



# Standard Classification System for Poly(Methyl Methacrylate) (PMMA) Molding and Extrusion Compounds<sup>1</sup>

This standard is issued under the fixed designation D788; 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.

*This standard has been approved for use by agencies of the U.S. Department of Defense.*

## 1. Scope\*

1.1 The purpose of this classification system is to provide a method of adequately identifying PMMA materials using a system consistent with that of Classification System **D4000**. It further provides a means for specifying these materials by the use of a simple line callout designation.

1.2 This classification system covers poly(methyl methacrylate) molding and extrusion compounds. These compounds are polymers based on methyl methacrylate, and at least 70 % of the polymer shall be polymerized from methyl methacrylate.

1.3 The properties in this classification system are those required to identify the compositions covered. Other requirements necessary to identify particular characteristics important to specific applications shall be described by using the suffixes as given in Section 5.

1.4 Acrylic molding and extrusion compounds are used frequently in applications where extreme clarity and the ability to retain that clarity and color under severe weathering and other environmental exposures are of primary significance. While the test specimen properties of this document extend to the evaluation of nonvirgin materials, the user must take precautions to ensure that parts made from these materials meet the desired end-use requirements. Accordingly, this specification allows for the use of those acrylic plastic materials that can be recycled, reconstituted, and reground provided the following:

1.4.1 The requirements as stated in this specification are met, and

1.4.2 The requirements of the particular end-use application are met.

1.5 This classification system and subsequent line callout (specification) are not intended for the selection of materials, but only as a means to call out plastic materials to be used for

the manufacture of parts. The selection of these materials is to be made by personnel with expertise in the plastics field in which the environment, inherent properties of the materials, performance of the parts, part design, manufacturing process, and economics are considered.

NOTE 1—This classification system is similar to ISO 8257-1:1987 in title only. The technical content is significantly different.

1.6 The values stated in SI units are to be regarded as standard.

1.7 *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.*

## 2. Referenced Documents

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

- [D149 Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies](#)
- [D150 Test Methods for AC Loss Characteristics and Permittivity \(Dielectric Constant\) of Solid Electrical Insulation](#)
- [D257 Test Methods for DC Resistance or Conductance of Insulating Materials](#)
- [D618 Practice for Conditioning Plastics for Testing](#)
- [D883 Terminology Relating to Plastics](#)
- [D1003 Test Method for Haze and Luminous Transmittance of Transparent Plastics](#)
- [D1238 Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer](#)
- [D1600 Terminology for Abbreviated Terms Relating to Plastics](#)
- [D3641 Practice for Injection Molding Test Specimens of Thermoplastic Molding and Extrusion Materials](#)
- [D3892 Practice for Packaging/Packing of Plastics](#)

<sup>1</sup> This classification system 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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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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

**TABLE 1 Transmission of Grade 2 Materials at Various Wavelengths<sup>A,B</sup>**

Wavelength, nm	Transmission, min, %
400	86
340	85
310	70
290	50
280	26
270	12

<sup>A</sup> Measured with UV spectrophotometer using an integrating sphere and a sample thickness of 3.2 mm.

<sup>B</sup> These requirements are in addition to the luminous transmittance requirements given in [Table 3](#).

### D4000 Classification System for Specifying Plastic Materials

#### E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

#### 2.2 ISO Standards and Recommendations:<sup>3</sup>

#### ISO 179 Plastics—Determination of Charpy Impact Properties—Part 1: Non-Instrumented Impact Test

#### ISO 294 Plastics—Injection Moulding of Test Specimens of Thermoplastic Materials—Part 1: General Principles, and Moulding of Multipurpose and Bar Test Specimens

#### ISO 306 Plastics—Thermoplastic Materials—Determination of Vicat Softening Temperature

#### ISO 489 Plastics—Determination of the Refractive Index of Transparent Plastics

#### ISO 527 Plastics—Determination of Tensile Properties

#### ISO 1133 Plastics—Determination of the Melt Flow Rate of Thermoplastics

#### ISO 3167 Plastics—Preparation and Use of Multipurpose Test Specimens

#### ISO 8257-1 Plastics—Poly(Methyl Methacrylate) (PMMA) Moulding and Extrusion Materials—Part 1

#### 2.3 SAE Standards:<sup>4</sup>

#### SAE J576 SAE Recommended Practice for Plastic Materials for Use in Optical Parts such as Lenses and Reflectors for Motor Vehicle Lighting Devices

#### SAE J2412 SAE Standard for Accelerated Exposure of Automotive Interior Trim Components Using a Controlled Irradiance Xenon-Arc Apparatus

#### SAE J2527 SAE Performance Based Standard for Accelerated Exposure of Automotive Exterior Materials Using a Controlled Irradiance Xenon-Arc Apparatus

### 3. Terminology

3.1 *Definitions*—The terminology used in this classification system is in accordance with Terminologies [D883](#) and [D1600](#).

