Designation: E 781 – 86 (Reapproved 2003)

Standard Practice for Evaluating Absorptive Solar Receiver Materials When Exposed to Conditions Simulating Stagnation in Solar Collectors With Cover Plates[1]

This standard is issued under the fixed designation E 781; 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 test procedure for evaluating absorptive solar receiver materials and coatings when exposed to sunlight under cover plate(s) for long durations. This practice is intended to evaluate the exposure resistance of absorber materials and coatings used in flat-plate collectors where maximum nonoperational stagnation temperatures will be approximately 200°C (392°F).

1.2 This practice shall not apply to receiver materials used in solar collectors without covers (unglazed) or in evacuated collectors, that is, those that use a vacuum to suppress convective and conductive thermal losses.

1.3 The values stated in SI units are to be regarded as the standard.

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

2. Referenced Documents

2.1 *ASTM Standards:*

B 537 Practice for Rating of Electroplated Panels Subjected to Atmospheric Exposure[2]

D 1898 Practice for Sampling of Plastics[3]

E 408 Test Methods for Total Normal Emittance of Surfaces Using Inspection-Meter Techniques[4]

E 434 Test Method for Calorimetric Determination of Hemispherical Emittance and the Ratio of Solar Absorptance to Hemispherical Emittance Using Solar Simulation[4]

E 772 Terminology Relating to Solar Energy Conversion[5]

E 903 Test Method for Solar Absorptance, Reflectance, and Transmittance of Materials Using Integrating Spheres[5]

E 962 Practice for Cleaning Cover Materials for Flat Plate Solar Collectors[5]

3. Terminology

3.1 *Definitions*—See Terminology E 772 for definitions.

4. Significance and Use

4.1 Although this practice is intended for evaluating solar absorber materials and coatings used in flat-plate collectors, no single procedure can duplicate the wide range of temperatures and environmental conditions to which these materials may be exposed during in-service conditions.

4.2 This practice is intended as a screening test for absorber materials and coatings. All conditions are chosen to be representative of those encountered in solar collectors with single cover plates and with no added means of limiting the temperature during stagnation conditions.

4.3 This practice uses exposure in a simulated collector with a single cover plate. Although collectors with additional cover plates will produce higher temperatures at stagnation, this procedure is considered to provide adequate thermal testing for most applications.

NOTE 1—Mathematical modelling has shown that a selective absorber, single glazed flat-plate solar collector can attain absorber plate stagnation temperatures as high as 226°C (437°F) with an ambient temperature of 37.8°C (100°F) and zero wind velocity; and a double glazed one as high as 245°C (482°F) under these conditions. The same configuration solar collector with a nonselective absorber can attain absorber stagnation temperatures as high as 146°C (284°F), if single glazed, and 185°C (360°F), if double glazed, with the same environmental conditions, (see "Performance Criteria for Solar Heating and Cooling Systems in Commercial Buildings," NBS Technical Note 1187 [6]).

4.4 This practice evaluates the thermal stability of absorber materials. It does not evaluate the moisture stability of absorber materials used in actual solar collectors exposed outdoors.

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[1] These test methods are under the jurisdiction of ASTM Committee E44 on Solar, Geothermal, and Other Alternative Energy Sources and is the direct responsibility of Subcommittee E44.05 on Solar Heating and Cooling Subsystems and Systems.

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[2] *Annual Book of ASTM Standards,* Vol 02.05.

[3] *Annual Book of ASTM Standards,* Vol 08.01.

[4] *Annual Book of ASTM Standards,* Vol 15.03.

[5] *Annual Book of ASTM Standards,* Vol 12.02.

[6] Available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

Moisture intrusion into solar collectors is a frequent occurrence in addition to condensation caused by diurnal breathing.

4.5 This practice differentiates between the testing of spectrally selective absorbers and nonselective absorbers.

4.5.1 *Testing Spectrally Selective Absorber Coatings and Materials*—Spectrally selective solar absorptive coatings and materials require testing in a covered enclosure that contains a selectively coated sample mounting plate, such that the enclosure and mounting plate simulate the temperature conditions of a selective flat-plate collector exposed under stagnation conditions.

