



# Standard Specification for Rubber Seals Used in Flat-Plate Solar Collectors<sup>1</sup>

This standard is issued under the fixed designation D 3667; 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 Department of Defense.*

## 1. Scope

1.1 This specification covers the general requirements for materials used in rubber seals of flat-plate solar collectors, except vertically mounted passive collectors. Particular applications may necessitate other requirements that would take precedence over these requirements when specified.

1.2 The design requirement pertains only to permissible deflections of the rubber during thermal expansion or contraction of the seal in use and the tolerances in dimensions of molded and extruded seals.

1.3 This specification does not include requirements pertaining to the fabrication or installation of the seals.

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

1.5 The following safety hazards caveat pertains only to the test methods portion, Section 9, of this specification: *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:

C 661 Test Method for Indentation Hardness of Elastomeric-Type Sealants by Means of a Durometer<sup>2</sup>

C 717 Terminology of Building Seals and Sealants<sup>2</sup>

C 719 Test Method for Adhesion and Cohesion of Elastomeric Joint Sealants Under Cyclic Movement (Hockman Cycle)<sup>2</sup>

D 395 Test Methods for Rubber Property—Compression Set<sup>3</sup>

D 412 Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers—Tension<sup>3</sup>

D 865 Test Method for Rubber—Deterioration by Heating in Air (Test Tube Enclosure)<sup>3</sup>

D 1149 Test Method for Rubber Deterioration—Surface Ozone Cracking in a Chamber<sup>3</sup>

D 1229 Test Method for Rubber Property—Compression Set at Low Temperatures<sup>3</sup>

D 1349 Practice for Rubber—Standard Temperatures for Testing<sup>3</sup>

D 1415 Test Method for Rubber Property—International Hardness<sup>3</sup>

D 1566 Terminology Relating to Rubber<sup>3</sup>

D 2137 Test Methods for Rubber Property—Brittleness Point of Flexible Polymers and Coated Fabrics<sup>3</sup>

D 2240 Test Method for Rubber Property—Durometer Hardness<sup>3</sup>

D 3182 Practice for Rubber—Materials, Equipment, and Procedures for Mixing Standard Compounds and Preparing Standard Vulcanized Sheets<sup>3</sup>

D 3183 Practice for Rubber—Preparation of Pieces for Test Purposes from Products<sup>3</sup>

G 7 Practice for Atmospheric Environmental Exposure Testing of Nonmetallic Materials<sup>4</sup>

G 26 Practice for Operating Light-Exposure Apparatus (Xenon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials<sup>4</sup>

### 2.2 Other Standards:

RMA Handbook—Rubber Products: Molded, Extruded, Lathe Cut, and Cellular<sup>5</sup>

## 3. Terminology Definitions

3.1 Refer to the definitions of terms in Terminology C 717 and Terminology D 1566.

## 4. Classification

### 4.1 Types:

4.1.1 Type C, intended for use in cold climates (below  $-10^{\circ}\text{C}$  in winter).

4.1.2 Type W, intended for use in warm climates (above  $-10^{\circ}\text{C}$  in winter).

### 4.2 Grades:

4.2.1 Grade designations represent differing degrees of hardness as follows:

4.2.1.1 Grade 2, hardness of  $20 \pm 5$ .

4.2.1.2 Grade 3, hardness of  $30 \pm 5$ .

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee D11 on Rubber and is the direct responsibility of Subcommittee D11.36 on Seals.

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<sup>2</sup> Annual Book of ASTM Standards, Vol 04.07.

<sup>3</sup> Annual Book of ASTM Standards, Vol 09.01.

<sup>4</sup> Annual Book of ASTM Standards, Vol 06.01.

<sup>5</sup> Available from the Rubber Manufacturers Association (RMA), 444 Madison Ave., New York, NY 10022.

- 4.2.1.3 *Grade 4*, hardness of  $40 \pm 5$ .
- 4.2.1.4 *Grade 5*, hardness of  $50 \pm 5$ .
- 4.2.1.5 *Grade 6*, hardness of  $60 \pm 5$ .
- 4.2.1.6 *Grade 7*, hardness of  $70 \pm 5$ .
- 4.2.1.7 *Grade 8*, hardness of  $80 \pm 5$ .

