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An American National Standard

AMERICAN SOCIETY FOR TESTING AND MATERIALS
100 Barr Harbor Dr., West Conshohocken, PA 19428

Standard Guide for On-Site Inspection and Verification of Operation of Solar Domestic Hot Water Systems[1]

This standard is issued under the fixed designation E 1160; 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 guide covers procedures and test methods for conducting an on-site inspection and acceptance test of an installed domestic hot water system (DHW) using flat plate, concentrating-type collectors or tank absorber systems.

1.2 It is intended as a simple and economical acceptance test to be performed by the system installer or an independent tester to verify that critical components of the system are functioning and to acquire baseline data reflecting overall short term system heat output.

1.3 This guide is not intended to generate accurate measurements of system performance (see ASHRAE standard 95-1981 for a laboratory test) or thermal efficiency.

1.4 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.5 *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 823 Practice for Nonoperational Exposure and Inspection of a Solar Collector[2]

E 904 Practice for Generating All-Day Thermal Performance Data for Solar Collectors[2]

E 1056 Practice for Installation and Service of Solar Domestic Water Heating Systems for One- and Two-Family Dwellings[2]

2.2 *ASHRAE Standards:*

93-1986 (ANSI B198.1-1977) Method of Testing to Determine the Thermal Performance of Solar Collectors[3]

95-1981 Method of Testing to Determine the Thermal Performance of Domestic Water Heating System[3]

2.3 *NIST Standard:*

76-1137 Thermal Data Requirements and Performance Evaluation Procedures for the National Solar Heating and Cooling Demonstration Program[4]

3. Summary of Guide

3.1 This guide recommends inspection procedures and tests for: general system inspection, collector efficiency, freeze protection, and controller and pump/blower operation.

3.1.1 Verification of satisfactory operation of these components indicates that the system is functioning. Tests are designed to take a minimum of time in preparation, testing and restoration of the system. They may use relatively inexpensive, nonintrusive instrumentation which system installers can reasonably be expected to have on hand.

3.2 Recommended tests for each component or subsystem fall into categories according to the level of complexity and cost (Note 1).

3.2.1 *Category A*—The most rudimentary tests, such as visual inspection.

3.2.2 *Category B*—Tests that require minimal instrumentation and skill.

3.2.3 *Category C*—Tests that require most expensive or sophisticated instrumentation or more time to perform.

NOTE 1—Category B tests should include Category A tests as prerequisite, etc.

3.2.4 Selection of the appropriate test is at the discretion of the tester and purchaser, who should be aware of the tradeoffs between cost and accuracy at each level of testing. The tester should make these clearly known to the purchaser of the system who may wish to assume the costs of more sophisticated testing (Note 2). Preferably there should be a part of the installation contract between the tester and purchaser spelling out test specifics (for example, Category A, B or C for each subtest).

NOTE 2—Consult your local National Balancing Bureau or Associated Air Balance Council.

3.3 Instrumentation includes sensors to monitor some or all of the following conditions:

3.3.1 Total incident solar radiation (in the plane of the collector array),

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[1] This guide 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 ASHRAE, 1791 Tullie Circle, N.E., Altanta, GA 30329.

[4] Available from National Institute of Standards and Technology, Gaithersburg, MD 20899.

3.3.2 Outdoor ambient temperature,

3.3.3 Internal building temperature near storage system,

3.3.4 Collector loop flow rate and temperatures, and

3.3.5 Storage temperature.

3.3.6 Each system should be instrumented to the practical level required for calculation (see NIST standard 76-1137 for another method to instrument and evaluate solar systems). Some sites may need additional instrumentation as a result of their unique requirements. Fig. 1 shows a typical closed loop system with the instrumentation required for the various tests.

3.4 The various types of available instrumentation are listed in Tables 1-4. Approximate cost ranges, accuracy and application information are given. Most of the necessary instruments are presently used in conventional heating and air conditioning work except the pyranometer or solar radiation flux-measuring instruments.

4. Significance and Use

4.1 This guide is intended for on-site assessment of in-service operation by short term measurement of appropriate system functions under representative operating conditions.

