BRITISH STANDARD

BS 7334-2:
1990
ISO 8322-2:
1989

Incorporating Amendment No. 1

Measuring instruments for building construction —

Part 2: Methods for determining accuracy in use: Measuring tapes

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Basic Data and Performance Criteria for Civil Engineering and Building Structures Standards Policy Committee (BDB/-) to Technical Committee BDB/4, upon which the following bodies were represented:

Association of County Councils
British Standards Society
Building Employers' Confederation
Chartered Institution of Building Services Engineers
Concrete Society
Department of Education and Science
Department of the Environment (Building Research Establishment)
Department of the Environment (Property Services Agency)
Incorporated Association of Architects and Surveyors
Institute of Building Control
Institute of Clerks of Works of Great Britain Inc.
Institution of Civil Engineers
Institution of Structural Engineers
Institution of Water and Environmental Management
Royal Institute of British Architects
Royal Institution of Chartered Surveyors

The following body was also represented in the drafting of the standard, through subcommittees and panels:

Chartered Institute of Building

This British Standard, having been prepared under the direction of the Basic Data and Performance Criteria for Civil Engineering and Building Structures Standards Policy Committee, was published under the authority of the Board of BSI and comes into effect on 30 September 1990

The following BSI references relate to the work on this standard:
Committee reference BDB/4
Draft for comment 87/10241 DC

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Amendments issued since publication

Amd. No.	Date	Comments
9318	November 1996	Indicated by a sideline in the margin

Contents

National foreword

This Part of BS 7334 has been prepared under the direction of the Basic Data and Performance Criteria for Civil Engineering and Building Structures Standards Policy Committee. It is identical with ISO 8322-2:1989 "*Building construction — Measuring instruments — Procedures for determining accuracy in use — Part 2: Measuring tapes*" published by the International Organization for Standardization (ISO); and gives the testing procedures to be adopted for measuring tapes.

The series of Parts comprising BS 7334 will assist in ascertaining whether particular measuring equipment is appropriate to intended measuring tasks; they are also intended for assessing the accuracy in use of measuring instruments in general use on construction sites.

- *— Part 1:1990 Theory;*
- *— Part 2:1990 Measuring tapes;*
- *— Part 3:1990 Optical levelling instruments;*
- *— Part 4:1992 Theodolites;*
- *— Part 5:1992 Optical plumbing instruments;*
- *— Part 6:1992 Laser instruments;*
- *— Part 7:1992 Instruments when used for setting out;*
- *— Part 8:1992 Electronic distance-measuring instruments up to 150 m.*

The parts are referred to in BS 5606:1990 "Guide to accuracy in building".

Cross-references

International standard	Corresponding British Standard
	BS ISO 3534 Statistics, vocabulary and symbols
ISO 3534-1:1993	BS ISO 3534-1:1993 Probability and general statistical terms (Identical)
ISO 3534-3:1985	BS ISO 3534-3:1985 Glossary of terms relating to the design of experiments (Identical)
	BS 5964 Building setting out and measurement
ISO 4463-1:1989	Part 1:1990 Methods of measuring, planning and organization and acceptance criteria (Identical)
ISO 4463-2:1995	Part 2:1996 Measuring stations and targets (Identical)
ISO 4463-3:1995	Part 3:1996 Check-lists for the procurement of surveys and measurement services (Identical)
ISO 7078:1985	BS 6953:1988 Glossary of terms for procedures for setting out, measurement and surveying in building construction (including guidance notes) (Identical)

The Technical Committee has reviewed the provisions of ISO 7077, to which reference is made in the text, and has decided that they are acceptable for use in conjunction with this standard.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 6, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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0 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. The complete series will consist of the following parts:

— *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.*

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

1 Scope

This part of ISO 8322 specifies test procedures to be adopted when determining and assessing the accuracy in use of tapes for measuring length.

2 Field of application

The procedures given in this part of ISO 8322 apply when these measuring tapes are used in building construction for surveying, check and compliance measurements, and also when obtaining accuracy data.

3 References

ISO 3534, *Statistics — Vocabulary and symbols.*

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

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

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

ISO 8322-1, *Building construction — Measuring instruments — Procedures for determining accuracy in use — Part 1: Theory.*

4 General

4.1 Before commencing surveying, check and compliance measurements, when obtaining accuracy data or setting out, it is important that the operator investigates that the accuracy in use of the measuring equipment is appropriate to the intended measuring task. This International Standard recommends that the operator carries 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.

The procedures are designed so that the systematic errors are largely eliminated and assume that the particular tape is in known and acceptable state of user adjustment according to methods detailed in the manufacturer's 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.

4.2 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 σ) of the measuring task, is 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 indicates that the accuracy in use associated with the given measuring equipment exceeds 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 is compared, as indicated in Figure 1, with 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 as near as possible similar environmental conditions to those which applied in that original series of measurements.

5 Procedures for measuring tapes

5.1 The following test procedures should be adopted for determining the accuracy in use by a particular survey team with a particular tape and its ancillary equipment. For setting out, compliance measurement and collecting accuracy data, only tapes recommended in ISO 4463 should be used.

