BRITISH STANDARD

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Specification for

Laboratory thermometers

UDC 536.512:542.2

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Laboratory Apparatus Standards Policy Committee LBC/4, upon which the following bodies were represented:

British Laboratory Ware Association
British Medical Association
Department of Health
Department of Trade and Industry (National Physical Laboratory)
Institute of Petroleum
Medical Sterile Products Association
Scientific Glassware Association

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Contents

Foreword

This British Standard has been prepared under the direction of the Laboratory Apparatus Standards Policy Committee and supersedes BS 593:1974, which is withdrawn.

This British Standard was first published in 1935 under the title "*General purpose laboratory thermometers*" and revised editions appeared in 1940 and under the new title "*Laboratory thermometers*" in 1954 and 1974.

This revision introduces changes to bring the standard up to date and in particular to take into account ISO 386:1977 *"Liquid-in-glass laboratory thermometers — Principles of design, construction and use",* published by the International Organization for Standardization, and changes in the availability of glasses and arrangements for calibration and testing.

BS 1704 was published in 1951 to meet the demand for a series of good quality thermometers, covering the most commonly used ranges of temperature, which could be manufactured in large quantities with reasonable accuracy and at a reasonable price. Laboratory thermometers of greater precision are specified in this standard. BS 5074 covers total immersion Celsius scale only thermometers.

The thermometers covered by this standard are grouped into the following series.

a) *Series A.* Thermometers about 400 mm long, with zeros, covering ranges of about 30 °C to 40 °C or about 55 °F to 75 °F, and graduated at each 0.1 °C or 0.2 °F.

b) *Series B.* Thermometers similar to those of series A, but with ranges of about 60 °C or about 110 °F and graduated at each 0.2 °C or 0.5 °F.

c) *Series F.* Thermometers intended for use in the distillation of certain solvents and based on those specified for this purpose by the Institute of Petroleum (IP) and the American Society for Testing of Materials (ASTM). No extension of the scale beyond the nominal range is specified for these thermometers; they are therefore identical with the corresponding IP and ASTM thermometers.

Series C, D and E thermometers included in previous editions have been omitted due to lack of demand.

Designations. For convenience of reference, each thermometer is given a designation (e.g. A20C/Total) indicating the following:

1) the series to which the thermometer belongs;

2) the nominal upper limit of the scale;

3) the immersion conditions under which the thermometer is intended to be used.

Graduation. The graduation of the thermometers is such that they can be read to as high an accuracy as can be certified by an approved calibration laboratory in the given temperature range (see Appendix A). The minimum spacing of the graduation lines is specified at about seven times the maximum width of the lines themselves, as it has been found from experience that a closer scale can not be read to the same accuracy.

Immersion. Series A and B thermometers include total and partial immersion thermometers for each temperature range in both Celsius and Fahrenheit scales. Series F thermometers are Celsius thermometers for use at partial immersion only.

Tolerances. The tolerances (maximum permissible errors) that apply to the Fahrenheit thermometers are close arithmetical equivalents of those that would apply to Celsius thermometers of identical ranges. No special significance should therefore be attached to the odd values (e.g. 1.1 °F) that occur among them.

Product certification. Users of this British Standard are advised to consider the desirability of third party certification of product conformity with this British Standard based on testing and continuing surveillance, which may be coupled with assessment of a supplier's quality systems against the appropriate Part of BS 5750.

Enquiries as to the availability of third party certification schemes may be forwarded by BSI to the Association of Certification Bodies. If a third party certification scheme does not already exist, users should consider approaching an appropriate body from the list of Association members.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 14, 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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1 Scope

This British Standard specifies requirements for series A, B and F laboratory thermometers (see foreword) calibrated either for total or for partial immersion, covering the overall temperature ranges – 30 °C to + 400 °C and – 23 °F to + 320 °F.

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

2 Type

Thermometers shall be of the mercury-in-glass, solid-stem type filled with dry inert gas at a suitable pressure.

3 Temperature scale

Thermometers shall be graduated in accordance with the Celsius scale as defined in the current definition of the International Practical Temperature Scale adopted by the General Conference on Weights and Measures (CGPM). The Fahrenheit scale is calculated from the Celsius scale.

4 Materials

The bulb of the thermometer shall be made of a thermometric glass approved by the National Physical Laboratory as suitable for the range of temperature covered (see Appendix B).

For thermometers in which the upper level of the scale is above 300 °C, the same thermometric glass shall be used for both the bulb and the stem.

NOTE For thermometers in which the upper level of the scale is 300 °C or less, it is recommended that the stem should be made of the same thermometric glass as the bulb but it is also permissible for the stem to be made of lead glass or other suitable glass with an enamel back.

5 Construction

5.1 General

Each thermometer shall have details as given in the appropriate table of Table 1 to Table 4. The shapes of the bulb and the expansion and contraction chambers shall be such that they do not entrap mercury or gas.

5.2 Stem and bulb

The stem diameter shall lie within the prescribed limits. The bulb shall be cylindrical, in line with the stem, and its diameter shall not exceed that of the stem.

