Designation: D7798 – 15

Standard Test Method for Boiling Range Distribution of Petroleum Distillates with Final Boiling Points up to 538 °C by Ultra Fast Gas Chromatography (UF GC)[1]

This standard is issued under the fixed designation D7798; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This test method covers the determination of the boiling range distribution of petroleum products and biodiesel formulations, B5, B10, and B20. It is applicable to petroleum distillates having a final boiling point not greater than 538 °C or lower at atmospheric pressure as measured by this test method. The difference between the initial boiling point and the final boiling point shall be greater than 55 °C.

1.2 The test method is not applicable for analysis of petroleum distillates containing low molecular weight components (for example naphthas, reformates, gasolines, full range crude oils). Materials containing heterogeneous mixtures (for example, alcohols, ethers, acids or esters, except biodiesels) or residue are not to be analyzed by this test method. See Test Methods D3710, D7096, D6352, or D7169.

1.3 This test method uses the principles of simulated distillation methodology. This test method uses gas chromatographic components that allow the entire analysis from sample to sample to occur in 5 min or less. In these instruments the column is heated directly at rates 10 to 15 times that of a conventional gas chromatograph and thus the analysis time is reduced from sample to sample.

1.4 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4.1 *Exception*—Appendix X1 includes temperatures in Fahrenheit for information only.

1.5 *This standard does not purport to address all of the safety concerns, if any, 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 prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D86 Test Method for Distillation of Petroleum Products at Atmospheric Pressure

D1160 Test Method for Distillation of Petroleum Products at Reduced Pressure

D2887 Test Method for Boiling Range Distribution of Petroleum Fractions by Gas Chromatography

D2892 Test Method for Distillation of Crude Petroleum (15-Theoretical Plate Column)

D3710 Test Method for Boiling Range Distribution of Gasoline and Gasoline Fractions by Gas Chromatography (Withdrawn 2014)[3]

D4626 Practice for Calculation of Gas Chromatographic Response Factors

D6300 Practice for Determination of Precision and Bias Data for Use in Test Methods for Petroleum Products and Lubricants

D6352 Test Method for Boiling Range Distribution of Petroleum Distillates in Boiling Range from 174 °C to 700 °C by Gas Chromatography

D6708 Practice for Statistical Assessment and Improvement of Expected Agreement Between Two Test Methods that Purport to Measure the Same Property of a Material

D7096 Test Method for Determination of the Boiling Range Distribution of Gasoline by Wide-Bore Capillary Gas Chromatography

D7169 Test Method for Boiling Point Distribution of Samples with Residues Such as Crude Oils and Atmospheric and Vacuum Residues by High Temperature Gas Chromatography

E355 Practice for Gas Chromatography Terms and Relationships

E594 Practice for Testing Flame Ionization Detectors Used

[1] This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.04.0H on Chromatographic Distribution Methods.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

***A Summary of Changes section appears at the end of this standard**

in Gas or Supercritical Fluid Chromatography
E1510 Practice for Installing Fused Silica Open Tubular Capillary Columns in Gas Chromatographs

3. Terminology

3.1 *Definitions:*

3.1.1 This test method makes reference to many common gas chromatographic procedures, terms, and relationships. Detailed definitions of these can be found in Practices E355, E594, and E1510.

3.1.2 *area slice, n—in gas chromatography*, the area, resulting from the integration of the chromatographic detector signal, within a specified retention time interval.

3.1.3 *corrected area slice, n—in gas chromatography*, an area slice corrected for baseline offset, by subtraction of the corresponding area slice in a previously recorded blank (non-sample) analysis.

3.1.4 *cumulative corrected area, n—in gas chromatography*, the accumulated sum of corrected area slices from the beginning of the analysis through to a given retention time, ignoring any non-sample areas (for example, solvent peak area).

3.1.5 *Final Boiling Point (FBP), n—in gas chromatography*, the temperature (corresponding to the retention time) at which a cumulative corrected area count equal to 99.5 % of the total sample area under the chromatogram is obtained.

3.1.6 *Initial Boiling Point (IBP), n—in gas chromatography*, the temperature (corresponding to the retention time) at which a cumulative corrected area count equal to 0.5 % of the total sample area under the chromatogram is obtained.

3.1.7 *slice rate, n—in gas chromatography*, the time interval used to integrate the continuous (analog) chromatographic detector response during an analysis, expressed in Hz.

3.1.7.1 *Discussion*—for example, integrations or slices per second.

3.1.8 *slice time, n—in gas chromatography*, the time duration of the slice, in seconds. The slice time is the time at the end of each contiguous area slice.

3.1.9 *total sample area, n—in gas chromatography*, the cumulative corrected area, from the initial area point to the final area point.

3.2 *Abbreviations:*

3.2.1 A common abbreviation of hydrocarbon compounds is to designate the number of carbon atoms in the compound. A prefix is used to indicate the carbon chain form, while a subscripted suffix denotes the number of carbon atoms (for example, n-C_{10} normal decane; iC_{14} = iso tetradecane).

4. Summary of Test Method

4.1 The boiling range distribution of hydrocarbon fractions obtained by physical distillation is simulated by the use of gas chromatography (GC). The GC column heating is accomplished by supplying heat to the column directly instead of an oven with a consequence that the elution time is considerably shortened. Thus, cycle times of 5 min or less (heating and cooling) is achieved. A non-polar capillary gas chromatographic column is used to separate the hydrocarbon components of the sample and cause them to elute in order of increasing boiling point.

4.2 Depending on the analyzer and column used, a sample aliquot is diluted with a viscosity reducing solvent or introduced neat into the chromatographic system. Sample vaporization is provided by separate heating of the point of injection or in conjunction with column oven heating.

4.3 The column temperature is raised at a reproducible linear rate to effect separation of the hydrocarbon components in order of increasing boiling point. The elution of sample components is quantitatively determined using a flame ionization detector. The detector signal integral is recorded as area slices for consecutive retention time intervals during the analysis.

4.4 Retention times of known normal paraffin hydrocarbons, spanning the scope of the test method (C_5 to C_{44}), are determined and correlated to their boiling point temperatures. (Refer to Table 1.) The normalized cumulative corrected sample areas for each consecutive recorded time interval are used to calculate the boiling range distribution. The boiling point temperature at each reported percent off increment is calculated from the retention time calibration.

5. Significance and Use

5.1 The boiling range distribution of petroleum distillate fractions provides an insight into the composition of feed stocks and products related to petroleum refining processes. A major advantage of the fast analysis time obtained by this test method is increasing product through put and reduced lab testing time by a minimum factor of 3. This gas chromatographic determination of boiling range may be used to replace conventional distillation methods for control of refining operations and for product specification testing with the mutual agreement of interested parties.

5.2 Boiling range distributions obtained by this test method are essentially equivalent to those obtained by true boiling point (TBP) distillation (see Test Method D2892). They are not equivalent to results from low efficiency distillations such as those obtained with Test Method D86 or D1160.

6. Apparatus

6.1 *Chromatograph*—The gas chromatographic system used shall have the following performance characteristics:

6.1.1 *Column Heating Assembly*—Capable of sustaining a programmed temperature operation from 40 °C up to 400 °C.

6.1.2 *Column Temperature Programmer*—The column should be capable of linear programmed temperature operation up to 400 °C at selectable linear rates from a minimum of 60 °C/min up to 350 °C/min. The programming rate shall be sufficiently reproducible to obtain the retention time repeatability for the mixture described in 7.6.

6.1.3 *Detector*—This test method requires a flame ionization detector (FID). The detector shall meet or exceed the following specifications as detailed in Practice E594. The

TABLE 1 Boiling Points of n-Paraffins[A,B]

Carbon Number	Boiling Point, °C	Boiling Point, °F
5	36	97
6	69	156
7	98	209
8	126	258
9	151	303
10	174	345
11	196	385
12	216	421
13	235	456
14	254	488
15	271	519
16	287	548
17	302	576
18	316	601
19	330	626
20	344	651
21	356	674
22	369	695
23	380	716
24	391	736
25	402	755
26	412	774
27	422	791
28	431	808
29	440	825
30	449	840
31	458	856
32	466	870
33	474	885
34	481	898
35	489	912
36	496	925
37	503	937
38	509	948
39	516	961
40	522	972
41	528	982
42	534	993
43	540	1004
44	545	1013

[A] API Project 44, October 31, 1972 is believed to have provided the original normal paraffin boiling point data that are listed in Table 1. However, over the years some of the data contained in both API Project 44 (Thermodynamics Research Center Hydrocarbon Project) and Test Method D2887 have changed, and they are no longer equivalent. Table 1 represents the current normal paraffin boiling point values accepted by Subcommittee D02.04 and found in all test methods under the jurisdiction of Section D02.04.0H.

