

DIN EN ISO 9488

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Ersatz für
DIN EN ISO 9488:2001-03**Sonnenenergie –
Vokabular (ISO 9488:2022);
Dreisprachige Fassung EN ISO 9488:2022**Solar energy –
Vocabulary (ISO 9488:2022);
Trilingual version EN ISO 9488:2022Énergie solaire –
Vocabulaire (ISO 9488:2022);
Version trilingue EN ISO 9488:2022

Gesamtumfang 112 Seiten

DIN-Normenausschuss Heiz- und Raumluftechnik sowie deren Sicherheit (NHRS)

Nationales Vorwort

Dieses Dokument (EN ISO 9488:2022) wurde vom Technischen Komitee ISO/TC 180 „Solar energy“ in Zusammenarbeit mit dem Technischen Komitee CEN/TC 312 „Thermische Solaranlagen und ihre Bauteile“ erarbeitet, dessen Sekretariat von NQIS/ELOT (Griechenland) gehalten wird.

Für die deutsche Mitarbeit ist der Arbeitsausschuss NA 041-01-56 AA „Solaranlagen (SpA CEN/TC 312 und ISO/TC 180)“ im DIN-Normenausschuss Heiz- und Raumluftechnik sowie deren Sicherheit (NHRS) verantwortlich.

Hinweise zur deutschen Übersetzung der Definition:

- von 3.2.1 „Strahlung“: die Definition ist in der englischen Referenzfassung folgendermaßen formuliert: „Emission und Übertragung von Energie in Form von elektromagnetischen Wellen oder Teilchen“.
- von 3.2.5 „Bestrahlungsstärke“: Die Übersetzung für den englischen Begriff „radiant energy“ ist nach 3.2.2 „Strahlungsenergie“ statt „Strahlungsleistung“.
- von 3.2.33 „wolkenlose Bestrahlungsstärke“: Anmerkung 3 zum Begriff ist in der englischen Referenzfassung nicht vorhanden.
- von 3.2.34 „Faktor für wolkenlosen Himmel“ Anmerkung 1 zum Begriff ist in der englischen Referenzfassung nicht vorhanden.
- von 3.2.36 „atmosphärischer Transmissionsfaktor“: Der Teil „auf eine horizontale Ebene“ ist in der englischen Referenzfassung nicht vorhanden.
- von 3.3.1 „Radiometrische Welt-Referenz“: Der Teil „mit einer Ungenauigkeit von weniger als 0,3 %“ ist in der englischen Referenzfassung nicht vorhanden.
- Von 3.3.8 „Diffusometer“: Die Übersetzung für den englischen Begriff „shading disk“ ist „Schattenscheibe“ statt „Schattenring“ und die Übersetzung für „shading ring“ ist „Schattenring“ statt „äquatoriales Schattenband“.
- von 3.4.1 „Absorptionsfaktor“: Die Übersetzung für den englischen Begriff „radiation“ ist nach 3.2.1 „Strahlung“ statt „Strahlungsfluss“.
- von 3.5.1 „Umgebungsluft“: Der Teil „ein thermisches Energiespeichersystem, einen Sonnenkollektor oder“ ist in der englischen Referenzfassung nicht vorhanden.
- von 3.6.4 „WISC“: Anmerkung 1 zum Begriff ist in der englischen Referenzfassung nicht vorhanden.
- von 3.6.11 „Parabolrinnenkollektor“, Anmerkung 1 zum Begriff: Die Übersetzung für den englischen Begriff „solar thermal collector“ ist nach 3.6.1 „Sonnenkollektor“ statt „Kollektor“.
- von 3.6.15 „Konzentrator-Kollektor aus parabolischen Segmenten“: Anmerkung 3 zum Begriff ist in der englischen Referenzfassung nicht vorhanden.
- von 3.7.6 „Aperturfläche“: Der Begriff „Sonnenstrahlung“ ist unter 3.2.13 zu finden statt unter 3.6.13.
- von 3.7.9 „Absorberfläche“, Anmerkung 1 zum Begriff: Der Begriff „konzentrierender Kollektor“ ist unter 3.6.9 zu finden statt unter 3.6.8.

