Designation: D 6338 – ~~98~~03

Standard Classification System for Highly Crosslinked Thermoplastic Vulcanizates (HCTPVs)[1]

This standard is issued under the fixed designation D 6338; 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

This classification system is intended as a means for the callout of materials for the fabrication of parts or end-use items. It is not intended for material selection, which should be performed by those with special expertise in the materials field. Material selection should be made after careful consideration of: part performance and design; the environment in which the part must function; the material properties covered and not covered by this classification system; the desired service lifetime of the part; the fabrication process for the part; and material and fabrication costs.

1. Scope

1.1 This classification system covers highly crosslinked thermoplastic vulcanizates (HCTPVs) for extrusion, molding and other fabrication methods. HCTPVs are thermoplastic elastomers (TPEs) consisting of two or more polymer systems at least one of which is rubbery and highly (>95 %) crosslinked and at least one of which is thermoplastic, with each system having its own phase. The thermoplastic phase will tend to be continuous and the rubbery phase discontinuous. The high level of crosslinking and ultrafine particle size (ca 1 µm diameter) of the rubbery phase give rise to properties more closely approaching those of conventional thermoset rubber, when compared to the same thermoplastic/rubbery polymer composition with a lower level (≤95 %) of crosslinking. The HCTPV polymer compositions may contain fillers, reinforcing agents, plasticizers, resins, antidegradants, colorants and other beneficial constituents. Recycled HCTPVs are not covered in this classification system.

1.2 Included in this classification system are the properties necessary to identify the respective compositions. For specialized applications, other requirements may be needed to identify specific characteristics.

1.3 As given in ~~Practice E 380,~~ IEEE/ASTM SI-10, values in SI units are to be regarded as standard.

NOTE 1—There is no equivalent ISO standard.

1.4 The following safety hazards caveat pertains only to the test methods portion, Section 12, of this classification system. *This standard does not purport to address all of the safety problems, 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:*

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[1] This specification is under the jurisdiction of ASTM Committee D~~-~~20 on Plastics and is the direct responsibility of Subcommittee D20.15 on Thermoplastic Materials.

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D 395 Test Methods for Rubber Property—Compression Set[2]
D 412 Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension[2]
D 471 Test Method for Rubber Property—Effect of Liquids[2]
D 573 Test Method for Rubber—Deterioration in an Air Oven[2]
D 618 Practice for Conditioning Plastics ~~and Electrical Insulating Materials~~ for Testing[3]
D 638 Test Method for Tensile Properties of Plastics[3]
D 883 Terminology Relating to Plastics[3]
D 1434 Test Method for Determining Gas Permeability Characteristics of Plastics and Sheeting[4]
D 1566 Terminology Relating to Rubber[2]
D 1898 Practice for Sampling of Plastics[5]
D 2240 Test Method for Rubber Property—Durometer Hardness[2]
D 3182 Practice for Rubber—Materials, Equipment, and Procedures ~~from~~ for Mixing Standard Compounds and Preparing Standard Vulcanized Sheets[2]
D 3892 Practice for Packaging/Packing of Plastics[6]
D 4000 Classification System for Specifying Plastics Materials[6]
D 4019 Standard Test Method for Moisture in Plastics by Coulometric Regeneration of Phosphorous Pentoxide[7]
E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
~~E 380 Practice~~[8]
IEEE/ASTM SI-10 Standard for Use of the International System of Units ~~(SI) (the Modernized~~ (SI): The Modern Metric System~~)~~[69]

3. Terminology

3.1 *Definitions*— Except for the terms defined below, technical terms pertaining to materials covered by this classification system are given in Terminologies D 883 and D 1566.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *dynamic vulcanization*, *n*—the process of intimate melt mixing a thermoplastic polymer with a suitably reactive rubbery polymer to generate a thermoplastic elastomer with a chemically crosslinked rubbery phase, resulting in properties closer to those of a thermoset rubber when compared to the same uncrosslinked composition.

3.2.2 *thermoplastic elastomer (TPE)*, *n*— a diverse family of rubberlike materials that, unlike conventional vulcanized rubbers, can be reprocessed and recycled like thermoplastic materials.

