



Standard Test Method for Distillation of Petroleum Products at Reduced Pressure¹

This standard is issued under the fixed designation D 1160; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This test method covers the determination, at reduced pressures, of the range of boiling points for petroleum products that can be partially or completely vaporized at a maximum liquid temperature of 400°C. Both a manual method and an automatic method are specified.

1.2 In cases of dispute, the referee test method is the manual test method at a mutually agreed upon pressure.

1.3 The values stated in SI units are to be regarded as the standard. The values in parentheses are for information only.

1.4 *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.* For specific hazard statements, see 6.1.4, 6.1.8.1, 10.11, and A3.2.1.

2. Referenced Documents

2.1 ASTM Standards:

D 613 Test Method for Cetane Number of Diesel Fuel Oil²

D 1193 Specification for Reagent Water³

D 1250 Guide for Petroleum Measurement Tables⁴

D 1298 Practice for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method⁴

D 4052 Test Method for Density and Relative Density of Liquids by Digital Density Meter⁵

D 4057 Practice for Manual Sampling of Petroleum and Petroleum Products⁵

D 4177 Practice for Automatic Sampling of Petroleum and Petroleum Products⁵

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *atmospheric equivalent temperature (AET)*—the temperature converted from the observed temperature using Eq

¹ This test method is under the jurisdiction of ASTM Committee D-2 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.08 on Volatility.

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² *Annual Book of ASTM Standards*, Vol 05.04.

³ *Annual Book of ASTM Standards*, Vol 11.01.

⁴ *Annual Book of ASTM Standards*, Vol 05.01.

⁵ *Annual Book of ASTM Standards*, Vol 05.02.

A7.1 or using Tables 1-6. The AET is the expected distillate temperature if the distillation was performed at atmospheric pressure and there was no thermal decomposition.

3.1.2 *end point (EP) or final boiling point (FBP)*—the maximum vapor temperature reached during the test.

3.1.3 *initial boiling point (IBP)*—the vapor temperature that is observed at the instant the first drop of condensate falls from the lower end of the condenser tube.

4. Summary of Test Method

4.1 The sample is distilled at an accurately controlled pressure between 0.13 and 6.7 kPa (1 and 50 mm Hg) under conditions that are designed to provide approximately one theoretical plate fractionation. Data are obtained from which the initial boiling point, the final boiling point, and a distillation curve relating volume percent distilled and atmospheric equivalent boiling point temperature can be prepared.

5. Significance and Use

5.1 This test method is used for the determination of the distillation characteristics of petroleum products and fractions that may decompose if distilled at atmospheric pressure. This boiling range, obtained at conditions designed to obtain approximately one theoretical plate fractionation, can be used in engineering calculations to design distillation equipment, to prepare appropriate blends for industrial purposes, to determine compliance with regulatory rules, to determine the suitability of the product as feed to a refining process, or for a host of other purposes.

5.2 The boiling range is directly related to viscosity, vapor pressure, heating value, average molecular weight, and many other chemical, physical, and mechanical properties. Any of these properties can be the determining factor in the suitability of the product in its intended application.

5.3 Petroleum product specifications often include distillation limits based on data by this test method.

5.4 Many engineering design correlations have been developed on data by this test method. These correlative methods are used extensively in current engineering practice.

6. Apparatus

6.1 The vacuum distillation apparatus, shown schematically in Fig. 1, consists in part of the components described below plus others that appear in Fig. 1 but are not specified, either as