- von 3.7.10 „Fluid-Eintrittstemperatur“ und 3.7.11 „Fluid-Austrittstemperatur“: Die Übersetzung für den englischen Begriff „heat transfer fluid“ ist nach 3.10.3 „Wärmeträgerfluid“ statt „Wärmeträger“.
- von 3.7.18 „Einfallswinkelfaktor“ Anmerkung 1 zum Begriff ist in der englischen Referenzfassung nicht vorhanden.
- von 3.9.5 „relative Zusatzenergieeinsparung“, Anmerkung 1 zum Begriff: In der englischen Referenzfassung ist in der Beschreibung für Q_{supp} noch ein „zusätzlich“ mit drin: „die von der *thermischen Solaranlage* (3.8.1) verbrauchte zusätzliche Endenergiemenge“.
- von 3.10.12 „Totvolumen“: In der englischen Referenzfassung steht „Volumen“ statt „Teilvolumen“.
- von 3.10.14/3.10.15 „Sicherheitsleitung“: die deutsche Übersetzung für „expansion vessel“ ist „Expansionsgefäß“ statt „Expansionsgerät“.

Aktuelle Informationen zu diesem Dokument können über die Internetseiten von DIN (www.din.de) durch eine Suche nach der Dokumentennummer aufgerufen werden.

Änderungen

Gegenüber DIN EN ISO 9488:2001-03 wurden folgende Änderungen vorgenommen:

- a) Aktualisierung der Definitionen;
- b) Aufnahme neuer Begriffe entsprechend der Entwicklung neuer Normen für die Solarthermie in den letzten zwei Jahrzehnten;
- c) redaktionelle Überarbeitung der Norm.

Frühere Ausgaben

DIN EN ISO 9488: 2001-03

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Deutsche Fassung

Sonnenenergie —
Vokabular (ISO 9488:2022)

Solar energy —
Vocabulary (ISO 9488:2022)

Énergie solaire —
Vocabulaire (ISO 9488:2022)

Diese Europäische Norm wurde vom CEN am 31. Januar 2022 angenommen.

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EUROPÄISCHES KOMITEE FÜR NORMUNG
EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION

CEN-CENELEC Management-Zentrum: Rue de la Science 23, B-1040 Brüssel

Europäisches Vorwort

Dieses Dokument (EN ISO 9488:2022) wurde vom Technischen Komitee ISO/TC 180 „Solar energy“ in Zusammenarbeit mit dem Technischen Komitee CEN/TC 312 „Thermische Solaranlagen und ihre Bauteile“ erarbeitet, dessen Sekretariat von NQIS/ELOT gehalten wird.

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Dieses Dokument ersetzt EN ISO 9488:1999.

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Anerkennungsnotiz

Der Text von ISO 9488:2022 wurde von CEN als EN ISO 9488:2022 ohne irgendeine Abänderung genehmigt.

English Version

Solar energy - Vocabulary (ISO 9488:2022)

Énergie solaire - Vocabulaire (ISO 9488:2022)

Sonnenenergie - Vokabular (ISO 9488:2022)

This European Standard was approved by CEN on 31 January 2022.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

European foreword

This document (EN ISO 9488:2022) has been prepared by Technical Committee ISO/TC 180 "Solar energy" in collaboration with Technical Committee CEN/TC 312 "Thermal solar systems and components" the secretariat of which is held by NQIS/ELOT.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2022, and conflicting national standards shall be withdrawn at the latest by October 2022.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN ISO 9488:1999.

Any feedback and questions on this document should be directed to the users' national standards body/national committee. A complete listing of these bodies can be found on the CEN website.

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Endorsement notice

The text of ISO 9488:2022 has been approved by CEN as EN ISO 9488:2022 without any modification.

Version Française

Énergie solaire - Vocabulaire (ISO 9488:2022)

Sonnenenergie - Vokabular (ISO 9488:2022)

Solar energy - Vocabulary (ISO 9488:2022)

La présente Norme européenne a été adoptée par le CEN le 31 janvier 2022.

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COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG
EUROPEAN COMMITTEE FOR STANDARDIZATION

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Bruxelles

Avant-propos européen

Le présent document (EN ISO 9488:2022) a été élaboré par le Comité Technique ISO/TC 180 « Énergie solaire » en collaboration avec le Comité Technique CEN/TC 312 « Installations solaires thermiques et leur composants » dont le secrétariat est tenu par NQIS/ELOT.

La présente Norme européenne devra recevoir le statut de norme nationale, soit par publication d'un texte identique, soit par entérinement, au plus tard en octobre 2022 et les normes nationales en contradiction devront être retirées au plus tard en octobre 2022.

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Ce document remplace l'EN ISO 9488:1999.