NOTE 1—The grade to be used in a particular application depends on the design of the seal and must be specified by the designer.

#### 4.3 Classes:

4.3.1 Seals shall be classified as follows:

- 4.3.1.1 Class PS, preformed rubber seal.
- 4.3.1.2 Class SC, sealing compound.

NOTE 2—Class SC material should not be used in designs where the seal is under mechanical stress.

## 5. Materials and Manufacture

5.1 Seals shall be rubber vulcanizates conforming to the requirements in Section 6 and resistant to deterioration by solar radiation.

5.1.1 Resistance to solar radiation can be determined by either desert outdoor exposure in accordance with Practice G 7, or laboratory exposure to a xenon arc in accordance with Practice G 26, Method C. Desert outdoor exposure shall be for at least six months including at least one month preceding and following the summer solstice. Laboratory exposure shall be for at least 1000 h with a chamber air (not black panel) temperature of  $70 \pm 2^\circ\text{C}$ . After exposure, slight surface chalking and dulling are permitted. Brittleness, cracking, loss of elongation, tackiness, or other deterioration affecting serviceability shall not be permitted.

## 6. Requirements

6.1 Class PS material shall conform to the requirements given in Table 1.

6.2 Class SC material shall conform to the requirements given in Table 2.

## 7. Dimensions

7.1 The design of the seal shall not permit the rubber to deflect more than 25 % in any direction during thermal expansion and contraction of the solar collector.

NOTE 3—If the thermal coefficient of linear expansion for the rubber is not known, a value of 0.0003/K may be assumed for design purposes.

7.2 The tolerances in dimensions shall conform to the following designations in the RMA Handbook:

#### 7.2.1 Molded Seals:

7.2.1.1 Commercial Dimensions—RMA A3-F3-T.032.

7.2.1.2 Critical Dimensions—RMA A2-F3-T.032.

#### 7.2.2 Extruded Seals:

7.2.2.1 Commercial Dimensions—RMA A2-F3.

## 8. Workmanship, Finish, and Appearance

8.1 Class PS seals shall be free of blisters, checks, cracks, and other imperfections that can affect their ability to make or maintain a watertight seal.

8.2 Class SC material shall be uniform in composition and be free of defects that may affect serviceability.

## 9. Test Methods

9.1 *Class PS Material*—Prepare the specimens as prescribed in Practice D 3183 and test the material in accordance with the test methods given in Table 1. For control of production, specimens may be taken from standard test sheets prepared in accordance with Practice D 3182, using the same unvulcanized material used to prepare the seals and vulcanizing the material at the same temperature used for the seals to an equivalent state of vulcanization.

9.2 *Class SC Material*—Prepare five sheets approximately 150 by 150 by 2 mm in accordance with instructions supplied with the sealing material. Also, prepare five adhesion specimens in accordance with Test Method C 719. Preferably, prepare each sheet and adhesion specimen from material in a

**TABLE 1 Requirements for Class PS Material Used to Seal Flat-Plate Solar Collectors**

Property	Grade						ASTM Method
	3	4	5	6	7	8	
Ultimate elongation, min, %	350	300	250	200	150	100	D 412
Compression set, max, %:							
after 70 h at 150°C	30	30	30	30	30	30	D 395 <sup>A</sup>
after 166 h at -10°C	60	60	60	60	60	60	D 1229 <sup>B</sup>
Resistance to heating (for 166 h at 150°C): <sup>C</sup>							D 865
Hardness change, max	10	10	10	10	10	10	D 1415 or D 2240
Ultimate elongation change, max, %	30	30	30	30	30	30	D 412
Tensile strength change, max, %	20	20	20	20	20	20	D 412
Volatiles lost, max, %	1	1	1	1	1	1	See 9.3
Volatiles condensable, max, %	0.1	0.1	0.1	0.1	0.1	0.1	See 9.4
Resistance to ozone:							D 1149
100 mPa, <sup>D</sup> for 166 h at 40°C				No cracking			
Resistance for low temperature:							D 2137
Type C only, max, °C	-40	-40	-40	-40	-40	-40	

<sup>A</sup> Method B.

