

**BUREAU OF INDIAN STANDARDS**

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*Draft Indian Standard*

**SOIL THERMOMETERS — SPECIFICATION**

*(First Revision)*

*भारतीय मानक मसौदा*

**मृदा थर्मोमीटर — विशिष्टि**

*(पहला पुनरीक्षण)*

ICS 17.200.20

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Glass, Glassware & Laboratoryware Sectional Committee, CHD 10

**Last date for Comments: 21 February 2024**

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**FOREWORD**

*(Formal clause to be added later)*

The measurement of soil temperature is of great importance in meteorological and agricultural studies, and is made with the thermometer bulbs exposed on the surface of the soil and at various depths up to 100 cm. The standard depths for soil temperature measurements are 5, 10, 20, 50 and 100 cm. Soil thermometers at depths of 5, 10 and 20 cm are part of the standard equipment at agricultural observatories in India. Bent-stem mercury-in-glass thermometers clamped to special triangular stands bent at 60 °C so that they can support the thermometers at the correct inclination to the ground, are used for the measurement of soil temperatures at shallow depths, while at greater depths lagged thermometers suspended in iron tubes sunk into the soil to the required depth are used. Details of these are given in Fig. 10 and Fig. 11.

As the temperature of the soil varies much more slowly than the air temperature, its mean value can be obtained with a higher degree of accuracy. In the surface layers, however, variations of appreciable magnitude may occur within small horizontal areas due to differences in the soil covering, but at lower depths the temperatures over a horizontal area are generally more uniform. At depths up to 50 cm the temperature can be read to an accuracy of 0.1 °C and the corrections of the thermometers should therefore be known to that degree of precision. At greater depths, the temperature variations are so slow that measurement to even greater accuracies is desirable.

This standard was first published in 1972 using the assistance derived from the specifications for soil thermometers prepared by the India Meteorological Department, Government of India, for use of meteorological observatories in the country.

In this first revision, Kerosene oil as a thermometric liquid has been added. A sampling plan for lot testing has been prescribed and several editorial changes such as the inclusion of the Reference clause, Hindi Title, ICS no, BIS certification marking clause, etc. have also been incorporated.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 'Rules for rounding off numerical values (*second revision*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

*Draft Indian Standard*  
**Soil Thermometers — Specification**  
*(First Revision)*

## **1 SCOPE**

This standard prescribes the requirements for soil thermometers for use at the soil surface and at depths of 5, 10, 20, 50 and 100 cm below the surface.

## **2 REFERENCE**

The standards given below contain provisions which through reference in this text, constitute provisions of and necessary adjuncts to this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated.

<i>IS No.</i>	<i>IS Title</i>
IS 2627 : 1979	Glossary of terms relating to liquid - In - Glass thermometers ( <i>first revision</i> )
IS 4610 : 1968	Specification for glass tubes for general purpose and reference thermometers
IS 6274 : 1971	Method of calibrating liquid - In - Glass thermometers

## **3 TERMINOLOGY**

For the purpose of this standard, the definitions given in IS 2627 shall apply.

## **4 TYPES, IMMERSION AND RANGES**

### **4.1 Types and Immersion**

The thermometers for use at the soil surface and at depths of 5, 10 and 20 cm shall be of liquid-in-glass enclosed-scale or sheathed solid-stem type and shall be graduated for vertical partial immersion.

**4.1.1** The thermometers for use at depths of 50 cm and 100 cm below the surface shall be of liquid-in-glass sheathed solid-stem type and shall be graduated for vertical total immersion.

### **4.2 Ranges**

The thermometers for use at the soil surface and at depths of 5, 10 and 20 cm shall have a range from – 20 to + 65 °C with the smallest scale division equivalent to 0.5 °C.

**4.2.1** The thermometers for use at depths of 50 and 100 cm below the surface shall have a range from – 20 to + 50 °C with the smallest scale division equivalent to 0.5 °C.

## **5 DESIGNATION**

The thermometers shall be designated by the name, type and depth of use separated by a hyphen.

Example:

A soil thermometer of enclosed-scale type meant for use at the soil surface shall be designated as ‘ST/ES-S’.

## **6 REQUIREMENTS**

### **6.1 Materials**

### 6.1.1 Glass

The stem of the thermometers of enclosed-scale type shall be of suitable clear transparent glass free from occlusions, striae, stresses and visual defects, such as bubbles, knots, reflection failure and roughness of the bore. Bulb tubing shall conform to IS 4610.

**6.1.1.1** The tubes used for the sheathed solid-stem type thermometers shall have an enamelled back to outline the scale etched on its front face and conform to IS 4610.

### 6.1.2 Thermometric Liquid

**6.1.2.1** The thermometric liquid shall be entirely free from contamination particularly of solid particles or of any liquid which produces a variation of volume with time.

**6.1.2.2** Recommended thermometric liquids and the approximate temperature ranges covered by them are given in Table 1.

