International Standard 653

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Long solid-stem thermometers for precision use

Thermomètres de précision, sur tige, type long

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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 653 was developed by Technical Committee ISO/TC 48, *Laboratory glassware and related apparatus*, and was circulated to the member bodies in September 1979.

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

Australia	Hungary	Romania
Brazil	India	South Africa, Rep. of
Canada	Italy	Spain
Czechoslovakia	Korea, Rep. of	United Kingdom
France	Libyan Arab Jamahiriya	USSR
Germany, F.R.	Netherlands	

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

USA

This International Standard cancels and replaces ISO Recommendation R 653-1968, of which it constitutes a technical revision.

Long solid-stem thermometers for precision use

0 Introduction

This International Standard is based on ISO 386, *Liquid-in-glass laboratory thermometers — Principles of design, construction and use.* It is one of four International Standards specifying requirements for basic series of long and short solid-stem and enclosed-scale thermometers, intended for general use in 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 scale 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 thermometers :

STL .... Long solid-stem thermometers;

STC .... Short solid-stem thermometers;

EL.................. Long enclosed-scale thermometers;

EC .... Short enclosed-scale thermometers.

The method for determining the change in the zero indication is given in the annex.

1 Scope and field of application

This International Standard specifies requirements for a basic series of liquid-in-glass solid-stem thermometers, not exceeding 375 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 Temperature scale

The thermometers shall be graduated in accordance with the Celsius scale as defined in the current definition of the International Practical Temperature Scale (IPTS) adopted by the Conférence générale des poids et mesures, and in accordance with the International System of Units (SI).

3 Immersion

3.1 The thermometers shall be adjusted for use at total immersion (i.e. the reading shall be correct when the thermometer is immersed so that the top of the liquid column is in the same plane as, or no more than two scale divisions above, the surface of the medium the temperature of which is required to be measured).

3.2 Thermometers having a smallest scale division of 0,1 °C or 0,2 °C may alternatively be adjusted for complete immersion (i.e. the reading shall be correct when the entire thermometer is immersed in the medium) and if so shall be identified by marking [see 10 b)].

4 Glass

The thermometer shall be made of suitable thermometric glass[1] selected and processed so that the finished thermometer shows the following characteristics.

4.1 Stress in the glass of the bulb and capillary stem shall be reduced to a level sufficient to minimize the possibility of fracture due to thermal or mechanical shock.

4.2 The bulb glass shall be stabilized by suitable heat treatment to ensure that the accuracy requirements of 9.1 and 9.3 can be met.

4.3 The legibility of the reading shall not be impaired by devitrification or clouding.

4.4 The image of the meniscus shall be distorted as little as possible by defects or impurities in the glass.

5 Liquid filling

Mercury shall be used as liquid filling, except for thermometers with a scale extending below − 38 °C for which the eutectic alloy of mercury and thallium (8,5 % thallium by mass) shall be used. The liquid filling shall be free from any contamination likely to interfere with the proper functioning of the thermometer.

1) An International Standard (ISO 4795) dealing with glasses for thermometer bulbs is in preparation.

6 Gas filling

Thermometers having an upper nominal limit above 100 °C shall be filled with a dry, inert gas. The pressure of the gas shall be high enough to raise the boiling point of the liquid filling sufficiently to minimize vaporization.

7 Construction

7.1 Shape

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

7.2 Top finish

The top of the thermometer should preferably be finished with a glass ring, the diameter of which shall not exceed that of the stem. Alternatively, a plain finish may be provided, and this is preferred for thermometers STL/1/180/420 and STL/2/0/600.

7.3 Capillary tube

The thermometer shall be made from capillary tube which has been so tested as to ensure that the requirements of 7.3.1 and 7.3.2 are satisfied.

7.3.1 The inside of the capillary tube shall be smooth.

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

7.3.3 If the capillary tube incorporates an enamel backing, it shall be so positioned that it lies behind the liquid column when the latter is viewed in alignment with the right-hand ends of the shortest scale lines and also when viewed in alignment with the left-hand ends of all of the scale lines.

