BRITISH STANDARD

BS 2000 Part 0
Section 0.1:
1999

Methods of test for petroleum and its products —

BS 2000 Part 0: General introduction

Section 0.1: Specifications — IP standard for thermometers

(Identical with IP — Annex A)

ICS 75.080

Confirmed
January 2010

National foreword

This British Standard supersedes BS 2000 Part 0 Section 0.1:1996 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PTI/13, Petroleum testing and terminology, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

The Institute of Petroleum publishes and sells all parts of BS 2000, and all BS EN petroleum test methods that would be Part of BS 2000, both in its annual publication "Standard methods for analysis and testing of petroleum and related products and British Standard 2000 Parts" and individually.

Further information is available from:

The Institute of Petroleum, 61 New Cavendish Street, London W1G 7AR. Tel: 020 7467 7100. Fax: 020 7255 1472

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Find" facility of the BSI Standards Electronic Catalogue.

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.

This British Standard, having been prepared under the direction of the Sector Policy and Strategy Committee for Materials and Chemicals, was published under the authority of the Standards Policy and Strategy Committee on 03 December 2001

Summary of pages

This document comprises a front cover, an inside front cover, pages 1 to 26, an inside back cover and a back cover

The BSI copyright date displayed in this document indicates when the document was last issued.

Amendments issued since publication

Amd. No.	Date	Comments

ISBN 0 580 38728 3

APPENDIX A

SPECIFICATIONS – IP STANDARD THERMOMETERS

1. INTRODUCTION

These specifications cover glass thermometers required in IP Standards and graduated in Celsius degrees. The thermometers shall conform to the following general requirements and to the detailed specifications listed.

Purchasers should not accept thermometers as complying with these specifications because they are marked with IP markings, as these inscriptions are identification marks and do not necessarily constitute a guarantee. Thermometers with other identification marks may be used provided they conform to all the other requirements of the specification.

Purchasers should satisfy themselves that the permissible scale errors, given in the table of special requirements, have not been exceeded.

It is essential that thermometers be marked with a material resistant to the action of hot petroleum products.

The format of the specification has been changed to conform with that agreed with ASTM in order to facilitate the harmonization of thermometers used in IP and ASTM methods. Thermometers numbered in the form ASTM *x*/IP *y* are those where the details have been agreed and are identical in the IP and ASTM handbooks. Such thermometers continue to be placed in the table according to their IP number. A list of these thermometers appears in Annex B together with thermometers that are comparable but still differ in certain details.

All temperature measurements should be traceable to the International Temperature Scale of 1990 (see Annex A).

2. GENERAL REQUIREMENTS

2.1. *Type* – Mercury-in-glass, solid stem except where otherwise stated. Gas (not air) filled. Top finished plain except in the case of Kin Visc thermometers which shall have a ring or button, Tank thermometers (IP 48C to IP 53C inclusive) when used in conjunction with the armoured case shall be finished with flattened button tops and thermometers ASTM 11C/IP 28C which may have ring or button.

2.2. *Stem* – The stem shall be made of suitable glass tubing with approximate circular section, plain front and enamel back unless otherwise specified.

2.3. *Bulb* – The bulb shall be made of a 'normal' thermometric glass for thermometers with maximum temperatures not exceeding 310°C and of borosilicate glass for higher temperatures.

The type of thermometric glass used shall have been approved by the National Physical Laboratory and selected from those listed in the Table below.

This table gives the identification stripe(s) or approved abbreviations of all glasses that have been approved for the manufacture of thermometer bulbs. At present only Jenaer Glaswerk Schott and Genossen Mainz continue to supply these glasses, however a comprehensive list is retained to assist

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 abbreviations	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.

owners of existing or old thermometers in the certification of both the bulb glass and the recommended working temperature ranges.

The glass of the bulb shall preferably be identified by a coloured stripe or stripes. If this identification is not provided, the glass should be identified by an inscription on the thermometer.

2.4. *Expansion and Contraction Chamber* – The following shall be the minimum distances between scale lines and the bulb and between scale lines and enlargements in the bore:

A 13 mm length of unchanged capillary between the bulb and the lowest scale line, if this is not above 100°C; a 30 mm length if the scale line is above 100°C.

A 5 mm length of unchanged capillary between an enlargement and the scale line immediately below, except at the top of the thermometer.

A 10 mm length of unchanged capillary between an enlargement other than the bulb, and the scale line immediately above if this is not above 100°C; a 30 mm length if the scale line is above 100°C.

No contraction chamber shall be above the immersion line or within 10 mm of the immersion line; it shall be of the long narrow type and where no auxiliary scale is present must be so located that the mercury stands in the contraction chamber at 0°C.

A 10 mm length of unchanged capillary above the highest scale line, if there is an expansion chamber at the top of the thermometer; a 30 mm length if there is no expansion chamber. For the purposes of this requirement, 'an expansion chamber' is interpreted as an enlargement at the top end of the capillary bore which shall have a capacity equivalent to not less than 20 mm of unchanged capillary.

2.5. *Scale Marks and Figuring* – The scale lines shall be clearly etched, and of uniform thickness, not exceeding the width given in the table for each thermometer. The lines shall be at right angles to the axis of the thermometer. When the thermometer is viewed from the front and in a vertical position the lines shall all finish on a line parallel to the axis on the left-hand side. The graduation lines shall be so positioned that the enamel backing in the stem provides a background for the mercury column when it is seen just beyond the left- or right-hand end of the short lines.

2.6. *Marking* – Each thermometer shall be marked with the IP or ASTM/IP thermometer type number where applicable, an identification number, and the maker's or vendor's name or trade mark. Some thermometers require special markings which are given in the footnotes to the thermometer specifications. Each thermometer shall also be marked with the immersion at which it is to be used – e.g. 'Total immersion,' '11 cm immersion.' Thermometers intended to be used at partial immersion should have a line etched round the stem to indicate the depth of immersion.

Thermometers intended to be used at 'Total immersion' should be immersed to the reading so that the bulb and liquid index column are at the temperature being measured.

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

2.8. *Bulb Stability:*

2.8.1. For all thermometers except kinematic viscosity thermometers and thermometers of similar accuracy: During manufacture, thermometers must be subjected to a suitable heat treatment in order to secure bulb stability as shown by the reproducibility of reading at some reference point such as the ice point (0°C).

This treatment shall be such that if the finished thermometer is subjected to the Bulb Stability Test described in 2.9.1, the change in the reference point shall not exceed 0.7 of the allowable scale error and the instrument error shall remain within the maximum error specified.

This Bulb Stability Test is appropriate to thermometers having an upper nominal limit above 100°C.

2.8.2. For kinematic viscosity thermometers and thermometers of similar accuracy: The changes in calibration of kinematic viscosity thermometers, and other thermometers of similar accuracy may become significant within a short period of time after initial calibration requiring a different procedure and criteria for the Bulb Stability Test of these thermometers.

During manufacture, thermometers must be subjected to a suitable heat treatment in order to secure bulb stability as shown by the reproducibility of reading at a reference point on the main scale, and at the ice point (if scale lines at 0°C are available on the thermometer). This treatment shall be such that, if the thermometer is subjected to the stability test described in 2.9.2, there shall be no change in the reading at the selected reference point on the main scale and at the ice point, and hence no change in difference between the corrections obtained at the two calibration temperatures.

In practice, however, measurements are subject to experimental error and, in deciding whether a thermometer complies with the requirement, allowance must be made for possible errors in the test (variously known as 'uncertainty of measurement' or 'limits of accuracy').

Thus, in practice, the maximum permitted observed difference between corrections at each calibration temperature, determined before and after the bulb stability test, is twice the stated uncertainty of measurement during calibration.

This Bulb Stability Test is normally restricted to IP kinematic viscosity thermometers used for measuring temperatures at and above 50°C and is especially applicable to the following:

IP 17C	IP 36C	
IP 32C	IP 66C	
IP 34C	IP 90C	IP 100C
IP 35C	IP 93C	IP 102C

Experience shows that a thermometer which has been calibrated to an uncertainty of ±0.01°C or

±0.02°C can reliably measure temperatures to the same accuracy only if due regard is given to all the conditions of use described in Annex D: Notes on Care and Use of Liquid-in-glass Thermometers.

2.9. *Bulb Stability Test:*

2.9.1. For all thermometers except kinematic viscosity thermometers and thermometers of similar accuracy: Heat the thermometer to a temperature equal to its highest reading and keep it at this temperature for 5 min. Allow the thermometer to cool with the test in the test bath or naturally in still air to 20°C above ambient or to 50°C whichever is the lower, and then determine the correction at the selected reference point. If natural cooling is used the correction 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 the start of the test, and re-determine the correction at the same reference point under the same condition as before. The most commonly used reference point is 0°C and the recommended procedure for standardization at this point is described in 2.10.

2.9.2. For kinematic viscosity thermometers and thermometers of similar accuracy:

(*a*) Heat the thermometer to the selected reference point on the main scale, maintain the temperature for at least 15 min and determine the scale correction at this point.

(*b*) Allow the thermometer to cool slowly in the test bath (or naturally in still air) to at least 20°C above ambient or to 50°C whichever is the lower, and then determine the correction after at least 15 min at the ice point. If natural cooling is used the correction should be determined within 1 h. If there are no scale lines at 0°C then the correction at the ice point cannot be determined but otherwise the procedure must be adhered to.

(*c*) Heat the thermometer again to the selected reference point on the main scale, and keep it at this temperature for 168 h. Allow the thermometer to cool as in (*b*) and then repeat the procedures described in (*a*) and (*b*). It must be emphasized that to obtain meaningful results, the procedure adopted after the 168 h period of heating must be identical to that used in the original calibration.

2.10. *Standardization at the Ice Point* – Select pieces of ice prepared from distilled or de-ionized water. Discard any cloudy or unsound portions. Rinse the ice with distilled or de-ionized water and shave or crush the ice into small pieces, avoiding direct contact with the hands or any chemically unclean objects. Fill a Dewar vessel (or an insulated porcelain container provided with means of draining away excess water) with the prepared ice. Add, while mixing with a chemically clean rod, sufficient distilled or de-ionized, preferably pre-cooled, water to form a slush, but not enough to float the ice. Make a cavity in the ice for the insertion of the thermometer under test by inserting vertically an open-ended glass tube of appropriate diameter. Withdraw a column of the ice-water mixture by closing the top of the tube before lifting it out. To show that the mixture is of the required consistency the column of ice may be released from the glass tube to stand on a flat surface as an unsupported column. Insert the thermometer into the cavity as far as the immersion line at the 0°C graduation, packing the ice gently about the stem to ensure good thermal contact with the bulb. As the ice melts, drain off excess water and gently repack the ice around the bulb and stem. Relieve excess ice pressure on the bulb by rotating the thermometer in the cavity. Read the thermometer by means of a low-powered optical aid, taking care to avoid parallax errors. Leave the thermometer in the ice for at least 10 min before taking the observation.