[B] Test Method D2887 has traditionally used n-paraffin boiling points rounded to the nearest whole degree for calibration. The boiling points listed in Table 1 are correct to the nearest whole number in both degrees Celsius and degrees Fahrenheit. However, if a conversion is made from one unit to the other and then rounded to a whole number, the result will not agree with the table value for a few carbon numbers. For example, the boiling point of n-heptane is 98.425 °C, which is correctly rounded to 98 °C in the table. However, converting 98.425 °C gives 209.165 °F, which rounds to 209 °F, while converting 98 °C gives 208.4 °F, which rounds to 208 °F. Carbon numbers 2, 4, 7, 8, 9, 13, 14, 15, 16, 25, 27, and 32 are affected by rounding.

flame jet should have an orifice of approximately 0.018 in. or 0.45 mm or as specified by the manufacturer.

6.1.3.1 Operating Temperature approximately 380 °C to 400 °C.

6.1.3.2 Sensitivity >0.005 coulombs/ g carbon.

6.1.3.3 Minimum Detectability 1×10^{-12} g carbon per second for n-C_{13}.

6.1.3.4 Linear Range $>10^6$.

6.1.3.5 Connection of the column to the detector shall be such that no temperature below the column inlet temperature exists. Refer to E1510 for proper installation and conditioning of the capillary column.

6.1.4 *Sample Inlet System*—Any sample inlet system capable of operating continuously at a temperature equivalent to the maximum column temperature employed. Programmed temperature vaporization (PTV) and programmable cool on-column injection and split injection systems have been used successfully. Table 2 gives some examples of operating conditions of commercially available instrumentation. The inlet should be capable to continuously deliver the sample components in to the column by maintaining the temperature higher than the column temperature.

6.1.5 *Carrier Gas Flow Control*—The chromatograph shall be equipped with carrier gas pressure or flow control capable of maintaining constant carrier gas flow control through the column throughout the column temperature program cycle. The flow shall not vary by more than 1 % from the initial temperature to the end column temperature.

6.2 *Microsyringe*—Syringes of 0.1 µL to 5 µL capacity are suitable for this test method. Consult manufacturer for specific details on requirements for syringes compatible with autosampler and injection technique used.

6.2.1 Automatic syringe injection is required to achieve best precision.

6.3 *Column*—This test method is limited to the use of non-polar wall coated open tubular (WCOT) columns of high thermal stability. Fused silica, and stainless steel columns, with a 0.32 mm to 0.18 mm inside diameter have been successfully used. Cross-linked or bonded 100 % dimethyl-polysiloxane stationary phases with film thickness of 0.1 µm to 1.0 µm have been used. It is required that the choice of these two variables (column i.d. and phase thickness) allow the elution of C_5 to C_{44} during the temperature programming phase of the column. The column and conditions shall provide separation of typical petroleum hydrocarbons in order of increasing boiling point and meet the column resolution requirements of 8.2.1. The column shall provide a resolution of at least three (3) using the test method operating conditions. Table 2 gives some examples of columns used successfully.

6.4 *Data Acquisition System:*

6.4.1 *Computer*—Means shall be provided for determining the accumulated area under the chromatogram. This can be done by means of a computer based chromatography data system. The computer system shall have normal chromatographic software for measuring the retention time and areas of eluting peaks (peak detection mode). In addition, the system shall be capable of converting the continuously integrated detector signal into area slices of fixed duration (area slice mode). These contiguous area slices, collected for the entire analysis, are stored for later processing. Gas Chromatographs with analog to digital conversion of the detector signal, shall be operated within the linear range of the detector/electrometer system used. Since the chromatogram is developing in a very short time and since the peaks elute at a fast rate, it is necessary to acquire the signals at 50 Hz to 100 Hz.

TABLE 2 Examples of UFGC Operating Conditions and Column Assembly Heating Types

Parameters	Instrument A	Instrument B	Instrument C
	Resistively heated columns	Resistively heated columns	Resistively heated columns
Inlet Temperature	Programmable TPI; 100 °C to 360 °C @ 300 °C/min-1.0 min	Split: Split ratio 50:1- 150:1 350 °C	Split/Splitless 0.4 min purge delay
Auto sampler	required	required	required
Data collection	100 Hz	100 Hz	100 Hz
Column	4 m-0.25 mm-0.25 µ pdms	2 m-0.32 mm-0.20 µ pdms	5 m-0.53 mm-2.65 µ pdms
Inlet/FID Transfer Lines	360 °C	350 °C	340 °C
Flow conditions	4 mL/min	1 mL/min	9 mL/min
Make-up gas	25 mL/min		25 mL/min
Detector	Flame Ionization 400 °C	Flame Ionization 350 °C	Flame Ionization 380 °C
Column program	40 °C to 360 °C at 160 °C/min-1min	40 °C to 375 °C at 60 °C/min	40 °C (0.5 min) to 240 °C at 100 °C/min then 340 °C at 100 °C/min-0.5 min
Equilibration time	2 min	1.5 min	2 min
Sample size	0.2 µL	0.3 µL to 0.08 µL	0.2 µL
Sample dilution	2 % in CS_2	2 % in CS_2 up to neat	neat
Calibration dilution	1 % total solids in CS_2	0.1 % by weight each component in CS_2	1 % total solids in CS_2
Carrier	He	H_2	He

7. Reagents and Materials

7.1 *Carrier Gas*—Helium, or hydrogen of high purity (99.999 %) have been used as shown in Table 2. (**Warning—** Helium and Hydrogen are compressed gases under high pressure.) (**Warning—**Hydrogen is an extremely flammable gas.) Additional purification is recommended by the use of molecular sieves or other suitable agents to remove water, oxygen, and hydrocarbons. Available pressure shall be sufficient to ensure a constant carrier gas flow rate.

7.2 *Hydrogen*—Hydrogen of high purity (99.999 %) is used as fuel for the flame ionization detector (FID). (**Warning—** Hydrogen is an extremely flammable gas.)

7.3 *Air*—High purity (for example hydrocarbon free) compressed air is used as the oxidant for the flame ionization detector (FID). (**Warning—**Compressed air is a gas under high pressure and supports combustion.)

7.4 *Solvents*—Unless otherwise indicated, it is intended that all solvents conform to the specifications of the committee on Analytical Reagents of the American Chemical Society where such specifications are available.[4] Other grades may be used provided it is first ascertained that the solvent is of sufficiently high purity to permit its use without lessening the accuracy of the determination. The polar solvent used to dissolve the sample shall not interfere with any of the peaks of the sample components.

7.4.1 *Carbon Disulfide (CS_2)*—(99+ % pure) may be used as a viscosity reducing solvent and as a means of reducing mass of sample introduced onto the column to ensure linear detector response and reduced peak skewness. It is miscible with hydrocarbons and provides a relatively small response with the FID. The quality (hydrocarbon content) should be determined by this test method prior to use as a sample diluent. (**Warning—**Carbon disulfide is extremely flammable and toxic.)

7.5 *Cyclohexane (C_6H_{12})*—(99+ % pure) may be used as a viscosity reducing solvent. It is miscible with hydrocarbons; however, it has a high response to the FID. Use Cyclohexane for the retention time solvent only The quality (hydrocarbon content) should be determined by this test method prior to use as a sample diluent. (**Warning—**Cyclohexane is flammable.)

7.6 *Calibration Mixture*—A qualitative mixture of n-paraffins (nominally C_5 to C_{44}) dissolved in a suitable solvent. The concentration is adjusted for the injection technique used (for example, direct injection, PTV split etc). For direct injections approximately one part of n-paraffin mixture to one hundred parts of solvent may be satisfactory. At least one compound in the mixture shall have a boiling point lower than the initial boiling point of the sample being analyzed, as defined in the scope of this test method (1.1). Calibration mixtures containing normal paraffins with the carbon numbers 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 20, 24, 28, 32, 36, 40, and 44 have been found to provide a sufficient number of points to generate a reliable calibration curve.

7.7 *Response Linearity Mixture*—If the calibration mixture is prepared quantitatively it may be used to determine the linearity of the detector. Alternatively, response and injection discrimination over the boiling range of interest may be tested with a mixture of at least two petroleum oils which yield a baseline gap between the two to allow relative determination of concentration. The two fractions that constitute the blend should contain no aromatic components.

