calculated maximum joint clearance in 7.3.3.

7.4 Procedure for dealing with components or joints with dissimilar characteristics

7.4.1 Different values of component target size and component systematic deviation

The calculations in 7.3.2 and 7.3.3 assume that the values for the expression:

> $W_{\mathrm{comp}} + \mu_{\mathrm{comp}}$ (target size of component + systematic deviation of component)

are equal for all the n components. If they differ significantly add them together instead of multiplying them by n.

7.4.2 Different values of $J_{\min}$

The calculation in 7.1.4 assumed that all of the $(n + 1)$ joints have equal values for $J_{\min}$. If they differ, add their values for $J_{\min}$ together instead of multiplying $J_{\min}$ by $(n + 1)$.

7.5 Procedure if some joints in a sequential assembly are to be constructed to a constant width

Sometimes a constant joint width is to be achieved between successive components until the last few components are placed, when the last few joints have to share the remaining gaps. In such cases, in the calculations, treat the constant width joints as though they were components.

7.6 Procedure if deviations are not independent

Where more than one component is to occupy a space, the calculations assume that all deviations are independent of each other. This cannot be assumed if, for example, it is known that components will all be produced from the same mould, or if gaps will be determined by the occurrence of oversized or undersized components, as when placing every component in relation to a grid.

Such dependencies are called correlations, and the strength of a dependency is measured by the correlation coefficient, r. This is zero, for example, when components are drawn randomly from stock made up of many production runs, but could be as high as 0,8 when components come from the same mould over a comparatively short production run.

If a number, m, of the component size deviations are mutually correlated, the expression

$$\sqrt{n\sigma^2_{\mathrm{comp}} + \sigma^2_{\mathrm{sp}}}$$

becomes

$$\sqrt{n\sigma^2_{\mathrm{comp}} + rm(m - 1)\sigma^2_{\mathrm{comp}} + \sigma^2_{\mathrm{sp}}}$$

The value of r will seldom be known accurately, so that it must be estimated subjectively. If there is reason to believe that positive mutual correlation will exist, it is better to use an arbitrary value for r of, say, 0,5 than to neglect it. However in the calculation of target sizes for standard components for general use, correlation between component sizes may be ignored.

Annex A

Inherent deviations[1]

A.1 Modifications to the procedures to take account of inherent deviations (see ISO 3443-1) are as follows:

A.1.1 Additional symbols

N_c	The arithmetic sum of those parts of the reversible inherent deviations affecting the component that tend to reduce its size, averaged over all components
N_j	The arithmetic sum of those parts of the reversible inherent deviations in the components or elements affecting a joint that tend to reduce joint clearance
P_c	The arithmetic sum of those parts of the reversible inherent deviations affecting the component that tend to increase its size
P_j	The arithmetic sum of those parts of the reversible inherent deviations in the components or elements affecting a joint that tend to increase joint clearance

A.1.2 Modification of expressions

Modify the expressions in the body of this standard as follows.

In 7.1.2, substitute:

$$(n+1)(J_{\text{max}}-J_{\text{min}}) > (Q+q)\sqrt{n\sigma^2_{\text{comp}}+\sigma^2_{\text{sp}}}+P_j+N_j$$

In 7.1.3 add N_c to the component size — lower target size limit W_{min}.

In 7.1.4 subtract P_c from the component size — upper target size limit W_{max}.

In 7.3.2 subtract $\frac{n}{n+1} \times P_c$ from the minimum predicted joint clearance j_{min}.

In 7.3.3 add $\frac{n}{n+1} \times N_c$ to the maximum predicted joint clearance j_{max}.

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[1] When including the effects of inherent (time-dependent) deviations, which can be appropriate where components have one or more dimensions exceeding 2 m, the accuracy analysis should generally be done at both assembly and service stages. The resulting accuracy characteristics are then determined on the basis of calculation at both stages.

Annex B

Worked examples

B.1 Horizontal axis, single component

B.1.1 General

In this example the target size of an aluminium window has to be determined for the situation when a design requires windows to be fitted singly into spaces between two unplastered concrete columns cast *in situ*. Data are as follows. (See figure 3.)

