SURFACE VEHICLE STANDARD

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Standard Reference Elastomers (SREs) for Characterizing the Effect of Liquids on Vulcanized Rubbers

RATIONALE

This standard has modified under a cadence of normal review and to update formatting, SRE formulas, footnotes, chemical manufacturers/distributors, and ASTM standard callouts. Due to low demand, various SREs have also been discontinued.

FOREWORD

The development of these standard reference elastomers (SREs) is based on static and dynamic automotive fluid sealing applications for passenger cars and light-duty trucks.

1. SCOPE

This SAE Standard specifies requirements for vulcanized rubbers in sheet form for use as standards in characterizing the effect of test liquids and service fluids. The appendices contain the standard reference elastomer formulas.

The property changes of the SRE in contact with the indicated fluid under specified test conditions are the responsibility of the user. See 7.3 and Table 1.

This standard is not designed to provide formulations of elastomeric product compositions for actual service.

1.1 Safety

This standard may involve hazardous materials, operations, and equipment. It does not address the safety concerns which may be associated with its use. It is the responsibility of any user of this standard to consult and establish appropriate health and safety practices, and determine the applicability of regulatory limitations before use.

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2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM D412 Standard for Vulcanized Rubber and Thermoplastic Elastomers - Tension

ASTM D471 Standard for Rubber Property - Effect of Fluids

ASTM D1349 Standard Practice for Rubber - Standard Temperatures for Testing

ASTM D1418 Standard Practice for Rubber and Rubber Latices - Nomenclature

ASTM D3182 Standard Practice for Rubber - Materials, Equipment, and Procedures for Mixing Standard Compounds and Preparing Standard Vulcanized Sheets

ASTM D3767 Standard Practice for Rubber - Measurement of Dimensions

ASTM D4678 Standard Practice for Rubber - Preparation, Testing Acceptance, Documentation, and Use of Reference Materials

2.1.2 ISO Publications

Copies of these documents are available online at https://webstore.ansi.org/.

ISO 1629 Rubber and Latices - Nomenclature

ISO 2230 Vulcanized Rubber Property - Guide to Storage

3. SRE COMPOSITION

3.1 The recommended mixing procedures and specified properties are from the identified materials in the appendices.

3.2 The compounding and preparation ensure the property profile:

a. Agrees sufficiently with the material group and applications it represents;

b. Exhibits reasonable “sensitivity” to designated fluid additive and base stock changes; and

c. Is consistent for reliable reproducibility.

3.3 SRE compound materials must be readily available worldwide.

4. SUMMARY OF PREPARATION

4.1 Each compound shall be a homogeneous mix of all materials shown in the appendices, weighed to the accuracy required in ASTM D3182.

4.2 The mixing of compounds and vulcanization of test sheets follow ASTM D3182, modified to details given in each annex condition and procedure.

4.3 Approved Mixing and Distribution Facilities

4.3.1 An SRE by definition is mixed only by approved designated facilities authorized to mix and distribute these compounds. See 4.3.2.

4.3.2 Approved Facility

Akron Rubber Development Lab, 2887 Gilchrist Road, Akron, OH 44305.

4.3.3 Labs can mix approved SRE formulations for internal use only.

5. REQUIREMENTS AND TESTING

5.1 Sheet Dimensions

The vulcanized sheets meet ASTM D3182 Figure 1 mold cavity dimensions measured to ASTM D3767.

5.1.1 All sheets are tested for thickness. One test sheet from each lot (all sheets from a single batch vulcanized under the same conditions) is tested for the specified properties for compliance with the tolerances given in the appendices.

5.2 Sheet Appearance

The molded sheet must be free of any surface defects or internal voids observed with normally corrected vision.

5.3 Identification

Using mold marks or visible, durable ink, mark each sheet along one edge with the ASTM D1418/ISO 1629 nomenclature letters with SRE formulation number, mix number, lot number, and grain direction (arrow). Separate each item with a slash (/) mark (see Figure 1).

