BS 2000 :
Part 170 : 1995

Methods of test for

Petroleum and its products

Part 170. Petroleum products - Determination of flash point - Abel closed cup method

(Identical with IP 170/95)

BSi
British Standards

Foreword

This British Standard was published under the authority of the Materials and Chemicals Sector Board and comes into effect on 31 March 1995.

This British Standard supersedes BS 2000 : Part 170 : 1992, which is withdrawn.

BS 2000 comprises a series of test methods for petroleum and its products that are published by the Institute of Petroleum (IP) and have been accorded the status of a British Standard. Each method should be read in conjunction with the preliminary pages of 'IP Standard methods for analysis and testing of petroleum and related products' which gives details of the BSI/IP agreement for publication of the series, provides general information on safety precautions, sampling and other matters, and lists the methods published as Parts of BS 2000.

The numbering of the Parts of BS 2000 follows that of the corresponding methods published in 'IP Standard methods for analysis and testing of petroleum and related products'. Under the terms of the agreement between BSI and the Institute of Petroleum, the revised version of BS 2000 : Part 170 will be published by the IP (in 'Standard methods for analysis and testing of petroleum and related products' and as a separate publication). BS 2000 : Part 170 : 1995 is thus identical with IP 170/95.

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

The following BSI references relate to the work of this standard:
Committee reference PTI/13
Draft for comment 95/120491 DC

Petroleum products – Determination of flash point – Abel closed cup method

This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations.

1 Scope

This standard specifies a method for the determination of the closed cup flash point of petroleum products and other liquids having flash points between −30 °C and 70 °C inclusive. However, the precision given for the method is only valid for flash points in the range −5 °C to 66,5 °C.

NOTE 1 This method should be used to measure and describe the properties of materials, products, or assemblies in response to heat and flame under controlled laboratory conditions, and should not be used to describe or appraise the fire hazard or fire risk of materials, products, or assemblies under actual fire conditions. However, results of this test may be used as elements of a fire risk assessment which takes into account all of the factors which are pertinent to an assessment of the fire hazard of a particular end use.

NOTE 2 Flash point is used in shipping, storage, handling and safety regulations as a classification property to define 'flammable' and 'combustible' materials. Precise definition of the classes is given in each particular regulation.

NOTE 3 Flash point may indicate the possible presence of highly volatile materials in a relatively non-volatile or non-flammable material.

NOTE 4 Since the presence of small proportions of highly volatile materials need to be detected, this test should be the first determination on a received sample.

2 Normative references

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

ISO 3170 : 1988, *Petroleum liquids – Manual sampling.*

ISO 3171 : 1988, *Petroleum liquids – Automatic pipeline sampling.*

3 Definition

For the purposes of this standard, the following definition applies.

flash point: The lowest temperature, corrected to a barometric pressure of 101,3 kPa, at which application of a test flame causes the vapour of the test portion to ignite under the specified conditions of test.

4 Principle

The test portion is placed in the cup of an Abel apparatus and heated at specified rates. A small test flame is directed into the cup at regular intervals and the flash point is taken as the lowest temperature at which application of the test flame causes the vapour above the test portion to ignite with a distinct flash inside the cup.

NOTE 5 Separate test procedures are defined for liquids flashing between −30 °C and 18,5 °C inclusive, and between 19 °C and 70 °C inclusive.

5 Reagents and materials

5.1 Solvent, low volatility aromatic solvent (benzene-free) for removal of traces of sample from the oil test cup.

NOTE 6 The choice of solvent will depend upon the previous sample, and the tenacity of the residue. Mixed solvents, such as toluene-acetone-methanol (TAM) may be efficacious for the removal of gum-type deposits.

5.2 Ethanediol (ethylene glycol), corrosion inhibited.

6 Apparatus

6.1 Flash point apparatus

Use an Abel petroleum testing apparatus, provided with a cover and fitted with a stirrer as described in annex A.

NOTE 7 Equipment which is partially or wholly automated may be used provided that it has been established that results obtained will not differ from those obtained by the manual procedure.

If automated testers are used, ensure that all of the manufacturer's instructions for calibrating, adjusting, and operating the instrument are followed. In any cases of dispute, the flash point as determined manually shall be considered the referee test.

6.2 Oil cup thermometer

Use an oil cup thermometer conforming to the specification given in annex C. It shall be fitted into a collar as described in annex B.

6.3 Heating vessel thermometer

Use a heating vessel thermometer conforming to the specification given in annex C. It shall be fitted into a collar as described in annex B.

6.4 Low temperature thermometer

Use a low temperature thermometer conforming to the specification given in annex C.

6.5 Timer

Use one of the following:

a) metronome, that beats at a frequency of 75 beats per min to 80 beats per min;

b) pendulum, of 610 mm effective length, counting one beat from one extremity of the swing to the other;

c) electric/electronic timing device, which can measure intervals of 0,75 s to 0,80 s.

6.6 Barometer

Use either a Fortin type or other suitable type of barometer, readable to, and with an accuracy of 1 hPa. Do not use aneroid barometers pre-corrected to give sea level readings, such as those used at weather stations and airports.

6.7 Cooling bath, either liquid or metal block or a recirculating cooler.

6.8 Oil cup thermal insulator

Use either a cover made of foam plastics or woollen material.

7 Sampling

7.1 Obtain samples according to the procedures given in ISO 3170, ISO 3171, or an equivalent National Standard, and place in tightly sealed containers appropriate to the material being sampled.

7.2 Samples shall not be taken or stored in plastic containers, since volatile materials may diffuse through the walls.

8 Apparatus preparation

Support the tester on a level steady table. Unless tests are made in a draught-free room or compartment, surround the tester on three sides with a shield, each section of which shall be approximately 450 mm wide and 600 mm high.