7.4 Expansion volume

7.4.1 An expansion volume shall be provided at the top of the capillary tube.

NOTE — Overheating is liable to change the zero point of a thermometer and a redetermination will be necessary if it occurs.

7.4.2 The volume above the scale shall be at least equivalent to that occupied by an interval of 50 °C of the scale.

7.4.3 This volume should preferably consist of an expansion chamber, and with the exception of thermometers STL/1/180/420 and STL/2/0/600, this chamber, if present, shall be pear-shaped with the hemisphere at the top.

7.4.4 For thermometers STL/0,1/ − 25/ + 5, STL/0,1/ − 5/ + 25, STL/0,2/ − 55/ + 5 and STL/0,2/ − 35/ + 25, the lower end of the expansion chamber shall be so elongated as to avoid the risk of a break in the mercury column during storage at ambient temperature.

7.5 Contraction chamber

Thermometers having a lower limit of the main scale above 0 °C shall be provided with a contraction chamber to allow for the inclusion of an auxiliary scale (see figure 1, type B). The contraction chamber shall be so elongated and as narrow as possible to avoid risk of a break in the mercury column at ambient temperature.

7.6 Position of chambers

No enlargement of the bore shall be so located as to produce any variation (greater than that permitted in 7.3) in the cross section of the capillary tube in the scale portion, and in all cases there shall be at least 5 mm of unchanged capillary between any enlargement and the nearest scale line. The distance from the top of the contraction chamber to the first scale line of the scale immediately above it shall be not less than 13 mm, except that for thermometers STL/0,5/190/310 and STL/1/180/420, this distance shall be not less than 30 mm.

7.7 Dimensions

The dimensions of the thermometers shall be as given in table 1 and figure 1.

8 Marking

8.1 The scale ranges and scale intervals of the thermometers shall be as given in table 2.

8.2 The scale lines shall be clearly and durably marked and of uniform thickness, which shall not exceed 0,12 mm. The lines shall be at right angles to the axis of the thermometer.

8.3 When the thermometer is held in a vertical position and viewed from the front, the left-hand ends of all the scale lines shall lie on an imaginary vertical line. When the thermometer is viewed so that the right-hand ends of the shortest scale lines align with the left-hand side of the bore, the medium and longer lines referred to shall extend across the bore towards the right.

Table 1 — Dimensions (see also figure 1)

Dimensions in millimetres

Dimensions		Type A	Type B
Total length	max.	375	375
Distance from top of bulb (shoulder) to lower nominal limit of scale	min.	20	—
Distance from top of bulb (shoulder) to 0 °C scale line	min.	—	20
Length of main scale (nominal limits)	min.	240	195
Distance from upper nominal limit of scale to top of thermometer	min.	25	25
Diameter of stem		5,5 to 8,0	5,5 to 8,0
External diameter of bulb :	min.	5	5
	max.	not greater than that of stem	
Length of bulb to shoulder	min.	15	15
Distance from shoulder of bulb to lower end of parallel-sided capillary tube	max.	5	5
Distance from top of bulb funnel to lowest scale line	min.	13	13
Distance from bottom of contraction chamber to highest scale line on scale below it	min.	—	5
Distance from top of contraction chamber to lowest scale line on scale above it	min.	—	13*
Distance from highest scale line to bottom of expansion chamber	min.	10	10

* Except for thermometers STL/0,5/190/310 and STL/1/180/420, for which this dimension should be at least 30 mm.