Column coordinating size C_{col} = 300 mm

Column target size W_{col} = 270 mm

Space coordinating size C_{sp} = 2 100 mm

Space target size W_{sp} = 2 130 mm

Space standard deviation σ_{sp} = 8,9 mm

Space systematic deviation μ_{sp} = 1,9 mm } taken from accuracy surveys

Component systematic deviation μ_{comp} = 0 mm } assumed to be small enough to be ignored

Component standard deviation σ_{comp} = 1 mm } assumed to have been obtained from measurement surveys

Number of components n = 1

Min. clearance required by the jointing technique J_{min} = 5 mm

Max. clearance required by the jointing technique J_{max} = 35 mm

B.1.2 Deduction and extension

The calculations are as follows:

Deduction D (for columns) = 300 − 270 = 30 mm

therefore

Extension E (for space) = 30 mm

B.1.3 Risk of misfit (see 7.1.1)

In the case of aluminium windows, misfits that are too tight cannot be readily modified. Therefore a low probability of misfitting the minimum joint clearance will be required. 1 in 1 000 is appropriate. The corresponding value of q is given by the graph at figure 2 as $q = 3,1$. The probability of misfitting the maximum joint clearance can be much higher. 1 in 20 is acceptable, $Q = 1,6$.

B.1.4 Checking the jointing technique (see 7.1.2)

$$(n + 1)(J_{max} - J_{min}) = 2\ (35 - 5) = 60 \text{ mm}$$

$$(Q + q)\sqrt{n\sigma^2_{comp} + \sigma^2_{sp}} = 4,7 \times \sqrt{1 \times 1^2 + 8,9^2} = 42,1 \text{ mm}$$

The former is greater, so the jointing technique can accommodate the range of variation in actual size of the component and space.

Dimensions in millimetres

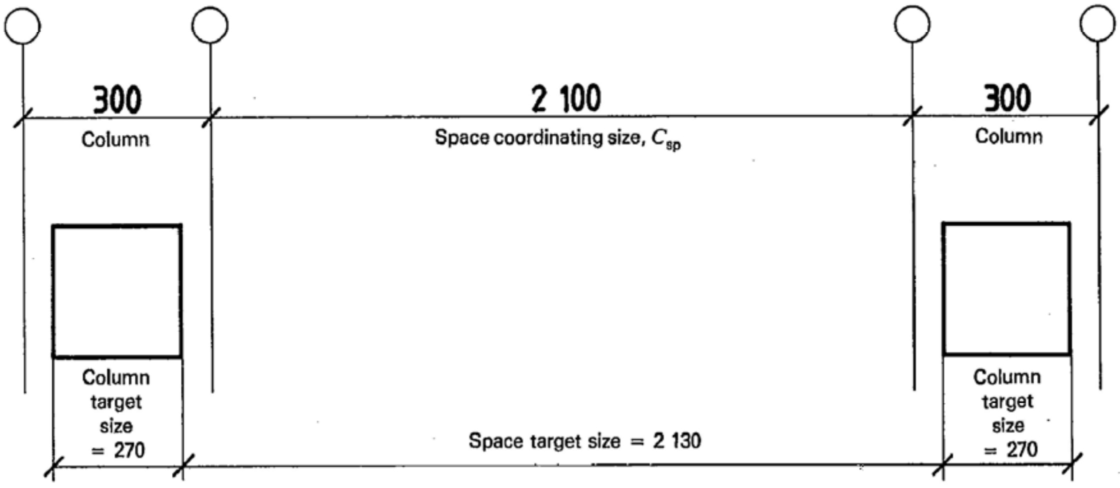

Figure 3 — Plan of opening between columns for a window

B.1.5 Component size — lower target size limit (see 7.1.3)

$$\frac{C_{sp} + E + \mu_{sp}}{n} = \frac{2\,100 + 30 + 1{,}9}{1} = 2\,131{,}9 \text{ mm}$$

plus

$$\frac{Q\sqrt{n\sigma^2_{comp} + \sigma^2_{sp}}}{n} = \frac{1{,}6 \times \sqrt{1 \times 1^2 + 8{,}9^2}}{1} = 14{,}3 \text{ mm}$$

minus

$$\frac{(n + 1)J_{max}}{n} = \frac{2 \times 35}{1} = 70 \text{ mm}$$

minus

$$\mu_{comp} = 0 \text{ mm}$$

Component size — lower target size limit $W_{min} = 2\,131{,}9 + 14{,}3 - 70 - 0 = 2\,076$ mm.