5.2 Observation procedure (see the table)

5.2.1 Establish four points in a straight line so that the distance from the first point to the last point is at least greater than a full length of the tape or commensurate with that expected on a particular construction site (see Figure 2).

Make distances A-B, B-C and C-D as dissimilar as possible.

The points shall be in stable locations for the duration of the test measurements.

5.2.2 The measuring procedure shall be the same as on site. If the readings of the tape are to be corrected for the influence of tension, sag and temperature on site, the same correction procedures have to be made during the standard procedure for the determination of the accuracy in use of the tape.

5.2.3 Each of the two series of measurements, which should be carried out on separate days, shall consist of five separate readings of the distances A-B, A-C, A-D, B-C, B-D and C-D running on (see column 1 in the table). The five separate readings of each distance should not be measured consecutively.

5.2.4 Record the environmental conditions. Changes of environmental conditions may render the test result inapplicable. In such a case the test should be repeated under the new conditions.

5.3 Calculation procedure

The calculation neglects the relationship between the sum of different lengths and the separate values.

Carry out the following calculation separately for each length of each series of measurements.

5.3.1 Calculate the arithmetic mean $\bar{x}$ (column 4) of the values in column 3.

For example: distance A-B: 9,635 8

5.3.2 Calculate the deviation of each value from the arithmetic mean (column 5).

For example: distance A-B, number 3: + 0,2

To minimize the effect of rounding errors, the calculation of each deviation v should be carried out to the nearest 0,1 mm.

As an arithmetic check the sum of the five deviations should be zero.

5.3.3 Calculate the squares of all values in column 5 and the sum of the squares.

Assumptions: $\pm P$ 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 deviations obtained in the field tests

