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INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

ISO RECOMMENDATION

R 656

SHORT ENCLOSED-SCALE THERMOMETERS
FOR PRECISION USE

1st EDITION

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BRIEF HISTORY

The ISO Recommendation R 656, *Short enclosed-scale thermometers for precision use*, was drawn up by Technical Committee ISO/TC 48, *Laboratory glassware and related apparatus*, the Secretariat of which is held by the British Standards Institution (BSI).

Work on this question by the Technical Committee began in 1954 and led, in 1959, to the adoption of a Draft ISO Recommendation.

In October 1963, this Draft ISO Recommendation (No. 674) was circulated to all the ISO Member Bodies for enquiry. It was approved, subject to a few modifications of an editorial nature, by the following Member Bodies:

Argentina	Hungary	Poland
Australia	India	Spain
Austria	Israel	Switzerland
Belgium	Italy	U.A.R.
Chile	Japan	United Kingdom
Czechoslovakia	Korea, Rep. of	U.S.S.R.
France	Netherlands	Yugoslavia
Greece	New Zealand	

Two Member Bodies opposed the approval of the Draft:

Germany
U.S.A.

The Draft ISO Recommendation was then submitted by correspondence to the ISO Council, which decided, in February 1968, to accept it as an ISO RECOMMENDATION.

**SHORT ENCLOSED-SCALE THERMOMETERS
FOR PRECISION USE**

INTRODUCTION

This ISO Recommendation is based on ISO Recommendation R 386, *Principles of construction and adjustment of liquid-in-glass laboratory thermometers*. It is one of four ISO Recommendations specifying requirements for basic series of long and short solid-stem and enclosed-scale thermometers, intended for general use for precision work.

For ease of reference, each thermometer of the series has been allocated a combination of letters and figures indicating the type of thermometer, the value of the smallest graduation interval and the upper and lower limits of the nominal scale range. The letter abbreviations given below have been selected, after taking into account the descriptions in various languages usually given to these types of thermometer:

STL	Long solid-stem thermometers,
STC	Short solid-stem thermometers,
EL	Long enclosed-scale thermometers,
EC	Short enclosed-scale thermometers.

1. SCOPE

This ISO Recommendation specifies requirements for a basic series of short enclosed-scale thermometers, not exceeding 250 mm in length, for general use in precision work.

NOTE. — There are in existence many different specifications for thermometers of the general types covered by this series. It is intended that this series should replace all such specifications except those for which there is a well-established justification.

2. TYPE OF THERMOMETER

The thermometer should be of the liquid-in-glass enclosed-scale type.

3. TEMPERATURE SCALE

The temperature scale to which the thermometers refer is the International Practical Scale of Temperature, adopted by the Conférence Générale des Poids et Mesures in 1960 as the revised edition of the International Temperature Scale of 1948.

4. IMMERSION

The thermometers should be adjusted for use at total immersion (i.e., the reading should be correct when the thermometer is immersed at least to the end of the liquid column in the medium whose temperature is required to be measured).

NOTE. — If thermometers divided to 0.1 or 0.2 degree Celsius are required to read correctly when the complete thermometer is immersed in the medium, this should be stated in the purchasing contract and the thermometer should be specially marked.

5. GLASS

The glass should be selected so that the finished thermometer shows the following characteristics:

- 5.1 Strain in the glass should be reduced to a level sufficient to minimize the possibility of fracture due to thermal or mechanical shock.
- 5.2 The bulb glass should be stabilized by suitable heat treatment to ensure that the accuracy requirements of section 10 can be met.
- 5.3 The errors in the finished thermometer resulting from the thermometric properties of the glass used for the bulb should be within the limits specified in section 10.
NOTE. — The maximum temperature up to which a glass may be used depends on the degree of stability required and is related to the viscosity of glass at the temperature concerned.
- 5.4 The accuracy of the reading should not be impaired by devitrifying or clouding during manufacture.
- 5.5 The meniscus should be distorted as little as possible by defects or impurities in the glass.

6. LIQUID FILLING

Mercury should be used as liquid filling, except for thermometers with a scale extending below -38°C . For temperatures down to -55°C , the eutectic alloy of mercury and thallium (8.5% thallium by mass) should be used.

7. GAS FILLING

Only a dry, inert gas may be used as gas filling. It is essential that thermometers intended for use above 100°C should be gas-filled. The pressure of the gas should be high enough to raise the boiling point of the mercury sufficiently to ensure that reliable readings are obtained over the complete thermometer scale.

8. CONSTRUCTION

8.1 Shape

The thermometers should be straight and their external cross-section approximately circular.

8.2 Top finish

The top of the thermometer should be finished with a spherical end separated by a constricted neck, or with a glass ring.

