

AS/NZS 4445.1:1997

ISO 9459.1:1993

Australian/New Zealand Standard[®]

**Solar heating—Domestic water
heating systems**

**Part 1: Performance rating
procedure using indoor test
methods**

STANDARDS AUSTRALIA
✓

STANDARDS NEW ZEALAND
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AS/NZS 4445.1:1997

This Joint Australian/New Zealand Standard was prepared by Joint Technical Committee CS/28, Solar Water Heaters. It was approved on behalf of the Council of Standards Australia on 22 November 1996 and on behalf of the Council of Standards New Zealand on 22 November 1996. It was published on 5 January 1997.

The following interests are represented on Committee CS/28:

Australian and New Zealand Solar Energy Society
Department of Energy, N.S.W.
Energy Efficiency & Conservation Authority of New Zealand
Energy Management Association
Energy Research Centre
Energy Victoria
Metal Trades Industry Association of Australia
Solar Energy Industries Association of Australia
South Australian Water Corporation
University of New South Wales

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This Standard was issued in draft form for comment as DR 96044.

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PUBLISHED JOINTLY BY:

STANDARDS AUSTRALIA
1 The Crescent,
Homebush NSW 2140 Australia

STANDARDS NEW ZEALAND
Level 10, Standards House,
155 The Terrace,
Wellington 6001 New Zealand

PREFACE

The Standard was prepared by the Joint Standards Australia/New Zealand Committee CS/28 on Solar Water Heaters. It is identical with and has been reproduced from ISO 9459.1—1993: *Solar heating—Domestic water heating systems, Part 1: Performance rating procedure using indoor test methods*. The objective of this Standard is to provide a uniform indoor test method for rating solar domestic water heating systems for thermal performance, under benchmark conditions. The proposed adoption of ISO 9459.1 will initially exist in parallel with AS 2813—1985, *Solar water heaters—Methods of test for thermal performance—Simulator method*, as an alternate method of test. Once enough experience is gained with the methods of test presented in ISO 9459.1, Committee CS/28 will consider the withdrawal of AS 2813.

This Joint Standard is one of the following series that applies to solar domestic water heating systems:

AS/NZS

4445 Solar heating—Domestic water heating systems

4445.1 Part 1: Performance rating procedure using indoor test methods

Other titles in this series will be:

- Performance test for solar only systems.
- Performance test for solar plus supplementary systems.
- System performance characterization by means of component tests and computer simulation.
- System performance characterization by means of whole system tests and computer simulation.

Under arrangements made between Standards Australia, Standards New Zealand and ISO, as well as certain other Standards Organizations, users of this Standard are advised that the number of this Standard is not reproduced on each page, its identity is shown only on the cover.

This Standard is not intended to be a mandatory replacement for any performance rating test methods already in use in Australia or in New Zealand.

Statements expressed in mandatory terms in notes to text, tables and figures are deemed to be requirements of this Standard.

The terms 'normative' and 'informative' have been used in this Standard to define the application of the annex to which they apply. A 'normative' annex is an integral part of a Standard, whereas an 'informative' annex is only for information and guidance.

As this Standard is reproduced from an International Standard, the following applies:

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- (c) A full point substitutes for a comma when referring to a decimal marker. References to International Standards should be replaced by equivalent Australia/New Zealand Standards, as follows:

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<i>Reference to International Standard</i>	<i>Australian/New Zealand Standard</i>
ISO	AS
9059 Solar energy—Calibration of field pyrheliometers by comparison to a reference pyrheliometer	—
9060 Solar energy—Specification and classification of instruments for measuring hemispherical solar and direct solar radiation	—
9806.1 Test methods for solar collectors Part 1: Thermal performance of glazed liquid heating collectors including pressure drop	2535 Solar collectors with liquid as the heating transfer fluid—Method for testing thermal performance
	NZS
	4613 Domestic solar water heaters
9845.1 Solar energy—Reference solar spectral irradiance at the ground at different receiving conditions Part 1: Direct normal and hemispherical solar irradiance for air mass 1,5	—
9846 Solar energy—Calibration of a pyranometer using a reference pyrheliometer World Meteorological Organization, <i>Guide to Meteorological Instruments and Methods of Observation</i> , No. 8, 5th Edition, WMO, Geneva, 1983, Chapter 9—World radiometric reference, known as the WRR	—

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First published as AS/NZS 4445.1:1997.

