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Standard Practice for Rubber IRM 901, IRM 902, and IRM 903 Replacement Oils for ASTM No. 1, ASTM No. 2, ASTM No. 3 Oils, and IRM 905 formerly ASTM No. 5 Oil[1]

This standard is issued under the fixed designation D5964; 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.

INTRODUCTION

Test Method D471 was revised in February 1995, establishing IRM 902 and IRM 903 as replacements for ASTM No. 2 and No. 3 immersion oils, respectively. Unlike ASTM No. 2 and No. 3 oils, the two IRM oils are severely hydrotreated, have a demonstrated negative Ames test and do not require cancer warning labels under the OSHA Hazard Communication Standard published in November 1983. Although it was attempted to match the effect of the ASTM oils on rubber properties in immersion testing as closely as possible, in general, neither of the IRM oils produces test results exactly identical to the ASTM oils it replaced.

Test Method D471 was again revised in October 2006, establishing IRM 901 as a replacement for ASTM No. 1 immersion oil. The replacement was necessitated by the sudden unavailability of ASTM No. 1 oil. Comprehensive research and development was conducted to establish a suitable replacement. A Precision and Bias statement will be prepared in accordance with Practice D4483 at the conclusion of a forthcoming interlaboratory test program and included in Test Method D471. Although an attempt was made to match the effect of the ASTM No. 1 oil on rubber properties in immersion testing as closely as possible, preliminary findings indicate that IRM 901 oil produces test results that are not identical to the ASTM oil it replaced. Please refer to Test Method D471, Table 1, for a description of the specific characteristics of IRM 901 and ASTM No. 1 oils.

The selections for replacement ASTM No. 2 and No. 3 oils were made on the basis of an objective comprehensive test program as described in this practice and decisions on the data generated in this program were made in open meetings of Subcommittee D11.15. The SAE Committee on Automotive Rubber Specifications (CARS) made a recommendation on the replacement oils that was identical to the decisions made by D11.15.

This practice addresses the need for establishing a correlation between test results obtained with IRM versus ASTM oils, based on results of the described test program. Although the test program was quite comprehensive, it cannot begin to address the numerous variations in compound recipes used in the rubber industry. Correlations established by this practice may therefore not always provide satisfactory results. In this case it is suggested that other approaches be used, such as a direct comparison of each specific rubber compound in the respective ASTM and IRM oils. All new specifications, including oil immersion testing, shall be established using IRM 901, IRM 902, and IRM 903 in place of ASTM No. 1, ASTM No. 2, and ASTM No. 3 oils, respectively.

1. Scope

1.1 This practice covers three immersion oils to be used as replacements for ASTM No. 1, No. 2, and No. 3 immersion oils as called for in Test Method D471. The immersion oils will be designated as IRM 901 as a replacement for ASTM No. 1 oil, IRM 902 as a replacement for ASTM No. 2 oil, and IRM 903 as a replacement for ASTM No. 3 oil. The new reference oils have been developed under a new Committee D11 policy on reference materials (see Practice D4678 for background on the new policy and procedures).

1.2 The oils, IRM 901, IRM 902, and IRM 903, are similar but not fully equivalent to ASTM No.1, ASTM No. 2, and

[1] This practice is under the jurisdiction of ASTM Committee D11 on Rubber and Rubber-like Materials and is the direct responsibility of Subcommittee D11.15 on Degradation Tests.

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TABLE 1 Specifications and Typical Properties of IRM Reference Oils

