

British Standard Methods of test for

Petroleum and its products

Part 123. Distillation of petroleum products

(identical with IP 123/84)

Méthodes d'essai du pétrole et des produits pétroliers

Partie 123. Distillation des produits pétroliers

Verfahren zur Prüfung von Erdöl und Erdölprodukten

Teil 123. Destillation von Erdölprodukten

Foreword

BS 2000 comprises a series of test methods for petroleum and its products that have been published previously by the Institute of Petroleum (IP) and have been accorded the status of British Standards. Each method should be read in conjunction with BS 2000 : Part 0 'General introduction', which gives details of the BSI/IP agreement for publication of the series, lists more than 60 methods published in this way in 1982 and 1983, and provides general information on safety precautions, sampling and other matters. It is envisaged that Part 0 will be revised from time to time to take account of the publication of additional methods.

The numbering of the other Parts follows that of the corresponding methods published in 'IP Standards for petroleum and its products, Part 1 Methods for analysis and testing'. BS 2000 : Part 123 is thus identical with IP 123/84.

The previous edition of this Part* was identical with IP 123/82 and previously this IP method was published in A5 format as BS 4349, which was withdrawn in 1983. In the present revision the significant changes include the following.

- (a) The addition of a new clause setting out the significance of the method.
- (b) The reduction of the hole diameter in the flask support board for groups 1 and 2 from 50 mm to 37.5 mm.
- (c) The addition of a figure to show the position of the thermometer in the distillation flask.
- (d) The introduction of new precision data for gasoline and oxygenated gasoline tested by both the manual and automatic distillation methods.
- (e) The addition of statements to show which appendices and annexes are 'mandatory information' and which are 'non-mandatory information'.

It is intended to issue further revisions when necessary in line with any changes that may be made in subsequent editions of this IP method.

Correspondence with international standards. This British Standard is related to ISO 3405-1975, but is not equivalent in technical content. The main differences are the following.

- (a) *Terminology.* In ISO 3405 the terms 'volume recovered', 'percentage recovered' and 'total percentage recovered' are used whereas in this Part of BS 2000 the terms used for the same definitions are 'per cent recovered', 'per cent recovery' and 'per cent total recovery' respectively.
- (b) *Automatic distillation.* This Part of BS 2000 includes in appendices a procedure for the use of automatic apparatus for distillation and tables of comparative manual and automatic distillation results. ISO 3405 does not include these appendices.
- (c) The new precision data for gasoline and oxygenated gasoline.

The automatic method has been proposed for inclusion in ISO 3405 as part of a revision in course of preparation.

Caution. Attention is drawn to the safety precautions mentioned in Part 0 of this British Standard.

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

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

*Published in 1983 and now withdrawn.

Method (identical with IP 123/84^{1, 2, 3})**SCOPE**

1. This method of test covers the distillation of motor gasolines, aviation gasolines, aviation turbine fuels, special boiling point spirits, naphthas, white spirit, kerosines, gas oils, distillate fuel oils, and similar petroleum products.

NOTE 1: For the distillation of natural gasoline, see method ASTM D216-IP 191, Method of Test for Distillation of Natural Gasoline. For the distillation of volatile organic liquids or relatively pure solvents, see method ASTM D1078 or IP 195, Distillation range of volatile organic liquids.

NOTE 2: For the distillation of aviation turbine fuels and other products of such wide boiling range that the low distillation thermometer specified in Group 3 of Table 1 is inadequate, this method may be applied by substituting the high distillation thermometer, together with the other test conditions specified in Group 3 (see Section 9 (c)).

NOTE to note 1. BS 2000 : Part 191 is identical with IP 191 and BS 2000 : Part 195 is identical with IP 195.

SUMMARY OF METHOD

2. A 100 ml sample is distilled under prescribed conditions which are appropriate to its nature (Table 1). Systematic observations of thermometer readings and volumes of condensate are made, and from these data, the results of the test are calculated and reported.