### 4. Basis of Classification

4.1 Poly(methyl methacrylate) molding and extrusion compounds are classified into groups in accordance with their composition. These groups are subdivided into classes and

<sup>3</sup> Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

<sup>4</sup> Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, <http://www.sae.org>.

**TABLE 2 Electrical Properties of Unmodified PMMA**

Property	Test Method	Requirement
Insulation resistance, min, Mohm	<a href="#">D257</a>	$1 \times 10^7$
Dielectric strength min, kV/mm <sup>A</sup>	<a href="#">D149</a>	13.8
Dielectric constant at 1 MHz, max	<a href="#">D150</a>	4.5
Dissipation factor at 1 MHz, max	<a href="#">D150</a>	0.05

<sup>A</sup> kV/mm  $\times$  25.4 = V/mil.

grades as shown in [Table 3](#). A complete classification must include reference to melt-flow rate, as discussed in [4.2](#) and [5.1.4](#).

4.1.1 To facilitate the incorporation of future or special materials, the “other/unspecified” category (0) for group, class, and grade is given in [Table 3](#).

4.1.2 When the grade of the basic material is not shown, or is not important, the use of “0” grade classification shall be used in this classification system.

4.2 The melt-flow rate can vary within a given group, class, and grade and can overlap classes or grades. For this reason, the melt-flow rate shall be specified using Suffix V.

4.2.1 Although the values listed in Suffix V are necessary to include the range of properties available in existing materials, users must not infer that every melt-flow rate exists for each class or grade.

NOTE 2—An example of this classification system is as follows: The designation PMMA0112 indicates:

PMMA = poly(methyl methacrylate) as found in Terminology [D1600](#),  
 01 = unmodified (group),  
 1 = minimum 77°C Vicat, etc. (class) and  
 2 = ultraviolet transmitting (grade).  
 (See [Note 4](#) for a more complete example.)

NOTE 3—Major industries using these materials now require internationally accepted test methods for product specifications. For this reason, ISO test methods have been used in [Table 3](#) and elsewhere in this classification system where appropriate. Similar ASTM standards have been listed in [Section 2](#). Many of these ASTM standards are now or soon will be equivalent. In future editions, a note in the ASTM standard will indicate the degree of equivalency with a particular international standard. The corresponding ASTM test method is to be substituted as long as the specimen size and all other conditions of the test method noted in this classification system as applying to the ISO test method are also applied to the ASTM standard.

4.3 Grade 1 materials are used where special ultraviolet transmission, filtering, or stabilization characteristics are not required.

4.4 Grade 2 materials are used for those specialized applications in which the greatest amount of transmission of UV light is required. The transmission properties are given in [Table 1](#).

4.5 Grade 3 materials (transparent UV stabilized or transparent UV absorbing) are used when either special resistance to slight color change over long exposure times or high-intensity UV radiation is required, or when the material is required to filter out ultraviolet light. These applications are varied and require specific light transmission or color-stability properties to be specified by the user.

**TABLE 3 PMMA Poly(Methyl Methacrylate) Materials Detail Requirements**

Note—The values listed were developed for natural colors. Colorants or other additives, or both, have the potential to alter these properties.