7.8 *Reference Material*—The Reference Gas Oil (RGO) whose values are listed in D2887 is used in this test method. Depending on the analyzer and the columns used, either a neat sample or a solution in CS_2 is used. Solutions of the RGO are made and chromatographed and it is a requirement that the reference Boiling Point values be obtained (see D2887 TableX) in order to proceed with sample analysis.

[4] *Reagent Chemicals, American Chemical Society Specifications*, American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the United States *Pharmacopeia and National Formulary*, U.S. Pharmacopeial Convention, Inc. (USPC), Rockville, MD.

8. Preparation of Apparatus

8.1 *Gas Chromatograph Setup:*

8.1.1 Place the gas chromatograph and ancillary equipment into operation in accordance with the manufacturer's instructions. Recommended operating conditions for several approaches used for ultra fast gas chromatographs are shown in Table 2.

8.1.2 When attaching the column to the detector inlet, ensure that the end of the column terminates as close as possible to the FID jet. Follow the instructions in E1510 or as specified by the manufacturer.

8.1.3 The FID should be periodically inspected and, if necessary, remove any foreign deposits formed in the detector from combustion of silicone liquid phase or other materials. Such deposits will change the response characteristics of the detector.

8.1.4 The inlet liner and initial portion of the column shall be periodically inspected and replaced if necessary to remove extraneous deposits or sample residue.

8.1.5 *Column Conditioning*—A new column will require conditioning at the upper test method operating temperature to reduce or eliminate significant liquid phase bleed, resulting in a stable chromatographic baseline. Follow the guidelines outlined in E1510 or as suggested by manufacturer. Columns may also be conditioned by repeated blank cycles until the baseline as stabilized and quality control reference samples are within specifications.

8.2 *System Performance Specification:*

8.2.1 *Column Resolution*—The column resolution, influenced by both the column physical parameters and operating conditions, affects the overall determination of boiling range distribution. Resolution is therefore specified to maintain equivalence between different systems (laboratories) employing this test method. Resolution is determined using Eq 1 and the C_{16} and C_{18} n-paraffins from a calibration mixture analysis (see 7.6). Resolution (R) should be at least three (3) using the identical conditions employed for sample analyses. An example illustrating the use of this calculation is shown in Fig. 4.

$$R = 2(t_2 - t_1)/(1.699\,(w_2 + w_1)) \quad (1)$$

where:

R = resolution,
t_1 = time (s) for the n-C_{16} peak maximum,
t_2 = time (s) for the n-C_{18} peak maximum,
w_1 = peak width (s), at half height, of the n-C_{16} peak, and
w_2 = peak width (s), at half height, of the n-C_{18} peak.

8.2.2 *Detector Response Calibration*—This test method assumes that the FID response to petroleum hydrocarbons is proportional to the mass of individual components. This shall be verified when the system is put in service, and whenever any changes are made to the system or operational parameters. Analyze the response linearity mixture (7.7) using the identical procedure to be used for the analysis of samples (Section 9). Calculate the relative response factor for each n-paraffin (relative to n-eicosane, C_{20}) as per Practice D4626 and Eq 2:

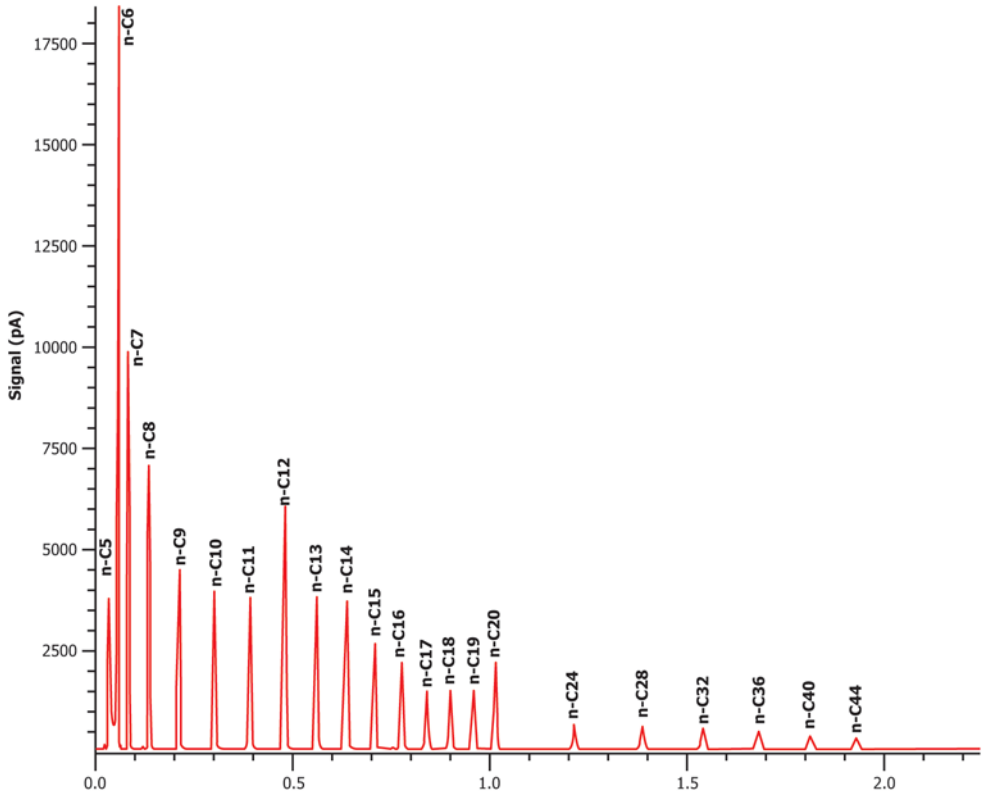

FIG. 1 Calibration Chromatogram Obtained at 200 °C/Min

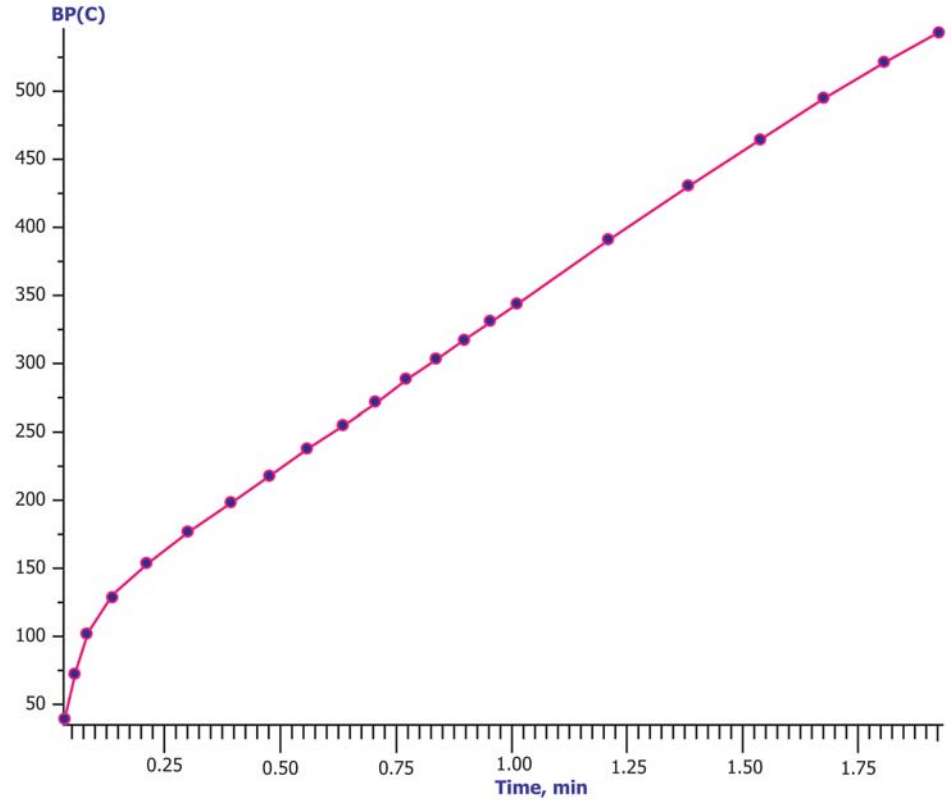

FIG. 2 Example Boiling Point Calibration Plot Obtained from an Ultra Fast Gas Chromatogram