TABLE 1. Test conditions

	Group 1	Group 2	Group 3	Group 4
Sample characteristics:				
Vapour pressure at 100°F, lb (bar) (ASTM D323 or IP 69, IP 171)	9.5 (0.66) or above	Below 9.5 (0.66)	Below 9.5 (0.66)	Below 9.5 (0.66)
Distillation { Initial boiling point†	—	—	212°F (100°C) or below	Above 212°F (100°C)
End (final boiling) point†	482°F (250°C) or below	482°F (250°C) or below	Above 482°F (250°C)	Above 482°F (250°C)
Preparation of apparatus:				
Thermometer —				
ASTM thermometer No.	Low; 7F (7C)	Low; 7F (7C)	Low; 7F (7C)	High; 8F (8C)
IP thermometer No.	5C	5C	5C	6C
Diameter of hole in flask support, inch (mm)	1.5 (37.5)	1.5 (37.5)	2.0 (50)	2.0 (50)
Temperature at start of test —				
Flask and thermometer	55–65°F (13–18°C)	55–65°F (13–18°C)	55–65°F (13–18°C)	Not above ambient
Flask support and shield	Not above ambient	Not above ambient	Not above ambient	—
Graduate and 100 ml charge	55–65°F (13–18°C) (125 ml)	55–65°F (13–18°C) (125 ml)	55–65°F (13–18°C) (125 ml)	55°F (13°C) to ambient (125 ml)
Flask (Section 4 (a))				
Conditions during test procedure:				
Temperature of condenser bath	32–34°F (0–1°C)	32–40°F (0–4°C)	32–40°F (0–4°C)	32–140°F‡ (0–60°C)
Temperature of bath around graduate	55–65°F (13–18°C)	55–65°F (13–18°C)	55–65°F (13–18°C)	Within ± 5°F (± 3°C) of temperature of distillation charge
Time from first application of heat to initial boiling point, min	5–10	5–10	5–10	5–15
Time from initial boiling point to 5% recovered, sec	60–75	60–75	—	—
Uniform average of condensation from 5% recovered to 5 ml residue in flask, ml per min	4–5	4–5	4–5	4–5
Time from 5 ml residue to end point, min	3–5	3–5	5 max	5 max

† As determined under all test conditions of the group concerned.

‡ The proper condenser bath temperature will depend upon the wax content of the sample and of its distillation fractions. The minimum temperature which permits satisfactory operation should be used. In general, a bath temperature in the 32–40°F (0–4°C) range is suitable for kerosine and products meeting the specifications for Grade No. 1 fuel oil as prescribed in the Specification for Fuel Oils (ASTM Designation: D396), and those meeting the specifications for Grade No. 1 diesel fuel oil as prescribed in the Classification of Diesel Fuel Oils (ASTM Designation D975). In some cases involving Grade No. 2 fuel oil (ASTM Specifications D396), Grade No. 2D diesel fuel oil (ASTM Classification D975), gas oils and similar distillates, it may be necessary to hold the condenser bath temperature at some point in the 100–140°F (38–60°C) range, in order to avoid the condensation of solid waxy material in the condenser tube.

1 bar = 10⁵ N/m² = 10⁵ Pascal.

¹ This method combines the former Methods B and C of IP 123/58, Method A being included in ASTM D216-IP 191.

² The former method IP 123/68 recognized the use of both manual and automatic apparatus. This method continues to do so but in addition gives the complete method solely for application to automatic apparatus (Annex XI and its Appendices B1 and B2).

³ Under the standardization procedure of ASTM, this method is under the jurisdiction of the ASTM Committee D-2 on Petroleum Products and Lubricants.

In the IP, this method is under the jurisdiction of the Standardization Committee.

SIGNIFICANCE

3. (a) Distillation (volatility) characteristics of petroleum products are indicative of performance in their intended applications. Petroleum product specifications generally include distillation limits to ensure products of suitable volatility performance.

3. (b) The empirical results obtained by use of this distillation method have been found to correlate with automotive equipment performance factors and with other characteristics of petroleum products related to volatility.

DEFINITIONS

4. (a) *Initial Boiling Point* – The thermometer reading which is observed at the instant that the first drop of condensate falls from the lower end of the condenser tube.

(b) *End Point* or *Final Boiling Point* – The maximum thermometer reading obtained during the test. This usually occurs after the evaporation of all liquid from the bottom of the flask. The term ‘maximum temperature’ is a frequently used synonym. ⁴

(c) *Dry Point* – The thermometer reading which is observed at the instant the last drop of liquid evaporates from the lowest point in the flask. Any drops or film of liquid on the side of the flask or on the thermometer are disregarded.

