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## Standard Classification System for Highly Crosslinked Thermoplastic Vulcanizates (HCTPVs)(HCTPV) Based on ASTM Standard Test Methods<sup>1</sup>

This standard is issued under the fixed designation D6338; 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 ( $\epsilon$ ) 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)(HCTPV) for extrusion, molding and other fabrication methods. ~~HCTPVs~~—Highly crosslinked thermoplastic vulcanizates (HCTPV) are thermoplastic elastomers (TPEs)(TPE) 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  $\mu\text{m}$  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 ( $\leq 95$  %) of crosslinking. The HCTPV polymer compositions may contain fillers, reinforcing agents, plasticizers, resins, antidegradants, colorants and other beneficial constituents. Recycled HCTPVsHCTPV are not covered in this classification system.

1.2 ~~Included~~—The properties included in this classification system are the properties standard are those required to identify the compositions covered. Other requirements necessary to identify the respective compositions. For specialized applications, other requirements may be needed to identify specific characteristics. particular characteristics important to specialized applications are to be specified by using suffixes as given in Section 5.

1.3 This classification system and subsequent line callout (specification) are intended to provide a means of calling out plastic materials used in the fabrication of end items or parts. It is not intended for the selection of materials. Material selection can be made by those having expertise in the plastic field only after careful consideration of the design and the performance required of the part, the environment to which it will be exposed, the fabrication process to be employed, the costs involved, and the inherent properties of the material other than those covered by this standard.

1.4 As given in **IEEE/ASTM SI-10**, values in SI units are to be regarded as standard.

NOTE 1—There is no known ISO equivalent to this standard.

1.5 This standard is based on testing completed in accordance with ASTM standard test methods.

1.6 The following safety hazards caveat pertains only to the test methods portion, Section ~~12~~**11**, of this classification system. *This standard does not purport to address all of the safety ~~problems~~ concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate ~~safety~~ safety, health and ~~health~~ 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.*

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee **D20** on Plastics and is the direct responsibility of Subcommittee **D20.15** on Thermoplastic Materials. Current edition approved ~~Aug. 1, 2010~~ Aug. 1, 2017. Published ~~September 2010~~ August 2017. Originally approved in 1998. Last previous edition approved in ~~2009~~2010 as ~~D6338 – 09~~ D6338 - 10. DOI: ~~10.1520/D6338-10~~ 10.1520/D6338-17.

\*A Summary of Changes section appears at the end of this standard

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

- D395 Test Methods for Rubber Property—Compression Set
- D412 Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension
- D471 Test Method for Rubber Property—Effect of Liquids
- D573 Test Method for Rubber—Deterioration in an Air Oven
- D618 Practice for Conditioning Plastics for Testing
- D638 Test Method for Tensile Properties of Plastics
- D883 Terminology Relating to Plastics
- D1434 Test Method for Determining Gas Permeability Characteristics of Plastic Film and Sheet
- D1566 Terminology Relating to Rubber
- D2240 Test Method for Rubber Property—Durometer Hardness
- D3182 Practice for Rubber—Materials, Equipment, and Procedures for Mixing Standard Compounds and Preparing Standard Vulcanized Sheets
- D3892 Practice for Packaging/Packing of Plastics
- D4000 Classification System for Specifying Plastic Materials
- D6869 Test Method for Coulometric and Volumetric Determination of Moisture in Plastics Using the Karl Fischer Reaction (the Reaction of Iodine with Water)
- E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
- IEEE/ASTM SI-10 Standard for Use of the International System of Units (SI): The Modern Metric System

## 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 **D883** and **D1566**.

### 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.

4.1 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. 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 for group (00), class (0), and grade (0) is shown in Table HCTPV. Basic properties are to be obtained from Table A.

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

<sup>2</sup> 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.

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

4.1.4 A six-character designation shall show the specific requirements for the HCTPV in the “Other” category. This designation shall consist of the letter A and five digits comprising the property requirements in the order they appear in Table A.