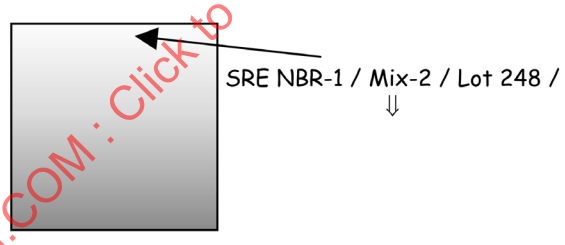

Figure 1 - Identification protocol of test slabs example

5.4 Lot Testing

A sufficient number of molded test sheets from each lot (all sheets from a single batch vulcanized under the same conditions) is tested for compliance to specified properties using the appropriate test (see 7.1).

5.4.1 Each shipped lot will include the approved lab(s) certification that the material complies with its annex requirements.

5.4.2 Test specimens are cut 15mm in from the sheet edge, with the longitudinal axis parallel to the sheet grain direction.

5.4.3 Test 5 specimens for each physical property, and 5 specimens for volume change.

6. STORAGE

6.1 Test sheets are stored in accordance with ISO 2230. After 1 year, they are retested or discarded.

6.2 When the composition of any SRE is revised or changed, authorized lab(s) shall not discard stored test sheets for that SRE until new changes are approved by SAE Committee on Automotive Rubber Specifications (CARS).

6.3 In the event SRE changes are made, do not distribute the previous SRE formulation, except for comparative purposes. Authorized lab(s) will phase in the revised SRE when changes are approved.

7. APPLICATION

7.1 Development of SRE

Candidate selection (sensitivity) is based on percent change per ASTM D412, die C, tensile strength, elongation at break, and tensile stress at 50%. ASTM D471 percent volume change rounds out the requirements. Hardness measurements may be made but evidence from the Inter Lab Test program indicates that hardness is much less sensitive to differences in “rubber stiffness” compared to 50% modulus.

7.1.1 Test conditions reflect OEM automotive fluid system requirements and the material classification limits. Test temperature conditions follow ASTM D1349 practice. To achieve equilibrium, immerse test specimens 168 hours or longer (as designated).

7.1.2 For each material classification, the tester should be aware of the effect of aeration on a candidates physical properties during immersion testing. Use the fluid treatment (static or aerated) most representative of the intended use. Appendix tables are based on static immersion.

7.2 Test Fluid

Use ASTM Service Liquid 107 (ASTM SL107) to evaluate SRE candidate selection and establish a property loss baseline for engine oil applications using the properties in 7.1. ASTM SL107 is available from the ASTM Test Monitoring Center, 6555 Penn Ave., Pittsburgh, PA 15206.

7.3 Appendices A through H

Appendices A through G gives all formulations for the selected SREs of this standard. Appendix H provides a summary table for SRE properties. Part 1 contains delta or percent change in property values for each SRE after immersion for 168 hours in ASTM Service Fluid 105 at temperatures as specified in Table 1. Part 2 contains the original properties for each SRE prior to immersion. The summary table results were obtained in an interlaboratory test program with all of the SREs as listed in the annex and table using data from eight typical industry laboratories. Prior to the final analysis as indicated in the summary table, outlier values were deleted.

7.3.1 The interlaboratory test program did not contain a sufficiently large database to obtain interlaboratory standard deviations based on 20 or more degrees of freedom, DF. Thus the value equivalent to the classical or standard (±) 3 sigma limit (at the DF applicable to each SRE), is defined in the table as t*SDev, where t is the tabulated 95% confidence or p=0.05 level t value at the DF applicable to the standard deviation, SDev, as evaluated in the test program.

Table 1 - SRE test temperature

SRE	Temperature (°C)
NBR-1, NBR-2	100
All others	150

7.4 Appendix I

Appendix I provides protocol for creation, maintenance and control of formulations for the selected SREs of this standard.