B.1.6 Component size — upper target size limit (see 7.1.4)

$$\frac{C_{sp} + E + \mu_{sp}}{n} = 2\,131{,}9 \text{ mm (see B.1.5)}$$

minus

$$\frac{q\sqrt{n\sigma^2_{comp} + \sigma^2_{sp}}}{n} = \frac{3{,}1 \times \sqrt{1 \times 1^2 + 8{,}9^2}}{1} = 27{,}8 \text{ mm}$$

minus

$$\frac{(n + 1)J_{min}}{n} = \frac{2 \times 5}{1} = 10 \text{ mm}$$

minus

$$\mu_{comp} = 0 \text{ mm}$$

Component size — upper target size limit $W_{max} = 2\,131{,}9 - 27{,}8 - 10 - 0 = 2\,094$ mm

B.1.7 Selecting a component target size (see 7.1.6)

2 085 mm would be ideal but 2 090 mm would be perfectly acceptable and probably more convenient, i.e. 10 mm less than the coordinating size.

B.1.8 Known target size of component

If in this example the target size of the aluminium window were already known from a manufacturer's catalogue, the extension (and hence the target size for the space and for the column) can be calculated (see 7.2). The maximum and minimum joint clearances will be taken to be the same as those in B.1.1 and the same risks of misfit adopted. Thus $Q = 1{,}6$ and $q = 3{,}1$.

B.1.9 Maximum extension (see 7.2.2)

$$n(W_{comp} + \mu_{comp}) = 1 \times (2\,090 + 0) = 2\,090 \text{ mm}$$

plus

$$(n + 1)J_{max} = 2 \times 35 = 70 \text{ mm}$$

minus

$$Q\sqrt{n\sigma^2_{comp} + \sigma^2_{sp}} = 1{,}6 \times \sqrt{1 \times 1^2 + 8{,}9^2} = 14{,}3 \text{ mm}$$

minus

$$\mu_{sp} = 1{,}9 \text{ mm}$$

minus

$$C_{sp} = 2\,100 \text{ mm}$$

Maximum extension $E_{max} = 2\,090 + 70 - 14{,}3 - 1{,}9 - 2\,100 = 43{,}8$ mm

B.1.10 Minimum extension (see 7.2.3)

$$n(W_{comp} + \mu_{comp}) = 1 \times (2\,090 + 0) \text{ mm} = 2\,090 \text{ mm}$$

plus

$$(n + 1)J_{min} = 2 \times 5 = 10 \text{ mm}$$

plus

$$q\sqrt{n\sigma^2_{comp} + \sigma^2_{sp}} = 3{,}1 \times \sqrt{1 \times 1^2 + 8{,}9^2} = 27{,}8 \text{ mm}$$

minus

$$\mu_{sp} = 1{,}9 \text{ mm}$$

minus

$$C_{sp} = 2\,100 \text{ mm}$$

Minimum extension $E_{min} = 2\,090 + 10 + 27{,}8 - 1{,}9 - 2\,100 = 25{,}9$ mm

B.1.11 Space target size

A value of extension within the range 25,9 mm to 43,8 mm, say 30 mm, when added to the space coordinating size gives the space target size.

Target space size $W_{sp} = 2\,100 + 30 = 2\,130$ mm.

B.1.12 Column target size

This selected value of extension for the infilling component is also the value of deduction for the members, the columns, forming the space.

Column target size $W_{col} = 300 - 30 = 270$ mm.

B.2 Horizontal axis, three components

B.2.1 General

In this example, three timber framed panels manufactured to known target sizes have to be fitted into the space between the ends of precast concrete cross walls and the resulting joint clearances have to be calculated. The timber panels will be of two types, two with a coordinating size of 2 100 mm and one with a coordinating size of 900 mm. The panels are standard components and have a target size 10 mm less than the coordinating size. Measurement surveys show that systematic error in manufacture produces a deviation of the mean of − 1,3 mm on the length of each panel. Inherent deviations will not be taken into account in this example. Data are as follows. (See figure 4.)

Component coordinating size for C1, $C_{\text{comp, C1}}$	= 2 100 mm	
Component coordinating size for C2, $C_{\text{comp, C2}}$	= 900 mm	
Space target size W_{sp}	= 5 140 mm	
Space standard deviation σ_{sp}	= 8,8 mm	from accuracy surveys
Space systematic deviation μ_{sp}	= +0,7 mm	
Component standard deviation, C1 and C2, σ_{comp}	= 1,6 mm	
Component systematic deviation for C1 and C2, μ_{comp}	= − 1,3 mm	
Component target size for C1, $W_{\text{comp, C1}}$	= 2 090 mm	10 mm less than coordinating size
Component target size for C2, $W_{\text{comp, C2}}$	= 890 mm	
Number of components n	= 3	

All joints will be assumed to use the same jointing techniques (or different techniques with the same operating limits of clearance).

The calculations are as follows.