3.2.3 *thermoplastic vulcanizate (TPV)*, *n*— a thermoplastic elastomer with a chemically crosslinked rubbery phase, produced by the dynamic vulcanization.

4. Classification

4.1 Highly crosslinked thermoplastic vulcanizates are classified into groups according to the rubbery polymer(s) present. These groups are subclassified into classes and grades as shown in Table HCTPV.

4.1.1 To illustrate this classification system: the designation HCTPV 0121 would indicate HCTPV = highly crosslinked thermoplastic vulcanizate, 01 (group) = EPDM rubber >95 % crosslinked, 2 (class) = medium hardness, and 1 (grade) meeting the requirements in Table HCTPV.

4.1.2 To enable the incorporation of special or future materials, the "Other" category (0) for group, class and grade is given in Table HCTPV. Basic properties can be obtained from Table A.

4.2 There is no distinction between reinforced and unreinforced highly crosslinked thermoplastic vulcanizates.

4.3 A six-character designation shall show the specific requirements for the HCTPVs. This designation shall consist of the letter A and five digits comprising the property requirements in the order they appear in Table A.

4.3.1 The following is an example of this classification system: Designation HCTPV 0110 A45643 indicates the following, with the Table A requirements:

where:
HCTPV 0110 = fully crosslinked thermoplastic vulcanizate, based on EPDM rubber >95 % crosslinked, low hardness from Table HCTPV,

[2] *Annual Book of ASTM Standards*, Vol 09.01.
[3] *Annual Book of ASTM Standards*, Vol 08.01.
[4] *Annual Book of ASTM Standards*, Vol 15.09.
[5] Discontinued; see *1997 Annual Book of ASTM Standards* , Vol 08.0~~2~~1.
[6] *Annual Book of ASTM Standards*, Vol ~~14.02.~~ 08.02.
[7] Discontinued; see *2001 Annual Book of ASTM Standards* , Vol 08.02.
[8] *Annual Book of ASTM Standards*, Vol 14.02.
[9] Available from ASTM International Headquarters

A = Table A property requirements,
4 = 65 ± 5 Shore A hardness, Test Method D 2240, 5 s delay,
5 = 14 MPa, tensile strength, min, Test Method D 412 at 23°C,
6 = 6.0 MPa, tensile strength, min, Test Method D 412 at 100°C,
4 = 80 %, weight change, max, Test Method D 471, IRM 903 oil, 24 h/121°C, and
3 = 30 %, compression set, max, Test Method D 395, Procedure B, 22 h/100°C.

The designation HCTPV 0100 would indicate no properties being specified.

4.3.2 Although the values listed are necessary to include the range of properties available in existing materials, users should not infer that every possible combination of the properties exists or can be obtained.

5. Suffixes

5.1 Necessary requirements for superseding or supplementing the property-table or cell-table requirements shall be specified with suffixes. The first suffix letter indicates the special requirements needed; the second letter indicates the test method or conditions, or both, with a there-digit number indicating the specific requirements. Permissible suffixes are listed in Table 3 of Classification D 4000.

5.1.1 Additional suffixes will be added to this specification as test requirements and methods are developed or requested, or both.

6. Basic Requirements

6.1 Basic requirements from property or cell tables are always in effect, unless superseded by specific suffix requirements, which always take precedence.

7. General Requirements

7.1 Material composition shall be uniform and shall conform to the requirements of this specification. The product form and color of the HCTPVs shall be mutually agreed to by the parties involved.

8. Detail Requirements

8.1 Test specimens and their preparation shall conform to Table HCTPV and Table A, and applicable suffix requirements.

8.2 For purposes of determining conformance, all specified limits for a specification (line call out) based on this classification system are absolute limits, as defined in Practice E 29.

8.2.1 With the absolute method, an observed value or a calculated value is not rounded, but is to be compared directly with the limiting value. Conformance or nonconformance is based on this comparison.

9. Sampling

9.1 Materials shall be sampled in accordance with the procedure in Practice D 1898. An acceptable alternative shall be statistical sampling shown to be adequate. A unit of manufacture for shipment shall be a production lot of HCTPV or a uniformly mixed blend of two or more such production lots.

