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Standard Practice for Nonoperational Exposure and Inspection of a Solar Collector[1]

This standard is issued under the fixed designation E 823; 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.

ε1 NOTE—Keywords were added editorially in October 1995.

1. Scope

1.1 This practice defines the procedure to expose a solar thermal collector to an outdoor or simulated outdoor environment in a nonoperational model. The procedure provides for periodic inspections and a post-exposure disassembly and inspection of the collector.

1.2 *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:*

E 772 Terminology Relating to Solar Energy Conversion[2]

E 892 Tables for Terrestrial Solar Spectral Irradiance at Air Mass 1.5 for a 37° Tilted Surface[2]

2.2 *ASHRAE Standard:*

93-77 Methods of Testing to Determine the Thermal Performance of Solar Collectors[3]

3. Significance and Use

3.1 Exposure in a nonoperational mode provides for conditioning and assessment of the physical appearance of a solar collector resulting from moderately severe solar irradiation, ambient temperature, and effects of moisture on the various materials or construction.

3.2 This practice describes actual exposure conditions that have a high probability of occurring sometime during the installation of a solar collector, or during operation, or malfunction of a solar energy system.

3.3 This practice shall be considered to be a limited aging test in that it does not address those aging effects resulting from fluid-to-collector interfaces.

3.4 This practice applies to all solar thermal collector types.

4. Test Specimen

4.1 The exposure specimen shall consist of a complete collector. The collector specimens may be equipped with self-contained, self-actuated protective devices.

5. Collector Mounting

5.1 The exposure specimen shall consist of a complete air or liquid solar collector undergoing the nonoperational mode exposure. Cap (not seal) all inlet, outlet, and vent ports not normally exposed to rain.

5.2 Locate the exposure rack such that it is clear of obstruction that may cause shadows or nonuniform reflections on the collector.

5.3 During exposure, mount the collector to the exposure rack in accordance with the manufacturer's instructions. When specific exposure mounting instructions are not provided, mount the collector to permit air movement on all sides and edges. Cover the collector for protection from the weather elements until the exposure period commences.

6. Nonoperational Mode Exposure

6.1 Mount the collector securely to an adjustable rack, prepare for nonoperational mode, and expose at the following conditions:

6.1.1 A minimum of 30 days during which, for each day, the cumulative minimum radiant exposure, measured in the plane of the collector, shall be 17 000 kJ/m^2·day (1500 Btu/ft^2·day). Minimum conditions do not need to be met for 30 consecutive days.

6.1.2 *Simulated Solar Radiation*:

6.1.2.1 For solar simulation, one solar exposure day is defined as the exposure for 5 h to a minimum solar irradiance of 950 W/m^2 (300 Btu/ft^2·h) and not to exceed 1150 W/m^2 (365 Btu/ft^2·h) at an ambient temperature characteristic of outdoor exposure (nominal range from 15 to 35°C (70 to 95°F)). Simulator exposure is to be followed by setting the collector outdoors overnight in accordance with 5.2.

6.1.2.2 The simulated solar spectrum shall generally conform to the Air Mass 1.5 global distribution as described in Standard E 892.

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[1] This practice is under the jurisdiction of ASTM Committee E-44 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 12.02.

[3] Available from American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE), Publications Sales Dept., 1791 Tullie Circle, N.E., Atlanta, GA 30329.

6.1.3 The energy distribution in the 0.3 to 0.4-μm range shall not deviate more than ±25 % from the Air Mass 1.5 spectrum as measured in 0.05-μm bands. The energy distribution from 0.4 to 2.5 μm shall not deviate by more than ±15 % from the Air Mass 1.5 spectrum as measured in 0.10-μm bands.

6.1.4 A minimum continuous period of 1 h exposure at a solar irradiance greater than 950 W/m^2 (300 Btu/h·ft^2). This condition must be experienced in the exposure day in order to qualify the exposure time as part of the 30-h requirement. Once the minimum 1-h exposure period is met, all exposure time (including the 1-h period) above the minimum solar irradiance and ambient temperature requirement during the same exposure day may be included in the 30-h requirement of 6.1.4.

6.1.5 A minimum of 30 h accumulated radiant exposure with a solar irradiance not less than 950 W/m^2 (300 Btu/h·ft^2) concurrent with an ambient temperature of at least 25°C (80°F). Measure the solar irradiance in the plane of the collector aperture with a pyranometer. The average air velocity at the test station, measured at a height corresponding to the mid-height of the collector, should be less than 4.5 m/s (10 mph). Record air velocity as part of the test data.