Il convient que l'utilisateur adresse tout retour d'information et toute question concernant le présent document à l'organisme national de normalisation de son pays. Une liste exhaustive desdits organismes se trouve sur le site web du CEN.

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Notice d'entérinement

Le texte de l'ISO 9488:2022 a été approuvé par le CEN en tant que EN ISO 9488:2022 sans aucune modification.

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 180, *Solar energy*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 312, *Thermal solar systems and components*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 9488:1999), which has been technically revised.

The main changes compared to the previous edition are as follows:

- update of definitions;
- addition of several new terms, according to the development of new standards for solar thermal technology in the past two decades.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Solar energy — Vocabulary

1 Scope

This document defines basic terms relating to the work of ISO/TC 180. The committee covers standardization in the field of the measurement of solar radiation and solar energy utilization in space and water heating, cooling, industrial process heating and air conditioning. Consequently, the vocabulary within this document is focussed on definitions relating to those measurement and utilisation technologies.

Since the 1999 version of this document there has been considerable development in solar photovoltaic technologies and high temperature solar thermal technologies that use heat to produce electricity or to provide high temperatures for processes that require elevated temperatures. This standard has some definitions that are useful also for those technologies; however, there are other documents that cover vocabulary for these technologies in more detail.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1 Terms for solar geometry

3.1.1

aphelion

<of Earth> point in the Earth's orbit at which it is furthest from the Sun

Note 1 to entry: At the aphelion, the Earth is approximately 152×10^6 km from the Sun.

3.1.2

perihelion

<of Earth> point in the Earth's orbit at which it is closest to the Sun

Note 1 to entry: At the perihelion, the Earth is approximately 147×10^6 km from the Sun.

3.1.3

solar declination

δ

angle subtended between the Earth-sun line and the plane of the equator (north positive)

Note 1 to entry: The solar declination is zero on equinox dates, varying between $+23,45^\circ$ (June 22) and $-23,45^\circ$ (December 22).

3.1.4

solar azimuth angle

solar azimuth

γ_s
angular displacement from the chosen reference direction of the projection of a straight line from the apparent position of the sun to the point of observation, onto the horizontal plane

Note 1 to entry: To avoid errors, the same definition (reference direction and measuring direction) must be used for both solar azimuth and inclined surface azimuth.

Note 2 to entry: The reference direction can be either North or South and the azimuth angular displacement from the reference direction can range from 0° to 360° or -180° to $+180^\circ$.

Note 3 to entry: The geographic azimuth is measured clockwise from due north 0° to 360° .

Note 4 to entry: The two most common definitions in use for solar energy applications are:

- 1) Solar azimuth is 0° for a northern hemisphere location (north of the tropics at latitude angles $> +23,45^\circ$) at *solar noon* (3.1.9). Angular displacements east are negative and west are positive, i.e. $-180^\circ \leq \gamma_s \leq +180^\circ$. This definition results in a simple set of equations; however, it leads to counter intuitive values for southern hemisphere locations (outside of the tropics at latitude angles $< -23,45^\circ$), the solar azimuth angle being 180° for a north facing inclined *solar collector* (3.6.1) in the southern hemisphere (see Reference [3]).
- 2) Solar azimuth angle is 0° at *solar noon* (3.1.9) for both Northern & Southern hemispheres (outside the tropics). Angular displacements east are negative and west are positive, i.e. $-180^\circ \leq \gamma_s \leq +180^\circ$. For this definition, the solar azimuth angle of a *solar collector* (3.6.1) tilted towards the equator at *solar noon* (3.1.9) in both north and south hemispheres is 0° (outside the tropics).

3.1.5

zenith

point vertically above the observer

3.1.6

solar zenith angle

θ_z
angular distance of the sun from the vertical

3.1.7

solar altitude angle

solar elevation angle

h
complement of the *solar zenith angle* (3.1.6)

$$h = 90^\circ - \theta_z$$

3.1.8

solar hour angle

ω
angle between the sun projection on the equatorial plane at a given time and the sun projection on the same plane at *solar noon* (3.1.9)

Note 1 to entry: The solar hour angle changes by approximately 360° within 24 h (approximately 15° within 1 h). This angle is negative for morning hours and positive for afternoon hours, i.e. ω (in degrees) $\approx 15 (t_{\text{Hr}} - 12)$ where t_{Hr} is the *solar time* (3.1.10) in hours.

