International Standard 4463

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

Measurement methods for building — Setting out and measurement — Permissible measuring deviations

Méthodes de mesurage pour la construction — Piquetage et mesurage — Écarts de mesurage admissibles

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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.

International Standard ISO 4463 was developed by Technical Committee ISO/TC 59, *Building construction*, and was circulated to the member bodies in February 1977.

It has been approved by the member bodies of the following countries :

Australia	Ireland	Romania
Denmark	Israel	South Africa, Rep. of
Finland	Korea, Rep. of	Spain
France	Mexico	Sweden
Germany, F. R.	Netherlands	Turkey
Hungary	Norway	United Kingdom
Iran	Poland	Yugoslavia

The member body of the following country expressed disapproval of the document on technical grounds :

Belgium

Printed in Switzerland

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Measurement methods for building — Setting out and measurement — Permissible measuring deviations

0 Introduction

This International Standard forms one of a series concerning measurement methods for building, and can be regarded as a frame for further reference standards for all setting out work. The other documents of this series are currently under preparation.

1 Scope

This International Standard deals with the different stages of the setting out work, i.e. the measuring of the primary framework (traverses, grids, etc.) on the site, the setting out of reference lines (baselines), the transfer (plumbing up) of reference lines to other floors, the setting out of position points and the levelling procedure for these different stages.

It gives values for permissible deviations when measuring and setting out and recommends certain procedures and instruments to be used.

Guidance is given on how inaccuracies can be controlled during the setting out process when using instruments and methods which are currently in common use in building construction.

2 Field of application

This International Standard applies to all usual types of building construction. Specialist operations such as the setting out of precision machinery require individual treatment.

3 Reference

ISO 1803, *Tolerances for building — Vocabulary.* [1)]

4 Definitions

For the purpose of this International Standard, the following definitions apply.

4.1 primary point : Point which has been established by measurement. Primary points are referred to the national, municipal or other agreed reference systems and constitute the reference points for setting out the secondary points. These may have been adjusted locally.

4.2 secondary point : Point which, on its own or in combination to form lines, constitutes a reference point for the setting out of position points. A structural grid may be constituted from a system of secondary points.

4.3 position point : Point which marks the position of a certain detail of a building.

4.4 grid : Two sets of parallel horizontal lines which are at right angles to each other.

4.5 primary bench mark : Bench mark which has been established by levelling. Primary bench marks are referred to the national, municipal or other agreed reference systems and constitute the reference levels for the establishment of secondary bench marks. These may have been adjusted locally.

4.6 secondary bench mark : Transferred bench mark established by levelling, which constitutes the reference level for setting out the position levels.

4.7 position level : Point which marks the level of a certain detail of a building.

4.8 check measurement : Independent measurement to check the correctness and accuracy of a previous measurement.

1) At present under revision.

4.9 anblock method : Adjustment method by which adjacent local systems of measuring points, for example those determined by the polar measuring method from a number of instrument stations, are connected together in one co-ordinate system (a block).

NOTE — This method allows the number of necessary instrument stations to be reduced (compare figures 4 and 5).

4.10 discrepancy : Difference between the measured and calculated values of points with given co-ordinates (for example between the points 10 and 320 in figures 4 and 5).

4.11 deviation : [See definition in ISO 1803].

The deviations in this International Standard refer to the difference between the determined values of the distance, angles and levels and their given or calculated values (see figure 1).

4.12 permissible deviation (E) : Specified limit of deviation.

In this International Standard, the permissible deviations for given or calculated distances, angles and levels (vertical distances) are specified. It is assumed that permissible deviations are both positive and negative and of equal numerical value (see figure 2).

4.13 tolerance : [See definition in ISO 1803].

5 General

The setting out of buildings may be compared with the procedure for measuring topographic details for general mapping purposes.

The purpose of setting out is to indicate the position of proposed features. This may be contrasted with the purpose of land surveying which is to determine the position of existing features (topography or cadastral surveying). Such a survey is based on a number of previous measuring operations according to a general procedure.

Starting from first order triangulation points, the point to be located is usually reached after a long series of measuring operations (secondary and other lower order triangulation nets, polygons, etc.).

As all these measuring operations are subject to inaccuracies, the accuracy of the determined position of a certain point *generally decreases in proportion* to the number of operations according to the law of propagation of errors (see figure 3). For all measuring work, it is therefore very important to keep the number of operations as small as possible.

For general topographic or cadastral surveys (see figure 3), the accuracies obtained (mean standard errors between 5 mm and 30 mm) are usually sufficient, but they cannot be accepted for most technical work, for example, precision setting out and deformation measurements.

When setting out buildings, the accuracy requirements have to be related to internal accuracies (i.e. between points A, B, C and D in figures 3 and 4). The accuracy of setting out within a building is more critical than the accuracy of the location of a point, for example, in the national co-ordinate system.

Using different polygons for the setting out of the main points of a building (corner points or base lines as in figure 3) can lead to inaccuracies between the main points. This is because these polygons are often part of a measuring series with different grades of accuracy.