8. NOTES

8.1 Revision Indicator

A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

PREPARED BY SAE COMMITTEE ON AUTOMOTIVE RUBBER SPECS

APPENDIX A

A.1 NITRILE RUBBER

A.1.1 Standard formulas for the following nitrile rubber compounds are given in Tables A2 and A3:

Table A1 - NBR cure types

Number	Type
NBR-1	Sulfur-cured
NBR-2	Peroxide-cured

A.1.2 SREs shall be weighed in accordance with Section 5 of ASTM D3182 and mixed in accordance with Section 7 of ASTM D3182.

A.1.3 Recommended Standard Tensile Sheet Cures

Cure NBR-1 specimen 10 minutes at 168 °C (335 °F). No post-cure.

Cure NBR-2 specimen 10 minutes at 182 °C (360 °F). No post-cure.

A.1.4 Composition

Table A2 - Composition of SRE NBR-1

Ingredient	Parts by Mass
NBR with 28 ± 0.5% by mass of acrylonitrile(1)	100.0
Zinc oxide(2)	5.0
Stearic acid	2.0
STANGARD 500(3)	2.0
Carbon black N774	70.0
PLASTHALL 7050(4)	5.0
SPIDER Sulfur(5)	0.5
N-Cyclohexyl-2-benzothiazolesulphenamide (CBTS)	1.0
Tetramethyl thiuram disulfide (TMTD)	1.0
Tetraethyl thiuram disulfide (TETD)	1.0
Total	187.5

(1) NIPOL DN2850, Zeon Chemicals, Inc. No equivalent known.
(2) Zinc oxide 77HT, activator, HB Chemical or equivalent.
(3) Blend from Harwick standard.
(4) Monomeric plasticizer, Hallstar Company. No equivalent.
(5) Vulcanizing agent, Hallstar Company or equivalent.

Table A3 - Composition of SRE NBR-2

Ingredient	Parts by Mass
NBR with 28 ± 0.5% by mass of acrylonitrile(1)	100.0
Zinc oxide(2)	5.0
Stearic acid	2.0
STANGARD 500(3)	2.0
Carbon black N774	70.0
PLASTHALL 7050(4)	5.0
40% Dicumyl peroxide on Burgess KE Clay(5)	3.0
Total	187.0

(1) NIPOL DN2850, Zeon Chemicals, Inc. No equivalent known.
(2) Zinc oxide 77HT, activator, HB Chemical or equivalent.
(3) Blend from Harwick standard.
(4) Monomeric plasticizer, Hallstar Company. No equivalent.
(5) DICUP 40 KE, vulcanizing agent, Harwick Standard Distribution Corp. or equivalent.

APPENDIX B

B.1 POLYACRYLATE RUBBER

B.1.1 Standard formulas for the following polyacrylate rubber compounds are given in Tables B2 and B3:

Table B1 - ACM cure type

Number	Type
ACM-1	Sodium stearate-cured
ACM-2	Diamine DOTG free cure system

B.1.2 SREs shall be weighed in accordance with Section 5 of ASTM D3182 and mixed in accordance with Section 7 of ASTM D3182.

B.1.3 Recommended Standard Tensile Sheet Cures

Cure ACM-1 specimen 10 minutes at 170 °C (338 °F). No post-cure.

Cure ACM-2 specimen 6 minutes at 190 °C (374 °F). Post-cure 4 hours at 177 °C (350 °F).

B.1.4 Composition

Table B2 - Composition of SRE ACM-1

Ingredient	Parts by Mass
Acrylic rubber(1)	100.0
Stearic acid	1.0
4,4'-Bis(α,α-dimethylbenzyl)diphenylamine(2)	2.0
Carbon black N550	80.0
Sodium stearate	4.0
conc. fatty acid ester(3)	2.0
HyTemp NPC-25(4)	4.0
Total	191.0

(1) HYTEMP 4052, Zeon Chemicals, Inc. No equivalent known.
(2) Naugard 445, antioxidant, Akrochem Corp. or equivalent.
(3) Process aid, Struktol WB222. No equivalent.
(4) Vulcanizing agent, Zeon Chemicals, Inc. No equivalent.

