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SURFACE VEHICLE STANDARD

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Thermoplastic Elastomer Classification System

1. ***Scope—***This classification system tabulates the properties of thermoplastic elastomers (TPEs) that are intended for, but not limited to, use in automotive applications.

NOTE 1—For the purposes of this document a TPE is defined as a polymeric material that, without further chemical modification, is capable of recovering from deformations quickly and forcibly and is also capable of being repeatedly softened by heating and hardened by cooling within a temperature range characteristic of the material.

NOTE 2—When the TPE product is to be used for purposes where the requirements are too specific to be completely prescribed by this classification system, it is necessary for the purchaser to consult the supplier in advance to establish the appropriate properties, test methods, and specification test limits.

This classification system is based on the premise that the properties of TPEs can be arranged into characteristic material designations. These designations are determined by type, based on resistance to heat aging; and class, based on resistance to volume change resulting from oil immersion. Basic levels are thus established which, together with values describing additional requirements, permit complete description of the properties of all TPEs.

In all cases where provisions of this classification system would conflict with those of the detailed specifications for a particular product, the latter shall take precedence.

This classification is based on SI units.

1.1 **Purpose—**The purpose of this classification system is to provide guidance to the engineer in the selection of practical, commercially available TPE materials, and further, to provide a method by which these materials may be specified by the use of a simple line call-out designation.

This classification system was developed to permit the addition of descriptive values for future materials without complete reorganization of the classification system and to facilitate the incorporation of future new methods of test to keep pace with changing industry requirements. See Appendix A for the development of additions to this document.

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2. References

2.1 Applicable Publications—The following publications form a part of this specification to the extent specified herein.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J200—Classification System for Rubber Materials
SAE J369—Flammability of Automotive Interior Materials—Horizontal Test Method
SAE J1885—Accelerated Exposure of Automotive Interior Trim Components Using a Controlled Irradiance Water Cooled Xenon-Arc Apparatus

2.1.2 ASTM PUBLICATIONS—Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM D 256—Standard Test Methods for Impact Resistance of Plastics and Electrical Insulating Materials
ASTM D 297—Standard Test Methods for Rubber Products—Chemical Analysis
ASTM D 369—Standard Test Method for Specific Gravity of Creosote Fractions and Residues
ASTM D 395—Standard Test Methods for Rubber Property—Compression Set
ASTM D 412—Standard Test Methods for Rubber Properties in Tension
ASTM D 430—Standard Test Methods for Rubber Deterioration—Dynamic Fatigue
ASTM D 471—Standard Test Method for Rubber Property—Effect of Liquids
ASTM D 518—Standard Test Method for Rubber Deterioration—Surface Cracking
ASTM D 573—Standard Test Method for Rubber—Deterioration in an Air Oven
ASTM D 624—Standard Test Method for Rubber Property—Tear Resistance
ASTM D 696—Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics
ASTM D 750—Standard Test Method for Rubber Deterioration in Carbon-Arc or Weathering Apparatus
ASTM D 790—Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
ASTM D 792—Standard Test Methods for Specific Gravity (Relative Density) and Density of Plastics by Displacement
ASTM D 865—Standard Test Method for Rubber—Deterioration by Heating in Air (Test Tube Enclosure)
ASTM D 925—Standard Test Methods for Rubber Property—Staining of Surfaces (Contact, Migration, and Diffusion)
ASTM D 1052—Standard Test Method for Rubber Deterioration—Cut Growth Using Ross Flexing Apparatus
ASTM D 1053—Standard Test Methods for Rubber Property—Stiffening at Low Temperatures; Flexible Polymers and Coated Fabrics
ASTM D 1171—Standard Test Method for Rubber Deterioration—Surface Ozone Cracking Outdoors or Chamber (Triangular Specimens)
ASTM D 1329—Standard Test Method for Evaluating Rubber Property—Retraction at Low Temperature (TR Test)
ASTM D 1349—Standard Practice for Rubber—Standard Temperatures for Testing
ASTM D 1505—Standard Test Method for Density of Plastics by the Density-Gradient Technique
ASTM D 1525—Standard Test Method for Vicat Softening Temperature of Plastics
ASTM D 2137—Standard Test Methods for Rubber Property—Brittleness Point of Flexible Polymers and Coated Fabrics
ASTM D 2240—Standard Test Method for Rubber Property—Durometer Hardness
ASTM D 2990—Standard Test Methods for Tensile, Compressive, and Flexural Creep and Creep Rupture of Plastics
ASTM D 3029—Standard Test Methods for Impact Resistance of Rigid Plastic Sheeting or Parts by Means of a Tup (Falling Weight)
ASTM D 3418—Standard Test Method for Transition Temperatures of Polymers by Thermal Analysis
ASTM D 3677—Standard Test Methods for Rubber—Identification by Infrared Spectrophotometry

