INTERNATIONAL STANDARD

ISO 8322-7

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Building construction — Measuring instruments — Procedures for determining accuracy in use —

Part 7:
Instruments when used for setting out

Construction immobilière — Instruments de mesure — Procédures de détermination de l'exactitude d'utilisation —

Partie 7: Instruments utilisés pour l'implantation

Reference number
ISO 8322-7:1991(E)

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 voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 8322-7 was prepared by Technical Committee ISO/TC 59, *Building construction*, Sub-Committee SC 4, *Limits and fits in building construction*.

ISO 8322 consists of the following parts, under the general title *Building construction — Measuring instruments — Procedures for determining accuracy in use*:

- *Part 1: Theory*
- *Part 2: Measuring tapes*
- *Part 3: Optical levelling instruments*
- *Part 4: Theodolites*
- *Part 5: Optical plumbing instruments*
- *Part 6: Laser instruments*
- *Part 7: Instruments when used for setting out*
- *Part 8: Electronic distance-measuring instruments up to 150 m*
- *Part 9: Electronic distance-measuring instruments up to 500 m*
- *Part 10: Testing short-range reflectors*

International Organization for Standardization
Case Postale 56 • CH-1211 Genève 20 • Switzerland

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Introduction

This International Standard consists of a series of parts specifying test procedures to be adopted when determining and assessing the accuracy in use of measuring instruments in building construction. The first part gives the theory; subsequent parts give the procedures for determining the accuracy in use of measuring instruments for measurements.

For testing measuring instruments for land surveying purposes and for measuring procedures in ordnance survey, other International Standards are in preparation.

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Building construction — Measuring instruments — Procedures for determining accuracy in use —

Part 7:
Instruments when used for setting out

1 Scope

This part of ISO 8322 specifies test procedures to be adopted for the determination of the accuracy in use for setting out with theodolite and steel tape and with a theodolite.

The procedures given in this part of ISO 8322 apply to steel tapes and/or theodolites when used for setting out in building construction using methods in which systematic errors can be largely compensated or disregarded. They are such that the operations can be conveniently and rapidly carried out on a construction site and the results give a reasonable indication of the accuracy in use.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 8322. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 8322 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 3534:1977, *Statistics — Vocabulary and symbols.*

ISO 4463-1:1989, *Measurement methods for building — Setting-out and measurement — Part 1: Planning and organization, measuring procedures, acceptance criteria.*

ISO 7077:1981, *Measuring methods for building — General principles and procedures for the verification of dimensional compliance.*

ISO 7078:1985, *Building construction — Procedures for setting out, measurement and surveying — Vocabulary and guidance notes.*

3 General

3.1 Before setting out, it is important that the operator investigate whether the accuracy in use of the measuring equipment is appropriate to the intended measuring task. This International Standard recommends that the operator carry out test measurements under field conditions to establish the accuracy achieved when he uses a particular measuring instrument and its ancillary equipment.

To ensure that the assessment takes account of various environmental influences, two series of measurements need to be carried out under different conditions. The particular conditions to be taken into account may vary depending on where the tasks are to be undertaken. These conditions will include variations in air temperature, wind speed, cloud cover and visibility. Note should also be made of the actual weather conditions at the time of measurement and the type of surface over which the measurements are made. The sets of conditions chosen for the tests should match those expected when the intended measuring task is actually carried out. See ISO 7077 and ISO 7078.

Assumptions: P is the permitted deviation of the measuring task

A is the accuracy in use, generally expressed as deviation $\pm A$; (both $\pm P$ and $\pm A$ are considered to include the dimensional variability associated with $\pm$ 2,5 times the standard deviation σ)