**TABLE 1 TEMPERATURE RANGES FOR VARIOUS THERMOMETRIC LIQUIDS**

(Clause 6.1.2.2)

SI No.	Thermometric Liquid	Approximate Temperature Range, °C
(1)	(2)	(3)
i.	Mercury	-38 to +600
ii.	Mercury-thallium alloy [8.5 percent (m/m) of thallium]	-55 to +600
iii.	Alcohol	-80 to +50
iv.	Toluene (IS 537)	-90 to +50
v.	Technical pentane	-200 to +30
vi.	Kerosene Oil	-20 to +150

**6.1.2.3** The organic liquid used as the liquid filling shall, wherever possible, be coloured by means of light-fast dye which does not stain the glass. Alcohol shall comply in all respects with the provisions of Special Grade of IS 321 subject to the following modifications:

- a) *Aldehydes and ketones* — Alcohol shall not contain more than 0.02 percent (m/m) of aldehydes and ketones, calculated as acetaldehyde (CH<sub>3</sub>CHO); and
- b) *Amines* — Alcohol shall give no indication of the presence of amines when tested by adding to 10 ml of alcohol, 10 ml of distilled water followed by 2 drops of a saturated solution of *p*-nitrophenol in water. Not more than 0.05 ml (1 drop) of 0.1 N sulphuric acid shall be required to discharge any yellow colour produced.

## 6.2 Construction

### 6.2.1 Thermometers for the Surface and for Depths of 5, 10 and 20 cm

#### 6.2.1.1 Stem

The stem shall be straight and preferably lens-fronted in the graduated portion. The lens front shall magnify the mercury column in the bore to a width of at least 1 mm. It shall be bent near the bulb at an angle of 120 °C, the bend being in the form of a curve approximately 10 mm in radius.

**6.2.1.2** No enlargement of bore shall be permissible in the graduated portion of the stem or within 10 mm from either end of the scale.

#### 6.2.1.3 Bulb

The bulb shall be cylindrical and in alignment with the stem. The shape and finish of the bulb shall be such as not to entrap the thermometric liquid.

**6.2.1.4** The top of the outer glass case shall be finished smooth and round.

**6.2.1.5** *Expansion chamber*

The thermometers shall be so constructed as to withstand a temperature of 80 °C without damage. An elongated or pear-shaped expansion chamber with a hemispherical top and without re-entrant shoulders shall be provided at the top end of the capillary in line with the capillary bore to enable the thermometers to withstand the above temperature.

**6.2.2** *Specific Requirements for Enclosed-Scale Type Thermometers*

**6.2.2.1** *Pattern*

The thermometers shall conform to the shapes prescribed in Fig. 1 to Fig. 4.

**6.2.2.2** The capillary tube shall be enclosed in an outer case of stout clear glass tubing of approximately 20 mm diameter in the graduated portion and 10 mm in the lower ungraduated portion. It shall be supported inside the outer case by plugs of asbestos, cotton or similar material, inserted as shown in Fig. 1 to Fig. 4.

**6.2.2.3** The opal glass scale shall be sliding fit in the outer case and be held in position between two pieces of cork so that there is no relative movement between the stem and the scale.

**6.2.3** *Specific Requirements for Sheathed Solid-Stem Type Thermometers*

**6.2.3.1** *Pattern*

The thermometers shall conform to the shapes prescribed in Fig. 5 to Fig. 8. The entire stem shall be enclosed in an outer sheath of stout clear glass tubing of approximately 20 mm diameter finished smooth and round at the top. The outer glass cover shall have a low heat capacity and, therefore, not be unduly bulky. At the same time it shall be sufficiently robust to withstand the normal risks of handling and transport.

**6.2.3.2** The thermometer shall be supported inside the outer glass tubing by two pieces of cork, one at the top above the scale and the other below it. The cork piece at the top shall not conceal the expansion chamber.

**6.2.3.3** The thermometers shall be suitably annealed before graduation.

**6.2.4** *Thermometers for 50 cm and 100 cm Depths*

**6.2.4.1** *Pattern*

Tile thermometers shall conform to the shape prescribed in Fig. 9. The stem shall be straight and the bulb spherical and in alignment with the stem.

**6.2.4.2** No enlargement of the bore shall be permissible in the graduated portion of the stem or within 10 mm from either end of the scale.

**6.2.4.3** The thermometer shall be mounted centrally in an outer glass case, at least 1.5 mm thick, as shown in Fig. 9. The upper end of the thermometer stem shall be fused to a piece of short glass tubing of approximately the same diameter as the stem. This glass tubing shall be securely fused to the end of the outer glass case and shall terminate in a bulb shape and extend about 25 mm above the joint.

**6.2.4.4** A stout piece of rubber tubing about 65 mm long and approximately 25 mm external diameter shall be securely wound at one end round the upper part of the outer case and at the other end round a boxwood plug by means of suitable copper wire. The top of the bore of the thermometer tube shall be visible below the edge of the rubber tubing after assembly.

**6.2.4.5** Two rubber rings each about 3 mm thick shall be provided to fit tightly round the outer glass case as shown in Fig. 9. A brass screw eye shall be screwed into the wooden plug at top for attaching the-thermometer to a chain.

**6.2.4.6** The lower end of the thermometer shall be embedded in a plug of pure paraffin wax to a height of about 38 mm from the bottom of the glass case.

**6.2.4.7** The shape and finish of the bulb shall be such as not to entrap the thermometric liquid.

**6.2.4.8** The thermometer shall be provided with an expansion chamber satisfying the requirements given in **6.2.1.5** to enable it to withstand a temperature of 65 °C without damage.

**6.2.4.9** The thermometer shall be suitably annealed before engraving.

### 6.3 Dimensions

The thermometers shall conform to the dimensions shown in Table 2 read with Fig. 1 to Fig. 9.

