



Standard Specification for Rubber Seals Used in Concentrating Solar Collectors¹

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1. Scope

1.1 This specification covers the general requirements for materials used in rubber seals of concentrating solar collectors. Particular applications may necessitate other requirements that would take precedence over these requirements when specified.

1.2 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 Durometer²
- C 717 Terminology of Building Seals and Sealants²
- C 719 Test Method for Adhesion and Cohesion of Elastomeric Joint Sealants Under Cyclic Movement (Hockman Cycle)²
- D 395 Test Methods for Rubber Property—Compression Set³
- D 412 Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension³
- D 865 Test Method for Rubber—Deterioration by Heating in Air (Test Tube Enclosure)³
- D 1149 Test Method for Rubber Deterioration—Surface Ozone Cracking in a Chamber³

- D 1229 Test Method for Rubber Property—Compression Set at Low Temperatures³
- D 1349 Practice for Rubber—Standard Temperatures for Testing³
- D 1415 Test Method for Rubber Property—International Hardness³
- D 1566 Terminology Relating to Rubber³
- D 2137 Test Methods for Rubber Property—Brittleness Point of Flexible Polymers and Coated Fabrics³
- D 2240 Test Method for Rubber Property—Durometer Hardness³
- D 3182 Practice for Rubber—Materials, Equipment, and Procedures for Mixing Standard Compounds and Preparing Standard Vulcanized Sheets³
- D 3183 Practice for Rubber—Preparation of Pieces for Test Purposes from Products³
- G 7 Practice for Atmospheric Environmental Exposure Testing of Nonmetallic Materials⁴
- G 151 Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources⁵
- G 155 Practice for Operating Xenon Arc Light Apparatus for Exposure of Nonmetallic Materials⁵

2.2 Other Standards:

- RMA Handbook— Rubber Products: Molded, Extruded, Lathe Cut, and Cellular⁴

3. Terminology

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°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 in accordance with Test Methods D 1415 and D 2240 as follows:

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² *Annual Book of ASTM Standards*, Vol 04.07.

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

⁴ Available from the Rubber Manufacturers Association (RMA), 444 Madison Ave., New York, NY 10022.

⁵ *Annual Book of ASTM Standards*, Vol 14.04.

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

5.1.1 *Desert outdoor exposure*, in accordance with recommended Practice G 7 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.

5.1.2 *Xenon arc laboratory exposure*, in accordance with recommended Practice G 151 and G 155 using daylight filters and operating conditions as described below:

5.1.2.1 The irradiance level shall be maintained at $0.55 \pm 0.02 \text{ W}/(\text{m}^2 \cdot \text{nm})$ 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.

5.1.2.2 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 water spray temperature is typically $21 \pm 5^\circ\text{C}$, but may be lower if ambient water temperature is low and a holding tank is not used to store

purified water. The immersion water is kept at a constant temperature, which shall be less than 40°C .

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

5.1.2.3 The uninsulated black panel temperature (BPT) shall be maintained at $63 \pm 2.5^\circ\text{C}$ 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.

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

5.1.2.5 The chamber air temperature shall be maintained at $48 \pm 2^\circ\text{C}$ at the control point in equipment that uses water spray for wetting and provides for adjustment of the chamber air temperature.

5.1.2.6 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 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 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. Tolerance is determined by the machine variables. The tolerance specified is the maximum deviation allowable from the set point at the control sensor during equilibrium conditions.

5.2 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.

TABLE 1 Requirements for Class PS Material Used to Seal 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 MST ^A	30	30	30	30	30	30	D 395 ^B
after 166 h at -10°C	60	60	60	60	60	60	D 1229 ^C
Resistance to heating (for 166 h at MST ^A):							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, 100 mPa, ^D for 166 h at 40°C			no cracking				D 1149
Resistance to low temperature, Type C only, max, $^\circ\text{C}$	-40	-40	-40	-40	-40	-40	D 2137

^A The test temperature is based on the maximum service temperature (MST) which normally occurs when the collector is under stagnation conditions and is receiving the maximum radiation flux to which it will be exposed. The test temperature listed in Practice D 1349 that is between 25 and 49°C above the maximum service temperature is used. These temperatures are: 150, 175, 200, 225, and 250°C .

^B Method B.

^C 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 the test.

^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 D 1149.

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 -F3-T.032.

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

7.2.2 *Extruded Seals:*

7.2.2.1 *Commercial Dimensions*—RMA -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, such as partially vulcanized lumps.

9. Test Methods

9.1 *Class PS Material*—Prepare the specimens in accordance with Practice D 3183 and test the specimens 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 the 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

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 in accordance with 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 and 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 $23 \pm 2^\circ\text{C}$. 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.

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

Property	Grade			ASTM Method
	2	3	4	
Ultimate elongation, min, %	200	150	100	D 412
Resistance to heating (for 166 h at MST ^A):				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 ^B
Volatiles condensable, max, %	0.1	0.1	0.1	see 9.4 ^B
Resistance to ozone, 100 mPa, ^C for 166 h at 40°C		no cracking		D 1149
Resistance to low temperature, Type C only, max, °C	-40	-40	-40	D 2137
Adhesion loss (max, - cm ²) ^D	9	9	9	C 719 ^E

^A The test temperature is based on the maximum service temperature (MST) which normally occurs when the collector is under stagnation conditions and is receiving the maximum radiation flux. The test temperature listed in Practice D 1349 that is between 25 and 49°C above the maximum service temperature is used. These temperatures are: 150, 175, 200, 225, and 250.

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

^C 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.

^D The combined loss in bond and cohesion areas for the three specimens tested shall not exceed 9 cm².

^E The temperature in 6.3 of Test Method C 719 shall be modified to the MST (see footnote^A).

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 3771, 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 concentrating solar collectors; preformed seals; rubber; sealing compounds

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