3.1.9

solar noon

local time of day at which the sun crosses the observer's meridian

3.1.10 solar time

t_{sol}

hour of the day as determined by the apparent angular motion of the sun across the sky, with *solar noon* (3.1.9) as the reference point for 12:00 h

Note 1 to entry: $t_{\text{sol}} = t_{\text{st}} + 4 (L_{\text{st}} - L_{\text{loc}}) + E$, where t_{st} is the standard time, L_{st} is the longitude of the standard meridian for the local time zone and L_{loc} is the longitude of the location in question with both longitudes specified in degrees west ($0^\circ \leq L^\circ \leq 360^\circ$). E is the equation of time, which takes into account the perturbations in the Earth's rate of rotation around the sun that affect the time at which the sun crosses the observer's meridian.

Note 2 to entry: The correction $4 (L_{\text{st}} - L_{\text{loc}}) + E$ is expressed in minutes. An additional correction is needed if the standard time is a daylight saving time.

3.1.11 angle of incidence incidence angle

θ

angle between the line joining the centre of the solar disc to a point on an irradiated surface and the outward normal to the irradiated surface

3.1.12 solar tracker sun tracker

power-driven or manually operated movable support which may be employed to keep a device oriented toward a given direction with respect to the sun.

3.1.13 equatorial tracker

sun-following device having an axis of rotation parallel to the Earth's axis

Note 1 to entry: The parameters of motion are the hour angle and the declination of the sun.

3.1.14 altazimuth tracker

sun-following device which uses the *solar elevation angle* (3.1.7) and the *azimuth angle* (3.1.4) of the sun as coordinates of movement

3.1.15 sun-path diagram

graphic representation of *solar altitude* (3.1.7) versus *solar azimuth* (3.1.4), showing the position of the Sun as a function of time for various dates of the year

Note 1 to entry: If *solar time* (3.1.10) is used, the diagram is valid for all locations of the same latitude.

3.1.16 heliodon

solar-angle simulator for conducting shading assessments on buildings or collector arrays, usually having a model table which tilts for the latitude and rotates for the hour of day, and a lamp to represent the sun, mounted at some distance away on a vertical rail, allowing adjustment for declination

3.1.17 solarscope

device similar to a *heliodon* (3.1.16), but having a fixed horizontal model table and a light source movable to any solar altitude and azimuth

3.2 Radiation terms and quantities

3.2.1

radiation

emission and transfer of energy in the form of electromagnetic waves or particles

[SOURCE: WMO R0260^[4]]

Note 1 to entry: *Radiation* can also be used to refer to multiple quantities used to describe the process called radiation. For example, *radiation* could mean *energy* or *irradiance* (3.2.5) (see Reference [5]).

3.2.2

radiant energy

quantity of energy transferred by *radiation* (3.2.1)

[SOURCE: WMO R0200^[4]]

3.2.3

radiant flux

radiation flux

flux of radiation

ϕ

power emitted, transferred or received in the form of *radiation* (3.2.1)

3.2.4

radiance

radiant flux (3.2.3) emitted, transmitted, reflected or received by a given surface, per unit of solid angle per unit of projected area

Note 1 to entry: Unit: $\text{W}\cdot\text{m}^{-2}\cdot\text{sr}^{-1}$.

3.2.5

irradiance

G

quotient of the *radiant flux* (3.2.3) incident on the surface and the area of that surface, or the rate at which *radiant energy* (3.2.2) is incident on a surface, per unit area of that surface

Note 1 to entry: Unit: $\text{W}\cdot\text{m}^{-2}$.

3.2.6

irradiation

DEPRECATED: insolation

H

incident energy per unit area of a surface, found by integration of solar *irradiance* (3.2.5) over a specified time interval

3.2.7

radiant exitance

M

<at a point on a surface> *radiant flux* (3.2.3) leaving the element of the surface, divided by the area of that element

Note 1 to entry: Formerly called radiant emittance.

Note 2 to entry: The *radiant energy* (3.2.2) may leave the surface by emission, reflection and/or transmission.

3.2.8

ultraviolet radiation

electromagnetic radiation of wavelength in the range of 10 nm to 400 nm

Note 1 to entry: UVA radiation has a wave-length range of 315 nm to 400 nm; UVB radiation has a wavelength range of 280 nm to 315 nm; UVC radiation (wavelength range 280 nm to X-rays) cannot be detected by solar energy technologies.