4.1.5 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,  
 A = Table A property requirements,  
 4 = 65 ± 5 Shore A hardness, Test Method **D2240**, 5 s delay,  
 5 = 14 MPa, tensile strength, min, Test Method **D412** at 23°C,  
 6 = 6.0 MPa, tensile strength, min, Test Method **D412** at 100°C,  
 4 = 80 %, weight change, max, Test Method **D471**, IRM 903 oil, 24 h/121°C, and  
 3 = 30 %, compression set, max, Test Method **D395**, Procedure B, 22 h/100°C.

The designation HCTPV 0100 would indicate no properties being specified.

4.1.6 ~~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.~~ If no properties are specified, the designation would be HCTPV 0110 A00000.

## 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 three-digit number indicating the specific requirements. Permissible suffixes are listed in Table 3 of Classification.~~ When additional requirements are needed that are not covered by the basic requirements or cell table requirements, they shall be indicated through the use of suffixes. **D4000**.

5.1.1 ~~A list of suffixes can be found in Classification System D4000 (Table 3) and are to be used for additional requirements as appropriate. Additional suffixes will be added to this specification that standard as test requirements methods and methods requirements are developed or requested, or both, and requested.~~

## 6. Basic General Requirements

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

6.2 The plastics composition shall be uniform and shall conform to the requirements specified herein.

## 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.~~

## 7. Detail Requirements

7.1 ~~Test specimens and their preparation.~~ The materials shall conform to Table HCTPV and Table the requirements in Tables HCTPV, A, and applicable suffix requirements: suffix requirements as they apply.

7.2 For purposes of determining conformance, all specified limits for a specification (line call out) callout based on this classification system are absolute limits, as defined in Practice **E29**.

7.2.1 With the absolute method, an observed value or a calculated value using the number of significant figures, as specified by the test method used in determining the value, is not rounded, but is to be compared directly with the limiting value. Conformance or nonconformance is based on this comparison.

## 8. Sampling

8.1 Sampling shall be statistically adequate to satisfy the requirements of **12.4**.

8.2 ~~Sampling shall be statistically adequate to satisfy the requirements of Section 13.~~ 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.

## 9. Specimen Preparation

9.1 Test specimens shall be prepared by a rigorously specified injection molding process, unless specifically mentioned to the contrary. This process shall be as specified in Practice **D3182**, or as specified by the HCTPV supplier, with due regard given to the anisotropic nature of HCTPV molded parts.

## 10. Conditioning

10.1 Prior to testing, test specimens shall be conditioned in the standard laboratory atmosphere in accordance with Procedure A of Practice **D618**.

10.2 Tests shall be carried out at  $23 \pm 2^\circ\text{C}$  and  $50 \pm 10\%$  relative humidity, in accordance with Practice ~~humidity~~ **D618**.

## 11. Test Methods

11.1 Properties covered by this classification shall be measured by the following Test Methods, as applicable: **D395**; **D412**; **D471**; **D573**; **D638**; **D1434**; **D2240**; **D6869**.

11.1.1 The number of ~~tests~~ samples tested shall be consistent with the requirements of ~~Section 9.18.1~~ and ~~13.212.4~~.

## 12. Inspection and Certification

12.1 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.

12.2 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.

12.3 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 ~~13.412.4~~.

12.4 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).

NOTE 2—The ASTM publication *Manual on Presentation of Data and Control Chart Analysis, 8th Edition*, stock number MNL7-8TH-EB, provides detailed information about statistical process control.

12.5 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.

