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INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

ISO RECOMMENDATION
R 386

PRINCIPLES OF CONSTRUCTION AND ADJUSTMENT OF LIQUID-IN-GLASS LABORATORY THERMOMETERS

1st EDITION
September 1964

For each individual country the only valid standard is the national standard of that country.

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BRIEF HISTORY

The ISO Recommendation R 386, *Principles of Construction and Adjustment of Liquid-in-Glass Laboratory Thermometers*, 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 1951 and led, in 1960, to the adoption of a Draft ISO Recommendation.

In April 1960, this Draft ISO Recommendation (No. 349) 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:

Australia	Germany	Romania
Austria	Greece	Spain
Belgium	India	Sweden
Canada	Israel	United Kingdom
Chile	Japan	U.S.A.
Colombia	Netherlands	U.S.S.R.
Czechoslovakia	New Zealand	
France	Poland	

No Member Body opposed the approval of the Draft.

The Draft ISO Recommendation was then submitted by correspondence to the ISO Council, which decided, in September 1964, to accept it as an ISO RECOMMENDATION.

ISO Recommendation R 386 September 1964

PRINCIPLES OF CONSTRUCTION AND ADJUSTMENT OF LIQUID-IN-GLASS LABORATORY THERMOMETERS

1. SCOPE

This ISO Recommendation is intended to provide guidance for drawing up specifications for liquid-in-glass laboratory thermometers. Each thermometer consists of a glass bulb filled with liquid and connected with a glass capillary tube. A scale is associated with the tube in such a way that the temperature can be read from the height of the liquid in the tube.

2. TYPES OF THERMOMETERS

Two types of liquid-in-glass thermometers are distinguished.

2.1 *Solid-stem thermometer*

Thermometer having a thick-walled capillary stem, on which the scale is permanently marked.

2.2 *Enclosed-scale thermometer*

Thermometer having a capillary stem and a separate strip bearing the scale, both being enclosed in a protective sheath.

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

In measuring a temperature, one of the following methods should be used:

(*a*) either the bulb and the section of the capillary tube filled with liquid should be completely immersed in the medium whose temperature is to be measured,

(*b*) or the temperature and the length of that section of the capillary tube filled with liquid and emerging from the medium should be measured and a correction made for any difference between the measured value and the specified value of the emergent liquid column temperature.

The following definitions should be used:

4.1 *Total immersion thermometer.* Thermometer whose reading should be correct, when the thermometer is immersed at least to the end of the liquid column in the medium, the temperature of which is to be measured.

NOTE. — If in special instances it is required that the reading should be correct, when the complete thermometer is immersed in the medium, this should be specified.

4.2 *Partial immersion thermometer.* Thermometer whose reading should be correct, when the thermometer is immersed to a prescribed depth, and when the emergent liquid column is under prescribed conditions.

4.3 *Emergent liquid column.* That part of the capillary tube filled with the filling liquid of the thermometer which is not immersed in the medium, the temperature of which is to be measured.

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 the 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

The general requirements for the liquid filling should include the following:

6.1 The filling should remain liquid throughout the temperature range under the conditions prevailing in the thermometer.

6.2 The liquid should be entirely free from contamination.

6.3 The boiling point of the liquid should be high enough to minimize distillation under the conditions prevailing in the thermometer.

6.4 For liquids which wet glass, the requirements should also include the following:

6.4.1 The physical properties of the liquid should be such as to ensure that the drainage time when the thermometer is cooled, is within specified limits.

6.4.2 The liquid should preferably be coloured by means of a light-fast dye which does not stain the glass.

7. GAS FILLING

When gas filling is employed above the filling liquid, a dry, inert gas should be used, at a pressure which raises the boiling point of the liquid sufficiently to ensure that reliable readings are obtained over the complete thermometer scale.

8. CONSTRUCTION

8.1 Shape

The thermometers should generally be straight, and their external cross-section approximately circular, unless specified to the contrary. For special thermometers, deviation from the straight shape is allowed. In the case of solid-stem thermometers, an external lens-shaped deviation from the circular cross-section is allowed, to facilitate reading.

8.2 Top finish

The top of the thermometer may be finished with a glass ring, the diameter of which should not exceed that of the stem. If a finish other than a ring is provided, its diameter should also not exceed that of the stem.

8.3 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%. The size of the bore should be such that the maximum sticking of the liquid does not exceed a specified amount.

8.4 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 stem.* 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; an exception is permissible in the case of high-pressure gas filling.

8.5 Contraction chamber

To prevent the liquid from withdrawing into the main bulb at about 0 °C, or to allow the inclusion of an auxiliary scale, the bore may be enlarged above the bulb. This contraction chamber should be elongated in form, and its top should be at least 10 mm below the immersion line, or at least 30 mm for a thermometer with a scale extending above 250 °C.

8.6 Enlargement of bore

No enlargement of the bore should be so located as to produce any variation in the cross-section of the capillary in the scale portion.

8.7 Specification of dimensions

The following dimensions of a thermometer should preferably be specified (as required):

8.7.1 *Total length* (overall length of the thermometer, including bulb and top finish). The maximum dimension only should be specified.

8.7.2 *Bulb length* (to be measured from the bottom of the bulb to the point at which the internal bulb diameter begins to decrease as the bulb merges into the stem, as shown in Fig. 1). In general the minimum dimension only should be specified.

