



Designation: E881 – 92 (Reapproved 2022)

Standard Practice for Exposure of Solar Collector Cover Materials to Natural Weathering Under Conditions Simulating Stagnation Mode¹

This standard is issued under the fixed designation E881; 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 practice covers a procedure for the exposure of solar collector cover materials to the natural weather environment at elevated temperatures that approximate stagnation conditions in solar collectors having a combined back and edge loss coefficient of less than $1.5 \text{ W}/(\text{m}^2 \cdot ^\circ\text{C})$.

1.2 This practice is suitable for exposure of both glass and plastic solar collector cover materials. Provisions are made for exposure of single and double cover assemblies to accommodate the need for exposure of both inner and outer solar collector cover materials.

1.3 This practice does not apply to cover materials for evacuated collectors, photovoltaic cells, flat-plate collectors having a combined back and edge loss coefficient greater than $1.5 \text{ W}/(\text{m}^2 \cdot ^\circ\text{C})$, or flat-plate collectors whose design incorporates means for limiting temperatures during stagnation.

1.4 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 ASTM Standards:²

D1435 Practice for Outdoor Weathering of Plastics

¹ This practice is under the jurisdiction of ASTM Committee E44 on Solar, Geothermal and Other Alternative Energy Sources and is the direct responsibility of Subcommittee E44.20 on Optical Materials for Solar Applications.

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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.

E765 Practice for Evaluation of Cover Materials for Flat Plate Solar Collectors (Withdrawn 1991)³

E772 Terminology of Solar Energy Conversion

E782 Practice for Exposure of Cover Materials for Solar Collectors to Natural Weathering Under Conditions Simulating Operational Mode

G7/G7M Practice for Natural Weathering of Materials

2.2 Other Documents:⁴

Federal Specification HH-I-558B, Amendment 3 Insulation Blocks, Boards, Felts, Sleeving (Pipe and Tube Covering), and Pipe Fitting Covering Thermal (Mineral Fiber, Industrial Type), August 1976

3. Terminology

3.1 Definitions:

3.1.1 For definitions of terms used in this practice, refer to Terminology E772.

4. Significance and Use

4.1 This practice describes a weathering box test fixture and establishes limits for the heat loss coefficients. Uniform exposure guidelines are provided to minimize the variables encountered during outdoor exposure testing.

4.2 Since the combination of elevated temperature and solar radiation may cause some solar collector cover materials to degrade more rapidly than either exposure alone, a weathering box that elevates the temperature of the cover materials is used.

4.3 This practice may be used to assist in the evaluation of solar collector cover materials in the stagnation mode. No single temperature or procedure can duplicate the range of temperatures and environmental conditions to which cover materials may be exposed during stagnation conditions. To assist in evaluation of solar collector cover materials in the operational mode, Practice E782 should be used. Insufficient data exist to obtain exact correlation between the behavior of materials exposed in accordance with this practice and actual in-service performance.

³ The last approved version of this historical standard is referenced on www.astm.org.

⁴ Federal Specification HH-I-558B has several classes of insulation material intended for high-temperature use.



4.4 This practice may also be useful in comparing the performance of different materials at one site or the performance of the same material at different sites, or both.

4.5 Means of evaluating the effects of weathering are provided in Practice E765, and in other ASTM test methods that evaluate material properties.

4.6 Exposures of the type described in this practice may be used to evaluate the stability of solar collector cover materials when exposed outdoors to the varied influences that comprise weather. Exposure conditions are complex and changeable. Important factors are material temperature, climate, time of year, presence of industrial pollution, etc. Generally, because it is difficult to define or measure precisely the factors influencing degradation due to weathering, results of outdoor exposure tests must be taken as indicative only. Repeated exposure testing at different seasons over a period of more than one year is required to confirm exposure tests at any one location. Control samples must always be used in weathering tests for comparative analysis.

5. Weathering Box Test Fixture

5.1 Test Fixture Requirements:

5.1.1 The weathering box test fixture shall be constructed such that the combined back and edge loss coefficient is less than $1.5 \text{ W/(m}^2\cdot^\circ\text{C)}$ ($0.264 \text{ Btu/(ft}^2\cdot\text{h}\cdot^\circ\text{F)}$) (Note 1). (The method for determining this coefficient is outlined in Appendix X1 of this practice.) The distance between the absorber and the closest cover plate shall be between 13 and 38 mm (0.5 and 1.5 in.). For a double-cover exposure the separation between the inner and outer cover shall be between 13 and 38 mm (0.5 and 1.5 in.). Not more than 10 % of the absorber plate area shall be shaded when the sun is at a 30° angle with the plane of the front surface of the exposure box.

NOTE 1—A good flat-plate solar collector has a combined back and edge loss coefficient of less than about $1.5 \text{ W/(m}^2\cdot^\circ\text{C)}$ ($0.264 \text{ Btu/(ft}^2\cdot\text{h}\cdot^\circ\text{F)}$).