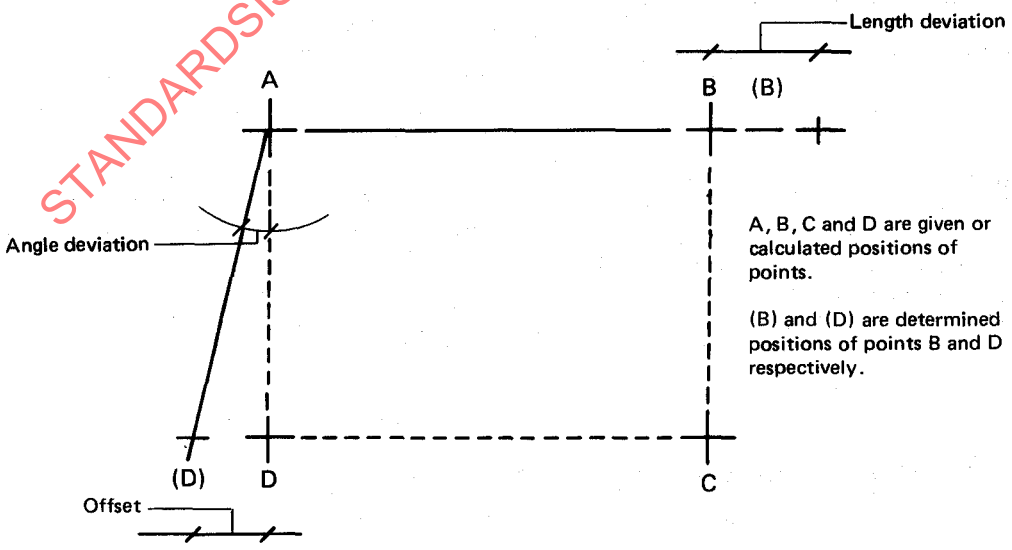

Figure 1 — Internal accuracies of setting out are checked by measuring angles and lengths

INTERNATIONAL STANDARD ISO 4463-1979 (E)/ERRATUM

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Measurement methods for building — Setting out and measurement — Permissible measuring deviations

ERRATUM

Replace the Erratum published on 1980-09-15 by the following :

Page 2

Figure 1, position (B) at the top right of the figure : the indication (B) at position B must be re-positioned approximately 7 mm to the right exactly above the cross situated at the extreme right of point B.

Page 7

Sub-clause 6.4.1, seventh line : replace the permissible deviation of the angles "± 0,004 5" by "± 0,045".

Page 9

Sub-clause 8.2, line 8 : "± 0,067 5/$\sqrt{L}$ degree" should read "± 0,067 $K/\sqrt{L}$ degree".