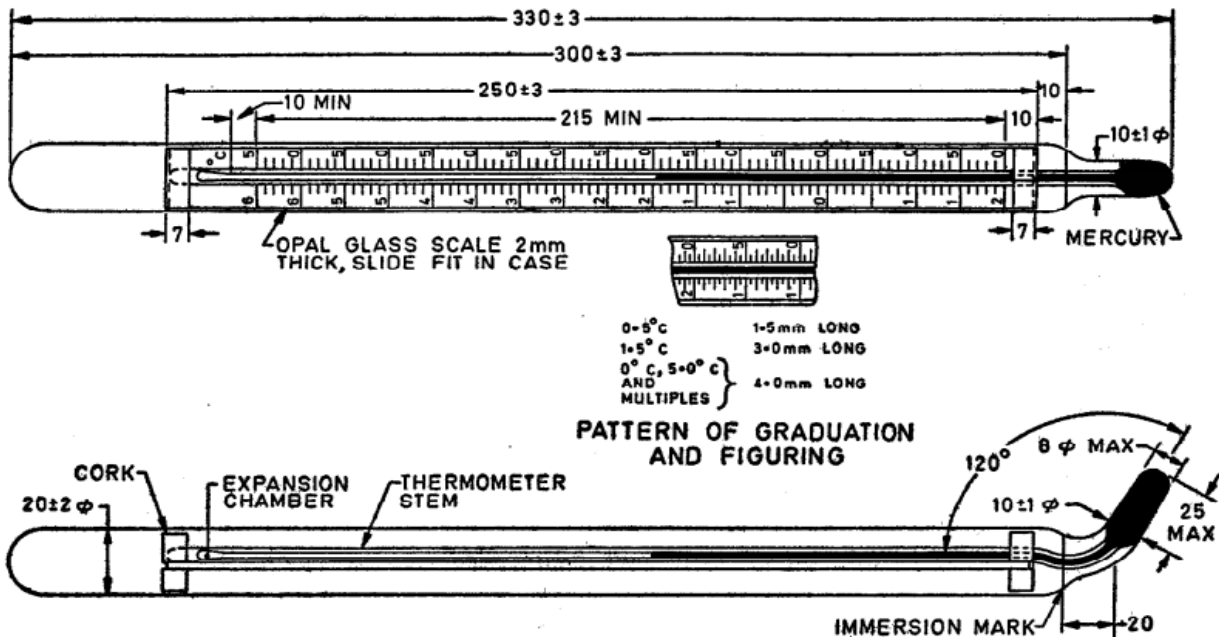
**TABLE 2 DIMENSIONAL REQUIREMENTS OF SOIL THERMOMETERS**

(Clause 6.3)

SI No.	PARTICULARS	REQUIREMENTS								
		(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
i)	Designation	ST/ES-S	ST/SS-S	ST/ES-5	ST/SS-5	ST/ES-S	ST/ES-10	ST/SS-10	ST/ES-20	ST/SS-50 and ST/SS-100
ii)	Nominal range, °C	- 20 to + 65	- 20 to + 65	- 20 to + 65	- 20 to + 65	- 20 to + 65	- 20 to + 65	- 20 to + 65	- 20 to + 65	- 20 to + 65
iii)	Smallest scale division, °C	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
iv)	Overall length, mm	(330 ± 3)	(330 ± 3)	(330 ± 4)	(330 ± 4)	(330 ± 5)	(330 ± 5)	(330 ± 6)	(330 ± 6)	(330 ± 3)
v)	Length of the main scale, mm, <i>Min</i>	215	215	215	215	215	215	215	215	175
vi)	Length of the bulb, mm, <i>Max</i>	25	25	25	25	25	25	25	25	–
vii)	External diameter of the bulb, mm, <i>Max</i>	8	8*	8	8*	8	8*	8	8*	(10 ± 1)†
viii)	External diameter of the stem, mm	–	6 to 8	–	6 to 8	–	6 to 8	–	6 to 8	(6.0 ± 0.5)
ix)	Distance of the immersion mark from the top of the bulb, mm	20	20	60	60	115	115	230	230	–

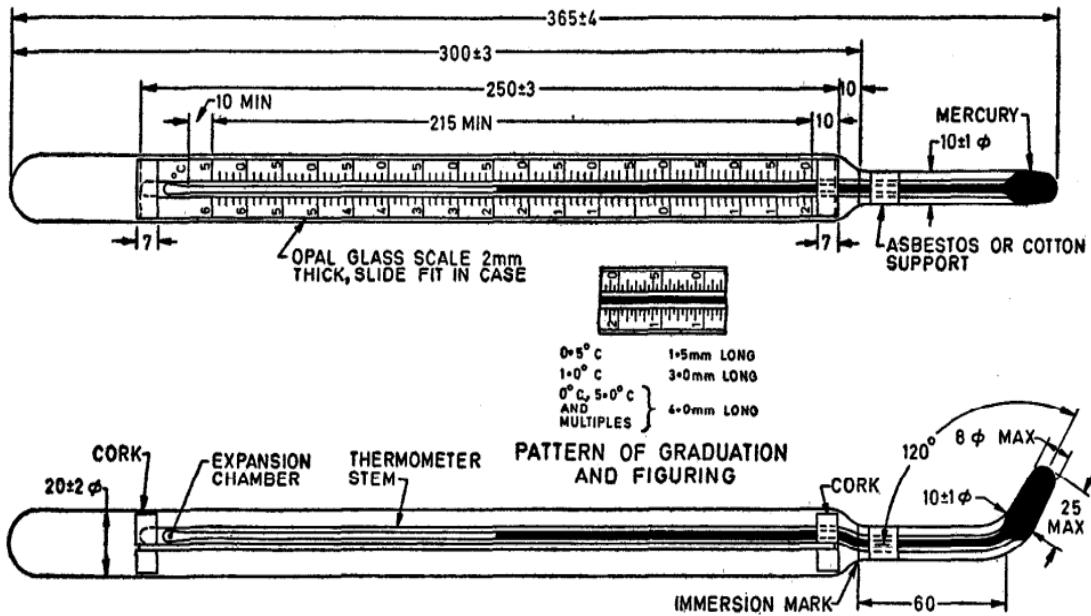
\*Bulb diameter shall be less than that of the stem.

