



Standard Specification for Rubber Seals Used in Flat-Plate Solar Collectors¹

This standard is issued under the fixed designation D3667; 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.

This standard has been approved for use by agencies of the U.S. 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 standard. No other units of measurement are included in this standard.

1.5 The following safety hazards caveat pertains only to Section 9, Test Methods, 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:²

- [C661 Test Method for Indentation Hardness of Elastomeric-Type Sealants by Means of a Durometer](#)
- [C717 Terminology of Building Seals and Sealants](#)
- [C719 Test Method for Adhesion and Cohesion of Elastomeric Joint Sealants Under Cyclic Movement \(Hockman Cycle\)](#)

¹ This specification is under the jurisdiction of ASTM Committee D11 on Rubber and is the direct responsibility of Subcommittee D11.37 on Coated Fabrics, Rubber Threads and Seals.

Current edition approved July 1, 2016. Published July 2016. Originally approved in 1978. Last previous edition approved in 2010 as D3667–05 (2010). DOI: 10.1520/D3667-16.

² 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.

- [D395 Test Methods for Rubber Property—Compression Set](#)
 - [D412 Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension](#)
 - [D865 Test Method for Rubber—Deterioration by Heating in Air \(Test Tube Enclosure\)](#)
 - [D1149 Test Methods for Rubber Deterioration—Cracking in an Ozone Controlled Environment](#)
 - [D1229 Test Method for Rubber Property—Compression Set at Low Temperatures](#)
 - [D1349 Practice for Rubber—Standard Conditions for Testing](#)
 - [D1415 Test Method for Rubber Property—International Hardness](#)
 - [D1566 Terminology Relating to Rubber](#)
 - [D2137 Test Methods for Rubber Property—Brittleness Point of Flexible Polymers and Coated Fabrics](#)
 - [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](#)
 - [D3183 Practice for Rubber—Preparation of Pieces for Test Purposes from Products](#)
 - [G7 Practice for Atmospheric Environmental Exposure Testing of Nonmetallic Materials](#)
 - [G151 Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources](#)
 - [G155 Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials](#)
- 2.2 *Other Standards:*³
- [RMA Handbook—Rubber Products: Molded, Extruded, Lathe Cut, and Cellular](#)

3. Terminology

3.1 *Definitions*—Refer to the definitions of terms in Terminology [C717](#) and Terminology [D1566](#).

4. Classification

4.1 Types:

³ Available from Rubber Manufacturers Association (RMA), 1400 K St., NW, Suite 900, Washington, DC 20005, <http://www.rma.org>.

4.1.1 *Type C*, intended for use in cold climates (below -10 °C in winter).

4.1.2 *Type W*, intended for use in warm climates (above -10 °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 ± 5 .

4.2.1.2 *Grade 3*, hardness of 30 ± 5 .

4.2.1.3 *Grade 4*, hardness of 40 ± 5 .

4.2.1.4 *Grade 5*, hardness of 50 ± 5 .

4.2.1.5 *Grade 6*, hardness of 60 ± 5 .

4.2.1.6 *Grade 7*, hardness of 70 ± 5 .

4.2.1.7 *Grade 8*, hardness of 80 ± 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.

5.2 Resistance to solar radiation can be determined by one of the following:

5.2.1 Desert outdoor exposure, in accordance with recommended Practice G7 using the exposure rack at an angle of 45° for unbacked exposure of the specimens. Desert outdoor exposure shall be for at least six months including at least one month preceding and following the summer solstice.

5.2.2 Xenon arc laboratory exposure, in accordance with recommended Practice G151 and G155 using daylight filters and operating conditions as described below:

5.2.2.1 The irradiance level shall be maintained at 0.55 ± 0.02 W/(m²·nm) at 340 nm at the control point. For equivalent broad band irradiance levels and tolerances at 300 to 400 nm and 300 to 800 nm, consult the manufacturer of the apparatus.