Except when following the procedure for the Bulb Stability Test described in 2.9.1 or 2.9.2, observations at the ice point should be made after the thermometer has been registering normal ambient room temperature for at least 24 h in order to reduce any error caused by the depression of zero.

2.11. *Verification* – For referee purposes, only thermometers which have been tested at the National Physical Laboratory or other approved testing laboratory shall be used, and the appropriate corrections shall be applied. Satisfactory thermometers should be marked by the testing centre with the year of test and a certificate of corrections issued.

It is desirable that thermometers be re-tested at intervals not exceeding five years. In the case of high-accuracy, finely divided thermometers such as the Kin Visc thermometers, it is desirable to have the zero or a point on the main stem rechecked at more frequent intervals.

Additional information on the care and use of liquid-in-glass thermometers is given in Annex C.

2.12. *Emergent Column Temperatures* – The scale error of IP partial immersion thermometers shall not exceed the specified amount when the temperatures of the emergent column are as stated in the table below. The emergent column temperatures for intermediate temperatures shall be obtained by interpolation from a smooth curve using the points in the table. Since it may not be possible during manufacture and testing to control these emergent column temperatures to the required values, the corrections resulting from the difference between the actual and specified temperatures must be calculated as described below, and allowed for in determining whether or not the thermometer complies with the specification.

The correction to a thermometer reading for an exposed column temperature differing from that obtained during calibration (or, for example, as given on an NPL Certificate) may be calculated by applying to the observed thermometer correction an additional correction obtained by evaluating the expression $KN(t-T)$.

where:

K = the differential expansion of the liquid in the particular type of glass used and an average value of 0.00016 may be assumed for mercury-in-glass Celsius thermometers;

N = the length of the exposed column expressed in degrees;

t = the mean temperature of the exposed column during calibration or as given in the NPL Certificate;

T = the mean temperature of the exposed column under conditions of use or as required by the specification.

TABLE. Emergent column temperatures

Temperature	Average temperature of emergent column
IP 1C −38 to +50°C 21°C over entire range	
IP 2C −80 to +20°C 21°C over entire range	
IP 8C 0 to 45°C 15°C over entire range	
IP 9C 40 to 85°C 30°C over entire range	
IP 15C −5 to +110°C	
0°C	19°C
20°C	20°C
40°C	31°C
70°C	40°C
100°C	48°C
IP 16C 90 to 370°C	
100°C	61°C
150°C	65°C
200°C	71°C
250°C	78°C
300°C	87°C
350°C	99°C
IP 17C 32 to 82°C 25°C over entire range	
IP 20C −38 to +42°C	
−35°C	5°C
−20°C	15°C
0°C	20°C
20°C	25°C
40°C	30°C
IP 21C 25 to 105°C	
25°C	25°C
50°C	40°C
75°C	45°C
100°C	45°C
IP 22C 195 to 205°C 40°C over entire range	
IP 28C −6 to 400°C	
0°C	18°C
50°C	34°C
100°C	44°C
150°C	54°C
200°C	64°C
250°C	77°C
300°C	91°C
350°C	108°C
IP 37C 144 to 156°C 40°C over entire range	
IP 40C to 120°C 30°C over entire range	
IP 41C 100 to 230°C 40°C over entire range	
IP 42C −38 to +30°C 15°C over entire range	
IP 43C 10 to 110°C 25°C over entire range	
IP 44C 15 to 121°C 30°C over entire range	
IP 45C 15 to 30°C 20°C over entire range	
IP 59C 90 to 170°C	
100°C	70°C
130°C	60°C
160°C	50°C
IP 62C −5 to +300°C	
0°C	19°C
50°C	35°C
100°C	49°C
150°C	61°C
200°C	70°C
250°C	76°C
300°C	80°C
IP 63C 32 to 127°C 25°C over entire range	
IP 72C −37 to +21°C 21°C over entire range	
IP 73C −5 to 400°C	
0°C	19°C
100°C	50°C
200°C	75°C
300°C	89°C
400°C	94°C
IP 74C −35 to +70°C 21°C over entire range	
IP 75C −30 to +80°C 21°C over entire range	
IP 76C 10 to 55°C 25°C over entire range	
IP 77C −2 to +52°C 25°C over entire range	
IP 78C 24 to 78°C 25°C over entire range	
IP 79C 48 to 102°C 30°C over entire range	
IP 80C 72 to 126°C 30°C over entire range	
IP 81C 98 to 152°C	
100°C	30°C
115°C	33°C
130°C	35°C
150°C	35°C

Temperature	Average temperature of emergent column
IP 82C 95 to 255°C	
100°C	30°C
150°C	35°C
200°C	40°C
250°C	45°C
IP 83C 123 to 177°C	
35°C over entire range	
IP 84C 148 to 202°C	
35°C over entire range	
IP 85C 173 to 227°C	
175°C	34°C
190°C	38°C
205°C	40°C
225°C	40°C
IP 86C 198 to 252°C	
40°C over entire range	
IP 87C 223 to 277°C	
225°C	40°C
240°C	40°C
255°C	41°C
275°C	46°C
IP 88C 248 to 302°C	
45°C over entire range	
IP 91C 0 to 110°C	
30°C over entire range	
IP 98C 100 to 300°C	
100°C	60°C
150°C	65°C
200°C	70°C
250°C	75°C
300°C	80°C
IP 101C 20 to 150°C	
40°C	30°C
70°C	40°C
100°C	50°C
130°C	60°C
150°C	65°C

The emergent column temperature may be estimated preferably by a Faden or thread thermometer of suitable bulb length placed alongside the emergent column or alternatively 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 1 cm from the point of emergence and the others evenly spaced along the length of the exposed column at intervals not exceeding 10 cm.

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 emergent column temperature should be adopted for the thermometer in use as when it was standardized.

SPECIAL NOTE

Existing stocks of thermometers conforming to previous specifications may be used, when appropriate. New thermometers shall conform to the current requirements.

EXPLANATORY NOTES

In the Notes beneath some of the thermometer specifications is a number (e.g. 1976) indicating either the year of original inclusion in the IP Standards for Petroleum and its Products handbook or adoption in the handbook as a joint ASTM/IP specification thermometer. Where no number is stated then there has been no major modification to the thermometer's specification details since 1973.

a–Toluene or other suitable liquid coloured red with a permanent dye shall be used as the activating liquid.

b–An expansion chamber is provided for relief of gas pressure to avoid distortion of the bulb at higher temperatures and it is not for the purpose of joining mercury separations. Under no circumstances should the thermometer be heated above the highest temperature reading.

c–Under certain test conditions, the bulb of the thermometer may be 28°C above the temperature indicated by the thermometer, and at an indicated temperature of 371°C the temperature of the bulb is approaching a critical range if it is made of Normal thermometric glass.

e–The stem shall be made with an enlargement having a diameter (I) of 7.5 to 8.5 mm and a length (J) of 2.5 to 5 mm, the bottom of the enlargement (K) being 64 to 66 mm from the bottom of the bulb. These dimensions shall be measured with the test gauge shown in Fig. 2.

f–Top of contraction chamber to be not more than 41 mm from the bottom of the bulb.

g–Bulb shape ellipsoidal. See Fig. 1.

h–Bulb shape spherical, and a swelling to be provided in the stem to ensure that the thermometer shall be fixed in its brass collar so that the distance from the top of the collar to the bottom of the bulb is 61.00 ± 1.25 mm for the 'oil cup' and 88.90 ± 2.54 mm for the 'water bath' thermometers. The brass collar shall be of the following dimensions: Outside diameter, push fit in socket. Thickness of tube, 22 swg (0.69–0.73 mm). Thickness of flange 2.51–2.56 mm. See also IP 170, Annex B.

i–Top of contraction chamber to be between 100 and 125 mm from the bottom of the bulb (H).

j–The range −0.3°C to +0.3°C is for checking purposes only.

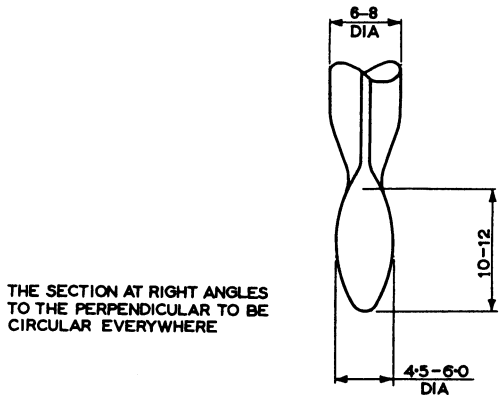
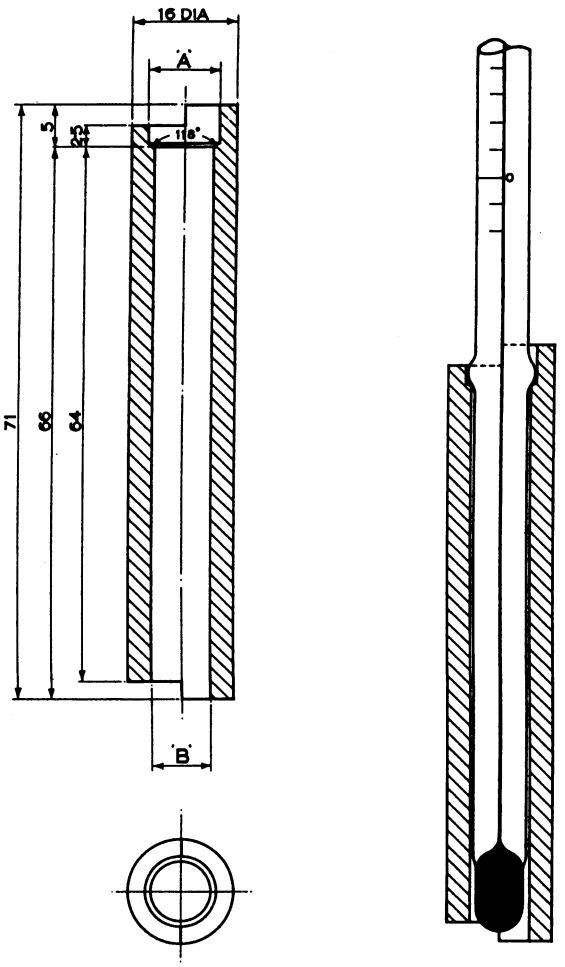


Fig. 1. Bulb of 'congealing point' thermometer.