ASTM D 3850—Standard Test Method for Rapid Thermal Degradation of Solid Electrical Insulating Materials by Thermogravimetric Method
ASTM E 691—Practice for Conducting an Interlaboratory Test Program to Determine the Precision of Test Methods
ASTM G 53—Recommended Practice for Operating Light- and Water-Exposure Apparatus (Fluorescent UV-Condensation Type) for Exposure of Nonmetallic Materials

2.1.3 FMVSS PUBLICATION—Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

FMVSS 302—Flammability of Interior Materials—Passenger Car, Multi-Purpose Passenger Vehicles

2.1.4 ISO PUBLICATIONS—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ISO 34—Rubber, vulcanized—Determination of tear strength (trouser, angle and crescent test pieces)
ISO 899—Plastics—Determination of tensile creep
ISO 3384—Rubber, vulcanized—Determination of stress relaxation in compression at ambient and at elevated temperatures
ISO 3795—Road vehicles, and tractors and machinery for agriculture and forestry—Determination of burning behaviour of interior materials

2.1.5 UL PUBLICATION—Available from Underwriters Laboratories, 333 Pfingsten Road, Northbrook, IL 60062-2096.

UL-94—Test for Flammability of Plastic Materials for Parts, Devices, and Appliances

3. Type and Class

3.1 TPEs shall be designated on the basis of type (heat aging resistance), and class (resistance to volume change resulting from oil immersion). These are each indicated by the letter designations as shown in Tables 1 and 2.

TABLE 1—BASIC REQUIREMENTS FOR ESTABLISHING TYPE BY TEMPERATURE

Type	Test Temperature °C
A	70
B	100
C	125
D	150
E	175
F	200
G	225
H	250
J	275

TABLE 2—BASIC REQUIREMENTS FOR ESTABLISHING CLASS BY VOLUME CHANGE RESULTING FROM IMMERSION IN IRM903 OIL

Class	Volume Change, Max, %
A	No requirement(1)
B	–20 to 140
C	–20 to 120
D	–20 to 100
E	–10 to 80
F	–10 to 60
G	–10 to 40
H	–5 to 30
J	–5 to 20
K	–5 to 10

1. See 3.1.2.

3.1.1 Type is based on changes in tensile strength (measured in the stronger direction) of not more than –30%, in elongation (measured in the same direction as tensile strength) of not more than –50%, and in hardness of not more than ±15 points after heat aging for 70 h according to ASTM D 573 at an appropriate temperature. The temperatures at which these materials shall be tested for determining type are listed in Table 1.

3.1.2 Class is based on the resistance of the material to volume change after 70 h immersion according to ASTM D 471 in IRM903 Oil[1] at the same temperature used to determine type, except that a maximum temperature of 150 °C (the upper limit of oil stability) shall be used. Limits of volume changes for each class are shown in Table 2. Note that some TPEs classified as Class A (no requirement for oil resistance) are so classified because they contain components that are extracted during oil immersion. This extraction results in apparent volume changes that are misleading in that they indicate that such materials are suitable for service requiring oil immersion, when in fact they are not.