†Spherical bulb.



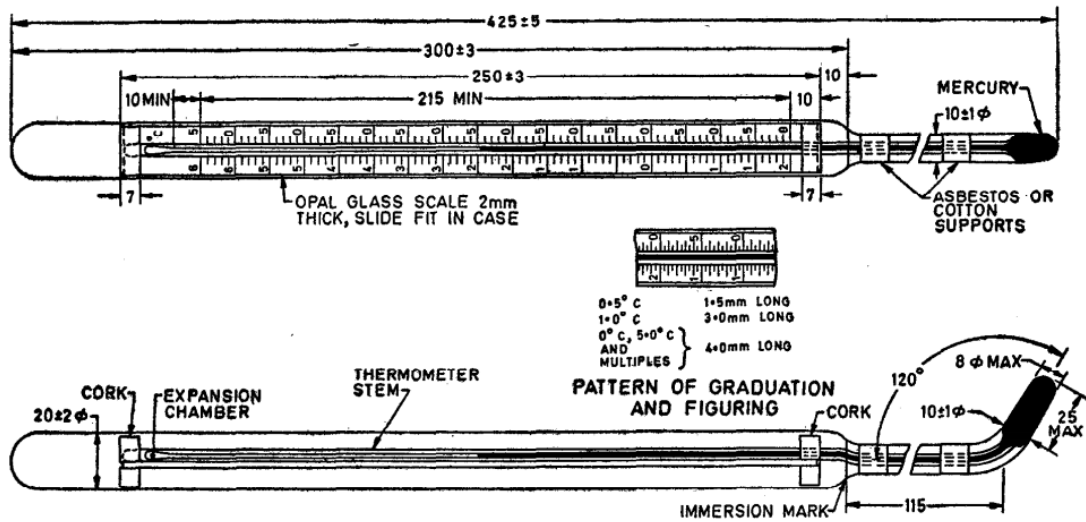
All dimensions in millimetres.

FIG. 1 SOILTHERMOMETER, ENCLOSED-SCALE, 120° BENT, FOR SURFACE, RANGE - 20 °C TO + 65 °C



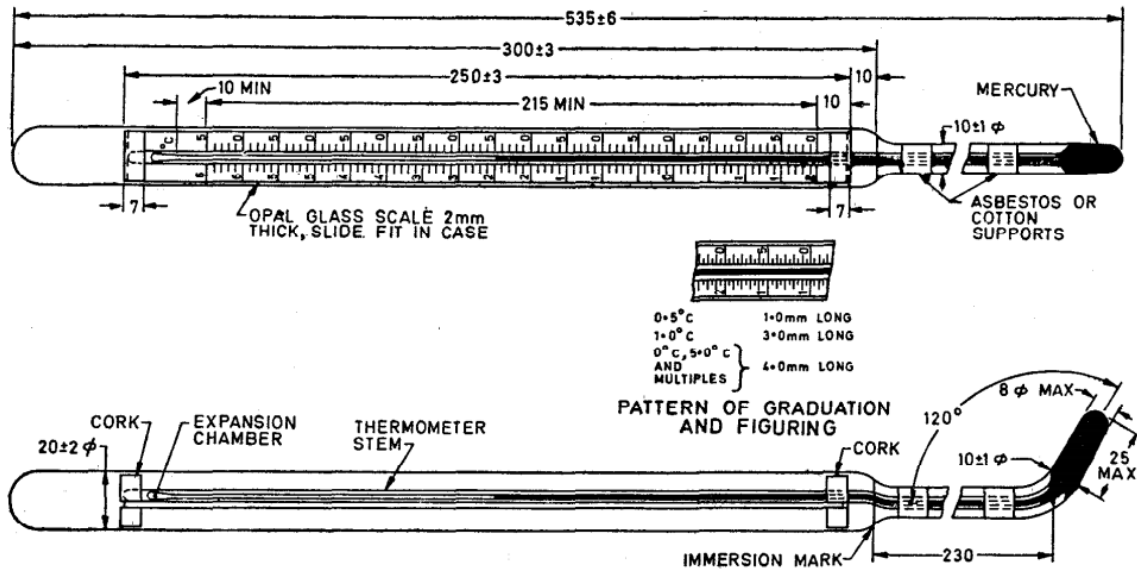
All dimensions in millimetres.

FIG. 2 SOILTHERMOMETER, ENCLOSED-SCALE, 120° BENT, FOR 5 cm DEPTH, RANGE - 20 °C TO + 65 °C



All dimensions in millimetres.