9 Procedure

9.1 Procedure for liquids flashing between −30 °C and 18,5 °C

9.1.1 Note the ambient pressure of the laboratory at the time of test by recording the barometric pressure and the temperature of the barometer used or its immediate surroundings.

9.1.2 Fill the heating vessel completely and the inner (air) chamber which surrounds the oil test cup (hereinafter referred to as just 'cup') to a depth of at least 38 mm with a mixture of equal volumes of ethanediol (5.2) and water.

9.1.3 Cool the heating vessel, using either a cooling bath or recirculating cooler (6.7), to −35 °C, or to at least 9 °C below the expected flash point of the material being tested, whichever is the higher, measuring the temperature with a low temperature thermometer (6.4). Carry out a trial flash point determination if necessary.

While cooling, stir the water-ethanediol mixture in the heating vessel either manually or mechanically, or by means of a gentle stream of air introduced into the heating vessel by a tube inserted through the thermometer socket and reaching to the bottom of the heating vessel.

CAUTION – Eye protection shall be worn to guard against the possible risk from drops splashed or liquid thrown off whilst stirring.

9.1.4 Cool the sample as received, in a cooling bath or refrigerator to below −35 °C, or to at least 17 °C below the expected flash point, whichever is the higher, before opening the container. Replace the closure with a cork carrying a low temperature thermometer (6.4) to check the temperature. Maintain the sample at this temperature or lower until all flash point tests on the sample are completed.

Cool liquids which crystallise on cooling to just above their crystallising points.

9.1.5 Wash the cup with an appropriate solvent (5.1) to remove any traces of gum or residue remaining from a previous test. Dry using a stream of clean air. Place a low temperature thermometer (6.4) in position in the cover of the cup. Loosely assemble the cover and cup. Cover with the thermal insulator (6.8), and cool the assembly in a cooling bath or refrigerator until the thermometer registers −35 °C or at least 17 °C below the expected flash point, whichever is the higher.

If a liquid cooling bath is used, ensure that neither cooling liquid nor vapour enters the cup, which could affect the flash point of the product under test.

NOTE 8 A low temperature thermometer which is alcohol filled is used when cooling the cup and cover to avoid the risk of freezing the mercury in the flash point thermometer and the consequent rupture of the thread.

NOTE 9 Cooling a cover or cup that is wet with dew or melted frost to below 0 °C can cause sticking due to ice (e.g. sticking of the slide). Wiping the apparatus dry with a duster or a piece of absorbent paper before cooling to below 0 °C is usually sufficient to prevent icing, but, alternatively, icing can be minimized by the use of a thermal insulating cover (6.8) and by lubricating the outer face of the lip of the cup and the slide with ethanediol, glycerol, or a silicone lubricant.

9.1.6 Position the heating vessel on a firm level surface. Place the cup in position in the apparatus (see clause A.2) and replace the low temperature thermometer by an oil cup thermometer (6.2). Remove the cover and pour in the test portion without undue agitation, avoiding as far as possible the formation of air bubbles, until the level just reaches the point of the index gauge on the wall of the cup. Do not move the apparatus after filling. Place the cover on the cup and push it down into position. Ignite the test flame, adjust its size to approximately 3,8 mm in diameter, and maintain it at

that size throughout the test, comparing it frequently with the projecting white bead mounted on the cover of the oil cup.

9.1.7 Remove the low temperature thermometer from the heating vessel and insert the heating vessel thermometer (6.3).

9.1.8 Apply heat to the heating vessel in such a manner that the temperature of the test portion in the oil cup rises at a rate of 1 °C/min.

Stir the test portion in a clockwise direction (i.e. to give a downward thrust) at approximately 30 r/min or as close to this rate as the viscosity of the material permits. When testing viscous products ensure that the stirring action does not push the test portion above the filling mark. Continue stirring in a steady manner for the duration of the test but do not stir during the application of the test flame.

Measure the temperature rise over a period of 5 min, during which period the actual temperature rise shall be 5 °C ± 0,5 °C.

9.1.9 When the temperature of the test portion reaches −35 °C or at least 9 °C below the expected flash point, start the timer (6.5), apply the test flame by slowly and uniformly opening the slide in the cover while the timer beats three times, and closing it during the fourth beat. If a flash occurs, discontinue the test, discard the test portion and proceed in accordance with 9.1.3, commencing the test at −35 °C or at least 17 °C below the previous starting temperature, whichever is the higher. If no flash occurs proceed in accordance with 9.1.10.

9.1.10 Apply the test flame in this manner every 0,5 °C rise in temperature until a distinct flash occurs in the interior of the cup, or until a temperature corresponding to a corrected temperature of 18,5 °C is reached, see 10.2. Record the temperature of the test portion when the flash occurs.

NOTE 10 The test portion is deemed to have flashed when a large flame appears and instantaneously propagates itself over its surface.

Do not confuse the true flash point with the bluish halo that sometimes surrounds the test flame or an enlarged flame at applications preceding the one that causes the actual flash.

9.1.11 Record as the observed flash point the temperature read on the thermometer at the time the test flame application caused a distinct flash in the interior of the cup.

9.2 Procedure for liquids flashing between 19 °C and 70 °C

9.2.1 Note the ambient pressure of the laboratory at the time of test by recording the barometric pressure and the temperature of the barometer used or its immediate surroundings.

9.2.2 Fill the heating vessel completely and the inner (air) chamber which surrounds the oil cup to a depth of at least 38 mm with water.

9.2.3 Cool the heating vessel, using either a cooling bath or a recirculating cooler (6.7), to at least 9 °C below the expected flash point of the material being tested, or to 10 °C, whichever is the higher. Carry out a trial flash point determination if necessary.