## 13. Packaging and Marking

13.1 Practice **D3892** shall apply to packing; packaging and markings.

## 14. Keywords

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

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TABLE HCTPV Requirement Details for Highly Crosslinked Thermoplastic Vulcanizates

Group	Description	Class	Description	Grade	Description	Hardness, Test Method <b>D2240</b> , A/D Durometer, Typical, 5-s delay	Tensile Strength, 23°C, Test Method <b>D412</b> , MPa, min	Ultimate Elongation, 23°C, Test Method <b>D412</b> , % min	Volume Change, Test Method <b>D471</b> , IRM-903 oil, 70 h/125°C, % max	Compression-Set, Test Method <b>D395</b> , 25% deflection, 22 h/70°C, % max	Air Aging, Test Method <b>D573</b> , 168h/150°C, Ultimate Elongation, % change, max	Moisture, Test Method <b>D6869</b> , % max	Air Permeability, Test Method <b>D1434</b> , Method V, 2.1 kg/cm <sup>2</sup> (30 psi), 23°C, 44 to 59% RH, cm <sup>2</sup> , mm/m <sup>2</sup> day, atm, max		
01	EPDM Rubber, >95% Crosslinked	1	Low Hardness	1		55-A	3.6	280	120	30	3	0.08	1000		
				2		64-A	5.7	340	110	35	30	0.08	1000		
				3		73-A	7.0	380	90	40	40	0.08	1000		
		2	Medium Hardness	0	Other										
				1		80-A	9.0	440	85	45	40	0.08	1000		
				2		87A	14.0	480	80	55	40	0.08	1000		
		3	High Hardness	0	Other										
				1		40-D	17.0	500	70	65	50	0.08	1000		
				2		50-D	20.0 <sup>A</sup>	500	60	75	50	0.08	1000		
		4	Ultralow Hardness	0	Other										
				1		35-A	1.4	200	160	35	40	0.08	1000		
				2		45-A	2.1	200	150	35	40	0.08	1000		
02	Nitrile Rubber, >95% Crosslinked	1	Low Hardness	0	Other										
				1		70-A	4.0	175	25	30	50 <sup>B</sup>	0.15	1500		
		2	Medium Hardness	0	Other										
				1		80-A	7.0	200	20	45	50 <sup>B</sup>	0.15	1500		
				2		87-A	11.0	300	15	55	50 <sup>B</sup>	0.15	1500		
		3	High Hardness	0	Other										
				1		45-D	13.0	350 <sup>A</sup>	15	65	50 <sup>B</sup>	0.15	1500		
0	Other	0	Other												

<sup>A</sup>Test Method **D638** used.

<sup>B</sup>Temperature of 125°C used.

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<https://standards.iteh.ai/catalog/standards/sist/e318c2c-4a7d-8dae-1e7e73e4ebe1/astm-d6338-17>

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

Group	Description	Class	Description	Grade	Description	Hardness, Test Method D2240, A/D Durometer, Typical; 5-s delay	Tensile Strength, 23°C, Test Method D412, MPa, min	Ultimate Elongation, 23°C, Test Method D412, % min	Volume Change, Test Method D471, IRM-903 oil, 70 h/125°C; % max	Compression-Set, Test Method D395; Method B, 25% deflection; 22-h/70°C; % max	Air Aging Test Method D573; 168h/150°C, Ultimate Elongation; % change max	
03	EPDM Rubber, >95 % Crosslinked, Non-hygroscopic	1	Low Hardness	1		55-A	4.0	300	160	40	40	
				2		65-A	6.0	400	160	40	40	
		2	Medium Hardness	1	Other	75-A	8.0	400	140	45	40	
				2		80-A	9.0	500	90	50	40	
				3		90-A	13.0	600	60	60	40	
		3	Ultralow Hardness	1	Other	35-A	2.5	300	170	25	40	
				2		45-A	3.5	350	170	30	40	
		0	Other	0	Other							
				0	Other							
		04	Butyl/halobutyl Rubber, >95 % Crosslinked	1	Low Hardness	1		65-A	5.0	300	130	40
0	Other											
2	Medium Hardness			1		75-A	6.0	400	115	55	40	
				2		85-A	10.0	400	90	75	40	
3	High Hardness			0	Other							
				1		45-D	13.0	400	65	80	40	
0	Other	0	Other									
00	Other	0	Other	0	Other							

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