8.3 Strip bearing the scale

The strip bearing the scale should be of translucent material suitable for the temperature to be measured. It should be placed tightly against the capillary tube inside the sheath, in such a way that it can freely expand in length; a suitable method of fixing is by fusing a glass tube to the sheath and to the upper end of the strip bearing the scale.

8.4 Capillary tube

The inside of the capillary tube should be smooth. The cross-sectional area of the bore should not show variations from the average greater than 10%, and the bore should be wide enough to ensure that jumping of the meniscus does not exceed one-fifth of the graduation interval.

8.5 Expansion chamber (safety chamber)

A thermometer should not be heated above its top normal working temperature. To avoid serious results from momentary accidental overheating, a safety volume should be provided

at the top of the capillary tube.* The volume above the scale should be at least equivalent to that occupied by an interval of 80 degrees Celsius of the scale. If this volume takes the form of an expansion chamber, this should be pear-shaped with the hemisphere at the top, except for thermometer EC/1/290/410. For thermometers in which the upper limit of the scale is below room temperature, the lower end of the "pear" should be considerably elongated, to avoid risk of a break in the liquid column at room temperature.

8.6 Contraction chamber

A thermometer in which the lower limit of the main scale is above 0 °C should be provided with a contraction chamber to allow for the inclusion of an auxiliary scale (see Fig. 1, Type B, page 7). The contraction chamber should be elongated and as narrow as possible, to avoid risk of a break in the liquid column at room temperature.

8.7 Position of chambers

No enlargement of the bore should be so located as to produce any variation in the cross-section of the capillary tube in the scale portion, and in no case should such an enlargement be located less than 5 mm from the nearest graduation line. The distance from the top of the contraction chamber to the first graduation line of the scale immediately above it should be not less than 13 mm, except that, for thermometers EC/0.5/245/305, EC/1/190/310 and EC/1/290/410, this distance should be not less than 30 mm.

8.8 Dimensions

The dimensions of the thermometers should be as given in Table 1 below and Figure 1, page 7.

TABLE 1. — Dimensions (see also Fig. 1)

		Dimensions in millimetres		
Dimensions		Type A	Type B	Type C
Total length	max.	250	250	250
Distance from top of bulb (shoulder) to lower nominal limit of scale	min.	30	—	30
Distance from top of bulb (shoulder) to 0 °C graduation line	min.	—	30	—
Length of main scale (nominal limits)	min.	120	80	80
Distance from upper nominal limit of scale to top of thermometer	min.	50	50	—
Distance from 0 °C graduation line to top of thermometer	min.	—	—	50
Diameter of sheath		7.0 ± 0.5	7.0 ± 0.5	7.0 ± 0.5
External diameter of bulb		5.0 ± 0.5	5.0 ± 0.5	5.0 ± 0.5
Length of bulb to shoulder	min.	15	15	15
Distance from shoulder of bulb to lower end of parallel-sided capillary tube	max.	5	5	5
Distance from bottom of contraction chamber to highest graduation line on scale below it	min.	—	—	5
Distance from top of contraction chamber to lowest graduation line on scale above it	min.	—	13**	13

* Overheating is liable to change the zero of the thermometer, and a redetermination is therefore necessary, if it takes place.

** Except for thermometers EC/0.5/245/305, EC/1/190/310 and EC/1/290/410, for which this dimension should be at least 30 mm.