A = 8.5 mm
B = 7.11 to 7.16 mm

Fig. 2. Test gauge for checking enlargement on thermometers IP 15C, 16C, and 101C.

k–Each 0.5°C line to be longer than each 0.1°C line.

l–The contraction chamber to be 80 to 120 mm from the bottom of the bulb.

m–5 to 8 mm stem diameter to be interpreted as 'not go' or 'go' through rings of these dimensions.

n–A metal sleeve shall be permanently attached to the thermometer. The surfaces of the thermometer and of the sleeve shall be roughened or indented to ensure an effective key between the cement and the surfaces. For dimensions and location of sleeve (which shall form an integral part of the thermometer) see IP 31 Section 4(b).

o–The stem immediately above the bulb shall be reduced in diameter to be approx equal to, but not smaller than, that of the bulb over a length of approx 20 mm.

p–A swelling 8 to 10 mm in diameter, the bottom of which shall be 250 ± 2 mm from the bottom of the bulb shall be provided to ensure that the thermometer is used at the correct immersion and to support it in the inner tube of the apparatus.

q–A swelling is to be provided in the stem to ensure that the thermometer shall be fixed in its brass collar so that the distance from the top of the collar to the bottom of the bulb is 61.0 ± 1.3 mm for the IP 43C thermometer and 88.9 ± 2.5 mm for the IP 44C thermometer. The brass collar shall be of the following dimensions: Outside diameter, push fit in socket; thickness of tube, 0.69 ± 0.73 mm. See IP 170, Annex B.

r–Contraction chamber of long narrow shape required. Bottom of bulb to top of contraction chamber (H) 30 mm max.

s–Contraction chamber required. Bottom of bulb to top of contraction chamber (H) 35 mm max. Mercury shall not recede into bulb at 0°C.

t–Contraction chamber required. Bottom of bulb to top of contraction chamber (H) 41 mm max.

u–Bulb bottom shall be essentially hemispherical.

v–A suitable mercury–thallium alloy shall be used as the activating liquid, and the thermometer should be suitably marked to indicate this filling (*e.g.* Hg/Tl).

w–The length of unchanged capillary between the nearest scale mark and contraction chamber shall be not less than 10 mm.

x–The expansion chamber shall be of the long narrow type 10 to 20 mm in length. The length of unchanged capillary between the nearest scale mark and expansion chamber shall not be less than 10 mm.

y–The range −0.6°C to +0.6°C for checking purposes only.

z–Bottom of contraction chamber to bottom of bulb, 290 mm min. Top of contraction chamber to bottom of bulb, 310 mm max.

aa–Contraction chamber required. Bottom of chamber to bottom of bulb, 180 mm min. Top of chamber to bottom of bulb (H) 205 mm max.

bb–A swelling is to be provided in the stem to ensure that the thermometer is fixed in its brass collar with the distance from the top of the collar to the bottom of the bulb 61 ± 1.5 mm–see also IP 170, Annex B. The dimensions of the collar shall be as specified in Method IP 170.

cc–A swelling is to be provided in the stem to ensure that the thermometer is fixed in its brass collar with the distance from the top of the collar to the bottom of the bulb 89 ± 2.5 mm–see also IP 170, Annex B. The dimensions of the collar shall be as specified in method IP 170.

dd–A swelling is to be provided in the stem to ensure that the thermometer shall be fixed in its brass collar so that the distance from the top of the collar to the bottom of the bulb is 93 ± 0.5 mm. The swelling shall be 1.5 mm to 2.0 mm greater than the stem and have a length (J) of 3.0 mm to 5.0 mm. The brass collar shall be of the following dimensions: Internal diameter 7.0 mm, outside diameter below flange to taper from 7.8 mm to 7.9 mm at the top. Length of collar 15 mm. Thickness of flange 3 mm. Diameter of flange 13 mm. The flange is to be provided with a knurled edge.

ee–Contraction chamber required. Top of chamber to bottom of bulb (H), max 35 mm. Mercury to be near bottom of chamber at 0°C.

ff–The thermometer to be numbered for use when viewed horizontally and with the bulb to the right.

gg–Contraction chamber not required, but mercury shall not recede into bulb at 0°C.

hh–Where thermometers are required for use with top suspension armoured cases, they must be finished with a flattened button of suitable dimensions. See Petroleum Measurement Manual Part IV paragraph 3.8.2. and Fig. 7(b).

ii–The ranges of angle stem thermometers to be as follows:

IP 54C as for IP 48C
IP 55C as for IP 49C
IP 56C as for IP 50C
IP 57C as for IP 51C
IP 58C as for IP 52C

jj–Contraction chamber of long narrow shape required. Bottom of bulb to top of contraction chamber (H) 60 mm max. Mercury shall be in the chamber at 0°C.

kk–The stem shall be made with an enlargement having a diameter (I) of 8.0 to 10.0 mm, and a length (J) of 4.0 to 7.0 mm, the bottom of the enlargement (K) being 112 to 116 mm from the bottom of the bulb.

ll–The scale lines at the test temperatures of 37.8°C shall be indicated by an arrow or other suitable mark.

mm–The thermometer may be furnished with an optional plain, ring or button top to be included in the total length.

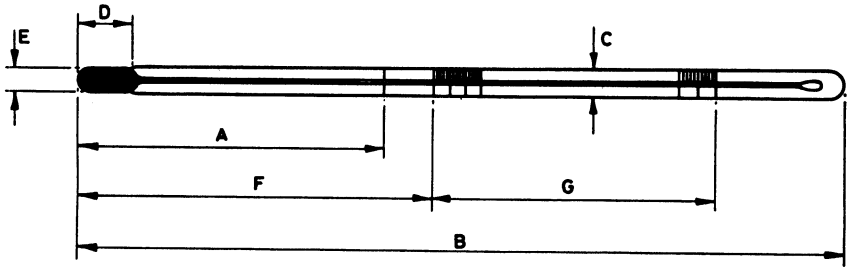


Fig. 3.

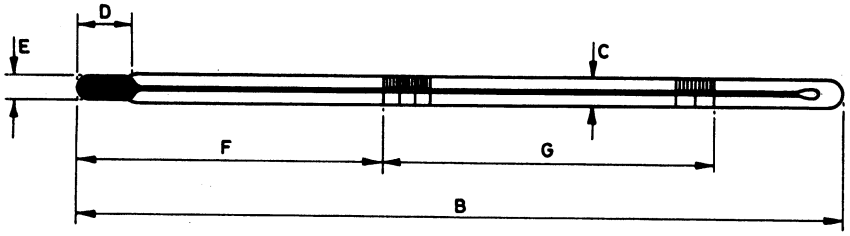


Fig. 4.

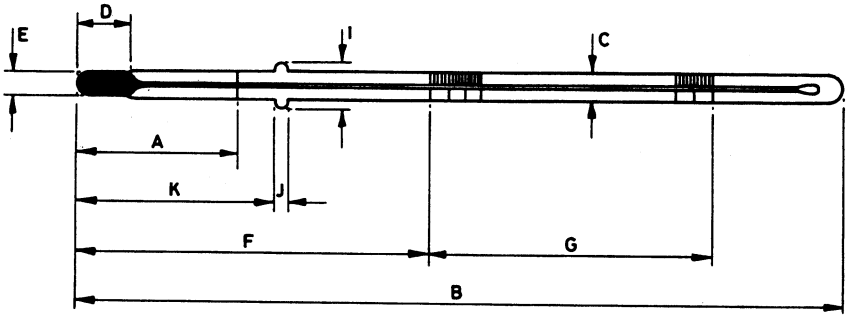


Fig. 5.

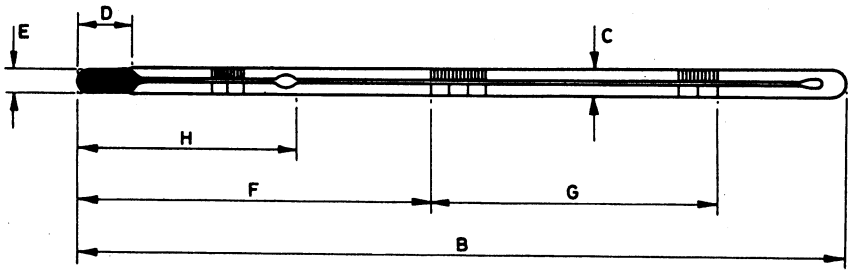


Fig. 6.

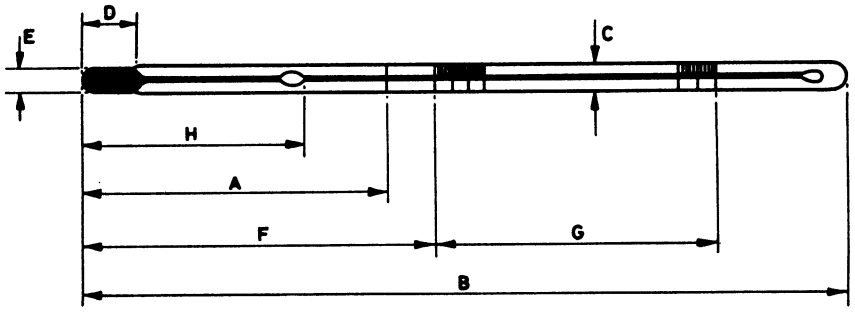


Fig. 7.

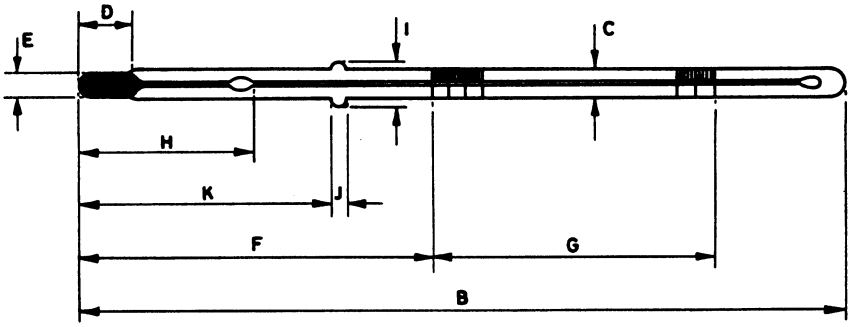


Fig. 8.

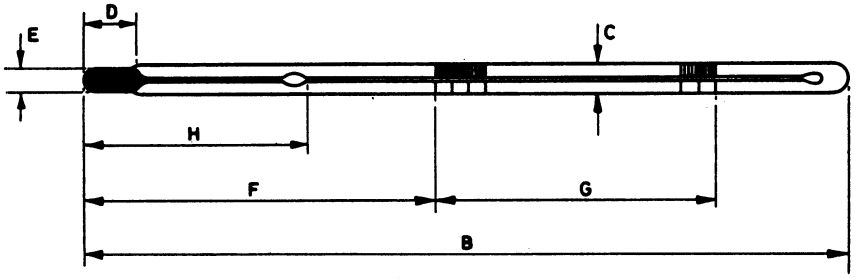


Fig. 9.

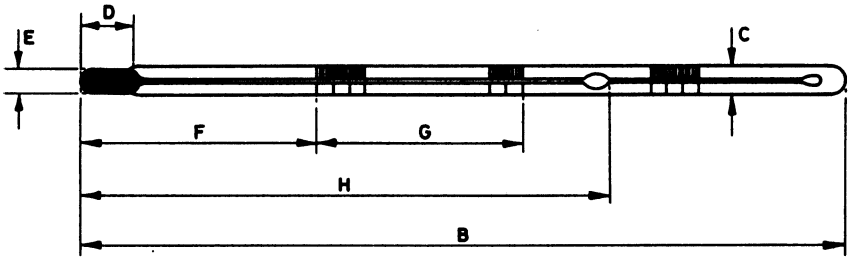


Fig. 10.