**TABLE 1 Temperature-Pressure Conversion Table for Petroleum Hydrocarbons
(From 0.13 kPa (1 mm Hg))**

Vapor Temperature	AET Boiling Point at 101.3 kPa (760 mm Hg) Absolute Pressure									
	Degrees Celsius									
	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
35	195	196	196	198	198	199	199	201	201	202
40	202	203	203	205	205	206	206	207	207	209
45	209	210	210	211	211	213	213	214	214	216
50	216	217	217	218	218	220	220	221	221	222
55	222	224	224	225	225	226	226	228	228	229
60	229	230	230	232	232	233	233	234	234	236
65	236	237	237	238	238	240	240	241	241	242
70	242	244	244	245	245	247	247	248	248	249
75	249	251	251	252	252	253	253	255	255	256
80	256	257	257	259	259	260	260	261	261	263
85	263	264	264	265	265	266	266	268	268	269
90	269	270	270	272	272	273	273	274	274	276
95	276	277	277	278	278	280	280	281	281	282
100	282	284	284	285	285	286	286	288	288	289
105	289	290	290	292	292	293	293	294	294	295
110	295	297	297	298	298	299	299	301	301	302
115	302	303	303	305	305	306	306	307	307	308
120	308	310	310	311	311	312	312	314	314	315
125	315	316	316	318	318	319	319	320	320	321
130	321	323	323	324	324	325	325	327	327	328
135	328	329	329	330	330	332	332	333	333	334
140	334	336	336	337	337	338	338	339	339	341
145	341	342	342	343	343	345	345	346	346	347
150	347	348	348	350	350	351	351	352	352	353
155	353	355	355	356	356	357	357	359	359	360
160	360	361	361	362	362	364	364	365	365	366
165	366	367	367	369	369	370	370	371	371	372
170	372	374	374	375	375	376	376	377	377	379
175	379	380	380	381	381	382	382	384	384	385
180	385	386	386	387	387	389	389	390	390	391
185	391	392	392	394	394	395	395	396	396	397
190	397	399	399	400	400	401	401	402	402	404
195	404	405	405	406	406	407	407	409	409	410
200	410	411	411	412	412	414	414	415	415	416
205	416	417	417	419	419	420	420	421	421	422
210	422	423	423	425	425	426	426	427	427	428
215	428	430	430	431	431	432	432	433	433	434
220	434	436	436	437	437	438	438	439	439	441
225	441	442	442	443	443	444	444	445	445	447
230	447	448	448	449	449	450	450	451	451	453
235	453	454	454	455	455	456	456	458	458	459
240	459	460	460	461	461	462	462	464	464	465
245	465	466	466	467	467	468	468	470	470	471
250	471	472	472	473	473	474	474	476	476	477
255	477	478	478	479	479	480	480	482	482	483
260	483	484	484	485	485	486	486	488	488	489
265	489	490	490	491	491	492	492	493	493	495
270	495	496	496	497	497	498	498	499	499	501
275	501	502	502	503	503	504	504	505	505	506
280	506	508	508	509	509	510	510	511	511	512
285	512	514	514	515	515	516	516	517	517	518
290	518	519	519	521	521	522	522	523	523	524
295	524	525	525	526	526	528	528	529	529	530
300	530	531	531	532	532	533	533	535	535	536
305	536	537	537	538	538	539	539	540	540	542
310	542	543	543	544	544	545	545	546	546	547
315	547	548	548	550	550	551	551	552	552	553
320	553	554	554	555	555	557	557	558	558	559
325	559	560	560	561	561	562	562	563	563	565
330	565	566	566	567	567	568	568	569	569	570
335	570	571	571	573	573	574	574	575	575	576
340	576	577	577	578	578	579	579	581	581	582
345	582	583	583	584	584	585	585	586	586	587
350	587	588	588	590	590	591	591	592	592	592

to design or performance. Some of these parts are not essential for obtaining satisfactory results from the tests but are desirable components of the assembly for the purpose of promoting the

efficient use of the apparatus and ease of its operation. Both manual and automatic versions of the apparatus must conform to the following requirements. Additional requirements for the