Table B3 - Composition of SRE ACM-2

Ingredient	Parts by Mass
Acrylic rubber(1)	100.0
Stearic acid	1.0
4,4'-Bis(α,α-dimethylbenzyl)diphenylamine(2)	2.0
Polyoxyethylene stearyl ether phosphate(3)	0.5
Carbon black N550	65.0
Octadecylamine(4)	0.5
Hexamethylenediamine Carbamate (HMDC)	0.6
Rhenogran XLA-60(5)	2.0
Total	171.6

(1) HYTEMP AR12, Zeon Chemicals, Inc. No equivalent known.
(2) Naugard 445, antioxidant, Akrochem Corp. or equivalent.
(3) VANFRE VAM, processing aid, Vanderbilt Chemicals, LLC. or equivalent.
(4) ARMEEN 18D, processing aid, Akzo Nobel or equivalent.
(5) DOTG free vulcanizing agent from Rhein Chemie. No equivalent.

APPENDIX C

C.1 ETHYLENE ACRYLIC RUBBER

C.1.1 Standard formulas for the following ethylene acrylic rubber compounds are given in Tables C2, C3, and C4:

Table C1 - AEM cure type

Number	Type
AEM-1	DOTG- diamine cured
AEM-2	DOTG-free cured AEM G
AEM-3	DOTG-free cured AEM GLS

C.1.2 SREs shall be weighed in accordance with Section 5 of ASTM D3182 and mixed in accordance with Section 7 of ASTM D3182.

C.1.3 Recommended Standard Tensile Sheet Cures

Cure AEM-1, AEM-2, and AEM-3 specimens 5 minutes at 177 °C (350 °F). Post-cure 4 hours at 175 °C (347 °F).

C.1.4 Composition

Table C2 - Composition of SRE AEM-1

Ingredient	Parts by Mass
VAMAC® G(1)	100.0
4,4'-Bis(α,α-dimethylbenzyl)diphenylamine(2)	2.0
Stearic acid	1.5
Octadecylamine(3)	0.5
Polyoxyethylene stearyl ether phosphate(4)	1.0
Carbon black N550	60.0
Hexamethylenediamine Carbamate (HMDC)	1.5
di-o-tolylguanidine (DOTG)	4.0
Total	170.5

(1) VAMAC® is a registered tradename for ethylene/acrylic rubber from Celanese. No equivalent known.
(2) Naugard 445, antioxidant, Akrochem Corp. or equivalent.
(3) ARMEEN 18D, processing aid, Akzo Nobel or equivalent.
(4) VANFRE VAM, processing aid, R.T. Vanderbilt Company, Inc. or equivalent.

Table C3 - Composition of SRE AEM-2

Ingredient	Parts by Mass
VAMAC® G[1]	100.0
4,4'-Bis(α,α-dimethylbenzyl)diphenylamine[2]	2.0
Stearic acid	1.5
Octadecylamine[3]	0.5
Polyoxyethylene stearyl ether phosphate[4]	1.0
Carbon black N550	55.0
Hexamethylenediamine Carbamate (HMDC)	1.2
ACT 55[5]	2.0
Plasticizer TP 759[6]	10.0
Total	173.2

(1) VAMAC® is a registered tradename for ethylene/acrylic rubber from Celanese. No equivalent.
(2) Naugard 445, antioxidant, Akrochem Corp. or equivalent.
(3) ARMEEN 18D, processing aid, Akzo Nobel or equivalent.
(4) VANFRE VAM, processing aid, Vanderbilt Chemicals, LLC or equivalent.
(5) Vulcofac ACT 55, DOTG free accelerator from Chem Spec - distributor for Safic Alcan. No equivalent.
(6) Plasticizer, Hallstar Company. No equivalent.