s are the standard deviations obtained in field tests

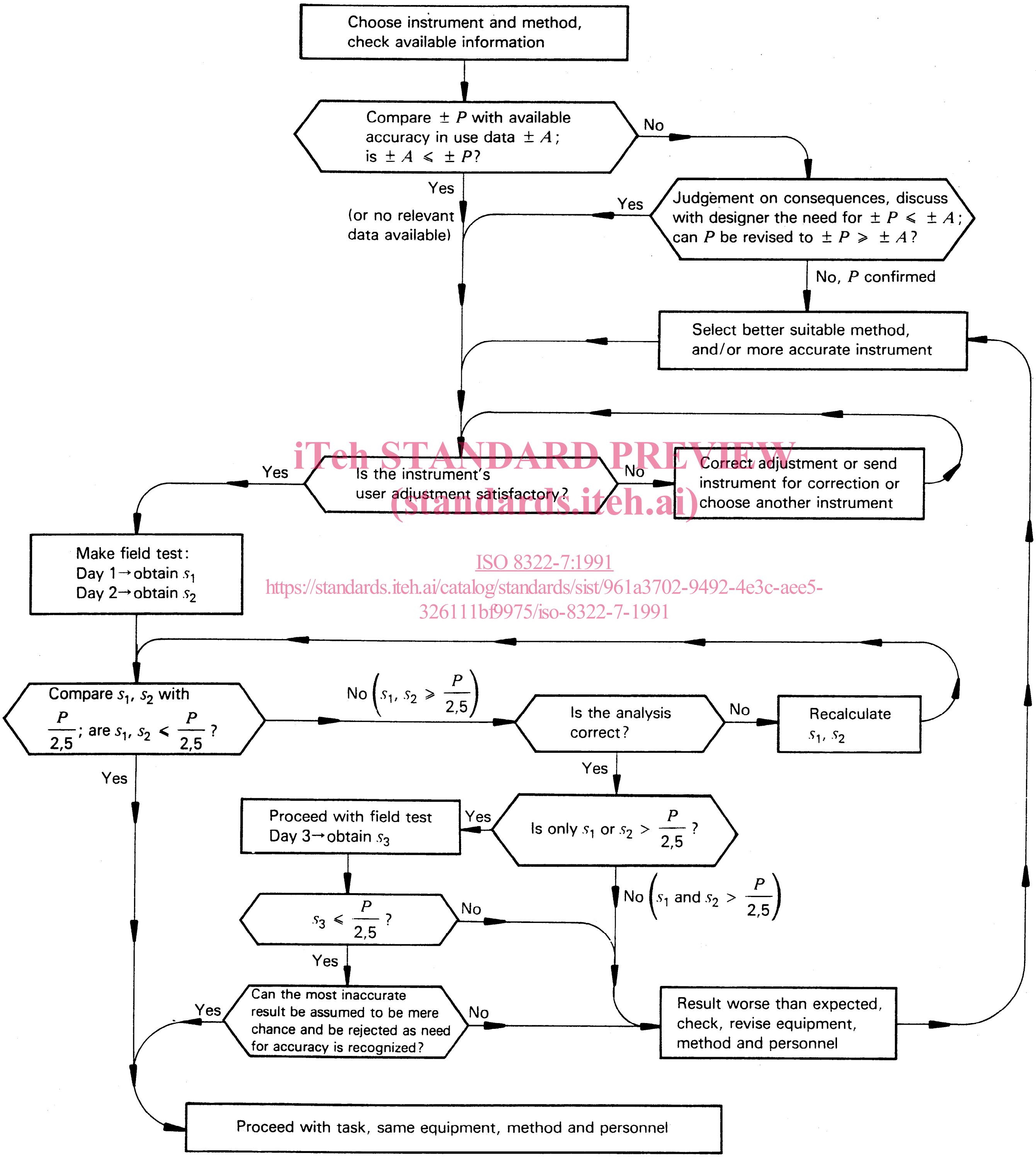


Figure 1 — Flow diagram for accuracy-in-use tests

For each of the tests, the preferred minimum sample size is indicated in the relevant clauses. However, if particular circumstances dictate the acceptance of smaller sample sizes, this must be in the knowledge that the assessment will be less reliable. The procedures are designated so that the systematic errors are largely eliminated and assume that the particular instruments are in known and acceptable states of user adjustment according to methods detailed in the manufacturers' handbooks.

Accuracy-in-use procedures require repeat tests to be made with the same instrumentation and the same observer, within a short interval of time. These are "repeatability conditions" as defined in ISO 3534.

The accuracy in use is expressed in terms of the standard deviation.

3.2 Figure 1 indicates schematically the decisions to be made when establishing that the accuracy associated with a given surveying method and particular measuring equipment is appropriate to the intended measuring task. In particular, the decisions apply when adopted by a particular operator under a range of environmental conditions which are likely to occur when the task is actually carried out. Where the contract documentation specifies the required tolerance for the intended measuring task, it is recommended that this tolerance, which is normally given in terms of the permitted deviation P ($P = 2{,}5\,\sigma$) of the measuring task, be compared with the accuracy-in-use data obtained either from previous accuracy-in-use tests or from general data A which indicate the expected accuracy in use of given measuring equipment. On those occasions that the previously obtained data indicate that the accuracy in use associated with the given measuring equipment does not meet the specified permitted deviation of the measuring task, consideration should be given to either selecting a different method and/or a more precise instrument or discussing with the designer the need for such a small permitted deviation. See ISO 4463-1.