6.1.6 The nonoperational mode exposure is only concluded after the requirements of 6.1.1 and 6.1.4 have been met. Exposure times under 6.1.1 and 6.1.4 shall be accumulated independently during the same exposure period, as opposed to sequentially meeting the requirements of one section and then the other.

6.2 *Thermal Shock/Water Spray Penetration*—This test is intended to induce the thermal stresses that will occur when rain impinges on a heated collector in order to determine the penetration of rain into the collector and the effect of such penetration or moisture condensation, if any, on collector performance.

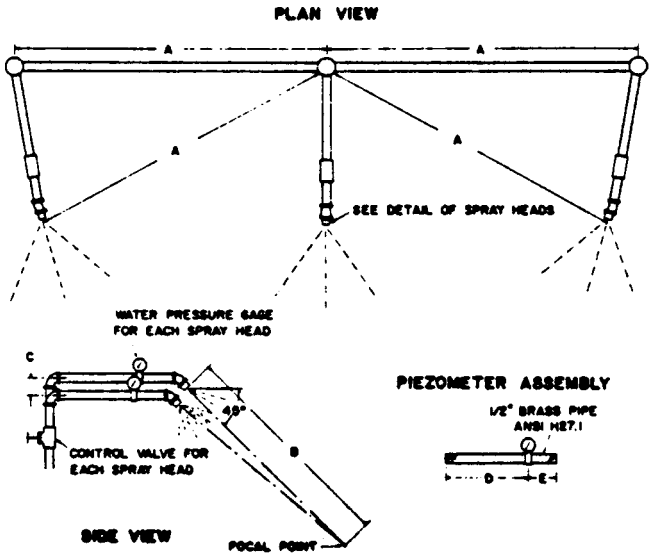
6.2.1 *Period of Test*—Perform the test three times during the nonoperational mode exposure period; once during the first 10 days of the exposure period as defined in 6.1.1, and once each during the second and third 10 days of the exposure period.

6.2.2 *Pre-Test Exposure*—Conduct the spray test after at least 1 h of radiant exposure with a minimum solar irradiance of 850 W/m^2 (270 Btu/ft^2·h) measured in the plane of the collector.

6.2.3 *Apparatus*—The test apparatus shall consist of three or more spray heads mounted in a water supply rack as shown in Fig. 1 and Fig. 2. Spray heads shall be constructed in accordance with Fig. 1 and Fig. 2. The water pressure for all tests shall be maintained at 35 kPa (5 psi) at each spray head. This pressure will provide about 0.3 m/h (12 in./h) of rain at the water flow of 190 L/h (50 gal/h) per nozzle. The supply water temperature shall not exceed 30°C (86°F).

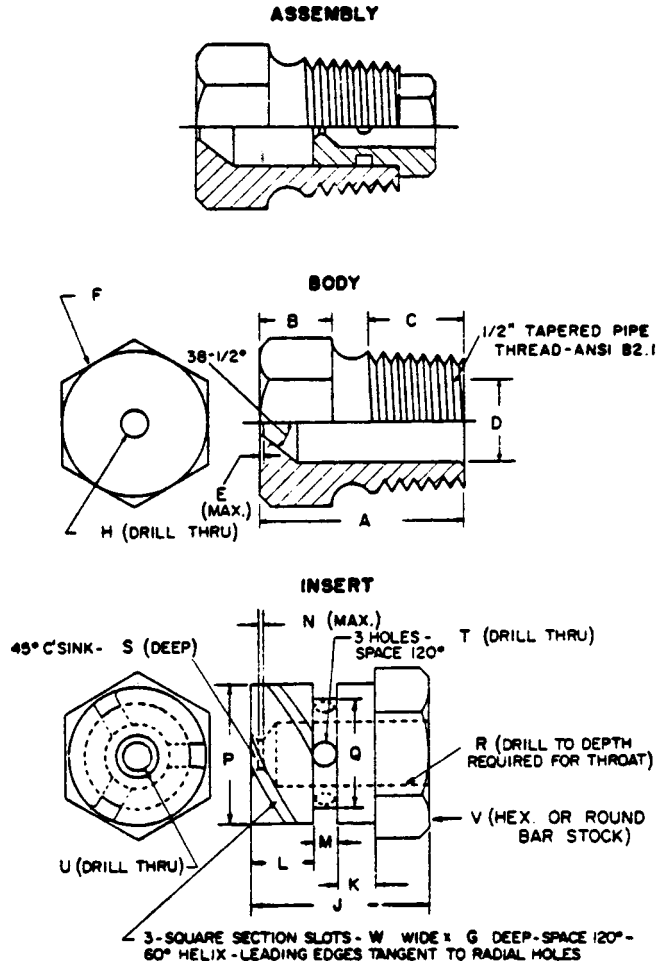
6.2.4 *Procedure*—Position the spray apparatus to direct a downward spray from a distance of 1.0 m (3 ft) at an angle of 45 ± 5° with the collector cover plate surface, as illustrated in Fig. 3. Direct the spray onto the cover plate surface and the top and side edges of the collector which have been exposed as described in 6.2. Adjust the water pressure at each spray head to 35 kPa (5 psi). Maintain the water spray for 15 min per test period. Observe and record occurrence of water penetration into the collector interior. Perform the test three times as specified in 6.2.1.