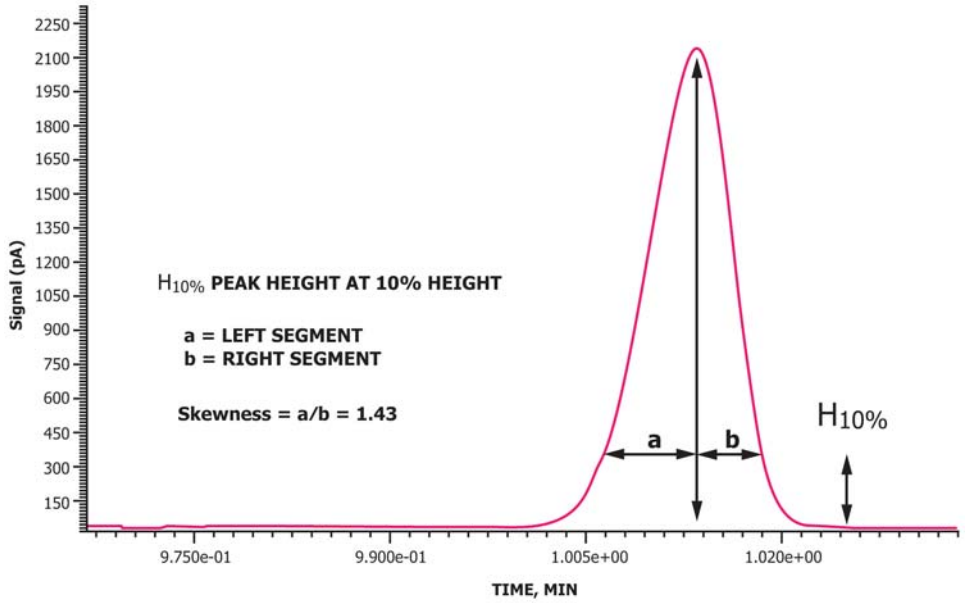

FIG. 3 Designation of Parameters for Calculation of Peak Skewness Obtained from an Ultra Fast Chromatogram

$$F_n = (M_n / A_n) / (M_{20} / A_{20}) \quad (2)$$

where:

F_n = relative response factor,
M_n = mass of the n-paraffin in the mixture,
A_n = peak area of the n-paraffin in the mixture,
M_{20} = mass of the n-eicosane in the mixture, and
A_{20} = peak area of the n-eicosane in the mixture.

The relative response factor (F_n) of each n-paraffin shall not deviate from unity by more than ±5 %.

8.2.3 *Column Temperature*—The column temperature program profile is selected such that at least the C_5 peak can be differentiated from the solvent and that the maximum boiling point (545 °C) n-paraffin (C_{44}) is eluted from the column before end of the run time. The actual program rate used will

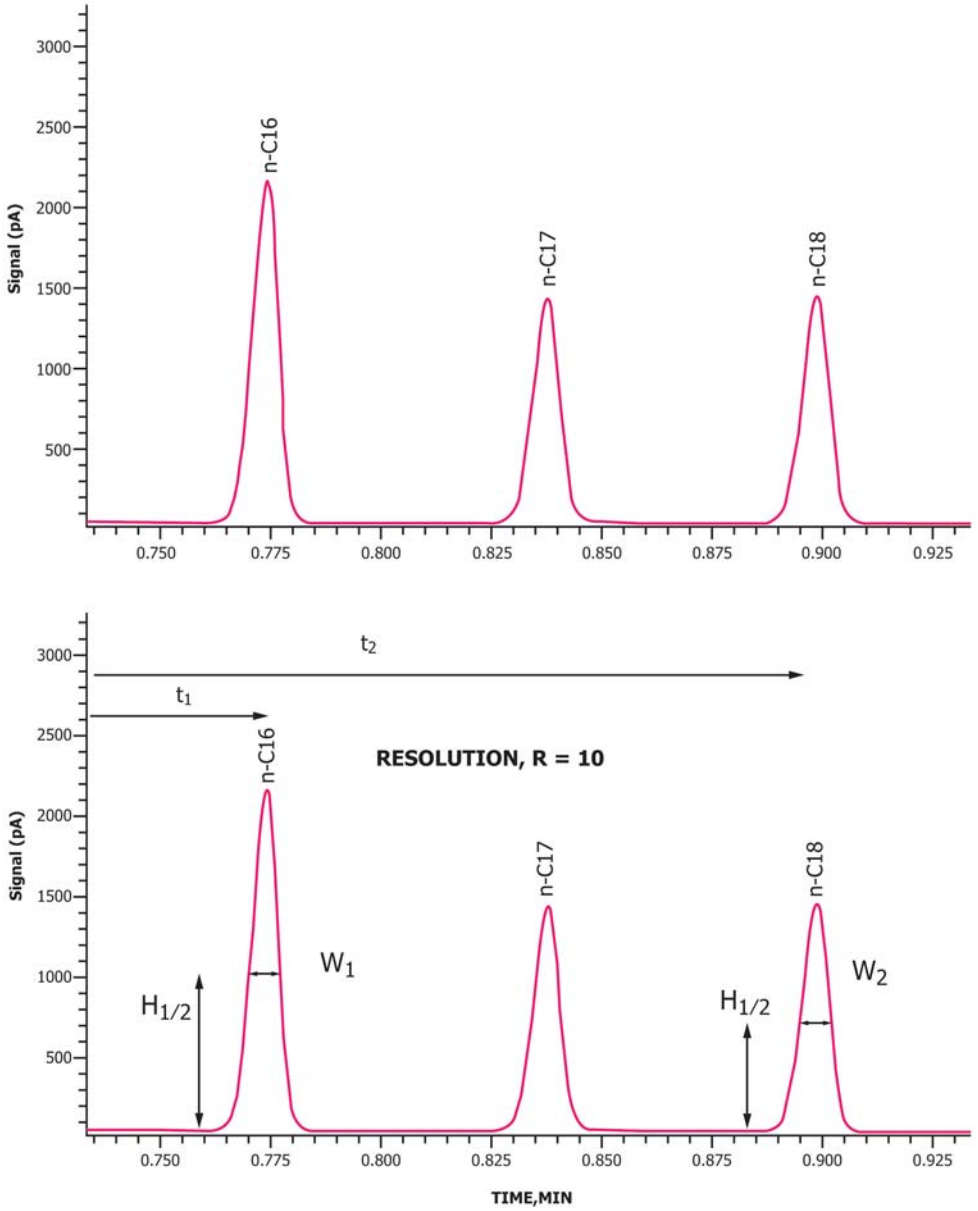

FIG. 4 Example for the Resolution Calculation for an Ultra Fast GC Calibration

be influenced by other operating variables such as column dimensions, liquid phase film thickness, carrier gas and flow rate, and sample size.

8.2.4 *Column Elution Characteristics*—The column liquid phase is the non-polar phase 100 % dimethyl-polysiloxane.

9. Procedure

9.1 *Analysis Sequence Protocol*—Define and use a predetermined schedule of analysis events designed to achieve maximum reproducibility for these determinations. The schedule will include cooling the column oven and injector to the initial starting temperature, equilibration time, sample injection and system start, analysis, and final temperature hold time.

9.1.1 After chromatographic conditions have been set to meet performance requirements, program the column temperature upward to the maximum temperature to be used and hold that temperature for the selected time. Following the analysis sequence protocol, cool the column to the initial starting temperature.

9.1.2 During the cool down and equilibration time, ready the computer system. If a retention time calibration is being performed, use the peak detection mode. For samples and base line compensation (with or without solvent injection), use the area slice mode operation. The recommended slice rate for this test method is 100.0 Hz. See Annex A1 for selection of the acquisition rate.

9.1.3 At the exact time set by the schedule, inject either the calibration mixture, solvent, or sample into the chromatograph; or make no injection (baseline blank). At the time of injection, start the chromatograph time cycle and the integrator/computer data acquisition. Follow the analysis protocol for all subsequent repetitive analyses or calibrations.

9.2 *Baseline Blank*—Perform a blank analysis (baseline blank) at least once per day. The blank analysis may be without injection or by injection of an equivalent solvent volume as used with sample injections, depending upon the subsequent data handling capabilities for baseline/solvent compensation. The blank analysis is typically performed prior to sample analyses, but may be useful if determined between samples or at the end of a sample sequence to provide additional data regarding instrument operation or residual sample carry over from previous sample analyses.

NOTE 1—If automatic baseline correction is provided by the gas chromatograph, further correction of area slices may not be required. However, if an electronic offset is added to the signal after baseline compensation, additional area slice correction may be required in the form of offset subtraction. Consult the specific instrumentation instructions to determine if an offset is applied to the signal. If the algorithm used is unclear the slice area data can be examined to determine if further correction is necessary. Determine if any offset has been added to the compensated signal by examining the corrected area slices of those time slices which precede the elution of any chromatographic unretained substance. If these corrected area slices (representing the true baseline) deviate from zero, subtract the average of these corrected area slices from each corrected area slice in the analysis. It is recommended that the blank or solvent injection be made in the slice mode so as to offset slice by slice for sample and blank.