**TABLE 2 Temperature-Pressure Conversion Table for Petroleum Hydrocarbons
(From 0.27 kPa (2 mm Hg))**

Vapor Temperature	AET Boiling Point at 101.3 kPa (760 mm Hg) Absolute Pressure									
	Degrees Celsius									
	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
35	181	183	183	184	184	185	185	187	187	188
40	188	189	189	191	191	192	192	193	193	195
45	195	196	196	197	197	199	199	200	200	201
50	201	203	203	204	204	205	205	207	207	208
55	208	209	209	211	211	212	212	213	213	215
60	215	216	216	217	217	218	218	220	220	221
65	221	222	222	224	224	225	225	226	226	228
70	228	229	229	230	230	232	232	233	233	234
75	234	236	236	237	237	238	238	240	240	241
80	241	242	242	243	243	245	245	246	246	247
85	247	249	249	250	250	251	251	253	253	254
90	254	255	255	256	256	258	258	259	259	260
95	260	262	262	263	263	264	264	266	266	267
100	267	268	268	269	269	271	271	272	272	273
105	273	275	275	276	276	277	277	278	278	280
110	280	281	281	282	282	284	284	285	285	286
115	286	287	287	289	289	290	290	291	291	293
120	293	294	294	295	295	296	296	298	298	299
125	299	300	300	301	301	303	303	304	304	305
130	305	307	307	308	308	309	309	310	310	312
135	312	313	313	314	314	315	315	317	317	318
140	318	319	319	321	321	322	322	323	323	324
145	324	326	326	327	327	328	328	329	329	331
150	331	332	332	333	333	334	334	336	336	337
155	337	338	338	339	339	341	341	342	342	343
160	343	344	344	346	346	347	347	348	348	349
165	349	351	351	352	352	353	353	354	354	356
170	356	357	357	358	358	359	359	361	361	362
175	362	363	363	364	364	365	365	367	367	368
180	368	369	369	370	370	372	372	373	373	374
185	374	375	375	377	377	378	378	379	379	380
190	380	382	382	383	383	384	384	385	385	386
195	386	388	388	389	389	390	390	391	391	393
200	393	394	394	395	395	396	396	397	397	399
205	399	400	400	401	401	402	402	404	404	405
210	405	406	406	407	407	408	408	410	410	411
215	411	412	412	413	413	414	414	416	416	417
220	417	418	418	419	419	420	420	422	422	423
225	423	424	424	425	425	427	427	428	428	429
230	429	430	430	431	431	433	433	434	434	435
235	435	436	436	437	437	439	439	440	440	441
240	441	442	442	443	443	444	444	446	446	447
245	447	448	448	449	449	450	450	452	452	453
250	453	454	454	455	455	456	456	458	458	459
255	459	460	460	461	461	462	462	463	463	465
260	465	466	466	467	467	468	468	469	469	471
265	471	472	472	473	473	474	474	475	475	476
270	476	478	478	479	479	480	480	481	481	482
275	482	484	484	485	485	486	486	487	487	488
280	488	489	489	491	491	492	492	493	493	494
285	494	495	495	496	496	498	498	499	499	500
290	500	501	501	502	502	503	503	504	504	506
295	506	507	507	508	508	509	509	510	510	511
300	511	513	513	514	514	515	515	516	516	517
305	517	518	518	520	520	521	521	522	522	523
310	523	524	524	525	525	526	526	528	528	529
315	529	530	530	531	531	532	532	533	533	534
320	534	536	536	537	537	538	538	539	539	540
325	540	541	541	542	542	544	544	545	545	546
330	546	547	547	548	548	549	549	550	550	552
335	552	553	553	554	554	555	555	556	556	557
340	557	558	558	559	559	561	561	562	562	563
345	563	564	564	565	565	566	566	567	567	569
350	569	570	570	571	571	572	572	573	573	574

automatic apparatus can be found in Annex A9.

6.1.1 *Distillation Flask*, of 500-mL capacity, made of borosilicate glass or of quartz conforming to the dimensions given

in Fig. 2 and having a heating mantle with insulating top.