Before obtaining an overall estimate of the accuracy in use, it is recommended that each standard deviation for a given series of measurements undertaken under particular environmental conditions be compared, as indicated in figure 1, to the specified permitted deviation. Where the comparison shows that the specified permitted deviation has not been achieved for one series of measurements, an additional series of measurements should be carried out under environmental conditions as near as possible similar to those which applied in that original series of measurements.

4 Setting out using theodolite and steel tape

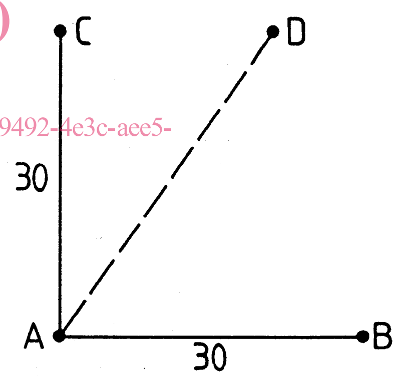
4.1 General

This clause gives both the test measurement procedure and the calculation procedure to be used in the determination of the accuracy in use of theodolites in association with steel tapes for setting out horizontal angles and positions. The measurement results should be given in a table (see table 1-B). An example of a completed table is given in table 1-A.

4.2 Accuracy test procedure

The following test procedure shall be adopted for determinating the expected accuracy in use for a particular instrument used by a particular survey team. The ancillary equipment used and the environmental conditions shall be similar to those expected in the actual setting out work.

Dimensions in metres



BAC = 90° (100 gon) or arbitrary angle

Figure 2 — Layout of target points

4.2.1 Observations

a) Establish stations A for the theodolite and B for the permanent target to provide a base line AB, approximately 30 m long.

b) Establish a horizontal marking target and overlay at point C, at a distance of approximately 30 m from A such that the angle BAC is approximately a right angle (see figure 2).

c) The stations A, B and C shall be reliably defined in stable locations for the duration of the test measurements.

d) In the case where the most common angle on a project is not a right angle, the angle BAC shall be similar to that. If the polar setting out method is to be used, then an appropriate angle (for example, BAD) shall be chosen.

e) Two targets are required, one to establish the end of the base line B and the other at C, to receive marks which can be read by the use of transparent overlays. The target at B shall be similar to those which will be used on the actual setting out work (for example, a nail in a rigid board or stake if this is what will be used in practice). The target at C shall be designed so that marks can be made on a horizontal surface and their location read with reference to a transparent rectangular x, y grid overlay graduated in millimetres and with the positive x direction parallel to AB. The horizontal surface shall be formed of a material which will accept pencil marks and can be easily wiped clean. This will ensure that successive marks are not biased in any way by previous marks. Fix the transparent overlay so that it always returns to the same position.

f) Record the environmental conditions. Changes in environmental conditions during the construction period may render the test result inapplicable. In such a case repeat the test under the new conditions.

g) Now use the theodolite to establish a line on the target at C first in the face-left position and then in the face-right position. Using the tape, set out the distance AC (≈ 30 m) and make a mark on each of the lines representing the face-left and face-right measurements (see figure 3). Draw a pencil line between these two points and take the bisection of this line as the result of the first measurement to establish point C. The location of this point is recorded by using the coordinates x and y on the transparent overlay and the target surface wiped clean. Make four such measurements with the theodolite centring disturbed and reset between each measurement. After each set of four measurements the theodolite and tripod are lifted, turned through approximately 90° (100 gon) and recentred. Make a total of four such sets.

h) Make a further four sets (16 measurements) on another day.