10. Specimen Preparation

10.1 Test specimens shall be prepared by a rigorously specified injection molding process, unless specifically mentioned to the contrary. This process should be as specified in Practice D 3182, or as specified by the HCTPV supplier. Due regard should be given to the anisotropic nature of HCTPV molded parts.

11. Conditioning

11.1 Prior to testing, test specimens shall be conditioned in the standard laboratory atmosphere in accordance with Procedure A of Practice D 618.

11.2 Tests shall be carried out at 23 ± 2°C and 50 ± 5 percent relative humidity, in accordance with Practice D 618.

12. Test Methods

12.1 Properties covered by this classification shall be measured by the following Test Methods, as applicable: D 395; D 412; D 471; D 573; D 638; D 1434; D 2240; D 4019.

12.1.1 The number of tests shall be consistent with the requirements of Section 9 and 13.2.

13. Inspection and Certification

13.1 Inspection and certification of the material supplied with reference to a specification based on this classification system shall be for conformance to the requirements specified herein.

13.2 Lot-acceptance inspection shall be the basis on which acceptance or rejection of the lot is made. The lot-acceptance inspection shall consist of the tests listed as they apply: hardness; weight change in IRM 903 oil; moisture content; air permeability.

13.3 Periodic-check inspection shall consist of the tests specified for all requirements of the material under this classification system. Inspection frequency shall be adequate to ensure the material is certifiable in accordance with 13.4.

13.4 Certification shall be that the material was manufactured by a process in statistical control, sampled, tested, and inspected in accordance with this classification system, and that the average values for the lot meet the requirements of the specification (line callout).

13.5 A report of the test results shall be furnished when requested. The report shall consist of the results of the lot-acceptance inspection for the shipment and the results of the most recent periodic-check inspection.

14. Packaging and Marking

14.1 Practice D 3892 shall apply to packing; packaging and markings.

15. Keywords

15.1 dynamic vulcanization; highly crosslinked thermoplastic vulcanizate; line callout; thermoplastic elastomer; thermoplastic vulcanizate

TABLE HCTPV Requirement Details for Highly Crosslinked Thermoplastic Vulcanizates