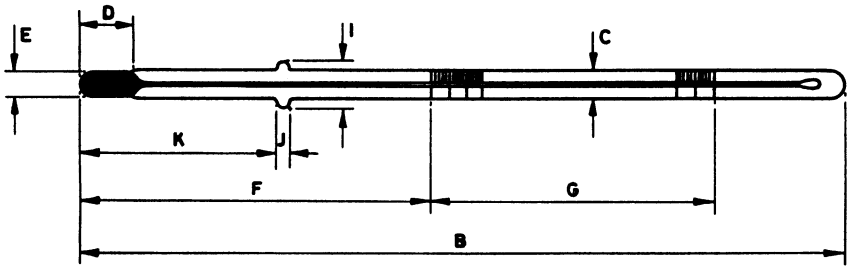


Fig. 11.

	NUMBER	IP 1C/ASTM5C	IP 2C/ASTM 6C	IP 3C
	NAME	CLOUD AND POUR	LOW CLOUD AND POUR	DEMULSIFICATION
	Reference figure number	3	3	4
	Temperature range	−38°C to +50°C	−80°C to +20°C	−1°C to +105°C
A	Immersion mm	108	76	Total
	Scale marks:			
	Subdivisions	1°C	1°C	0.5°C
	Long lines at each	5°C	5°C	1°C and 5°C
	Numbers at each	10°C	10°C	5°C
	Maximum line width mm	0.15	0.15	0.15
	Scale error, max	0.5°C	1°C down to −33°C 2°C below −33°C	0.5°C
	Expansion chamber:			
	Permit heating to	100°C	60°C	Required
B	Total length, mm	225 to 235	225 to 235	—
C	Stem OD, mm	6.0 to 8.0	6.0 to 8.0	5.5 to 8.0
D	Bulb length, mm	7 to 10	7 to 10	—
E	Bulb OD, mm	5.5 min but not greater than stem	5.0 min but not greater than stem	not greater than stem
	Scale location:			
	Bottom of bulb to line at	−38°C	−70°C	—
F	Distance, mm	120 to 130	100 to 120	—
G	Length of scale range, mm	65 to 85	70 to 100	170 min
	Notes	See table for emergent stem temperatures 1975	*a*, and see table for emergent stem temperatures 1977	

	NUMBER	IP 4C	IP 5C/ASTM 7C	IP 6C/ASTM 8C	IP 8C
	NAME	CRUDE OIL DISTILLATION	DISTILLATION LOW	DISTILLATION HIGH	FLUSHING-CASE LOW
	Reference figure number	4	4		3
	Temperature range	−4°C to +360°C	−2°C to +300°C	−2°C to +400°C	0°C to 45°C
A	Immersion, mm	Total	Total		65
	Scale marks:				
	Subdivisions	2°C	1°C		0.2°C
	Long lines at each	10°C	5°C		1°C and 5°C
	Numbers at each	20°C	10°C		5°C
	Maximum line width mm	0.15	0.15		0.15
	Scale error, max	2°C	0.5°C to 150°C 1°C above 150°C	1°C to 300°C 1.5°C above 300°C	0.2°C
	Expansion chamber:				
	Permit heating to	Required	Required		100°C
B	Total length, mm	300 to 320	380 to 390		330 to 350
C	Stem OD, mm	5.5 to 8.0	6.0 to 8.0		5.5 to 8.0
D	Bulb length, mm	10 to 20	10 to 15		10 to 16
E	Bulb OD, mm	not greater than stem	5.0 min and not greater than stem		not greater than stem
	Scale location:				
	Bottom of bulb to line at	0°C	0°C		0°C
F	Distance, mm	95 min	100 to 110	30 to 40	115 min
G	Length of scale range, mm	150 to 180	225 to 255	290 to 330	150 to 190
	Notes	*b* 1977	*b* and *c* 1977		See table for emergent stem temperatures 1976

	NUMBER	IP 9C	IP 14C/ASTM 114C
	NAME	FLUSHING-CASE MEDIUM	AVIATION FUEL FREEZING POINT
	Reference figure number	3	4
	Temperature range	40°C to 85°C	–80°C to +20°C
A	Immersion, mm	65	Total
	Scale marks:		
	Subdivisions	0.2°C	0.5°C
	Long lines at each	1°C and 5°C	1°C
	Numbers at each	5°C	5°C
	Maximum line width mm	0.15	0.15
	Scale error, max	0.2°C	1°C
	Expansion chamber:		
	Permit heating to	100°C	45°C
B	Total length, mm	330 to 350	295 to 305
C	Stem OD, mm	5.5 to 8.0	6.0 to 8.0
D	Bulb length, mm	10 to 16	8 to 16
E	Bulb OD, mm	not greater than stem	not greater than stem
	Scale location:		
	Bottom of bulb to line at	40°C	–80°C
F	Distance, mm	115 min	50 to 70
G	Length of scale range, mm	150 to 190	170 to 210
	Notes	See table for emergent stem temperatures 1976	*a* 1975

	NUMBER	IP 15C/ASTM 9C	IP 16C/ASTM 10C	IP 17C/ASTM 14C
	NAME	LOW PENSKY-MARTENS	HIGH PENSKY-MARTENS	WAX MELTING POINT
	Reference figure number	5	5	7
	Temperature range	–5°C to +110°C	90°C to 370°C	38°C to 82°C
A	Immersion, mm	57	57	79
	Scale marks:			
	Subdivisions	0.5°C	2°C	0.1°C
	Long lines at each	1°C and 5°C	10°C	0.5°C
	Numbers at each	5°C	20°C	1°C
	Maximum line width mm	0.15	0.15	0.10
	Scale error, max	0.5°C	1°C to 260°C 2°C above 260°C	0.1°C
	Expansion chamber:			
	Permit heating to	160°C	Required	100°C
B	Total length, mm	285 to 295	285 to 295	370 to 380
C	Stem OD, mm	6.0 to 7.0	6.0 to 7.0	6.0 to 8.0
D	Bulb length, mm	9 to 13	7 to 10	18 to 28
E	Bulb OD, mm	5.5 min and not greater than stem	4.5 min and not greater than stem	5.0 to 6.0
	Scale location:			
	Bottom of bulb to line at	0°C	90°C	40°C
F	Distance, mm	85 to 95	80 to 90	115 to 125
G	Length of scale range, mm	140 to 175	145 to 180	210 to 240
	Notes	*e*, and see table for emergent stem temperatures 1975	*b* and *e*, and see table for emergent temperatures 1977	*f*, and see table for emergent stem temperatures 1977

	NUMBER	IP 18C/ASTM 54C	IP 20C/ASTM 33C	IP 21C/ASTM 34C
	NAME	CONGEALING POINT	LOW ANILINE POINT	MEDIUM ANILINE POINT
	Reference figure number	4	3	3
	Temperature range	20°C to 100.6°C	−38°C to +42°C	25°C to 105°C
A	Immersion, mm	Total	50	50
	Scale marks:			
	Subdivisions	0.2°C	0.2°C	0.2°C
	Long lines at each	1°C	1°C	1°C
	Numbers at each	2°C	2°C	2°C
	Maximum line width mm	0.15	0.10	0.10
	Scale error, max	0.2°C	0.2°C	0.2°C
	Expansion chamber:			
	Permit heating to	110°C	100°C	150°C
B	Total length, mm	305 to 315	415 to 425	415 to 425
C	Stem OD, mm	6.0 to 8.0	6.0 to 7.5	6.0 to 7.5
D	Bulb length, mm	10 to 12	10 to 20	10 to 20
E	Bulb OD, mm	4.5 to 6.0	5.0 min but not greater than stem	5.0 min but not greater than stem
	Scale location:			
	Bottom of bulb to line at	20°C	−35°C	25°C
F	Distance, mm	60 to 70	100 to 125	100 to 115
G	Length of scale range mm	170 to 215	240 to 280	240 to 280
	Notes	*g* 1975	See table for emergent stem temperatures 1977	see table for emergent stem temperatures 1977

	NUMBER	IP 22C	IP 23C/ASTM 18C	IP 24C/ASTM 22C
	NAME	OXIDATION	REID VAPOUR PRESSURE	OXIDATION STABILITY
	Reference figure number	3	8	8
	Temperature range	195°C to 205°C	34°C to 42°C	95°C to 103°C
A	Immersion, mm	100	Total	Total
	Scale marks:			
	Subdivisions	0.1°C	0.1°C	0.1°C
	Long lines at each	0.5°C	0.5°C	0.5°C
	Numbers at each	1°C	1°C	1°C
	Maximum line width mm	0.15	0.15	0.15
	Scale error, max	0.2°C	0.1°C	0.1°C
	Expansion chamber:			
	Permit heating to	Required	100°C	155°C
B	Total length, mm	290 to 310	270 to 280	270 to 280
C	Stem OD, mm	5.0 to 8.0	6.0 to 7.0	6.0 to 8.0
D	Bulb length, mm	25 to 35	25 to 35	25 to 35
E	Bulb OD, mm	not greater than stem	not greater than stem	5.0 min but not greater than stem
	Scale location:			
	Bottom of bulb to line at	195°C	34°C	95°C
F	Distance, mm	165 min	130 to 150	135 to 150
G	Length of scale range, mm	70 to 110	60 to 90	70 to 100
	Notes	See table for emergent stem temperatures	*kk* and *ll*	*jj* and *kk* 1977

	NUMBER		
	NAME	ABEL WATER-BATH CELSIUS	ABEL OIL CUP CELSIUS
	Reference figure number	11	11
	Temperature range	32°C to 88°C	10°C to 65°C
A	Immersion, mm	—	—
	Scale marks:		
	Subdivisions	0.5°C	0.5°C
	Long lines at each	1°C and 5°C	1°C and 5°C
	Numbers at each	5°C	5°C
	Maximum line width mm	0.15	0.15
	Scale error, max	0.5°C	0.2°C
	Expansion chamber:		
	Permit heating to	Required	Required
B	Total length, mm	228 approx	228 approx
C	Stem OD, mm	6.1 to 7.1	6.1 to 7.1
D	Bulb length, mm	20 approx	—
E	Bulb OD, mm	not greater than stem	8.9 ± 1.3
	Scale location:		
	Bottom of bulb to line at	32°C	10°C
F	Distance, mm	100 to 111	70 to 80
G	Length of scale range, mm	90 min	120.6 min
	Notes	*h* except bulb shape shall be cylindrical	*h*