9.2.4 Cool the sample in its container, either in a refrigerator or a cooling bath, to 2 °C or at least 17 °C below the expected flash point, whichever is the higher, before opening. Maintain the sample at this temperature or lower until all flash point tests on the sample are completed.

9.2.5 Wash the cup with an appropriate solvent (5.1) to remove any traces of gum or residue remaining from a previous test. Dry using a stream of clean air. Place an oil cup thermometer (6.2) in position in the cover of the cup. Loosely assemble the cover and cup, and cool in a refrigerator or a cooling bath until the thermometer registers 2 °C or at least 17 °C below the expected flash point, whichever is the higher.

If a liquid cooling bath is used, ensure that neither cooling liquid nor vapour enters the cup, which could affect the flash point of the product under test.

9.2.6 Position the heating vessel on a firm level surface. Place the cup in position in the apparatus (see clause A.2). Remove the cover and pour in the test portion without undue agitation, avoiding as far as possible the formation of air bubbles, until the level just reaches the point of the index gauge on the wall of the cup. Do not move the apparatus after filling. Place the cover on the cup and push it down into position. Ignite the test flame, adjust its size to approximately 3,8 mm in diameter, and maintain it at that size throughout the test, comparing it frequently with the projecting white bead mounted on the cover of the oil cup.

9.2.7 Apply heat to the heating vessel in such a manner that the temperature of the test portion in the oil cup rises at a rate of 1 °C/min.

Stir in a clockwise direction (i.e. to give a downward thrust) at approximately 30 r/min or as close to this rate as the viscosity of the material permits. When testing viscous products, ensure that the stirring action does not push the test portion above the filling mark. Continue stirring in a steady manner for the duration of the test but do not stir during the application of the test flame.

9.2.8 When the temperature of the test portion reaches 10 °C or at least 9 °C below the expected flash point, start the timer (6.5), apply the test flame by slowly and uniformly opening the slide in the cover while the timer beats three times, and closing it during the fourth beat. If a flash occurs, discontinue the test, discard the test portion and proceed in accordance with 9.1.2 or 9.2.3, as appropriate, commencing the test at least 17 °C below the previous starting temperature. If no flash occurs proceed in accordance with 9.2.9.

9.2.9 Apply the test flame in this manner every 0,5 °C rise in temperature until a distinct flash occurs in the interior of the cup, or until a temperature corresponding to a corrected temperature of 70 °C is reached. Record the temperature of the test portion when the flash occurs.

NOTE 11 The test portion is deemed to have flashed when a large flame appears and instantaneously propagates itself over its surface.

Do not confuse the true flash point with the bluish halo that sometimes surrounds the test flame or an enlarged flame at applications preceding the one that causes the actual flash.

9.2.10 Record as the observed flash point the temperature read on the thermometer at the time the test flame application causes a distinct flash in the interior of the cup.

10 Calculation

10.1 If required (see note 12), correct the barometric pressure reading taken in accordance with 9.1.1 or 9.2.1 to 0 °C as specified in annex D.

NOTE 12 Some barometers are designed to automatically correct the barometric pressure to 0 °C.

10.2 Calculate the corrected flash point, F, using the following equation.

$$F = C + 0{,}25(101{,}3 + P)$$

where

C is the observed flash point, in °C;

P is the barometric pressure at 0 °C, in kPa.

NOTE 13 Where the barometric pressure is in units other than kPa, the corrections may be made using the following equations.

$$F = C + 0{,}025(1013 - M)$$

$$F = C + 0{,}033(760 - H)$$

where

C is the observed flash point, in °C;

M is the barometric pressure at 0 °C, in hPa or mbar;

H is the barometric pressure at 0 °C, in mmHg.

11 Expression of results

Report the fully corrected result, to the nearest 0,5 °C.

12 Precision

12.1 Repeatability

The difference between successive test results obtained by the same operator with the same apparatus under constant operating conditions on identical test material, in the normal and correct operation of the test method, would exceed the value below only in one case in twenty:

$$r = 1{,}0\,°C$$

12.2 Reproducibility

The difference between two test results independently obtained by different operators operating in different laboratories on nominally identical test material, in the normal and correct operation of the test method, would exceed the value below only in one case in twenty:

$$R = 1{,}5\,°C$$

NOTE 14 The precision data quoted in 12.1 and 12.2 applies over the range −5 °C to 66,5 °C.

13 Test report

The test report shall contain at least the following information:

a) a reference to this standard;

b) all details necessary for the complete identification of the sample tested;

c) the result of the test (see clause 11);

d) any deviation, by agreement or otherwise, from the procedure specified;

e) the date of the test.

Annex A (normative)
Abel flash point apparatus

The apparatus shall consist of an oil test cup, cover assembly and heating vessel as described below.

A.1 Test cup

The test cup shall be made of brass and conform to the form and dimensions shown in figure A.1.

A gauge consisting of a rod bent upwards and terminating in a point, shall be fixed within the cup through the wall, and silver soldered or brazed in place.

A.2 Test cup cover assembly

The cup shall be provided with a close fitting cover made of brass and conform to the form and dimensions shown in figure A.1. A downward projecting rim barely reaching the flange on the cup shall either be made solid with the top or silver soldered or brazed in place.

Upon the cover shall be mounted a thermometer socket, a bush for the stirrer, trunnions to support an oil test gas jet, a pair of guides in which a slide moves, and a white bead. The top of the cover shall be pierced by three rectangular holes symmetrically placed on a diameter, one in the centre and the other two as close as practicable to the inner sides of the rim and opposite each other.

These three holes shall be covered or uncovered by means of a slide moving in suitably disposed guides. The slide shall have two perforations, one corresponding in all particulars to the centre hole in the cover and the other to one of the holes at the side. The movement of the slide shall be restricted by suitable stops, and its length and the disposition of the holes shall be such, that at the outer extremity of the movement of the slide the holes in the cover are just completely opened, and at the inner extremity of the movement of the slide they are completely closed.