Table 2 — Graduation

Designation	Inscription	Scale interval	Main scale	Auxiliary scale	Type (see figure 1)
		°C	°C	°C	
STL/0,1/ − 25/ + 5	STL 1	0,1	− 25 to + 5	—	A
STL/0,1/ − 5/ + 25	STL 2	0,1	− 5 to + 25	—	A
STL/0,1/20/45	STL 3	0,1	20 to 45	− 0,5 to + 0,5	B
STL/0,1/40/65	STL 4	0,1	40 to 65	− 0,5 to + 0,5	B
STL/0,1/60/85	STL 5	0,1	60 to 85	− 0,5 to + 0,5	B
STL/0,1/80/105	STL 6	0,1	80 to 105	− 0,5 to + 0,5	B
STL/0,2/ − 55/ + 5	STL 7	0,2	− 55 to + 5	—	A
STL/0,2/ − 35/ + 25	STL 8	0,2	− 35 to + 25	—	A
STL/0,2/ − 15/ + 45	STL 9	0,2	− 15 to + 45	—	A
STL/0,2/35/85	STL 10	0,2	35 to 85	− 1 to + 1	B
STL/0,2/75/125	STL 11	0,2	75 to 125	− 1 to + 1	B
STL/0,2/115/165	STL 12	0,2	115 to 165	− 1 to + 1	B
STL/0,2/155/205	STL 13	0,2	155 to 205	− 1 to + 1	B
STL/0,5/ − 35/ + 115	STL 14	0,5	− 35 to + 115	—	A
STL/0,5/90/210	STL 15	0,5	90 to 210	− 3 to + 3	B
STL/0,5/190/310	STL 16	0,5	190 to 310	− 3 to + 3	B
STL/1/ − 30/ + 270	STL 17	1	− 30 to + 270	—	A
STL/1/180/420	STL 18	1	180 to 420	− 5 to + 5	B
STL/2/0/600	STL 19	2	0 to 600	—	A

