ANSI/ASHRAE Standard 109-1986 (RA 2003)

ASHRAE STANDARD

Methods of Testing to Determine the Thermal Performance of Flat-Plate Solar Collectors Containing a Boiling Liquid

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ANSI/ASHRAE Standard 109-1986 (RA 2003), Methods of Testing to Determine the Thermal Performance of Flat-Plate Solar Collectors Containing a Boiling Liquid

(This foreword is not part of this standard but is included for information purposes only.)

FOREWORD

This standard is a reaffirmation of Standard 109-1986, which was also reaffirmed in 1996. It is written to provide a uniform method for evaluating the thermal performance of flat-plate solar collectors that use the latent heat of a liquid-vapor phase change to remove energy from the collector. Standard 109 is based on ASHRAE Standard 93-1986 and the work of J.A. Clark and A. I. Al-Tamimi at the University of Michigan. It applies to collectors containing refrigerants and boiling fluids, but concentrators and integral condenser collectors are considered outside the scope of the standard. As experimental and operational data accumulate, it may be possible to include such collectors under revisions of this standard.

1. PURPOSE

The purpose of this standard is to provide test methods for determining the thermal performance of flat-plate solar energy collectors that use boiling fluids for thermal energy transfer.

2. SCOPE

2.1 This standard applies to flat-plate solar collectors in which some of the fluid entering the collector boils and some fraction leaves as a saturated vapor.

2.2 The collector heat transfer fluid may be any fluid that boils during its passage through the collector.

2.3 This standard contains methods for conducting tests outdoors under natural solar irradiance and for conducting tests indoors under simulated solar irradiance.

2.4 This standard provides test method and calculation procedures for determining steady-state and quasi-steady-state thermal performance, time, and angular response characteristics of solar collectors.

2.5 This standard is not applicable to those collectors in which the thermal storage or condenser unit is integral with the collector.

3. DEFINITIONS AND NOMENCLATURE

3.1 Terms

***absorber*:** that part of the solar collector that receives the incident radiation energy and transforms it into thermal energy.

***absorber area*:** the total heat transfer area from which the absorbed irradiance heats the transfer fluid, or the area of the absorber medium if both transfer fluid and solid surfaces jointly perform the absorbing function.

***air mass*:** the ratio of the mass of atmosphere in the actual earth-sun path to the mass that would exist if the sun were directly overhead at sea level.

***angle of incidence*:** the angle between the direct solar irradiance and the normal to the aperture plane.

***aperture area*:** the maximum projected area of a solar collector through which the unconcentrated solar radiant energy is admitted.

***area, gross collector*:** the maximum projected area of the complete collector module including integral mounting means.

collector, flat plate: a nonconcentrating solar collector in which the absorbing surface is essentially planar.

condenser: a heat exchanger in which the primary heat transfer vapor changes its state to a liquid phase.

cover, collector: the material covering the aperture to provide thermal and environmental protection.

***instantaneous efficiency*:** the ratio of the energy removed by the transfer fluid per unit of collector area to the total solar radiation incident on the collector per unit area (aperture or gross) during a test period for which the condition of the test corresponds to the steady state or quasi-steady state.

***irradiance, instantaneous*:** the rate at which solar radiation is incident on a unit surface area in unit time, measured in Btu/(h·ft^2)[W/m^2].

***irradiance, integrated average*:** the summation of the solar radiation incident on a unit surface area during a specified time period divided by the duration of that time period, reported in Btu/(h·ft^2)[W/m^2].

***latent heat of vaporization*:** the heat energy required to cause a change of state of a substance from a saturated liquid to a saturated vapor, measured in Btu/lb$_m$ (J/kg).

***pyranometer*:** a radiometer used to measure the global solar radiation incident upon a surface per unit time per unit area. This energy includes the direct radiation, the diffuse sky radiation, and the solar radiation reflected from the foreground.

***pyrheliometer*:** a radiometer used to measure the direct radiation on a surface normal to the sun's rays.

***quasi-steady state*:** a condition of operation of the collector and/or system in which the measured solar irradiance flow rates and thermodynamic states of temperature and pressure at various points in the collector and/or system do not vary significantly during the period of test measurements.

***solar collector*:** a device designed to absorb incident solar radiation for the purpose of transferring energy to a heat transfer fluid.

***standard gravity*:** to be taken as 32.174 ft/s^2 (9.80 m/s^2).

***steady state*:** a condition of operation of the collector and/or system in which the measured solar irradiance flow rates and thermodynamic states of temperature and pressure at various points in the collector and/or system do not vary during the period of test measurements.

***tilt angle*:** angle between the horizontal plane and the plane of the collector aperture.

***time constant*:** the time required for the fluid leaving a solar collector to attain a temperature corresponding to 63.2% of the difference between its initial value and its quasi-steady-state value following a step increase in temperature.

***transfer fluid*, *primary*:** the fluid that flows through the solar collector.

***transfer fluid*, *secondary*:** the fluid that flows through the condenser as a coolant.