	NUMBER	IP 28C/ASTM 11C	IP 29C/ASTM 44C
	NAME	CLEVELAND OPEN FLASH	KIN VISC 20°C
	Reference figure number	3	6
	Temperature range	−6°C to +400°C	18.6°C to 21.4°C and −0.3°C to + 0.3°C
A	Immersion, mm	25	Total
	Scale marks:		
	Subdivisions	2°C	0.05°C
	Long lines at each	10°C	0.1°C and 0.5°C
	Numbers at each	20°C	1°C
	Maximum line width mm	0.15	0.10
	Scale error, max	2°C to 260°C 4°C above 260°C	0.1°C at 20°C and 21.1°C
	Expansion chamber:		
	Permit heating to	Required	105°C
B	Total length, mm	305 to 315	300 to 310
C	Stem OD, mm	6.0 to 8.0	6.0 to 8.0
D	Bulb length, mm	7 to 10	45 to 55
E	Bulb OD, mm	4.5 min but not greater than stem	not greater than stem
	Scale location:		
	Bottom of bulb to line at	0°C	18.6°C
F	Distance, mm	45 to 55	145 to 165
G	Length of scale range, mm	210 to 240	40 to 90
	Notes	*h* except bulb shape shall be cylindrical	*b*, and see table for emergent stem temperatures 1985 *mm*

	NUMBER		
	NAME		
	Reference figure number		
	Temperature range	*i*, *j* and *k*	*i* and *j*
A	Immersion, mm		
	Scale marks:		
	Subdivisions		
	Long lines at each		
	Numbers at each		
	Maximum line width mm		
	Scale error, max		
	Expansion chamber:		
	Permit heating to		
B	Total length, mm		
C	Stem OD, mm		
D	Bulb length, mm		
E	Bulb OD, mm		
	Scale location:		
	Bottom of bulb to line at		
F	Distance, mm		
G	Length of scale range, mm		
	Notes		

	NUMBER	IP 30C/ASTM 45C	IP 31C/ASTM 28C	IP 32C/ASTM 121C
	NAME	KIN VISC 25°C	KIN VISC 37.8°C	KIN VISC 98.9°C
	Reference figure number	6	6	6
	Temperature range	23.6°C to 26.4°C and –0.3°C to +0.3°C	36.6°C to 39.4°C and –0.3°C to +0.3°C	98.6°C to 101.4°C and –0.3°C to +0.3°C
A	Immersion, mm	Total	Total	Total
	Scale marks:			
	Subdivisions	0.05°C	0.05°C	0.05°C
	Long lines at each	0.1°C and 0.5°C	0.1°C and 0.5°C	0.1°C and 0.5°C
	Numbers at each	1°C	0.5°C	1°C
	Maximum line width mm	0.10	0.10	0.10
	Scale error, max	0.1°C at 25°C	0.1°C at 37.8°C	0.1°C at 98.9°C and 100°C
	Expansion chamber:			
	Permit heating to	105°C	105°C	130°C
B	Total length, mm	300 to 310	300 to 310	300 to 310
C	Stem OD, mm	6.0 to 8.0	6.0 to 8.0	6.0 to 8.0
D	Bulb length, mm	45 to 55	45 to 55	45 to 55
E	Bulb OD, mm	not greater than stem	not greater than stem	not greater than stem
	Scale location:			
	Bottom of bulb to line at	23.6°C	36.6°C	98.6°C
F	Distance, mm	145 to 165	145 to 165	145 to 165
G	Length of scale range, mm	40 to 90	40 to 90	40 to 90
	Notes	*i*, *j* and *k* / *i* and *j*	*i*, *j* and *k* / *i* and *j*	*i*, *j* and *k* / *i* and *j*

	NUMBER	IP 33C/ASTM 128C	IP 34C/ASTM 29C	IP 35C/ASTM 47C
	NAME	KIN VISC 0°C	KIN VISC 54.4°C	KIN VISC 60°C
	Reference figure number	4	6	6
	Temperature range	−1.4°C to +1.4°C	52.6°C to 55.4°C and –0.3°C to +0.3°C	58.6°C to 61.4°C and –0.3°C to +0.3°C
A	Immersion, mm	Total	Total	Total
	Scale marks:			
	Subdivisions	0.05°C	0.05°C	0.05°C
	Long lines at each	0.1°C and 0.5°C	0.1°C and 0.5°C	0.1°C and 0.5°C
	Numbers at each	1°C	1°C	1°C
	Maximum line width mm	0.10	0.10	0.10
	Scale error, max	0.1°C at 0°C	0.1°C at 54.4°C	0.1°C at 60°C
	Expansion chamber:			
	Permit heating to	105°C	105°C	105°C
B	Total length, mm	300 to 310	300 to 310	300 to 310
C	Stem OD, mm	6.0 to 8.0	6.0 to 8.0	6.0 to 8.0
D	Bulb length, mm	45 to 55	45 to 55	45 to 55
E	Bulb OD, mm	not greater than stem	not greater than stem	not greater than stem
	Scale location:			
	Bottom of bulb to line at	−1.4°C	52.6°C	58.6°C
F	Distance, mm	145 to 165	145 to 165	145 to 165
G	Length of scale range, mm	40 to 90	40 to 90	40 to 90
	Notes	*k*	*j*, *k* and *l* / *j* and *l*	*j*, *k* and *l* / *j* and *l*

	NUMBER	IP 36C/ASTM 129C	IP 37C	IP 38C
	NAME	KIN VISC 93.3°C	SLUDGE	PEN
	Reference figure number	6	3	4
	Temperature range	91.6°C to 94.4°C and −0.3°C to +0.3°C	144°C to 156°C	23°C to 27°C
A	Immersion, mm	Total	100	Total
	Scale marks:			
	Subdivisions	0.05°C	0.2°C	0.1°C
	Long lines at each	0.1°C and 0.5°C	1°C	0.5°C
	Numbers at each	1°C	2°C	1°C
	Maximum line width mm	0.10	0.15	0.15
	Scale error, max	0.1°C at 93.3°C	0.2°C at 150°C	0.1°C at 25°C
	Expansion chamber:			
	Permit heating to	120°C	required	100°C
B	Total length, mm	300 to 310	260 to 280	250 to 270
C	Stem OD, mm	6.0 to 8.0	5.0 to 8.0	5.0 to 8.0
D	Bulb length, mm	45 to 55	10 to 25	20 to 40
E	Bulb OD, mm	not greater than stem	not greater than stem	not greater than stem
	Scale location:			
	Bottom of bulb to line at	91.6°C	150°C	25°C
F	Distance, mm	145 to 165	170 to 210	170 to 210
G	Length of scale range, mm	40 to 90	50 to 80	40 to 60
	Notes	*j*, *k* and *l*	*j* and *l*	See table for emergent stem temperatures	*m*

	NUMBER	IP 39C	IP 40C	IP 41C	IP 42C
	NAME	DENSITY	DROP POINT LOW	DROP POINT HIGH	BREAKING POINT
	Reference figure number	4	3		5
	Temperature range	−1°C to +38°C	20°C to 120°C	100°C to 230°C	−38°C to + 30°C
A	Immersion, mm	Total	100		250
	Scale Marks:				
	Subdivisions	0.1°C	1°C		0.5°C
	Long lines at each	0.5°C	5°C		1°C and 5°C
	Numbers at each	1°C	10°C		5°C
	Maximum line width mm	0.15	0.15		0.15
	Scale error, max	0.1°C	1°C		0.5°C
	Expansion chamber:				
	Permit heating to	100°C	Required		80°C
B	Total length, mm	430 to 450	240 to 260		360 to 380
C	Stem OD, mm	5.5 to 8.0	4.5 to 6.0		6.0 to 7.0
D	Bulb length, mm	15 to 25	6.0 max		10 to 16
E	Bulb OD, mm	not greater than stem	3.35 to 3.65		not greater than stem
	Scale location:				
	Bottom of bulb to line at	−1°C	20°C	100°C	—
F	Distance, mm	45 to 65	100 min		—
G	Length of scale range, mm	295 to 345	100 min		not less than 60
	Notes		*n*, *o*, and see table for emergent stem temperatures		*p*, and see table for emergent stem temperatures

	NUMBER	IP 43C	IP 44C	IP 45C
	NAME	FP CUT-BACK (INT)	FP CUT-BACK (EXT)	REFRACTOMETER
	Reference figure number	11	11	3
	Temperature range	10°C to 110°C	15°C to 121°C	15°C to 30°C
A	Immersion, mm	—	—	22
	Scale Marks:			
	Subdivisions	0.5°C	0.5°C	0.2°C
	Long lines at each	1°C and 5°C	1°C and 5°C	1°C
	Numbers at each	5°C	5°C	1°C
	Maximum line width mm	0.15	0.15	0.15
	Scale error, max	0.2°C	0.5°C	0.2°C
	Expansion chamber:			
	Permit heating to	Required	Required	Required
B	Total length, mm	305 approx	305 approx	150 to 170
C	Stem OD, mm	6.1 to 7.6	6.1 to 7.6	5 to 6
D	Bulb length, mm	—	20 approx	10 max
E	Bulb OD, mm	8.9 ± 1.5	not greater than stem	not greater than stem
	Scale location:			
	Bottom of bulb to line at	10°C	15°C	15°C
F	Distance, mm	76 min	102 min	40 to 50
G	Length of scale range, mm	178 min	152 min	80 to 100
	Notes	*q*	*q*	See table for emergent stem temperatures

	NUMBER	IP 46C	IP 47C/ASTM 13C	IP 48C
	NAME	WESTPHAL BALANCE	LOSS ON HEATING	TANK LOW
	Reference figure number	4	4	4
	Temperature range	14.5°C to 21°C	155°C to 170°C	−38°C to + 30°C
A	Immersion, mm	Total	Total	Total
	Scale Marks:			
	Subdivisions	0.1°C	0.5°C	0.5°C
	Long lines at each	0.5°C	1°C and still longer at 5°C	1°C
	Numbers at each	0.5°C	5°C and arrows at 162°C and 164°C	5°C
	Maximum line width mm	0.15	0.15	0.15
	Scale error, max	0.1°C	0.5°C	0.25°C
	Expansion chamber:			
	Permit heating to	Required	200°C	43°C
B	Total length, mm	150 to 170	150 to 160	305 to 315
C	Stem OD, mm	5.0 to 6.5	5.5 to 7.0	6.0 to 7.5
D	Bulb length, mm	8 to 10	10 to 15	10 to 18
E	Bulb OD, mm	not greater than stem	5.0 min but not greater than stem	Not less than 5.5 not greater than stem
	Scale location:			
	Bottom of bulb to line at	14.5°C	155°C	−38°C
F	Distance, mm	40 to 50	50 to 60	50 to 60
G	Length of scale range, mm	80 to 100	40 to 60	210 to 240
	Notes		*r* 1977	*hh* 1976

