Designation: F146 – 12

Standard Test Methods for Fluid Resistance of Gasket Materials[1]

This standard is issued under the fixed designation F146; 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 These test methods cover the determination of the effect on physical properties of nonmetallic gasketing materials after immersion in test fluids. The types of materials covered are Type 1, Type 2, Type 3, and Type 7 as described in Classification F104. These test methods are not applicable to the testing of vulcanized rubber, a procedure that is described in Test Method D471. It is designed for testing specimens cut from gasketing materials or from finished articles of commerce. These test methods may also be used as a pre-treatment for Multi-Layer Steel, MLS, or Metal Layer Gasket materials adhesion testing per Test Method D3359. The pre-treatment of MLS or Metal Layer Gasket materials pertains only as a pre-cursor to the adhesion test. Other physical property tests described in this standard are not applicable to MLS or Metal Layer Gasket materials.

1.2 The values stated in SI units are to be regarded as the standard. The inch-pound units in parentheses are for information only.

1.3 Refer to the current Material Safety Data Sheet (MSDS) and any precautionary labeling provided by the supplier of any materials referred to in these test methods.

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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D412 Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension

D471 Test Method for Rubber Property—Effect of Liquids

D3359 Test Methods for Measuring Adhesion by Tape Test

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

F36 Test Method for Compressibility and Recovery of Gasket Materials

F104 Classification System for Nonmetallic Gasket Materials

F147 Test Method for Flexibility of Non-Metallic Gasket Materials

F152 Test Methods for Tension Testing of Nonmetallic Gasket Materials

3. Summary of Test Methods

3.1 Appropriate test specimens are subjected to complete immersion in test fluids. After immersing the specimens in the various test fluids, the effect on physical properties is expressed as change in tensile strength, compressibility in softened condition, flexibility, volume change, and thickness and weight changes from the original condition.

4. Significance and Use

4.1 These test methods provide a standardized procedure to measure the effect of immersion in specified fluids under definite conditions of time and temperature. The results of these test methods are not intended to give any direct correlation with service conditions in view of the wide variations in temperature and special uses encountered in gasket applications. The specific test fluids and test conditions outlined were selected as typical for purposes of comparing different materials and can be used as a routine test when agreed upon between the purchaser and the manufacturer.

5. Apparatus

5.1 *Circulating-Hot-Air Ovens,* two, capable of maintaining 100 ± 1°C (212 ± 2°F) and 149 ± 2°C (300 ± 3.6°F), or aluminum block fitted for use with test tubes, or heating mantle, capable of maintaining 100 ± 1°C (212 ± 2°F).

5.2 *Desiccator,* containing anhydrous calcium chloride or silica gel.

5.3 *Analytical Balance.*

[1] These test methods are under the jurisdiction of ASTM Committee F03 on Gaskets and are the direct responsibility of Subcommittee F03.40 on Chemical Test 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.

TABLE 1 Loads and Pressure

Type	Total Load on Presser Foot (Reference)		Load on Sample	
	N	oz	kPa	psi
1[A]	2.50	9.0	79.3 ± 6.9	11.5 ± 1.0
2	1.11	4.0	35 ± 6.9	5.1 ± 1.0
3	1.75	6.3	55 ± 6.9	8.0 ± 1.0

[A]Materials of Type 1 and Type 7 that exhibit a minimum thickness increase of 35 % in IRM 903 shall be tested after immersion in any fluid by using a total load on the pressure foot of 0.83 N (3.0 oz) which becomes 26.4 ± 6.9-kPa (3.8 ± 1.0-psi) load on the sample.

5.4 *Thickness Gage,* actuated by dead load weights, having dial graduations of 0.02 mm (0.001 in.) with anvil not less than presser foot diameter of 6.4 ± 0.127 mm (0.252 ± 0.005 in.). Dead weight loads are listed in Table 1.