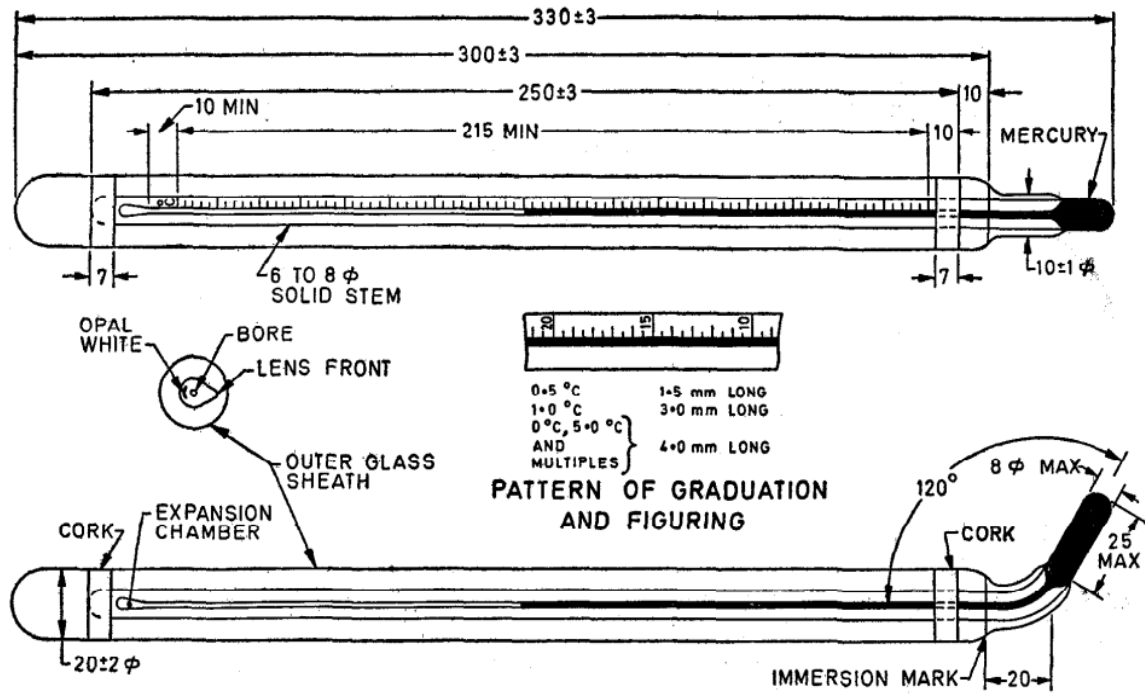
FIG. 3 SOILTHERMOMETER, ENCLOSED-SCALE, 120° BENT, FOR 10 cm DEPTH, RANGE - 20 °C TO + 65 °C



All dimensions in millimetres.

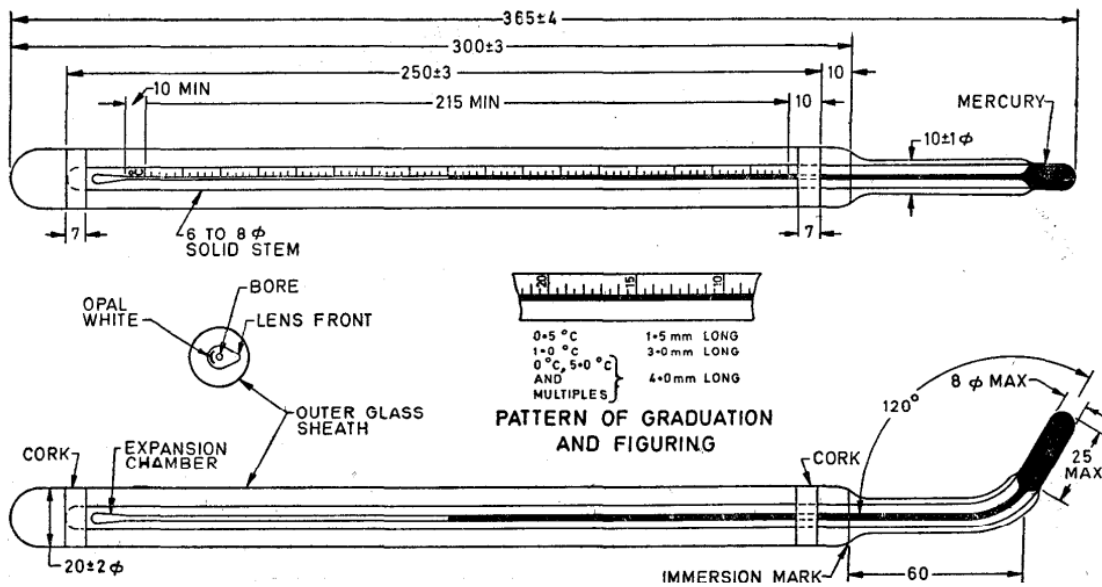
FIG. 4 SOILTHERMOMETER, ENCLOSED-SCALE, 120° BENT, FOR 20 cm DEPTH, RANGE - 20 °C TO + 65 °C