6.3 Clean the outermost surface of the collector cover, including any reflectors, every 30 days during the exposure period, or more frequently if visual inspection indicates dirt buildup. Use the manufacturer's recommended cleaning procedure if available. Perform cleaning and rinsing such that no visible residue remains on the surface. Do not clean the collector while it is hot. Take care to avoid scratching plastic



Item	in.	mm
A	28	710
B	55	1400
C	2¼	55
D	9	230
E	3	75

FIG. 1 Rain-Test Spray-Head Piping



Item	in.	mm	Item	in.	mm
A	1 7/32	31.0	N	1/32	0.80
B	7/16	11.0	P	0.575	14.61
C	9/16	14.0		0.576	14.63
D	0.578	14.68	Q	0.453	11.51
	0.580	14.73		0.454	11.53
E	1/64	0.40	R	1/4	6.35
F	[A]	[A]	S	1/32	0.80
G	0.06	1.52	T	(No. 35)[B]	2.79
H	(No. 9)[B]	5.0	U	(No. 40)[B]	2.49
J	23/32	18.3	V	5/8	16.0
K	5/32	3.97	W	0.06	1.52
L	1/4	6.35			
M	3/32	2.38			

[A] Optional—To serve as a wrench grip.
[B] ANSI B94.11 drill size.

FIG. 2 Rain-Test Spray Head

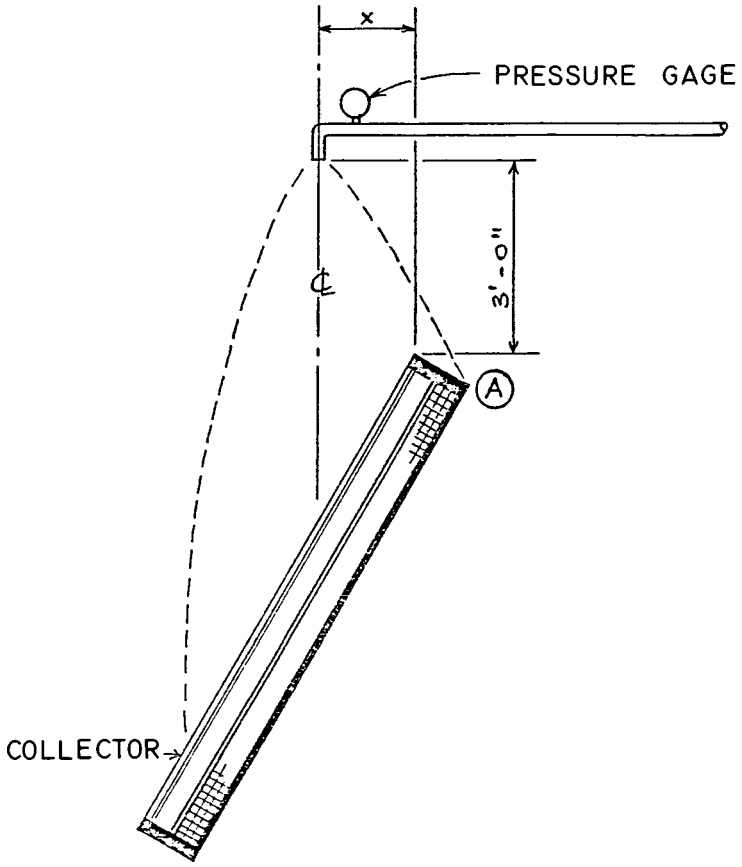
materials. Note and report the cleaning frequency (Section 9).