9.3 *Retention Time vs. Boiling Point Calibration*—A retention time vs. boiling point calibration should be performed weekly, whenever maintenance is performed on the GC or as dictated by the GC performance. Inject an appropriate aliquot (0.2 µL to 1.0 µL) of the calibration mixture (7.6) into the chromatograph, using the analysis sequence protocol. Obtain a normal (peak detection) data record in order to determine the peak retention times and the peak areas for each component. Collect a time slice area record if a boiling range distribution report is desired. Fig. 2 illustrates a graphical plot of a calibration analysis.

9.3.1 Inspect the chromatogram of the calibration mixture for evidence of skewed (non-Gaussian shaped) peaks. Skewness is often an indication of overloading the sample capacity of the column, which will result in displacement of the peak apex relative to non-overloaded peaks. Distortion in retention time measurement and hence errors in boiling point temperature calibration will be likely if column overloading occurs. The column liquid phase loading has a direct bearing on acceptable sample size. Reanalyze the calibration mixture using a smaller sample size or a more dilute solution to avoid peak distortion. Peak tailing will cause skewness values of less than one. Examine any possible instrument sites where tailing may occur. Typical retention time chromatogram is shown in Fig. 1.

9.3.1.1 *Skewness Calculation*—Calculate the ratio a/b on all peaks in the calibration mixture as indicated by the designations in Fig. 3. The first segment, a is the width in seconds of the portion of the peak eluting prior to the time of the peak apex and measured at 10 % of peak height, and the segment b, is the width in seconds of the portion of the peak eluting after the time of the peak apex at 10 % of peak height. Fig. 3 shows for C_{20} the example calculation. Insure that the skewness of all the calibration peaks are within 0.8 to 1.8.

9.3.2 Prepare a calibration table based upon the results of the analysis of the calibration mixture by recording the time of each peak maximum and the boiling point temperature in degrees Celsius (or Fahrenheit) for every component in the mixture. The n-paraffin boiling point temperatures (atmospheric equivalent temperatures) are listed in Table 1. An example of a typical calibration graph, showing retention times vs. boiling points for each n-paraffin, is found in Fig. 2. Calibration report is shown in Table 3.

9.4 *Sample Preparation*—Sample aliquots are introduced into the gas chromatograph as solutions in a suitable solvent (for example carbon disulfide) or neat depending on the columns and GC being used.

9.4.1 Dilute the sample to approximately 2 mass percent with the solvent or as appropriate to ensure that the column is not overloaded. Table 2 gives some examples of dilutions and operating conditions used.

9.4.2 Ensure that the injection size chosen does not exceed the linear range of the detector. The typical sample size ranges from 0.2 µL to 2.0 µL of the diluted sample. The maximum sample signal amplitude should not exceed the maximum calibration signal amplitude or the maximum signal of the consensus quality control reference material. A sample chromatogram of the Reference Gas Oil is found in Fig. 5 and Fig. 6. Typical values for this reference material and the comparison with the accepted values is shown in Table 4.

9.4.3 The Reference Gas Oil No. 1 sample is used to verify both the chromatographic and calculation processes involved in this test method. Perform an analysis of the gas oil following the analysis sequence protocol. Collect the area slice data and provide a boiling point distribution report as described in Section 11.

9.4.4 The results of this reference analysis shall agree with the values given in Table 4 within the range specified. If it does not meet the criteria in Table 4, check that all hardware is

TABLE 3 Example Calibration Report Obtained from Chromatogram in Fig. 1

Component	Retention Time, min	Boiling Point, °C	Skewness
n-C5	0.029	36.1	0.18
n-C6	0.054	68.9	1.08
n-C7	0.08	98.4	1.27
n-C8	0.132	126.1	1.38
n-C9	0.209	151.1	1.43
n-C10	0.298	174.1	1.46
n-C11	0.389	196.1	1.18
n-C12	0.478	216.3	1.31
n-C13	0.558	235.4	1.25
n-C14	0.634	253.9	1.24
n-C15	0.706	271.1	1.15
n-C16	0.774	287.2	1.39
n-C17	0.838	302.2	1.24
n-C18	0.899	316.1	1.26
n-C19	0.957	330	1.26
n-C20	1.013	343.9	1.41
n-C24	1.211	391.1	1.14
n-C28	1.385	431.1	1.13
n-C32	1.541	466.1	1.14
n-C36	1.682	496.1	1.14
n-C40	1.812	522.2	1
n-C44	1.929	545	1.05

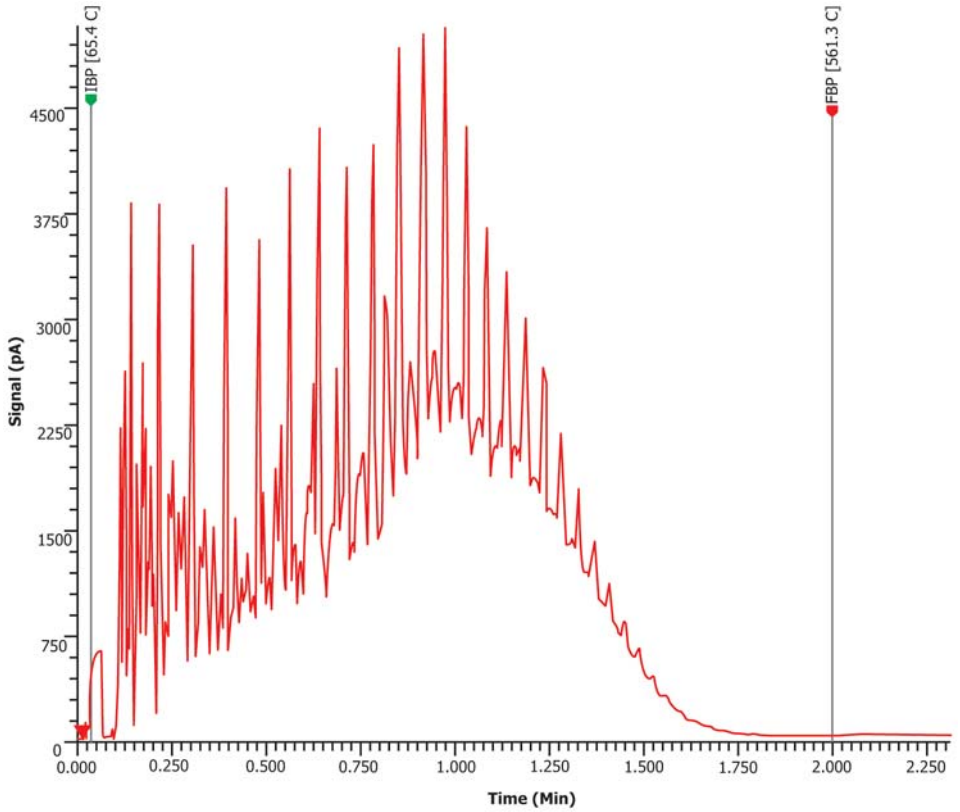

FIG. 5 Chromatogram of the Reference Gas Oil Obtained with Ultra Fast Chromatographic Conditions (Instrument A)

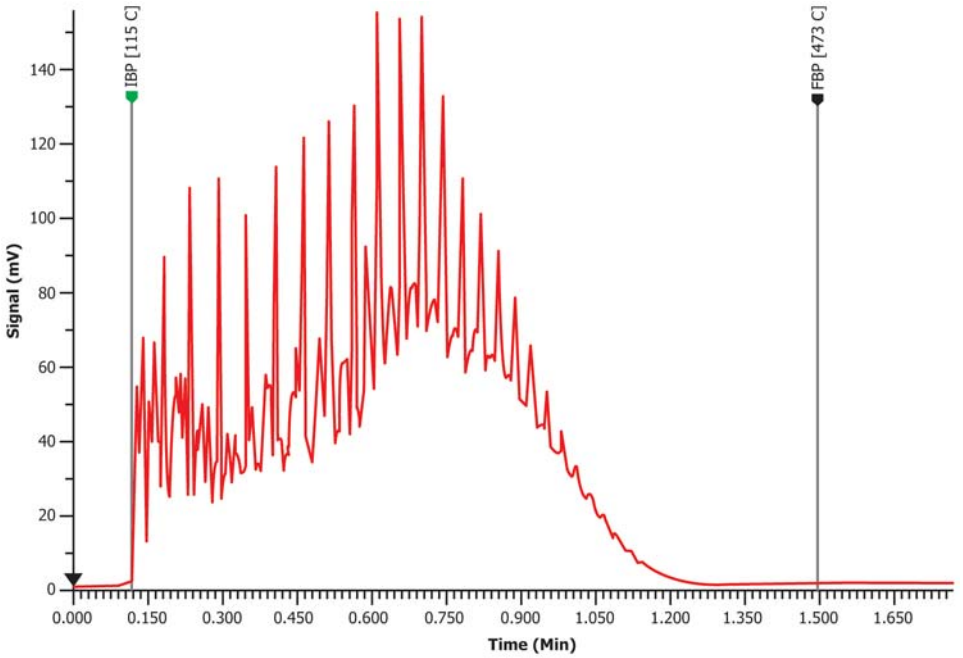

FIG. 6 Chromatogram of the Reference Gas Oil Obtained with Ultra Fast Chromatographic Conditions (Instrument B)

operating properly and all instrument settings are as recommended by the manufacturer. Rerun the retention boiling point calibration as described in 9.3.