Dimensions in millimetres

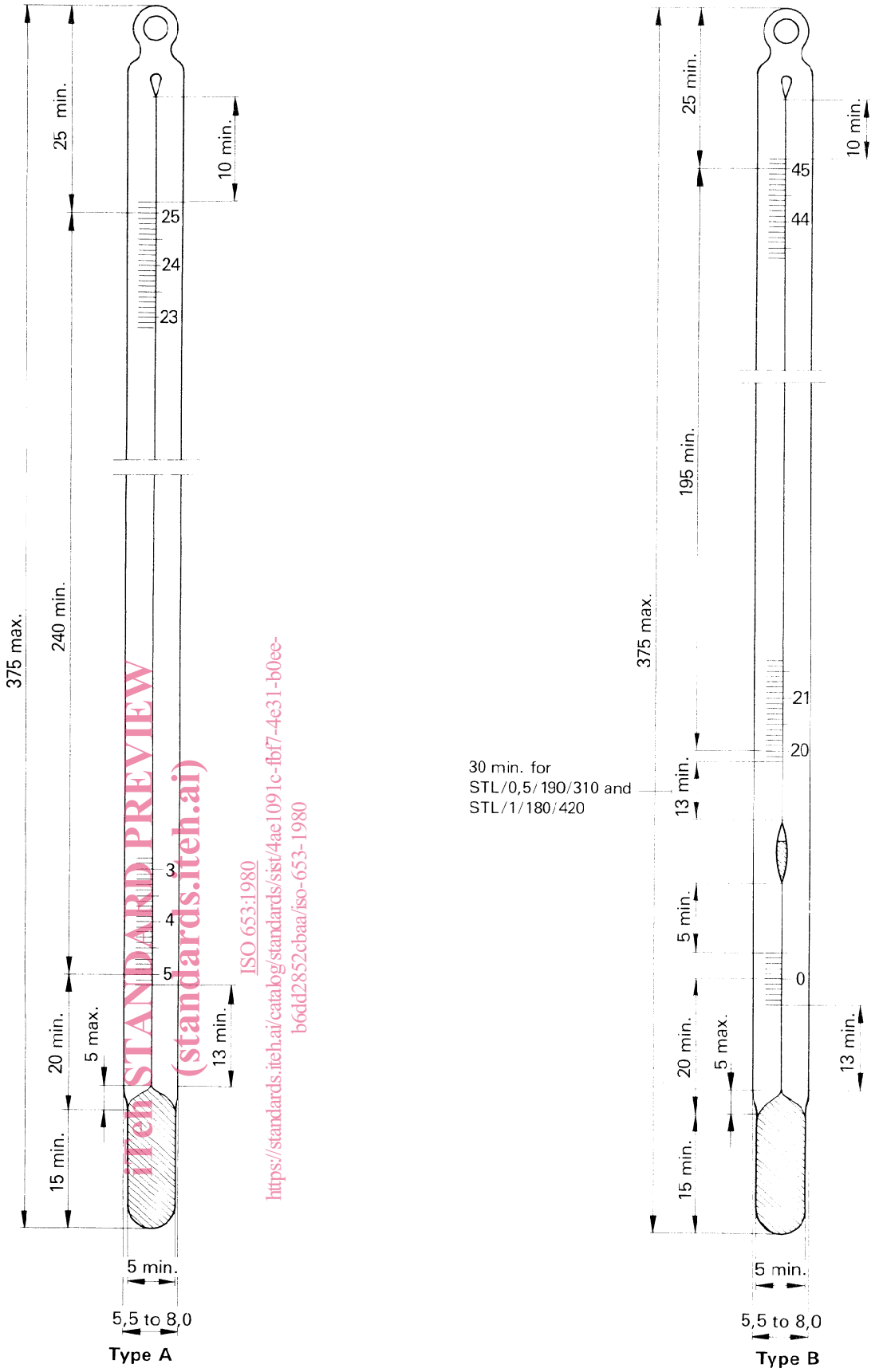

Figure 1 — Long solid-stem thermometers for precision use

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

8.4 The length of the short scale lines shall be approximately 1 mm. The medium scale lines shall be nominally 1,5 times the length of the short scale lines, and the long scale lines shall be nominally 2,5 times the length of the short scale lines.

8.5 The arrangement of the scale lines shall be as follows :

8.5.1 On thermometers where the smallest scale division is 1 °C or 0,1 °C :

a) every tenth scale line shall be a long line;

b) there shall be a medium line midway between two consecutive long lines;

c) there shall be four short lines between consecutive medium and long lines (see drawings A and D of figure 2).

8.5.2 On thermometers where the smallest scale division is 2 °C or 0,2 °C :

a) every fifth scale line shall be a long line;

b) there shall be four short lines equally spaced between two consecutive long lines (see drawings B, E and G of figure 2).

8.5.3 On thermometers where the smallest scale division is 0,5 °C :

a) every tenth scale line shall be a long line;

b) there shall be four medium lines equally spaced between two consecutive long lines;

c) there shall be one short line between two consecutive medium lines or between consecutive medium and long lines (see drawings C and F of figure 2).

8.6 The figures shall be placed either slightly to the left or right of the line to which they refer, as preferred, in such a way that an extension of the line would bisect them or pass immediately under them. The figures may be placed either parallel to, or at right angles to, the axis of the thermometer, as preferred.

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

8.7 Every tenth scale line shall be figured.

Thus, in the case of a smallest scale division of :

0,1 °C, the series of figures shall be : 1 — 2 — 3 — etc.

1 °C, the series of figures shall be : 10 — 20 — 30 — etc.

0,2 °C, the series of figures shall be : 2 — 4 — 6 — etc.

2 °C, the series of figures shall be : 20 — 40 — 60 — etc.

0,5 °C, the series of figures shall be : 5 — 10 — 15 — etc.

The auxiliary scale shall be figured at 0 °C.

Scale lines at 0 °C or 10 °C or 100 °C should be emphasised (for example, by full figuring if either the first or first and second digits are omitted at intermediate scale lines).

8.8 The pigment filling shall remain in the scale lines, figures and inscriptions under normal conditions of use and under such other special conditions as may be specified between purchaser and vendor or manufacturer.

8.9 Each end of the scale shall be extended by two to five divisions beyond the nominal limits of the scale.

8.10 All negative numbers should be indicated by minus signs, for example − 5 or $\overline{5}$ as preferred, so placed that they are not liable to be confused with the scale lines, or other marking.