Property Specifications	IRM 901	IRM 902	IRM 903	IRM 905	ASTM Test Method
Specified Properties:					
Aniline point, °C (°F)	124 ± 1 (255 ± 2)	93 ± 3 (199 ± 5)	70± 1 (158 ± 2)	115 ± 1 (239 ± 2)	D611
Kinematic viscosity (mm^2/s (cSt))					
38°C (100°F)		...	31.9–34.1	...	D445
99°C (210°F)	18.12 – 20.34	19.2–21.5	...	10.8–11.9	D445
Gravity, API, 16°C (60°F)	28.8 ± 1	19.0–21.0	21.0–23.0	...	D287
Viscosity-Gravity constant	0.790 – 0.805	0.860–0.870	0.875–0.885	...	D2501
Flash point COC, °C (°F)	243 (469) min	240 (464) min	163 (325) min	243 (469) min	D92
Naphthenics, C_N (%)	27 avg	35 min	40 min	...	D2140
Paraffinics, C_P (%)	65 min	50 max	45 max	...	D2140
Typical Properties:					
Pour point, °C (°F)	–12 (10)	–15 (5)	–42.8 (–45)	–15 (5)	D97
ASTM Color	L 3.5	L 2.0	L 0.5	L 1.0	D1500
Refractive index	1.4848	1.5083	1.5004	1.4808	D1747
UV Absorbance, 260 nm	0.8	1.43	1.43	...	D2008
Aromatics, C_A (%)	3	10	12	4	D2140

ASTM No. 3 oil, respectively. Refer to Table 1 for a description of the typical properties and specifications for these oils.

1.3 ASTM No. 5 Oil was accepted into Specification D5900 as an industry reference material in 2010 and designated as IRM 905. The composition, and properties of this immersion oil were not changed and the data in Table 1 remains current. It was listed among the IRM immersion oils in Test Method D471 in 2010.

1.4 This practice gives the necessary background and details on the changeover from the previous oils to the new oils. See Annex A1 for additional information on the commercial oils selected to replace ASTM No. 2 and No. 3 oil and the test program conducted for this selection process. The changeover from ASTM to IRM oils is proposed in two steps:

1.4.1 *Step 1*—A transition phase that makes use of the Equivalent Volume Swell (EVS) for each of the two replacement oils. EVS(902) is the ASTM No. 2 percent volume swell value calculated from the measured percent volume swell value using IRM 902 as the immersion liquid. A similar calculation can be used to calculate the analogous EVS(903) and EVS(903) values. The EVS value is obtained as a correction of the measured IRM 901, 902, or 903 percent volume swell value. The EVS values may be used to determine if volume swell specifications are met when the specifications are expressed in terms of ASTM No. 1, No. 2, or No. 3 limits, and

1.4.2 *Step 2*—A longer term policy change or conversion of specifications from ASTM No. 1, No. 2, and No. 3 values to IRM 901, 902, and 903 values.

1.5 The EVS values are calculated on the basis of "correction equations" derived from one of two sources.

1.5.1 Correction equations derived from the results of the comprehensive evaluation program conducted to select each of the two replacement oils from a group of three candidate oils for ASTM No. 2 and No. 3 oils. This program is described in Annex A1.

1.5.2 Correction equations derived from in-house customized or specific testing programs to make direct comparisons of the volume swell (and other important properties) of the IRM and ASTM oils. These programs should be conducted in each laboratory of those organizations that engage in producer-user specification testing for rubber immersion performance.

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 appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D92 Test Method for Flash and Fire Points by Cleveland Open Cup Tester

D97 Test Method for Pour Point of Petroleum Products

D287 Test Method for API Gravity of Crude Petroleum and Petroleum Products (Hydrometer Method)

D412 Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension

D445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)

D471 Test Method for Rubber Property—Effect of Liquids

D611 Test Methods for Aniline Point and Mixed Aniline Point of Petroleum Products and Hydrocarbon Solvents

D1414 Test Methods for Rubber O-Rings

D1418 Practice for Rubber and Rubber Latices—Nomenclature

[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.