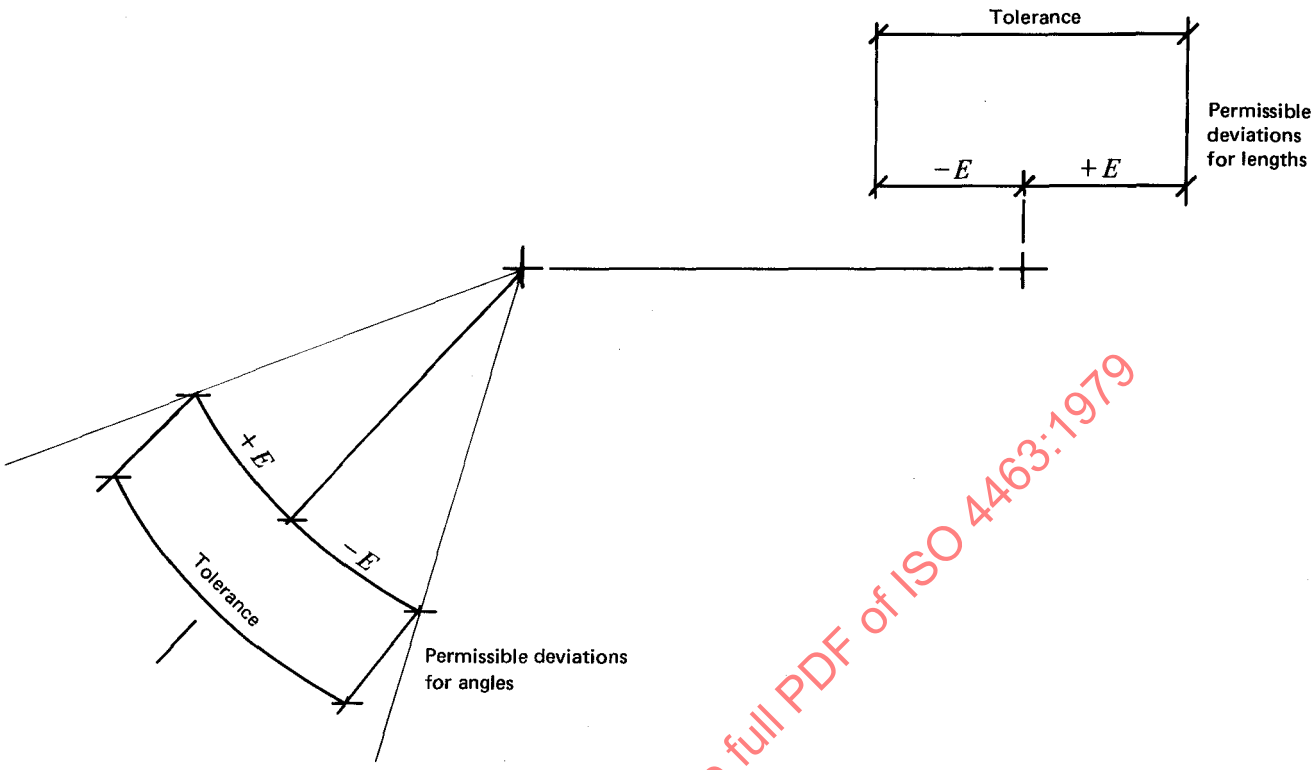


Figure 2 — The permissible deviations express the accuracy requirements as shown

Corner and base line points must be set out so as to limit inaccuracies. It is from these that the building elements and components, such as walls and columns, are located. If this is disregarded, serious practical problems are likely to arise during the erection of the building. For example, windows or other components may not fit between columns.

It is essential therefore that the setting out is carefully controlled throughout.

The setting out process can be controlled by dividing it into four stages. Figure 4 gives an example of the general principles.

Most setting out begins at one or more points in the national, municipal or other agreed co-ordinate system. For large projects, it is often necessary to set up a local traverse or a network of triangles containing primary points. From these primary points, the secondary points (points on base lines) can be established by means of intersection, resection, polar method, etc. Finally, the locations of columns, walls, etc. (position points) are determined from the secondary system.

Setting out small projects will usually commence with the secondary system or even position points. This can also be the case when the setting out has to be related to grids on the building site (see clause 9).

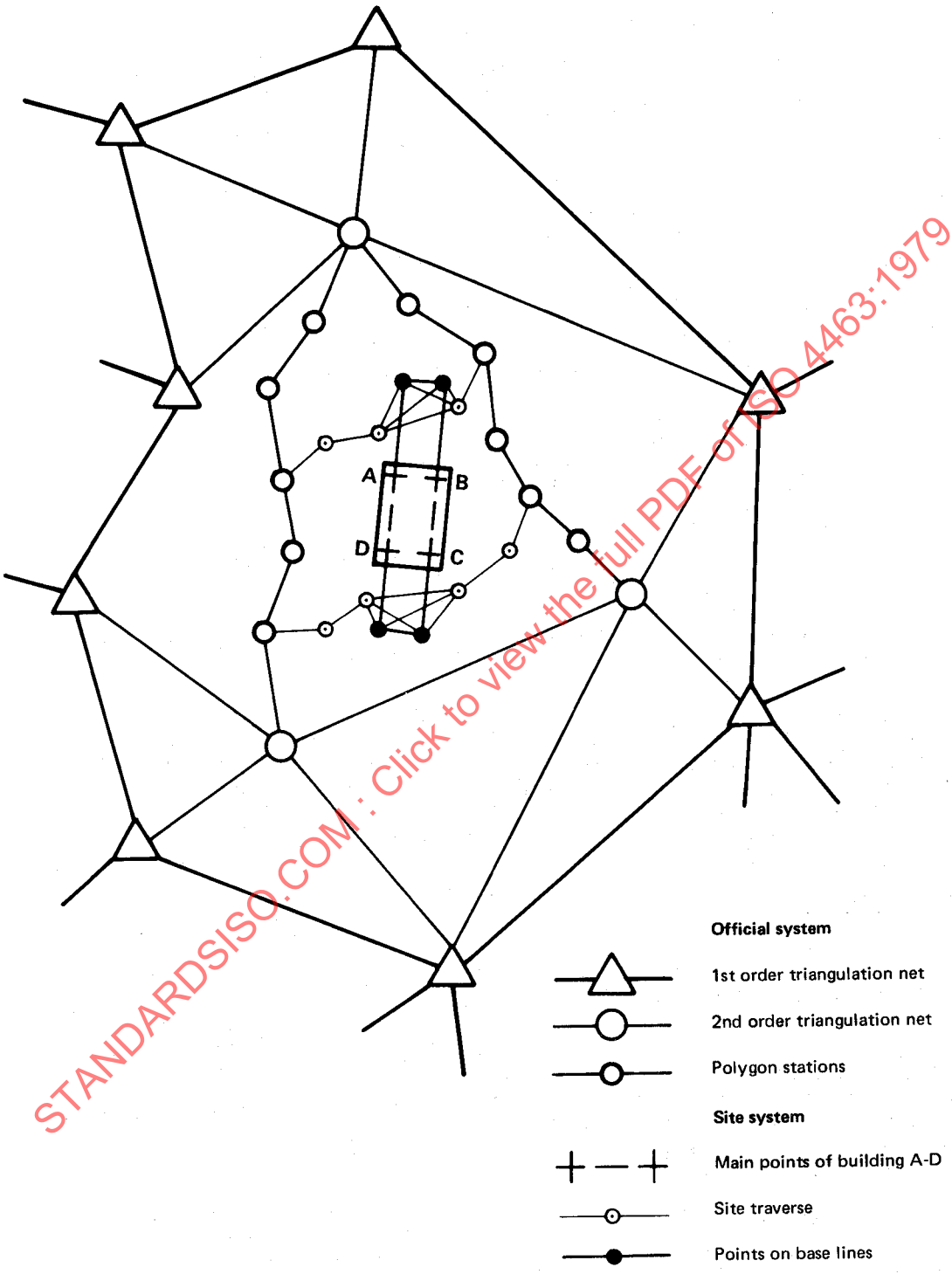
As emphasised above, the accuracy of setting out should not be influenced by discrepancies in the surrounding official reference points. It may therefore be necessary to make the adjustment of the measuring values within the primary system, i.e. as a free net, and not in relation to the points of the surrounding official reference system. In such cases, primary systems are only connected to the national, municipal or other agreed co-ordinate system.