3.2 The letter designations shall always be followed by a one-digit number and a letter to specify the hardness (Shore A or D) measured after a 5 s delay, and two two-digit numbers (separated by a solidus) to specify the tensile strength – for example, 5A15/08. The first digit and the letter indicate durometer hardness, for example, 5A for 50 ± 5 Shore A. The next two-digit numbers indicate the tensile strengths measured in the parallel (i.e., with the long axis of the test specimen parallel to the direction of flow) and perpendicular directions, respectively; for example, 15/08 for 15 MPa in the parallel direction and 8 MPa in the perpendicular direction.

4. Grade Numbers, Suffix Letters, and Numbers

4.1 Grade Numbers—Since the basic requirements do not always sufficiently describe all the necessary qualities, provision is made for deviation or adding requirements through a system of prefix grade numbers. Grade No. 1 indicates that only the basic requirements are compulsory and no suffix requirements are permitted. Grades other than No. 1 are used to indicate that deviations or additional requirements are necessary. Available Suffix Grade Numbers are listed in the last column of the Basic Requirements Table (Table 3). A grade number is written as a material prefix number preceding the letters for type and class.

1. See 3.1.2.

TABLE 3—BASIC REQUIREMENTS AND AVAILABLE SUFFIX GRADE NUMBERS FOR CLASSIFICATION OF TPE MATERIALS(1)

Durometer Hardness Shore A ± 5 Points	Tensile Strength min. MPa Par./Perp.	Ultimate Elongation min. % Par./Perp.	Heat Aged ASTM D 573 70 h @ 125 °C	Oil Immersion ASTM D 471 IRM903 Oil 70 h @ 125 °C	Compression Set ASTM D 395 Method B, Plied Max % 22 h @ 70 °C	Available Suffix Grade Numbers
CA Materials—Basic Requirements						
60	3/4	600/700	Hardness ±15 Pts	No Requirement	60	—
60	3/5	250/600	Tensile –30% Max.	No Requirement	55	—
70	4/4	100/350	Elongation –50% Max.	No Requirement	65	—
CC Materials—Basic Requirements						
			Hardness ±15 Pts			
70	5/5	150/200	Tensile –30% Max.	Volume Change –10% to 120% Max.	45	—
			Elongation –50% Max.			
CD Materials—Basic Requirements						
			Hardness ±15 Pts			
70	4/5	250/300		Volume Change –10% to 100% Max.	35	—
			Tensile –30% Max.			
80	5/6	200/350			40	—
			Elongation –50% Max.			
CF Materials—Basic Requirements						
			Hardness ±15 Pts			
70	5/6	200/250	Tensile –30% Max.	Volume Change –10% to 60% Max.	65	—
			Elongation –50% Max.			

1. All appropriate ASTM specifications will be adhered to except for test specimen gages. Test specimen gages will be specified in 10.1 of this specification.

4.2 Suffix Letters—The suffix letters which indicate additional tests, together with their meaning, appear in Table 4.

TABLE 4—MEANING OF SUFFIX LETTERS

Suffix Letter	Test Required
A	Heat Resistance
B	Compression Set Resistance
C	Ozone Resistance
D	Flexural Modulus
EA	Fluid Resistance (Aqueous)
EF	Fluid Resistance (Fuels)
EO	Fluid Resistance (Oils and Lubricants)
F	Low-Temperature Resistance
G	Tear Resistance
H	Flex Resistance
J	Abrasion Resistance
K	Adhesion
M	Flammability Resistance
N	Impact Resistance
P	Staining Resistance
Q	Analytical Properties
T	Creep Resistance/Stress Relaxation
U	Thermal Properties—High-Temperature Testing
W	UV Resistance
Y	Specific Gravity
Z	Special Requirements

4.3 Suffix Numbers—Each suffix letter shall be followed by two suffix numbers. The first suffix number indicates the method of test; time of test is part of the method and is taken from the listings in Table 5. The second suffix number indicates the temperature of test and is taken from Table 6.