6.4 During the period of nonoperational exposure, inspect the collector once per week, preferably in the morning to detect condensation. Note any observed change or degradation. Do not replace or repair components of the collector once the exposure sequence has commenced.

6.5 As required, adjust the rack to a tilt angle or orientation, or both, that will maintain the incident solar irradiance levels specified in 6.1.

7. Post-Exposure Cleaning

7.1 After completion of the exposure periods outlined in Section 6, clean the exterior collector cover surface and any exterior reflective surfaces in accordance with 6.3. Make a final visual inspection of the collector. Report any changes or degradation observed.



NOTE 1—*X* as required to develop coverage at top back edge *A*.

FIG. 3 Test Arrangement for Thermal Shock/Rain Spray Test

8. Other Properties[4]

8.1 As an option, document other specific material properties of the solar collector components, such as coating absorptance, cover transmittance, insulation, thermal conductivity, etc., for evaluation and comparison with pre-exposure values using samples taken from the exposed collector.

9. Report

9.1 The following data shall be measured, recorded, and reported daily:

9.1.1 *Thirty Days Accumulated Radiant Exposure*—The total daily solar radiant exposure shall be obtained from continuously measured values (analog recorder, integrator, or data acquisition sampling at least every minute). The total daily solar radiant exposure and the maximum and minimum daily ambient temperature shall be reported for each day with the corresponding date.

9.1.2 *Thirty Hours Accumulated Radiant Exposure*—The solar irradiance shall be continuously measured (analog recorder, integrator, or data acquisition sampling at least every minute). The ambient temperature shall be sampled at least every 15 min. Actual values of solar irradiance and ambient temperature above the minimum requirement of 6.2 shall be reported. The date and time of occurrence for each useful period shall be reported.

9.1.3 The average wind velocity should be measured and reported during each exposure period meeting the 30-h requirement (see 6.1.4).

9.1.4 The date of each cover cleaning as required in 6.3 shall be reported.

9.2 *Premature Exposure Termination*—The time and reason for any premature exposure termination shall be recorded.

9.3 *Materials and Subcomponents*—Observed changes in materials or configuration and the presence of water condensation or other changes noted during inspections described in Sections 6 or 7 shall be reported. The date of observation shall also be reported.

9.4 *Collector Disassembly and Inspection*—The collector shall be disassembled and a detailed inspection performed and reported. The visual inspection should not reveal any impairment of function or evidence of degradation which could be expected, in normal service, to progress to the point of causing failure or significant impairment of function during the collector design life. Typical examples of deterioration are shown in Table 1.

9.5 *Collector Description*—The collector characteristics specified in ASHRAE Standard 93-77 plus any self-contained protection devices shall be reported.

[4] Standard procedures for evaluating physical and optical properties are currently under development by ASTM and others, and will be referenced in this practice when available.

TABLE 1 Collector Disassembly and Final Inspection

Materials	Descriptions of Deterioration
Cover:	cracking, crazing, scratching, buckling, or severe clouding.
Absorber:	severe deformation[A] of the absorber, severe deformation[A] of the fluid flow passages, loss of bonding between fluid flow passages and absorber plate, leakage from fluid flow passages or connections, loss of mounting integrity, and severe corrosion[A] or other deterioration caused by chemical action (corrosive fluxes, volatiles from collector materials, salt spray, etc.)
Absorptive coatings:	checking, cracking, blistering, or flaking of the absorber coating
Collector enclosure:	cracking or warping of the collector enclosure materials
Reflective surfaces:	cracking, craxing, or delamination of reflective surfaces
Insulation:	swelling of other detrimental changes in the collector insulation that adversely affect collector performance water retained in the insulation
Gaskets, cauling, and sealants:	cracking, loss of elasticity, or loss of adhesion
Hoses:	leakage or damage to hoses inside the collector enclosure or leakage from mechanical connections

[A]Deformation or corrosion shall be considered severe if it impairs the function of the collector or there is evidence that it will progress under operating conditions and lead to impairment of function.

10. Precision and Bias

10.1 The solar irradiance measurement accuracy shall be equivalent to or exceed the requirements for a WMO Class 2 pyranometer.

10.2 Ambient temperature measurement accuracy shall be at least ±2°C (3.6°F).

10.3 Wind and relative humidity measurement accuracy shall be at least ±10 %.

10.4 The radiant exposure time shall be determined with an accuracy of at least ±5 %.

11. Keywords

11.1 radiant exposure measurement; solar collector; solar energy; solar irradiance measurement; solar thermal collector; thermal shock; water spray

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