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 9459-1 was prepared by Technical Committee ISO/TC 180, *Solar energy*, Subcommittee SC 4, *Systems — Thermal performance, reliability and durability*.

ISO 9459 consists of the following parts, under the general title *Solar heating — Domestic water heating systems*:

- *Part 1: Performance rating using indoor test methods*
- *Part 2: Performance test for solar only systems*
- *Part 3: Performance test for solar plus supplementary systems*
- *Part 4: System performance characterization by means of component tests and computer simulation*
- *Part 5: System performance characterization by means of whole system tests and computer simulation*

Annexes A, B, C and D form an integral part of this part of ISO 9459. Annex E is for information only.

Introduction

International Standard ISO 9459 has been developed to help facilitate the international comparison of solar domestic water heating systems. Because a generalized performance model which is applicable to all systems has not yet been developed, it has not been possible to obtain an international consensus for one test method and one standard set of test conditions. It has therefore been decided to promulgate the currently available simple methods while work continues to finalize the more broadly applicable procedures. The advantage of this approach is that each part can proceed on its own.

ISO 9459 is divided into five parts within three broad categories, as described below.

Rating test

ISO 9459-1, *Performance rating using indoor test methods*, involves testing for periods of one day for a standardized set of reference conditions. The results, therefore, allow systems to be compared under identical solar, ambient and load conditions.

Black box correlation procedures

ISO 9459-2 is applicable to solar-only systems and solar-preheat systems. The performance test for solar-only systems is a "black box" procedure which produces a family of "input-output" characteristics for a system. The test results may be used directly with daily mean values of local solar irradiation, ambient air temperature and cold water temperature data to predict annual system performance.

ISO 9459-3 applies to solar plus supplementary systems. The performance test is a "black box" procedure which produces coefficients in a correlation equation that can be used with daily mean values of local solar irradiation, ambient air temperature and cold water temperature data to predict annual system performance. The test is limited to predicting annual performance for one load pattern.

Testing and computer simulation

ISO 9459-4, a procedure for characterizing annual system performance, uses measured component characteristics in the computer simulation program "TRNSYS". Procedures for characterizing the performance of system components other than collectors are also presented in this part of ISO 9459. Procedures for characterizing the performance of collectors are given in ISO 9806-1, ISO 9806-2 and ISO 9806-3.

ISO 9459-5 presents a procedure for dynamic testing of complete systems to determine system parameters for use in a computer model. This model may be used with hourly values of local solar irradiation, ambient air temperature and cold water temperature data to predict annual system performance.

The procedures defined in ISO 9459-2, ISO 9459-3, ISO 9459-4 and ISO 9459-5 for predicting yearly performance allow the output of a system to be determined for a range of climatic conditions.

The results of tests performed in accordance with ISO 9459-1 provide a rating for a standard day.

The results of tests performed in accordance with ISO 9459-2 permit performance predictions for a range of system loads and operating conditions, but only for an evening draw-off.

The results of tests performed in accordance with ISO 9459-4 or ISO 9459-5 are directly comparable. These procedures permit performance predictions for a range of system loads and operating conditions.

System reliability and safety will be dealt with in a future standard.

AUSTRALIAN/NEW ZEALAND STANDARD

Solar heating — Domestic water heating systems —**Part 1:****Performance rating procedure using indoor test methods****1 Scope**

This part of ISO 9459 establishes a uniform indoor test method for rating solar domestic water heating systems for thermal performance, under benchmark conditions.

It applies only to solar water heating systems designed solely to heat potable water to be supplied for domestic water usage.

The test procedures described in this part of ISO 9459 are applicable to systems of solar storage capacity of 0,6 m³ or less. It includes procedures for testing solar domestic hot water systems either with solar irradiance simulators or thermal simulation (non-irradiated) methods.

The test procedures in this part of ISO 9459 which employ a non-irradiated solar collector array in series with a conventional heat source do not apply to integral collector storage systems, nor to systems in which thermosiphon flow occurs, nor to any system employing a collector/heat transfer fluid combination which cannot be tested in accordance with the collector test.