5.5 *Cutting Dies,* appropriate for cutting steel, with sharp edges free from nicks or burrs, in the following sizes:

5.5.1 25.4 by 50.8 mm (1 by 2 in.),

5.5.2 28.6-mm (1.126-in.) diameter, 645.2-mm^2 (1-in.^{2}) area circular die,

5.5.3 Test Methods D412, Die A, 12.7-mm (0.500-in.) width, and

5.5.4 12.7 by 152.4 mm (0.50 by 6 in.).

5.6 *Conditioned Cabinet or Room,* maintained at 21 to 29°C (70 to 85°F) and from 50 to 55 % relative humidity.

5.7 *Test Tubes,* with 38-mm (1.50-in.) outside diameters and 305-mm (12-in.) overall lengths,[3] fitted with aluminum foil-covered compressible stoppers.

5.8 *Immersion Containers,* of configuration required to accommodate specimen sizes.

5.9 *Boiling Flask with Reflux Condenser,* of configuration required to accordance specimen sizes.

5.10 *Light-Metal Wire Screens,* sized to fit within immersion containers (5.8).

5.11 *Watchglass or Ground-Glass Tared Weighing Bottle.*

5.12 *Immersion Fluids*—ASTM Oil No. 1[4] (IRM 901),[5] IRM 903,[6] ASTM Fuel B, distilled water, ethylene glycol, propylene glycol, and other test fluids as needed.

TABLE 2 Properties, Characteristics and Test Methods

Type of Material	Physical Property	Fluid[6]	Test Duration, h	Temperature, °C (°F)
1, 7	Compressibility	IRM 903	5	149 (300)
	Tensile strength	IRM 903	5	149 (300)
	Thickness increase	ASTM Fuel B	5	21 to 29 (70 to 85)
	Weight increase	IRM 903	5	149 (300)
2	Flexibility	ASTM Oil No. 1 (IRM 901)	70	100 (212)
	Volume change	ASTM Oil No. 1 (IRM 901)	70	100 (212)
	Volume change	IRM 903	70	100 (212)
	Volume change	ASTM Fuel B	22	21 to 29 (70 to 85)
3	Weight change	ASTM Fuel B	22	21 to 29 (70 to 85)
		IRM 903	22	21 to 29 (70 to 85)
		distilled water	22	21 to 29 (70 to 85)
	Thickness increase	ASTM Fuel B	22	21 to 29 (70 to 85)
		IRM 903	22	21 to 29 (70 to 85)
		distilled water	22	21 to 29 (70 to 85)

5.13 *Absorbent Paper,* rapid qualitative-type or similar absorptive texture.[7]

6. Test Specimens

6.1 Specimens to be tested shall be cleanly die-cut so as to be flat, clean, and free of projecting fibers, fillers, particulates, etc.

6.1.1 Specimens for immersion in liquids for change in thickness, weight, or volume shall be single-ply with 25.4 by 50.8-mm (1 by 2-in.) dimensions or 28.6-mm (1.126-in.) diameter disks.

6.1.2 Specimens for loss of tensile strength in test fluids shall be of Die A or alternative as permitted in Test Methods F152.

6.1.3 Specimens for compressibility measurement after immersion in test fluids shall be 645.2 mm^2 (1 in.^{2}) in circular square-inch disks plied in number in accordance with Test Method F36.

6.1.4 Specimens for flexibility after immersion in test fluids shall be 12.7 by 152.4 mm (0.5 by 6 in.) by single thickness.

7. Temperature of Test Measurement

7.1 Conduct all measurements on test specimens that are set at a temperature of 21 to 29°C (70 to 85°F).

8. Conditioning

8.1 Prior to testing, the user should condition specimens as specified in Classification F104.

9. Procedure

9.1 Conduct tests in accordance with Table 2 or otherwise agreed upon between the producer and the user. These test methods are applicable to ethylene glycol, propylene glycol, commercial coolants and blends with water thereof (see Note 1), distilled water, and other commercial oils and fuels. The

[3] Suitable test tubes of this size were obtained from Edwin H. Benz Co., 703 Maplehurst Rd., Providence, RI 02908-5398 and are available from most scientific supply houses.