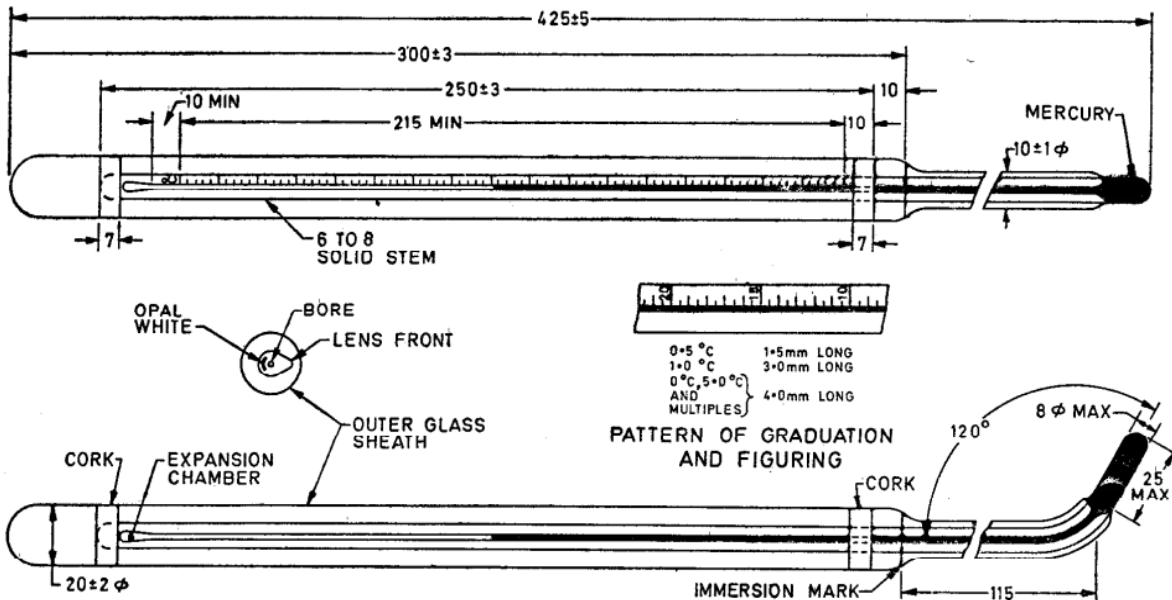
All dimensions in millimetres

FIG. 5 SOILTHERMOMETER, SHEATHED, SOLID-STEM, 120° BENT, FOR SURFACE, RANGE - 20 °C TO + 65 °C



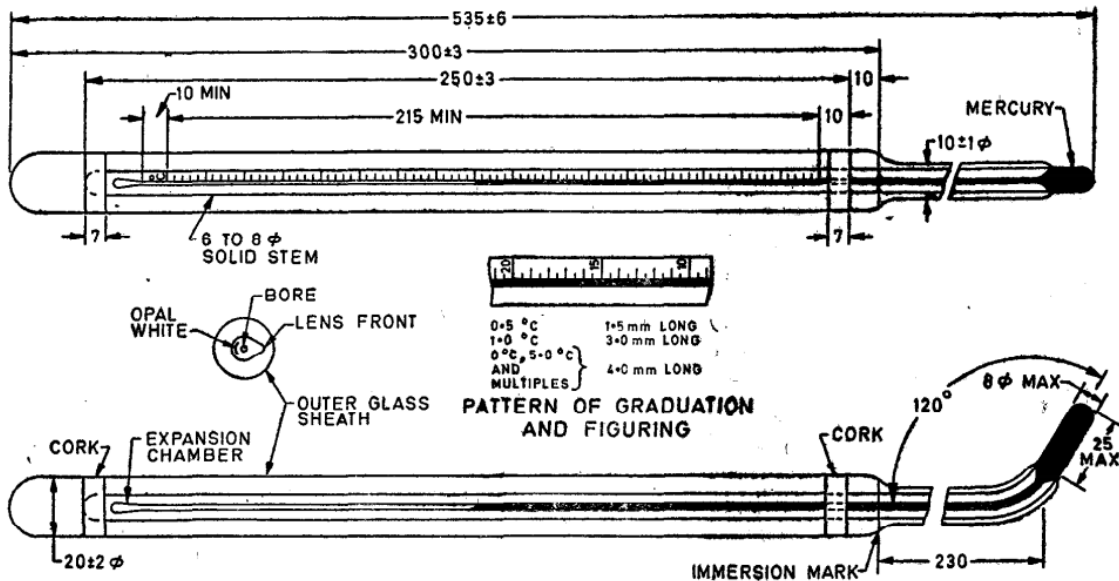
All dimensions in millimetres

FIG. 6 SOILTHERMOMETER, SHEATHED, SOLID-STEM, 120° BENT, FOR 5 cm DEPTH, RANGE - 20 °C TO + 65 °C



All dimensions in millimetres

FIG. 7 SOILTHERMOMETER, SHEATHED, SOLID-STEM, 120° BENT, FOR 10 cm DEPTH, RANGE - 20 °C TO + 65 °C



All dimensions in millimetres

FIG. 8 SOILTHERMOMETER, SHEATHED, SOLID-STEM, 120° BENT, FOR 20 cm DEPTH, RANGE - 20 °C TO + 65 °C

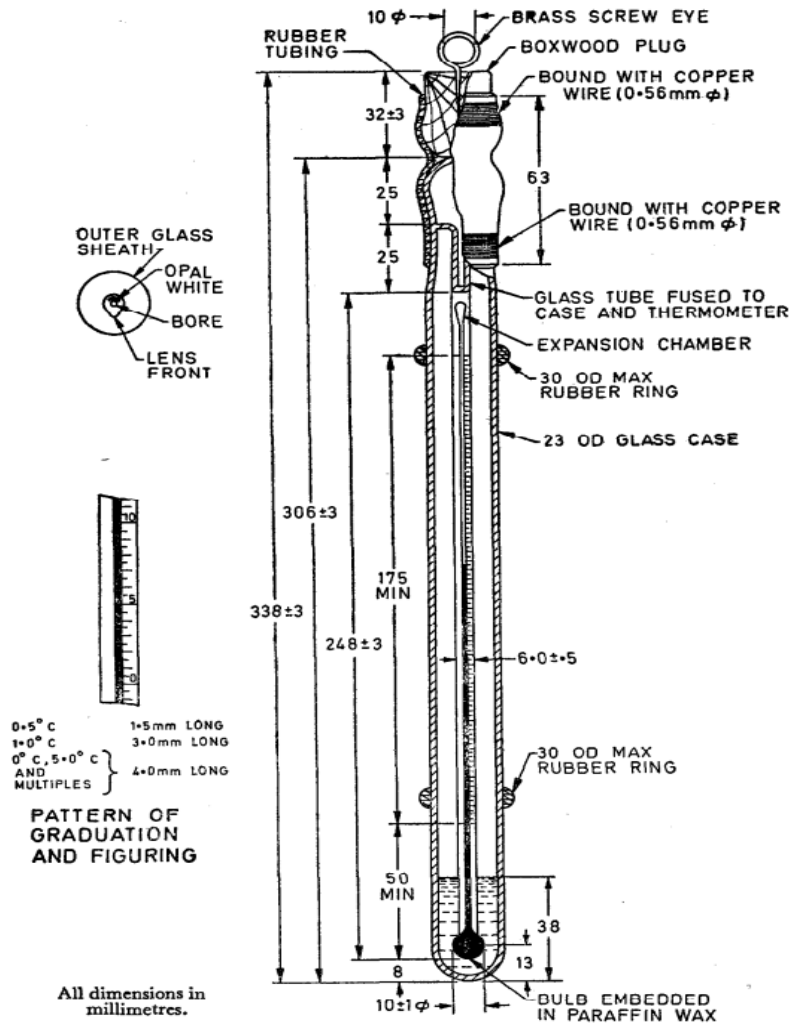


FIG. 9 SOIL THERMOMETER FOR 50 AND 100 cm DEPTHS,  
 RANGE - 20 °C TO + 50 °C

#### 6.4 Immersion Line

The thermometers for use at the soil surface and at depths of 5, 10 and 20 cm shall be marked for immersion at 20, 60, 115 and 230 mm respectively from the top of the bulb.

#### 6.5 Graduation and Figuring

6.5.1 The graduation lines and figures shall be clearly engraved on the opal glass scale or solid stem at each 0.5 °C and shall be of uniform thickness not exceeding 0.15 mm. They shall be filled with black pigment.