5.3 Expansion chamber

To minimize the effect of being accidentally overheated, an expansion volume shall be provided at the top of the stem. If this takes the form of an expansion chamber, it shall be pearshaped with the hemisphere at the top and there shall be at least 10 mm of unchanged capillary tube above the highest scale line. If the expansion volume takes the form of an unchanged capillary tube, there shall be a length of at least 30 mm above the highest scale line.

NOTE A thermometer should not be heated above its maximum working temperature. Overheating is liable to change the indication of the thermometer, and if this takes place a recalibration may be necessary.

5.4 Contraction chamber

The design of the contraction chamber shall be such that the mercury does not recede into the main bulb at the ice point (0 °C or 32 °F). No contraction chamber shall be above the immersion line.

5.5 Englargement of bore

No enlargement of the bore shall be within 10 mm of the immersion line or of any part of the scale.

5.6 Top finish

The thermometer shall be plain finished or with a glass ring or button as requested by the user. The outside diameter of the ring or button, when provided, shall not exceed that of the stem.

6 Annealing

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

7 Stabilization

The thermometer shall be stabilized before graduation using a process such that, when tested in accordance with Appendix C, the maximum error and maximum change in error over any interval of the finished thermometer are within the limits given in the appropriate table of Table 1 to Table 4, and the rise at the selected reference point is not greater than the maximum error given.

8 Graduation and figuring (including immersion line)

8.1 Scale lines

The scale lines shall be clearly etched or otherwise durably marked and of uniform thickness not exceeding the value given in the appropriate table of Table 1 to Table 4. The lines shall lie in planes at right angles to the axis of the thermometer.

When the thermometer is held in a vertical position and viewed from the front:

a) the left-hand ends of all the scale lines shall lie on an imaginary vertical line;

b) when the right-hand ends of the scale lines denoting the smallest interval are aligned with the left-hand side of the bore, all the other scale lines shall extend across the bore.

In the case of F255C/100, B140F/, B230F/ and B320F/ thermometers the two series of "longer lines" (see Table 2 to Table 4) shall show a marked difference in length.

With the exception of series F thermometers, the scale of the thermometer shall be extended at each end of the nominal range by the number of scale lines given in the appropriate table of Table 1 to Table 4.

8.2 Figuring

When the thermometer is held in a vertical position and viewed from the front, the figures may be either horizontal or vertical, provided all are clearly visible, and shall be placed so that they would be intersected by the line to which they refer if it were extended.

With the exception of A160C/, B110C/, B160C/, B210C/, B260C/, F175C/, F275C, A160F/ and A265F/thermometers, which shall be fully figured in accordance with the appropriate table of Table 1 to Table 4, any part of the scale extending above 100 °C or 100 °F shall be fully figured only at each 100 °C or 100 °F.

The scale shall be partially figured in accordance with the appropriate table of Table 3 to Table 4, using two figures at every 10° and one figure only at every 5° or less.

NOTE Figure 1 and Figure 2 show diagrammatically the graduation and figuring specified for typical thermometers.

8.3 Immersion lines

In partial immersion thermometers, a line shall be etched on the stem at the point to which the thermometer is intended to be immersed. If the immersion point is below the lowest scale line, the immersion line shall be a ring carried completely round the stem. If the immersion point is above the lowest scale line, the immersion line shall be confined to the back of the stem.

The depth of immersion for partial immersion thermometers shall be as given in Table 2 or Table 4, as appropriate, to within ± 1 mm, and shall be measured from the bottom of the bulb.

NOTE Recommended values for the mean temperature of the emergent stem during calibration are given in Appendix D.

9 Marking

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

a) the symbol °C or °F to indicate whether the Celsius or Fahrenheit temperature scale is employed (abbreviations of these names, i.e. C or F, are permissible);

b) the inscription "Total immersion" or "100 mm immersion", etc. (or a suitable abbreviation) to indicate the immersion for which the thermometer is calibrated;

c) an inscription to indicate the gas filling employed, e.g. "Nitrogen filled" (or a suitable abbreviation);

d) the identification of the bulb glass, e.g. by a coloured stripe or stripes on the bulb or by an approved abbreviation on the stem (see Appendix B);

e) an identification number;

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

g) the designation allocated to the thermometer, e.g. A20C/Total, as given in the appropriate table of Table 1 to Table 4;

h) the number of this British Standard, i.e. BS 593 [1)].

[1)] Marking BS 593 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is therefore solely the responsibility of the person making the claim. Such a declaration is not be confused with third party certification of conformity, which may also be desirable.