9.4.5 Perform this reference gas oil confirmation test at least once per day or as often as required to establish confidence in consistent compliance with 9.4.4. A secondary standard may

TABLE 4 Reference Gas Oil Values and Comparison with Accepted Values Obtained from Fig. 5

% Off	BP(°C)	QC(°C)	(–)	Limit
IBP	118.4	115.6	2.8	7.6
5	152.3	151.1	1.1	3.8
10	176.8	175.6	1.2	4.1
15	202	200.6	1.4	4.5
20	225.2	223.9	1.3	4.8
25	244.3			
30	260.6	259.4	1.1	4.7
35	275.9			
40	290.4	288.9	1.5	4.3
45	304.1			
50	313.8	310.2	1.6	4.3
55	322.9			
60	333.8	331.7	2.1	4.3
65	344.7	342.8	2	4.3
70	355.9	353.3	2.6	4.3
75	368.3	365.6	2.8	4.3
80	381.1	377.8	3.3	4.3
85	394	391.1	3	4.3
90	410.5	406.7	3.8	4.3
95	432.1	428.3	3.8	5
FBP	471.2	475.6	4.4	11.8

also be used provided the Boiling Point distribution has been obtained under the condition of 9.4.4.

9.5 *Sample Analysis*—Using the analysis sequence protocol inject a neat or diluted sample aliquot into the gas chromatograph. Collect a contiguous time slice record of the entire analysis (area slice mode).

10. Calculations

10.1 The calculations for obtaining Boiling Point Distribution are reported in the Annex. The calculations are intended for use of programmers to perform the calculations.

11. Reports

11.1 Report the temperature to the nearest 0.5 °C (1 °F) at 1 % intervals between 1 % and 99 % and at the IBP (0.5 %) and the FBP (99.5 %) and reference this test method.

11.1.1 Other report formats based upon users' needs may be employed.

NOTE 2—If a plot of the boiling point distribution curve is desired, export the boiling point distribution for a plot. Many of the simulated distillation software's provide this plot.

12. Precision and Bias

12.1 *Precision*—The following precision was determined in accordance with Practice D6300.

12.1.1 *Repeatability*—The difference between repetitive results obtained by the same operator in a given laboratory applying the same test method with the same apparatus under constant operating conditions on identical test material within short intervals of time would in the long run, in the normal and correct operation of the test method, exceed the values listed in Table 5 only in one case in 20, for property ranges listed in Table 6.

12.1.2 *Reproducibility*—The difference between two single and independent results obtained by different operators applying the same test method in different laboratories using different apparatus on identical test material would, in the long run, in the normal and correct operation of the test method, exceed the values listed in Table 5 only in one case in 20, for property ranges listed in Table 6.

12.2 *Bias*—No information can be presented on the bias of the procedure in Test Method D7798 because the properties are defined by the method.

12.3 *Between-Method Bias:*

12.3.1 *Outcome of the Application of Practice D6708:*

12.3.1.1 *For T30, T50, and T70*—No bias-correction considered in Practice D6708 can further improve the agreement between results from D7798 and D2887 Procedure A, for the materials and ranges studied (reference Table 6 and Research Report RR:D02-1806).[5]

12.3.1.2 *For IBP, T10, T90, FBP*—The degree of agreement between results from D7798 and D2887 Procedure A can be further improved by applying correction equations as listed in Table 7, for the materials and ranges studied, as shown in Table 6 and described in RR:D02-1806).

12.3.1.3 For applications where D7798 is used as an alternative to D2887 Procedure A, for properties without sample-specific biases, bias-corrected results from D7798, as per correction equations in Table 7, can be considered as practically equivalent to results from D2887 Procedure A, for sample types and property ranges studied (reference Table 6 and Research Report RR:D02-1806).

12.3.2 *Between-Method Reproducibility (R_{XY})*—Differences between bias-corrected results from D7798 per Table 7 and D2887 Procedure A, for the sample types and property ranges studied (Table 6), are expected to exceed the following Between-Methods reproducibility (R_{XY}), as defined in Practice D6708, about 5 % of the time as shown in Table 8.

[5] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1806. Contact ASTM Customer Service at service@astm.org.

TABLE 5 Repeatability and Reproducibility Limits

NOTE 1—*X* is the average of the two results in °C and *Y* is the average of the two results in °F. The degrees of freedom associated with the reproducibility estimate for IBP, T5 to T95 are less than the minimum requirement of 30 (in accordance with Practice D6300). Users are cautioned that the actual reproducibility may be significantly different than these estimates.

% Off	Repeatability (r) °C	Repeatability (r) °F	df_r	Reproducibility (R) °C	Reproducibility (R) °F	df_r
IBP	1.485	2.673	77	7.671	13.807	23
T5	0.768	1.382	78	3.976	7.156	10
T10 to T95	0.712	1.281	640	2.696	4.852	12
FBP	0.022 (X-200)	0.022 (Y-392)	71	0.037 (X-200)	0.037 (Y-392)	32

TABLE 6 Range of D7798 Sample Averages in ILS Study

% Off	°C	°F
IBP	102.83 – 328.65	185.10 – 591.57
T5	143.22 – 359.50	257.79 – 647.10
T10	160.49 – 367.79	288.89 – 662.02
T20	174.84 – 379.67	314.72 – 683.41
T30	184.98 – 389.80	332.97 – 701.65
T40	197.24 – 399.30	355.03 – 718.75
T50	209.14 – 408.64	376.46 – 735.55
T60	219.47 – 417.80	395.05 – 752.05
T70	233.07 – 427.21	419.53 – 768.97
T80	246.42 – 437.57	443.57 – 787.62
T90	260.69 – 451.98	469.25 – 813.57
T95	271.28 – 464.85	488.30 – 836.74
FBP	291.42 – 504.64	524.56 – 908.36

13. Keywords

13.1 boiling range distribution; correlation; distillation; gas chromatography; petroleum; petroleum fractions; petroleum products; simulated distillation; ultra fast gas chromatograph

TABLE 7 D6708 Assessment Outcome: D2887A (referee) versus D7798

	Can bias correction improve agreement?	Bias-corrected D7798 Use (°C)	Sample specific bias?	Range of D7798 sample averages in ILS study (°C)
IBP	Y	=D7798 + 3.042	y	See Table 6
10 %	Y	=D7798 + 0.795	n	See Table 6
30 %	N	=D7798	n	See Table 6
50 %	N	=D7798	y	See Table 6
70 %	N	=D7798	y	See Table 6
90 %	Y	=D7798 – 0.996	y	See Table 6
FBP	Y	0.982 · D7798 + 5.839	n	See Table 6

TABLE 8 Between-Method Reproducibility

NOTE 1—R_X is reproducibility of D7798; R_Y is reproducibility of D2887 Procedure A. Use either °C or °F values of R.

	Range of D7798 Sample Averages in ILS Study	Between-Method Reproducibility (R_{XY})
IBP	See Table 6	$[0.66\cdot(R_x^2 + R_y^2)]^{0.5}$
10 %	See Table 6	$[0.5\cdot(R_x^2 + R_y^2)]^{0.5}$
30 %	See Table 6	$[0.5\cdot(R_x^2 + R_y^2)]^{0.5}$
50 %	See Table 6	$[0.69\cdot(R_x^2 + R_y^2)]^{0.5}$
70 %	See Table 6	$[0.73\cdot(R_x^2 + R_y^2)]^{0.5}$
90 %	See Table 6	$[0.58\cdot(R_x^2 + R_y^2)]^{0.5}$
FBP	See Table 6	$[0.5\cdot(R_x^2 + R_y^2)]^{0.5}$

ANNEX

(Mandatory Information)

A1. PEAK INTEGRATION AND BOILING POINT ALGORITHM CALCULATIONS

A1.1 Acquisition Rate Requirements

A1.1.1 The number of slices required at the beginning of data acquisition depends on chromatographic variables such as the column flow, column film thickness, and initial column temperature as well as column length. In addition the detector signal level has to be as low as possible at the initial temperature of the analysis. The detector signal level for both the sample signal and the blank at the beginning of the run has to be similar for proper zeroing of the signals.