6.1.2 *Vacuum-Jacketed Column Assembly*, of borosilicate



Documents

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**TABLE 3 Temperature-Pressure Conversion Table for Petroleum Hydrocarbons
(From 0.67 kPa (5 mm Hg))**

Vapor Temperature	AET Boiling Point at 101.3 kPa (760 mm Hg) Absolute Pressure									
	Degrees Celsius									
	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
35	162	163	163	165	165	166	166	167	167	169
40	169	170	170	171	171	172	172	174	174	175
45	175	176	176	178	178	179	179	180	180	181
50	181	183	183	184	184	185	185	187	187	188
55	188	189	189	191	191	192	192	193	193	194
60	194	196	196	197	197	198	198	200	200	201
65	201	202	202	203	203	205	205	206	206	207
70	207	208	208	210	210	211	211	212	212	214
75	214	215	215	216	216	217	217	219	219	220
80	220	221	221	223	223	224	224	225	225	226
85	226	228	228	229	229	230	230	231	231	233
90	233	234	234	235	235	236	236	238	238	239
95	239	240	240	242	242	243	243	244	244	245
100	245	247	247	248	248	249	249	250	250	252
105	252	253	253	254	254	255	255	257	257	258
110	258	259	259	260	260	262	262	263	263	264
115	264	265	265	267	267	268	268	269	269	270
120	270	272	272	273	273	274	274	275	275	277
125	277	278	278	279	279	280	280	282	282	283
130	283	284	284	285	285	287	287	288	288	289
135	289	290	290	292	292	293	293	294	294	295
140	295	296	296	298	298	299	299	300	300	301
145	301	303	303	304	304	305	305	306	306	308
150	308	309	309	310	310	311	311	312	312	314
155	314	315	315	316	316	317	317	319	319	320
160	320	321	321	322	322	323	323	325	325	326
165	326	327	327	328	328	330	330	331	331	332
170	332	333	333	334	334	336	336	337	337	338
175	338	339	339	341	341	342	342	343	343	344
180	344	345	345	347	347	348	348	349	349	350
185	350	351	351	353	353	354	354	355	355	356
190	356	357	357	359	359	360	360	361	361	362
195	362	363	363	365	365	366	366	367	367	368
200	368	369	369	371	371	372	372	373	373	374
205	374	375	375	377	377	378	378	379	379	380
210	380	381	381	383	383	384	384	385	385	386
215	386	387	387	389	389	390	390	391	391	392
220	392	393	393	395	395	396	396	397	397	398
225	398	399	399	400	400	402	402	403	403	404
230	404	405	405	406	406	408	408	409	409	410
235	410	411	411	412	412	413	413	415	415	416
240	416	417	417	418	418	419	419	421	421	422
245	422	423	423	424	424	425	425	426	426	428
250	428	429	429	430	430	431	431	432	432	433
255	433	435	435	436	436	437	437	438	438	439
260	439	440	440	442	442	443	443	444	444	445
265	445	446	446	447	447	449	449	450	450	451
270	451	452	452	453	453	454	454	456	456	457
275	457	458	458	459	459	460	460	461	461	462
280	462	464	464	465	465	466	466	467	467	468
285	468	469	469	471	471	472	472	473	473	474
290	474	475	475	476	476	477	477	479	479	480
295	480	481	481	482	482	483	483	484	484	485
300	485	487	487	488	488	489	489	490	490	491
305	491	492	492	493	493	495	495	496	496	497
310	497	498	498	499	499	500	500	501	501	503
315	503	504	504	505	505	506	506	507	507	508
320	508	509	509	510	510	512	512	513	513	514
325	514	515	515	516	516	517	517	518	518	519
330	519	521	521	522	522	523	523	524	524	525
335	525	526	526	527	527	529	529	530	530	531
340	531	532	532	533	533	534	534	535	535	536
345	536	537	537	539	539	540	540	541	541	542
350	542	543	543	544	544	545	545	546	546	547

glass, consisting of a distilling head and an associated condenser section as illustrated in the dimensioned drawing, Fig. 3. The head shall be enclosed in a completely silvered glass

vacuum jacket with a permanent vacuum of less than 10^{-5} Pa (10^{-7} mm Hg) (Note 1). The attached condenser section shall be enclosed in water jackets as illustrated and have an adapter



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**TABLE 4 Temperature-Pressure Conversion Table for Petroleum Hydrocarbons
(From 1.33 kPa (10 mm Hg))**