5. Composition and Manufacture

5.1 Materials specified according to this classification shall be manufactured from polymers, together with added compounding materials of such nature and quantity as to produce materials that comply with the specified requirements. All materials and workmanship shall be in accordance with good commercial practice, and the resulting product shall be free of porous areas, weak sections, bubbles, foreign matter, or other defects affecting performance.

5.2 Color—Materials shall be tested in their typical commercially available colors.

6. Basic Requirements

6.1 The basic requirements for physical properties specified in Table 3 are based on test results obtained on test specimens having the highest and lowest tensile strength specified for each grade and durometer range. Test results from specimens prepared from finished products may not duplicate values obtained from standard test specimens.

TABLE 5—TEST METHODS[1]

Basic Requirements and First Suffix No. Requirement or Suffix Letter	Basic	1	2	3	4	5	6	7	8
Durometer Hardness[2]	D 2240								
Tensile Strength and Elongation	D 412 Die C								
Suffix A Heat Resistance		D 573, 70 h	D 573, 168 h	D 573, 1008 h	D 865, 70 h	D 865, 168 h	D 865, 1008 h		
Suffix B, Compression Set Resistance	Method B, Plied	D 395, 22 h Method B, Plied	D 395, 70 h Method B, Plied	D 395, 168 h Method B, Plied	D 395, 1008 h Method B, Solid	D 395, 22 h Method B, Solid	D 395, 70 h Method B, Solid	D 395, 168 h Method B, Solid	D 395, 1008 h
Suffix C, Ozone Resistance		D 1171 Ozone Exposure Method A	D 1171 Ozone Exposure Method B	D 518					
Suffix D Flexural Modulus		D 790, Method 1, Tangent, 13 mm/min	D 790, Method 1, Secant, 13 mm/min						
Suffix EA Fluid Resistance (Aqueous)		D 471, Water, 70 h	D 471, Equal Parts by Volume Distilled Water - Ethylene Glycol 70 h[3]						
Suffix EF, Fluid Resistance (Fuels)		D 471, Reference Fuel A 70 h	D 471, Reference Fuel B, 70 h	D 471, Reference Fuel C, 70 h	D 471, Reference Fuel D, 70 h	D 471, 85 Volume % Reference Fuel D Plus 15 Vol % Denatured Anhydrous Ethanol, 70 h	D 471, 85 Volume % Reference Fuel C Plus 15 Vol % Denatured Anhydrous Methanol, 70 h	D 471, 85 Volume % Reference Fuel C Plus 15 Vol % Denatured Anhydrous Ethanol, 70 h	
Suffix EO, Fluid Resistance (Oils and Lubricants)		D 471, ASTM Oil No. 1 70 h	D 471, IRM902 Oil 70 h	D 471, IRM903 Oil 70 h	D 471, IRM903 Oil 168 h	D 471, IRM902 Oil, 168 h	D 471, IRM903 Oil 168 h	D 471, Service Fluid No. 101, 70 h	D 471, Fluid as Desig- nated in Table 3 of this Spec, 70 h
Suffix F, Low-Temperature Resistance		D 2137, Method A 5 min, Para 9.3.2, 3 min	D 1053, Method A	D 2137, 38.1 mm Die, Para 9.3.2, 22 h	D 1329, 38.1 mm Die, 50% Elongation, 10% min Retraction	D 1329 50% Elongation 50% min Retraction			
Suffix G, Tear Resistance		D 624, Die B	D 624, Die C	ISO 34 Trouser Tear					
Suffix H, Flex Resistance		D 430, Method A	D 430, Method B	D 430, Method C	D 1052				
Suffix J, Abrasion Resistance[4]									
Suffix K, Adhesion[4]									
Suffix M, Flammability Resistance		ISO 3795		SAE J369	UL-94	FMVSS-302			
Suffix N, Impact Resistance		D 3029	D 256						
Suffix P, Staining Resistance		D 925, Method A	D 925, Method B, Control Panel						
Suffix Q, Analytical Properties		D 3677	D 297	D 3850	D 3418				
Suffix T, Creep Resistance/Stress Relaxation			D 2990	ISO 3384	ISO 899				
Suffix U, Thermal Properties		D 412 Die C	D 696		D 1525				