A1.1.2 The sampling frequency has to be adjusted so that at least a significant number of slices are acquired prior to the start of elution of sample or solvent. For example, if the time for start of sample elution is 0.06 min (3.6 s), a sampling rate of 5 Hz would acquire 18 slices. However a rate of 1 Hz would only acquire 3.6 slices which would not be sufficient for zeroing the signals. Rather than specifying number of slices, it is important to select an initial time segment, that is, 1 or 2 s. Insure that the smallest number of slices is 5 or greater.

A1.1.3 Verify that the slice width used to acquire the sample chromatogram is the same used to acquire the blank run chromatogram.

A1.2 *Chromatogram Offset for Sample and Blank*—Perform a slice offset for the sample chromatogram and blank chromatogram. This operation is necessary so that the signal is corrected from its displacement from the origin. This is achieved by determining an average slice offset from the slices accumulated in the first segment (that is, first *s*) and performing a standard deviation calculation for the first N slices accumulated. It is carried out for both sample signal and baseline signal.

A1.2.1 *Sample Offset:*

A1.2.1.1 Calculate the average slice offset of sample chromatogram using the first second of acquired slices. Insure that no sample has eluted during this time and that the number of slices acquired is at least 5. Throw out any of the first N slices selected that are not within one standard deviation of the average and re-compute the average. This eliminates any area that is due to possible baseline upset from injection.

A1.2.1.2 Subtract the average slice offset from all the slices of the sample chromatogram. Set negative slices to zero. This will zero the chromatogram.

A1.2.2 *Blank Offset:*

NOTE A1.1—If you are using electronic baseline compensation proceed to A1.4. It is strongly recommended that the offset method use the slices acquired by running a blank with or without solvent according on how the sample was prepared. Use these slices for the offset or zero calculations.

A1.2.2.1 Repeat A1.2.1 using the blank run table.

A1.3 *Offset the Sample Chromatogram with Blank Chromatogram*—Subtract from each slice in the sample chromatogram table with its correspondent slice in the blank run chromatogram table. Set negative slices to zero.

A1.4 *Determination of Baseline Drift*—This procedure is optional but it ascertains that after the signals are corrected the

initial signal magnitude is close to the final signal magnitude. This is visible when the Simulated Distillation software displays the chromatogram.

A1.4.1 Calculate the average and standard deviation of the slices occurring in the first second for the sample chromatogram after carrying out A1.3.

A1.4.2 Eliminate any of the selected number of slices that are not within one standard deviation of the average and re-compute the average. This eliminates any area that is due to possible baseline upset from injection.

A1.4.3 Record the average area slice as Initial Baseline Signal.

A1.4.4 Repeat A1.4.1 and A1.4.2 using the last area slices acquired in the last 1 s of the chromatogram.

A1.4.5 Record the average area slice as Final Baseline Signal.

A1.4.6 Compare and report the Initial and Final Baseline Signals. These numbers should be similar.

A1.5 Determine the Start of Sample Elution Time

A1.5.1 *Calculate the Total Area*—Add all the corrected slices in the table. If the sample to be analyzed has a solvent peak, start counting area from the point at which the solvent peak has eluted completely. Otherwise, start at the first corrected slice.

A1.5.2 *Calculate the Rate of Change between each Two Consecutive Area Slices*—Begin at the slice set in A1.5.1 and work forward. The rate of change is obtained by subtraction the area of a slice from the area of the immediately preceding slice and dividing by the slice width. The time where the rate of change first exceeds 0.0001 % per second of the total area (see A1.5.1) is defined as the start of the sample elution time. To reduce the possibility of noise or an electronic spike falsely indicating the start of sample elution time, a 1 s slice average can be used instead of a single slice. For noisier baselines, a slice average larger than 3 s may be required.

A1.6 Determine the End of Sample Elution Time

A1.6.1 *Calculate the Rate of Change between each Two Consecutive Area Slices*—Begin at the end of run and work backward. The rate of change is obtained by subtracting the area of a slice from the area of the immediately preceding slice and dividing by the slice width. The time where the rate of change first exceeds 0.0001 % per second of the total area (see A1.5.1) is defined as the end of sample elution time. To reduce the possibility of noise or an electronic spike falsely indicating the end of sample elution a 1 s slice average can be used instead of a single slice. For noisier baselines a slice average larger than 3 s may be required.

A1.7 *Calculate the Sample Total Area*—Add all the slices from the slice corresponding to the start of sample elution time to the slice corresponding to the end of sample elution time.

A1.8 *Normalize to Area Percent*—Divide each slice in the sample chromatogram table by the total area (see A1.7) and multiply it by 100.

A1.9 Calculate the Boiling Point Distribution Table

A1.9.1 *Initial Boiling Point*—Add slices in the sample chromatogram until the sum is equal to or greater than 0.5 %. If the sum is greater than 0.5 %, interpolate (refer to the algorithm in A1.11.1) to determine the time that will generate the exact 0.5 % of the area. Calculate the boiling point temperature corresponding to this slice time using the calibration table. Use interpolation when required (refer to the algorithm in A1.11.2).

A1.9.2 *Final Boiling Point*—Add slices in the sample chromatogram until the sum is equal to or greater than 99.5 %. If the sum is greater than 99.5 %, interpolate (refer to the algorithm in A1.11.1) to determine the time that will generate the exact 99.5 % of the area. Calculate the boiling point temperature corresponding to this slice time using the calibration table. Use interpolation when required (refer to the algorithm in A1.11.2).

A1.9.3 *Intermediate Boiling Point*—For each point between 1 % and 99 %, find the time where the accumulative sum is equal to or greater than the area percent being analyzed. As in A1.9.1 and A1.9.2, use interpolation when the accumulated sum exceeds the area percent to be estimated (refer to the algorithm in A1.11.1). Use the calibration table to assign the boiling point.

A1.10 *Report Results*—Print the boiling point distribution table.

A1.11 Calculation Algorithms

A1.11.1 Calculations to determine the exact point in time that will generate the X percent of total area, where X = 0.5, 1, 2, . . . , 99.5 %.

A1.11.1.1 Record the time of the slice just prior to the slice that will generate an accumulative slice area larger than the X percent of the total area. Let us call this time, T_s, and the accumulative area at this point, A_c.

A1.11.1.2 Calculate the fraction of the slice required to produce the exact X percent of the total area:

$$A_x = \frac{X - A_c}{A_{c+1} - A_c} \tag{A1.1}$$

A1.11.1.3 Calculate the time required to generate the fraction of area A_x:

$$T_f = A_x \cdot W \tag{A1.2}$$

where:

T_f = fraction of time that will yield A_x,
W = the slice width, and
A_x = fraction of the slice that will yield the exact percent.

A1.11.1.4 Record the exact time where the accumulative area is equal to the X percent of the total area:

$$T_t = T_s + T_f \tag{A1.3}$$

A1.11.2 Interpolate to determine the exact boiling point given the retention time corresponding to the cumulative slice area.

A1.11.2.1 Compare the given time against each retention time in the calibration table. Select the nearest standard having

a retention time equal to or larger than the interpolation time. (The retention time table shall be sorted in ascending order.)

A1.11.2.2 If the interpolation time is equal to the retention time of the standard, record the corresponding boiling point.

A1.11.2.3 If the retention time is not equal to the retention time of the standards (see 9.3), interpolate the boiling point temperature as follows:

A1.11.2.4 If the interpolation time is less than the first retention time in the calibration table, then extrapolate using the first two components in the table:

$$BP_x = m_1 \cdot (RT_x - RT_1) + BP_1 \quad \text{(A1.4)}$$

where:

m_1 = $(BP_2 - BP_1) / (RT_2 - RT_1)$,
BP_x = boiling point extrapolated,
RT_x = retention time to be extrapolated,
RT_1 = retention time of the first component in the calibration table,
BP_1 = boiling point of the first component in the calibration table,
RT_2 = retention time of the second component in the calibration table, and
BP_2 = boiling point of the second component in the calibration table.

