Designation: D 5593 – 99ε1

Standard Classification for Thermoplastic Elastomers—Olefinic (TEO)[1]

This standard is issued under the fixed designation D 5593; 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.

ε[1] NOTE—Editorially corrected the description for Group 02, Class 1 in Table TEO in April 2002.

INTRODUCTION

This classification is intended to be a system for calling out olefinic thermoplastic elastomers used in the fabrication of end items or parts. It is not intended for the selection of materials. Material selection should be made by those having expertise in the plastics field after careful consideration of the design and the performance required of the part, the environment to which it will be exposed, the fabrication processes to be employed, and the inherent properties of the material other than those covered by this classification.

1. Scope *

1.1 This classification covers olefinic thermoplastic elastomers (TEOs) made directly in a reactor or through a compounding process and suitable for injection molding, extrusion, blow molding, or other melt processing. Compounding ingredients may be present as necessary for the applications and may consist of reinforcements, fillers, stabilizers, colorants, and other ingredients.

1.2 This classification allows for the use of those TEO materials, which can be recycled, reground, and reprocessed, provided that the requirements as stated in this classification are met. The proportions of recycled material used, as well as the nature and the amount of any contaminant, however, cannot be practically covered in this classification.

1.3 The properties included in this classification are those required to identify the compositions for most applications. Other requirements may be necessary to further identify particular characteristics. These may be specified by using the suffixes in accordance with Section 5.

1.4 The values stated in SI units are to be regarded as the standard. The inch-pound units are for information only.

1.5 The following precautionary caveat pertains only to the test method portion, Section 11, of this classification: *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.*

NOTE 1—There is no similar or equivalent ISO standard.

2. Referenced Documents

2.1 *ASTM Standards:*

D 256 Test Methods for Impact Resistance of Plastics and Electrical Insulating Materials[2]

D 412 Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers—Tension[3]

D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing[2]

D 624 Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomer[3]

D 638 Test Method for Tensile Properties of Plastics[2]

D 648 Test Method for Deflection Temperature of Plastics Under Flexural Load[2]

D 696 Test Method for Coefficient of Linear Thermal Expansion of Plastics[2]

D 746 Test Method for Brittleness Temperature of Plastics and Elastomers by Impact[2]

D 790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials[2]

D 792 Test Methods for Density and Specific Gravity (Relative Density) and Density of Plastics by Displacement[2]

D 883 Terminology Relating to Plastics[2]

D 1238 Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer[2]

D 1435 Practice for Outdoor Weathering of Plastics[2]

D 1566 Terminology Relating to Rubber[3]

D 1600 Terminology Relating to Abbreviated Terms Relating to Plastics[2]

[1] This classification is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.15 on Thermoplastic Materials.

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[2] *Annual Book of ASTM Standards*, Vol 08.01.

[3] *Annual Book of ASTM Standards*, Vol 09.01.

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

D 1898 Practice for Sampling Plastics[4]
D 2240 Test Method for Rubber Property—Durometer Hardness[3]
D 3418 Test Method for Transition Temperatures of Polymers by Thermal Analysis[5]
D 3641 Practice for Injection Molding Test Specimens of Thermoplastic Molding and Extrusion Materials[5]
D 3763 Test Method for High-Speed Puncture Properties of Plastic Using Load and Displacement Sensors[5]
D 3892 Practice for Packaging/Packing of Plastics[5]
D 4000 Classification System for Specifying Plastic Materials[5]
D 5033 Guide for the Development of Standards Relating to Proper Use of Recycled Plastics[5]
E 29 Practice for Using Significant Digits in Test Data to Determine Conformance to Specifications[5, 6]
E 380 Practice for Use of the International System of Units (SI)[6]

2.2 *DOT Standard:*

Department of Transportation Federal Motor Vehicle Safety No. FMVSS 302—Flammability of Interior Materials—Passenger Car, Multi-Purpose Passenger Vehicles[7]

2.3 *UL Standard:*

UL-94 Standards for Tests for Flammability of Plastic Materials for Parts, Devices and Appliances[8]

3. Terminology

3.1 *Definitions*—Definitions of terms pertaining to plastics used in this classification are in accordance with Terminology D 883, Terminology D 1566, and Guide D 5033.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *thermoplastic elastomer (TPE)*—a diverse family of rubber-like materials that, unlike conventional vulcanized rubbers, can be processed and recycled like thermoplastics.

3.2.2 *thermoplastic elastomer, olefinic (TEO)*—a class of materials consisting of blends of elastomers and olefinic thermoplastics that can be manufactured either directly in a reactor or through a compounding process and can be processed using conventional thermoplastics equipment.

