



# Standard Test Method for Rubber Property—Effect of Liquids<sup>1</sup>

This standard is issued under the fixed designation D 471; 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 reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

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

<sup>ε1</sup> NOTE—Footnote 4 was corrected editorially in September 2008.

## 1. Scope

1.1 This test method covers the required procedures to evaluate the comparative ability of rubber and rubber-like compositions to withstand the effect of liquids. It is designed for testing: (1) specimens of vulcanized rubber cut from standard sheets (see Practice D 3182), (2) specimens cut from fabric coated with vulcanized rubber (see Test Methods D 751), or (3) finished articles of commerce (see Practice D 3183). This test method is not applicable to the testing of cellular rubbers, porous compositions, and compressed sheet packing, except as described in 11.2.2.

1.2 ASTM Oils No. 2 and No. 3, formerly used in this test method as standard test liquids, are no longer commercially available and in 1993 were replaced with IRM 902 and IRM 903, respectively (see Appendix X1 for details).

1.3 ASTM No. 1 Oil, previously used in this test method as a standard test liquid, is no longer commercially available and in 2005 was replaced with IRM 901; refer to Table 1, Footnote A, and Appendix X3 for details.

1.4 This test method includes the following:

Change in Mass (after immersion)	Section 10
Change in Volume (after immersion)	Section 11
Dimensional-Change Method for Water-Insoluble Liquids and Mixed Liquids	Section 12
Change in Mass with Liquid on One Surface Only	Section 13
Determining Mass of Soluble Matter Extracted by the Liquid	Section 14
Change in Tensile Strength, Elongation and Hardness (after immersion)	Section 15
Change in Breaking Resistance, Burst Strength, Tear Strength and Adhesion for Coated Fabrics	Section 16
Calculation (of test results)	Section 17

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

1.6 *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 appro-*

*priate safety and health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

- D 92 Test Method for Flash and Fire Points by Cleveland Open Cup Tester
- D 97 Test Method for Pour Point of Petroleum Products
- D 287 Test Method for API Gravity of Crude Petroleum and Petroleum Products (Hydrometer Method)
- D 412 Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension
- D 445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)
- D 611 Test Methods for Aniline Point and Mixed Aniline Point of Petroleum Products and Hydrocarbon Solvents
- D 751 Test Methods for Coated Fabrics
- D 865 Test Method for Rubber—Deterioration by Heating in Air (Test Tube Enclosure)
- D 975 Specification for Diesel Fuel Oils
- D 1217 Test Method for Density and Relative Density (Specific Gravity) of Liquids by Bingham Pycnometer
- D 1415 Test Method for Rubber Property—International Hardness
- D 1500 Test Method for ASTM Color of Petroleum Products (ASTM Color Scale)
- D 1747 Test Method for Refractive Index of Viscous Materials
- D 2008 Test Method for Ultraviolet Absorbance and Absorptivity of Petroleum Products
- D 2140 Test Method for Carbon-Type Composition of Insulating Oils of Petroleum Origin
- D 2240 Test Method for Rubber Property—Durometer Hardness

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee D11 on Rubber and is the direct responsibility of Subcommittee D11.15 on Degradation Tests.

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<sup>2</sup> 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.

**TABLE 1 Specifications and Typical Properties of ASTM and IRM Reference Oils**

Property	ASTM Oil No. 1 <sup>A</sup>	ASTM Oil No. 5	IRM 901	IRM 902	IRM 903	ASTM Method
<i>Specified Properties:</i>						
Aniline Point, °C (°F)	124 ± 1 (255 ± 2)	115 ± 1 (239 ± 2)	124 ± 1 (255 ± 2)	93 ± 3 (199 ± 5)	70 ± 1 (158 ± 2)	D 611
Kinematic Viscosity (mm <sup>2</sup> /s [cSt])						
38°C (100°F)	...	...	...	...	31.9–34.1	D 445
99°C (210°F)	18.7–21.0	10.8–11.9	18.12–20.34	19.2–21.5	...	D 445
Gravity, API, 16°C (60°F)	...	...	28.8 ± 1	19.0–21.0	21.0–23.0	D 287
Viscosity-Gravity Constant	...	...	0.790–0.805	0.860–0.870	0.875–0.885	D 2140
Flash Point COC, °C (°F)	243 (469) min	243 (469) min	243(469) min	240 (464) min	163 (325) min	D 92
Naphthenics, C <sub>N</sub> (%)	...	...	27 (avg)	35 min	40 min	D 2140
Paraffinics, C <sub>P</sub> (%)	...	...	65 min	50 max	45 max	D 2140
<i>Typical Properties:</i>						
Pour Point, °C (°F)	...	–15 (5)	–12 (10)	–12 (10)	–31 (–24)	D 97
ASTM Color	...	L 1.0	L 3.5	L 2.5	L 0.5	D 1500
Refractive Index	...	1.4808	1.4848	1.5105	1.5026	D 1747
UV Absorbance, 260 nm	...	...	0.8	4.0	2.2	D 2008
Aromatics, C <sub>A</sub> (%)	...	4	3	12	14	D 2140

<sup>A</sup> ASTM Oil No. 1 is no longer commercially available, the specifications are left in place for the purpose of reference until such time as an interlaboratory test program is conducted to determine precision and bias. Refer to [Appendix X3](#).