The trunnions supporting the test gas jet shall be fixed onto the top of the guides and the gas jet shall be mounted in the trunnions so that it is free to oscillate. The test gas jet shall be arranged so that when the slide is moved so as to uncover the holes, the oscillating test gas jet is caught by a pin fixed in the slide and tilted over the central hole in such a way that the lower edge of the cover bisects the circle formed by the bore of the jet when in the lowest position. The flame shall then occupy a central position within the hole in both directions.

The thermometer socket shall be in the form of a split tube, mounted on a diameter at right angles to the diameter through the centres of the holes, and fitted at such an angle as to bring the bulb of the thermometer when in place, vertically below the centre of the cover and at the correct distance from it.

A bush for the stirrer shall be mounted on the cover in a position diametrically opposite the thermometer mounting. Its length and the angle at which it is set shall be such that the stirrer rod clears the oil level gauge and the blades operate below the level of and without fouling the thermometer bulb. The bush shall be placed as near as practicable to the outer edge of the cover.

A white bead made of suitable material, the dimensions of which represent the size of test flame to be used, shall be mounted in a visible position on the cover.

A.3 Stirrer

This shall be made of brass and conform to the form and dimensions given in figure A.1.

It shall consist of a round stem having four blades or vanes silver soldered in place at one end. The blades of the stirrer shall be set so that the liquid is thrust in a downward direction when the stirrer is rotated clockwise.

A collar shall be fixed on the stem so that when the stem is inserted into the stirrer bush from below, it is arrested at a position such that the correct length protrudes into the oil test cup. The top end of the stem shall be reduced and screwed.

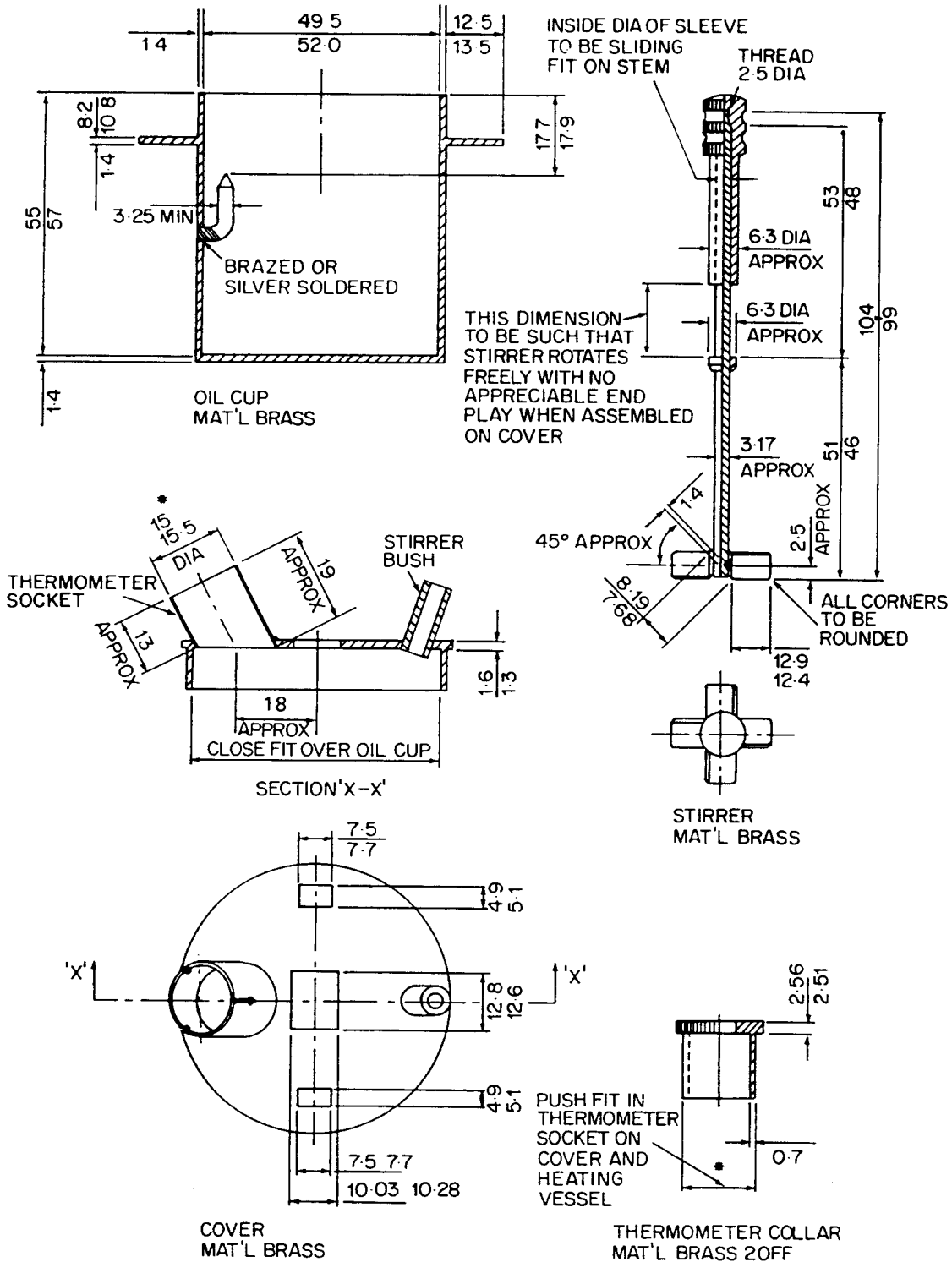
A long sleeve having an internally screwed, knurled knob soldered to its upper end, shall be passed over the upper end of the stem and screwed home. The length of the sleeve shall be such that a flat-faced collar at its lower end just comes into contact with the upper end of the stirrer bush, leaving the stirrer free to rotate without appreciable vertical play.