6.5.2 The graduation lines shall be at right angles to the axis of the thermometer when the thermometer is viewed from the front in a vertical position.

6.5.3 The graduation lines in the enclosed-scale type thermometers shall be 8 mm and 12 mm long for 0.5 °C and 1 °C respectively. The graduation lines for 5 °C and its multiples shall be as long as the full width of the scale. In the sheathed solid-stem type thermometers these shall be 1.5, 3 and 4 mm long respectively.

#### NOTE

The length of graduation line for 0 °C mark shall be the same as that for 5 °C and its multiples.

**6.5.3.1** In the enclosed-scale type thermometers the graduation lines shall extend on the scale equally on either side of the axis.

**6.5.3.2** In the sheathed solid-stem type thermometers, the left-hand ends of the graduation lines shall lie on an imaginary line parallel to the axis. No graduation line shall cross the bore.

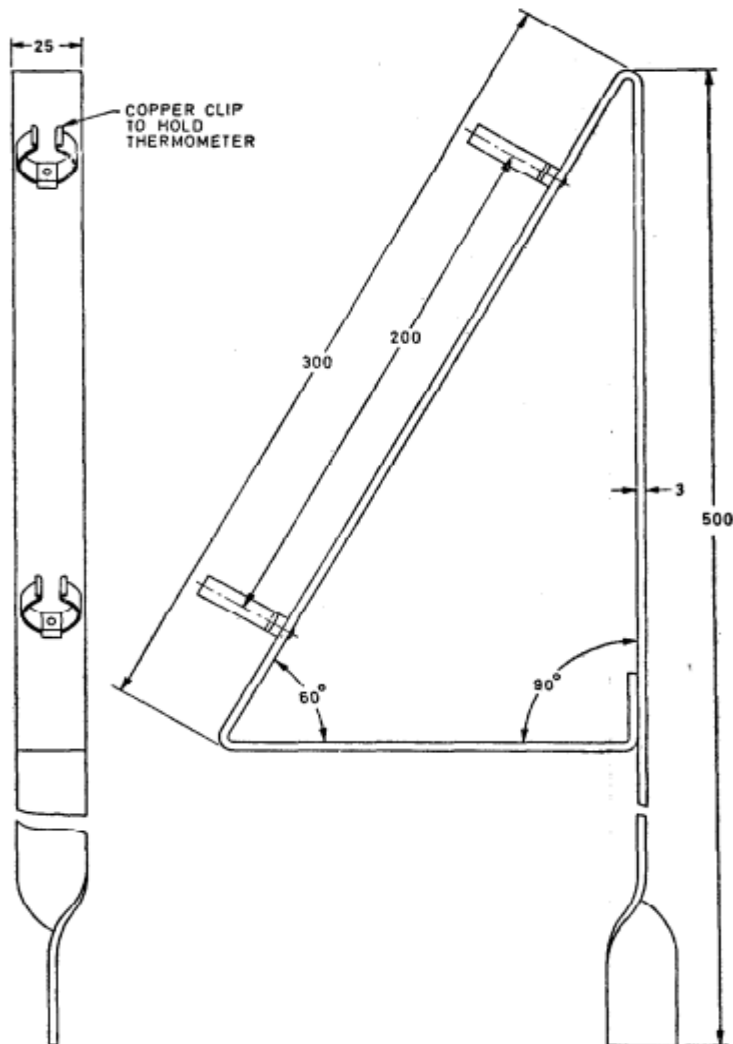
**6.5.4** Graduation lines indicating temperatures equivalent to 0 °C, 5 °C and its multiples shall be marked with bold figures of uniform thickness.