Group	Description	Class	Description <sup>A</sup>	Grade	Description <sup>A</sup>	Charpy Impact, Test Method ISO 179 <sup>B</sup> kJ/m <sup>2</sup> , min	Tensile Strength, Test Method ISO 527, <sup>D</sup> MPa, min	Luminous Transmittance, Test Method D1003, <sup>E</sup> %, min	Haze, Test Method D1003, <sup>E</sup> %, max	Index of Refraction, Test Method ISO 489 <sup>E</sup>	Tensile Modulus, Test Method ISO 527, <sup>C</sup> MPa, min	Vicat Softening Temperature, Test Method ISO 306, <sup>F</sup> °C, min
01	Unmodified <sup>G</sup>	1	Formerly	1	General purpose	...	58	90	2.5	1.48-1.50	2700	77
			Grade 5	2	UV transmitting <sup>H</sup>	...	58	90	2.5	1.48-1.50	2700	77
			(D788 - 84)	3	UV stabilized <sup>I</sup>	...	58	90	2.5	1.48-1.50	2700	77
		2	Formerly	1	General purpose	...	62	90	2.5	1.48-1.50	2700	86
			Grade 6	2	UV transmitting <sup>H</sup>	...	62	90	2.5	1.48-1.50	2700	86
			(D788 - 84)	3	UV stabilized <sup>I</sup>	...	62	90	2.5	1.48-1.50	2700	86
		3	Formerly	1	General purpose	...	65	90	2.5	1.48-1.50	2700	95
			Grade 8	2	UV transmitting <sup>H</sup>	...	65	90	2.5	1.48-1.50	2700	95
			(D788 - 84)	3	UV stabilized <sup>I</sup>	...	65	90	2.5	1.48-1.50	2700	95
		4	Higher Vicat Softening Point than Former Grade 8	1	General purpose	...	65	90	2.5	1.48-1.50	2700	104
				2	UV transmitting <sup>H</sup>	...	65	90	2.5	1.48-1.50	2700	104
				3	UV stabilized <sup>I</sup>	...	65	90	2.5	1.48-1.50	2700	104
02	Impact modified <sup>J</sup>	1	1	1	1.2	51	88	4.0	1.48-1.50	2600	95	
			0	Other/unspecified	...	...	...	...	...	...		
		2	3	1	2.0	38	88	4.0	1.48-1.50	2500	90	
			4	1	4.3	31	88	4.0	1.48-1.50	1700	85	
03	Heat-Resistance modified <sup>K</sup>	1	1	1	General purpose	...	65	90	2.5	1.48-1.50	2700	113
			2	2	UV transmitting <sup>H</sup>	...	65	90	2.5	1.48-1.50	2700	113
			3	3	UV stabilized <sup>I</sup>	...	65	90	2.5	1.48-1.50	2700	113
			4	4	Impact modified also	tbd	56	88	4.0	1.48-1.50	tbd	113
		2	1	1	General purpose	...	65	90	2.5	1.48-1.50	2700	122
			2	2	UV transmitting <sup>H</sup>	...	65	90	2.5	1.48-1.50	2700	122
			3	3	UV stabilized <sup>I</sup>	...	65	90	2.5	1.48-1.50	2700	122
			4	1	General purpose	...	58	90	2.5	1.48-1.52	2700	113
00	Other	0	1	1	General purpose	...	58	90	2.5	1.48-1.52	2700	122
			0	Other/unspecified	...	...	...	...	...	...		

<sup>A</sup>No descriptions are listed unless needed to describe a special grade or class. All other categories are listed by requirements.

<sup>B</sup>Method designation shall be ISO 179/1eA. Specimen shall be type 1 (4 by 10 by 80 mm) with a type A notch radius of 0.25 mm and shall be positioned edgewise for impact. Specimens shall be conditioned in an oven for 16 hours at a set temperature that is 25°C below the Vicat softening temperature.

<sup>C</sup>Method designation shall be ISO 527-2/1A/1. Specimens shall be type 1A and tested at 1 mm/min. Specimens shall be conditioned in an oven for 16 hours at a set temperature that is 25°C below the Vicat softening temperature.

<sup>D</sup>Method designation shall be ISO 527-2/1A/5. Specimens shall be type 1A and tested at 5 mm/min. Specimens shall be conditioned in an oven for 16 hours at a set temperature that is 25°C below the Vicat softening temperature.

<sup>E</sup>Test specimens are 3.2-mm thick of colorless material.

<sup>F</sup>Method designation shall be ISO 306/B50. Specimens shall be 4 mm thick and >10 mm long by >10 mm wide. Specimens shall be conditioned in an oven for 16 hours at a set temperature that is 25°C below the Vicat softening temperature. After conditioning, they must be placed in a desiccator at 23 ± 2°C immediately after molding for at least 1 hour to prevent water pickup and kept dry until ready for test. Specimens must be tested at a temperature rate of 50°C/h with a 50 N load.

<sup>G</sup>Unmodified group materials are polymerized from 70 to 100 % methacrylate monomer and 0 to 30 % acrylic comonomers.

<sup>H</sup>See 4.4 for description.

<sup>I</sup>See 4.5 for description.

<sup>J</sup>Impact-modified materials contain 50 to 95 % unmodified polymer and 5 to 50 % of impact modifier(s), maintaining the requirement that the overall composition of these materials is polymers made from monomers, at least 70 % of which are methyl methacrylate.

<sup>K</sup>Heat-resistance modified materials are polymerized from 70 to 95 % methyl methacrylate monomer and 5 to 30 % comonomers.