Group	Description	Class	Description	Grade	Description	Hardness, Test Method D 2240, A/D Durometer, Typical, 5 s delay	Tensile Strength, 23°C, Test Method D 412, MPa, min	~~Tensile Strength, 100°C,~~ Ultimate Elongation, 23°C, Test Method D 412, ~~MPa~~ % min	~~Weight~~Volume Change, Test Method D 471, IRM 903 oil, ~~24 h/121°C,~~ 70 h/125°C, % max	Compression Set, Test Method D 395, Method B, 25 % deflection, 22 h/~~10~~70°C, % max	Air Aging, Test Method D 573, 168h/ 150°C, Ultimate Elongation, % ~~min~~ change, max	Moisture, Test Method D 4019, % max	Air Permeability, Test Method D 1434, Method V, 2.1 kg/cm [30 psi], 23°C, 44 to 59 % RH, cm^2, mm/m^2 day, atm, max	
~~01~~	~~EPDM Rubber, >95 % Crosslinked~~	~~1~~	~~Low Hardness~~	~~1~~		~~55 A~~	~~4~~	~~1.4~~	~~120~~	~~25~~	~~200~~	~~0.06~~	~~1000~~	
01	EPDM Rubber, >95 % Crosslinked	1	Low Hardness	1		55 A	3.6	280	120	30	3	0.08	1000	
				~~2~~		~~64 A~~	~~6~~	~~2.1~~	~~105~~	~~35~~	~~30~~	~~200~~	~~0.06~~	1000
				2		64 A	5.7	340	110	35	30	0.08	~~0.06~~	1000
				~~3~~		~~73 A~~	~~7~~	~~2.5~~	~~86~~	~~35~~	~~250~~	~~0.06~~	~~1000~~	
				3		73 A	7.0	380	90	40	40	0.08	1000	
				0	Other									
		~~2~~	~~Medium Hardness~~	~~1~~		~~80 A~~	~~10~~	~~3.5~~	~~80~~	~~45~~	~~40~~	~~300~~	~~0.06~~	1000
		2	Medium Hardness	1		80 A	9.0	440	85	45	40	0.08	~~0.06~~	1000
				~~2~~		~~87A~~	~~14~~	~~4.9~~	~~72~~	~~45~~	~~350~~	~~0.06~~	~~1000~~	
				2		87A	14.0	480	80	55	40	0.08	1000	
				0	Other									
		~~3~~	~~High Hardness~~	~~1~~		~~40 D~~	~~17~~	~~6.7~~	~~68~~	~~65~~	~~50~~	~~400~~	~~0.06~~	1000
		3	High Hardness	1		40 D	17.0	500	70	65	50	0.08	~~0.06~~	1000
				~~2~~		~~50 D~~	~~24~~[A]	~~8.4~~	~~65~~	~~75~~	~~50~~	~~450~~	~~0.06~~	1000
				2		50 D	20.0[A]	500	60	75	50	0.08	~~0.06~~	1000
				0	Other									
		~~4~~	~~Ultralow Hardness~~	~~1~~		~~35 A~~	~~2~~	~~0.5~~	~~170~~	~~25~~	~~150~~	~~0.06~~	~~1000~~	
		4	Ultralow Hardness	1		35 A	1.4	200	160	35	40	0.08	1000	
				~~2~~		~~45 A~~	~~3~~	~~1.0~~	~~140~~	~~25~~	~~200~~	~~0.06~~	~~1000~~	
				2		45 A	2.1	200	150	35	40	0.08	1000	
				0	Other									
		0	Other	0	Other									
~~02~~	~~Nitrile Rubber, >95 % Crosslinked~~	~~1~~	~~Low Hardness~~	~~1~~		~~70 A~~	~~5~~	~~2.1~~	~~7~~	~~35~~	~~100~~	~~0.15~~	~~1500~~	
02	Nitrile Rubber, >95 % Crosslinked	1	Low Hardness	1		70 A	4.0	175	25	30	50[B]	0.15	1500	
				0	Other									
		~~2~~	~~Medium Hardness~~	~~1~~		~~80 A~~	~~7~~	~~2.5~~	~~7~~	~~40~~	~~150~~	~~0.15~~	~~1500~~	
		2	Medium Hardness	1		80 A	7.0	200	20	45	50[B]	0.15	1500	
				~~2~~		~~87 A~~	~~11~~	~~3.8~~	~~7~~	~~45~~	~~200~~	~~0.15~~	~~1500~~	
				2		87 A	11.0	300	15	55	50[B]	0.15	1500	
				0	Other									
		~~3~~	~~High Hardness~~	~~1~~		~~45 D~~	~~14~~	~~6.0~~[A]	~~14~~	~~60~~	~~270~~	~~0.15~~	~~1500~~	
		3	High Hardness	1		45 D	13.0	350[A]	15	65	50[B]	0.15	1500	
				0	Other									
		0	Other	0	Other									

[A] Test Method D 638 used.
[B] Temperature of 125°C used.

TABLE HCTPV Requirement Details for Highly Crosslinked Thermoplastic Vulcanizates *(continued)*

