



# Standard Specification for Rubber Seals Used in Concentrating Solar Collectors<sup>1</sup>

This standard is issued under the fixed designation D3771; 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 reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

## 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 standard. No other units of measurement are included in this 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:<sup>2</sup>

- D661 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)
- D395 Test Methods for Rubber Property—Compression Set

<sup>1</sup> 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.

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<sup>2</sup> 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.

- 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:
- RMA Handbook—Rubber Products: Molded, Extruded, Lathe Cut, and Cellular<sup>3</sup>

## 3. Terminology

3.1 Refer to the definitions of terms in Terminology C717 and Terminology D1566.

## 4. Classification

### 4.1 Types:

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

<sup>3</sup> Available from the Rubber Manufacturers Association (RMA), 444 Madison Ave., New York, NY 10022.

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 in accordance with Test Methods **D1415** and **D2240** as follows:

- 4.2.1.1 *Grade 2*, hardness of  $20 \pm 5$ .
- 4.2.1.2 *Grade 3*, hardness of  $30 \pm 5$ .
- 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 Resistance to solar radiation can be determined by one of the following:

5.1.1 *Desert outdoor exposure*, in accordance with recommended Practice **G7** using the exposure rack at an angle of  $45^{\circ}$  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 **G151** and **G155** 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 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  $26^{\circ}\text{C}$ . 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  $55^{\circ}\text{C}$ .

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 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.

5.2 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  $0.0003/\text{K}$  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 **D3183** 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 **D3182**, using the same

**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	D412
Compression set, max, %:							
after 70 h at MST <sup>A</sup>	30	30	30	30	30	30	D395 <sup>B</sup>
after 166 h at – 10°C	60	60	60	60	60	60	D1229 <sup>C</sup>
Resistance to heating (for 166 h at MST <sup>A</sup> ):							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 condensible, max, %	0.1	0.1	0.1	0.1	0.1	0.1	see 9.4
Resistance to ozone, 100 mPa, <sup>D</sup> for 166 h at 40°C			no cracking				D1149
Resistance to low temperature, Type C only, max, °C	–40	–40	–40	–40	–40	–40	D2137
Resistance to Outdoor or Xenon Arc Exposure	No brittleness, cracking, tackiness, or other deterioration affecting serviceability.						G7 or G155

<sup>A</sup> 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 D1349 that is between 25 and 49°C above the maximum service temperature is used. These temperatures are: 150, 175, 200, 225, and 250°C.

<sup>B</sup> Method B.

<sup>C</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 the test.

<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 Methods D1149.

**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	D412
Resistance to heating (for 166 h at MST <sup>A</sup> ):				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 <sup>B</sup>
Volatiles condensible, max, %	0.1	0.1	0.1	see 9.4 <sup>B</sup>
Resistance to ozone, 100 mPa, <sup>C</sup> for 166 h at 40°C		no cracking		D1149
Resistance to low temperature, Type C only, max, °C	–40	–40	–40	D2137
Adhesion loss (max, – cm <sup>2</sup> ) <sup>D</sup>	9	9	9	C719 <sup>E</sup>
Resistance to Outdoor or Xenon Arc Exposure	No brittleness, cracking, tackiness, or other deterioration affecting serviceability.			G7 or G155

<sup>A</sup> 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 D1349 that is between 25 and 49°C above the maximum service temperature is used. These temperatures are: 150, 175, 200, 225, and 250.

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

<sup>C</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 Methods D1149.

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

<sup>E</sup> The temperature in 6.3 of Test Method C719 shall be modified to the MST (see footnote<sup>A</sup>).

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 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 in accordance with Test Method D865.

**9.4 Determine volatiles condensible** 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 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 D3771, 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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