## 5. Suffixes

5.1 When additional requirements are needed, based on the application, that are not covered by the basic cell-table requirements, they shall be indicated through the use of suffixes. In general, suffixes consist of a suffix letter, which gives the requirement needed, a first digit, which gives the test condition, and a second digit, which gives the specific requirement.

5.1.1 Suffix E = Electrical requirements, as designated by the following digits:

### First Digit

- 0 = to be specified by the user.
- 1 = specimen thickness, 3.2 mm, nominal.

### Second Digit

- 0 = to be specified by the user.
- 1 = volume resistivity, dielectric constant, and dissipation factor meet property limits as given in Table 2.

**TABLE 4 A Heat-Stability Properties of PMMA**

Property	Test Method	Requirement
Change in tensile strength	ISO 527	±15 % max
Change in impact strength	ISO 179	±15 % max

**TABLE 4B Heat-Stability Properties of PMMA**

Property	Test Method	Requirement
Change in tensile strength	ISO 527	±15 % max
Change in tensile elongation	ISO 527	±20 % max
Change in impact strength	ISO 179	±15 % max

5.1.2 Suffix H = Heat-stability requirements, as designated by the following digits:

First Digit	
0	= to be specified by the user.
1	= 1000 h at 70 ± 2°C.
2	= 1000 h at 80 ± 2°C.
3	= 1000 h at 90 ± 2°C.

Second Digit	
0	= to be specified by the user.
1	= change in tensile strength and impact strength not to exceed limits as given in <a href="#">Table 4A</a> after aging in an air-circulating oven at the conditions indicated by the first digit and subsequent conditioning according to <a href="#">Section 12</a> .
2	= change in tensile strength, tensile elongation, and impact strength not to exceed limits as given in <a href="#">Table 4B</a> after aging in an air-circulating oven at the conditions indicated by the first digit and subsequent conditioning according to <a href="#">Section 12</a> .

5.1.3 Suffix T = Light Transmission and Haze, Modification, as designated by the following digits:

First Digit	
0	= unspecified
1	= light diffusing polymer modified, minimum transmission 80 %
2	= light diffusing polymer modified, minimum transmission 70 %

T1 and T2 materials diffuse light without significant loss of light transmission. They contain either unmodified polymer from Group 1 or impact modified polymer from Group 2 of [Table PMMA](#) and acrylic based light diffusing modifier maintaining the requirement of [paragraph 1.2](#). The overall composition shall have a minimum of 70 % methyl methacrylate units in the various polymers.

T1 materials shall meet the requirements of the appropriate category in [Table PMMA](#) except:

- Luminous Transmittance- 80 % min. at 3.2 mm thickness.
- Haze- not applicable.
- Refractive Index- 1.49-1.53.

T2 materials shall meet the requirements of the appropriate category in [Table PMMA](#) except:

- Luminous Transmittance- 70 % min. at 3.2 mm thickness.
- Haze- not applicable.
- Refractive Index- 1.49-1.53.

5.1.4 Suffix V = Melt-flow property requirements as designated by the following digits, determined in accordance with [ISO 1133-1981, Condition 13](#) (equivalent to [Test Method D1238](#) at [Conditions 230/3.8](#)):

First Digit	
0	= unspecified.
1	= greater than 0 g/10 min.
2	= greater than 2 g/10 min.
3	= greater than 3 g/10 min.
4	= greater than 6 g/10 min.
5	= greater than 11 g/10 min.
6	= greater than 17 g/10 min.
7	= greater than 23 g/10 min.

NOTE 4—An example of this classification system for a PMMA resin with specified melt-flow rate properties is as follows:

The designation PMMA0112V5 indicates:

PMMA0112	= Unmodified, minimum 77°C Vicat, etc., ultraviolet transmitting material from <a href="#">Table 3</a> ,
V	= Melt-flow property requirements, from V suffix requirements above,
5	= Greater than 11 g/10 min. Melt-flow rate from V suffix requirements above.

5.1.5 Suffix W = Resistance to weathering as designated by the following digits:

First Digit	
0	= to be specified by the user.
1	= exposure as defined in <a href="#">SAE J576</a> .
2	= exposure as defined in <a href="#">SAE J2412</a> .
3	= exposure as defined in <a href="#">SAE J2527</a> .

Second Digit	
0	= to be specified by the user.
1	= meets the requirements of <a href="#">SAE J576</a> .

5.2 An additional list of suffixes is found in [Classification System D4000](#) and shall be used for additional requirements, as appropriate.

## 6. Basic Requirements

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

## 7. General Requirements

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

## 8. Detail Requirements

8.1 Test specimens for the various materials shall conform to the requirements prescribed in [Table 3](#), Suffix V requirements, and optional other suffix requirements, as they apply.