The test procedures in this part of ISO 9459 do not require the solar water heating system to be subjected to freezing conditions. Consequently, the energy consumed or lost by a system while operating in the freeze-protection mode is not determined.

This part of ISO 9459 is not generally applicable to concentrating or evacuated tube systems, unless the collimation requirements of 6.3.1.3 are met.

It is not intended to be used for testing the individual components of the system, nor is it intended to abridge any safety or health requirements.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 9459. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 9459 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 9059:1990, *Solar energy — Calibration of field pyrhemometers by comparison to a reference pyrhemometer.*

ISO 9060:1990, *Solar energy — Specification and classification of instruments for measuring hemispherical solar and direct solar radiation.*

ISO 9806-1:—¹⁾, *Test methods for solar collectors — Part 1: Thermal performance of glazed liquid heating collectors including pressure drop.*

ISO 9845-1:1992, *Solar energy — Reference solar spectral irradiance at the ground at different receiving conditions — Part 1: Direct normal and hemispherical solar irradiance for air mass 1,5.*

ISO 9846:—¹⁾, *Solar energy — Calibration of a pyranometer using a reference pyrhemometer.*

1) To be published.

World Meteorological Organization, *Guide to Meteorological Instruments and Methods of Observation*, No. 8, 5th edition, WMO, Geneva, 1983, Chapter 9 — World radiometric reference, known as the WRR.

3 Definitions

For the purposes of this part of ISO 9459, the following definitions apply.

3.1 absorber: That part of a collector that receives radiant energy and transforms it into thermal energy.

3.2 accuracy: Ability of an instrument to indicate the true value of the measured physical quantity.

3.3 ambient air: Air in the space (either indoors or outdoors) surrounding the thermal energy storage device or solar collectors, whichever is applicable.

3.4 angle of incidence (of direct solar radiation): Angle between the solar radiation beam and the outward-drawn normal from the plane considered.

3.5 aperture area: Of a solar thermal collector, maximum projected area through which the unconcentrated solar radiation is admitted.

NOTE 1 For concentrating collectors, the gross aperture area includes any area of the reflector or refractor shaded by the receiver and its supports and including gaps between reflector segments within a collector module. Net aperture area, sometimes called effective aperture area, excludes any shaded area or gaps between reflector segments.

3.6 aperture plane: Plane at or above the solar collector through which the unconcentrated solar radiation is admitted.

3.7 area, gross collector: Maximum projected area of a completed solar collector module, exclusive of integral means of mounting and connecting fluid conduits. For an array of collectors, including devices such as evacuated tube or concentrating collectors, gross area includes the entire area of the array.

3.8 auxiliary energy: Energy provided by an auxiliary thermal (heat) source.

3.9 auxiliary thermal (heat) source: Source of thermal energy, other than solar, used to supplement the output provided by the solar energy system; usually in the form of electrical resistance heat or thermal energy derived from combustion of fossil fuels.

3.10 collector, solar; solar thermal collector: Device designed to absorb radiant energy and to transfer

the thermal energy so gained to a fluid passing through it.

3.11 collector, concentrating: Solar collector that uses reflectors, lenses or other optical elements to redirect and concentrate the solar radiation passing through the aperture onto an absorber of which the surface area may be smaller than the aperture area.

3.12 collector, flat-plate: Non-concentrating solar collector in which the absorbing surface is essentially planar.

3.13 collector loop: Continuous path followed by the primary heat transfer fluid in a solar energy system.

3.14 collector loop heater: Heater installed within the collector loop when testing the solar domestic water heating system with a non-irradiated array.

3.15 collector tilt angle: Lower angle between the aperture plane of a solar collector and the horizontal plane.

3.16 control: Device for regulation of the solar thermal system or component in normal operation; can be manual or automatic.

3.17 direct irradiance: Irradiance produced by direct radiation on a given plane.

3.18 direct solar radiation: Radiation received from a small solid angle centred on the sun's disc, on a given plane.

NOTE 2 In general direct solar radiation is measured by instruments with field-of-view angles of up to 15°. Therefore a part of the scattered radiation around the sun's disc (circumsolar radiation) is included. More than 99 % of the direct solar radiation on the earth's surface is contained within the wavelength range from 0,3 µm to 3,0 µm.