NOTE 3: The end (final boiling) point, rather than the dry point, is intended for general use. The dry point may be reported in connexion with special purpose naphthas, such as used in the paint industry. Also, it should be substituted for the end (final boiling) point whenever the sample is of such a nature that the precision of the end (final boiling) point cannot consistently meet the requirements given in Section 10.

(d) *Decomposition Point* – The thermometer reading which coincides with the first indications of thermal decomposition of the liquid in the flask.

NOTE 4: Characteristic indications of thermal decomposition are an evolution of fumes, and erratic thermometer readings which usually show a decided decrease after any attempt is made to adjust the heat.

(e) *Per Cent Recovered* – The volume in ml of condensate observed in the receiving graduate, in connexion with a simultaneous thermometer reading.

(f) *Per Cent Recovery* – The maximum per cent recovered, as observed in accordance with Section 8 (g).

(g) *Per Cent Total Recovery* – The combined per cent recovery and residue in the flask, as observed in accordance with Section 8 (h).

(h) *Per Cent Loss* – 100 minus the per cent total recovery.

(i) *Per Cent Residue* – The per cent total recovery minus the per cent recovery, or the volume of residue in millilitres if measured directly.

(j) *Per Cent Evaporated* – The sum of the per cent recovered and the per cent loss.

APPARATUS

5. All items listed in Paragraphs (a) to (g) shall conform to the Specifications for Distillation Equipment (Appendix A3), and all references are to those specifications, rather than to the text of this method.

(a) *Flask* – 125 ml, as shown in Section A3.2, Fig. A5.

(b) *Condenser and Cooling Bath* – Section A3.3, Figs A3 and A4.

(c) *Shield* – Section A3.4, Figs A3 and A4.

(d) *Heater* – Section A3.5, Figs A3 and A4.

(e) *Flask Support* – Section A3.6.

(f) *Graduated Cylinder* – Section A3.7; 100 ml, as shown in Fig. A6.

(g) *Thermometer* – Section A3.8, ASTM Thermometers 7F (7C) and 8F (8C) or IP Thermometer 5C or 6C.

NOTE 5: Data have been obtained which indicate that the Precision-Shell Automatic Distillation Apparatus⁴ is capable of giving test results which correspond in level and precision with those obtained by the manual procedures of this method, when the apparatus has been calibrated according to instructions supplied by the manufacturer. A condensed summary of these supporting data is given in Appendix A1.

Another automatic distillation apparatus based on the Shell design is the Gallenkamp ASDA.⁵

NOTES to 5(f). The graduated cylinder referred to is described elsewhere in the text as ‘the graduate’; the latter term is deprecated.

A cylinder complying with BS 658 is suitable.

NOTE to 5(g). The detailed specifications for IP thermometers 5C and 6C are given in BS 2000 : Part 0 : Addendum 1.

⁴ Available from Precision Scientific Co., Chicago, Ill.

⁵ Available from A. Gallenkamp & Co., Ltd, London.

SAMPLE

6. (a) In the case of any product having a Reid Vapour Pressure of 9.5 lb (655 mbar) or higher, cool the sample bottle to the temperature range indicated in Table 1 for measuring the distillation charge. Collect the sample in the previously cooled bottle, preferably by immersing the bottle in the liquid, where possible, and discarding the first sample. Where immersion is not possible, the sample shall be drawn off into the previously cooled bottle in such a manner that agitation is kept at a minimum. Close the bottle immediately with a tight-fitting stopper, and place it in an ice bath or refrigerator capable of maintaining the sample at a temperature not to exceed 60°F (15°C).

(b) Samples of materials that visibly contain water are not suitable for testing. If the sample is not dry, and the initial boiling point is below 150°F (66°C), obtain another sample which is free from suspended water for the test. If the initial boiling point is above 150°F (66°C), shake the sample with anhydrous sodium sulphate or other suitable drying agent and separate it from the drying agent by decanting.

PREPARATION OF APPARATUS

7. (a) Refer to Table 1 and select the flask, flask support, and thermometer which are required by the sample to be tested. Bring the respective temperatures of the flask, thermometer, graduate, flask support, and shield to their required values for starting the test.