D1500 Test Method for ASTM Color of Petroleum Products (ASTM Color Scale)
D1747 Test Method for Refractive Index of Viscous Materials
D2000 Classification System for Rubber Products in Automotive Applications
D2008 Test Method for Ultraviolet Absorbance and Absorptivity of Petroleum Products
D2140 Practice for Calculating Carbon-Type Composition of Insulating Oils of Petroleum Origin
D2240 Test Method for Rubber Property—Durometer Hardness
D2501 Test Method for Calculation of Viscosity-Gravity Constant (VGC) of Petroleum Oils
D4052 Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter
D4483 Practice for Evaluating Precision for Test Method Standards in the Rubber and Carbon Black Manufacturing Industries
D4678 Practice for Rubber—Preparation, Testing, Acceptance, Documentation, and Use of Reference Materials
D5900 Specification for Physical and Chemical Properties of Industry Reference Materials (IRM)

3. Significance and Use

3.1 The reference immersion oils described in this practice are required for the development of oil-resistant rubber compounds for use in environments where contact with petroleum-based solvents and oils is encountered. Tests for tensile strength, percent elongation at break, hardness, and percent volume swell are performed after a specified immersion time period (at a specified temperature) in the evaluation of oil-resistant rubbers. The results of such testing by rubber product manufacturers and their customers are used to develop oil-resistant rubbers or compounds, or both.

3.2 Testing with ASTM Oils No. 1, No. 2, and No. 3 is used to verify compliance with purchase specifications which reference the oil-resistant classes of rubbers and elastomers listed in Table 6 of Classification D2000. These oils are also used in comparative performance evaluation testing of O-rings and O-ring compounds as cited in Test Methods D1414. The use of these reference oils is required for the development and selection of oil-resistant rubber compounds having acceptable or optimum performance characteristics, or both.

4. Specifying IRM 901, 902, and 903 Reference Immersion Oils

4.1 The two oils selected to replace ASTM No. 2 and ASTM No. 3 immersion oils, designated IRM 902 and IRM 903, respectively, were selected on the basis of the closest match to ASTM No. 2 and ASTM No. 3 oils in the comprehensive evaluation program as outlined in Annex A1.[3]

4.2 The oil selected to replace ASTM No. 1 immersion oil was selected on the basis of the closest match to ASTM No. 1 oil in an evaluation program and designated as IRM 901.

4.3 The (petroleum) specifications and typical properties of IRM 901, 902, and 903 are given in Table 1.

5. Converting ASTM Oil to IRM Oil Volume Swell Values

5.1 *Basis of Conversion*—One of the important issues for any user of the IRM oils, especially producer-consumer operations, is the relationship and conversion of the customary ASTM oil volume swell values for proprietary and commercial compounds to volume swell values for the new IRM oils. As outlined in the scope, this can be done on the basis of two approaches.

5.1.1 Calculating EVS values for IRM 901, IRM 902, or IRM 903 for any commercial compound based on (*1*) selecting from Table A1.1 and Appendix X1, the compound nearest to the commercial compound in composition, and (*2*) using the percent difference (PC d) value for this compound in the conversion or correction calculation. This EVS value is an approximate value.

5.1.2 Organizing a special in-house testing program to obtain volume swell values under the appropriate conditions (time and temperature of immersion) for the selected ASTM and IRM oils for the proprietary or commercial compounds of interest. Once data for both oils are obtained, the relationship between the two oils is established.

5.1.3 If needed for future applications, calculations can be made to correct or convert the ASTM values to the IRM values or vice-versa for other compounds where the correction can be legitimately applied. This approach gives corrections that are specific to the compounds of interest; it is direct and substantially more accurate than the approximate approach and is the recommended conversion procedure for exact and critical specification applications if corrections of this sort are required.

5.2 *Conversion Using the EVS Procedure*—Two procedures are given: (*1*) for converting IRM values to equivalent ASTM values, and (*2*) for converting ASTM values to IRM values. The second operation may be of value in converting existing ASTM value specifications to IRM value specifications as the old ASTM oil specification values are phased out.

[3] The sole source of supply of the reference immersion oils (IRM 901, IRM 902, and IRM 903) known to the committee at this time is R. E. Carroll, Inc., P.O. Box 5806, Trenton, NJ 08638-0806. 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,[1] which you may attend.