<sup>B</sup> Set to be measured at 10 s after release. Lubricated plates or polytetrafluoroethylene film is recommended if the rubber adheres to the metal compression plates during test.

<sup>C</sup> The test temperature of 150°C is used to test seals for cover plates. A seal in contact with an absorber plate should be tested at a standard test temperature listed in Practice D 1349 next above the maximum temperature of the absorber plate in service (which generally occurs under stagnation conditions and maximum radiation flux) but not less than 150°C. The higher test temperatures are: 175, 200, 225, and 250.

<sup>D</sup> 100 mPa of ozone partial pressure is equivalent to 100 ppm at standard atmospheric pressure (100 kPa). See new terminology on ozone content expressions described in Test Method D 1149.

**TABLE 2 Requirements for Class SC Material Used to Seal Flat-Plate Solar Collectors**

Property	Grade			ASTM Method
	2	3	4	
Ultimate elongation, min, %	200	150	100	D 412
Resistance to heating (for 166 h at 125°C)				D 865
Hardness change, max	10	10	10	C 661
Ultimate elongation change, max,%	30	30	30	D 412
Tensile strength change, max,%	20	20	20	D 412
Volatiles lost, max,%	1	1	1	See 9.3 <sup>A</sup>
Volatiles condensable, max,%	0.1	0.1	0.1	See 9.4 <sup>A</sup>
Resistance to ozone:				D 1149
100 mPa, for 166 h at 40°C		No cracking		
Resistance to low temperature				D 2137
Type C only, max, °C	−40	−40	−40	
Adhesion loss, max, cm <sup>2B</sup>	9	9	9	C 719

<sup>A</sup> This test is not required if the design precludes condensing of the volatiles on the cover plate(s) of the solar collector.

<sup>B</sup> The combined loss in bond and cohesion areas for the three specimens tested shall not exceed 9 mm<sup>2</sup>.

different container. Condition the sheets and adhesion specimens for 14 days at a temperature of 23°C and relative humidity of 50 %. Test the material in accordance with the test methods given in Table 2.

9.3 Determine volatiles lost from the difference in mass of the specimens before and after heating for 166 h at the temperature given in Table 1 or Table 2 and as prescribed in Test Method D 865.

9.4 Determine volatiles condensable at 23°C from the difference in mass of the outlet tubes before and after heating the specimens for 166 h at the temperature given in Table 1 or Table 2 in accordance with Test Method D 865. If necessary, cool the exposed portion of the outlet tube with a stream of air to maintain a temperature of 23 ± 2°C. If any volatiles condense on the inlet tube or other parts of the apparatus, add the mass of this condensed material to the mass of the material on the outlet tube.

## 10. Inspection and Rejection

10.1 *Class PS Material*—Manufacturers of preformed seals may use their quality control systems for production inspection to ensure the seals conform with this specification, provided appropriate records are kept. In case of dispute regarding the quality of a delivered product, a sample of five seals shall be taken from the lot and tested for compliance with this specification. If one of the five seals does not conform, a second sample of five seals may be taken and tested. If two or more of the ten seals do not conform, the lot may be rejected.

10.2 *Class SC Material*—Manufacturers may use their quality control systems to ensure production conforms with this specification. In case of dispute regarding the quality of a delivered product, five test sheets and five adhesion specimens shall be prepared, preferably from five different packages, in accordance with the instructions supplied with the sealing material. If one of the five sheets or adhesion specimens does not conform, an additional five sheets or adhesion specimens may be prepared and tested. If two or more of the ten sheets or adhesion specimens do not conform, the lot may be rejected.

## 11. Product Marking

11.1 The following information shall be marked either on the seal, packaging, label, or tag:

- 11.1.1 Name, brand, or trademark of the manufacturer,
- 11.1.2 Type and grade,
- 11.1.3 Compliance with Specification D 3667, and
- 11.1.4 Other information required by the manufacturer or purchaser.

## 12. Packaging and Package Marking

12.1 Material shall be protected by suitable packaging to prevent damage during shipment or storage prior to installation in the solar collector.

## 13. Keywords

13.1 flat-plate solar collectors; preformed seals; rubber; sealing compounds

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