(b) Fill the condenser box to cover the condenser tube with any non-flammable coolant which is suitable for the temperature required by Table 1, such as chopped ice, water, brine, or ethylene glycol solution. If chopped ice is used, add sufficient water to cover the condenser tube. If necessary, make any suitable provision, such as circulation, stirring, or air blowing, so as to maintain the required condenser bath temperature throughout the test. Similarly, make any necessary provision so that the temperature of the bath around the graduate will remain within the limits required in Table 1.

(c) Remove any residual liquid in the condenser tube by swabbing with a piece of soft, lint-free cloth attached to a cord or copper wire.

(d) Bring the temperature of the sample within the range prescribed in Table 1. Measure 100 ml of the sample in the graduated cylinder and transfer it as completely as practicable to the distillation flask, taking care that none of the liquid flows into the vapour tube.

(e) Fit the thermometer, provided with a snug-fitting, well-rolled cork, tightly into the neck of the flask so that the bulb is centred in the neck and the lower end of the capillary is level with the highest point on the bottom of the inner wall of the vapour tube. (See Fig 1.)

(f) Place the flask containing the charge in its support; and by means of a

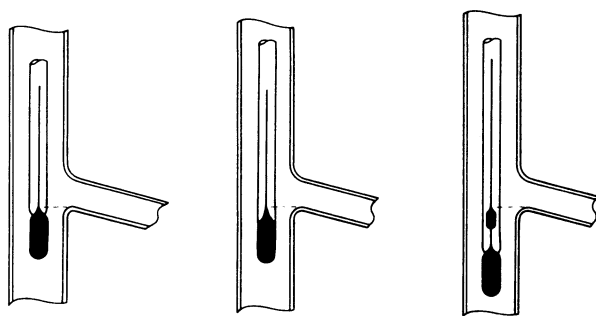


Fig. 1. Position of thermometer in distillation flask.

cork through which the vapour tube has been passed, make a tight connexion with the condenser tube. Adjust the flask so that it is in a vertical position, and so that the vapour tube extends into the condenser tube for a distance of 1 to 2 in (25 to 50 mm).

(g) Place the graduate that was used to measure the charge, without drying, into its bath under the lower end of the condenser tube so that the end of the condenser tube is centred in the graduate and extends therein for a distance of at least 1 in (25 mm), but not below the 100 ml mark. Cover the graduate closely with a piece of blotting paper, or similar material, suitably weighted, which has been cut to fit the condenser tube snugly. Maintain the level of the bath around the graduate so that it is at least as high as the 100 ml mark.

(h) Note and record the prevailing barometric pressure, and proceed at once with the distillation, as given in Section 8.

PROCEDURE

8. (a) Apply heat to the distillation flask and contents. The heating at this stage must be so regulated that the time interval between the first application of heat and the initial boiling point does not exceed the limit as prescribed in Table 1.

(b) Immediately after observing the initial boiling point, move the graduate so that the tip of the condenser touches its inner wall. Continue to regulate the heating so that the rate of condensation into the graduate shall be uniform and within the limits prescribed in Table 1. Repeat any distillation which did not meet the foregoing conditions.

(c) In the interval between the initial boiling point and the end of the distillation, observe and record whatever data are necessary for the calculation and reporting of the results of the test as prescribed in Section 9. These observed data may include thermometer readings at prescribed percentages recovered, or percentages recovered at prescribed thermometer readings, or both. Record all volumes in the graduate to the nearest 0.5 ml and all thermometer readings to the nearest 1.0°F (0.5°C).

NOTE 6: In cases in which no specific data requirements have been indicated, record the initial boiling point, the end point (final boiling point) or dry point, or both, and thermometer readings at 5% and 95% recovered and at each multiple of 10% recovered from 10 to 90, inclusive.

(d) If a decomposition point is observed, discontinue the heating and resume the procedure as directed in Paragraph (g). Otherwise, proceed as directed in Paragraph (e).

(e) When the residual liquid in the flask is approximately 5 ml, make a final adjustment of the heat, if necessary, so that the time from the 5 ml of liquid residue in the flask to the end (final boiling) point shall meet the requirements given in Table 1. If this condition is not satisfied, repeat the test, with appropriate modification of the final heat adjustment.

(f) Observe and record the end (final boiling) point or dry point, or both, as required, and discontinue the heating. At the end (final boiling) point, observe if all the liquid has evaporated from the bottom of the flask. If not, include a note of this fact in the report as prescribed in Section 9.