Vapor Temperature	AET Boiling Point at 101.3 kPa (760 mm Hg) Absolute Pressure									
	Degrees Celsius									
	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
35	147	148	148	149	149	151	151	152	152	153
40	153	154	154	156	156	157	157	158	158	159
45	159	161	161	162	162	163	163	164	164	166
50	166	167	167	168	168	170	170	171	171	172
55	172	173	173	175	175	176	176	177	177	178
60	178	180	180	181	181	182	182	183	183	185
65	185	186	186	187	187	188	188	190	190	191
70	191	192	192	193	193	195	195	196	196	197
75	197	198	198	200	200	201	201	202	202	203
80	203	205	205	206	206	207	207	208	208	210
85	210	211	211	212	212	213	213	215	215	216
90	216	217	217	218	218	219	219	221	221	222
95	222	223	223	224	224	226	226	227	227	228
100	228	229	229	231	231	232	232	233	233	234
105	234	235	235	237	237	238	238	239	239	240
110	240	242	242	243	243	244	244	245	245	247
115	247	248	248	249	249	250	250	251	251	253
120	253	254	254	255	255	256	256	258	258	259
125	259	260	260	261	261	262	262	264	264	265
130	265	266	266	267	267	269	269	270	270	271
135	271	272	272	273	273	275	275	276	276	277
140	277	278	278	279	279	281	281	282	282	283
145	283	284	284	285	285	287	287	288	288	289
150	289	290	290	292	292	293	293	294	294	295
155	295	296	296	298	298	299	299	300	300	301
160	301	302	302	304	304	305	305	306	306	307
165	307	308	308	310	310	311	311	312	312	313
170	313	314	314	316	316	317	317	318	318	319
175	319	320	320	321	321	323	323	324	324	325
180	325	326	326	327	327	329	329	330	330	331
185	331	332	332	333	333	335	335	336	336	337
190	337	338	338	339	339	341	341	342	342	343
195	343	344	344	345	345	346	346	348	348	349
200	349	350	350	351	351	352	352	354	354	355
205	355	356	356	357	357	358	358	359	359	361
210	361	362	362	363	363	364	364	365	365	366
215	366	368	368	369	369	370	370	371	371	372
220	372	373	373	375	375	376	376	377	377	378
225	378	379	379	380	380	382	382	383	383	384
230	384	385	385	386	386	387	387	389	389	390
235	390	391	391	392	392	393	393	394	394	396
240	396	397	397	398	398	399	399	400	400	401
245	401	403	403	404	404	405	405	406	406	407
250	407	408	408	410	410	411	411	412	412	413
255	413	414	414	415	415	416	416	418	418	419
260	419	420	420	421	421	422	422	423	423	425
265	425	426	426	427	427	428	428	429	429	430
270	430	431	431	433	433	434	434	435	435	436
275	436	437	437	438	438	439	439	441	441	442
280	442	443	443	444	444	445	445	446	446	447
285	447	449	449	450	450	451	451	452	452	453
290	453	454	454	455	455	456	456	458	458	459
295	459	460	460	461	461	462	462	463	463	464
300	464	466	466	467	467	468	468	469	469	470
305	470	471	471	472	472	473	473	475	475	476
310	476	477	477	478	478	479	479	480	480	481
315	481	482	482	484	484	485	485	486	486	487
320	487	488	488	489	489	490	490	491	491	493
325	493	494	494	495	495	496	496	497	497	498
330	498	499	499	500	500	502	502	503	503	504
335	504	505	505	506	506	507	507	508	508	509
340	509	510	510	512	512	513	513	514	514	515
345	515	516	516	517	517	518	518	519	519	520
350	520	522	522	523	523	524	524	525	525	525

at the top for connection to the vacuum source. A light drip-chain shall hang from the drip tip of the condenser to a point 5 mm below the 10-mL mark of the receiver as shown in

Fig. 4. Alternatively, instead of the metal drip-chain, a metal trough may be used to channel the distillate to the wall of the receiver. This trough may either be attached to the condenser