9. GRADUATION AND FIGURING

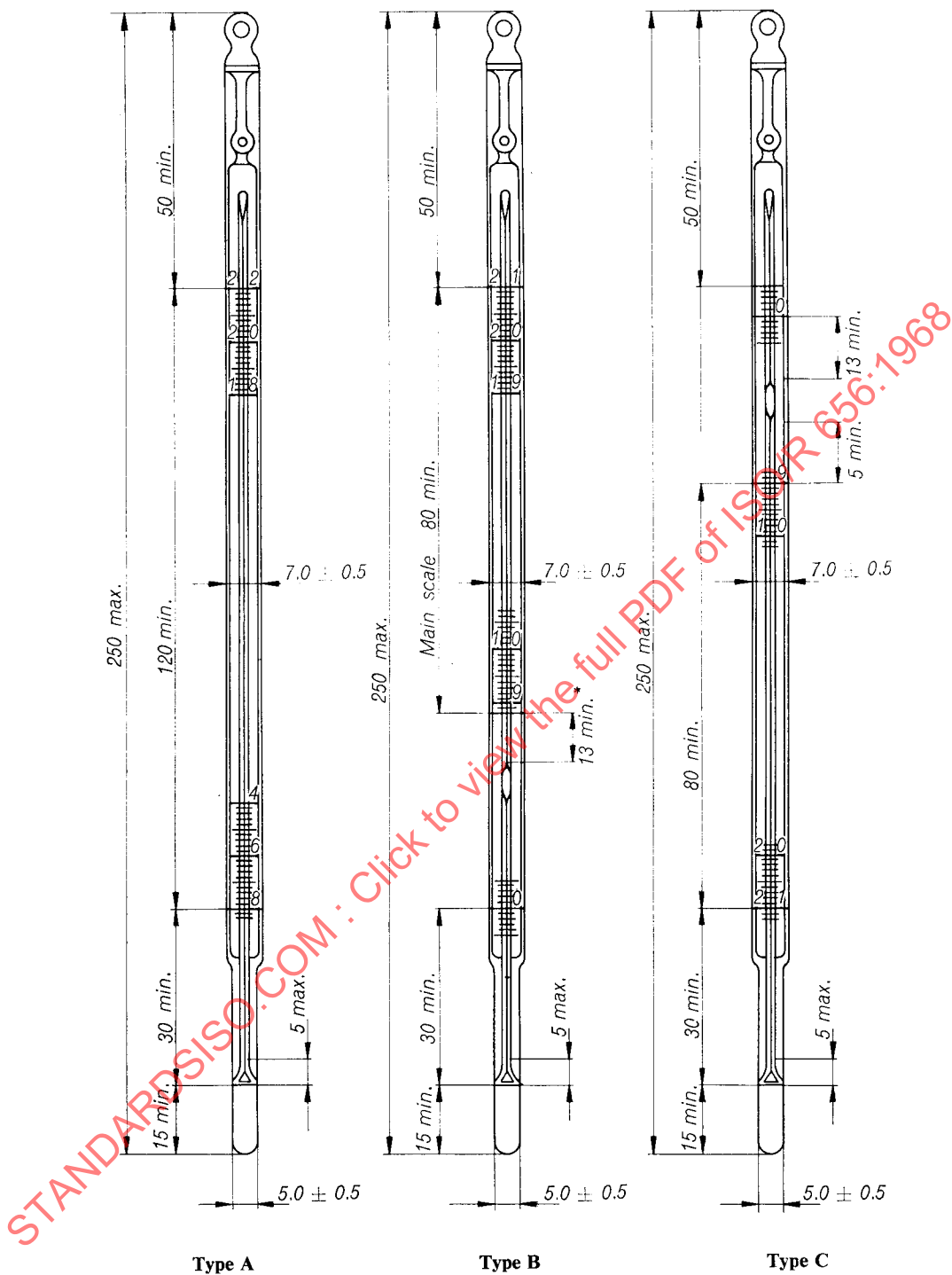
9.1 The scales and graduation intervals of the thermometers should be as given in Table 2 below.

TABLE 2. — Graduation

Designation	Graduation interval	Main scale	Auxiliary scale *	Type (see Fig. 1)
	degrees Celsius	°C	°C	
EC/0.1/−21/−9	0.1	−21 to −9	−0.5 to +0.5	C
EC/0.1/−11/+1	0.1	−11 to +1	—	A
EC/0.1/−1/+11	0.1	−1 to +11	—	A
EC/0.1/9/21	0.1	9 to 21	−0.5 to +0.5	B
EC/0.1/19/31	0.1	19 to 31	−0.5 to +0.5	B
EC/0.1/29/41	0.1	29 to 41	−0.5 to +0.5	B
EC/0.1/39/51	0.1	39 to 51	−0.5 to +0.5	B
EC/0.1/49/61	0.1	49 to 61	−0.5 to +0.5	B
EC/0.1/59/71	0.1	59 to 71	−0.5 to +0.5	B
EC/0.1/69/81	0.1	69 to 81	−0.5 to +0.5	B
EC/0.1/79/91	0.1	79 to 91	−0.5 to +0.5	B
EC/0.1/89/101	0.1	89 to 101	−0.5 to +0.5	B
EC/0.2/−38/−18	0.2	−38 to −18	−1 to +1	C
EC/0.2/−22/+2	0.2	−22 to +2	—	A
EC/0.2/−8/+22	0.2	−8 to +22	—	A
EC/0.2/18/42	0.2	18 to 42	−1 to +1	B
EC/0.2/38/62	0.2	38 to 62	−1 to +1	B
EC/0.2/58/82	0.2	58 to 82	−1 to +1	B
EC/0.2/78/102	0.2	78 to 102	−1 to +1	B
EC/0.2/98/122	0.2	98 to 122	−1 to +1	B
EC/0.2/118/142	0.2	118 to 142	−1 to +1	B
EC/0.2/138/162	0.2	138 to 162	−1 to +1	B
EC/0.2/158/182	0.2	158 to 182	−1 to +1	B
EC/0.2/178/202	0.2	178 to 202	−1 to +1	B
EC/0.5/−55/+2**	0.5	−55 to +2	—	A
EC/0.5/−38/+35	0.5	−38 to +35	—	A
EC/0.5/−5/+70	0.5	−5 to +70	—	A
EC/0.5/45/105	0.5	45 to 105	−3 to +3	B
EC/0.5/95/155	0.5	95 to 155	−3 to +3	B
EC/0.5/145/205	0.5	145 to 205	−3 to +3	B
EC/0.5/195/255	0.5	195 to 255	−3 to +3	B
EC/0.5/245/305	0.5	245 to 305	−3 to +3	B
EC/1/−30/+120	1	−30 to +120	—	A
EC/1/90/210	1	90 to 210	−5 to +5	B
EC/1/190/310	1	190 to 310	−5 to +5	B
EC/1/290/410	1	290 to 410	−5 to +5	B