[4] ASTM Oil No. 1 was available from Penreco, 4426 E. Washington Blvd., Los Angeles, CA 90028; ASTM Fuel A and ASTM Fuel B are available from Chevron Phillips Co., 10001 Six Pines Drive, The Woodlands, TX 77380. Refer to Test Method D471 for further information regarding immersion test fluids.

[5] ASTM Oil No. 1 was used for original interlaboratory testing and has since been replaced with IRM 901 as approved by ASTM Committee D04-11. Users may continue to use ASTM Oil No. 1 but should be aware that IRM 901 from R.E. Carrol, Inc., P.O. Box 5806, Trenton, NJ 08638 is the commercially available replacement going forward.

[6] IRM 903 is available from R. E. Carrol, Inc., P. O. Box 5806, Trenton, NJ 08638. The user should be aware that results may differ. ASTM Oil No. 3 is no longer commercially available due to potential health risks associated with its use. IRM 903 has been approved by Committee D-11 as a replacement for ASTM Oil No. 3.

[7] Whatman Filter Paper No. 4 has demonstrated proper absorptive character for oils and is recommended to obtain repeatable results.

producer must be aware that different coolant mixtures may yield different results.

NOTE 1—Coolant mixtures are typically tested under boiling reflux conditions.

9.2 *Thickness*—Measure specimens with a thickness measuring device actuated by a dead-weight load. Graduate the dial in 0.0254-mm (0.001-in.) or smaller units; estimate readings to the nearest 0.00254 mm (0.0001 in.). The anvil shall have a diameter not less than that of the presser foot, which has a diameter of 6.4 ± 0.127 mm (0.252 ± 0.005 in.).

9.2.1 Loads and pressure shall be in accordance with Table 1.

9.2.2 Take readings by lowering the presser foot gently until it is in contact with the specimen. Take a sufficient number of readings, depending on the size of the specimen, to provide a reliable average value.

9.3 *Weight*—Determine the initial weight of a specimen by removing it from the conditions required after conditioning (Section 5) and placing it immediately in the tared weighing bottle. Measure the weight of the test specimen to the nearest 1 mg (0.001 g) and record where calculations for percentage of weight change are to be taken.

9.4 *Immersion in Fluids:*

9.4.1 *Elevated Temperature*—Place appropriate specimens in the test tubes or boiling flask, using only one material per test tube. Pour enough fresh fluid into the tube to completely cover the specimens and ensure that they are immersed. Insert the aluminum-foil covered stoppers into the test tubes before placing them in the supporting rack within the oven.

9.4.1.1 At the end of the test period, remove and immediately immerse the specimens in a cool (21 to 29°C (70 to 85°F)), fresh portion of the test fluid for 30 to 60 min. Then withdraw the specimens from the cooled-down test fluid and immediately blot the samples with sheets of blotting paper to remove excess liquid from the surfaces. Exercise care when removing the excess fluid so that no squeezing action occurs on the sample. Specimens over 0.79 mm (0.031 in.) in thickness should also be blotted on the edges.

9.4.2 *Room Temperature*—Place appropriate specimens in the immersion containers using pieces of light-metal screens to separate individual specimens of one test material from those of another and the bottom of the container, and also to ensure that the specimens remain immersed in the test fluid. Pour enough fresh test fluid over the specimens to ensure that the specimens are wetted and covered by the fluid. Use enough fluid to provide a minimum of 10 mL for each specimen in the container.

9.4.3 *Volatile Fluids*—When withdrawing specimens that have been immersed in a highly volatile fluid such as Fuel B, immediately test for the desired properties.

9.4.4 *Contamination*—Immersion tests should contain materials with similar chemistries to ensure that adjacent samples are not contaminated as a result of chemical breakdown. If such information is not available, then the material should be tested by itself in fresh fluid to determine compatibility with said fluid.

9.5 *Compressibility After Immersion*—After subjecting the specimens to immersion, test them in accordance with Test Method F36, except the time to apply the major load shall be between 5 and 10 s to avoid rupturing the test specimen.