(g) While the condenser tube continues to drain into the graduate, observe the volume of condensate at 2 min intervals until two successive observations agree. Measure this volume accurately, and record it, to the nearest 0.5 ml, as per cent recovery. If the distillation was previously discontinued under the conditions given in Paragraph (d), deduct the per cent recovery from 100, report this difference as 'Per Cent Residue and Loss,' and omit the procedure given in Paragraphs (h) and (i).

(h) After the flask has cooled, pour its contents into the condensate in the graduate and allow to drain until no appreciable increase in the volume of liquid in the graduate is observed. Record this volume, to the nearest 0.5 ml as per cent total recovery.

NOTE 7: As an alternative procedure, drain the cooled liquid remaining in the flask into a small cylinder graduated in 0.1 ml, and observe its volume. Add this observed volume to the per cent recovery, in order to obtain per cent total recovery.

(i) Deduct the per cent total recovery from 100 to obtain the per cent loss.

CALCULATIONS AND REPORT

9. (a) For each test, calculate and report whatever data are required by the specification involved, or as customarily established for the sample under test, or in accordance with Note 6.

(b) Report all percentages to the nearest 0.5, all thermometer readings to the nearest 1.0°F (0.5°C), and the barometric pressure to the nearest mm.

(c) When ASTM thermometer 8F (8C) or IP thermometer 6C is used in testing aviation turbine fuels and similar products, pertinent thermometer readings may be obscured by the cork. To provide the desired data, a second distillation according to Group 3 of Table 1 may have been performed. In such cases, readings from ASTM thermometer 7F (7C) or IP thermometer 5C may be reported in place of the obscured ASTM thermometer 8F (8C) or IP thermometer 6C readings, and the test report shall so indicate. If, by agreement, the obscured readings are waived, the test report shall so indicate.

(d) When the report is to be based on thermometer readings corrected to 1013 mbar (760 mmHg) barometric pressure [Note 8], obtain the correction to be applied to each thermometer reading by means of the Sydney Young equation as given below, or by the use of Table 2. After applying the corrections and rounding each result to the nearest 1.0°F (0.5°C), use the corrected thermometer readings in all further calculations and reporting.

NOTE to 9(a). Test results should be reported as having been obtained in accordance with BS 2000 : Part 123.

NOTE to 9(b). Barometric pressure should be reported to the nearest 0.5 mbar.

For Celsius readings:

$$C_c = 0.00012 (760 - P) (273 + t_c)$$

or $C_c = 0.00009 (1013 - P_b) (273 + t_c)$

TABLE 2. Approximate corrected thermometer readings

Temperature range		Correction* per 13.33 mbar (10 mmHg) difference in pressure	
°C	°F	°C	°F
10–30	50–86	0.35	0.63
30–50	86–122	0.38	0.68
50–70	122–158	0.40	0.72
70–90	158–194	0.42	0.76
90–110	194–230	0.45	0.81
110–130	230–266	0.47	0.85
130–150	266–302	0.50	0.89
150–170	302–338	0.52	0.94
170–190	338–374	0.54	0.98
190–210	374–410	0.57	1.02
210–230	410–446	0.59	1.06
230–250	446–482	0.62	1.11
250–270	482–518	0.64	1.15
270–290	518–554	0.66	1.19
290–310	554–590	0.69	1.24
310–330	590–626	0.71	1.28
330–350	626–662	0.74	1.32
350–370	662–698	0.76	1.37
370–390	698–734	0.78	1.41
390–410	734–770	0.81	1.45

* To be added in case barometric pressure is below 1013 mbar (760 mm); to be subtracted in case barometric pressure is above 1013 mbar (760 mm).

For Fahrenheit readings:

$$C_f = 0.00012 (760 - P) (460 + t_f)$$

or $C_f = 0.00009 (1013 - P_b) (460 + t_f)$

where:

C_c and C_f = corrections to be added algebraically to the observed thermometer readings t_c or t_f , respectively. Convenient approximations of these corrections are given in Table 2.

P = barometric pressure, mmHg, prevailing at the time of the test.

P_b = barometric pressure, mbar, prevailing at the time of the test.