8.2 For purposes of determining conformance, all specified limits for a specification (line callout) based on this classification system are absolute limits, as defined in [Practice E29](#).

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 Sampling shall be statistically adequate to satisfy the requirements of [13.4](#).

**TABLE 5 Melt Temperature Conditions**

NOTE 1—The melt temperature was determined by using the hot-probe technique as described in Practice D3641 and ISO 294.

Viscosity Classification	Melt Temperature, °C
V0	270
V1	265
V2	250
V3	250
V4	240
V5	230
V6	220
V7	210

9.2 A batch or lot, consisting of one or blends of two or more “production runs,” shall be constituted as a unit of manufacture as prepared for shipment.

## 10. Number of Tests

10.1 The number of tests shall be consistent with the requirements of Section 9 and 13.4.

## 11. Specimen Preparation

11.1 The specimens shall be prepared by the injection molding process under the conditions outlined in Table 5 and Table 6. Specimens shall be prepared using an average injection velocity of  $200 \pm 100$  mm/s through the parallel section of the test specimen. Injection velocity shall be calculated as follows:

$$V_{av} = \frac{V_s}{(T_i \times A_c \times n)} \quad (1)$$

where:

$V_{av}$  = average injection velocity, (mm/s),

$T_i$  = injection time, s,

$V_s$  = shot volume,  $\text{mm}^3$ ,

$n$  = number of cavities, and

$A_c$  = cross sectional area of parallel section of test specimen ( $4 \text{ mm} \times 10 \text{ mm} = 40 \text{ mm}^2$ ).

11.2 Materials must be dried prior to molding to ensure bubble-free test specimens. A moisture content of 0.08 % or less is usually sufficient.

## 12. Conditioning

12.1 Molded test specimens shall be oven conditioned as indicated in Table 3, then conditioned as follows:

12.1.1 Condition test specimens in standard laboratory atmosphere in accordance with Procedure A (40/23/50) of Practice D618 before performing the required tests.

12.1.2 The specimens for Vicat softening temperature shall not be conditioned in accordance with Procedure A of Practice D618. After oven conditioning, the Vicat test specimens must

**TABLE 6 Mold Temperature Conditions**

Group/Class Designation	Mold Temperature, °C
PMMA011	50
PMMA012	60
PMMA013	70
PMMA014	70
PMMA021	60
PMMA022	50
PMMA023	50

be placed in a desiccator at  $23 \pm 2^\circ\text{C}$  immediately after molding for at least 1 hour to prevent water pickup and kept dry until ready for test.

12.2 Perform all tests in the standard laboratory atmosphere (23/50) in accordance with Practice D618.

## 13. Certification and Inspection

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 melt flow rate, Vicat softening point on all grades, and Izod impact on impact-modified materials.

13.3 Periodic check inspection shall consist of the tests specified for all requirements of the material under this classification system. The supplier shall determine and use an inspection frequency that shall be adequate to ensure that the material is certifiable in accordance with 13.4.

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

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

## 14. Packing, Packaging, and Package Marking

14.1 The provisions of Practice D3892 apply to packaging, packing, and marking of containers for plastic materials.

## 15. Keywords

15.1 acrylic; acrylic plastic; acrylic resins; clear weatherable plastics; line callout; plastic; plastic materials; PMMA; poly(methyl methacrylate); recycled; transparent plastics



**APPENDIX**
**(Nonmandatory Information)**
**X1. CROSS-REFERENCES**

X1.1 See **Table X1.1** and **Table X1.2**.

**TABLE X1.1 Cross-Reference to Prior Version of This Classification System (ASTM D788 - 84)**

Former Grade Designation	This Specification
Grade 5	PMMA0111V0
Grade 6	PMMA0121V0
Grade 8	PMMA0131V0

**TABLE X1.2 Cross-Reference Designations to Federal Specifications**

Federal Specification L-P-380C	This Specification
Type I—General-Purpose	
Class 1	PMMA0111V0
Class 2	PMMA0121V0
Class 3	PMMA0131V0
Type II—Electrical-Type Material	
Class 1	PMMA0111E11V0
Class 2	PMMA0121E11V0
Class 3	PMMA0131E11V0

**SUMMARY OF CHANGES**

Committee **D20** has identified the location of selected changes to this standard since the last issue (D788 – 14) that may impact the use of this standard. (September 1, 2016)

(1) Removed old 1.4.2.

(2) Revised conditioning statement in **12.1**.

(3) Updated weathering standards in **5.1.5**.

(4) Added two class categories to high heat group in **Table 3**.

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