This International Standard also gives guidance on this aspect of setting out and recommends that the establishment of primary systems should be entrusted to personnel with relevant professional qualifications, as the accuracy of primary points depends not only on the accuracy of the measuring operations but also on the configuration of the primary system. For the setting out of the secondary and lower order systems, an engineer or surveyor with detailed knowledge of building survey techniques should be engaged. The setting out of position points can usually be carried out by a foreman on the site.

Generally the connection of primary systems to the official co-ordinate system has to be carried out in consultation with the survey department of the local authority.

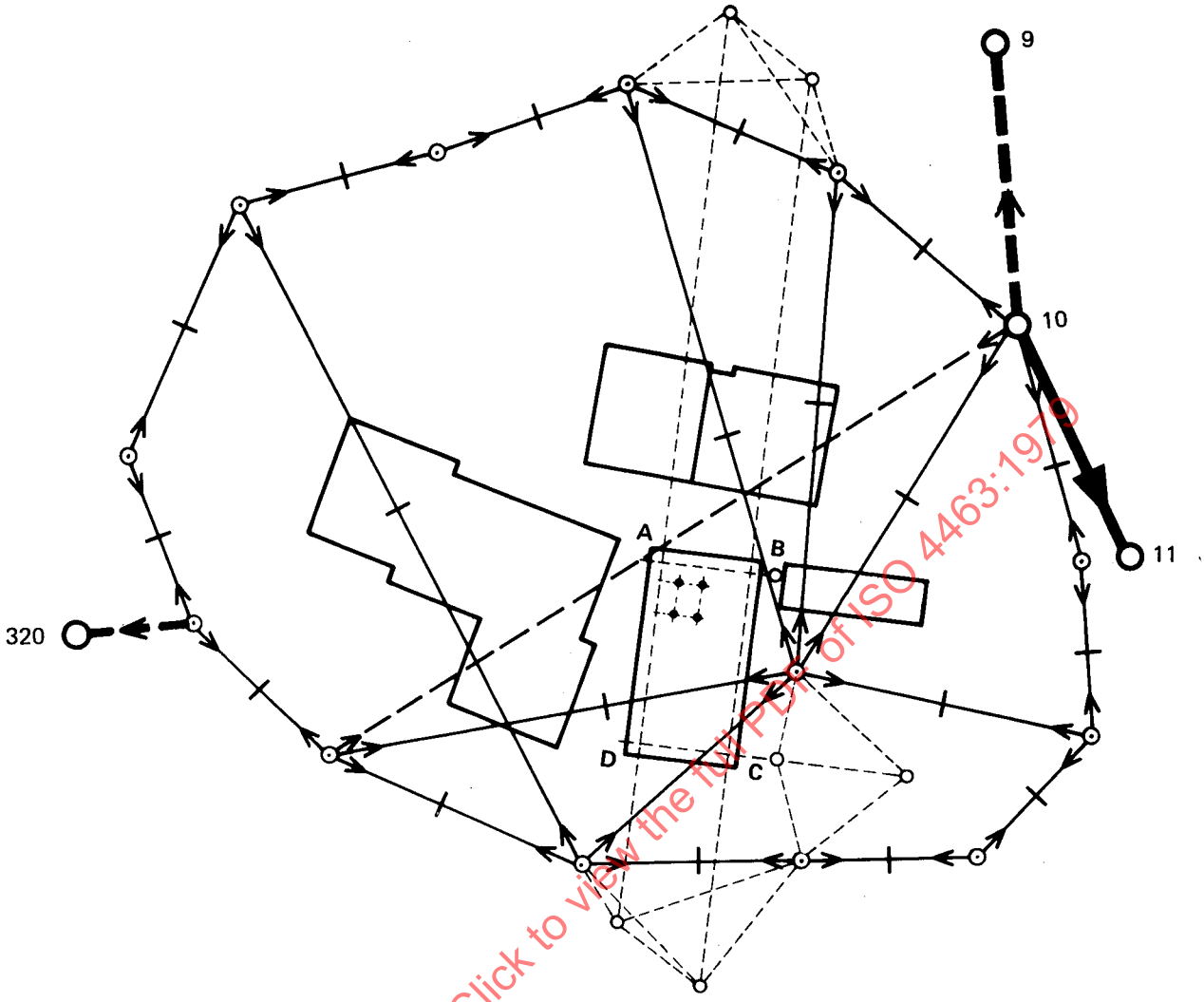
The accuracy requirements in this International Standard are expressed by permissible deviations (E)[1] for lengths, angles and levels, obtained as a result of measuring operations (see figure 2).