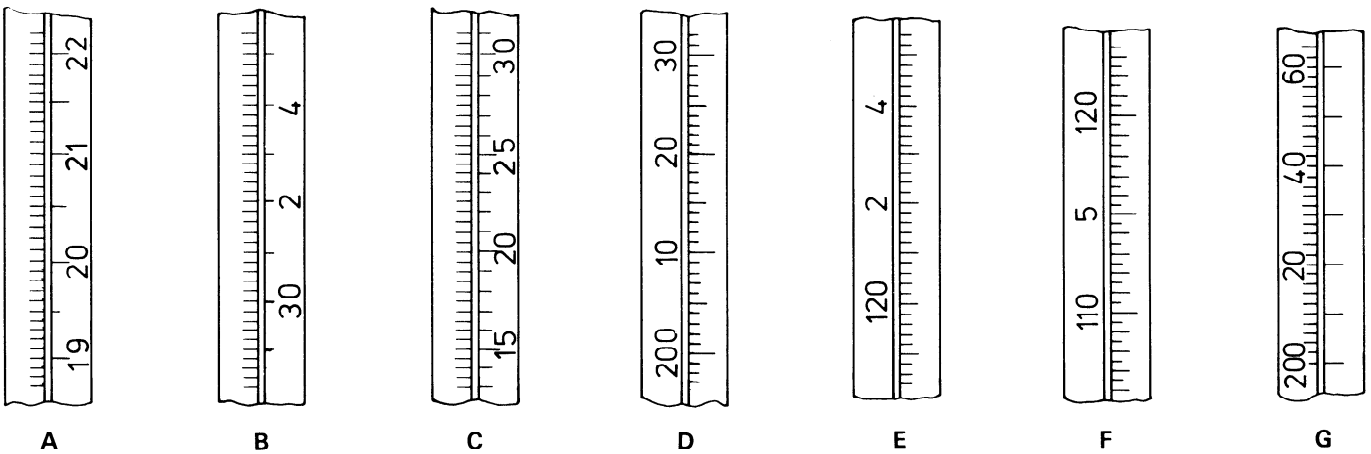

Figure 2 — Alternative types of graduation and figuring

9 Accuracy

9.1 Instrument error

The maximum permissible instrument error shall not be more than one scale division when the thermometer is in a vertical position and at the prevailing atmospheric pressure under the conditions of immersion and average emergent liquid column temperature specified for use.

9.2 Interval error

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

9.3 Change in zero

When a thermometer having an upper nominal limit above 100 °C is maintained over a period of 24 h at the highest temperature of the scale, the change in the zero point, determined by the method described in the annex, shall not exceed 0,7 of a scale division, and the scale error shall remain within the limit of one scale division specified in 9.1.

10 Inscriptions

The following inscriptions shall be durably and legibly marked on the thermometer :

a) temperature scale indication : the official symbol "°C"; an abbreviation of the name Celsius (for example "C") is also permitted;

b) for thermometers described in 3.2, the indication "complete" or a suitable abbreviation. Otherwise, an indication of the immersion is not required;

c) gas filling, if any, for example "nitrogen filled", "vacuous", or a suitable abbreviation;

d) identification of the bulb glass, preferably by means of a coloured stripe or stripes, or by an inscription on the thermometer;

e) manufacturer's identification or serial number the last two digits of which may indicate the year of manufacture (where required);

f) vendor's and/or maker's name or readily identifiable mark;

g) specification number, i.e. "ISO 653" or national equivalent;

h) designation number as in table 2, for example "STL 2".

Annex

Method of determining change in zero indication

(This annex forms part of the standard.)

Heat the thermometer, immersed in a test bath, to a temperature equal to its highest reading and keep it at this temperature for 5 min. Allow the thermometer to cool either naturally in still air or slowly in the test bath (at a reproducible rate) to 20 °C above ambient temperature or to 50 °C, whichever is the lower, and then determine the zero. If natural cooling is used, the zero should be determined within 1 h. Heat the thermometer again to a temperature equal to its highest reading, keep it at this temperature for 24 h, allow the thermometer to cool to one of the two temperatures referred to above, at the same rate as at the start of the test, and redetermine the zero under the same conditions as before.

NOTE — This test is appropriate to thermometers having an upper nominal limit above 100 °C.