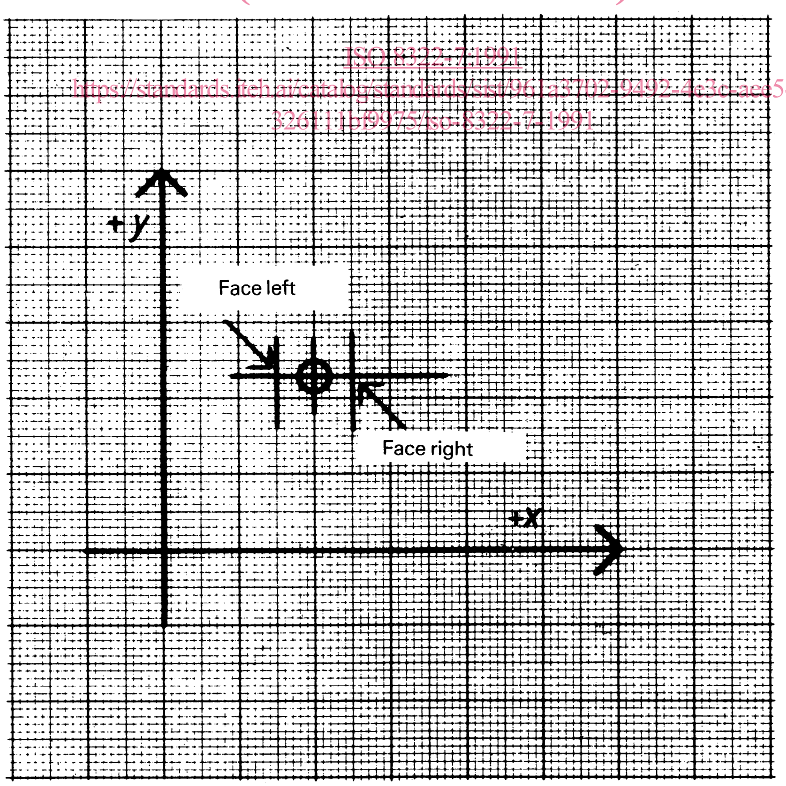


Figure 3 — Measurements

4.2.2 Calculation procedure

A complete example of the analysis is given in table 1-A using the measurements given in columns 2 and 5 and it is recommended that this form of presentation be generally adopted.

a) Calculate the means $\bar{x}$ and $\bar{y}$

EXAMPLE

$\bar{x}$ = 39,9 mm
$\bar{y}$ = 67,6 mm

b) Calculate the deviations $v_x = (x - \bar{x})$ and $v_y = (y - \bar{y})$ (columns 3 and 6).

EXAMPLE

Measurement 2:
$v_x = -1,1$ mm
$v_y = -2,9$ mm

As an arithmetic check, the sum of each of the 16 deviations in the x and y directions should be zero.

c) Calculate the squares of the deviations v_x^2 and v_y^2 (columns 4 and 7).

EXAMPLE

Measurement 2:
$v_x^2 = 1,21$ mm²

$v_y^2 = 8,41$ mm²

d) Calculate the standard deviations for the first day as the square roots of the sums of squares divided by 15 (= number of redundant observations).

EXAMPLE

$$s_{x_1} = \sqrt{\frac{49,26}{15}} = 1,8 \text{ mm}$$

$$s_{y_1} = \sqrt{\frac{402,46}{15}} = 5,2 \text{ mm}$$

e) Repeat the calculation procedure using the second day's observations to produce the standard deviations s_{x_2} and s_{y_2}.

EXAMPLE

s_{x_2} = 2,4 mm
s_{y_2} = 4,8 mm

f) The estimated overall standard deviations, s_x and s_y, in the x and y directions for any single setting out of a position are

$$s_x = \sqrt{\frac{s_{x_1}^2 + s_{x_2}^2}{2}}$$

$$s_y = \sqrt{\frac{s_{y_1}^2 + s_{y_2}^2}{2}}$$

EXAMPLE

s_x = 2,1 mm

s_y = 5,0 mm

5 Setting out with a theodolite

5.1 General

This clause gives both the test measurement procedure and the calculation procedure to be used in the determination of the accuracy in use of theodolites for setting out horizontal angles. Measurement results should be given in a table (see table 2-B). An example of a completed table is given in table 2-A.

5.2 Accuracy test procedure

The following test procedure shall be adopted for determining the expected accuracy in use for a particular instrument used by a particular operator. The ancillary equipment used and the environmental conditions shall be similar to those expected in the actual setting out work.

5.2.1 Observations

a) Establish stations A and B to provide a base line AB, approximately 30 m long. With the theodolite set up over point A, establish the target at station C at a distance of approximately 30 m from A such that the target lines are approximately perpendicular to direction AC and angle BAC is approximately a right angle (see figure 4). In the case where the most common angle on a project is not a right angle, the angle BAC shall be similar to that. If the polar setting out method is to be used, then an appropriate angle (for example, BAD) shall be chosen.

The stations A, B and C shall be reliably defined in stable locations for the duration of the test measurements.