	NUMBER	IP 49C	IP 50C	IP 51C
	NAME	TANK MEDIUM	TANK HIGH	TANK HEATED FUEL
	Reference figure number	4	4	9
	Temperature range	−15°C to +40°C	10°C to 65°C	35°C to 120°C
A	Immersion mm	Total	Total	Total
	Scale Marks: Subdivisions Long lines at each Numbers at each Maximum line width mm	 0.5°C 1°C 5°C 0.15	 0.5°C 1°C 5°C 0.15	 0.5°C 1°C 5°C 0.15
	Scale error, max	0.25°C	0.25°C	0.5°C
	Expansion chamber: Permit heating to	 80°C	 110°C	 210°C
B	Total length, mm	305 to 315	305 to 315	305 to 315
C	Stem OD, mm	6.0 to 7.5	6.0 to 7.5	6.0 to 7.5
D	Bulb length, mm	10 to 18	10 to 18	10 to 18
E	Bulb OD mm	Not less than 5.5 not greater than stem	Not less than 5.5 not greater than stem	Not less than 5.5 not greater than stem
	Scale location: Bottom of bulb to line at	 −15°C	 10°C	 35°C
F	Distance, mm	50 to 60	50 to 60	50 to 60
G	Length of scale range, mm	210 to 240	210 to 240	210 to 240
	Notes	*hh* 1976	*hh* 1976	*hh* 1976

	NUMBER	IP 52C	IP 53C	IP 54C to 58C
	NAME	TANK BITUMEN	TANK CARGO	ANGLE STEM
	Reference figure number	9	4	—
	Temperature range	90°C to 260°C	0°C to 80°C	See note *ii*
A	Immersion, mm	Total	Total	As required
	Scale Marks: Subdivisions Long lines at each Numbers at each Maximum line width, mm	 1°C 5°C 10°C 0.15	 0.5°C 1°C 5°C 0.15	 0.5°C Depending on range Depending on range 0.15
	Scale error, max	1°C	0.25°C	Depending on range
	Expansion chamber: Permit heating to	 300°C	 125°C	40°C Above upper limit of range
B	Total length, mm	305 to 315	305 to 315	As required
C	Stem OD, mm	6.0 to 7.5	6.0 to 7.5	6.0 to 7.5
D	Bulb length, mm	8 to 12	10 to 18	10 to 18
E	Bulb OD, mm	Not less than 5.5 not greater than stem	Not less than 5.5 not greater than stem	Not less than 5.5 not greater than stem
	Scale location: Bottom of bulb to line at	 90°C	 0°C	 Lowest graduation
F	Distance, mm	50 to 60	50 to 60	As required
G	Length of scale range, mm	210 to 230	210 to 240	210 to 230
	Notes	*hh* 1976	*hh* 1976	*ii* 1976

	NUMBER	IP 59C/ASTM 35C	IP 60C/ASTM 15C	IP 61C/ASTM 16C	IP 62C/ASTM 2C
	NAME	HIGH ANILINE POINT	SOFTENING POINT LOW	SOFTENING POINT HIGH	PARTIAL IMMERSION
	Reference figure number	7	4		3
	Temperature range	90°C to 170°C	−2°C to +80°C	30°C to 200°C	−5°C to +300°C
A	Immersion, mm	50	Total		76
	Scale Marks:				
	Subdivisions	0.2°C	0.2°C	0.5°C	1°C
	Long lines at each	1°C	1°C	1°C	5°C
	Numbers at each	2°C	2°C	5°C	10°C
	Maximum line width mm	0.10	0.15		0.15
	Scale error, max	0.4°C	0.2°C	0.3°C	1°C
	Expansion chamber:				
	Permit heating to	220°C	130°C	250°C	Required
B	Total length, mm	415 to 425	390 to 400		385 to 395
C	Stem OD, mm	6.0 to 7.5	6.0 to 8.0		6.0 to 7.0
D	Bulb length, mm	10 to 20	9 to 14		10 to 15
E	Bulb OD, mm	not less than 5.0 and not greater than stem	4.5 to 5.5		5.0 to 6.0
	Scale location:				
	Bottom of bulb to line at	90°C	0°C	30°C	0°C
F	Distance, mm	100 to 115	75 to 90		100 to 110
G	Length of scale range, mm	240 to 280	245 to 285	245 to 280	225 to 265
	Notes	*s*, contraction chamber required. Bottom of bulb to top of contraction chamber (H) 35 mm max. Mercury shall be near the middle of the chamber at 0°C 1979		1977	*b*, and see table for emergent stem temperatures 1975

	NUMBER	IP 63C/ASTM 61C	IP 64C/ASTM 12C	IP 65C
	NAME	PETROLATUM MELTING POINT	DENSITY WIDE RANGE	KIN VISC LOW
	Reference figure number	7	4	10
	Temperature range	32°C to 127°C	−20°C to +102°C	−51.6°C to −34°C and −0.6°C to +0.6°C
A	Immersion, mm	79	Total	Total
	Scale Marks:			
	Subdivisions	0.2°C	0.2°C	0.1°C
	Long lines at each	1°C	1°C	0.5°C and 1°C
	Numbers at each	2°C	2°C	1°C starting at −51°C
	Maximum line width mm	0.15	0.15	0.10
	Scale error, max	0.2°C	0.15°C	0.1°C
	Expansion chamber:			
	Permit heating to	150°C	150°C	105°C
B	Total length, mm	375 to 385	415 to 425	410 to 425
C	Stem OD, mm	6.0 to 8.0	6 to 8	7 to 8
D	Bulb length, mm	18 to 28	15 to 20	30 to 40
E	Bulb OD, mm	5.0 to 6.0	6 min but not greater than stem	6 to 7
	Scale location:			
	Bottom of bulb to line at	32°C	−20°C	−51.6°C
F	Distance, mm	105 to 115	35 to 50	60 to 90
G	Length of scale range, mm	200 to 240	305 to 350	140 to 225
	Notes	*t* and *u* and see table for emergent stem temperatures 1975	1977	*k*, *v*, *x*, *w*, *y* and *z* *v*, *w*, *x*, *y* and *z*

	NUMBER	IP 66C/ASTM 46C	IP 67C/ASTM 72C	IP 68C/ASTM 73C
	NAME	KIN VISC 50°C	KIN VISC −17.8°C	KIN VISC −40°C
	Reference figure number	6	10	10
	Temperature range	48.6°C to 51.4°C and −0.3°C to +0.3°C	−19.4°C to −16.6°C and −0.3°C to +0.3°C	−41.4°C to −38.6°C and −0.3°C to +0.3°C
A	Immersion, mm	Total	Total	Total
	Scale Marks:			
	Subdivisions	0.05°C	0.05°C	0.05°C
	Long lines at each	0.1°C and 0.5°C	0.1°C and 0.5°C	0.1°C and 0.5°C
	Numbers at each	1°C	1°C	1°C
	Maximum line width mm	0.10	0.10	0.10
	Scale error, max	0.1°C at 50°C	0.1°C at −17.8°C	0.1°C at −40°C
	Expansion chamber:			
	Permit heating to	105°C	105°C	105°C
B	Total length, mm	300 to 310	300 to 310	300 to 310
C	Stem OD, mm	6.0 to 8.0	6.0 to 8.0	6.0 to 8.0
D	Bulb length, mm	45 to 55	45 to 55	45 to 55
E	Bulb OD, mm	not greater than stem	not greater than stem	not greater than stem
	Scale location:			
	Bottom of bulb to line at	48.6°C	−19.4°C	−41.4°C
F	Distance, mm	145 to 165	80 to 110	80 to 110
G	Length of scale range, mm	40 to 90	40 to 90	40 to 90
	Notes	*i, j, k,* and *w*	*i, j,* and *w*	*j, k, w, x* and *aa*	*j, w, x* and *aa*	*j, k, v, w, x* and *aa*	*j, v, w, x* and *aa*

	NUMBER	IP 69C/ASTM 74C	IP 71C/ASTM 126C	IP 72C/ASTM 71C
	NAME	KIN VISC −53.9°C	KIN VISC −26.1°C	OIL IN WAX
	Reference figure number	10	10	3
	Temperature range	−55.4°C to −52.6°C and −0.3°C to +0.3°C	−27.4°C to −24.6°C and −0.3°C to +0.3°C	−37°C to +21°C
A	Immersion, mm	Total	Total	76
	Scale Marks:			
	Subdivisions	0.05°C	0.05°C	0.5°C
	Long lines at each	0.1°C and 0.5°C	0.1°C and 0.5°C	1°C
	Numbers at each	1°C	1°C	5°C
	Maximum line width mm	0.10	0.10	0.15
	Scale error, max	0.1°C at −53.9°C	0.1°C at −26.1°C	0.2°C
	Expansion chamber:			
	Permit heating to	105°C	105°C	105°C
B	Total length, mm	300 to 310	300 to 310	350 to 360
C	Stem OD, mm	6.0 to 8.0	6.0 to 8.0	6.0 to 8.0
D	Bulb length, mm	45 to 55	45 to 55	15 to 20
E	Bulb OD, mm	not greater than stem	not greater tham stem	6.0 to 7.0
	Scale location:			
	Bottom of bulb to line at	−55.4°C	−27.4°C	−37°C
F	Distance, mm	80 to 110	80 to 110	170 to 185
G	Length of scale range, mm	40 to 90	40 to 90	105 to 140
	Notes	*j, k, v, w, x* and *aa*	*j, v, w, x* and *aa*	*j, k, w, x* and *aa*	*j, w, x* and *aa*	see table for emergent stem temperatures 1975

	NUMBER	IP 73C/ASTM 3C	IP 74C	IP 75C
	NAME	PARTIAL IMMERSION	ABEL OIL CUP WIDE RANGE	ABEL WATER BATH – WIDE RANGE
	Reference figure number	3	5	5
	Temperature range	−5°C to +400°C	−35°C to +70°C	−30°C to +80°C
A	Immersion, mm	76	61	89
	Scale Marks:			
	Subdivisions	1°C	0.5°C	0.5°C
	Long lines at each	5°C	1°C and 5°C	1°C and 5°C
	Numbers at each	10°C	5°C	5°C
	Maximum line width mm	0.15	0.15	0.15
	Scale error, max	1.0°C up to 301°C 1.5°C over 301°C	0.5°C below 0°C 0.2°C at and above 0°C	0.5°C
	Expansion chamber:			
	Permit heating to	Required	Required	Required
B	Total length, mm	410 to 420	300 to 320	300 to 320
C	Stem OD, mm	6.0 to 7.5	6 to 7	6 to 7
D	Bulb length, mm	10 to 15	7.5 to 10.5	7.5 to 10.5
E	Bulb OD, mm	5.0 to 6.0	not greater than stem	not greater than stem
	Scale location:			
	Bottom of bulb to line at	0°C	−35°C	−30°C
F	Distance, mm	100 to 110	70 to 80	100 to 110
G	Length of scale range, mm	250 to 290	not less than 195	164 min
	Notes	*b*, and see table for emergent stem temperatures 1975	*bb*, and see table for emergent stem temperatures	*cc*, and see table for emergent stem temperatures