5.2.2.2 The default exposure cycle shall be 102 min light only followed by 18 min light plus either water spray on the front surface or immersion in water. The spray water can be fresh or recirculated from a holding tank. The temperature of the spray water is uncontrolled and for fresh water typically ranges between 16 and 26°C. Recirculated spray water can be at a higher temperature. Immersion water is generally in a holding tank for recirculation. The uncontrolled temperature of the recirculated immersion water during operation of the weathering device typically ranges between 45 and 55°C.

NOTE 3—Water spray and immersion in water are different kinds of moisture exposures and may produce different results.

5.2.2.3 The uninsulated black panel temperature (BPT) shall be maintained at 63 ± 2.5 °C at the control point during the dry period of exposure to light. For the equivalent insulated black

panel temperature (black standard temperature (BST)), consult the manufacturer of the apparatus.

5.2.2.4 Relative humidity shall be maintained at 60 ± 10 % at the control point during the dry period of exposure to light in xenon arc apparatus that uses water spray for wetting.

5.2.2.5 The chamber air temperature shall be maintained at 48 ± 2 °C at the control point in equipment that uses water spray for wetting and provides for adjustment of the chamber air temperature.

5.2.2.6 The exposure duration shall be by agreement between the parties concerned. The exposure time shall be at least 1000 h, but long enough to produce a substantial change in the property of interest in the least stable formulation of the type of material being evaluated.

NOTE 4—The specified set point is the target condition for the control sensor as programmed by the user. When a Standard calls for a particular set point, the user programs the exact number. The tolerances (maximum allowed operational fluctuations) specified with the set point do not imply that the user is allowed to program a set point higher or lower than the exact set point specified. The operational fluctuations specified are the maximum deviations allowable from the set point at the control sensor during equilibrium conditions. The machine variables determine the operational fluctuations. If under equilibrium conditions they exceed those allowed, stop the test and correct the problem before continuing.

5.3 After exposure, slight surface chalking and dulling are permitted. Brittleness, cracking, 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 5—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 D3183 and test the material in accordance with the

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

Property	Grade						ASTM Test Method
	3	4	5	6	7	8	
Ultimate elongation, min, %	350	300	250	200	150	100	D412
Compression set, max, %:							
after 70 h at 150°C	30	30	30	30	30	30	D395 ^A
after 166 h at -10°C	60	60	60	60	60	60	D1229 ^B
Resistance to heating (for 166 h at 150°C): ^C							D865
Hardness change, max	10	10	10	10	10	10	D1415 or D2240
Ultimate elongation change, max, %	30	30	30	30	30	30	D412
Tensile strength change, max, %	20	20	20	20	20	20	D412
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:							D1149
100 mPa, ^D for 166 h at 40°C				No cracking			
Resistance to low temperature:							D2137
Type C only, max, °C	-40	-40	-40	-40	-40	-40	
Resistance to Outdoor or Xenon arc exposure	No brittleness, cracking, tackiness, or other deterioration affecting serviceability						See 5.2

^A Method B.

^B 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.

^C 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 D1349 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.

^D 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 D1149.

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

Property	Grade			ASTM Test Method
	2	3	4	
Ultimate elongation, min, %	200	150	100	D412
Resistance to heating (for 166 h at 125°C)				D865
Hardness change, max	10	10	10	C661
Ultimate elongation change, max, %	30	30	30	D412
Tensile strength change, max, %	20	20	20	D412
Volatiles lost, max, %	1	1	1	See 9.3 ^A
Volatiles condensable, max, %	0.1	0.1	0.1	See 9.4 ^A
Resistance to ozone:				D1149
100 mPa, for 166 h at 40°C		No cracking		
Resistance to low temperature:				D2137
Type C only, max, °C	-40	-40	-40	
Adhesion loss, max, cm ^{2B}	9	9	9	C719
Resistance to Outdoor or Xenon arc exposure	No brittleness, cracking, tackiness, or other deterioration affecting serviceability			See 5.2

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

^B The combined loss in bond and cohesion areas for the three specimens tested shall not exceed 9 mm².

test methods given in Table 1. For control of production, specimens may be taken from standard test sheets prepared in accordance with Practice D3182, 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 C719. Preferably, prepare each sheet and adhesion specimen from material in a 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 D865.

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 D865. 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 D3667, 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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