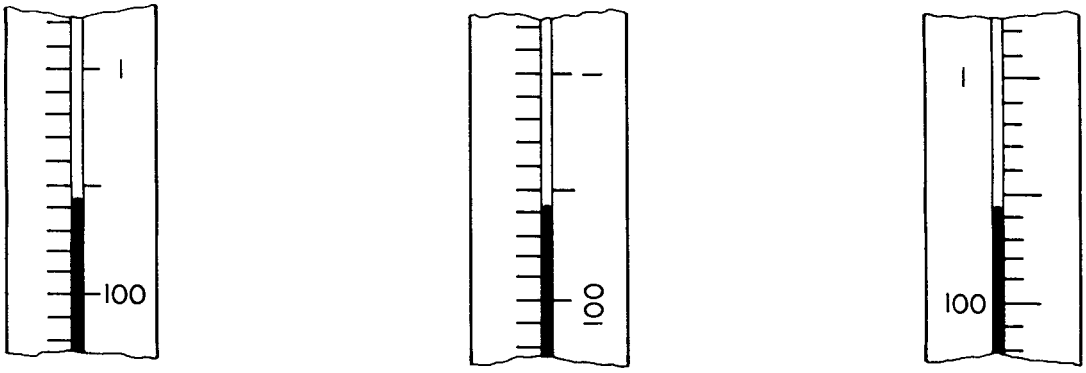

Figure 1 — Examples of figuring for laboratory thermometers

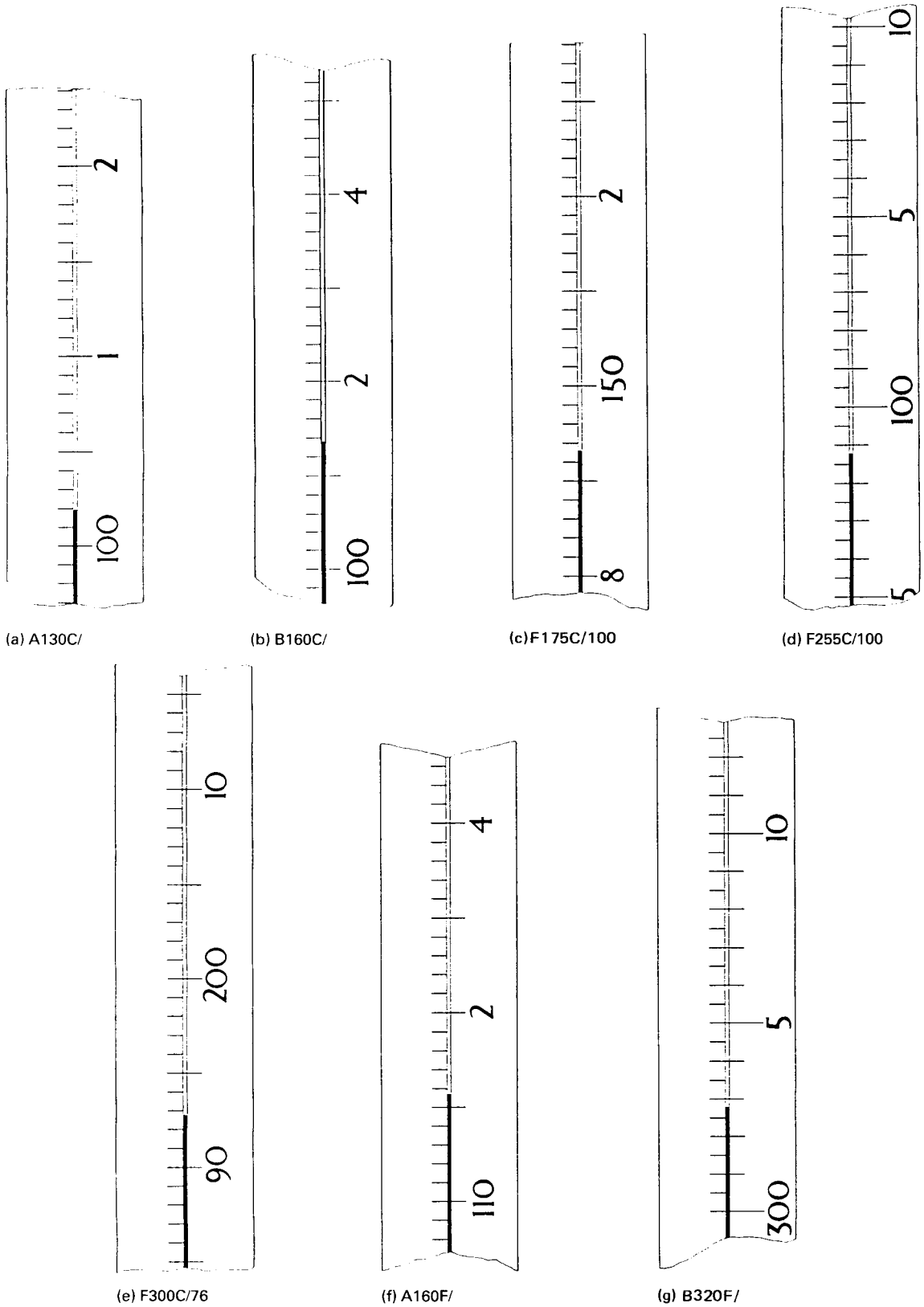

Figure 2 — Diagrammatic indication of graduation of laboratory thermometers

Table 1 — Details of total immersion Celsius thermometers

Designation	Nominal range	Graduation interval	Interval for longer lines	Interval for partial figuring	Interval for full figuring	Maximum thickness of graduation lines	Maximum overall length	Minimum scale length distance between upper and lower nominal limits of main scale	Extension of scale at each end beyond nominal limit (number of graduations)	Bulb length[a]	Stem diameter	Minimum distance from bottom of bulb to lower nominal limit of main scale	Maximum error	Maximum change in error over any interval[b]
	°C	°C	°C	°C	°C	mm	mm	mm		mm	mm	mm	°C	°C
A10C/Total	– 30 to + 10	0.1	0.5	1	10	0.10	405	270	5	10 to 17	5.5 to 7.0	30	0.4	0.4/5
A20C/Total	– 20 to + 20	0.1	0.5	1	10	0.10	405	270	5	10 to 17	5.5 to 7.0	30	0.2	0.2/5
A40C/Total	0 to + 40	0.1	0.5	1	10	0.10	405	270	5	10 to 17	5.5 to 7.0	30	0.2	0.2/5
A70C/Total	– 0.5 to + 0.5 and 40 to 70	0.1	0.5	1	10	0.10	405	200	5	10 to 17	5.5 to 7.0	100	0.2	0.2/5
A100C/Total	– 0.5 to + 0.5 and 70 to 100	0.1	0.5	1	10	0.10	405	200	5	10 to 17	5.5 to 7.0	100	0.2	0.2/5
A130C/Total	– 0.5 to + 0.5 and 100 to 130	0.1	0.5	1 and 10	100	0.10	405	200	5	10 to 17	5.5 to 7.0	100	0.2	0.2/5
A160C/Total	– 0.5 to + 0.5 and 130 to 160	0.1	0.5	1 and 10	at 130 and 160	0.10	405	200	5	10 to 17	5.5 to 7.0	100	0.2	0.2/5
B60C/Total	– 20 to + 60	0.2	1	2	10	0.10	405	270	5	10 to 17	5.5 to 7.0	30	0.3	0.3/10
B110C/Total	– 1 to + 1 and 50 to 110	0.2	1	2 and 10	50	0.10	405	200	5	10 to 17	5.5 to 7.0	100	0.3	0.3/10
B160C/Total	– 1 to + 1 and 100 to 160	0.2	1	2 and 10	50	0.10	405	200	5	10 to 17	5.5 to 7.0	100	0.4	0.4/10
B210C/Total	– 1 to + 1 and 150 to 210	0.2	1	2 and 10	50	0.10	405	200	5	10 to 17	5.5 to 7.0	100	0.6	0.6/10
B260C/Total	– 1 to + 1 and 200 to 260	0.2	1	2 and 10	50	0.10	405	200	5	10 to 17	5.5 to 7.0	100	1.0	1.0/10

[a] Bulb length is 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.

[b] Maximum change in error over any interval is expressed in the form $\frac{\text{interval error}}{\text{interval}}$, where the interval error is the algebraic difference between the errors at opposite ends of the interval, e.g. $\frac{0.2\ °C}{5\ °C}$ means that the change in error over any interval of 5 °C is not to exceed 0.2 °C.

Table 2 — Details of partial immersion Celsius thermometers