3.2.9

visible radiation light

electromagnetic radiation of wavelengths causing visual sensations for humans

Note 1 to entry: Visible radiation is generally accepted to be within the wavelength band of 380 nm to 780 nm

3.2.10

infrared radiation

electromagnetic radiation of wavelengths longer than those of *visible radiation* (3.2.9) and shorter than about 1 mm

3.2.11

shortwave radiation

radiation of wavelength shorter than 3 μm but longer than 280 nm

Note 1 to entry: This definition is linked to radiation typically measured with *pyrheliometers* (3.3.5) and *pyranometers* (3.3.4) that are often considered as measuring *solar irradiance* (3.2.5) even though the wavelength range excludes a small part of the *solar spectrum* (3.2.16).

Note 2 to entry: This term is specific to solar energy applications

3.2.12

longwave radiation

radiation of wavelength greater than 3 μm , typically originating from sources at terrestrial temperatures

Note 1 to entry: Examples of sources of longwave radiation are clouds, atmosphere, ground and terrestrial objects.

Note 2 to entry: Sometimes is called *thermal radiation*.

Note 3 to entry: This definition is linked to radiation typically measured with *pyrgeometers* (3.3.7) that are considered as measuring *irradiance* (3.2.5) from sources at terrestrial temperatures even though the wavelength range includes a small part of the *solar spectrum* (3.2.16).

Note 4 to entry: This term is specific to solar energy applications.

3.2.13

solar radiation

DEPRECATED: *shortwave radiation*

DEPRECATED: insolation

radiation (3.2.1) emitted by the sun

3.2.14

solar energy

energy emitted by the sun in the form of electromagnetic waves

Note 1 to entry: Solar energy is primarily in the wavelength region from 0,3 μm to 3,0 μm .

Note 2 to entry: Solar energy is generally understood to mean any energy made available by the capture and conversion of *solar radiation* (3.2.13).

3.2.15

solar flux

radiant flux (3.2.3) originating from the sun

3.2.16

solar spectrum

distribution by wavelength (or frequency) of electromagnetic radiation emitted from the sun

3.2.17

direct radiation

direct solar radiation

beam radiation

beam solar radiation

solar radiation (3.2.13) incident on a given plane, and originating from a small solid angle centred on the sun's disk

Note 1 to entry: In general, direct solar radiation is measured by instruments with *field-of-view angles* (3.3.6) of up to 6°. Therefore, a part of the scattered radiation around the sun's disk [*circumsolar radiation* (3.2.18)] is included, as the solar disk itself has a *field-of-view angle* (3.3.6) of about 0,5°.

Note 2 to entry: Direct radiation is usually measured at normal incidence.

Note 3 to entry: Approximately from 97 to 99 % of the direct solar radiation received at the ground is contained within the wavelength range from 0,3 µm to 3 µm (see Reference [6]).

Note 4 to entry: Further details on *circumsolar radiation* (3.2.18) and its role for direct radiation are provided in *irradiance* (3.2.5), *circumsolar irradiance* (3.2.19), *circumsolar contribution* (3.2.20), *sunshape* (3.2.21) and *direct solar irradiance* (3.2.28).

3.2.18

circumsolar radiation

radiation (3.2.1) scattered by the atmosphere so that it appears to originate from an area of the sky immediately adjacent to the sun

Note 1 to entry: Circumsolar radiation causes the solar aureole.

Note 2 to entry: Further details on *circumsolar radiation* and its role for *direct radiation* (3.2.17) are provided in *circumsolar irradiance* (3.2.19), *circumsolar contribution* (3.2.20), *sunshape* (3.2.21) and *direct solar irradiance* (3.2.28).

3.2.19

circumsolar irradiance

quotient of the *radiant flux* (3.2.3) of the *circumsolar radiation* (3.2.18) on a given plane *receiver* (3.7.3) surface to the area of that surface

Note 1 to entry: If the *receiver* (3.7.3) plane is perpendicular to the axis of the solid angle, the circumsolar irradiance is called circumsolar normal irradiance. Circumsolar irradiance is usually measured at normal incidence.

3.2.20

circumsolar contribution

contribution of a specific portion of the circumsolar normal irradiance to the direct normal irradiance

Note 1 to entry: The circumsolar contribution refers to a specific ring-shaped angular region described by an inner and the outer angular distance from the centre of the sun.

Note 2 to entry: If the inner angle describing this angular region is the half-angle of the sun disk the circumsolar contribution is also called circumsolar ratio.