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**TABLE 5 Temperature-Pressure Conversion Table for Petroleum Hydrocarbons
(From 2.67 kPa (20 mm Hg))**

Vapor Temperature	AET Boiling Point at 101.3 kPa (760 mm Hg) Absolute Pressure									
	Degrees Celsius									
	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
35	131	132	132	133	133	135	135	136	136	137
40	137	138	138	139	139	141	141	142	142	143
45	143	144	144	146	146	147	147	148	148	149
50	149	151	151	152	152	153	153	154	154	155
55	155	157	157	158	158	159	159	160	160	162
60	162	163	163	164	164	165	165	166	166	168
65	168	169	169	170	170	171	171	173	173	174
70	174	175	175	176	176	177	177	179	179	180
75	180	181	181	182	182	183	183	185	185	186
80	186	187	187	188	188	190	190	191	191	192
85	192	193	193	194	194	196	196	197	197	198
90	198	199	199	200	200	202	202	203	203	204
95	204	205	205	206	206	208	208	209	209	210
100	210	211	211	212	212	214	214	215	215	216
105	216	217	217	218	218	220	220	221	221	222
110	222	223	223	224	224	226	226	227	227	228
115	228	229	229	230	230	232	232	233	233	234
120	234	235	235	236	236	238	238	239	239	240
125	240	241	241	242	242	244	244	245	245	246
130	246	247	247	248	248	250	250	251	251	252
135	252	253	253	254	254	256	256	257	257	258
140	258	259	259	260	260	261	261	263	263	264
145	264	265	265	266	266	267	267	269	269	270
150	270	271	271	272	272	273	273	274	274	276
155	276	277	277	278	278	279	279	280	280	282
160	282	283	283	284	284	285	285	286	286	287
165	287	289	289	290	290	291	291	292	292	293
170	293	294	294	296	296	297	297	298	298	299
175	299	300	300	301	301	303	303	304	304	305
180	305	306	306	307	307	308	308	310	310	311
185	311	312	312	313	313	314	314	315	315	317
190	317	318	318	319	319	320	320	321	321	322
195	322	324	324	325	325	326	326	327	327	328
200	328	329	329	331	331	332	332	333	333	334
205	334	335	335	336	336	338	338	339	339	340
210	340	341	341	342	342	343	343	344	344	346
215	346	347	347	348	348	349	349	350	350	351
220	351	353	353	354	354	355	355	356	356	357
225	357	358	358	359	359	361	361	362	362	363
230	363	364	364	365	365	366	366	367	367	369
235	369	370	370	371	371	372	372	373	373	374
240	374	375	375	377	377	378	378	379	379	380
245	380	381	381	382	382	383	383	385	385	386
250	386	387	387	388	388	389	389	390	390	391
255	391	393	393	394	394	395	395	396	396	397
260	397	398	398	399	399	400	400	402	402	403
265	403	404	404	405	405	406	406	407	407	408
270	408	410	410	411	411	412	412	413	413	414
275	414	415	415	416	416	417	417	419	419	420
280	420	421	421	422	422	423	423	424	424	425
285	425	426	426	428	428	429	429	430	430	431
290	431	432	432	433	433	434	434	435	435	437
295	437	438	438	439	439	440	440	441	441	442
300	442	443	443	444	444	445	445	447	447	448
305	448	449	449	450	450	451	451	452	452	453
310	453	454	454	456	456	457	457	458	458	459
315	459	460	460	461	461	462	462	463	463	464
320	464	466	466	467	467	468	468	469	469	470
325	470	471	471	472	472	473	473	474	474	475
330	475	477	477	478	478	479	479	480	480	481
335	481	482	482	483	483	484	484	485	485	487
340	487	488	488	489	489	490	490	491	491	492
345	492	493	493	494	494	495	495	496	496	498
350	498	499	499	500	500	501	501	502	502	502

drip tip as shown in Fig. 4 or it may also be located in the neck of the receiver.

NOTE 1—There is no simple method to determine the vacuum in the jacket once it is completely sealed. A Tesla coil can be used, but the spark