NOTE 8: Thermometer readings shall be corrected to 1013 mbar (760 mmHg) pressure except when product definitions, specifications or agreements between the buyer and the seller indicate, specifically, that such correction is not required or that correction shall be made to some other base pressure. The report shall include the observed pressure and shall state whether corrections have or have not been applied.

(e) After barometric corrections of the thermometer readings have been made, if required, the following data require no further calculation prior to reporting: initial boiling point, dry point, end (final boiling) point, decomposition point, per cent recovery, per cent total recovery, and all pairs of corresponding values involving percentages recovered and thermometer readings. Per cent loss and per cent residue are calculated in accordance with their respective definitions as set forth in Section 4 (h) and (i).

(f) It is advisable to base the report on relationships between thermometer readings and percentages evaporated in any case in which the sample is a gasoline, or any other product classed under Group 1 in Table 1, or in which the per cent loss is greater than 2.0. Otherwise, the report may be based on relationships between thermometer readings and percentages evaporated or recovered. Every report must indicate clearly which basis has been used.

(g) To report percentages evaporated at prescribed thermometer readings, add the per cent loss to each of the observed percentages recovered at the prescribed thermometer readings, and report these results as the respective percentages evaporated.

(h) To report thermometer readings at prescribed percentages evaporated, use either of the two following procedures, and indicate on the report whether the graphical procedure or the arithmetical procedure has been used.

(i) *Graphical Procedure* – Using graph paper with uniform subdivisions, plot each thermometer reading (corrected for barometric pressure, if required) against its corresponding per cent recovered. Plot the initial boiling point at 0% recovered. Draw a smooth curve connecting the points. For each prescribed per cent evaporated, deduct the distillation loss, in order to obtain the corresponding

per cent recovered, and take from the graph the thermometer reading which this per cent recovered indicates [Note 9]. Values obtained by graphical interpolation procedures are affected by the care with which the plot is made.

(ii) *Arithmetical Procedure* – Deduct the distillation loss from each prescribed percentage evaporated in order to obtain the corresponding percentage recovered. Calculate each required thermometer reading as follows:

$$T = T_L + \frac{(T_H - T_L)(R - R_L)}{(R_H - R_L)}$$

where:

- T = thermometer reading at the prescribed per cent evaporated
 R = per cent recovered corresponding to the prescribed per cent evaporated
 R_H = per cent recovered adjacent to, and higher than R , at which a thermometer reading ' T_H ' was noted, and
 R_L = per cent recovered adjacent to, and lower than R , at which a thermometer reading ' T_L ' was noted.

NOTE 9: Values obtained by the arithmetical procedure are affected by the extent to which the distillation graph is non-linear. Intervals between successive data points must, at any stage of the test, be at least as narrow as indicated in Note 6. In no case shall a calculation be made which involves extrapolation.

NOTE 10: See Appendix A2. for numerical examples illustrating the foregoing graphical and arithmetical procedures.

(i) If thermometer readings are corrected to 1013 mbar (760 mmHg) pressure, the actual loss shall be corrected to 1013 mbar (760 mmHg) pressure, according to the equation given below. The corresponding corrected per cent recovery is computed on the basis that it is greater than the actual recovery by the same amount as the corrected loss is less than the actual loss. When reporting data, state whether the corrections have or have not been applied.

Corrected loss = $AL + B$, . . . etc. . . . pressure.

TABLE 3. Values of the constants 'A' and 'B' used in obtaining corrected distillation loss

Observed barometric pressure mbar (mmHg)	A	B	Observed barometric pressure mbar (mmHg)	A	B
747	560	0.231	893	670	0.400
760	570	0.240	906	680	0.428
773	580	0.250	920	690	0.461
787	590	0.261	933	700	0.500
800	600	0.273	946	710	0.545
813	610	0.286	960	720	0.600
826	620	0.300	973	730	0.667
840	630	0.316	986	740	0.750
853	640	0.333	1000	750	0.857
866	650	0.353	1013	760	1.000
880	660	0.375			0.000

where:

- L = per cent loss as calculated from test data, and
 A and B = numerical constants, the values of which depend upon the prevailing barometric pressure. These constants are listed in Table 3, in connexion with the prevailing pressure.

