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Solar energy — Methods of testing preformed rubber seals and sealing compounds used in collectors

Énergie solaire — Méthodes d'essai des joints préformés en caoutchouc et des composés pour l'étanchéité utilisés dans les capteurs (DIS distribué en version anglaise seulement)

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Contents

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 9953 was prepared by Technical Committe ISO/TC 180, *Solar energy*.

Annex A forms an integral part of this International Standard.

Solar energy — Methods of testing preformed rubber seals and sealing compounds used in collectors

1 Scope

1.1 This International Standard gives requirements for the classification and testing of rubbers used to seal solar energy collectors in order to aid selection for specific applications.

NOTE Particular rubber applications, when specified, may necessitate other requirements that take precedence over these requirements.

1.2 The design requirements in this International Standard pertain only to permissible deflection of the rubber during thermal expansion or retraction of the seal in use and to the tolerances on dimensions of moulded and extruded seals.

1.3 This International Standard does not include requirements pertaining to geometrical design, fabrication or installation of the seals.

1.4 This International Standard is applicable in conjunction with long-term ageing and weathering tests. However, if long-term tests are performed, it is recommended that ISO 4892-2 be complied with for ageing tests and ISO 877 for accelerated weathering tests and material exposure tests, respectively.

NOTE The environmental conditions, test specimen configuration and any test deviations should be agreed upon between the parties involved. Also, if long-term tests are performed, the specific tests described in this International Standard should be performed before and after long-term testing is carried out.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 37:1994, *Rubber, vulcanized or thermoplastic — Determination of tensile stress-strain properties.*

ISO 48:1994, *Rubber, vulcanized or thermoplastic — Determination of hardness (hardness between 10 IRHD and 100 IRHD).*

ISO 188: –[1)], *Rubber, vulcanized — Accelerated ageing and heat-resistance tests.*

ISO 471:1995, *Rubber — Temperatures, humidities, and times for conditioning and testing.*

ISO 812:1991, *Rubber, vulcanized — Determination of low-temperature brittleness.*

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1) To be published. (Revision of ISO 188:1982)

ISO 815:1991, *Rubber, vulcanized or thermoplastic — Determination of compression set at ambient, elevated or low temperatures.*

ISO 877:1994, *Plastics—Methods of exposure to direct weathering, to weathering using glass-filtered daylight, and to intensified weathering by daylight using Fresnel 1 mirrors.*

ISO 1431-1:1989, *Rubber, vulcanized or thermoplastic — Resistance to ozone cracking — Part 1: Static strain test.*

ISO 3302-1:1996, *Rubber — Tolerances for products — Part 1: Dimensional tolerances.*

ISO 4632-1:1982, *Rubber, vulcanized — Classification system — Part 1: Description of the classification system.*

ISO 4661-1:1993, *Rubber, vulcanized or thermoplastic — Preparation of samples and test pieces — Part 1: Physical tests.*

ISO 4661-2:1987, *Rubber, vulcanized — Preparation of samples and test pieces — Part 2: Chemical tests.*

ISO 4892-2:1994, *Plastics — Method of exposure to laboratory light sources — Part 2: Xenon-arc sources.*

ISO 7619:1997, *Rubber — Determination of indentation hardness by means of pocket hardness meters.*

3 Classification

3.1 Sealing

Sealing can be accomplished by one of the following methods:

a) a preformed rubber seal (PS);

b) a sealing compound (SC).

NOTE Sealing compounds should not be used in collectors in which the seal is under mechanical stress.

3.2 Seal type

The following type classification is in accordance with ISO 4632-1. The type selected should be based on the maximum service temperature which normally occurs when the collector is under stagnation conditions and is receiving the maximum radiation flux to which it will be exposed.

Table 1 gives the maximum service temperatures and the test temperatures required in tables 3 and 4.