**D 2699** Test Method for Research Octane Number of Spark-Ignition Engine Fuel

**D 3182** Practice for Rubber—Materials, Equipment, and Procedures for Mixing Standard Compounds and Preparing Standard Vulcanized Sheets

**D 3183** Practice for Rubber—Preparation of Product Pieces for Test Purposes from Products

**D 4483** Practice for Evaluating Precision for Test Method Standards in the Rubber and Carbon Black Manufacturing Industries

**D 4485** Specification for Performance of Engine Oils

**D 4806** Specification for Denatured Fuel Ethanol for Blending with Gasolines for Use as Automotive Spark-Ignition Engine Fuel

**E 145** Specification for Gravity-Convection and Forced-Ventilation Ovens

2.2 *SAE Standards*:<sup>3</sup>

**J 300** Engine Oil Viscosity Classification

### 3. Summary of Test Method

3.1 This test method provides procedures for exposing test specimens to the influence of liquids under definite conditions of temperature and time. The resulting deterioration is determined by measuring the changes in physical properties, such as stress/strain properties, hardness, and changes in mass, volume, and dimension, before and after immersion in the test liquid.

3.2 The precision statement in Section 19 is based on an interlaboratory test program run in 1981, using six different rubbers with ASTM Reference Fuels B, C, D<sup>4</sup> and ASTM Oils No. 1 and No. 3.

3.3 The precision statement in [Appendix X2](#) is based on an interlaboratory test program conducted in 1993 to establish replacements for ASTM Oils No. 2 and No. 3. Because of the limited number of participating laboratories, only repeatability could be evaluated, and it was necessary to use pooled values of four No. 2 type oils (No. 2 plus three candidate replacement oils) and four No. 3 type oils (No. 3 plus three candidate replacement oils). Twelve rubbers were tested in this program.

3.4 ASTM Oils No. 1, No. 2, and No. 3 have been replaced by IRM 901, IRM 902, and IRM 903, respectively.

### 4. Significance and Use

4.1 Certain rubber articles, for example, seals, gaskets, hoses, diaphragms, and sleeves, may be exposed to oils, greases, fuels, and other fluids during service. The exposure may be continuous or intermittent and may occur over wide temperature ranges.

4.2 Properties of rubber articles deteriorate during exposure to these liquids, affecting the performance of the rubber part, which can result in partial failure.

4.3 This test method attempts to simulate service conditions through controlled accelerated testing, but may not give any direct correlation with actual part performance, since service conditions vary too widely. It yields comparative data on which to base judgment as to expected service quality.

<sup>3</sup> Available from Society of Automotive Engineers (SAE), 400 Commonwealth Drive, Warrendale, PA 15096.

<sup>4</sup> The sole source of supply of the reference fuels known to the committee at this time is Chevron Phillips Chemical Company, LP, 10001 Six Pines Drive, The Woodlands, TX 77380. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,<sup>1</sup> which you may attend.

4.4 This test method is suitable for specification compliance testing, quality control, referee purposes, and research and development work.

## 5. Test Conditions

5.1 *Temperature and Immersion Periods*—Unless otherwise specified the test temperature and immersion period shall be as indicated in **Table 2**, depending upon the anticipated service conditions, unless otherwise agreed upon between customer and supplier:

5.1.1 When the temperature of the testing room is other than the standard  $23 \pm 2^\circ\text{C}$  ( $73 \pm 4^\circ\text{F}$ ) the temperature of test shall be reported.

5.1.2 When the relative humidity (RH %) of the testing environment is known to effect the performance of a test liquid, the RH % shall be reported.

5.1.3 The choice of the immersion period will depend upon the nature of the vulcanizate, the test temperature, and the liquid to be used. To obtain information on the rate of deterioration it is necessary to make determinations after several immersion periods.

5.1.4 The tolerance for any immersion period shall be  $\pm 15$  min or  $\pm 1\%$  of the immersion period, whichever is greater.

5.1.5 The immersion periods enumerated in **Table 2** are frequently used, and are considered standard; however, they may be varied according to a material's testing requirements or anticipated exposure in service.

5.2 *Illumination*—Immersion tests shall be made in the absence of direct light.

## 6. Standard Test Liquids

6.1 For test purposes, it is desirable to use the liquid that will come into contact with the vulcanizate in service. For comparative tests with liquids of unknown or doubtful composition, samples of liquid from the same container or shipment shall be used. Many commercial products, particularly those of petroleum origin, are subject to sufficient variation that it is not practical to use them for test liquids. It is then advisable to use a standard test liquid, such as described in **6.1.1** and **6.1.2**, covering the range of properties that may be encountered in the particular service.

6.1.1 *IRM and ASTM Oils*—The test shall be conducted in one of the petroleum-base IRM or ASTM oils (**Note 1**) specified in **Table 1** that has its aniline point nearest that of the oil with which the vulcanizate is expected to come in contact in service except as indicated in **6.1.3**.