Note 3 to entry: Depending on the *circumsolar irradiance* (3.2.19) measurement instrument or the solar technology involved, different wavelength ranges are included. In order to describe *circumsolar irradiance* (3.2.19) correctly, the wavelength range or the spectral response of the instrument or the involved technology has to be specified.

3.2.21

sunshape

azimuthal average radiance profile as a function of the angular distance from the centre of the solar disc, normalized to 1 at the centre of the disc and considering the wavelength range of *shortwave radiation* (3.2.11).

3.2.22

hemispherical radiation

hemispherical solar radiation

solar radiation (3.2.13) received by a plane surface from a solid angle of 2π sr

Note 1 to entry: The *tilt angle* (3.10.1) and the *azimuth* (3.10.2) of the surface should be specified, e.g. horizontal.

Note 2 to entry: Hemispherical solar radiation is composed of direct solar radiation and diffuse solar radiation (solar energy scattered in the atmosphere as well as solar radiation reflected by the ground).

Note 3 to entry: Solar engineers commonly use the term *global radiation* (3.2.23) in place of *hemispherical radiation*. This use is a source of confusion if the referenced surface is not horizontal.

Note 4 to entry: Approximately 97 % to 99 % of the hemispherical solar radiation incident at the Earth's surface is contained within the wavelength range from 0,3 μm to 3 μm (see Reference [6]).

3.2.23

global radiation

global solar radiation

hemispherical solar radiation received by a horizontal plane on the Earth's surface

Note 1 to entry: Approximately 97 % to 99 % of the global solar radiation incident at the Earth's surface is contained within the wavelength range from 0,3 μm to 3 μm (see Reference [6]).

Note 2 to entry: Solar engineers commonly use the term *global radiation* in place of *hemispherical radiation* (3.2.22). This use is a source of confusion if the referenced surface is not horizontal.

3.2.24

diffuse radiation

diffuse solar radiation

hemispherical solar radiation minus direct solar radiation

Note 1 to entry: For the purposes of solar energy technology, diffuse radiation includes a part of solar radiation scattered in the atmosphere as well as a part of solar radiation reflected by the ground, depending on the *tilt angle* (3.10.1) of the receiver surface.

Note 2 to entry: The *tilt angle* (3.10.1) and the *azimuth* (3.10.2) of the receiver surface should be specified, e.g. horizontal.

3.2.25

atmospheric radiation

DEPRECATED: sky radiation

longwave radiation (3.2.12) emitted by and propagated through the atmosphere

[SOURCE: WMO A2940^[4]]

3.2.26

extra-terrestrial solar radiation

solar radiation (3.2.13) received at the limit of the Earth's atmosphere

[SOURCE: WMO E1370^[4]]

3.2.27

solar constant

G_{sc}
solar irradiance outside the Earth's atmosphere on a plane normal to the direction of this radiation, when the Earth is at its mean distance from the sun ($149,5 \times 10^6$ km)

Note 1 to entry: Historically the solar constant is considered to be $1\,367 \text{ W}\cdot\text{m}^{-2} \pm 7 \text{ W}\cdot\text{m}^{-2}$. The new value of $1\,361,1 \text{ W}\cdot\text{m}^{-2}$, from the most recent determination of the solar constant, is currently under consideration, see Reference [7].

3.2.28

direct solar irradiance

G_b
quotient of the *radiant flux* (3.2.3) on a given plane receiver surface received from a small solid angle centred on the sun's disk to the area of that surface

Note 1 to entry: If the plane is perpendicular to the axis of the solid angle, direct normal solar irradiance G_{bn} is received.

Note 2 to entry: Unit: $\text{W}\cdot\text{m}^{-2}$.

Note 3 to entry: Approximately 97 % to 99 % of the direct solar radiation received at ground level is contained within the wavelength range from $0,3 \mu\text{m}$ to $3 \mu\text{m}$ (see Reference [3]). Depending on the direct irradiance measurement instrument or the solar technology involved, different wavelength ranges are included. In order to describe direct irradiance correctly, the wavelength range or the spectral response of the instrument or the involved technology has to be specified.

Note 4 to entry: In general, direct normal solar irradiance is measured by instruments with *field-of-view angles* (3.3.6) of up to 6° . The currently recommended instrument design uses 5° field-of-view (see Reference [5]). A part of the scattered radiation around the Sun's disk (*circumsolar radiation* (3.2.18)) is included, as the solar disk itself has a *field-of-view angles* (3.3.6) of about $0,5^\circ$.