Group	Description	Class	Description	Grade	Description	Hardness, Test Method D 2240, A/D Durometer, Typical, 5 s delay	Tensile Strength, 23°C, Test Method D 412, MPa, min	~~Tensile Strength, 100°C,~~Ultimate Elongation, 23°C, Test Method D 412, ~~MPa~~ % min	~~Weight~~Volume Change, Test Method D 471, IRM 903 oil, ~~24 h/121°C,~~ 70 h/125°C, % max	Compression Set, Test Method D 395, Method B, 25 % deflection, 22 h/~~10~~70°C, % max	Air Aging, Test Method D 573, 168h/150°C, Ultimate Elongation, % ~~min~~ change, max	Moisture, Test Method D 4019, % max	Air Permeability, Test Method D 1434, Method V, 2.1 kg/cm [30 psi], 23°C, 44 to 59 % RH, cm^2, mm/m^2 day, atm, max	
~~03~~	~~EPDM Rubber, >95 % Crosslinked, Non-hygroscopic~~	~~1~~	~~Low Hardness~~	~~1~~		~~55 A~~	~~3~~	~~1.6~~	~~135~~	~~46~~	~~360~~	~~0.02~~	~~1000~~	
03	EPDM Rubber, >95 % Crosslinked, Non-hygroscopic	1	Low Hardness	1		55 A	4.0	300	160	40	40	0.02	1000	
				~~2~~		~~65 A~~	~~5~~	~~2.0~~	~~135~~	~~50~~	~~400~~	~~0.02~~	~~1000~~	
				2		65 A	6.0	400	160	40	40	0.02	1000	
				0	Other									
		~~2~~	~~Medium Hardness~~	~~1~~		~~75A~~	~~7~~	~~2.2~~	~~125~~	~~54~~	~~300~~	~~0.02~~	~~1000~~	
		2	Medium Hardness	1		75A	8.0	400	140	45	40	0.02	1000	
				~~2~~		~~80 A~~	~~9~~	~~5.4~~	~~90~~	~~58~~	~~350~~	~~0.02~~	~~1000~~	
				2		80 A	9.0	500	90	50	40	0.02	1000	
				~~3~~		~~90 A~~	~~22~~	~~7.3~~	~~60~~	~~68~~	~~320~~	~~0.02~~	~~1000~~	
				3		90 A	13.0	600	60	60	40	0.02	1000	
				0	Other									
		~~3~~	~~Ultralow Hardness~~	~~1~~		~~35 A~~	~~2~~	~~0.9~~	~~165~~	~~35~~	~~270~~	~~0.02~~	~~1000~~	
		3	Ultralow Hardness	1		35 A	2.5	300	170	25	40	0.02	1000	
				~~2~~		~~45 A~~	~~2~~	~~1.5~~	~~150~~	~~30~~	~~40~~	~~360~~	0.02	1000
				2		45 A	3.5	350	170	30	40	~~360~~	0.02	1000
				0	Other									
		0	Other	0	Other									
~~04~~	~~Butyl/halobutyl Rubber, >95 % Crosslinked~~	~~1~~	~~Low Hardness~~	~~1~~		~~65 A~~	~~5~~	~~2.3~~	~~130~~	~~45~~	~~250~~	~~0.08~~	~~50~~	
04	Butyl/halobutyl Rubber, >95 % Crosslinked	1	Low Hardness	1		65 A	5.0	300	130	40	40	0.08	50	
				0	Other									
		~~2~~	~~Medium Hardness~~	~~1~~		~~75 A~~	~~6~~	~~2.7~~	~~115~~	~~55~~	~~280~~	~~0.08~~	~~55~~	
		2	Medium Hardness	1		75 A	6.0	400	115	55	40	0.08	55	
				~~2~~		~~85 A~~	~~10~~	~~4.5~~	~~90~~	~~75~~	~~300~~	~~0.08~~	~~60~~	
				2		85 A	10.0	400	90	75	40	0.08	60	
				0	Other									
		~~3~~	~~High Hardness~~	~~1~~		~~45 D~~	~~13~~	~~7.0~~	~~65~~	~~80~~	~~450~~	~~0.08~~	~~70~~	
		3	High Hardness	1		45 D	13.0	400	65	80	40	0.08	70	
				0	Other									
		0	Other	0	Other									
00	Other	0	Other	0	Other									

TABLE A Detail Requirements for Highly Crosslinked Thermoplastic Vulcanizates

Designation Order Number	Property	0	1	2	3	4	5	6	7	8	9
1	Hardness, Test Method D 2240, Shore A/D, ±5	unspecified	35A	45A	55A	65A	75A	85A	40D	50D	specify value
2	Tensile strength, Text Method D 412,[A] 23°C, MPa, min	unspecified	2	4	7	10	14	18	24	30	specify value
3	Tensile strength, Test Method D 412,[A] 100°C, MPa, min	unspecified	0.5	1.0	2.0	3.0	4.0	6.0	8.0	10.0	specify value
4	Weight change, Test Method D 471, IRM 903 oil, 24h/121°C, % max	unspecified	180	140	100	80	60	40	20	10	specify value
5	Compression set, Test Method D 395, Method B, 25 % defl., 22 h/100°C, compression molded type A specimens, % max	unspecified	20	25	30	35	40	50	65	80	specify value

[A]Use Test Method D 638 for 50D hardness.