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100 Barr Harbor Dr., West Conshohocken, PA 19428
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Standard Practice for Rubber IRM 902 and IRM 903 Replacement Oils for ASTM No. 2 and ASTM No. 3 Oils¹

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INTRODUCTION

Test Method D 471 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.

The selections for replacement 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 902 and IRM 903 in place of ASTM No. 2 and No. 3 oils, respectively.

1 Scope

1.1 This practice covers two new immersion oils to be used as replacements for ASTM No. 2 and No. 3 immersion oils as called for in Test Method D 471. The new immersion oils will be designated as 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 D-11 policy on reference materials (see Practice D 4678 for background on the new policy and procedures).

1.2 The new oils, IRM 902 and IRM 903, are similar but not fully equivalent to ASTM No. 2 and ASTM No. 3 oil, respectively.

1.3 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 the two ASTM oils and the test program conducted for this selection process. The changeover from

ASTM to IRM oils is proposed in two steps:

1.3.1 *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) value. Either EVS value is obtained as a correction of the measured IRM 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. 2 or No. 3 limits, and

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

1.4 The EVS values are calculated on the basis of “correction equations” derived from one of two sources.

1.4.1 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 each ASTM oil. This program is described in Annex A1.

¹ This practice is under the jurisdiction of ASTM Committee D-11 on Rubber and is the direct responsibility of Subcommittee D11.15 on Degradation Tests.
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1.4.2 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 two 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.

1.5 *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:

- D 92 Test Method for Flash and Fire Points by Cleveland Open Cup²
- D 97 Test Method for Pour Point of Petroleum Products²
- D 287 Test Method for API Gravity of Crude Petroleum and Petroleum Products (Hydrometer Method)²
- D 412 Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers—Tension³
- D 445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and the Calculation of Dynamic Viscosity)²
- D 471 Test Method for Rubber Property—Effect of Liquids³
- D 611 Test Methods for Aniline Point and Mixed Aniline Point of Petroleum Products and Hydrocarbon Solvents²
- D 1414 Test Methods for Rubber O-Rings⁴
- D 1418 Practice for Rubber and Rubber Latexes—Nomenclature³
- D 1500 Test Method for Color of ASTM Petroleum Products (ASTM Color Scale)²
- D 1747 Test Method for Refractive Index of Viscous Materials²
- D 2000 Classification System for Rubber Products in Automotive Applications⁴
- D 2008 Test Method for Ultraviolet Absorbance and Absorptivity of Petroleum Products²
- D 2140 Test Method for Carbon-Type Composition of Insulating Oils of Petroleum Origin⁵
- D 2240 Test Method for Rubber Property—Durometer Hardness³
- D 4483 Practice for Determining Precision for Test Method Standards in the Rubber and Carbon Black Industries³
- D 4678 Practice for Rubber—Preparation, Testing, Acceptance, Documentation, and Use of Industry Reference Materials³

3 Significance and Use

3.1 The two 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. 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 D 2000. These oils are also used in comparative performance evaluation testing of O-rings and O-ring compounds as cited in Test Methods D 1414. 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 902 and IRM 903 Reference Immersion Oils

4.1 The two oils selected to replace ASTM No. 2 and ASTM No. 3 immersion oils have commercial names.⁶ These new oils 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.

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

5. Converting “ASTM Oil-IRM Oil” Volume Swell Values

5.1 *Basis of Conversion*—One of the important issues for any user of the new 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 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

² Annual Book of ASTM Standards, Vol 05.01.

³ Annual Book of ASTM Standards, Vol 09.01.

⁴ Annual Book of ASTM Standards, Vol 09.02.

⁵ Annual Book of ASTM Standards, Vol 10.03.

⁶ Cal-2, designated as IRM 902, and Cal-3, designated as IRM 903, are manufactured by Calumet Lubricants Co., HC 62 Box 460, Princeton, LA 71067. The new reference immersion oils, IRM 902 and IRM 903, are distributed for the manufacturer by R. E. Carroll, Inc., P.O. Box 5806, Trenton, NJ 08638-0806, and Penreco Co., 4426 E. Washington Blvd., Los Angeles, CA 90023-4476.

TABLE 1 Specifications and Typical Properties of IRM Reference Oils

Property Specifications	ASTM Test Method	IRM 902	IRM 903
Aniline point, °C (°F)	D 611	93 ± 3 (199 ± 5)	70 ± 1 (158 ± 2)
Kinematic viscosity (mm ² /s (cSt))			
38°C (100°F)	D 445	...	31.9–34.1
99°C (210°F)	D 445	19.2–21.5	...
Gravity, API, 16°C (60°F)	D 287	19.0–21.0	21.0–23.0
Viscosity-Gravity constant	D 2140	0.860–0.870	0.875–0.885
Flash point COC, °C (°F)	D 92	240 (464) min	163 (325) min
Naphthenics, C _N (%)	D 2140	35 min	40 min
Paraffinics, C _P (%)	D 2140	50 max	45 max
Typical Properties			
Pour point, °C (°F)	D 97	–12 (10)	–31 (–24)
ASTM Color	D 1500	L 2.5	L 0.5
Refractive index	D 1747	1.5105	1.5026
UV Absorbance, 260 nm	D 2008	4.0	2.2
Aromatics, C _A (%)	D 2140	12	14

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.

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.

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

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.

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

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 903 and 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 new 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 D 412; hardness (Shore A) in accordance with Test Method D 2240; and percent volume swell in accordance with Test Method D 471.

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"