9.6 *Tensile Strength After Immersion*—After subjecting the specimens to immersion in test fluid, test them in accordance with Test Methods F152 using the original dry measurements as as reference values.

9.7 *Thickness Change After Immersion*—Remeasure the specimens that were subjected to the immersion in test fluids to measure the change in thickness in accordance with the procedure in 9.2. The change in thickness of the specimens is to be calculated as an expression of percentage change from the original thickness.

NOTE 2—Great care must be taken to record the swollen thickness when the needle slows to a different rate which reflects indentation into the softened specimen.

9.8 *Flexibility After Immersion*—Test specimens which are to be measured for flexibility after immersion in fluids in accordance with the procedure in Test Method F147.

9.9 *Volume Change After Immersion*—Test specimens to be tested for volume change in accordance with Test Method D471. For materials having less than specific gravity 1.00, use the following procedure if a Jolly balance is employed:

9.9.1 Level and zero the Jolly balance and ensure it is properly shielded from drafts.

9.9.2 Attach a small metal sinker (about 5 g is usually sufficient) to the weighing hook so that it is totally immersed in water.

9.9.3 Weigh the specimen in air and record the scale reading, SR_1.

9.9.4 Then weigh the specimen in distilled water and record the scale reading, SR_2.

9.9.5 The original volume, V_1, then equals $SR_1 - SR_2$.

9.9.6 After removing the specimen from the test medium, repeat 9.9.3, 9.9.4, and 9.9.5. This gives the final volume, V_2. Change the distilled water used in the test frequently.

NOTE 3—**Caution:** Use the same sinker throughout.

9.9.6.1 Calculate the change in volume, V, as follows:

$$V = [(V_2 - V_1)/V_1] \times 100 \quad (1)$$

where:

V = change in volume, %,
V_2 = volume after removal from liquid, and
V_1 = original volume.

9.10 *Weight Change After Immersion*—Reweigh specimens that have been subjected to immersion in fluids using the procedure in accordance with 9.3. The change in weight of the specimens is to be calculated as an expression of percentage change on the original weight.

9.11 *Adhesion After Immersion for MLS or Metal Layer Gasket Material*—Test specimens of coated metal from Multi-Layer Steel, MLS, or Metal Layer Gasket Material subjected to immersion in fluids and tested for adhesion per ASTM D3359, Standard Test Methods for Measuring Adhesion by Tape Test.

TABLE 3 Interlaboratory Test Program

F104 Material Designation		Single Operator Repeatability, %	Multi-Laboratory Reproducibility, %
	Fluid, Thickness Change		
Type 1[A]			
(Class 1)	ASTM No. 3 Oil	5.02	25.7
(Class 2)		1.92	2.5
Type 3	ASTM No. 3 Oil	1.41	2.8
		1.41	2.8
Type 3	ASTM Fuel B	2.07	4.8
		1.39	4.0
Type 3	Distilled Water	1.34	4.9
		1.97	5.4
	Fluid, Weight Change		
Type 1[A]			
(Class 1)	ASTM No. 3 Oil	1.45	12.5
(Class 2)		2.78	5.7
	ASTM No. 3 Oil		
Type 3[B]			
Material A		1.58	5.9
Material B		2.16	7.2
	ASTM Fuel B		
Material A		1.56	3.8
Material B		1.82	5.7
	Distilled Water		
Material A		3.35	8.8
Material B		1.63	6.2
	Fluid, Volume Change		
Type 2	ASTM No. 3 Oil	2.5	9.4
	ASTM Fuel A	2.07	9.3

[A]Type 1 Class 1—A CA material, containing a normally higher swelling polymer.
Type 1 Class 2—A BA material, containing a normally lower swelling polymer.
[B]Type 3 Material A—A Class 3 material with an SBR polymer.
Type 3 Material B—A Class 3 material with an NBR polymer.

It is understood that the results will be reported per D3359 along with the specific immersion conditions used prior to said adhesion test. Other physical property tests described in this standard are not applicable for these materials.