PRECISION

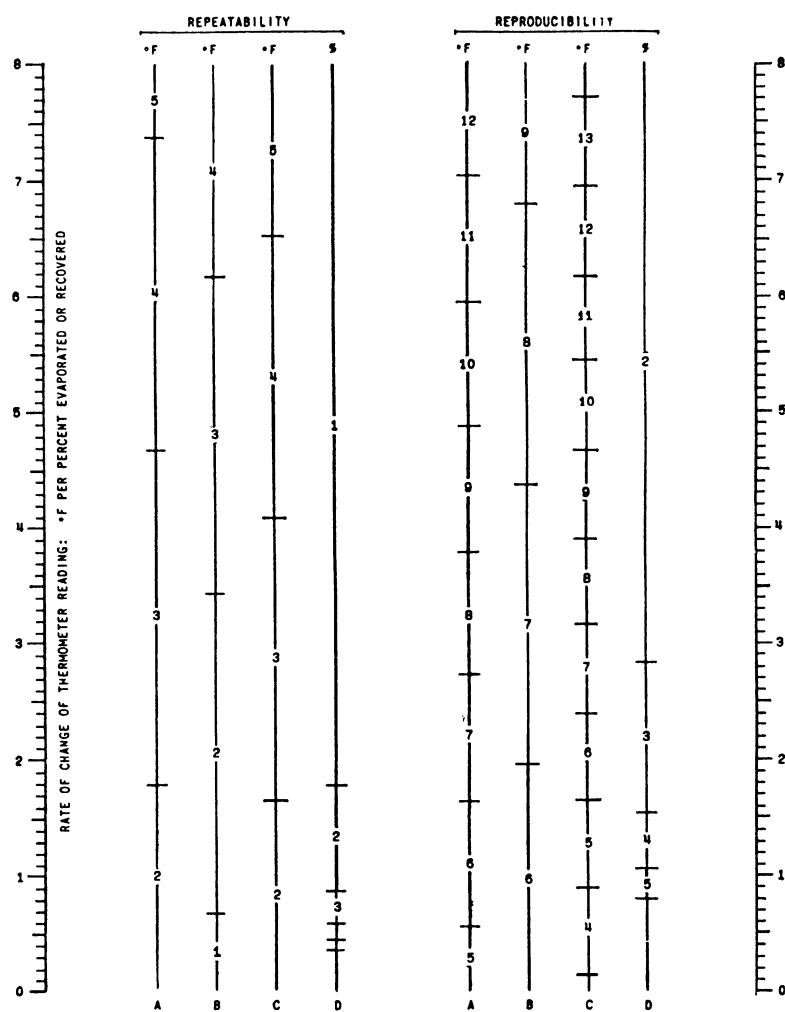
10. The following criteria should be used for judging the acceptability of results (95% confidence):

(a) Duplicate results obtained by the same operator and apparatus should not be considered suspect unless they differ by more than the repeatability which, according to Fig. 2 or 3, is appropriate to the test result obtained and to the rate of change in thermometer reading which prevailed at the stage at which the result was obtained.

(b) The results obtained by each of two laboratories should not be considered suspect unless the two results differ by more than the reproducibility which, according to Fig. 2 or 3, is appropriate to the test result obtained and to the rate of change in thermometer reading which prevailed at the stage at which the result was obtained.

(c) To facilitate the use of Fig. 2 or 3, the rate of change in thermometer reading in degrees Fahrenheit or Celsius per the percentage evaporated or recovered, at any point between the initial boiling point and the end (or final boiling) point or dry point, should be assumed to be the same as the average rate between two data points which are equidistant above and below the point in question. The span from the point in question to either of the other data points should not represent more than 10% evaporated or recovered in any case, nor more than 5% if the point in question is not included in the 10–90% range. For the initial boiling point, end (or final boiling) point, or dry point, the rate of change should be assumed to be the same as the average rate over an interval, not to exceed 5% evaporated or recovered, between the extreme point and the next data point above or below it.

(d) In Figs. 2 and 3, it will be noted that the left and right marginal scales,



- A. Initial boiling point, °F.
 B. End point or dry point, °F.
 C. Thermometer reading at prescribed per cent evaporated or recovered, °F.
 D. Per cent evaporated or recovered at prescribed thermometer reading, %.

Fig. 2. Precision of distillation method ASTM D86-IP 123 (Fahrenheit).