A flat-headed cylindrical plug shall be provided for insertion in the stirrer bush when the stirrer is not in use.

A.4 Heating vessel

This shall be made of copper and conform to the form and dimensions given in figure A.2. It shall consist of two flat-bottomed cylindrical copper vessels placed coaxially one inside the other and soldered at their tops to a flat copper ring, greater in outside diameter than the smaller vessel. Thus the space between the two vessels shall be totally enclosed and used as a water jacket and the smaller cylinder forms an inner (air) chamber.

An ebonite or fibre ring of right-angled section shall be fitted into the hole in the centre of the flat ring to form the top of the heating vessel. When the apparatus is in use, the oil cup shall fit into, and its flange rest upon, the ebonite or fibre ring so that the oil cup is centrally disposed within the inner (air) chamber of the heating vessel. The ebonite or fibre ring shall be secured in place by means of six small screws having their heads sunk below the surface of the ring to avoid metallic contact between the heating vessel and the oil test cup.



* IT IS RECOMMENDED THAT IN ORDER TO ACHIEVE INTERCHANGEABILITY THE INTERNAL DIA OF THE THERMOMETER SOCKET SHOULD BE BETWEEN 15·235 AND 15·253 AND THE EXTERNAL DIA OF THE THERMOMETER COLLAR BETWEEN 15·222 AND 15·232

All dimensions in millimetres

Figure A.1 – Abel flash point apparatus

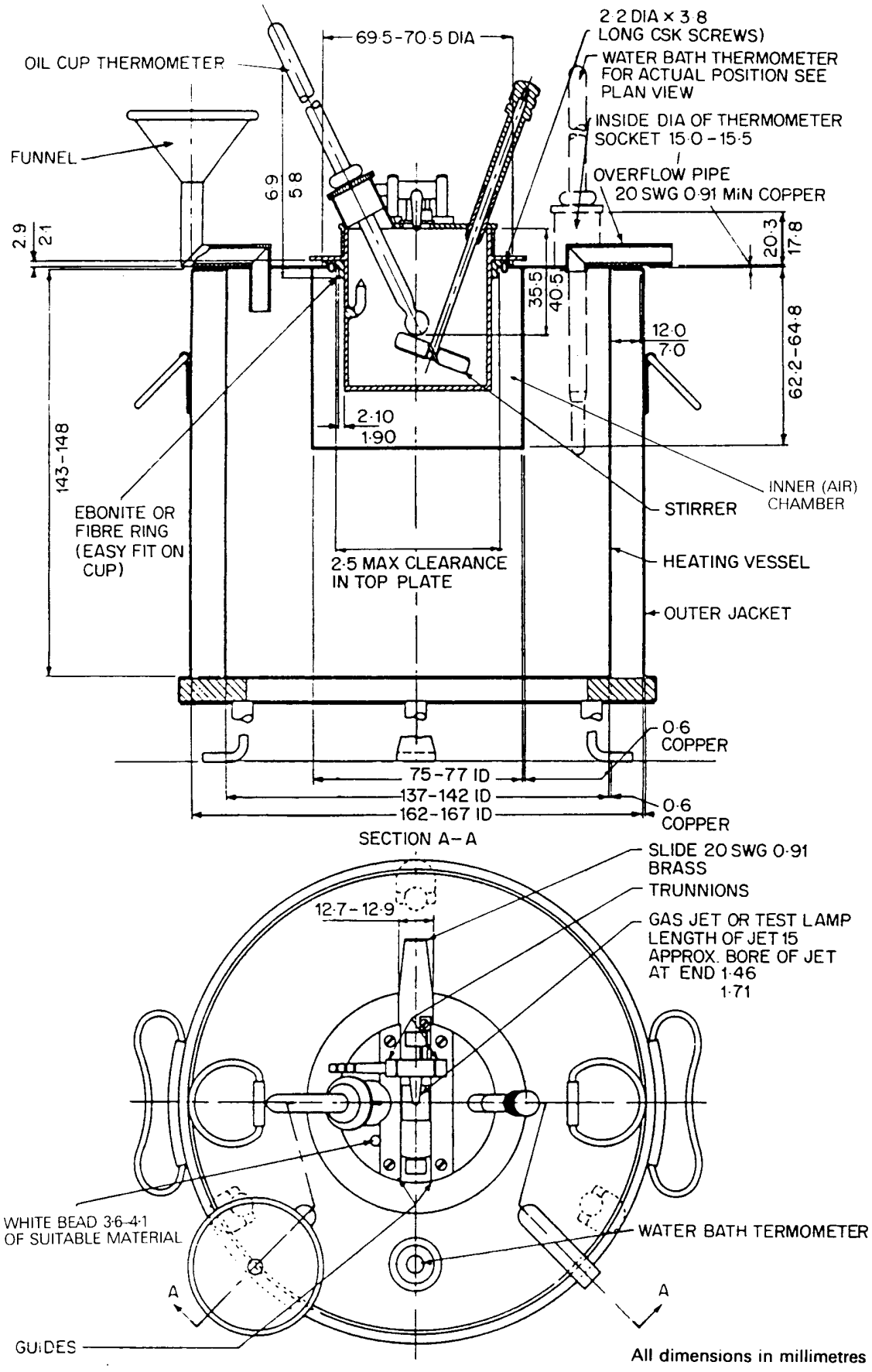


Figure A.2 – Abel flash point apparatus

A split socket, similar to that on the cover of the oil cup, but set vertically, shall allow a thermometer to be inserted into the water-space. A funnel and overflow pipe shall also be connected with the water space through the top plate and two loop handles provided thereon.