TABLE 5—TEST METHODS[1] (CONTINUED)

Basic Requirements and First Suffix No. Requirement or Suffix Letter	Basic	1	2	3	4	5	6	7	8
Suffix W, UV Resistance[5]		1 Year Fla Under Glass 5 Degrees	1 Year Fla Direct Exposure 5 degrees	D 750	G 53	SAE J1885			
Suffix Y, Specific Gravity		D 792	D 1505	D 297					
Suffix Z, Special Requirement									

1. All test methods are ASTM unless otherwise noted. All appropriate ASTM specifications will be adhered to except for test specimen gages. Test specimen gages will be specified in 10.1 of this specification.
2. For the purpose of developing Table 3, hardness values shall be obtained using 5 s delay. If the Shore A value is less than or equal to 90, only this value shall be reported. Otherwise, only the Shore D value shall be reported.
3. Volume increase by displacement method, except alcohol dip omitted. When determining changes in tensile strength, elongation, and hardness, test tube shall be 3/4 full after specimens are immersed. Determination to be made after 30 min. Cool in distilled water, acetone dip to be omitted.
4. Test methods to be determined.
5. This tests requires a sample of minimum dimensions 152 mm by 76 mm and a minimum thickness of 1.8 mm.

TABLE 6—SUFFIX NUMBERS TO INDICATE TEST TEMPERATURE

Applicable Suffix Requirements	Second Suffix Number	Test Temperature, °C[1]
	11	275
	10	250
	9	225
	8	200
	7	175
A, B, C, EA,	6	150
EF, EO, G,	5	125
H, K, L, T	4	100
	3	70
	2	38
	1	23
	0	(2)
	22	0
	23	–10
	24	–18
	25	–25
F, H, K	26	–35
	27	–40
	28	–50
	29	–55
	30	–65
	31	–75
	32	–80

1. These test temperatures are based on ASTM D 1349.
2. Ambient temperatures in the case of outdoor weathering.

6.2 The available materials are listed in the appropriate sections of Table 3, giving each hardness (measured after a 5 s delay) and tensile strength grade with its appropriate elongation value. The values of tensile strength and elongation are given for both the parallel (i.e., with the long axis of the test specimen parallel to the direction of flow) and perpendicular directions. The basic heat and oil aging requirements are also shown in this table.