B.2.2 Risk of misfit (see 7.3.1)

An acceptable risk of oversize joints will be assumed to be 1 in 100, (thus $Q = 2{,}3$) and of undersize joints 1 in 10, ($q = 1{,}3$).

B.2.3 Minimum predicted joint clearance (see 7.3.2 and 7.4.1)

$$\frac{C_{\text{sp}} + E + \mu_{\text{sp}}}{n + 1} = \frac{5\,140 + 0{,}7}{4} = 1\,285{,}2 \text{ mm}$$

minus

$$\frac{2W_{\text{comp, C1}} + W_{\text{comp, C2}} + 3\mu_{\text{comp}}}{n + 1}$$

$$= \frac{(2\,090 + 2\,090 + 890) + 3 \times (-1{,}3)}{4} = 1\,266{,}5 \text{ mm}$$

minus

$$\frac{q\sqrt{n\sigma^2_{\text{comp}} + \sigma^2_{\text{sp}}}}{n + 1} = \frac{1{,}3 \times \sqrt{3 \times 1{,}6^2 + 8{,}8^2}}{4} = 3{,}0 \text{ mm}$$

$j_{\text{min}} = 1\,285{,}2 - 1\,266{,}5 - 3{,}0 = 15{,}7$ mm.

B.2.4 Maximum predicted joint clearance (see 7.3.3)

This calculation differs only in the last item, which is:

plus

$$\frac{Q\sqrt{n\sigma^2_{\text{comp}} + \sigma^2_{\text{sp}}}}{n + 1} = \frac{2{,}3 \times \sqrt{3 \times 1{,}6^2 + 8{,}8^2}}{4} = 5{,}3 \text{ mm}$$

$j_{\text{max}} = 1\,285{,}2 - 1\,266{,}5 + 5{,}3 = 24{,}0$ mm.

B.2.5 Selecting a jointing technique (see 7.3.5)

An example of a satisfactory jointing technique would be one for which $J_{\text{min}} = 15$ mm and $J_{\text{max}} = 25$ mm.

Dimensions in millimetres

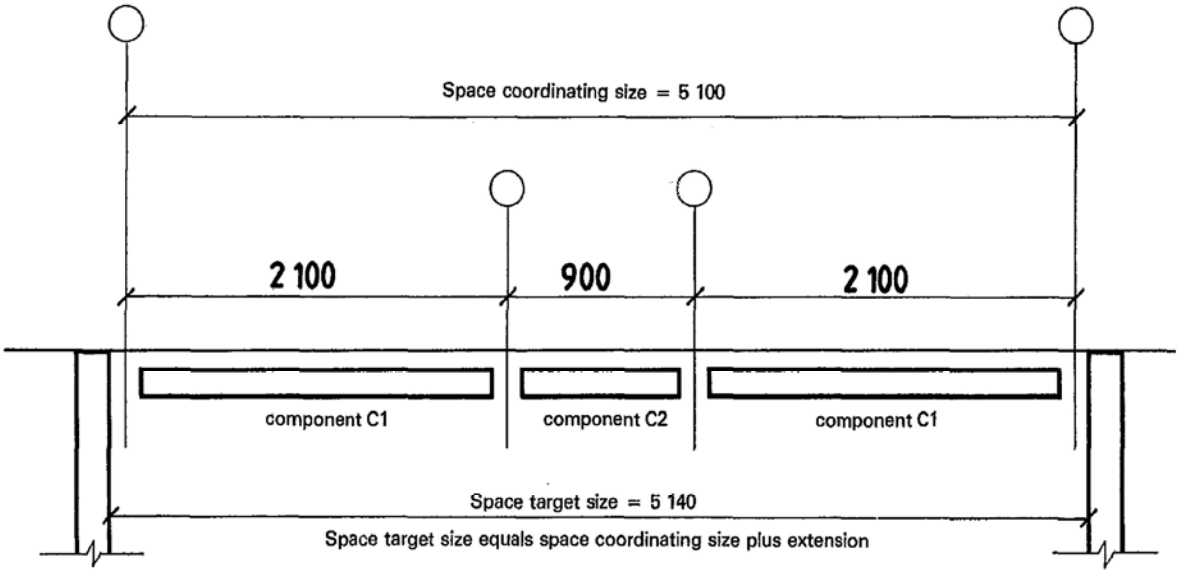

Figure 4 — Plan of opening between cross walls, for three panels

UDC 69.02 : 621.753.1

Descriptors : buildings, components, dimensional coordination, dimensional tolerances, clearances.

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