Table C4 - Composition of SRE AEM-3

Ingredient	Parts by Mass
VAMAC® GLS[1]	100.0
4,4'-Bis(α,α-dimethylbenzyl)diphenylamine[2]	2.0
Stearic acid	1.5
Octadecylamine[3]	0.5
Polyoxyethylene stearyl ether phosphate[4]	1.0
Carbon black N550	55.0
Hexamethylenediamine Carbamate (HMDC)	1.3
ACT 55[5]	2.0
Plasticizer TP 759[6]	10.0
Total	173.3

(1) VAMAC® is a registered tradename for ethylene/acrylic rubber from Celanese. No equivalent.
(2) Naugard 445, antioxidant, Akrochem Corp. or equivalent.
(3) ARMEEN 18D, processing aid, Akzo Nobel or equivalent.
(4) VANFRE VAM, processing aid, Vanderbilt Chemicals, LLC or equivalent.
(5) Vulcofac ACT 55, DOTG free from Chem Spec - distributor for Safic Alcan. No equivalent.
(6) Plasticizer, Hallstar Company. No equivalent.

APPENDIX D

D.1 HYDROGENATED NITRILE RUBBER

D.1.1 Standard formulas for the following hydrogenated nitrile rubber compounds are given in Table D2:

Table D1 - HNBR cure type

Number	Type
HNBR-1	Peroxide-cured

D.1.2 SREs shall be weighed in accordance with Section 5 of ASTM D3182 and mixed in accordance with Section 7 of ASTM D3182.

D.1.3 Recommended Standard Tensile Sheet Cures

Cure HNBR-1 specimen 10 minutes at 177 °C (350 °F). No post-cure.

D.1.4 Composition

Table D2 - Composition of SRE HNBR-1

Ingredient	Parts by Mass
HNBR with 36 ± 0.5% by mass of nitrile groups and ~5% of residual double bonds[1]	100.0
Zinc oxide[2]	5.0
Stearic acid	0.5
4,4'-Bis(α,α-dimethylbenzyl)diphenylamine[3]	1.5
Zinc 2-mercapto-toluimidazole[4]	1.0
Carbon black N774	50.0
Trioctyl trimellitate[5]	5.0
40% a,a'-bis-(t-butyl peroxy) diisopropylbenzene on Burgess KE Clay[6]	8.0
Total	171.0

(1) ZETPOL 2010, Zeon Chemicals, Inc. No equivalent known.
(2) Zinc Oxide 77HT, activator, HB Chemical or equivalent.
(3) Naugard 445, antioxidant, Akrochem Corp. or equivalent.
(4) VANOX ZMTI, antioxidant, Vanderbilt Chemicals, LLC or equivalent.
(5) PLASTHALL TOTM, plasticizer, Hallstar Company,or equivalent.
(6) VULCUP 40KE, vulcanizing agent, Harwick Standard Distribution Corp. or equivalent.

APPENDIX E

E.1 SILICONE RUBBER

E.1.1 Standard formulas for the following silicone rubber compounds are given in Table E2:

Table E1 - VMQ cure type

Number	Type
VMQ-1	Peroxide-cured

E.1.2 SREs shall be weighed in accordance with Section 5 of ASTM D3182 and mixed in accordance with Section 7 of ASTM D3182.

E.1.3 Recommended Standard Tensile Sheet Cures

Cure VMQ-1 specimen 10 minutes at 177 °C (350 °F). No post-cure.

E.1.4 Composition

Table E2 - Composition of SRE VMQ-1

Ingredient	Parts by Mass
Vinyl methyl silicone base polymer(1)	40.0
Vinyl methyl silicone base polymer(2)	60.0
Thermal stabilizing additive(3)	1.0
Magnesium oxide	3.0
50% 2,5-dimethyl-2,5-di (tertbutylperoxy) hexane(4)	1.0
Total	105.0

(1) RBB 2000-35, Dow Corning. No equivalent known.
(2) RBB 2001-65, Dow Corning. No equivalent known.
(3) RBB 9002, Dow Corning or equivalent.
(4) VAROX DBPH-50, vulcanizing agent, Vanderbilt Chemicals, LLC or equivalent.