7. Suffix Requirements

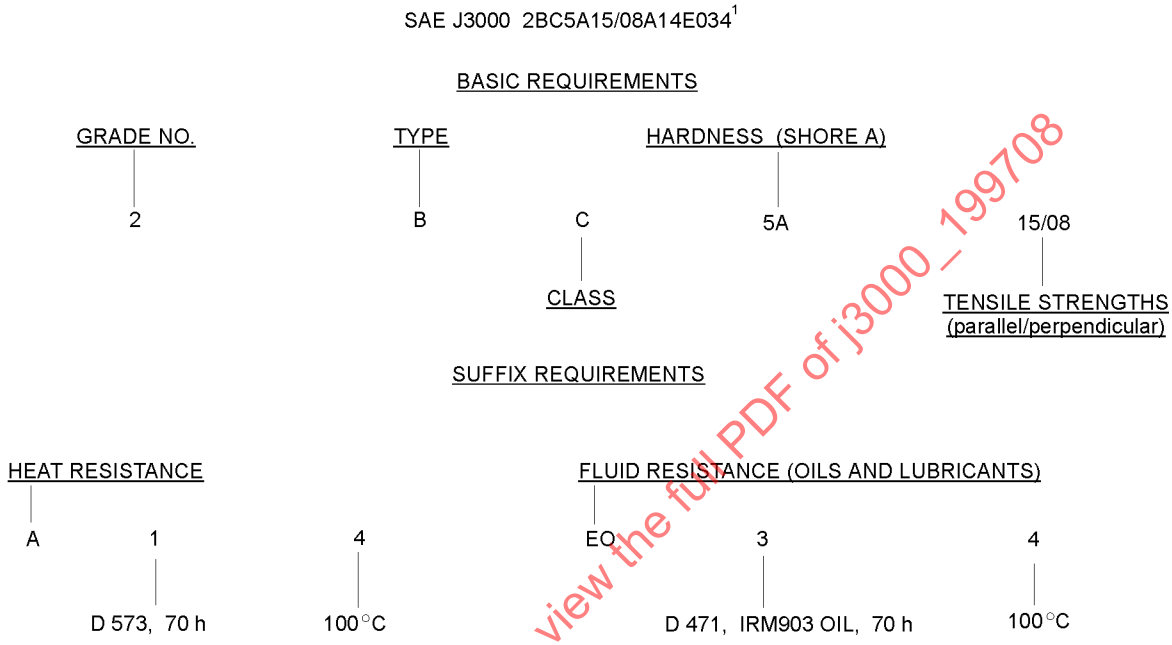
7.1 Suffix requirements shall be specified only as needed to define qualities necessary to meet service requirements. These suffix requirements are set forth for the various grade numbers. Not all available suffix requirements for a given material need be specified.

NOTE—Examples of the use of suffix letters and numbers would be A14 and EO34. Suffix A (Table 4) stands for heat resistance. Suffix 1 (Table 5) specifies that the test be run according to ASTM Method D 573 for 70 h, and Suffix 4 (Table 6) indicates the temperature of test as 100 °C. Similarly, Suffix EO34 indicates resistance to volume change resulting from immersion in IRM903 Oil, measured in accordance with ASTM Method D 471 for 70 h at 100 °C.

Basic requirements are always in effect, unless superseded by specific suffix requirements in the line call-out.

8. Line Call-Outs

8.1 A line call-out, which is used as a specification, shall contain the following: the document designation, the grade number, the material designation (type and class), the hardness and the tensile strengths in both parallel and perpendicular directions, followed by the appropriate suffix requirements. Figure 1 is an example of a line call-out:



[1] In this example, the basic requirements for heat aging resistance and resistance to volume change resulting from oil immersion are superseded by suffix requirements.

FIGURE 1—LINE CALL-OUTS

9. Methods of Test

9.1 The applicable methods of test are listed in Table 5.

10. Sample Preparation

10.1 Unless otherwise noted, samples are to be die-cut from injection molded rectangular plaques 3.0 mm ± 0.4 mm thick specimens of other thickness will not necessarily give comparable results. Annealing of test specimens and plaques or the use of atypical molding conditions is not permitted. Where appropriate, samples are to be tested in both parallel (i.e., with the long axis of the test specimen parallel to the direction of flow) and perpendicular directions. Plaque dimensions must be sufficient to permit this. Three samples are to be tested in each direction and the mean value in each direction is to be recorded for each property. If the properties of a material are measured on other than injection molded plaques, this shall be so noted.

10.2 Preparation of compression set test specimens shall be accomplished via injection or compression molding as specified in ASTM D 395, paragraph 5.2 or 5.3, or via plying up cylindrical discs cut from slabs as described in paragraph 5.5 of ASTM D 395. Preparation of standard test sheets or plaques for plying up discs shall be specified in 10.1 of this specification. Only Type 1 specimens (ASTM D 395, Section 5) are permitted.