1) This International Standard does not deal with a priori investigations of the accuracies when designing measuring procedures, for example the configuration of the primary system. However, it recommends that for such investigations the relationship between permissible deviations (E) and relative mean standard errors (S), i.e. the internal accuracy between points, be expressed by the formula $E = \pm 2{,}5\,S$.



NOTE — This procedure is not recommended (see 6.2).

Figure 3 — Example of setting out related to different reference points in the surrounding official co-ordinate system



A free net. Co-ordinates of the primary points are determined from a network of traverses.

Reference point of the national, municipal or other agreed system

Reference point of the primary system

10 11 Reference direction

Direction measurement

10 Reference point

Length measurement

Position check, not to be used in the adjustment

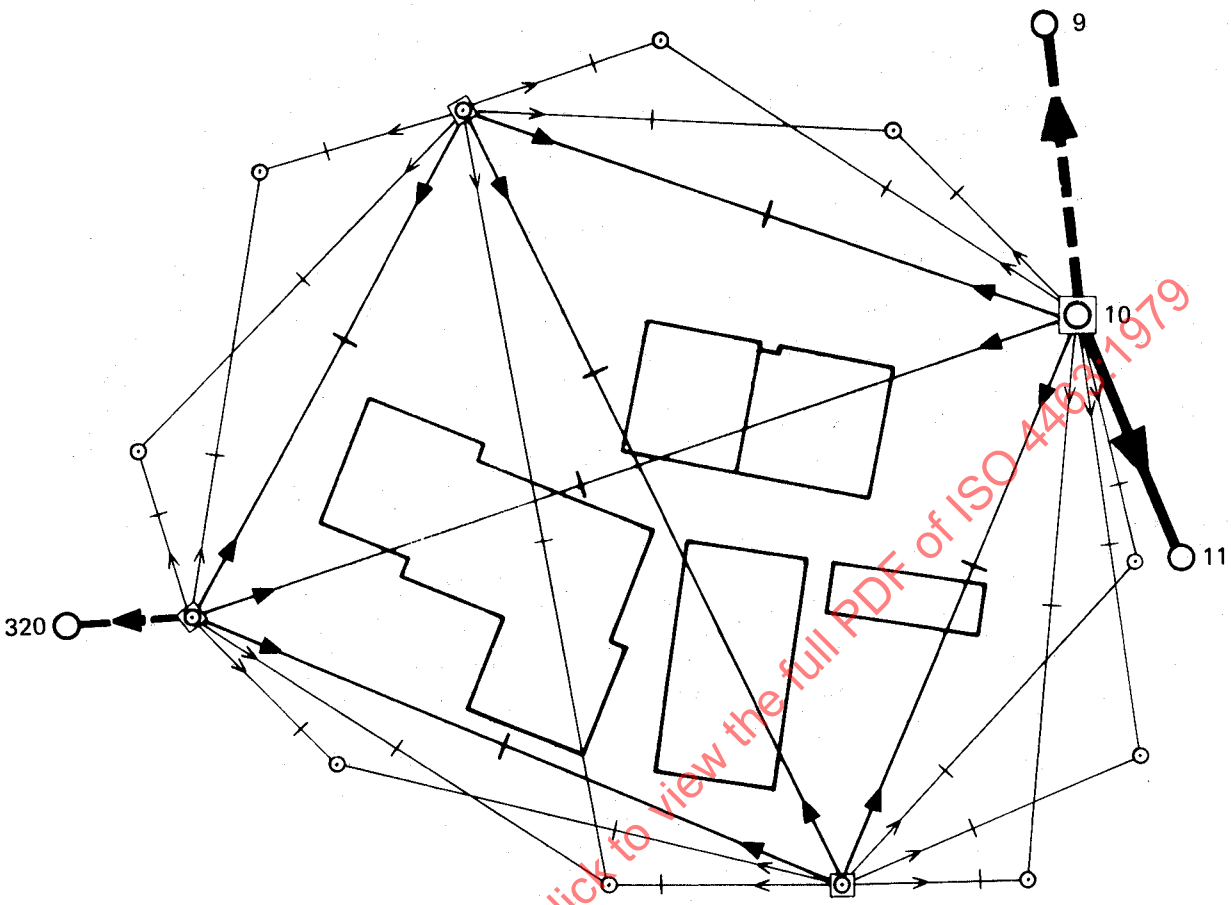
Reference point of the secondary system (baselines to be set out from the primary system)

A B D C Main points of building (part of the secondary system)

Position points (for example centre lines for columns)

NOTE — This free net is connected to the official co-ordinate system by one reference point (10) and one reference direction (10-11). This implies that the accuracies of the main points are not influenced by existing inaccuracies of the points in the national, municipal or other agreed reference system.