Designation	Nominal range	Graduation interval	Interval for longer lines	Interval for partial figuring	Interval for full figuring	Immersion	Maximum thickness of graduation lines	Overall length		Scale length (distance between upper and lower limits of main scale)		Extension of scale at each end beyond nominal range (number of graduations)	Bulb length[a]	Stem diameter	Distance from bottom of bulb to lower nominal limit of main scale		Maximum distance from bottom of bulb to top of contraction chamber	Maximum error	Maximum change in error over any interval[b]
								min.	max.	min.	max.				min.	max.			
	°C	°C	°C	°C	°C	mm	mm	mm		mm	mm		mm	mm	mm	mm	mm	°C	°C
A10C/100	– 30 to + 10	0.1	0.5	1	10	100	0.10		405	270		5	10 to 17	5.5 to 7.0	30		–	0.5	0.5/5
A20C/100	– 20 to + 20	0.1	0.5	1	10	100	0.10		405	270		5	10 to 17	5.5 to 7.0	30		–	0.3	0.3/5
A40C/100	0 to + 40	0.1	0.5	1	10	100	0.10		405	270		5	10 to 17	5.5 to 7.0	30		–	0.4	0.4/5
A70C/100	– 0.5 to + 0.5 and 40 to 70	0.1	0.5	1	10	100	0.10		405	200		5	10 to 17	5.5 to 7.0	100		70	0.4	0.4/5
A100C/100	– 0.5 to + 0.5 and 70 to 100	0.1	0.5	1	10	100	0.10		405	200		5	10 to 17	5.5 to 7.0	100		70	0.4	0.4/5
A130C/100	– 0.5 to + 0.5 and 100 to 130	0.1	0.5	1 and 10	100	100	0.10		405	200		5	10 to 17	5.5 to 7.0	100		70	0.4	0.4/5
A160C/100	– 0.5 to + 0.5 and 130 to 160	0.1	0.5	1 and 10	at 130 and 160	100	0.10		405	200		5	10 to 17	5.5 to 7.0	100		70	0.4	0.4/5
B60C/100	– 20 to + 60	0.2	1	2	10	100	0.10		405	270		5	10 to 17	5.5 to 7.0	30		–	0.4	0.4/10
B110C/100	– 1 to + 1 and 50 to 110	0.2	1	2 and 10	50	100	0.10		405	200		5	10 to 17	5.5 to 7.0	100		70	0.6	0.6/10
B160C/100	– 1 to + 1 and 100 to 160	0.2	1	2 and 10	50	100	0.10		405	200		5	10 to 17	5.5 to 7.0	100		70	0.8	0.8/10
B210C/100	– 1 to + 1 and 150 to 210	0.2	1	2 and 10	50	100	0.10		405	195		10	10 to 17	5.5 to 7.0	100		70	1.2	1.2/10
B260C/100	– 1 to + 1 and 200 to 260	0.2	1	2 and 10	50	100	0.10		405	195		10	10 to 17	5.5 to 7.0	100		70	2.0	2.0/10
F50C/100	– 2 to + 52	0.2	1	2	10	100	0.15	390	400	190	235	–	15 to 20	6.0 to 8.0	125	145	–	0.2	0.2/10
F75C/100	24 to 78	0.2	1	2	10	100	0.15	390	400	190	235	–	15 to 20	6.0 to 8.0	125	145	–	0.2	0.2/10
F100C/100	48 to 102	0.2	1	2	10	100	0.15	390	400	190	235	–	15 to 20	6.0 to 8.0	125	145	35	0.2	0.2/10
F125C/100	72 to 126	0.2	1	2 and 10	100	100	0.15	390	400	190	235	–	15 to 20	6.0 to 8.0	125	145	35	0.2	0.2/10
F150C/100	98 to 152	0.2	1	2 and 10	100	100	0.15	390	400	190	235	–	15 to 20	6.0 to 8.0	125	145	35	0.3	0.4/10