A1.11.2.5 If the interpolation time is between two retention times in the calibration table, then interpolate using the upper and lower standard components:

$$BP_x = m_u \cdot (RT_x - RT_1) + BP_1 \quad \text{(A1.5)}$$

where:

m_u = $(BP_u - BP_l) / (RT_u - RT_l)$,
BP_x = boiling point extrapolated,
RT_x = retention time to be extrapolated,
RT_l = retention time of the lower bound component in the calibration table,
BP_l = boiling point of the lower bound component in the calibration table,
RT_u = retention time of the upper bound component in the calibration table, and
BP_u = boiling point of the upper bound component in the calibration table.

A1.11.2.6 If the interpolation time is larger than the last retention time in the calibration table, then extrapolate using the last two standard components in the table:

$$BP_x = m_n \cdot (RT_x - RT_{n-1}) + BP_{n-1} \quad \text{(A1.6)}$$

where:

m_n = $(BP_n - BP_{n-1}) / (RT_n - RT_{n-1})$,
BP_x = boiling point extrapolated,
RT_x = retention time to be extrapolated,
RT_{n-1} = retention time of the standard component eluting prior to the last component in the calibration table,
BP_{n-1} = boiling point of the standard component eluting prior to the last component in the calibration table,
RT_n = retention time of the last component in the calibration table, and
BP_n = boiling point of the standard component in the calibration table.

APPENDIX

(Nonmandatory Information)

X1. BOILING POINTS OF NONPARAFFINIC HYDROCARBONS

X1.1 There is an apparent discrepancy in the boiling point of multiple ring-type compounds. When the retention time of these compounds are compared to n-paraffins of equivalent atmospheric boiling point, these ring compounds appear to be eluted early from methyl silicone columns. A plot showing 36 compounds other than n-paraffins plotted along the calibration curve for n-paraffins alone is shown in Fig. X1.1. The numbered dots are identified in Table X1.1. In this figure the atmospheric boiling points are plotted against the observed retention times. If columns contained different percentages of stationary phase or different temperature programming rates are used, the slope and curvature on the n-paraffin curve (solid line) would change, but the relative relationships would remain essentially the same. Deviations of simulated distillation boiling points, as estimated from the curve, from actual boiling points for a few compounds are shown in Table X1.2. The deviations obtained by plotting boiling points at 10 mm Hg rather than 76 mm Hg are tabulated also. It is apparent that the deviation is much less at 10 mm Hg pressure. This indicates that the distillation data produced by gas chromatography closely approximates those obtained in reduced pressure distillations. Since the vapor-pressure-temperature curves for multiple-ring type compounds do not have the same slope or curvature as those of n-paraffins, an apparent discrepancy would exist when n-paraffin boiling points at atmospheric pressure are used.

X1.2 However, this discrepancy does not introduce any significant error when comparing with laboratory distillation because the pressure shall be reduced in such procedures when overhead temperature reach approximately 260 °C (500 °F) to prevent cracking of the sample. Thus, distillation data are subject to the same deviations experienced in simulated distillation by gas chromatography.

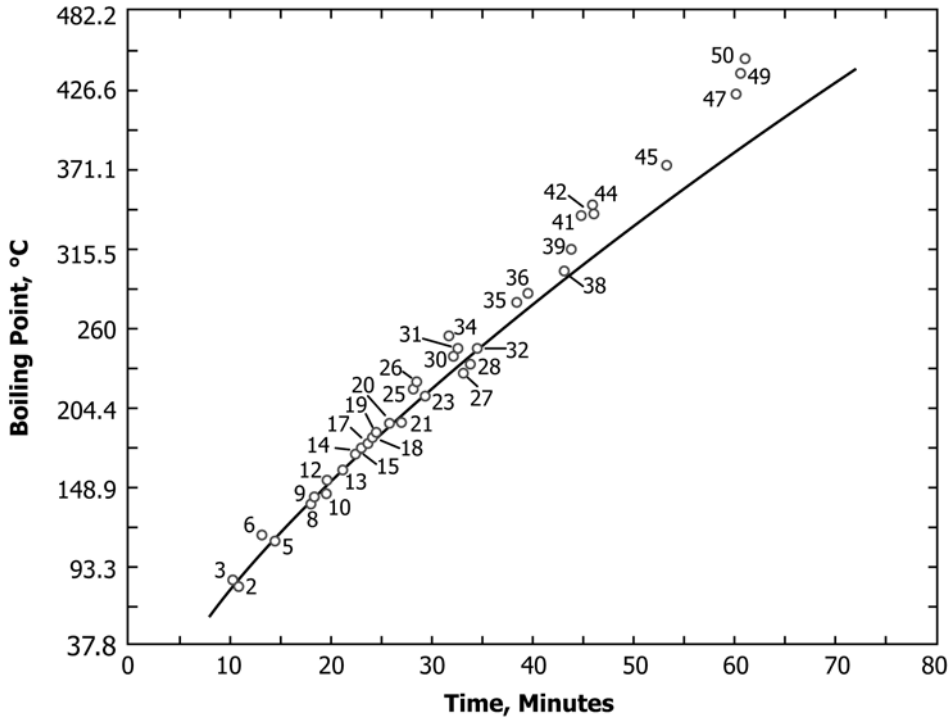

FIG. X1.1 Boiling Point—Retention Time Relationships for Several High-Boiling Multiple-Ring Type Compounds (see Table X1.1)

TABLE X1.1 Compound Identification—Number Dots (see Fig. X1.1)

Number	Boiling Point, °C (°F)	Compound	Number	Boiling Point, °C (°F)	Compound
2	80 (176)	Benzene	27	227 (441)	di-n-amylsilfide
3	84 (183)	Thiophene	28	234 (453)	tri-isopropylbenzene
5	111 (231)	Toluene	30	241 (466)	2-methlynaphthalene
6	116 (240)	Pyridine	31	295 (473)	1-methlynaphthalene
8	136 (277)	2,5-dimethlythiophene			
9	139 (282)	p-xylene	34	254 (894)	indole
10	143 (289)	di-n-propylsulfide	35	279 (534)	acenaphthene
12	152 (306)	Cumene			
13	159 (319)	1-hexahydroindan	38	298 (568)	n-decylbenzene
14	171 (339)	1-decene	39	314 (598)	1-octadecene
15	173 (344)	sec-butylbenzene			
17	178 (352)	2,3-dihydroindene	41	339 (642)	phenanthrene
18	183 (361)	n-butylbenzene	42	342 (647)	anthracene
19	186 (366)	trans-decalin			
20	194 (382)	cis-decalin	44	346 (655)	acridine
21	195 (383)	di-n-propyldisulfide	45	395 (743)	pyrene
23	231 (416)	1-dodecene	47	404 (496)	triphenylene
25	218 (424)	Naphthalene	49	438 (820)	naphthacene
26	221 (430)	2,3-benzothiophene	50	447 (837)	chrysene

TABLE X1.2 Deviations of Simulated Distillation Boiling Points from Actual Boiling Points

Compound	Boiling Point, °C (°F) (760 mm)	Deviations from Actual Boiling Point, °C (°F) (760 mm)	Deviations from Actual Boiling Point, °C (°F) (10 mm)
benzene	80 (176)	+3 (+6)	-2 (-4)
thiophene	84 (183)	+4 (+7)	+1 (+2)
toluene	111 (231)	+2 (+3)	-1 (-2)
p-xylene	139 (282)	0 (0)	+2 (+4)
1-dodecene	213 (416)	0 (0)	0 (0)
naththalene	218 (424)	-11 (-20)	-4 (-8)
2,3-benzothiophene	221 (430)	-13 (-23)	0 (0)
2-methylnaphthalene	241 (466)	-12 (-21)	-2 (-3)
1-methylnaphthalene	245 (473)	-12 (-21)	-1 (-1)
dibenzothiophene	332 (630)	-32 (-58)	-6 (-10)
phenanthrene	339 (642)	-35 (-63)	-9 (-16)
athracene	342 (647)	-36 (-64)	-8 (-15)
pyrene	395 (743)	-48 (-87)	-16 (-29)
chrysene	447 (837)	-60 (-108)	[A]

[A] No data at 10 mm for chrysene.

SUMMARY OF CHANGES

Subcommittee D02.04 has identified the location of selected changes to this standard since the last issue (D7798 – 13) that may impact the use of this standard. (Approved Oct. 1, 2015.)

(1) Added new Practice D6300 to Referenced Documents and to Section 12.

(2) Revised Section 12; added new Tables 5-8.