5.2.1 Eq 1 gives the EVS(902) value, the equivalent ASTM No. 2 oil percent volume swell value for IRM 902 oil, based on measured volume swell data in IRM 902 and data in Table A1.1 of Annex A1.

$$EVS(902) = \frac{MVS(902)}{\left(1 + \frac{PC\,d_1}{100}\right)} \quad (1)$$

where:

EVS (902) = EVS (approximate) for IRM 902 oil,
MVS (902) = measured percent volume swell in IRM 902 oil, and
PC d_1 = difference between volume swells in IRM 902 oil and ASTM No. 2 oil expressed as a relative percentage (from Table A1.1, selected in accordance with 5.1.1).

5.2.2 Eq 2 may be used for converting IRM values to ASTM values for compounds of commercial interest on the same basis as described above.

$$EVS(No.\ 2) = \frac{MVS(No.\ 2)}{\left(1 + \frac{PC\,d_2}{100}\right)} \quad (2)$$

where:

EVS (No. 2) = EVS (approximate) for ASTM No. 2 oil,
MVS (No. 2) = measured percent volume swell in ASTM No. 2 oil, and
PC d_2 = difference between volume swells in ASTM No. 2 oil and IRM 902 oil expressed as a relative percentage (from Table A1.1, selected in accordance with 5.1.1 (Note 1)).

NOTE 1—By definition PC d_2 = –PC d_1.

5.2.3 Eq 1 and Eq 2 may be used for IRM 901/ASTM No. 1 and IRM 903/ASTM No. 3 conversions or corrections by changing the parentheses values.

6. Testing Precision

6.1 Although a precision statement is not a mandatory section in a practice, the precision of volume swell testing is an important issue for the conversion from the original ASTM oils to the IRM oils. Annex A2 gives a review of the precision results obtained from the comprehensive program outlined in Annex A1. Refer to Annex A2 for precision information.

7. Keywords

7.1 ASTM oils; immersion tests; IRM oils; reference oils

ANNEXES

(Mandatory Information)

A1. BRIEF SUMMARY OF EVALUATION PROGRAM TO SELECT IRM 902 AND IRM 903

A1.1 Program Organization

A1.1.1 A comprehensive testing program was organized in early 1993 to evaluate three candidate immersion oils (commercially supplied by different manufacturers) for ASTM No. 2 oil and three candidate oils for ASTM No. 3 oil. The program consisted of evaluating each of the candidate oils along with the reference ASTM oil for their influence on compound physical properties in twelve typical oil-resistant rubber compounds, each prepared with a different rubber. Four properties were measured after 70 h immersion for each of the compounds: tensile strength, in MPa and percent elongation in accordance with Test Methods D412; hardness (Type A) in accordance with Test Method D2240; and percent volume swell in accordance with Test Method D471.

A1.1.2 The program was conducted in nine laboratories to prevent an undue burden on any one laboratory to conduct all the immersion and physical tests. The nine laboratories were divided into three groups and in each group one set of four rubber compounds was tested. The program was conducted to give duplicate test results to obtain a typical "Day 1—Day 2" estimate of test error for within-laboratory variation (repeatability) within each group. Between-laboratory variation was not assessed because the number of laboratories is too small to obtain a realistic reproducibility. A test result (obtained on each of the two days one week apart) is defined as the mean or median of the number of individual determinations as specified by each test method.

A1.1.3 The rubbers in each group and the immersion temperatures (70 h at each temperature) were as given below. Appendix X1 gives the formulations for the twelve compounds and identifies the rubbers according to the acronym (specified in Practice D1418) used for each base rubber.

A1.1.3.1 *Immersion at 100°C*—CR, ECO, NBR, TPV,

A1.1.3.2 *Immersion at 125°C*—EPDM, ACM, AEM, EVM, and

A1.1.3.3 *Immersion at 150°C*—FKM, FVMQ, HNBR, VMQ.

A1.2 Evaluation Program Results

A1.2.1 From the results of this comprehensive evaluation program two commercial oils were selected as the closest match to ASTM No. 2 and ASTM No. 3 oil, respectively. These two selected oils will be referred to as IRM 902 and IRM 903 in the remainder of this practice. A formal report on the