Table 2 — Details of partial immersion Celsius thermometers

Designation	Nominal range	Graduation interval	Interval for longer lines	Interval for partial figuring	Interval for full figuring	Immersion	Maximum thickness of graduation lines	Overall length		Scale length (distance between upper and lower limits of main scale)		Extension of scale at each end beyond nominal range (number of graduations)	Bulb length[a]	Stem diameter	Distance from bottom of bulb to lower nominal limit of main scale		Maximum distance from bottom of bulb to top of contraction chamber	Maximum error	Maximum change in error over any interval[b]
								min.	max.	min.	max.				min.	max.			
	°C	°C	°C	°C	°C	mm	mm	mm		mm	mm		mm	mm	mm	mm	mm	°C	°C
F175C/100	123 to 177	0.2	1	2 and 10	50	100	0.15	390	400	190	235	–	15 to 20	6.0 to 8.0	125	145	35	0.3	0.4/10
F200C/100	148 to 202	0.2	1	2 and 10	100	100	0.15	390	400	190	235	–	15 to 20	6.0 to 8.0	125	145	35	0.4	0.6/10
F225C/100	173 to 227	0.2	1	2 and 10	100	100	0.15	390	400	190	235	–	15 to 20	6.0 to 8.0	125	145	35	0.4	0.8/10
F250C/100	198 to 252	0.2	1	2 and 10	100	100	0.15	390	400	190	235	–	15 to 20	6.0 to 8.0	125	145	35	0.6	0.8/10
F275C/100	223 to 277	0.2	1	2 and 10	50	100	0.15	390	400	190	235	–	15 to 20	6.0 to 8.0	125	145	35	0.8	0.8/10
F300C/100	248 to 302	0.2	1	2 and 10	100	100	0.15	390	400	190	235	–	15 to 20	6.0 to 8.0	125	145	35	1.0	0.8/10
F255C/100	95 to 255	0.5	1 and 5	5 and 10	100	100	0.15	390	400	190	235	–	15 to 20	6.0 to 8.0	125	145	35	1.0	1.0/20
F150C/76	– 20 to + 150	1	5	10	100	76	0.15	317	327	170	200	–	19 to 25	6.0 to 7.0	111	118	–	0.8	0.8/20
F300C/76	– 5 to + 300	1	5	10	100	76	0.15	385	395	225	265	–	10 to 15	6.0 to 7.0	100	110	–	1.5	1.5/50
F400C/76	5 to + 400	1	5	10	100	76	0.15	410	420	250	290	–	10 to 15	6.0 to 7.5	100	110	–	1.5 up to 300°C 3.0 over 300°C	2.5/50

[a] Bulb length is 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.

[b] Maximum change in error over any interval is expressed in the form $\frac{\text{interval error}}{\text{interval}}$, where the interval error is the algebraic difference between the errors at opposite ends of the interval, e.g. $\frac{0.2\ °C}{10\ °C}$ means that the change in error over any interval of 10 °C is not to exceed 0.2 °C.