**6.5.5** The figures shall be placed immediately above the extended lines to which they refer as shown in Fig. 1 to Fig. 9.

**6.5.6** The number of divisions in 25 mm length shall not exceed 20.

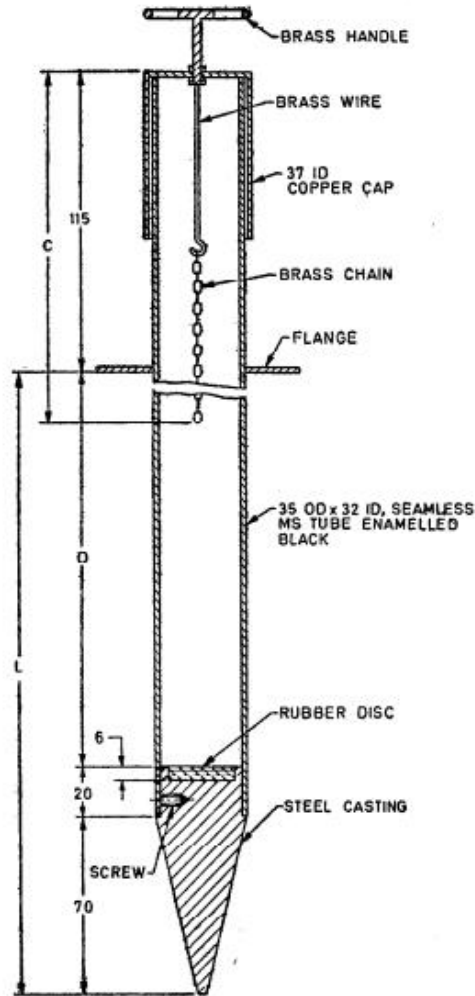
### 6.6 Triangular Stand and Iron Tube

The triangular stand for thermometers shown in Fig. 1 to Fig. 8 shall be as shown in Fig. 10 and the iron tube for thermometer shown in Fig. 9 shall be as shown in Fig. 11.



Material: Mild steel flat, painted black  
All dimensions in millimetres.

FIG. 10 TRIANGULAR STAND FOR SOIL THERMOMETERS, 120° BENT, FOR SURFACE, 5, 10 AND 20 cm DEPTHS



All dimensions in millimetres

	For 50 cm Depth	For 100 cm Depth
D	513	1 013
L	603	1 103
C	280	780

FIG. 11 IRON TUBE FOR SOIL THERMOMETERS, 50 AND 100 cm DEPTHS

## 7 ACCURACY

### 7.1 Scale Error

The maximum permissible scale error at any point shall be  $\pm 0.2$  °C below 0 °C and  $\pm 0.1$  °C above 0 °C.

### 7.2 Interval Error

The maximum change of error between two points separated by an interval of 10 °C on the stem shall not exceed 0.1 °C below 0 °C and 0.05 °C above 0 °C.

## 8 MARKING AND PACKING

### 8.1 Packing

The thermometers shall be packed as agreed to between the purchaser and the supplier.

### 8.2 Marking

8.2.1 Each thermometer shall be marked legibly and permanently with the following information:

- a) The letter 'C' near the top of the scale;
- b) Maker's name or recognized trade-mark, if any, at the back of the scale or stem;
- c) Serial number and year of manufacture; and
- d) Designation.

### 8.2.2 BIS Certification Marking

The product(s) conforming to the requirements of this standard may be certified as per the conformity assessment schemes under the provisions of the *Bureau of Indian Standards Act, 2016* and the Rules and Regulations framed thereunder, and the products may be marked with the standard mark.

## 9 SAMPLING

### 9.1 Lot

9.1.1 All thermometers of the same type in a single consignment and produced under similar conditions of manufacture shall constitute a lot.

9.1.2 Thermometers constituting the sample shall be drawn from each lot separately for deciding the conformity of the lot to the requirements of the specification.

### 9.2 Scale of Sampling

Number of thermometers to be selected at random from the lot shall depend on the lot size and shall be in accordance with col 3 of Table 3. In order to ensure randomness of selection, procedures given in IS 4905 may be followed.

**TABLE 3 SCALE OF SAMPLING**  
(Clause 9.2, 9.3.2)

Sl No.	No. of thermometers in the lot	Sample size	Rejection Number
(1)	(2)	(3)	(4)
i.	Less than 150	20	1
ii.	151 to 280	32	2
iii.	281 to 500	50	3
iv.	501 to 1 200	80	5
v.	1 201 and above	125	7

### 9.3 Criteria for conformity

9.3.1 For deciding the conformity of the lot to the requirements of this specification, the test results of each characteristic shall meet the corresponding requirements specified in the relevant clauses.

9.3.2 The lot shall be declared as conforming to the requirements of the specification, if the number of defectives is equal or less than the number given in col 4 of Table 3.