4.2 Primary application is for residential systems and medium-size multi-family units or commercial buildings. Use of back-up conventional DHW heating system is assumed to augment solar heating.

4.3 This guide is intended for use by suppliers, installers, consultants and homeowners in evaluating on-site operation of an installed system. Emphasis is placed on simplified measurements that do not require special skills, intrusive instrumentation, system modification or interruption of service to the purchaser.

4.4 The purpose of this guide is to verify that the system is functioning. Copies of all data and reports must be submitted by the testing group to the owner or his or her designated agent.

4.5 Data and reports from these procedures and tests may be used to compare the system performance over time, but should not be used to compare different systems or installations.

4.6 Test is for a newly installed system and also for periodic checking.

5. Procedures

5.1 *Preparation*:

5.1.1 Install and operate components and controls in accordance with manufacturer's instructions.

5.1.2 Use temporary portable instrumentation or any permanent instruments installed for continuous monitoring to evaluate system performance as long as accuracy is ±2 % of full scale and reproducibility is ≥5 % and instrumentation is installed properly in accordance with manufacturer's instruction.

5.1.3 Operate the system in a normal and satisfactory manner for several days before the on-site performance test. Operate the entire system at a nearly steady-state condition for at least a 2-h period before testing. Conduct tests for collector effectiveness under clear, sunny conditions.

5.2 *General Inspection*:

5.2.1 The ability to perform as intended for the specified period of time defines system durability and reliability. System performance depends on the proper operation of each of the subsystems. The manual containing drawings, specifications, and engineering data shall serve as a benchmark for the inspection.

5.2.2 The following components should be inspected for proper installation (see Practice E 1056) and operation to check for any malfunctions, leaks or improper adjustments. See Ref **(1)** for an Installation Checklist.

5.2.2.1 Collectors and connections,

5.2.2.2 Controls and sensors,

5.2.2.3 Insulation,

5.2.2.4 Interconnections—mechanical and electrical,

5.2.2.5 Pumps and motors,

5.2.2.6 Valves and fittings,

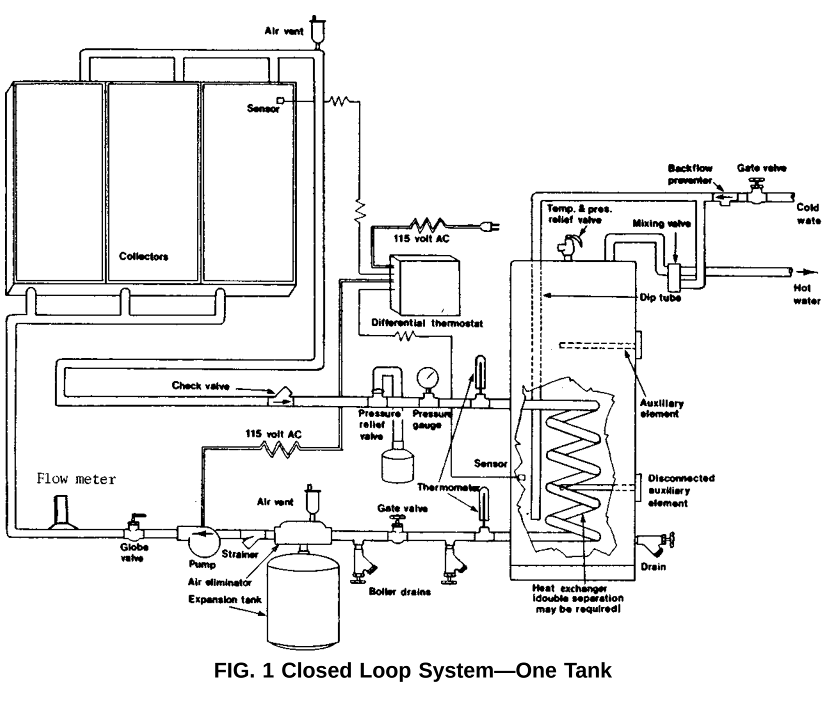

FIG. 1 Closed Loop System—One Tank

TABLE 1 Solar Radiation Probes

Type of Sensor	Approximate Cost (dollars)	Accuracy	Type of Output	Special Comments
Pyranometer	150 to 1000	1–3 % of instantaneous value	Analog electrical millivolt output, may need amplifier	Mounting point must be unshaded; some models increase error increase error by tilting
Integrating pyranometer	150 to 1000	5 % of integrated value	Mechanical totalizer (and analog electrical on some models)	Some models provide instantaneous reading
Photovoltaic solar cell	25 to 150	±5 % of instantaneous value	Analog	Drift or degradation over long periods