Table 3 — Details of total immersion Fahrenheit thermometers

Designation	Nominal range	Graduation interval	Interval for longer lines	Interval for partial figuring	Interval for full figuring	Maximum thickness of graduation lines	Maximum overall length	Minimum scale length (distance between upper and lower nominal limits of main scale)	Extension of scale at each end beyond nominal range (number of graduations)	Bulb length[a]	Stem diameter	Minimum distance from bottom of bulb to bottom of nominal main scale	Maximum error	Maximum change in error over any interval[b]
	°F	°F	°F	°F	°F	mm	mm	mm		mm	mm	mm	°F	°F
A50F/Total	– 23 to + 50	0.2	1	2	10	0.10	405	270	5	10 to 17	5.5 to 7.0	30	0.7	0.7/10
A70F/Total	– 5 to + 70	0.2	1	2	10	0.10	405	270	5	10 to 17	5.5 to 7.0	30	0.4	0.4/10
A105F/Total	30 to + 106	0.2	1	2	10	0.10	405	270	5	10 to 17	5.5 to 7.0	30	0.4	0.4/10
A160F/Total	31 to 33 and 104 to 161	0.2	1	2 and 10	at 110 and 160	0.10	405	200	5	10 to 17	5.5 to 7.0	100	0.4	0.4/10
A212F/Total	31 to 33 and 159 to 213	0.2	1	2 and 10	100	0.10	405	200	5	10 to 17	5.5 to 7.0	100	0.4	0.4/10
A265F/Total	31 to 33 and 211 to 267	0.2	1	2 and 10	at 220 and 260	0.10	405	200	5	10 to 17	5.5 to 7.0	100	0.4	0.4/10
A320F/Total	31 to 33 and 265 to 321	0.2	1	2 and 10	100	0.10	405	200	5	10 to 17	5.5 to 7.0	100	0.4	0.4/10
B140F/Total	– 5 to + 140	0.5	1 and 5	5 and 10	100	0.10	405	270	5	10 to 17	5.5 to 7.0	30	0.5	0.5/20
B230F/Total	30 to 34 and 120 to 230	0.5	1 and 5	5 and 10	100	0.10	405	200	5	10 to 17	5.5 to 7.0	100	0.5	0.5/20
B320F/Total	30 to 34 and 210 to 320	0.5	1 and 5	5 and 10	100	0.10	405	200	5	10 to 17	5.5 to 7.0	100	0.7	0.7/20

[a] Bulb length is 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.

[b] Maximum change in error over any interval is expressed in the form $\frac{\text{interval error}}{\text{interval}}$, where the interval error is the algebraic difference between the errors at opposite ends of the interval, e.g. $\frac{0.4\ °F}{10\ °F}$ means that the change in error over any interval of 10 °F is not to exceed 0.4 °F.

Table 4 — Details of partial immersion Fahrenheit thermometers

Designation	Nominal range	Graduation Interval	Interval for longer lines	Interval for partial figuring	Interval for full figuring	Immersion	Maximum thickness of graduation lines	Maximum overall length	Minimum scale length (distance between upper and lower nominal limits of main scale)	Extension of main scale at each end beyond nominal (number of graduation)	Bulb length[a]	Stem diameter	Minimum distance from bottom of bulb to bottom of nominal main scale	Maximum distance from bottom of bulb to top of contraction chamber	Maximum error	Maximum change in error over any interval[b]
	°F	°F	°F	°F	°F	mm	mm	mm			mm	mm	mm	mm	°F	°F
A50F/100	– 23 to + 50	0.2	1	2	10	100	0.01	405	270	5	10 to 17	5.5 to 7.0	30	–	1.0	1.0/10
A70F/100	– 5 to + 70	0.2	1	2	10	100	0.10	405	270	5	10 to 17	5.5 to 7.0	30	–	0.5	0.5/10
A105F/100	30 to 106	0.2	1	2	10	100	0.10	405	270	5	10 to 17	5.5 to 7.0	30	–	0.7	0.7/10
A160F/100	31 to 33 and 104 to 161	0.2	1	2 and 10	at 110 and 160	100	0.10	405	200	5	10 to 17	5.5 to 7.0	100	70	0.7	0.7/10
A212F/100	31 to 33 and 159 to 213	0.2	1	2 and 10	100	100	0.10	405	200	5	10 to 17	5.5 to 7.0	100	70	0.7	0.7/10
A265F/100	31 to 33 and 211 to 267	0.2	1	2 and 10	at 220 and 260	100	0.10	405	200	5	10 to 17	5.5 to 7.0	100	70	0.7	0.7/10
A320F/100	31 to 33 and 265 to 321	0.2	1	2 and 10	100	100	0.10	405	200	5	10 to 17	5.5 to 7.0	100	70	0.7	0.7/10
B140F/100	– 5 to + 140	0.5	1 and 5	5 and 10	100	100	0.10	405	270	5	10 to 17	5.5 to 7.0	30	–	0.7	0.7/20
B230F/100	30 to 34 and 120 to 230	0.5	1 and 5	5 and 10	100	100	0.10	405	200	5	10 to 17	5.5 to 7.0	100	70	1.1	1.1/20
B320F/100	30 to 34 to and 210 to 320	0.5	1 and 5	5 and 10	100	100	0.10	405	200	5	10 to 17	5.5 to 7.0	100	70	1.4	1.4/20

[a] Bulb length is 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.

[b] Maximum change in error over any interval is expressed in the form $\frac{\text{interval error}}{\text{interval}}$, where the interval error is the algebraic difference between the errors at opposite ends of the interval,

e.g. $\frac{0.5\ °F}{10\ °C}$ means that the change in error over any interval of 10 °F is not to exceed 0.5 °C.