The heating vessel shall rest upon a cast-iron tripod stand, attached to the ring of which is a cylindrical copper jacket not less than 0,56 mm in thickness flanged inwards at the top, and of such dimensions that the heating vessel, while resting firmly on the iron ring, just touches with its outward projecting flange the inward-turned flange of the jacket. Two handles shall be provided on the outer jacket.

A.5 Heating device

Use any suitable device for heating the heating vessel, such as gas flame, electric heater or spirit lamp.

Annex B (normative)

Positioning and fixing of oil cup and heating vessel thermometers into thermometer collar

B.1 The collar shall be made of brass, and shall be of the following dimensions:

a) outside diameter push fit in socket;

b) thickness of tube 0,69 mm – 0,73 mm;

c) thickness of flange 2,515 mm – 2,565 mm.

B.2 Secure the thermometer in the collar in accordance with figure B.1, by means of either:

a) a mixture of plaster-of-Paris and glycerine, or

b) an epoxy resin based commercial adhesive.

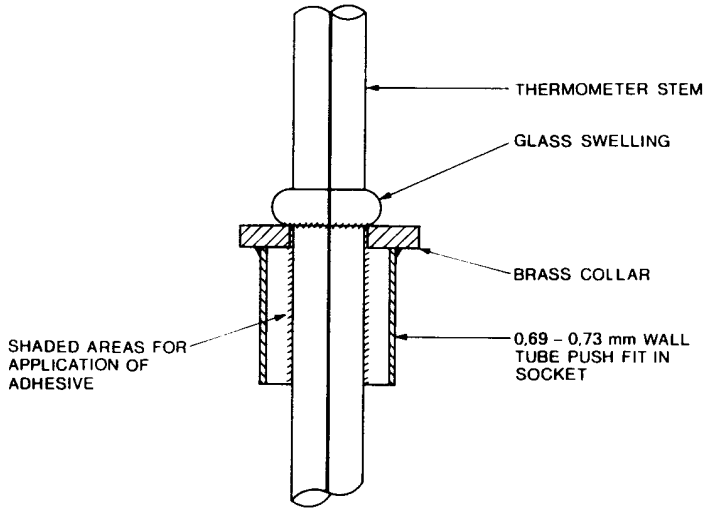


Figure B.1 – Position of thermometer stem in collar

Annex C (normative)

Thermometer specifications

C.1 Oil cup thermometer

Conforming to the specification given in table C.1.

NOTE C.1 The oil cup thermometer is illustrated in figure C.1. Thermometer IP 74C conforms to these requirements.

C.2 Heating vessel thermometer

Conforming to the specification given in table C.1.

NOTE C.2 The heating vessel thermometer is illustrated in figure C.1. Thermometer IP 75C conforms to these requirements.

C.3 Low temperature thermometer

Conforming to the specification given in table C.1.

NOTE C.3 The low temperature thermometer is illustrated in figure C.2. Thermometer IP 2C conforms to these requirements.

Table C.1 – Thermometer specifications

Thermometer	Abel oil cup wide range	Abel heating vessel wide range	Low temperature thermometer
Temperature range, °C	−35 to + 70	−30 to + 80	−80 to + 20
A-Immersion, mm	61	89	76
Scale marks:			
Subdivisions, °C	0,5	0,5	1
Long lines at each, °C	1 and 5	1 and 5	5
Numbers at each, °C	5	5	10
Max. line width, mm	0,15	0,15	0,15
Scale error, max, °C	0,5 below 0 0,2 at and above 0	0,5	1,0 above −33 2,0 below −33
Expansion chamber:			
Permit heating to, °C	Required	Required	60
B-Total length, mm	300 – 320	300 – 320	225 – 235
C-Stem OD, mm	6 – 7	6 – 7	6,0 – 8,0
D-Bulb length, mm	7,5 – 10,5	7,5 – 10,5	7 – 10
E-Bulb OD, mm	Not greater than stem	Not greater than stem	Not greater than stem
Scale location:			
Bottom of bulb to line at, °C	−35	−30	−70
F-Distance, mm	70 – 80	100 – 110	100 – 120
G-Length of scale range, mm	195 min	164 min	70 – 100
I-Swelling diameter, mm	9,5 – 10,5	9,5 – 10,5	—
J-Swelling depth, mm	3 – 5	3 – 5	—
K-Distance from base of swelling to bottom of bulb, mm	59,5 – 62,5	86,5 - 91,5	

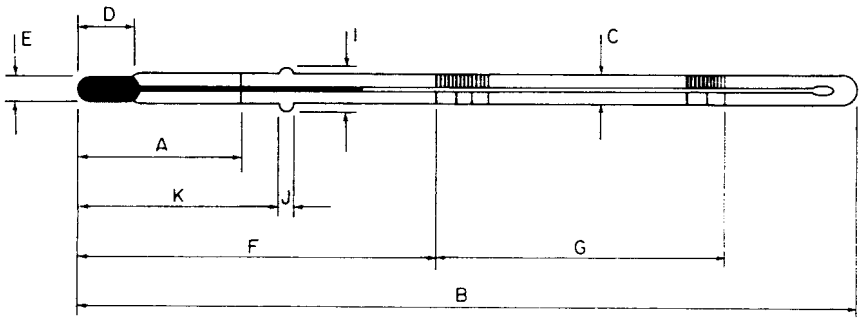


Figure C.1 – Oil cup and heating vessel thermometers

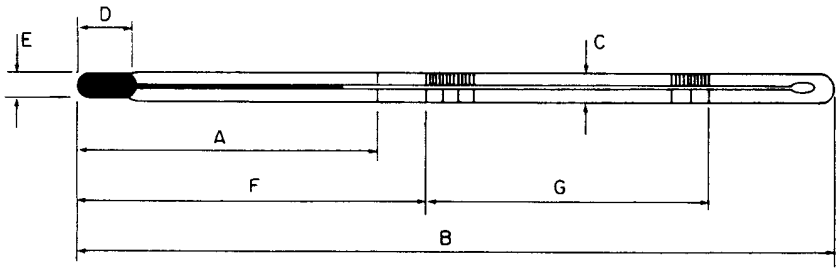


Figure C.2 – Low temperature thermometer

Annex D (normative)

Barometer corrections

NOTE D.1 The preferred unit of barometric pressure, agreed at the eighth Congress of the World Meterological Organisation, is the hectopascal (hPa). Barometers of the Fortin type are also usually calibrated in either these units or millibars (mbar). For these reasons the table of corrections, D.1, is given in these units.