**TABLE 2 Test Temperatures and Immersion Periods**

Temperature in $^\circ\text{C}$ ( $^\circ\text{F}$ )		Immersion Period, h
$-75 \pm 2$ ( $-103 \pm 4$ )	$85 \pm 2$ ( $185 \pm 4$ )	22
$-55 \pm 2$ ( $-67 \pm 4$ )	$100 \pm 2$ ( $212 \pm 4$ )	46
$-40 \pm 2$ ( $-40 \pm 4$ )	$125 \pm 2$ ( $257 \pm 4$ )	70
$-25 \pm 2$ ( $-13 \pm 4$ )	$150 \pm 2$ ( $302 \pm 4$ )	166
$-10 \pm 2$ ( $14 \pm 4$ )	$175 \pm 2$ ( $347 \pm 4$ )	670
$0 \pm 2$ ( $32 \pm 4$ )	$200 \pm 2$ ( $392 \pm 4$ )	1006
$23 \pm 2$ ( $73 \pm 4$ )	$225 \pm 2$ ( $437 \pm 4$ )	2998
$50 \pm 2$ ( $122 \pm 4$ )	$250 \pm 2$ ( $482 \pm 4$ )	4990
$70 \pm 2$ ( $158 \pm 4$ )		

**NOTE 1**—The aniline point of a petroleum oil appears to characterize the swelling action of that oil on rubber vulcanizates. In general, the lower the aniline point, the more severe the swelling action by the oil. The oils specified in **Table 1** cover a range of aniline points commonly found in lubricating oils.

6.1.2 *ASTM Reference Fuels*—When gasolines or diesel fuels are to be encountered in service, the test shall be conducted in one of the ASTM reference fuels (**Note 2**) specified in **Table 3**, except as indicated in **6.1.3**.

**NOTE 2**—The ASTM reference fuels in **Table 3** have been selected to provide the maximum and minimum swelling effects produced by commercial gasolines. Reference Fuel A has a mild action on rubber vulcanizates and produces results of the same order as low swelling gasolines of the highly paraffinic, straight run type. Reference Fuels B, C, and D simulate the swelling behavior of the majority of commercial gasolines, with Reference Fuel C producing the highest swelling which is typical of highly aromatic premium grades of automotive gasoline. Reference Fuel F (diesel fuel) swells rubber vulcanizates to a lesser extent than Reference Fuel B. Reference Fuels G, H, and I are fuel-alcohol blends (gasohol), which have a stronger swelling action than the corresponding fuel alone, where blends with methanol are more severe than blends with ethanol. Reference Fuel K, a methanol-rich blend, has a substantially weaker swelling action than that of the fuel used to prepare the blend. Reference Fuels I and K are also referred to as M15 and M85, respectively.

6.1.3 *Service Liquids*—Some commercial oils, fuels and other service liquids (see **Table 4**) are either non-petroleum or are compounded from special petroleum hydrocarbon fractions or mixtures of petroleum hydrocarbon fractions and other ingredients resulting in materials having properties beyond the range of the reference fluids listed in **Table 1** and **Table 3**. Immersion tests of rubber vulcanizates that are to come into contact with such fluids should be made in the actual service liquid.

6.1.4 *Water*—Since the purity of water varies throughout the world, all water immersion tests shall be conducted in distilled or deionized water.

## 7. Preparation of Specimen

7.1 Except as otherwise specified in the applicable specifications, specimens shall be prepared in accordance with the requirements of Practices **D 3182** and **D 3183**.

## 8. Apparatus

8.1 *For non-volatile liquids*, a glass test tube, having an outside diameter of 38 mm (1.5 in.) and an overall length of

**TABLE 3 ASTM Reference Fuels**

Fuel Type	Composition, Volume %
Reference Fuel A	Isooctane <sup>A</sup> , 100
Reference Fuel B	Isooctane <sup>A</sup> , 70; Toluene <sup>A</sup> , 30
Reference Fuel C	Isooctane <sup>A</sup> , 50; Toluene <sup>A</sup> , 50
Reference Fuel D	Isooctane <sup>A</sup> , 60; Toluene <sup>A</sup> , 40
Reference Fuel E	Toluene <sup>A</sup> , 100
Reference Fuel F	Diesel Fuel, Grade No. 2 <sup>B</sup> , 100
Reference Fuel G	Fuel D, 85; anhydrous denatured ethanol <sup>C</sup> , 15
Reference Fuel H	Fuel C, 85; anhydrous denatured ethanol <sup>C</sup> , 15
Reference Fuel I	Fuel C, 85; anhydrous methanol, 15
Reference Fuel K	Fuel C, 15; anhydrous methanol, 85

<sup>A</sup> Motor Fuels, Section 1, Test Method **D 2699**

<sup>B</sup> Specification **D 975**.

<sup>C</sup> Anhydrous ethanol denatured with unleaded gasoline, Section 4, Performance Requirements, Specification **D 4806**.