Table 1 — Seal types, test temperatures and maximum service temperatures (ISO 4632-1)

Type	Test temperature °C	Max. service temperature °C
B	100	70
C	125	100
D	150	125
E [1)]	175	150
F [1)]	200	175
G [1)]	225	200
H [1)]	250	225

[1)] Types E, F, G and H are not required for most solar collectors.

3.3 Seal grade

Table 2 shows differing degrees of rubber hardness in accordance with ISO 48 and ISO 7619. The grade to be used in a particular application depends on the design of the seal and shall be specified by the designer.

Table 2 — Grade designation for different degrees of hardness

Grade	Hardness
3	30 ± 5
4	40 ± 5
5	50 ± 5
6	60 ± 5
7	70 ± 5
8	80 ± 5

3.4 Seal class

3.4.1 The classes shown in table 3 are established based on resistance to low temperatures. The class selected should be based on the lowest temperature of the collector expected in service.

Table 3 — Seal classes, test temperatures and lowest service temperatures

Class	Climate	Test temperature °C	Lowest service temperature °C
W	Warm	0	− 10
M	Moderate	− 25	− 35
C	Cold	− 40	− 50
P	Polar	− 60	− 70

4 Materials

4.1 Seals shall be made from rubber compounds that are resistant to the effect of ultraviolet light and, when vulcanized as in 7.1, shall comply with the requirements in clause 5.

4.2 Seals shall be free from defects that adversely affect the serviceability of products. Surface texture of preformed seals should be appropriate to the method of manufacture decided by the parties concerned.

5 Dimensions and tolerances

5.1 Attention should be paid to the effects of seal thermal expansion. For this reason, dimensions will vary greatly in a solar collector due to the large range of temperatures reached.

NOTE If the thermal coefficient of linear expansion for the rubber is not known, a value of 0,000 3 K^{-1} may be assumed for design purposes.

5.2 The tolerance on dimensions shall conform to the following designations in ISO 3302-1:

5.2.1 Moulded seals

Good quality mouldings (Class M3)

High quality mouldings (Class M2)

5.2.2 Extruded seals

Good quality extrusion (Class E2)

NOTE The same consideration should be given to shrinkage.

6 Physical requirements

6.1 Preformed seals should conform to the requirements in table 4 when tested by the procedures given in clause 7.

NOTE The requirements for low-temperature flexibility and ozone resistance relate to the composition of the rubber vulcanized (type of rubber and formulation); these tests are required only when the composition is changed.

6.2 Sealing compounds shall conform to the requirements in table 5 when tested by the procedures in clause 7 (see note in 5.1).

7 Test methods

7.1 Preparation of test pieces

Prepare test pieces from preformed seals in accordance with ISO 4661-1 and test them in accordance with the test methods given in table 4.

For sealing compounds, prepare five sheets approximately 150 mm × 150 mm × 2 mm in accordance with instructions supplied by the manufacturer. Also, prepare five adhesion assemblies in accordance with annex A. Condition the sheets and adhesion assemblies for 14 days at standard laboratory conditions as given in ISO 471. Test the materials in accordance with test methods given in table 5.

Table 4 — Requirements for preformed seals

Property	Grade					Test method
	4	5	6	7	8	
Hardness, IRHD, $^{+5}_{-4}$	40	50	60	70	80	7.2
Elongation at break, min. %	300	250	200	50	100	7.3
Compression set, max. %						
After 24^{0}_{-2} h at high temperature[1]	30	30	30	30	30	7.4
After 166^{+2}_{0} h at low temperature	60	60	60	60	60	7.6
Resistance to heating[1]						7.5
Hardness, change, max. IRHD	10	10	10	10	10	7.2
Elongation at break, change, max. %	30	30	30	30	30	7.3
Tensile strength change, max. %	20	20	20	20	20	7.3
Volatiles lost, max. %	1	1	1	1	1	7.5.2
Volatiles lost, max. %	0,1	0,1	0,1	0,1	0,1	7.5.3
Resistance to ozone	no cracking					7.6
Resistance to low temperature[2] Classes M, C, and P only	no breaks or cracks					7.7

1) The temperature depends on the type.
2) The temperature depends on the class.