4.5.2 *Testing Nonselective Coatings and Materials*—Spectrally nonselective solar absorptive coatings and materials require testing in a covered enclosure that contains a nonselective coated sample mounting plate, such that the enclosure and mounting plate simulate the temperature conditions of a covered, nonselective flat-plate collector exposed under stagnation conditions.

5. Test Apparatus

5.1 *Test Enclosure* (Fig. 1), consisting of a box that approximates the dimensions of a typical flat-plate solar collector and shall have minimum dimensions of 0.75 by 1.5 by 0.1 m (29 by 60 by 4 in.) deep. The box should be constructed of materials that are impervious to moisture. Wood should not be used for construction of the box. Care shall be taken to prevent water leakage at joints, seams, and seals.

5.1.1 *Pre-Exposure of Test Box*—Prior to use, the test apparatus shall be placed in an operational environment where all components are allowed to equilibrate at the stagnation temperature for a sufficient length of time to allow for outgassing of the components. This procedure may aid in eliminating contamination of the cover plate and the samples during actual testing periods and is especially important where coatings employing organic components are used. If the cover plate is in place during this outgassing procedure, it shall be cleaned before the box is put into service in order to restore its original transmittance.

5.2 *Cover Plate*— The box shall have a single cover plate that is glazed and hinged to provide access.

5.2.1 Two types of cover plate materials may be used:

5.2.1.1 *Type I*—Tempered low-iron glass with spectral characteristics approximating those shown in Fig. 2.

5.2.1.2 *Type II*—Alternative types of solar transmitting glass or plastic materials might be used for the cover plate if the absorber is to be used under that material.

5.2.2 The solar-weighted transmittance values of the cover plate test patches (5.2.3 and 5.2.4) shall remain above the indicated percentage of their initial values in the following wavelength regions:

300 to 400 nm – 90 %
400 to 2100 nm – 95 %

5.2.3 An easily removable test patch of the cover material measuring 50 by 50 mm (2 by 2 in.) shall be fastened onto the inner surface of the transparent cover plate in or near one lower corner. By periodically measuring the transmittance of this test patch, an indication of the effect of any condensable effluents on the cover material can be monitored.

5.2.4 An easily removable specimen of the cover plate material measuring 50 by 50 mm (2 by 2 in.) should also be mounted directly on an exterior upper corner of the cover plate to monitor the effects of atmospheric contamination and ultraviolet degradation. These effects are generally more severe for plastic materials than for glass.

5.3 *Seals*—A seal that does not outgas at the stagnation temperature should be used to make the box weather-resistant.

5.4 *Insulation*—The bottom and sides of the enclosure shall be insulated to have a thermal conductance of less than 0.515 $W/(m^2 \cdot K)$(0.091 $Btu/(h \cdot ft^2 \cdot °F)$), that is, an *R* value of 11 or greater with materials that do not outgas at the stagnation temperature.

5.5 *Sample Mounting Plate*—A metallic mounting plate with lateral dimensions approximately the same as the internal enclosure dimensions (less the thickness of the insulation on the sides of the box) shall be mounted approximately 10 mm (0.4 in.) above the bottom insulation by a thermally insulating material.

5.5.1 The mounting plate used to support selective specimens shall have a selective surface. The solar absorptance (α) of the selective coating shall be greater than 0.90, and the room temperature emittance (ϵ) shall be less than 0.15 at all times.

5.5.2 The mounting plate used to support nonselective specimens shall be coated with any nonselective black coating that is thermally resistant to temperatures up to approximately 200°C (392°F). The solar absorptance (α) of the coatings

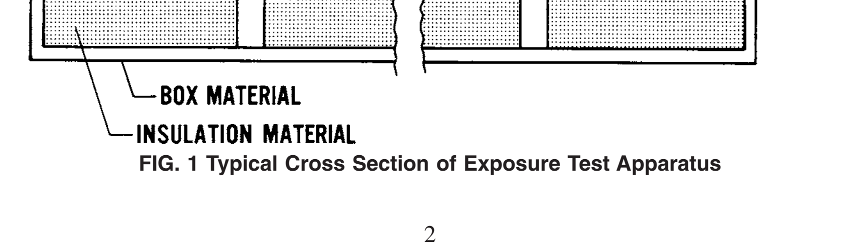

FIG. 1 Typical Cross Section of Exposure Test Apparatus