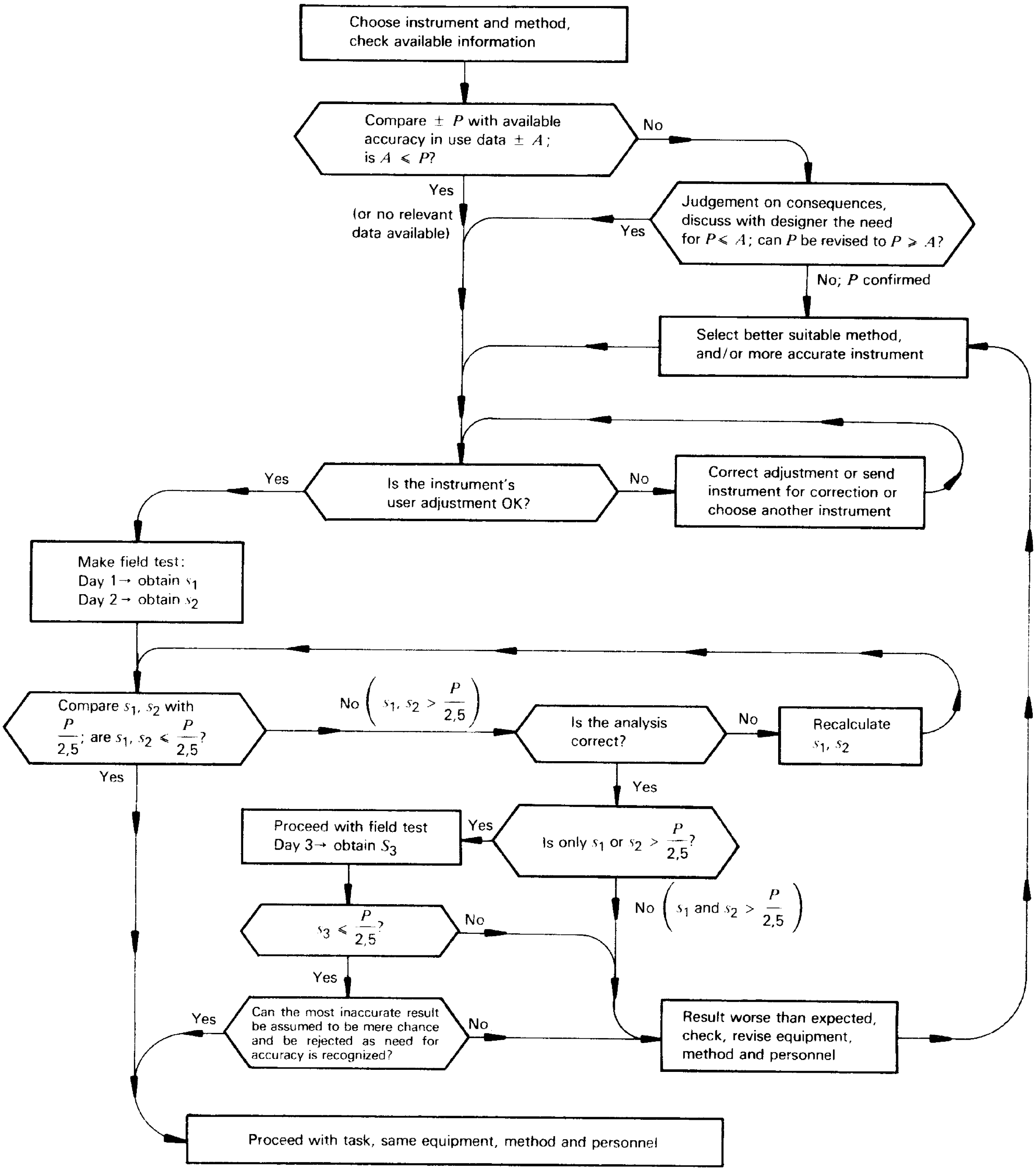

Figure 1 — Flow diagram for accuracy in use tests

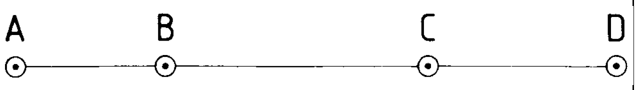

Figure 2 — Measuring distances

For example: For distance A-B the sum of the squares = 0,80

5.3.4 Calculate the overall sum of the squares.

For example: The sum of the first day is:

0,80 + 0,80 + 26,80 + 2,80 + 5,20 + 1,20 = 37,60

5.3.5 Calculate the standard deviation *s* of a length measured with the tape on the first day as the square root of the sum of squares divided by 24 = 6 × 4 (6 = number of sets; 4 = redundant observations).

For example:

$$s_1 = \sqrt{\frac{37,6}{24}} = \sqrt{1,57} = 1,2\ mm$$

5.3.6 Repeat procedures **5.3.1** to **5.3.5** on the second day to obtain s_2.

5.3.7 The overall standard deviation to be expected of any single measurement of a length is

$$s = \sqrt{\frac{s_1^2 + s_2^2}{2}}$$

For example: If s_2 = 1,8 mm then *s* = 2 mm.

Table 1a) — Field observations and calculation: Example

Date: ....

Location: ....

Observer: ....

Instrument: 30 m white clad steel tape, 5 kgf tension

Conditions: Bright, sunny, cool, fresh wind

Series: I

No.	Line	Length m	Mean $\bar{x}$ m	v mm	v^2 mm^2	Line	Length m	Mean $\bar{x}$ m	v mm	v^2 mm^2	Line	Length m	Mean $\bar{x}$ m	v mm	v^2 mm^2
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
1	A-B	9,636		+ 0,2	0,04	A-C	20,568		– 0,2	0,04	A-D	39,095		+ 0,8	0,64
2		9,636		+ 0,2	0,04		20,569		+ 0,8	0,64		39,092		– 2,2	4,84
3		9,636		+ 0,2	0,04		20,568		– 0,2	0,04		39,091		– 3,2	10,24
4		9,635		– 0,8	0,64		20,568		– 0,2	0,04		39,096		+ 1,8	3,24
5		9,636		+ 0,2	0,04		20,568		– 0,2	0,04		39,097		+ 2,8	7,84
			9,635 8	0	0,80			20,568 2	0	0,80			39,094 2	0	26,80

17	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**
1	B-C	10,930		+ 0,2	0,04	B-D	29,458		+ 0,6	0,36	C-D	18,528		+ 0,4	0,16
2		10,931		+ 1,2	1,44		29,459		+ 1,6	2,56		18,527		– 0,6	0,36
3		10,930		+ 0,2	0,04		29,457		– 0,4	0,16		18,527		– 0,6	0,36
4		10,929		– 0,8	0,64		29,457		– 0,4	0,16		18,528		+ 0,4	0,16
5		10,929		– 0,8	0,64		29,456		– 1,4	1,96		18,528		+ 0,4	0,16
			10,929 8	0	2,80			29,457 4	0	5,20			18,527 6	0	1,20

$$s_1^2 = \frac{0{,}80 + 0{,}80 + 26{,}80 + 2{,}80 + 5{,}20 + 1{,}20}{6 \times 4} = \frac{37{,}6}{24} = 1{,}57$$

$s_1 = 1{,}2$ mm

$s_2 = 1{,}8$ mm

$$s = \sqrt{\frac{1{,}2^2 + 1{,}8^2}{2}} = 1{,}5 \text{ mm}$$

$s = 2$ mm

Table 1b) — Field observations and calculation: data sheet

Date: ....
Location: ....
Observer: ....
Instrument:
Conditions:
Series:

No.	Line	Length m	Mean $\bar{x}$ m	v mm	v^2 mm^2	Line	Length m	Mean $\bar{x}$ m	v mm	v^2 mm^2	Line	Length m	Mean $\bar{x}$ m	v mm	v^2 mm^2
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
1	A-B					A-C					A-D				
2															
3															
4															
5															

17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	B-C					B-D					C-D				
2															
3															
4															
5															

$s_1^2 = \frac{\qquad}{\qquad} = \frac{\quad}{\quad} =$

$s_1 =$

$s_2 =$

$$s = \sqrt{\frac{\quad + \quad}{2}} = \quad \text{mm}$$

$s = \quad$ mm

Publications referred to

See national foreword.

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