4. Basis of Classification

4.1 Olefinic thermoplastic elastomers (TEO) are classified into three groups according to their major chemical composition (PP, PE, and other polyolefins). These groups are subdivided into three classes and four grades, depending on their flexural modulus. Table TEO lists the basic property requirements for these materials.

4.1.1 An example of this classification system is illustrated as follows:

TEO 0123 is a line-callout (specification) for a semi-flexible polypropylene-based material with the following properties:

Flexural modulus	= 600 MPa, min
Tensile strength	= 15 MPa, min
Tensile elongation	= 500 %, min
Shore hardness	= 55D ± 3
Tear resistance	= 70 kN/m, min

4.1.2 To facilitate the incorporation of future or special materials, the "other," category for group (00), class (0), and grade (0) is included in Table TEO. The basic properties of these materials are called out using Table A for example:

TEO 0120A33525 is a polypropylene-based semiflexible material with the following properties (see Table A):

Flexural modulus (3)	= 100 MPa, min
Tensile strength (3)	= 7 MPa, min
Elongation (5)	= 500 %, min
Shore hardness (2)	= 50A, min
Tear resistance (5)	= 50 kN/m, min

4.2 Compounded TEOs are of a proprietary nature, consequently there is no distinction between reinforced and unreinforced or filled and unfilled versions. Additives and modifiers are also used in this family of materials, and their presence is normally not disclosed.

5. Suffixes

5.1 Specific requirements that supersede or supplement Table A shall be shown by a suffix following the callout.

5.2 The list of suffixes found in Table 3 of Classification D 4000 may be used for additional requirements as appropriate. Other requirements might include color, specific gravity, melt flow rate, notched Izod impact, multiaxial impact strength, coefficient of linear thermal expansion, mold shrinkage, fogging, UV weatherability, thermal performance, chemical resistance, and other properties that are not listed in Table A. List of suffix properties appropriate for some of the more typical TEO applications are as follows:

A	= color
B	= fluid resistance
F	= flammability
G	= specific gravity
H	= heat resistance
J	= hardness
PA	= notched Izod impact
PX	= multiaxial impact
VC	= viscosity - melt flow rate
WE	= xenon-arc type weather resistance
WF	= florida outdoor weather resistance
ZC	= coefficient of linear thermal expansion
ZF	= fogging
ZM	= mold shrinkage

Acceptance criteria of these properties shall be specified by the user.

5.3 *Examples of Use of Suffixes*:

5.3.1 TEO0120A33525**PA000** is a TEO with properties in accordance with 4.1.2 and in addition a notched Izod impact requirement of no break in accordance with Table 3 of Classification D 4000.

5.3.2 TEO0120A33525**WF002** is the same TEO in 4.1.2 that needs to pass two-year Florida exposure (as specified by the user).

5.4 Other suffixes that may be used are listed in Table 3 of Classification D 4000.

[4] *Annual Book of ASTM Standards*, Vol 08.02.
[5] *Annual Book of ASTM Standards*, Vol 08.03.
[6] *Annual Book of ASTM Standards*, Vol 14.02.
[7] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.
[8] Available from Underwriters Laboratories, 333 Pfingsten Road, Northbrook, FL 60062-2096.

6. General Requirements

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

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

7. Detail Requirements

7.1 Test specimens for the various materials shall conform to the requirements in accordance with Table TEO, Table A, and suffix requirements as they apply.

7.2 For purposes of determining conformance, all specified limits for a specification (line callout) based on this classification system are absolute limits, in accordance with Practice E 29.

7.3 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.

8. Sampling

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

8.2 A lot of resin shall be considered as a unit of manufacture as prepared for shipment and may consist of a blend of two or more production runs or batches of materials.

9. Specimen Preparation

9.1 Prepare the test specimens by an injection molding process as specified in accordance with Specification D 3641 for the specific products tested. They are cut from sheets, molded shapes, or are molded to the desired finished dimensions.

9.2 If die-cut specimens are used, prepare them in the flow direction (for flexural modulus, tear strength, and Izod impact). For tensile testing of anisotropic materials, use five specimens normal to, and five parallel with, the principle axis of anisotropy.

10. Conditioning

10.1 Condition test specimens for 40 h minimum in the standard laboratory atmosphere of 23 ± 2°C and 50 ± 5 % relative humidity before performing the required tests.

10.2 Conduct tests in the standard laboratory atmosphere of 23 ± 2°C and 50 ± 5 % relative humidity in accordance with Practice D 618.