	NUMBER	IP 76C	IP 77C/ASTM 37C	IP 78C/ASTM 38C
	NAME	ENGLER VISCOSITY	SOLVENTS DISTILLATION	SOLVENTS DISTILLATION
	Reference figure number	5	3	3
	Temperature range	10°C to 55°C	−2°C to +52°C	24°C to 78°C
A	Immersion, mm	93	100	100
	Scale Marks:			
	Subdivisions	0.5°C	0.2°C	0.2°C
	Long lines at each	1°C	1°C	1°C
	Numbers at each	5°C	2°C	2°C
	Maximum line width mm	0.15	0.15	0.15
	Scale error, max	0.25°C	0.2°C	0.2°C
	Expansion chamber:			
	Permit heating to	100°C	80°C	105°C
B	Total length, mm	230 to 250	390 to 400	390 to 400
C	Stem OD, mm	5.0 to 6.5	6.0 to 8.0	6.0 to 8.0
D	Bulb length, mm	10 to 14	15 to 20	15 to 20
E	Bulb OD, mm	5 min and not greater tham stem	not greater than stem	not greater than stem
	Scale location:			
	Bottom of bulb to line at	10°C	−2°C	24°C
F	Distance, mm	105 to 115	125 to 145	125 to 145
G	Length of scale range, mm	70 to 95	190 to 235	190 to 235
	Notes	dd, and see table for emergent stem temperatures	See table for emergent stem temperatures 1977	See table for emergent stem temperatures 1977

	NUMBER	IP 79C/ASTM 39C	IP 80C/ASTM 40C	IP 81C/ASTM 41C
	NAME	SOLVENTS DISTILLATION	SOLVENTS DISTILLATION	SOLVENTS DISTILLATION
	Reference figure number	7	7	7
	Temperature range	48°C to 102°C	72°C to 126°C	98°C to 152°C
A	Immersion, mm	100	100	100
	Scale Marks:			
	Subdivisions	0.2°C	0.2°C	0.2°C
	Long lines at each	1°C	1°C	1°C
	Numbers at each	2°C	2°C	2°C
	Maximum line width mm	0.15	0.15	0.15
	Scale error, max	0.2°C	0.2°C	0.3°C
	Expansion chamber:			
	Permit heating to	130°C	150°C	180°C
B	Total length, mm	390 to 400	390 to 400	390 to 400
C	Stem OD, mm	6.0 to 8.0	6.0 to 8.0	6.0 to 8.0
D	Bulb length, mm	15 to 20	15 to 20	15 to 20
E	Bulb OD, mm	not greater than stem	not greater than stem	not greater than stem
	Scale location:			
	Bottom of bulb to line at	48°C	72°C	98°C
F	Distance, mm	125 to 145	125 to 145	125 to 145
G	Length of scale range, mm	190 to 235	190 to 235	190 to 235
	Notes	*ee*, and see table for emergent stem temperatures 1977	*ee*, and see table for emergent stem temperatures 1975	*ee*, and see table for emergent stem temperatures 1979

	NUMBER	IP 82C/ASTM 42C	IP 83C/ASTM 102C	IP 84C/ASTM 103C
	NAME	SOLVENTS DISTILLATION	SOLVENTS DISTILLATION	SOLVENTS DISTILLATION
	Reference figure number	7	7	7
	Temperature range	95°C to 255°C	123°C to 177°C	148°C to 202°C
A	Immersion, mm	100	100	100
	Scale Marks:			
	Subdivisions	0.5°C	0.2°C	0.2°C
	Long lines at each	1°C	1°C	1°C
	Numbers at each	5°C	2°C	2°C
	Maximum line width mm	0.15	0.15	0.15
	Scale error, max	1.0°C	0.3°C	0.4°C
	Expansion chamber:			
	Permit heating to	280°C	200°C	225°C
B	Total length, mm	390 to 400	390 to 400	390 to 400
C	Stem OD, mm	6.0 to 8.0	6.0 to 8.0	6.0 to 8.0
D	Bulb length, mm	15 to 20	15 to 20	15 to 20
E	Bulb OD, mm	not greater than stem	not greater than stem	not greater than stem
	Scale location:			
	Bottom of bulb to line at	95°C	123°C	148°C
F	Distance, mm	125 to 145	125 to 145	125 to 145
G	Length of scale range, mm	190 to 235	190 to 235	190 to 235
	Notes	*ee*, and see table for emergent stem temperatures 1979	*ee*, and see table for emergent stem temperatures 1979	*ee*, and see table for emergent stem temperatures 1977

	NUMBER	IP 85C/ASTM 104C	IP 86C/ASTM 105C	IP 87C/ASTM 106C
	NAME	SOLVENTS DISTILLATION	SOLVENTS DISTILLATION	SOLVENTS DISTILLATION
	Reference figure number	7	7	7
	Temperature range	173°C to 227°C	198°C to 252°C	223°C to 277°C
A	Immersion, mm	100	100	100
	Scale Marks:			
	Subdivisions	0.2°C	0.2°C	0.2°C
	Long lines at each	1°C	1°C	1°C
	Numbers at each	2°C	2°C	2°C
	Maximum line width mm	0.15	0.15	0.15
	Scale error, max	0.4°C	0.6°C	0.8°C
	Expansion chamber:			
	Permit heating to	250°C	275°C	300°C
B	Total length, mm	390 to 400	390 to 400	390 to 400
C	Stem OD, mm	6.0 to 8.0	6.0 to 8.0	6.0 to 8.0
D	Bulb length, mm	15 to 20	15 to 20	15 to 20
E	Bulb OD, mm	not greater than stem	not greater than stem	not greater than stem
	Scale location:			
	Bottom of bulb to line at	173°C	198°C	223°C
F	Distance, mm	125 to 145	125 to 145	125 to 145
G	Length of scale range, mm	190 to 235	190 to 235	190 to 235
	Notes	*ee*, and see table for emergent stem temperatures 1977	*ee*, and see table for emergent stem temperatures 1979	*ee*, and see table for emergent stem temperatures 1977

	NUMBER	IP 88C/ASTM 107C	IP 89C/ASTM 113C	IP 90C/ASTM 48C
	NAME	SOLVENTS DISTILLATION	SOFTENING POINT (BITUMEN) WIDE RANGE	KIN VISC 82.2°C
	Reference Figure number	7	4	6
	Temperature range	248°C to 302°C	−1°C to +175°C	80.6°C to 83.4°C and −0.3°C to +0.3°C
A	Immersion, mm	100	Total	Total
	Scale Marks:			
	Subdivisions	0.2°C	0.5°C	0.05°C
	Long lines at each	1°C	1°C	0.1°C and 0.5°C
	Numbers at each	2°C	5°C	1°C
	Maximum line width mm	0.15	0.10	0.10
	Scale error, max	1.0°C	0.5°C	0.1°C at 82.2°C
	Expansion chamber:			
	Permit heating to	325°C	225°C	105°C
B	Total length, mm	390 to 400	400 to 410	300 to 310
C	Stem OD, mm	6.0 to 8.0	6.0 to 8.0	6.0 to 8.0
D	Bulb length, mm	15 to 20	10 to 15	45 to 55
E	Bulb OD, mm	not greater than stem	4.5 to 5.5	not greater than stem
	Scale location:			
	Bottom of bulb to line at	248°C	0°C	−80.6°C
F	Distance, mm	125 to 145	80 to 90	145 to 165
G	Length of scale range, mm	190 to 235	250 to 290	40 to 90
	Notes	*ee*, and see table for emergent stem temperatures 1977	1975	*i, j, k* and *w* *i, j* and *w*

	NUMBER	IP 91C	IP 92C/ASTM 120C	IP 93C/ASTM 110C
	NAME	RAPID FLASH	KIN VISC 40C	KIN VISC 135C
	Reference figure number	3	6	6
	Temperature range	0°C to 110°C	38.6°C to 41.4°C and −0.3°C to +0.3°C	133.6°C to 136.4°C and −0.3°C to +0.3°C
A	Immersion, mm	44	Total	Total
	Scale Marks:			
	Subdivisions	1°C	0.05°C	0.05°C
	Long lines at each	5°C	0.1°C and 0.5°C	0.1°C and 0.5°C
	Numbers at each	10°C	1°C	1°C
	Maximum line width mm	0.15	0.10	0.10
	Scale error, max	0.5°C	0.1°C at 40°C	0.2°C
	Expansion chamber:			
	Permit heating to	Required	105°C	170°C
B	Total length, mm	195 to 200	300 to 310	300 to 310
C	Stem OD, mm	6 to 7	6.0 to 8.0	6.0 to 8.0
D	Bulb length, mm	10 to 14	45 to 55	45 to 55
E	Bulb OD, mm	4 to 6	not greater than stem	not greater than stem
	Scale location:			
	Bottom of bulb to line at	0°C	38.6°C	133.6°C
F	Distance, mm	48 to 52	145 to 165	160 to 180
G	Length of scale range, mm	115 to 135	40 to 90	40 to 90
	Notes	*ff*, and see table for emergent stem temperatures 1974	*i, j, k* and *w* 1975	*i, j, k* and *w* 1975

	NUMBER	IP 94C/ASTM 122C	IP 95C/ASTM 123C
	NAME	BROOKFIELD VISCOSITY	BROOKFIELD VISCOSITY
	Reference figure number	4	4
	Temperature range	−45°C to −35°C	−35°C to −25°C
A	Immersion, mm	Total	Total
	Scale Marks:		
	Subdivisions	0.1°C	0.1°C
	Long lines at each	0.5°C	0.5°C
	Numbers at each	1°C	1°C
	Maximum line width, mm	0.15	0.15
	Scale error, max	0.4°C	0.4°C
	Expansion chamber:		
	Permit heating to	80°C	80°C
B	Total length, mm	295 to 305	295 to 305
C	Stem OD, mm	5.5 to 8.0	5.5 to 8.0
D	Bulb length, mm	30 to 40	30 to 40
E	Bulb OD, mm	Not greater than stem	Not greater than stem
	Scale location:		
	Bottom of bulb to line at	−45°C	−35°C
F	Distance, mm	100 to 120	100 to 120
G	Length of scale range, mm	115 to 165	115 to 165
	Notes	*p* 1982	1982

	NUMBER	IP 96C/ASTM 124C	IP 97C/ASTM 125C	IP 98C
	NAME	BROOKFIELD VISCOSITY	BROOKFIELD VISCOSITY	RAPID FLASH (HIGH)
	Reference figure number	4	4	3
	Temperature range	−25°C to −15°C	−15°C to −5°C	100°C to 300°C
A	Immersion, mm	Total	Total	44
	Scale Marks:			
	Subdivisions	0.1°C	0.1°C	2°C
	Long lines at each	0.5°C	0.5°C	10°C
	Numbers at each	1°C	1°C	10°C
	Maximum line width, mm	0.15	0.15	0.15
	Scale error, max	0.2°C	0.2°C	2°C
	Expansion chamber:			
	Permit heating to	80°C	80°C	Required
B	Total length, mm	295 to 305	295 to 305	195 to 200
C	Stem OD, mm	5.5 to 8.0	5.5 to 8.0	6 to 7
D	Bulb length, mm	30 to 40	30 to 40	10 to 14
E	Bulb OD, mm	Not greater than stem	Not greater than stem	4 to 6
	Scale location:			
	Bottom of bulb to line at	−25°C	−15°C	100°C
F	Distance, mm	100 to 120	100 to 120	48 to 52
G	Length of scale range, mm	115 to 165	115 to 165	115 to 135
	Notes	1982	1982	*ff*, and see table for emergent stem temperatures