Table 5 — Requirements for sealing compounds

Property	Grade 3	Grade 5	Test method
Hardness, IRHD, $^{+5}_{-4}$	30	40	7.2
Elongation at break, min. %	150	100	7.3
Resistance to heating[a]			7.5
Hardness, change, max. IRHD	10	10	7.2
Elongation at break, change, max.%	30	30	7.3
Tensile strength change, max. %	20	20	7.3
Volatiles lost, max. %	1	1	7.5.2
Volatiles condensable, max. %	0,1	0,1	7.5.3
Resistance to ozone	no cracking		7.6
Resistance to low temperature[b] Classes M, C, and P only	no breaks no cracks		7.7
Adhesion loss[c], max. cm^2	9	9	7.8

(a) The temperature depends on the type—see Table 1.

(b) The temperature depends on the class—see Table 3.

(c) The combined loss in bond and cohesion areas for the three specimens tested shall not exceed 9 cm^2.

7.2 Hardness

Test in accordance with ISO 48 or ISO 7619.

7.3 Tensile strength and elongation at break

Test in accordance with ISO 37 (Type 2: dumbbell test piece).

7.4 Compression set

Test in accordance with ISO 815 at high temperatures and ISO 1653 at low temperatures (small ISO 815 disc as test piece).

7.5 Resistance to heating

7.5.1 Heat test pieces in a test tube in accordance with ISO 188, but for 14 days at the appropriate temperature for the type of seal given in table 1. The test tube shall be approximately 38 mm × 300 mm and be equipped with a two-hole heat-resistant stopper, a 9 mm × 420 mm inlet tube extending to within 25 mm of the bottom, a 9 mm × 380 mm outlet tube extending about 320 mm above the stopper, and a support to suspend three test pieces in the lower half of the test tube.

NOTE This high-temperature exposure is not an ageing process, and any correlation between this exposure and natural behaviour during service would be coincidental.

7.5.2 After heating, condition the test pieces at standard laboratory temperatures for at least 16 h and perform the required tests within 96 h.

7.5.3 Determine mass change (essentially due to volatiles lost) from the difference in masses of test pieces before and after ageing.

7.5.4 Determine condensables which are volatile at 23 °C from the difference in masses of the outlet tube before and after heating the test pieces. Ensure that the exposed portion of the outlet tube is maintained at a temperature of (23 ± 2) °C. If any volatiles condense on the inlet tube or other parts of the apparatus, they should be added to the mass of the material on the outlet tube.

7.6 Resistance to ozone

Determine in accordance with ISO 1431-1; Method A, 20 % elongation, ozone concentration in air 200×10^{-8}, for $96\ ^{+2}_{0}$ h at 40 °C.

7.7 Resistance to low temperature

Determine in accordance with ISO 812. Examine test pieces for brittleness (breaks or cracks) after test.

7.8 Adhesion loss

Determine in accordance with annex A.

8 Test report

The test report shall include at least the following information:

a) complete identification of the seal tested;

b) test methods and test conditions used (i.e. a reference to ISO 9553), including any deviations from specified procedures/conditions;

c) test results;

d) name of the person and organization responsible for the test.

Annex A
(normative)

Determination of adhesion of sealing compounds

A.1 Scope

This method is an accelerated laboratory procedure for evaluating the performance of a sealing compound (sealant) in a solar collector joint which is subjected to water immersion, cyclic movement and temperature change.

A.2 Apparatus

A.2.1 Compression-extension apparatus, designed to compress and extend an adhesion assembly with a 12,5 mm sealant joint by 25 % (that is, from 75 % to 125 % of the joint width) at a constant rate of 4 h per cycle (that is, 2 h for the compression cycle and 2 h for the extension cycle).

A.2.2 Oven, capable of being controlled to within ± 2 °C of the temperature given in table 1 for the type of seal tested.