11. Sampling and Inspection

11.1 A lot, unless otherwise specified, shall consist of all products of the same material submitted for inspection at the same time. It is recommended that the manufacturer should examine the current specification (based on statistically significant number of production lots) to verify that the data statistically reflect the maxima and/or minima of the product specification.

11.2 When proof of conformance with a specification based on this classification system is required, the supplier shall, upon request of the purchaser at time of ordering, furnish a sufficient number of samples to perform the required tests. Test specimens shall be prepared as described in 10.1.

12. Limitations of the Document in Establishing Material Specifications

12.1 The data in Table 3 are based on physical properties of thermoplastic elastomers obtained directly from standard samples die-cut from rectangular plaques injection molded under ideal conditions (for example, in a laboratory). They indicate combinations of properties that are believed to be obtainable. Table 3 was not necessarily developed on the basis of statistical data.

12.2 Setting of material specifications, the determination of Cpk values and a quality control plan are the responsibility of the producer and consumer.

12.3 It must be borne in mind that all physical tests are subject to test errors as indicated by precision statements included in many ASTM test procedures.

13. Notes

13.1 **Marginal Indicia—**The change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. An (R) symbol to the left of the document title indicates a complete revision of the report.

PREPARED BY THE SAE THERMOPLASTIC ELASTOMER SUBCOMMITTEE
OF THE SAE COMMITTEE ON AUTOMOTIVE RUBBER SPECIFICATIONS

APPENDIX A

DEVELOPMENT AND ADDITIONS OF THE SAE J3000 TABLES

A.1 Purpose—The purpose of this section is to set forth the procedure for establishing new tables or additions to existing tables for the SAE J3000 document.

A.2 Program Initiation

A.2.1 Present to the Committee on Automotive Rubber Specifications a proposal for an additional table or a revision to an existing table based upon preliminary laboratory data.

A.2.2 Identify the type and class of material to be added or the current material table to be modified.

A.2.3 Identify the number of compositions intended to be tested and the basic requirements for each composition.

A.2.4 Identify the proposed suffix requirements, if any, for each of the compositions intended to be tested.

A.2.5 In conjunction with the committee, secure a minimum of three accredited[2] laboratories which may include the proposer's laboratory. Assign a code number to each laboratory to ensure anonymity.

A.2.6 Provide a list of the required tests and test conditions to the three accredited laboratories requesting that the labs respond as to which tests they are able to run internally.

A.2.7 If any of the original three laboratories are unable to perform specific required tests, secure additional accredited laboratories to perform those specific tests. The additional laboratories need not complete the entire test program.

A.3 Sample Preparation

A.3.1 Prepare sufficient quantity of each of the compositions to provide samples for all of the required testing (five or three test specimens, as required, per test per laboratory). It is preferable to use production compositions but laboratory prepared compositions are acceptable.

A.3.2 Test for tensile, elongation, hardness, and compression set to verify that the composition meets the anticipated requirements.

A.3.3 Prepare the composition for molding and mold the samples as designated by ASTM or other approved procedures. It is imperative that all steps be taken to reduce variation. A single operator shall prepare the material for molding, and a single operator shall mold the samples. Prior to molding and periodically throughout the molding, the mold temperature shall be checked using a pyrometer or similar instrument. All slabs for dumbbell samples shall be produced from a single mold. All samples for testing volume, hardness etc., shall be produced from a single mold if possible.

A.3.4 Using the appropriate die, cut all test specimens required for a given composition. One operator shall cut all samples, and the die shall be inspected before cutting samples from a different composition. If a die is damaged during the course of cutting a composition it shall be repaired, and a new set of samples from that composition shall be prepared.

A.3.5 When all the required test specimens have been prepared from a given composition, all of the test specimens of the same type shall be mixed, and the appropriate number randomly selected for each laboratory.

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2. An accredited laboratory is one accredited (certified) by a generally recognized accrediting organization such as the American Association for Laboratory Accreditation (A2LA) or the International Organization for Standardization (ISO).