Appendix A Testing of thermometers

The examination and calibration of thermometers is undertaken by the National Physical Laboratory and by approved laboratories of the National Measurement Accreditation Service (NAMAS). Full details of services and fees can be obtained on application to individual laboratories. A list of NAMAS approved laboratories can be obtained from NAMAS, National Physical Laboratory, Teddington, Middlesex TW11 0LW (telephone 01-977 3222).

Table 5 and Table 6 give the uncertainty of test for certification of the thermometers.

Table 5 — Uncertainty of test for certification of laboratory thermometers with Celsius scales

Designation	Uncertainty of test	
	Total immersion thermometers	Partial immersion thermometers
	°C	°C
A10C/	± 0.05	± 0.05
A20C/	± 0.02	± 0.05
A40C/	± 0.02	± 0.05
A70C/	± 0.02	± 0.05
A100C/	± 0.02	± 0.05
A130C/	± 0.05	± 0.1
A160C/	± 0.05	± 0.1
B60C/	± 0.05	± 0.1
B110C/	± 0.05	± 0.1
B160C/	± 0.05	± 0.1
B210C/	± 0.1	± 0.2
B260C/	± 0.1	± 0.2
F50C/100	—	± 0.05
F75C/100	—	± 0.05
F100C/100	—	± 0.05
F125C/100	—	± 0.1
F150C/100	—	± 0.1
F175C/100	—	± 0.1
F200C/100	—	± 0.1
F225C/100	—	± 0.2
F250C/100	—	± 0.2
F275C/100	—	± 0.2
F300C/100	—	± 0.2
F255C/100	—	± 0.2
F150C/76	—	± 0.0
F300C/76	—	± 0.2
F400C/76	—	± 0.5

Table 6 — Uncertainty of test for certification of laboratory thermometers with Fahrenheit scales

Designation	Uncertainty of test	
	Total immersion thermometers	Partial immersion thermometers
	°F	°F
A50F/	± 0.1	± 0.1
A70F/	± 0.05	± 0.1
A105F/	± 0.05	± 0.1
A160F/	± 0.05	± 0.1
A212F/	± 0.05	± 0.1
A265F/	± 0.1	± 0.2
A320F/	± 0.1	± 0.2
B140F/	± 0.1	± 0.2
B230F/	± 0.1	± 0.2
B320F/	± 0.1	± 0.2

Appendix B Thermometric glasses approved by the National Physical Laboratory

Table 7 gives the identification stripe(s) or approved abbreviation of all glasses that have been approved for the manufacture of thermometer bulbs. Only Jenaer Glaswerk Schott & Genossen Mainz continue to supply glasses.

A comprehensive list is retained, however, to assist users of existing or old thermometers in the certification of both the bulb glass and the recommended working temperature ranges.

Table 7 — Identification stripe(s) or approved abbreviation and normal maximum working temperature of all glasses that have been approved for the manufacture of thermometer bulbs

Glass	Supplier	Identification stripe(s) or approved abbreviation	Normal maximum working temperature
			°C
Normal glass Schott-N16	Jenaer Glaswerk Schott & Genossen Mainz	Single red stripe or N16	350
Thermometric glass Schott-2954	Jenaer Glaswerk Schott & Genossen Mainz	Single black stripe	460
Schott-Supremax R 8409	Jenaer Glaswerk Schott & Genossen Mainz	SPX 8409	600
Normal glass	Whitefriars Glass Ltd.	Single blue stripe	350
Normal glass, dial	Plowden & Thompson Ltd.	Double blue stripe	350
Normal glass 7560	Corning Glass Co.	CN	350
Corning borosilicate glass	Corning Glass Co.	CB	450
Borosilicate glass	Whitefriars Glass Ltd.	Single white stripe	460

NOTE The maximum temperatures given in the last column are a guide to normal practice. The performance of a thermometer depends greatly on the stabilizing heat treatment which it has been given during manufacture, and a well made thermometer of "normal glass" may be quite satisfactory for many purposes at temperatures as high as 400 °C. On the other hand, for the best accuracy it may be preferred to use one of the borosilicate glasses for temperatures lower than 350 °C. In general the lower the maximum temperature of use in relation to the approved temperature of the glass, the better will be the "stability of zero" of the thermometer.

Appendix C Stabilization test

This test is appropriate to thermometers having a maximum temperature above 100 °C.

Heat the thermometer to a temperature equal to its upper nominal limit and keep it at this temperature for 5 min. Allow the thermometer to cool either naturally in still air or slowly in a controlled temperature (at a reproducible rate) to 20 °C above ambient temperature or to 50 °C, whichever is the lower, and then determine the correction at a selected reference point. If natural cooling in air is used the correction should be determined within 1 h.

Heat the thermometer again to a temperature equal to its upper nominal limit, keep it at this temperature for 24 h, allow the thermometer to cool to the same temperature and at the same rate as before, and then redetermine the correction under the same conditions as before.

The most commonly used reference point is 0 °C or 32 °F, but the lowest indicated temperature on the main scale may be selected.