5.1.2 Boxes that meet the requirements of 5.1.1 are described in Table 1. Figs. 1 and 2 illustrate the weathering box test fixtures. Although Fig. 1 shows a square box, any shape is permitted if the requirements in 5.1.1 are met. Appendix X1 of this practice describes the method for determining the combined back and edge loss coefficient.

5.2 Contents of the Weathering Box Test Fixture: (1) a box, (2) insulation, (3) absorber, (4) box top, (5) spacer, (6) glazing frame, and (7) adhesive tapes.

5.2.1 The box may have any dimensions and be made of any material as long as the requirements in 5.1.1 are met. A weep hole shall be drilled at the lower end of the bottom of the box to provide drainage and to minimize moisture accumulation.

NOTE 2—It is desirable that the box and box top be made of a material that will be unaffected by the exposure environment. A metal resistant to corrosion encountered in the environment would be suitable. If wood is used, it should be painted or treated on the exterior to make it resistant to moisture. In certain climates, only rot-resistant wood should be used to minimize deterioration during exposure.

5.2.2 The insulation shall be a material suitable for use at a high temperature (for example, 150°C (302°F)).⁴

NOTE 3—Insulation materials having resins or binders should not be used because elevated temperatures may cause the resin or binder to deteriorate and outgas. Outgassing products condense on the cover material, causing changes in the solar transmittance of the solar collector cover material.

5.2.3 The absorber shall be of an adequate size to cover the interior surface of the weathering box aperture. The absorber shall have a flat black nonselective coating having an absorptance not less than 0.90 after exposure.

5.2.4 The box top shall be of an adequate size to fit over the box.

NOTE 4—The box top is intended to protect the edges of the test specimen in contact with the box from reaching excessively high temperatures, to minimize exposure of the adhesive tape to sunlight, and to minimize moisture penetration into the exposure test fixture.

TABLE 1 Examples of Weathering Box Test Fixtures with Combined Heat Loss Coefficient for Back and Edge Losses Less Than $1.5 \text{ W/(m}^2\cdot^\circ\text{C)}$ ($0.264 \text{ Btu/(ft}^2\cdot\text{h}\cdot^\circ\text{F)}$)

	Example 1	Example 2
Box material	steel	aluminum
Insulation material	glass fiber	glass fiber
l , length of aperture inside edge insulation	0.25 m (9.8 in.)	0.61 m (24 in.)
w , width of aperture inside edge insulation	0.13 m (5.2 in.)	0.61 m (24 in.)
h , distance from top of absorber to bottom of cover plate	0.013 m (0.5 in.)	0.038 m (1.5 in.)
A_a , area of aperture of test fixture $A_a = (l \times w)$	0.033 m ² (51 in. ²)	0.372 m ² (576 in. ²)
A_b , area of back insulation $A_b = (l \times w)$	0.033 m ² (51 in. ²)	0.372 m ² (576 in. ²)
A_e , area of edge insulation $A_e = 2(l + w)h$	0.01 m ² (15 in. ²)	0.093 m ² (144 in. ²)
d_b , thickness of back insulation	0.077 m (3 in.)	0.05 m (2 in.)
d_c , thickness of box	0.001 m (0.04 in.)	0.002 m (0.08 in.)
d_e , thickness of edge insulation	0.013 m (0.5 in.)	0.025 m (1 in.)
K_b , conductivity of back insulation	0.038 W/(m ² ·°C) (0.22 Btu/(ft ² ·h·°F))	0.038 W/(m ² ·°C) (0.022 Btu/(ft ² ·h·°F))
K_c , conductivity of box	43 W/(m ² ·°C) (24.9 Btu/(ft ² ·h·°F))	204 W/(m ² ·°C) (118 Btu/(ft ² ·h·°F))
K_e , conductivity of edge insulation	0.038 W/(m ² ·°C) (0.022 Btu/(ft ² ·h·°F))	0.038 W/(m ² ·°C) (0.022 Btu/(ft ² ·h·°F))
A_b/A_a	1	1
A_e/A_a	0.305	0.25
d_b/K_b	2.03 m ² ·°C/W (11.4 (ft ² ·h·°F)/Btu)	1.32 m ² ·°C/W (7.5 (ft ² ·h·°F)/Btu)
d_c/K_c	$2.33 \times 10^{-5} \text{ m}^2\cdot^\circ\text{C/W}$ ($1.32 \times 10^{-4} \text{ (ft}^2\cdot\text{h}\cdot^\circ\text{F)/Btu}$)	$9.8 \times 10^{-6} \text{ m}^2\cdot^\circ\text{C/W}$ ($5.6 \times 10^{-5} \text{ (ft}^2\cdot\text{h}\cdot^\circ\text{F)/Btu}$)
d_e/K_e	0.342 m ² ·°C/W (1.94 (ft ² ·h·°F)/Btu)	0.658 m ² ·°C/W (3.74 (ft ² ·h·°F)/Btu)
U_L , back + U_L , edge	1.38 W/(m ² ·°C) (0.243 Btu/(ft ² ·h·°F))	1.14 W/(m ² ·°C) (0.201 Btu/(ft ² ·h·°F))