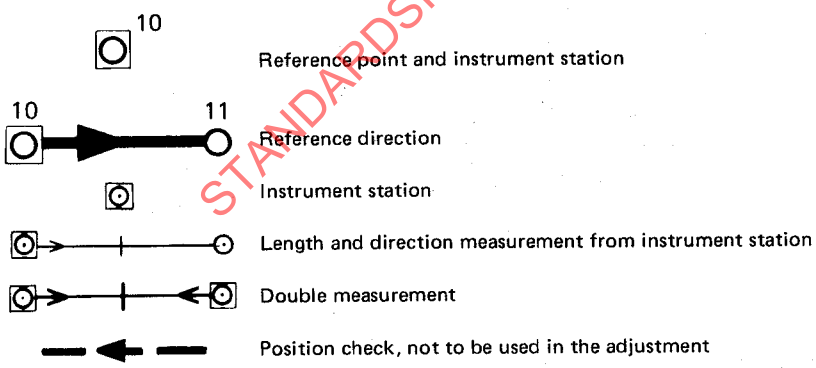
Figure 4 — Example of setting out related to a free net



A free net. Co-ordinates of the primary points are determined by measuring lengths and directions.

Reference point of the national, municipal or other agreed system

Reference point of the primary system



NOTE — The adjustment of the primary system has to be done in its entirety, according to the method of least squares. With the "anblock" method, the entire primary system is determined from only a few instrument stations.

Figure 5 — Example of "anblock" method for measuring a free net
(to be compared with figure 4)

6 Establishment of primary points

6.1 Introduction

This clause specifies the accuracy requirements with regard to the relative position of primary points and applies to building projects where the primary points constitute the reference points for the placing of buildings and parts thereof.

6.2 Primary system

Wherever possible, primary points shall, while being established, make up a framework which can be calculated and adjusted in its entirety. Points which cannot be formed by simultaneous adjustment into a framework may be determined from loop traverses (see figure 4), by means of redundant resection, intersection, simultaneous polar method, anblock method (see figure 5) or any similar method. All the primary points of a building site constitute the primary system.

As the accuracy of the main points, for example, A, B, C and D of the building is likely to be influenced by inaccuracies in the official system, the principle of connecting the site system to the official system by more than one reference point is not generally recommended.

6.3 Connection to existing systems

Information regarding suitable points in an official survey system to which the primary points can be connected is to be obtained from the appropriate authority. As far as possible their positions should be checked.

Any discrepancies in connecting the primary system to the official system are not normally adjusted in the primary system. They are not to be adjusted if this causes the relative positions of the primary points to be altered in such a way that the accuracy requirement of the positions of points, specified in this International Standard, is exceeded.

6.4 Permissible deviations of the position of a primary point

The accuracy of the position of a primary point may be assessed according to 6.4.1 or 6.4.2.

6.4.1 Measured and calculated values

The permissible deviations of the distances and angles obtained while measuring the positions of primary points, and those calculated from the adjusted co-ordinates of these points, shall not exceed the following :

Distances : $\pm\ 0{,}75\ \sqrt{L}$ mm

Angles :
$\pm\ 0{,}004\ 5/\sqrt{L}$ degree
or $\pm\ 0{,}05/\sqrt{L}$ gon[1)]
offset : ($\approx\ 0{,}8\ \sqrt{L}$ mm) (see figure 1)

where L is the distance in metres between the primary points concerned; in the case of angles, the shorter distance.

1) 1 gon = 0,9 degree

2) International Organization of Legal Metrology.

6.4.2 Checked and calculated values

The permissible deviations of the distance and angles obtained while checking the positions of primary points, and those calculated from the adjusted co-ordinates of the points, shall not exceed the following :

Distances : $\pm\ 2\ \sqrt{L}$ mm

Angles :
$\pm\ 0{,}135/\sqrt{L}$ degree
or $\pm\ 0{,}15/\sqrt{L}$ gon
offset : ($\approx\ 2{,}4\ \sqrt{L}$ mm) (see figure 1)

where L is the distance in metres between the primary points concerned; in the case of angles, the shorter distance.

6.5 Marking

Primary points shall be marked so that any displacement in their positions, due to external action, frost movement, etc., is prevented as far as possible. Primary points are to be indicated by precise marking, for example by punch marks. Whenever possible, primary points should be placed outside the actual working zone on the site.

6.6 Measurements

6.6.1 Distance measurement (see also 6.4.1)

a) If a measuring tape is used for distance measurement, its characteristics, for example concerning graduation accuracy and reference temperature need to be known. If possible, measuring tapes conforming to OIML[2)] recommendations or national standards are to be used. (In some cases this is strictly necessary, especially when this International Standard is to be used as a reference in contracts or for disputes.) All distances shall be measured at least twice. The values measured shall be corrected for temperature, sag, slope and tension. A tension device is to be used with the tape.

b) If the measurement is carried out with an electro-optical instrument, the systematic error of the instrument should be taken into consideration. The instrument shall be checked against a range of known distances. All distances should be measured at least twice.

6.6.2 Angular measurement (see also 6.4.1)

It is recommended that angles be measured with a "one second" theodolite. The measurements shall be made in at least two sets. Each set is formed by two observations, one on each face of the instrument.

6.7 Check measurements

6.7.1 Distance measurement

In the case of a check measurement using a measuring tape

6.6.1 a) applies. A different measuring tape should, however, be used.

In the case of a check measurement using an electro-optical instrument 6.6.1 b) applies.

6.7.2 Angular measurement

For a check measurement 6.6.2 applies. If possible another instrument should be used.

6.8 Errors

Discrepancies in primary systems on building sites are often the result of centering errors during the measuring operations.

Centering errors are caused by :

— instrument errors (optical plummets in theodolites and targets and "constrained or forced centering" should be checked regularly);

— badly defined points, for example, rough marks, excessive diameters.