Note 5 to entry: In order to describe direct normal solar irradiance accurately, it is necessary to specify how *circumsolar radiation* (3.2.18) is included in it using the following terms. B_n is the experimental direct normal irradiance.

$$B_n = \int_0^{2\pi} \int_0^{\alpha_L} P(\xi, \varphi) L(\xi, \varphi) \cos(\xi) \sin(\xi) d\xi d\varphi.$$

where

$L(\xi, \varphi)$ is the broadband sky radiance - usually expressed in $\text{W}\cdot\text{m}^{-2} \text{sr}^{-1}$ - for an element of sky whose angular position is defined by the angular distance ξ from the centre of the sun disk and the azimuth angle φ in the sun disk and the circumsolar region;

$P(\xi, \varphi)$ is the penumbra function of the measurement device that is sometimes also called "acceptance function";

α_L is the greatest angular distance from the sun disk centre for which radiation is measured by the instrument.

In atmospheric radiation transfer models, another parameter is often used: $B_n^{\text{ideal}}(\alpha_L)$. $B_n^{\text{ideal}}(\alpha_L)$ is the direct normal irradiance up to the angular limit, α_L , which in this case mostly corresponds to the sun disk half-angle ($\sim 0,27^\circ$). $B_n^{\text{ideal}}(\alpha_L)$ is calculated as B_n , the penumbra function being set equal to 1 (see also Reference [6]). In concentrating solar power plant models $B_n^{\text{ideal}}(\alpha_L)$ or B_n might be used depending on the *sunshape* (3.2.21) data applied in the model. The angular limit, α_L , also has to fit to the applied *sunshape* (3.2.21)

3.2.29

hemispherical irradiance

hemispherical solar irradiance

DEPRECATED: incident solar radiation intensity

DEPRECATED: instantaneous insolation

DEPRECATED: insolation

DEPRECATED: incident *radiant flux* density

G_{hem}

quotient of the *radiant flux* (3.2.3) on a given plane receiver surface received from a solid angle of 2π sr to the area of that surface

Note 1 to entry: The *tilt angle* (3.10.1) and the *azimuth* (3.10.2) of the surface should be specified, e.g. horizontal.

Note 2 to entry: Unit: $\text{W}\cdot\text{m}^{-2}$.

Note 3 to entry: Examples for hemispherical irradiance are *global irradiance* and the irradiance received in the plane of *solar collector* (3.6.1) [Plane of Array (POA) irradiance], also called "global tilted irradiance".

3.2.30

global irradiance

global solar irradiance

G_{h}

hemispherical solar irradiance on a horizontal plane on the Earth's surface

Note 1 to entry: Unit: $\text{W}\cdot\text{m}^{-2}$.

Note 2 to entry: Global irradiance always refers to a horizontal plane. Global irradiance should not be confused with global tilted irradiance, see *hemispherical irradiance* (3.2.29), Note 3.

3.2.31

diffuse solar irradiance

G_{d}

irradiance (3.2.5) of diffuse solar radiation on a given plane receiver surface

Note 1 to entry: The *tilt angle* (3.10.1) and the *azimuth* (3.10.2) of the receiving surface should be specified, e.g. horizontal.

Note 2 to entry: Unit: $\text{W}\cdot\text{m}^{-2}$.

3.2.32

spectral solar irradiance

E_{λ}

solar irradiance per unit wavelength interval at a given wavelength

Note 1 to entry: Unit: $\text{W}\cdot\text{m}^{-2}\cdot\mu\text{m}^{-1}$.

3.2.33

clear sky irradiance

G_{c}

global solar irradiance (3.2.30) during cloudless sky conditions

Note 1 to entry: Clear-sky irradiance is often determined with radiation transfer models using a cloudless atmosphere characterization based on climatological or meteorological reanalysis values. This allows the determination of clear-sky irradiance even for locations and times when the atmosphere is not cloudless.

Note 2 to entry: Unit: $\text{W}\cdot\text{m}^{-2}$.

3.2.34

clear sky index

k_c
global irradiance (3.2.30) divided by the *clear sky irradiance* (3.2.33) on a horizontal surface

$$k_c = \frac{G_h}{G_c}$$

3.2.35

extra-terrestrial irradiance

G_o
irradiance (3.2.5) of the *extra-terrestrial solar radiation* (3.2.26) on a horizontal plane above the Earth's atmosphere

Note 1 to entry: Unit: $W \cdot m^{-2}$.

