Designation: D 3903 – 03

Standard Specification for Rubber Seals Used in Air-Heat Transport of Solar Energy Systems[1]

This standard is issued under the fixed designation D 3903; 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.

1. Scope

1.1 This specification covers the general requirements for the rubber seals used in solar energy systems employing air-heat transport. Examples are duct and damper seals. Particular applications may necessitate other requirements that would take precedence over these requirements when specified.

NOTE 1—Rubber seals for the collector are covered in Specifications D 3667 and D 3771.[2]

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 10, of this specification: *This standard does not purport to address the safety concerns 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[3]

C 717 Terminology of Building Seals and Sealants[3]

C 719 Test Method for Adhesion and Cohesion of Elastomeric Joint Sealants Under Cyclic Movement (Hockman Cycle)[3]

D 395 Test Methods for Rubber Property—Compression Set[4]

D 412 Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension[4]

D 865 Test Method for Rubber—Deterioration by Heating in Air (Test Tube Enclosure)[4]

D 1149 Test Method for Rubber Deterioration—Surface Ozone Cracking in a Chamber[4]

D 1229 Test Method for Rubber Property—Compression Set at Low Temperatures[4]

D 1349 Practice for Rubber—Standard Temperatures for Testing[4]

D 1415 Test Method for Rubber Property—International Hardness[4]

D 1566 Terminology Relating to Rubber[4]

D 2137 Test Methods for Rubber Property—Brittleness Point of Flexible Polymers and Coated Fabrics[4]

D 2240 Test Method for Rubber Property—Durometer Hardness[4]

D 3182 Practice for Rubber—Materials, Equipment, and Procedures for Mixing Standard Compounds and Preparing Standard Vulcanized Sheets[4]

D 3183 Practice for Rubber—Preparation of Pieces for Test Purposes From Products[4]

D 3667 Specification for Rubber Seals Used in Flat-Plate Solar Collectors[2]

D 3771 Specification for Rubber Seals Used in Concentrating Solar Collectors[2]

G 7 Practice for Atmospheric Environment Exposure Testing of Nonmetallic Materials[5]

G 151 Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources[5]

G 155 Practice for Operating Xenon Arc Light Apparatus for Exposure of Nonmetallic Materials[5]

2.2 *Other Standards:*

RMA Handbook—Rubber Products: Molded, Extruded, Lathe Cut, and Cellular (Third Edition)[6]

3. Terminology

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

[1] 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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[2] *Annual Book of ASTM Standards*, Vol 09.02.

[3] *Annual Book of ASTM Standards*, Vol 04.07.

[4] *Annual Book of ASTM Standards*, Vol 09.01.

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

[6] Available from the Rubber Manufacturers Association (RMA), 1901 Pennsylvania Ave. N.W., Washington, DC 20006.

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*—Grade designations represent differing degrees of hardness as follows:

4.2.1 *Grade 2*, hardness of 20 ± 5.
4.2.2 *Grade 3*, hardness of 30 ± 5.
4.2.3 *Grade 4*, hardness of 40 ± 5.
4.2.4 *Grade 5*, hardness of 50 ± 5.
4.2.5 *Grade 6*, hardness of 60 ± 5.
4.2.6 *Grade 7*, hardness of 70 ± 5.
4.2.7 *Grade 8*, hardness of 80 ± 5.

NOTE 2—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*—Seals shall be classified as follows:

4.3.1 *Class PS*, preformed rubber seal.

4.3.2 *Class SC*, sealing compound.

NOTE 3—Class SC material should not be used in designs where the seal is under mechanical stress.

5. Ordering Information

5.1 Orders for material under this specification shall include the following information:

5.1.1 Type,
5.1.2 Grade,
5.1.3 Class,
5.1.4 Shape and dimensions,
5.1.5 Quantity,
5.1.6 ASTM designation and year of issue, and
5.1.7 Other requirements.

6. Materials and Manufacture

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

6.1.1 *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.

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

6.1.2.1 The irradiance level shall be maintained at 0.55 ± 0.02 W/(m^2·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.

6.1.2.2 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 ± 5°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 4—Water spray and immersion in water are different kinds of moisture exposures and may produce different results.

6.1.2.3 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.

6.1.2.4 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.

6.1.2.5 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.

6.1.2.6 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 5—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.

6.2 After exposure, slight surface chalking and dulling are permitted. Brittleness, cracking, loss of elongation, tackiness, or other deterioration affecting serviceability shall not be permitted.

7. Requirements

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

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

8. Dimensions

8.1 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 6—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.

8.2 The tolerances in dimensions of molded seals shall conform to the following designations in the RMA Handbook:

8.2.1 *Molded Seals*:
8.2.1.1 *Commercial Dimensions*—RMA -F3-T.032.
8.2.1.2 *Critical Dimensions*—RMA -F3-T.032.
8.2.2 *Extended Seals*:
8.2.2.1 *Commercial Dimensions*—RMA -F3.

9. Workmanship, Finish, and Appearance

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

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

TABLE 1 Requirements for Class PS Material Used to Seal Air-Heat Transport Systems

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 125°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 (166 h at 125°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
Volatiles lost, max, %	2	2	2	2	2	2	see 10.3
Resistance to ozone, 100 mPa,[D] for 166 h at 40°C	no cracking						D1149
Resistance to low temperature,							D2137
Type C only, max,° C	−40	−40	−40	−40	−40	−40	

[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 125°C should cover most applications in air ducts of solar energy systems. A seal in an air-heat transport system operating at temperatures above 100°C should be tested at a standard test temperature listed in Practice D 1349 at least 25°C above the maximum temperature in service. The higher test temperatures are: 150, 175, 200, 225, and 250°C.

[D] 100 mPa of ozone partial pressure is equivalent to 100 pphm 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	D412
Resistance to heating (166 h at 100°C):				D865
Hardness change, max	10	10	10	C661
Ultimate elongation change, max, %	30	30	30	D412
Volatiles lost, max, %	2	2	2	see 10.3
Resistance to ozone, 100 mPa,[A] for 166 h at 40°C	no cracking			D1149
Resistance to low temperature,				D2137
Type C only, max, °C	−40	−40	−40	
Adhesion loss, max, cm^{2}[B]	9	9	9	C719[C]

[A] 100 mPa of ozone partial pressure is equivalent to 100 pphm at standard atmospheric pressure (100 kPa). See new terminology on ozone content expressions described in Test Method D 1149.

[B] The combined loss in bond and cohesion areas for the three specimens tested shall not exceed 9 cm^{2}.

[C] The temperature in 6.3 of Test Method C 719 shall be modified to 100°C.

10. Test Methods

10.1 *Class PS Material*—Prepare the specimens as prescribed in Recommended 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.

10.2 *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 ± 2°C and relative humidity of 50 ± 5 %. Test the material in accordance with the test methods given in Table 2.

10.3 Determine the 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.

11. Inspection and Rejection

11.1 *Class PS Material*—Manufacturers of preformed seals may use their quality control systems for production inspection to assure 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 shall be rejected.

11.2 *Class SC Material*—Manufacturers may use their quality control systems to assure 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 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 shall be rejected.

12. Product Marking

12.1 The following information may be marked on either the seal, packaging, label, or tag:

12.1.1 Name, brand, or trademark of the manufacturer,

12.1.2 Type, grade, and class,

12.1.3 Compliance with this standard, Specification D 3903, and

12.1.4 Other information required by the manufacturer or the purchaser.

13. Packaging and Package Marking

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

14. Keywords

14.1 air-heat transport; rubber seals; solar energy systems