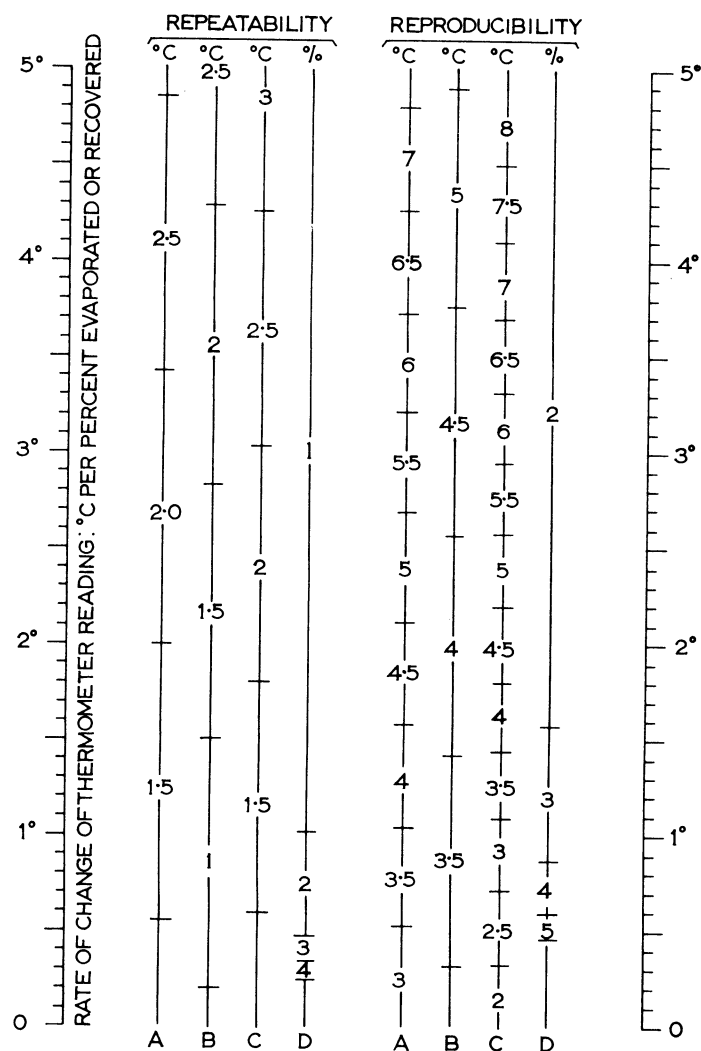


Fig. 3. Precision of distillation method ASTM D86-IP 123 (Celsius).

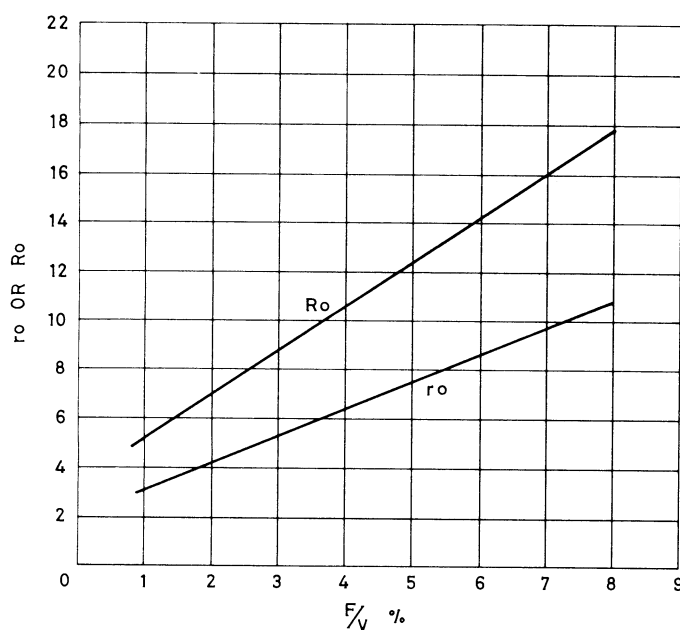


Fig. 4. Repeatability, r and Reproducibility, R . D - 86 Manual Method North American and IP Labs. For gasoline and oxygenated gasoline.

representing the rate of change in thermometer reading, are identical. This is to facilitate the establishing of a horizontal line across the chart and at the required level, which may be done in any convenient manner. Wherever this line intersects the appropriate precision scale, the zone in which such intersection falls will indicate the expected repeatability or reproducibility.