	NUMBER	IP 99C/ASTM 127C	IP 100C	IP 101C
	NAME	KIN VISC −20°C	KIN VISC 80°C	MEDIUM PENSKY-MARTENS
	Reference figure number	10	6	5
	Temperature range	−21.4°C to −18.6°C and −0.3°C to +0.3°C	78.6°C to 81.4°C and −0.3°C to +0.3°C	20°C to 150°C
A	Immersion, mm	Total	Total	57
	Scale marks:			
	Subdivisions	0.05°C	0.05°C	1°C
	Long lines at each	0.1°C and 0.5°C	0.1°C and 0.5°C	5°C
	Numbers at each	1°C	1°C	5°C
	Maximum line width, mm	0.10	0.10	0.15
	Scale error, max	0.1°C at −20°C	0.1°C at 80.0°C	1°C
	Expansion chamber:			
	Permit heating to	105°C	105°C	200°C
B	Total length, mm	300 to 310	300 to 310	285 to 295
C	Stem OD, mm	6.0 to 8.0	6.0 to 8.0	6.0 to 7.0
D	Bulb length, mm	45 to 55	20 to 35	9 to 13
E	Bulb OD, mm	not greater than stem	not greater than stem	5.5 min and not greater than stem
	Scale location:			
	Bottom of bulb to line at	−21.4°C	80.0°C	20°C
F	Distance, mm	80 to 110	170 to 210	85 to 95
G	Length of scale range, mm	40 to 90	40 to 90	140 to 175
	Notes	*j*, *k*, *w*, *x* and *aa*	*i*, *j*, *k*, and *w*	*e*, and see table for emergent stem temperatures 1982

	NUMBER	IP102C
	NAME	KIN VISC 150C
	Reference figure number	6
	Temperature range	148.6°C to 151.4°C −0.3°C to +0.3°C
A	Immersion, mm	Total
	Scale marks:	
	Subdivisions	0.05°C
	Long lines at each	0.1°C and 0.5°C
	Numbers at each	1°C
	Maximum line width mm	0.10
	Scale error, max	0.2°C
	Expansion chamber:	
	Permit heating to	185°C
B	Total length, mm	300 to 310
C	Stem OD, mm	6.0 to 8.0
D	Bulb length, mm	45 to 55
E	Bulb OD, mm	not greater than stem
	Scale location:	
	Bottom of bulb to line at	148.6°C
F	Distance, mm	160 to 180
G	Length of scale range, mm	40 to 90
	Notes	i, j, k, and w 1992

An identical ASTM thermometer is being developed.

ANNEX A

CHANGES IN THE NUMERICAL VALUES OF TEMPERATURE RESULTING FROM THE ADOPTION OF THE INTERNATIONAL TEMPERATURE SCALE OF 1990.

The International Temperature Scale of 1990 was adopted by the International Committee of Weights and Measures at its meeting in 1989, in accordance with the request embodied in Resolution 7 of the 18th General Conference of Weights and Measures 1987.

This scale replaces the International Practical Temperature Scale of 1968 (amended edition 1975) and the 1976 Provisional 0.5K to 30K Temperature Scale.

The following table for the range −100°C to 590°C gives the approximate differences between the IPTS-68 and ITS 90.

Differences between ITS-90 and IPTS-68:

$(t_{90}-t_{68})$/°C										
t_{90}/°C	0	−10	−20	−30	−40	−50	−60	−70	−80	−90
−100	0.013	0.013	0.014	0.014	0.014	0.013	0.012	0.010	0.008	0.008
0	0.000	0.002	0.004	0.006	0.008	0.009	0.010	0.0.11	0.012	0.012

t_{90}/°C	0	10	20	30	40	50	60	70	80	90
0	0.000	−0.002	−0.005	−0.007	−0.010	−0.013	−0.016	−0.018	−0.021	−0.024
100	−0.026	−0.028	−0.030	−0.032	−0.034	−0.036	−0.037	−0.038	−0.039	−0.039
200	−0.040	−0.040	−0.040	−0.040	−0.040	−0.040	−0.040	−0.039	−0.039	−0.039
300	−0.039	−0.039	−0.039	−0.040	−0.040	−0.041	−0.042	−0.043	−0.045	−0.046
400	−0.048	−0.051	−0.053	−0.056	−0.059	−0.062	−0.065	−0.068	−0.072	−0.075
500	−0.079	−0.083	−0.087	−0.090	−0.094	−0.098	−0.101	−0.105	−0.108	−0.112

ANNEX B

Comparable IP and ASTM thermometers.

IP	ASTM	ASTM	IP
*1C	5C	*2C	62C
*2C	6C	*3C	73C
*5C	7C	*5C	1C
*6C	8C	*6C	2C
*14C	114C	*7C	5C
*15C	9C	*8C	6C
*16C	10C	*9C	15C
*17C	14C	*10C	16C
*18C	54C	*11C	28C
*20C	33C	*12C	64C
*21C	34C	*13C	47C
*23C	18C	*14C	17C
*24C	22C	*15C	60C
*28C	11C	*16C	61C
*47C	13C	*18C	23C
*59C	35C	*22C	24C
*60C	15C	*33C	20C
*61C	16C	*34C	21C
*62C	2C	*35C	59C
*63C	61C	*37C	77C
*64C	12C	*38C	78C
*72C	71C	*39C	79C
*73C	3C	*40C	80C
*77C	37C	*41C	81C
*78C	38C	*42C	82C
*79C	39C	*54C	18C
*80C	40C	*61C	63C
*81C	41C	*71C	72C
*82C	42C	*102C	83C
*83C	102C	*103C	84C
*84C	103C	*104C	85C
*85C	104C	*105C	86C
*86C	105C	*106C	87C
*87C	106C	*107C	88C
*88C	107C	*113C	89C
*89C	113C	*114C	14C
92C	120C	110C	93C
93C	110C	120C	92C
*94C	122C	*122C	94C
*95C	123C	*123C	95C
*96C	124C	*124C	96C
*97C	125C	*125C	97C

*These thermometers have been agreed as IP and ASTM equivalents.

ANNEX C

NOTES ON CARE AND USE OF LIQUID-IN-GLASS THERMOMETERS

The scale corrections for mercury-in-glass thermometers may change during storage and use owing to contraction of the bulb, and to a lesser extent to volume changes of the contraction chamber. The changes are usually greatest during the first six months after manufacture but may continue at a slow rate, $\sim 0.01°C$/year throughout the thermometer life. Therefore, for accurate temperature measurement thermometers should be calibrated before use by direct comparison with reference instruments, in a constant temperature bath or a special calibrating bath designed to provide a slowly rising temperature.

As a general guide it is considered desirable that thermometers are re-tested at intervals not exceeding five years but for Kinematic Viscosity thermometers and other thermometers of similar accuracy these volume changes often become significant within a shorter period of time after the initial calibration.

Experience shows that a thermometer which has been calibrated to an accuracy (or uncertainty) of $\pm 0.01°C$ or $0.02°C$ can, in use, reliably measure temperatures to the same accuracy only if due regard is given to all of the following conditions at the time of use:

(a) The thermometer should be used within six months of the date of the calibration certificate when aiming for an accuracy of $\pm 0.01°C$ and twelve months for an accuracy of $\pm 0.02°C$. This interval may be extended at the discretion of the user after consideration of the results of a number of recalibrations of the main scale/or the ice point correction. The interval between recalibrations should be estimated for each thermometer depending on the rate of change of scale correction and the accuracy required and should not exceed five years. If regular recalibration at the working temperature is not possible the ice point correction should be determined when the thermometer is first calibrated and then at suitable intervals extending from six months to two years. The main scale correction can be adjusted by the amount of change of the ice point scale correction to allow for changes caused by bulb contractions. Recalibration using the ice point scale alone may not be reliable when the change is greater than one scale division (0.05°C).

(b) New thermometers should be carefully examined for flaws in the glass, defects such as cinders in the bore are likely to cause improper functioning of the mercury column and errors in the scale lines and figuring. Before each period of use the thermometer should be carefully examined to confirm that no gas has been trapped in the bulb or contraction chamber, that the mercury column is unbroken and that there are no globules of mercury in the expansion chamber or in the bore above the normal level of the mercury. Such defects should be rectified by methods described by the thermometer manufacturer or by reference to BS 1041 Part 2, Section 2:1 Liquid-in-glass thermometers.

(c) The thermometer should be supported vertically.

(d) The thermometer should be viewed with a simple optical aid that gives a magnification of about 5 and also eliminates parallax errors.

(e) The thermometer should be gently and repeatedly tapped at right angles to its axis while making observations.

(f) The thermometer should be immersed to the top of the mercury column with the remainder of the stem and the expansion volume at the uppermost end exposed to room temperature. In practice this means that a minimum amount of mercury column (say a length equivalent to one or two scale divisions) is allowed to protrude above the medium whose temperature is being measured. If this condition cannot be met then a correction due to the emergent liquid column being at room temperature instead of bulb temperature may be necessary using the formula given in Section 2.12 Emergent Column Temperatures in the IP Standard Thermometer Section. As an example, suppose an IP 32C

thermometer measuring a bath temperature of 100°C has an emergent liquid column equivalent to 1°C of the scale at an ambient temperature of 30°C then an additional correction of $+0.00016 \times (100-30) \times 1$ i.e. +0.01°C must be added to the corrected reading to obtain true temperature.

Do not submerge the expansion volume at the top of the thermometer.

(g) The thermometer readings should be made by an experienced observer and the mean of a series of observations preferred to a single observation.

(h) A small correction to the reading should be made if the ambient barometric pressure at the time of use differs markedly from that at the time of calibration as given on the certificate. For instance, if the barometric pressure is higher by 30 mb at the time of use compared to that prevailing at the time of calibration then the thermometer will read high and a correction of −0.005°C should be applied. Conversely, if the barometric pressure is lower by 30 mb at the time of use then a correction of +0.005°C should be made. However, this correction is not necessary if the correction to be applied to the main scale reading has been adjusted by the change in an ice point reading taken just before the thermometer is used. Should there be an appreciable delay between obtaining the ice point reading and use then a change in barometric pressure may require an additional correction as described.

(i) Two standardized liquid-in-glass thermometers should be used at all times.

BS 2000 Series

The Institute of Petroleum

61 New Cavendish Street
London
W1G 7AR

Tel: (020) 7467 7100
Fax: (020) 7255 1472
Web Page: http://www.petroleum.co.uk

Buying Parts of BS 2000

Orders for BS 2000 publications should be addressed to the Library at the Institute of Petroleum.

Copyright

IP

THE INSTITUTE
OF PETROLEUM

PTI/13