Appendix D Emergent liquid column temperatures for partial immersion thermometers

When the average temperature of the emergent liquid column in use differs from that prevailing during calibration, appropriate corrections are required, and it is therefore important that the conditions of calibration should be known. The values given in Table 8 for series A and B thermometers are those recommended by the National Physical Laboratory.For series F thermometers it has been decided to adopt the average emergent liquid column temperatures already specified by the American Society for Testing of Materials and these values are given in Table 9.

The average emergent liquid column temperatures may be estimated by a faden[2)] (or thread) thermometer of similar bulb length placed alongside the emergent column (preferred method) or by taking the mean of a series of auxiliary thermometers placed with the bottom of the bulb of the first of these thermometers at a distance of 10 mm from the point of emergence and the others evenly spaced along the length of the exposed column at intervals not exceeding 100 mm.

[2)] A faden thermometer is one with an extended bulb. These thermometers are produced in sets so that one may be selected with a bulb length as long as the emergent liquid column of the thermometer under test.

Table 8 — Recommended average temperature of emergent liquid column for series A and B thermometers

Celsius thermometer		Fahrenheit thermometer	
Designation	Average temperature of emergent liquid column	Designation	Average temperature of emergent liquid column
	°C		°F
A10C/100	15	A50F/100	60
A20C/100	20	A70F/100	70
A40C/100	20	A105F/100	70
A70C/100	30	A160F/100	85
A100C/100	30	A212F/100	85
A130C/100	40	A265F/100	105
A160C/100	40	A320F/100	105
B60C/100	20	B140F/100	70
B110C/100	30	B230F/100	85
B160/100	40	B320F/100	105
B210C/100	40		
B260C/100	60		

Up to a bulb temperature of about 100 °C the two methods give results that are in agreement for most practical purposes but above this temperature the faden thermometer method is recommended as giving the more reliable and reproducible results. Where possible, the same method for estimating the average emergent liquid column temperature should be adopted for the thermometer in use as when it was calibrated.

The effect on the thermometer reading caused by differences in average emergent temperatures of two conditions of use, i.e. the emergent liquid column temperature correction, F, is obtained from the equation

$$F = KN(T_1 - T_2)$$

where

K is the apparent expansion coefficient of the liquid in the particular type of glass used (in$(°C)^{-1}$ or $(°F)^{-1}$); typical values of $16 \times 10^{-5}(°C)^{-1}$ for Celsius and $9 \times 10^{-5}(°F)^{-1}$ for Fahrenheit mercury-in-glass thermometers may be assumed;

N is the length of the exposed liquid column (in °C or °F)(as measured by comparison with the engraved scale of the thermometer);

T_1 is the average emergent liquid column temperature under the first condition (in °C or °F);

T_2 is the average emergent liquid column temperature under the second condition (in °C or °F).

Since there are many possible combinations of conditions of use the following is given as a typical example of the application of the equation.

Example. A B260C/100 thermometer has been proved to read correctly at 260 °C for its specified average emergent liquid column temperature of 60 °C. Suppose it is used at 260 °C with an average emergent liquid column temperature of 48 °C. It is observed that the length of the mercury column from the immersion line to the 260 °C reading is equivalent to 68 °C. Since the thermometer was proved correct with an emergent liquid column temperature of 60 °C and is used at 48 °C, the thermometer will read low by an amount

$$16 \times 10^{-5}\ (°C)^{-1} \times 68\ °C \times (60 - 48) = 0.13\ °C.$$

Therefore a correction of + 0.13 °C has to be added to the thermometer reading to obtain the true temperature.

A convenient chart giving emergent liquid column temperature corrections for values of $(T_1 - T_2)$ from 0.1 °C to 500 °C and 0.1 °F to 900 °F has been prepared by the National Physical Laboratory and is published by HMSO.

Table 9 — Recommended average temperature of emergent liquid column for series F thermometers

Designation	Range	Thermometer reading	Average temperature of emergent liquid column
	°C	°C	°C
F50C/100	– 2 to + 52		25 over entire range
F75C/100	24 to 78		25 over entire range
F100C/100	48 to 102		30 over entire range
F125C/100	72 to 126		30 over entire range
F150C/100	98 to 152	100 115 130 150	30 33 35 35
F175C/100	123 to 177		35 over entire range
F200C/100	148 to 202		35 over entire range
F225C/100	173 to 227	175 190 205 225	34 38 40 40
F250C/100	198 to 252		40 over entire range
F275C/100	223 to 277	225 240 255 275	40 40 41 46
F300C/100	248 to 302		45 over entire range
F255C/100	95 to 255	100 150 200 250	30 35 40 45
F150C/76	– 20 to + 150	– 20 0 50 100 150	8 18 35 48 55
F300C/76	– 7 to + 300	0 75 150 225 300	19 42 61 73 80
F400C/76	– 76 to + 400	0 100 200 300 370	19 50 75 89 92

Publications referred to

BS 1704, *Specification for solid-stem general purpose thermometers*[3)].
BS 5074, *Specification for short and long solid-stem thermometers for precision use*[3)].
BS 5750, *Quality systems*[3)].

[3)] Referred to in the foreword only.

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