11. Test Methods

11.1 Test properties specified in this classification in accordance with the ASTM test methods referenced in Section 2.

11.2 Specific test conditions used to generate the properties listed in Table TEO and the cell table (Table A) are as follows:

Flexural modulus (Test Methods D 790): 12.7 mm/min (0.5 in./min) and 50-mm (2-in.) span
Tensile properties (Test Method D 638): 50 mm/min (2 in./min), or (Test Method D 412): 500 mm/min (20 in./min), for materials with no yield point
Shore hardness (Test Method D 2240): Shore A or Shore D with 5-s dwell time
Tear resistance (Test Method D 624): 50 mm/min (2 in./min), Type-C specimens

12. Certification and Inspection

12.1 Inspection and certification of the material supplied with reference to a specification based on this classification system shall be in conformance with 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 requirements might include properties not listed in Table TEO or Table A as they apply, for example:

TABLE TEO Classification of Olefinic Thermoplastic Elastomers

Group	Description	Class	Description	Grade	Flexural Modulus, Test Method D 790, MPa, minimum	Tensile Strength at Break, Test Method D 638, MPa, minimum	Elongation at Break, Test Method D 638, %, minimum	Hardness (5 s dwell), Test Method D 2240, Shore ±3	Tear Resistance, Test Method D 624, kN/m, minimum
01	PP Based	1	Flexible (<70 MPa)	1	20	2.0	600	55A	70
				2	40	7.0	600	70A	60
				3	60	9.0	600	80A	50
				0	...	...	...	...	...
		2	Semi-flexible (70 to 700 MPa)	1	80	9.0	600	45D	50
				2	200	17.0	600	50D	50
				3	600	15.0	500	55D	70
				0	...	...	...	...	...
		3	Semi-rigid (>700 MPa)	1	900	18.0	100	60D	20
				2	1300	16.0	100	62D	20
				3	>2000	15.0	...	70D	...
				0	...	...	...	...	...
02	PE Based	1	Flexible (<70 MPa)	1	20	...	...	...	...
				2	40	...	...	...	...
				3	60	...	...	...	...
				0	...	...	...	...	...
		2	Semi-flexible (70 to 700 MPa)	1	80	...	...	...	...
				2	200	...	...	...	...
				3	600	...	...	...	...
				0	...	...	...	...	...
		3	Semi-rigid (>700 MPa)	1	900	...	...	...	...
				2	1300	...	...	...	...
				3	>2000	...	...	...	...
				0	...	...	...	...	...
00	Other	0	other	0	other	...	...	...	...

Melt flow rate that provides certain indication of process control (often used as a lot-release parameter)
Carbon black content (for weather-stabilized materials)
Heat stabilizer content (for heat-stabilized materials, supplier's test showing positive presence)
Color (for precolored materials).

12.3 Periodic check inspection shall consist of the tests specified for all requirements of the materials under this specification. The supplier shall determine and use an inspection frequency adequate to ensure that the material is certifiable in accordance with 12.4.

12.4 Certification shall be that the material was manufactured, sampled, tested, and inspected in accordance with this specification and that the average values meet the requirements at a confidence level of 95 %.

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

13. Packaging and Package Marking

13.1 For packing, packaging, and marking, the provisions of Practice D 3892 apply.

14. Keywords

14.1 line callout; olefinic thermoplastic elastomers; thermoplastic elastomers

TABLE A Detail Requirements for Olefinic Thermoplastic Elastomers

Designation Order Number	Property	0	1	2	3	4	5	6	7	8	9
1	Flexural modulus, Test Method D 790, MPa, min	unspecified	10	50	100	400	700	1000	1500	2000	specify value
2	Tensile strength, Test Method D 638, MPa, min	unspecified	3.0	5.0	7.0	9.0	11.0	13.0	15.0	18.0	specify value
3	Elongation, Test Method D 638, %, min	unspecified	100	200	300	400	500	600	700	800	specify value
4	Hardness, Test Method D 2240, Shore, min	unspecified	40A	50A	60A	70A	80A	40D	50D	60D	specify value
5	Tear resistance, Test Method D 624, kN/m, min	unspecified	10	20	30	40	50	60	70	80	specify value

SUMMARY OF CHANGES

This section identifies the location of selected changes to this classification. For the convenience of the user, Committee D20 has highlighted those changes that may impact the use of this classification. This section may include descriptions of the changes or the reasons for the changes, or both.

D 5593 – 99:
(*1*) In 2.1, removed reference to Guide D 1999.
(*2*) In 4.1.2, changed "may be" to "are."
(*3*) In 9.1, in second sentence, changed "may be cut" to "are cut" and "may be molded" to "are molded."
(*4*) Removed 11.3 as there is no ISO standard.