3.19 domestic: For use in residential and small commercial buildings.

3.20 draw rate; water draw rate: Rate at which hot water is withdrawn from a system at a specified time.

3.21 equivalent length: Length of a straight section of pipe or duct causing the same pressure drop as that which actually occurs within the system at the same flowrate.

3.22 fluid transport: Transfer of air, water or other fluid between components of the system.

3.23 heat exchanger: Device specifically designed to transfer heat between two physically separated fluids. Heat exchangers may have either single or double walls.

3.24 heat transfer fluid: Fluid that is used to transfer thermal energy between components in a system.

3.25 irradiance: Power density of radiation incident on a surface, i.e. the radiant flux incident on a surface divided by the area of that surface, or the rate at which radiant energy is incident on a surface per unit area of that surface.

NOTE 3 Solar irradiance is often termed "incident solar radiation intensity", "instantaneous insolation", or "incident radiant flux density"; the use of these terms is deprecated.

3.26 load: Daily system hot water load defined as the product of the mass, specific heat and temperature increase of the water as it passes through the solar hot water system.

3.27 potable: Suitable for human consumption; drinkable.

3.28 precision: Measure of the closeness of agreement among repeated measurements of the same physical quantity.

3.29 preheating: See solar preheat system [5.1 b)].

3.30 pyranometer: Radiometer for measuring the irradiance on a plane receiver surface which results from the radiant fluxes incident from the hemisphere above within the wavelength range 0,3 μm to 3 μm .

NOTE 4 The spectral range given represents roughly the spectral range of solar radiation (also called solar or short-wave range) at the ground and is only nominal. Depending on the material used for the domes which protect the receiver surface of a pyranometer, the spectral limits of its responsivity approximate to the limits mentioned above.

3.31 pyrgeometer: Instrument for determining the irradiance on a plane receiving surface which results from the radiant fluxes incident from the hemisphere above within the approximate wavelength range 4 μm to 50 μm .

NOTE 5 The given spectral range is nearly identical with that of so-called terrestrial radiation or long-wave radiation, and is only nominal. Depending on the material used for the domes which protect the receiving surface of a pyrgeometer, the spectral limits of its responsivity approximate to the limits mentioned above.

3.32 pyrheliometer: Radiometer for measuring direct (solar) irradiance which results from the radiant

fluxes incident from a well-defined solid angle whose axis is perpendicular to the plane receiver surface.

NOTE 6 According to this definition pyrheliometers are applied to the measurement of direct solar irradiance at normal incidence. The field-of-view angle of pyrheliometers ranges typically from 5° to 10°.

3.33 solar energy: Energy emitted by the sun in the form of electromagnetic radiation (primarily in the wavelength range 0,3 μm to 3 μm), or any energy made available by the reception and conversion of solar radiation.

3.34 solar contribution: Ratio of the energy supplied by the solar part of a system to the total load of the system.

3.35 solar noon: Local time of day, for any given location, when the sun is at its highest altitude for that day, i.e. the time when the sun crosses the observer's meridian.

3.36 solar radiation: Radiation emitted by the sun, practically all of which is incident at the earth's surface at wavelengths less than 3 μm ; often termed "short-wave radiation".

3.37 solar irradiance simulator: Artificial source of radiant energy simulating solar radiation (usually an electric lamp or an array of such lamps).

3.38 solar storage capacity: Quantity of sensible heat that can be stored per unit volume of store for every degree of temperature change.

3.39 solar hot water system: Complete assembly of subsystems and components necessary to convert solar energy into thermal energy for the heating of water; may include an auxiliary heat source.

3.40 standard air: Air weighing 1,204 kg/m³ which approximates dry air at a temperature of 20 °C and a barometric pressure of 101,325 kPa.

3.41 standard barometric pressure: Barometric pressure of 101,325 kPa at 0 °C.

3.42 storage device (thermal): Container(s) plus all contents of the container(s) used for storing thermal energy.

NOTE 7 The transfer fluid and accessories such as heat exchangers, flow switching devices, valves and baffles which are firmly fixed to the thermal storage container(s) are considered a part of the storage device.

3.43 storage tank volumetric capacity: Measured volume of the fluid in the tank when full.