NOTE D.2 Table D.2 is also given for correcting observed barometric pressure for barometers calibrated in millimetres of mercury (mmHg).

NOTE D.3 It is important to note that the equation for correcting temperature readings for barometric pressure in 10.2 is entered in kilopascals.

Therefore the barometric pressure in hectopascals (hPa), millibars (mbar) or millimetres of mercury (mmHg) which has been corrected to 0 °C and if necessary for vertical distance, shall either be converted to kPa before being entered in the equation or the equations given in note 13 used.

Table D.1 – Correction of barometer readings to standard temperature 0 °C

Temperature °C	Barometer reading hPa or mbar						
	940	960	980	1000	1020	1040	1060
10,0	−1,61	−1,64	−1,68	−1,71	−1,74	−1,77	−1,81
10,5	−1,69	−1,72	−1,76	−1,79	−1,83	−1,86	−1,90
11,0	−1,77	−1,81	−1,84	−1,88	−1,91	−1,95	−1,99
11,5	−1,85	−1,89	−1,93	−1,96	−2,00	−2,04	−2,08
12,0	−1,93	−1,97	−2,01	−2,05	−2,09	−2,13	−2,17
12,5	−2,01	−2,05	−2,09	−2,13	−2,18	−2,22	−2,26
13,0	−2,09	−2,13	−2,18	−2,22	−2,26	−2,30	−2,35
13,5	−2,17	−2,22	−2,25	−2,30	−2,35	−2,39	−2,44
14,0	−2,25	−2,30	−2,34	−2,39	−2,44	−2,48	−2,53
14,5	−2,33	−2,38	−2,43	−2,47	−2,52	−2,57	−2,62
15,0	−2,41	−2,46	−2,51	−2,56	−2,61	−2,66	−2,71
15,5	−2,49	−2,54	−2,59	−2,65	−2,70	−2,75	−2,80
16,0	−2,57	−2,63	−2,68	−2,73	−2,78	−2,83	−2,89
16,5	−2,65	−2,71	−2,76	−2,82	−2,87	−2,92	−2,98
17,0	−2,73	−2,79	−2,84	−2,90	−2,96	−3,01	−3,07
17,5	−2,81	−2,87	−2,93	−2,99	−3,04	−3,10	−3,16
18,0	−2,89	−2,95	−3,01	−3,07	−3,13	−3,19	−3,25
18,5	−2,97	−3,03	−3,10	−3,16	−3,22	−3,28	−3,34
19,0	−3,05	−3,12	−3,18	−3,24	−3,30	−3,36	−3,43
19,5	−3,13	−3,20	−3,26	−3,33	−3,39	−3,45	−3,52
20,0	−3,21	−3,28	−3,35	−3,41	−3,48	−3,54	−3,61
20,5	−3,30	−3,36	−3,43	−3,50	−3,56	−3,63	−3,70
21,0	−3,38	−3,44	−3,51	−3,58	−3,65	−3,72	−3,79
21,5	−3,46	−3,53	−3,60	−3,67	−3,74	−3,81	−3,88
22,0	−3,54	−3,61	−3,68	−3,75	−3,82	−3,89	−3,96
22,5	−3,62	−3,69	−3,76	−3,83	−3,91	−3,98	−4,05
23,0	−3,70	−3,77	−3,85	−3,92	−3,99	−4,07	−4,14
23,5	−3,78	−3,85	−3,93	−4,00	−4,08	−4,16	−4,23
24,0	−3,86	−3,93	−4,01	−4,09	−4,17	−4,25	−4,32
24,5	−3,94	−4,02	−4,09	−4,17	−4,25	−4,33	−4,41
25,0	−4,01	−4,10	−4,18	−4,26	−4,34	−4,42	−4,50
25,5	−4,10	−4,18	−4,26	−4,34	−4,43	−4,51	−4,59
26,0	−4,18	−4,26	−4,34	−4,43	−4,51	−4,60	−4,68
26,5	−4,26	−4,34	−4,43	−4,51	−4,60	−4,69	−4,77
27,0	−4,34	−4,42	−4,51	−4,60	−4,69	−4,77	−4,86
27,5	−4,41	−4,50	−4,59	−4,68	−4,77	−4,86	−4,95
28,0	−4,49	−4,59	−4,68	−4,77	−4,86	−4,95	−5,04
28,5	−4,57	−4,67	−4,76	−4,85	−4,95	−5,04	−5,13
29,0	−4,65	−4,75	−4,84	−4,94	−5,03	−5,13	−5,22
29,5	−4,73	−4,83	−4,93	−5,02	−5,12	−5,21	−5,31
30,0	−4,81	−4,91	−5,01	−5,11	−5,20	−5,30	−5,40