A.2.3 Cold chamber, capable of being controlled to within ± 2 °C of the temperature given in table 3 for the class of seal tested.

A.2.4 "C" clamps.

A.2.5 Spacer blocks and substrate plates.

A.3 Adhesion assembly

A.3.1 Substrates

The substrates are the materials in the solar energy collector which are to be sealed. Aluminium and glass substrates shall be used for tests when substrates are not specified. The substrate plates shall measure at least 75 mm × 25 mm × 6 mm.

A.3.2 Primer

When the sealant manufacturer recommends use of a primer, substrate surfaces contacting the sealing compound shall be primed in accordance with recommendations.

A.3.3 Assembly

Prepare five assemblies for each substrate/sealing compound combination. Condition unopened packages of sealing compound for at least 24 h at standard laboratory temperature, in accordance with the manufacturer's instructions to the extent that they do not conflict with the following requirements:

a) Place two 12,5 mm spacer blocks between the parallel faces of two substrate plates to form a mould cavity measuring 12,5 mm × 12,5 mm × 50 mm.

b) Apply polyethylene adhesive tape or other suitable inert release agent to the surfaces of the spacers forming the cavity prevent adhesion of the spacers to the sealant. Hold the mould together with adhesive tape, rubber

bands or clamps. For multicomponent sealing compounds, mix thoroughly (for 5 min) 250 g of base compound with the appropriate amount of curing agent.

c) Fill the mould cavity with the sealing compound to be tested. Condition the test assembly for 21 days at standard laboratory conditions in accordance with ISO 471.

d) Separate the spacer blocks as soon as rigidity is achieved during the conditioning period, taking care to avoid damaging the sealant or adhesive bond.

A.4 Test procedure

A.4.1 Immerse the test assemblies in distilled water for 7 days. Following immersion, remove and flex each assembly twice about 60° to check the bond.

A.4.2 If the bond is firm, compress the joint by 25 % of the width of the sealant and clamp the compressed assembly. Place the clamped assembly in an oven for 7 days at the test temperature specified in table 1, appropriate for the type of sealing compound. Then remove the assemblies from the oven and allow them to cool, with the clamps removed, to standard laboratory temperature.

A.4.3 Place the assemblies in the compression-extension apparatus and subject them to 10 cycles at a rate of one cycle every 4 h and an amplitude of 25 % compression followed by 25 % extension. At the completion of the 10 cycles, insert spacer blocks between the substrate plates in the extended position, remove the assemblies from the apparatus, and examine the joints for bond failure or cohesive failure. Discontinue tests on assemblies with complete bond or cohesive failure.

A.4.4 Again compress the joint in the remaining assemblies by 25 % and, while compressed, place them in the oven for 16 h to 20 h at the test temperature (see table 1). Remove the assemblies from the oven and allow them to cool uncompressed to standard laboratory temperature for at least 2 h.

A.4.5 Place the assemblies in an extension apparatus within a cold chamber maintained at a temperature appropriate for the class of sealing compound (see 3.4). Set the grips of the apparatus at 9,5 mm apart and extend to 15,5 mm, and maintain in the cold chamber for a 2 h period. Insert spacers between the substrate plates at maximum extension and remove the assemblies from the apparatus. Allow them to warm to ambient temperature. Examine the sealant for bond failure or cohesive failure. Repeat the above cycle nine times. Discontinue the test on any assembly if complete bond or cohesive failure occurs.

A.4.6 Determine the combined loss in bond and cohesive areas, in square centimetres, for the three assemblies.

A.5 Test report

The test report shall contain at least the following information:

a) identification of the sealing compound;

b) type and class of sealing compound;

c) substrates used;

d) identification of primer if used;

e) total area of bond and cohesive failure;

f) description of failures;

g) name of person and organization responsible for the test.

ICS 27.160; 83.140.50

Descriptors: solar energy, solar heating, sunray collectors, joints, rubber products, seals (stoppers), classification, specifications, dimensions, physical properties, tests, physical tests.

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