7 Setting out of secondary points

7.1 Introduction

This clause specifies the accuracy requirements with regard to the relative positions of points in the same secondary system, between points in different secondary systems and between primary points (according to clause 6) and secondary points.

7.2 Secondary system

Secondary points constitute the reference points for setting out details of one or more buildings — unless a detail is set out directly from the primary points. Secondary points may be combined two-by-two to form base lines for detailed setting out. Secondary points can also be chosen as points of a site grid. (See clause 9.)

All the secondary points and the main points (see figure 4) of a building taken together form a secondary system.

7.3 Permissible deviations of the position of a secondary point.

7.3.1 In relation to a primary point

The permissible deviations for a checked distance from a given or calculated distance between a primary point and a secondary point shall not exceed $\pm 2\sqrt{L}$ mm, where L is the distance in metres.

7.3.2 Between points in the same secondary system

The permissible deviations for a checked distance from the given or calculated distance between two secondary points in the same secondary system shall not exceed $\pm 2\sqrt{L}$ mm, *where L is the distance in metres.*

For L less than 10 m, the permissible deviations are $\pm$ 6 mm.

The permissible deviations for a checked angle from the given or calculated angle between two lines in the same secondary system shall not exceed $\pm 0{,}135/\sqrt{L}$ degree ($\pm 0{,}15/\sqrt{L}$ gon), where L is the length in metres of the shorter side of the angle.

7.3.3 Between points in different secondary systems

The permissible deviations for a checked distance from the given or calculated distance between two points in different secondary systems for the same building project should not exceed $\pm K\sqrt{L}$ mm, where L is the distance in metres and K is a constant according to the accuracy requirements given in table 1 (see clause 8).

7.4 Measurements

7.4.1 Distance measurement

a) If a measuring tape is used for distance measurement, its characteristics concerning graduation accuracy and reference temperature need to be known. If possible measuring tapes conforming to OIML recommendations or national standards are to be used. (In some cases this is strictly necessary, especially when this International Standard is to be used as a reference in contracts or for disputes.) All distances shall be measured at least twice. The measurements shall be corrected for temperature, sag, slope and tension. A tension device is to be used with the tape.

b) If distance measurement is carried out with an electro-optical instrument, the systematic error of the instrument *shall be taken into consideration. The instrument shall be* checked against a range of known distances. All distances shall be measured at least twice.

7.4.2 Angular measurement

Angles should be measured with a theodolite reading to at least one minute. The measurements shall be made in at least one set. A set is formed by two observations, one on each face of the instrument.

7.5 Check measurements

7.5.1 Distance measurement

In the case of a check measurement using a measuring tape 7.4.1 a) applies. A different tape should however be used.

In the case of a check measurement using an electro-optical instrument 7.4.1 b) applies.

7.5.2 Angular measurement

For a check measurement 7.4.2 applies. If possible another instrument should be used.

8 Setting out of position points

8.1 Introduction

This clause specifies the accuracy requirements of the relative positions of position points.

8.2 Permissible deviations of a position point

The permissible deviations of a checked distance between a secondary point and a position point, or between two position points are $\pm K\sqrt{L}$ mm, where L is the specified distance in metres and K is a constant according to table 1.

For L less than 5 m, the permissible deviation is $\pm 2K$ mm.

The permissible deviations for a checked angle between two lines, dependent upon each other, through adjacent position points are $\pm 0{,}067\,5/\sqrt{L}$ degree ($\pm 0{,}075\,K/\sqrt{L}$ gon), where L is the length in metres of the shorter side of the angle and K is a constant according to table 1.

Table 1

K	**Examples of application**
10	Earthwork without any particular accuracy requirement, for example rough excavation, revetments, etc.
5	Earthwork subject to accuracy requirements, for example road works, pipe trenches, bases, etc.
2	*In situ* cast concrete structures, kerbs, etc.
1	Precast concrete structures, steel structures, etc.

Where the accuracy requirements for setting out are different from these stated above they shall be specified in the contract documents.

8.3 Setting out

Setting out for values of K of 5 or less shall be carried out according to 8.4.1 and 8.4.2.

8.4 Measurements

8.4.1 Distance measurement

a) If a measuring tape is used for distance measurement, its characteristics concerning graduation accuracy and reference temperature need to be known. If possible, measuring tapes conforming to OIML recommendations or national standards are to be used. (In some cases this is strictly necessary, especially when this International Standard is to be used as a reference in contracts or for disputes.) The measurements shall be corrected for temperature, sag, slope and tension. A tension device is to be used with the tape.

b) If distance measurement is carried out with an electro-optical instrument, the systematic error of the instrument should be taken into consideration. The instrument should be checked against a range of known distances.

8.4.2 Angular measurement

Angles shall be measured with a theodolite reading to at least one minute.

8.5 Check measurements

For a check measurement 8.4.1 and 8.4.2 apply.

9 Grids (See 4.4)

Some different grids are mentioned below.

On sites with a large number of parallel building lines, the setting out work can often be simplified by choosing the secondary system (see clause 7) such that a grid known as a site grid is formed.