TABLE 2 Thermal Sensors

Type of Sensor	Approximate Cost (dollars)	Accuracy	Convenience	Type of Output	Special Comments
Bimetalic thermometer	25 to 50	High; 1 % or less of full scale	Good, when installed correctly	Visual	Not reliable for differential temperatures, time lag present; clip on type available
Bulb type thermometer	25	High	Difficult to read because of small scale	Visual	Very fragile
Digital thermometer	100 +	Depends on type of probe(s), typically 0.5°C (1°F)	Excellent, one indicator can serve several locations (probes)	Visual (digital)	Probes typically cost $50
Thermocouple	25 to 30	Fair, 1°C (2°F)	Excellent when coupled with indicator	Analog (electrical)	Not reliable for measuring temperature differences; requires special wire for installation
Resistance temperature detectors (HTD)	60	High 0.25°C (0.5°F) or better	Excellent when coupled with indicator	Analog (electrical)	Especially suited for measuring temperature differences
Thermistors	1 to 30	Good, 0.5°C (1°F)	Excellent when coupled with indicator	Analog (electrical)	Not available in proper housing; can be damaged
Tapes	2 to 3	Fair, 1–3°C (2–5°F) steps	Excellent, reusable	Visual	Inexpensive

TABLE 3 Liquid Flow Sensors and Indicators

Type of Sensor	Approximate Cost (dollars)	Accuracy	Convenience	Type of Output
Pressure gages	50	Strictly a flow indicator	Low	Visual
Float type	30	Fair, + 5 % full scale accuracy	Moderate	Visual

TABLE 4 Air Flowmeters

Type of Sensor	Approximate Cost (dollars)[A]	Accuracy	Type of Output	Special Comments
Hot wire anemometer	600 to 1000	Moderate, 2 % of full scale; recalibration necessary	Analog (electrical)	Some models easily damaged by debris and improper handling; must be properly located in order to determine mean flow
Turbine	300	Good, 1 % of flow	Analog (electrical)	Must be properly located in order to determine mean flow
Pitot tube	300	Fair, 1 to 5 %	Visual or analog (electrical)	Standard for measuring duct velocities

[A] Includes readout device or transmitter.

5.2.2.7 Storage containers and media,

5.2.2.8 Heat exchangers,

5.2.2.9 Dampers and ducting,

5.2.2.10 Air or liquid systems leaks,

5.2.2.11 Interrelated support systems, including other air handlers, chillers, heaters, or heat pumps, and

5.2.2.12 Fans and air handlers.

5.2.3 Most of the failures reported have been in the collector subsystem and connections and controls with considerably fewer failures reported for valves and pump subsystems. There has been a high incidence of improper system operation due to controls improperly connected or adjusted.

5.2.4 A visual inspection should be made of all connections (see Practice E 1056, 6.7.6) to check for evidence of leaks or potential future corrosion due to improper use of materials (Practice E 1056, 6.7.2), improper joining of dissimilar metals (Practice E 1056, 6.7.14), or improper fluids (Practice E 1056, 6.5). See Ref **(2)** for a leak check on air systems. A pressure check on liquid systems should be done to see if it meets manufacturer's recommendations.

5.2.5 Check pumps for noise (most pumps are very quiet). Noisy fluid flow almost always indicates a bad pump, cavitation or air in the system and is symptomatic of further problems. In an open or drainback system noisy fluid flow will occur if there is water loss due to leakage. If a pump problem is suspected, one way to determine if the pump is seized or has other electrical problems is to touch the assembly to see if it is hotter than the fluid circulating through it. Also any burning odors may indicate electrical problems.

5.3 *Collector Operation and Effectiveness* (See Practice