APPENDIX F

F.1 FLUOROSILICONE RUBBER

F.1.1 Standard formulas for the following fluorosilicone rubber compounds are given in Table F2:

Table F1 - FVMQ cure type

Number	Type
FVMQ-1	Peroxide-cured

F.1.2 SREs shall be weighed in accordance with Section 5 of ASTM D3182 and mixed in accordance with Section 7 of ASTM D3182.

F.1.3 Recommended Standard Tensile Sheet Cures

Cure FVMQ-1 specimen 10 minutes at 177 °C (350 °F). Post-cure 4 hours at 200 °C (392 °F).

F.1.4 Composition

Table F2 - Composition of SRE FVMQ-1

Ingredient	Parts by Mass
Fluoro-vinyl methyl silicone base polymer(1)	100.0
Thermal stabilizing additive(2)	1.0
50% 2,5-dimethyl-2,5-di (tertbutylperoxy) hexane(3)	1.0
Total	102.0

(1) Dow Corning Silicones LS-2860. No equivalent known.
(2) RBB 9002, Dow Corning or equivalent.
(3) VAROX DBPH-50, vulcanizing agent, R.T. Vanderbilt Company, Inc. or equivalent.

APPENDIX G

G.1 FLUOROCARBON RUBBER

G.1.1 Standard formulas for the following fluorocarbon rubber compounds are given in Tables G2, G3, G4, and G5:

Table G1 - FKM cure type

Number	Type
FKM-1	Type 2, Bisphenol AF cure, 68% fluorine
FKM-2	Type 1, Bisphenol AF cure, 66% fluorine
FKM-3	Type 2, Peroxide cure, 68% fluorine
FKM-4	Type 3, Low Temp, T_g at -30°C, Peroxide cure

G.1.2 SREs shall be weighed in accordance with Section 5 of ASTM D3182 and mixed in accordance with Section 7 of ASTM D3182.

G.1.3 Recommended Standard Tensile Sheet Cures

Cure FKM-1 specimen 10 minutes at 177 °C (350 °F). Post-cure 24 hours at 200 °C (392 °F).

Cure FKM-2 specimen 10 minutes at 177 °C (350 °F). Post-cure 16 hours at 232 °C (450 °F).

Cure FKM-3 and FKM-4 specimens 10 minutes at 177 °C (350 °F). Post-cure 4 hours at 232 °C (450 °F).

G.1.4 Composition

Table G2 - Composition of SRE FKM-1

Ingredient	Parts by Mass
Type 2, Bisphenol AF cure, 68% fluorine(1)	97.5
Calcium hydroxide	3.0
Magnesium Oxide(2)	6.0
N990 MT Carbon Black(3)	25.0
VC 20(4)	0.5
VC 50(5)	2.0
VPA-1(6)	1.0
Total	135.0

(1) Viton B600 from Chemours Company. No equivalent.
(2) Elastomag 170 from Akrochem. No equivalent.
(3) Thermax Flowform from Cancarb, Ltd. No equivalent.
(4) Curative from Chemours Company. No equivalent.
(5) Curative from Chemours Company. No equivalent.
(6) Processing aid from Chemours Company. No equivalent.

Table G3 - Composition of SRE FKM-2

Ingredient	Parts by Mass
Type 1, Bisphenol AF cure, 66% Fluorine(1)	100.0
Calcium Hydroxide HP-XL(4)	6.0
Magnesium Oxide(2)	3.0
N990 MT Carbon Black(3)	30.0
Total	139.0

(1) Viton A401C from Chemours Company. No equivalent.
(2) Elastomag 170 from Rohm and Haas. No equivalent.
(3) Thermax Flowform from Cancarb, Ltd. No equivalent.
(4) From HallStar. No equivalent.