10. Report

10.1 Report the following information:

10.1.1 A complete description including commercial designation, source, manufacturer, thickness, and date of production if known,

10.1.2 Date of testing, and

10.1.3 Type of fluids used.

10.2 Results are to be expressed in values with one significant decimal place for weight, volume, and thickness changes.

10.3 Results of other measurements are to be expressed in accordance with their respective test methods.

11. Precision and Bias[8]

11.1 *Precision, Part 1*—Eleven laboratories participated in the round-robin consisting of two materials in each of Types 1 and 3 designations and immersed in ASTM Oil No. 3;[9] and ASTM Oil No. 1, Fuel B, and distilled water, respectively, and Type 2 in ASTM Oil No. 3 and Fuel A.

11.2 Two variations of literally an infinite number of material combinations were selected as an index to develop precision measures for material designations within Classification F104 (not inclusive for Types 1 and 3).

11.3 Test results, which are an average of values for measurements on three specimens, should not be considered suspect at 95 % confidence level if they do not exceed the variability listed (in absolute percent values) in accordance with Table 3.

11.4 *Precision and Bias, Part 2*—Six laboratories participated in a round-robin evaluation of ten materials, which focused specifically on IRM 903. There were six Type 1,7, three Type 3, and one Type 5 material evaluated for immersion weight change and thickness change in IRM 903 oil.

11.4.1 Results were evaluated in accordance with Practice E691, and reported in Table 4.

12. Keywords

12.1 ASTM Fuel B; ASTM Oil No. 1; ASTM Oil No. 3; compressibility (in softened condition); distilled water; flexibility; fluid; gasket materials; immersions; IRM 901; IRM 903; Jolly balance; multi-layer steel (adhesion after immersion); tensile strength; thickness change; volume change; weight change

[8] Mandel, J., "Repeatability and Reproducibility," *Materials and Research and Standards Magazine*, ASTM, (1971). Supporting data are available from ASTM Headquarters. Request RR:F03-1008 and RR:F03-1015.

[9] ASTM oil #3 was used for original interlab testing and has since been replaced with IRM 903 as approved by the ASTM committee D04.

TABLE 4 Interlaboratory Test Program—Part 2(IRM 903)[A]

% Weight Change					
Material	Average	Sr	SR	r	R
Type 1,7 (NBR)	8.69	0.91	0.91	2.54	2.54
Type 1,7 (NBR)	13.94	1.46	1.46	4.08	4.08
Type 1,7 (NBR)	15.88	0.76	1.16	2.14	3.26
Type 1,7 (SBR)	28.81	1.37	1.37	3.83	3.83
Type 1,7 (SBR)	29.39	1.55	1.62	4.35	4.52
Type 1,7 (SBR)	32.17	1.50	1.50	4.20	4.20
Type 3 (NBR)	26.40	0.55	2.40	1.53	6.73
Type 3 (NBR)	66.47	2.44	19.77	6.83	55.37
Type 3 (SBR)	100.25	3.11	15.98	8.70	44.76
Type 5	42.98	1.84	2.00	5.14	5.59
% Thickness Change					
Material	Average	Sr	SR	r	R
Type 1,7 (NBR)	4.45	0.86	1.83	2.40	5.13
Type 1,7 (NBR)	1.68	0.93	0.93	2.61	2.61
Type 1,7 (NBR)	5.23	0.54	2.63	1.52	7.37
Type 1,7 (SBR)	27.94	1.15	2.76	3.22	7.74
Type 1,7 (SBR)	20.91	2.02	3.32	5.66	9.31
Type 1,7 (SBR)	33.30	0.59	13.76	1.65	38.52
Type 3 (NBR)	2.01	1.84	1.90	5.14	5.33
Type 3 (NBR)	7.78	1.17	8.06	3.27	22.56
Type 3 (SBR)	21.04	1.14	6.58	3.18	18.44
Type 5	5.22	1.13	2.03	3.17	5.69

[A]Key: r = repeatability, R = reproducibility, S = standard deviation.