The centre lines of structural elements of a building, which together form the structural grid, are normally established with reference to base lines. The purpose of this grid is to locate the position of the structural elements of the building (see figure 6).

Planning authorities often make use of a system of reference lines, for example location grids, to divide large built-up areas or development schemes into smaller sections. The main function of such a reference system is to indicate the legal position (specified in planning laws or local regulations) of boundaries of properties, buildings, axes of streets, kerbs, manholes, etc. in the area in question.

Reference systems (after they have been established within the site) are therefore mostly regarded as error free. The accuracy requirements are given by national laws or other regulations and are often designed only in order to avoid disputes.

This can imply that, for example, a location grid is not always considered as a secondary system in the sense of this International Standard. In such a case, where requirements have to be ensured on both critical legal measurements from grid lines and internal accuracies, the following general method can be applied.

For each square of the location grid, the setting out is related to one grid station as a reference point, and to one grid line as a reference direction (see figure 7). This procedure, however, is the most general one, as objects other than buildings may influence the choice of a suitable procedure. It is therefore very important that the appropriate authority is consulted before the setting out work takes place.

Where accuracies of a location grid do not fulfil the requirements in this International Standard, the internal accuracy of the building system can be ensured by relating the setting out to one reference point and one reference direction.

Before choosing suitable points and directions, the appropriate authority is to be consulted.

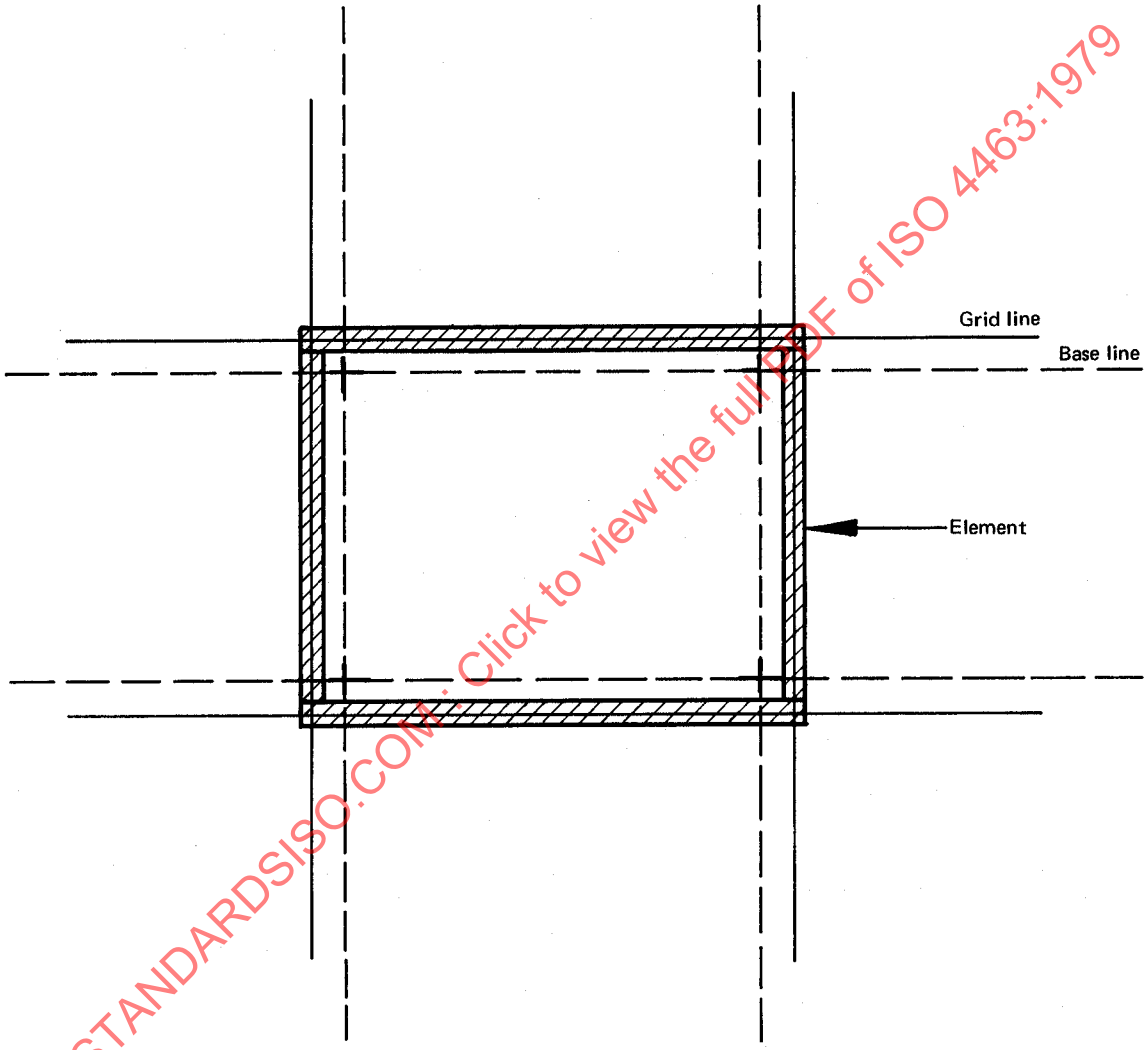


Figure 6 — Location of the position of the structural elements