8.7.3 *Distance from top of bulb funnel to lower nominal limit of scale.* If the thermometer has more than one scale, this distance should be to the lower nominal limit of the lowest scale. The minimum dimension only should be specified. This distance should be at least

30 mm for thermometers having the lower nominal limit $\geqslant$ 100 °C

13 mm for thermometers having the lower nominal limit $<$ 100 °C

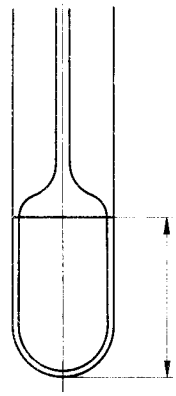

FIG. 1.
Measurement of bulb length

8.7.4 *Scale length.* The minimum dimension only should be specified. If the thermometer has more than one scale, the minimum dimension should be specified for each scale.

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

8.7.5 *Distance from upper nominal limit of scale to top of thermometer.* If the thermometer has more than one scale, this distance should be measured from the upper nominal limit of the highest scale. The minimum dimension only should be specified.

8.7.6 *Depth of immersion* (if required).

8.7.7 *Diameter of stem or sheath.* The maximum and minimum dimensions should be specified.

8.7.8 *External diameter of bulb.* The minimum dimension only should be specified. It should also be specified that the diameter of the bulb should not exceed that of the rest of the thermometer, except in cases where it is necessary for special reasons.

9. GRADUATION AND FIGURING

9.1 Graduation lines

The scheme of graduation and figuring should be stated in the individual specifications for thermometers.

9.1.1 A thermometer should preferably be graduated at every 0.01 - 0.1 - 1 or 10 degrees. A graduation in 0.02 - 0.05 - 0.2 - 0.5 - 2 or 5 degrees is permitted, however, provided the graduation in 0.1 - 1 or 10 degrees is sufficiently emphasized by longer lines.

9.1.2 The graduation lines should be clearly etched and of uniform thickness, which in no case should exceed one-fifth of the interval between consecutive lines. The lines should be at right angles to the axis of the thermometer. If the thermometer is intended to be read without (or with comparatively simple) optical equipment, the distance between two consecutive graduation lines should preferably be specified as about 1 mm. For enclosed-scale thermometers, owing to the reduction of parallax error, this distance may be reduced to 0.8 mm.

9.1.3 For solid-stem thermometers (see Fig. 2), the left-hand ends of the lines should lie on an imaginary vertical line, when the thermometer is viewed from the front and in a vertical position. The shortest lines should not extend across the bore, but the longer lines mentioned in clause 9.1.1 should be extended to the right-hand side. The figures should be placed either slightly to the left or to the right of the line, as preferred, in such a way that an extension of the line would bisect them, or immediately above the line to which they refer.

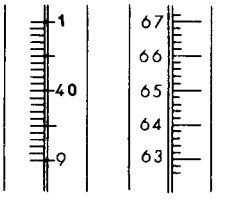

FIG. 2 A FIG. 2 B

FIG. 2.
Typical graduation for solid-stem thermometer

9.1.4 For enclosed-scale thermometers (see Fig. 3), the longest lines should extend across the scale and the shorter lines should extend equally on both sides of the bore, when the thermometer is viewed from the front and in a vertical position. The figures should be placed either slightly to the right of the line in such a way that an extension of the line would bisect them, or immediately above the line to which they refer.

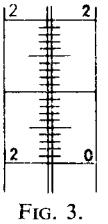

FIG. 3.
Typical graduation for enclosed-scale thermometer

9.1.5 The scale of the thermometer should be extended at least two divisions beyond the nominal limits. When appropriate, one or two auxiliary scales, centring around reference points (0 °C, 100 °C etc.), and consisting of at least five divisions below and five above the reference point, should be provided, in order to allow changes in the volume of the bulb to be detected.

9.1.6 The pigment filling should remain in the graduation lines and figures under specified conditions.

9.2 Immersion line

The immersion depth on any partial immersion thermometer should be indicated by a permanent line on the thermometer.

9.3 Datum line

On enclosed-scale thermometers, at least one datum line of thickness comparable with that of the graduation lines should be permanently marked, either on the sheath or on the capillary tube, so that its position may be read on the scale.

10. ACCURACY

10.1 Scale error

The maximum permissible scale error should not in general be more than one scale division.

10.2 Interval error

The maximum permissible error in a stated interval should not be more than x times one scale division, the value of x being specified in relation to the use of the particular thermometer.

10.3 Change in zero

After being subjected, under precisely defined conditions of test, to a temperature corresponding to the highest scale reading, the change in the reading corresponding to a temperature of 0 °C or other reference point, measured according to the conditions of test, should not be greater than that specified in the relevant thermometer specifications.

10.4 Time of response

The construction of the thermometer should be such that the response of the thermometer will satisfy specified requirements.

11. INSCRIPTIONS

The following inscriptions, as required, should be specified to 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*. On a partial immersion thermometer, the immersion depth should be indicated, e.g. "100 mm", and also the temperature of the emergent liquid column for which the thermometer was adjusted. On a total immersion thermometer, these inscriptions are not required.

(*c*) *Gas filling*, if any. E.g. "nitrogen filled", "vacuous".

(*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*.