* The auxiliary scale should be figured at the zero point.

** To be filled with mercury-thallium alloy.



* 30 min. for
EC/0.5/245/305
EC/1/190/310 and
EC/1/290/410

FIG. 1 — Short enclosed-scale thermometers for precision use
Dimensions in millimetres

NOTE. — The position of the top ring may be either as shown or at right angles to this.

- 9.2 The graduation lines should be clearly etched and of uniform thickness, which in no case should exceed 0.12 mm. The lines should be at right angles to the axis of the thermometer.
- 9.3 The lines forming the scale should extend equally on both sides of the bore when the thermometer is viewed from the front and in a vertical position. The length of the longest lines (i.e. the scale width) should be not less than 0.8 times the width of the strip bearing the scale. The arrangement and length of the other lines should be as specified in Table 3 below. The figures should be placed immediately above the line to which they refer, or slightly to the right of the lines in such a way that an extension of the lines would bisect them.

TABLE 3. — Lengths and graduation of graduation lines

Graduation interval	Graduation in degrees Celsius			
	0.1	0.2	0.5	1
Length				
$\frac{1}{3}$ scale width for	0.1	0.2	0.5	1
$\frac{1}{2}$ scale width for	—	1	1	—
$\frac{2}{3}$ scale width for	0.5	—	—	5
1 scale width for	1	5 and 10	5 and 10	10
Figured graduation line.	every 20 lines	every 50 lines*	every 20 lines	every 10 lines

* The twenty-fifth line between the fully figured lines should be numbered "5".

NOTE.— Figure 2 illustrates various suitable types of graduation and figuring for the thermometers, but these are not intended to be obligatory.

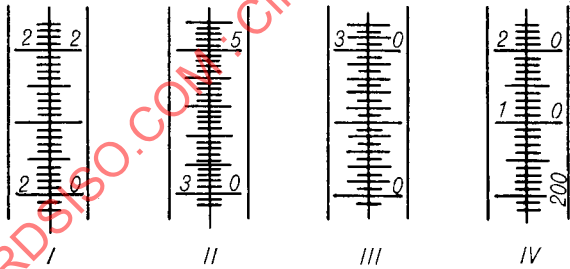


FIG. 2. — Alternative types of graduation and figuring

- 9.4 The scale of the thermometer should be extended from two to five divisions beyond the nominal limits.
- 9.5 The pigment filling should remain in the graduation lines, figures and inscriptions under conditions specified by agreement between purchaser and vendor.
- 9.6 *Datum line.* At the right-hand side of the sheath an indelible datum line, of thickness comparable to that of the graduation lines, should be placed on a level with the 0 °C graduation lines so that any displacement of the scale can easily be noticed.

10. ACCURACY

10.1 Scale error

The scale error, when the thermometer is subjected to a pressure of 1 atm (normal atmosphere), should not be greater than the smallest scale division.

10.2 Interval error

The absolute value of the algebraic difference between the errors at any two points which are not more than 50 divisions apart should not be greater than one scale division.

10.3 Change in zero

When a thermometer is maintained over a period of 24 hours at the highest temperature of the scale, the change in the zero point, determined by the method described in Annex A, should not exceed 0.7 of a scale division, and the scale error should remain within the limit of one scale division as specified in clause 10.1.

11. INSCRIPTIONS

The following inscriptions should be permanently and legibly marked on the thermometer:

- (a) *Unit of temperature.* Abbreviation of the name Celsius such as "C", or symbol "°C".
- (b) *Immersion.* An indication of the immersion is not required, except as stated in the Note to section 4.
- (c) *Gas filling,* if any. E.g. "nitrogen filled", "vacuous" or a suitable abbreviation.
- (d) *Bulb glass.* The bulb glass should preferably be identified either by means of a coloured stripe or stripes, or by an inscription on the thermometer.
- (e) *Identification number* (manufacturer's).
- (f) *Maker's or vendor's name or mark.*