Table D.2 – Correction of barometer readings to standard temperature 0 °C

Temperature °C	Barometer reading mmHg									
	700	720	740	760	780	800	820	840	860	880
10,0	−1,14	−1,17	−1,21	−1,24	−1,27	−1,30	−1,34	−1,37	−1,40	−1,44
10,5	−1,20	−1,23	−1,27	−1,30	−1,34	−1,37	−1,40	−1,44	−1,47	−1,51
11,0	−1,26	−1,29	−1,33	−1,36	−1,40	−1,44	−1,47	−1,51	−1,54	−1,58
11,5	−1,31	−1,35	−1,39	−1,43	−1,46	−1,50	−1,54	−1,58	−1,61	−1,65
12,0	−1,37	−1,41	−1,45	−1,49	−1,53	−1,57	−1,60	−1,64	−1,68	−1,72
12,5	−1,43	−1,47	−1,51	−1,55	−1,59	−1,63	−1,67	−1,71	−1,75	−1,79
13,0	−1,48	−1,53	−1,57	−1,61	−1,65	−1,70	−1,74	−1,78	−1,82	−1,86
13,5	−1,54	−1,58	−1,63	−1,67	−1,72	−1,76	−1,80	−1,85	−1,89	−1,94
14,0	−1,60	−1,64	−1,69	−1,73	−1,78	−1,83	−1,87	−1,92	−1,96	−2,01
14,5	−1,65	−1,70	−1,75	−1,80	−1,84	−1,89	−1,94	−1,98	−2,03	−2,08
15,0	−1,71	−1,76	−1,81	−1,86	−1,91	−1,96	−2,00	−2,05	−2,10	−2,15
15,5	−1,77	−1,82	−1,87	−1,92	−1,97	−2,02	−2,07	−2,12	−2,17	−2,22
16,0	−1,82	−1,88	−1,93	−1,98	−2,03	−2,09	−2,14	−2,19	−2,24	−2,29
16,5	−1,88	−1,94	−1,99	−2,04	−2,10	−2,15	−2,20	−2,26	−2,31	−2,37
17,0	−1,94	−1,99	−2,05	−2,10	−2,16	−2,22	−2,27	−2,33	−2,38	−2,44
17,5	−2,00	−2,05	−2,11	−2,17	−2,22	−2,28	−2,34	−2,39	−2,45	−2,51
18,0	−2,05	−2,11	−2,17	−2,23	−2,29	−2,35	−2,40	−2,46	−2,52	−2,58
18,5	−2,11	−2,17	−2,23	−2,29	−2,35	−2,41	−2,47	−2,53	−2,59	−2,65
19,0	−2,17	−2,23	−2,29	−2,35	−2,41	−2,48	−2,54	−2,60	−2,66	−2,72
19,5	−2,22	−2,29	−2,35	−2,41	−2,48	−2,54	−2,60	−2,67	−2,73	−2,79
20,0	−2,28	−2,34	−2,41	−2,47	−2,54	−2,60	−2,67	−2,74	−2,80	−2,87
20,5	−2,34	−2,40	−2,47	−2,54	−2,60	−2,67	−2,74	−2,80	−2,87	−2,94
21,0	−2,39	−2,46	−2,53	−2,60	−2,67	−2,73	−2,80	−2,87	−2,94	−3,01
21,5	−2,45	−2,52	−2,59	−2,66	−2,73	−2,80	−2,87	−2,94	−3,01	−3,08
22,0	−2,51	−2,58	−2,65	−2,72	−2,79	−2,86	−2,94	−3,01	−3,08	−3,15
22,5	−2,56	−2,64	−2,71	−2,78	−2,86	−2,93	−3,00	−3,08	−3,15	−3,22
23,0	−2,62	−2,69	−2,77	−2,84	−2,92	−2,99	−3,07	−3,14	−3,22	−3,29
23,5	−2,68	−2,75	−2,83	−2,91	−2,98	−3,06	−3,14	−3,21	−3,29	−3,36
24,0	−2,73	−2,81	−2,89	−2,97	−3,05	−3,12	−3,20	−3,28	−3,36	−3,44
24,5	−2,79	−2,87	−2,95	−3,03	−3,11	−3,19	−3,27	−3,35	−3,43	−3,51
25,0	−2,85	−2,93	−3,01	−3,09	−3,17	−3,25	−3,33	−3,42	−3,50	−3,58
25,5	−2,90	−2,99	−3,07	−3,15	−3,24	−3,32	−3,40	−3,48	−3,57	−3,65
26,0	−2,96	−3,04	−3,13	−3,21	−3,30	−3,38	−3,47	−3,55	−3,64	−3,72
26,5	−3,02	−3,10	−3,19	−3,28	−3,36	−3,45	−3,53	−3,62	−3,71	−3,79
27,0	−3,07	−3,16	−3,25	−3,34	−3,42	−3,51	−3,60	−3,69	−3,78	−3,86
27,5	−3,13	−3,22	−3,31	−3,40	−3,49	−3,58	−3,67	−3,76	−3,85	−3,93
28,0	−3,19	−3,28	−3,37	−3,46	−3,55	−3,64	−3,73	−3,82	−3,91	−4,01
28,5	−3,24	−3,34	−3,43	−3,52	−3,61	−3,71	−3,80	−3,89	−3,98	−4,08
29,0	−3,30	−3,39	−3,49	−3,58	−3,68	−3,77	−3,87	−3,96	−4,05	−4,15
29,5	−3,36	−3,45	−3,55	−3,64	−3,74	−3,84	−3,93	−4,03	−4,12	−4,22
30,0	−3,41	−3,51	−3,61	−3,71	−3,80	−3,90	−4,00	−4,10	−4,19	−4,29

Correction of observed barometric pressure

D.1 Correction to 0 °C

Read the temperature of the barometer or its immediate area. Enter the temperature into table D.1 or D.2, read off the correction and apply it to the observed barometric pressure.

D.2 Conversions to kilopascals

Where necessary convert the corrected barometric pressure to kilopascals, kPa, using the conversion factors given below.

$$kPa = hPa/mbar \times 10^{-1}$$

$$kPa = mmHg \times 0{,}133\ 322$$

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