3.2.36

clearness index

k
atmospheric *transmittance* (3.4.5) i.e. the *global irradiance* (3.2.30) divided by the *extra-terrestrial irradiance* (3.2.35)

$$k = \frac{G_h}{G_o}$$

3.2.37

isorad

curve, drawn on a map, indicating sites of equal solar *irradiation* (3.2.6) during a given interval of time

3.2.38

isohel

curve, drawn on a map, indicating sites of equal sunshine duration during a given interval of time

3.2.39

sky temperature

equivalent temperature of a blackbody radiating, on a horizontal surface, the same *longwave radiation* (3.2.12) as the atmosphere

3.3 Radiation measurement

3.3.1

world radiometric reference

WRR

measurement standard defining the SI unit of total *irradiance* (3.2.5)

Note 1 to entry: See Reference [5], subclause 7.1.2.2.

Note 2 to entry: The WRR was adopted by the WMO and has been in effect since 1 July 1980.

Note 3 to entry: In order to ensure its long-term stability, the WRR is maintained by a group (known as the World Standard Group) of at least four *pyrheliometers* (3.3.5) of different design which are under the auspices of the WMO World Radiation Centre at Davos, in Switzerland.

3.3.2

radiometer

instrument used for measuring radiation

Note 1 to entry: Depending on the construction of the instrument, the readout of the instrument will give either *irradiance* (3.2.5) or *irradiation* (3.2.6).

3.3.3

pyrradiometer

radiometer (3.3.2) for measuring the overall radiation including *shortwave* and *longwave radiation* (3.2.11, 3.2.12) on a plane surface from a solid angle of 2π sr

Note 1 to entry: Depending on the construction of the instrument, the readout of the instrument will give either *irradiance* (3.2.5) or *irradiation* (3.2.6).

3.3.4

pyranometer

radiometer (3.3.2) designed for measuring the solar *irradiance* (3.2.5) on a plane receiver surface

3.3.5

pyrheliometer

DEPRECATED: actinometer

radiometer (3.3.2) using a collimated detector for measuring the *direct solar irradiance* (3.2.28) under normal incidence

Note 1 to entry: Its spectral response should be approximately constant in the wavelength range of $0,3 \mu\text{m}$ to $3 \mu\text{m}$ and the acceptance angle is recommended to be 5° (see Reference [5]).

3.3.6

field-of-view angle

<*pyrheliometer* (3.3.5)> full angle of the geometrical cone which is defined by the centre of the *pyrheliometer* (3.3.5) receiver surface and the border of its aperture

3.3.7

pyrgeometer

radiometer (3.3.2) for measuring the longwave irradiance on a plane receiver surface

Note 1 to entry: This spectral range is similar to that of atmospheric *longwave radiation* (3.2.12) and is only nominal. The spectral response of a pyrgeometer depends largely on the material used for the dome(s) protecting its receiving surface.

3.3.8

diffusometer

radiometer (3.3.2) designed for measuring the diffuse solar radiation, consisting usually of a *pyranometer* (3.3.4) and a shading structure which can be a shading ball, a shading disk, a shading ring, a rotating shadowband or a shading mask

Note 1 to entry: For details, see ISO 9060 and ISO 9846.

3.4 Radiation properties and processes

3.4.1

absorptance

absorption factor

α

ratio of the *radiant flux* (3.2.3) absorbed by an element of a surface to that of the incident *radiation* (3.2.1)

Note 1 to entry: The absorptance may apply to either a single wavelength or a wavelength range.

3.4.2

emittance

ε

ratio of radiant exitance of a body to that of a full radiator (blackbody) at the same temperature

Note 1 to entry: The emittance may apply to either a single wavelength or a wavelength range.

Note 2 to entry: This term is often used interchangeably with emissivity.

3.4.3 reflectance reflection factor

ρ
ratio of the *radiant flux* (3.2.3) reflected from a surface to that of the incident *radiation* (3.2.1)

Note 1 to entry: The reflectance may apply to either a single wavelength or a wavelength range.

3.4.4 albedo

ratio of the *solar radiation* (3.2.13) (radiant or luminous energy) reflected by a surface, to that incident on it

Note 1 to entry: This is a generalized term for the average *reflectance* (3.4.3) of a defined surface area (usually of the earth or clouds); its use is discouraged in technical applications, where the preferred term is "reflectance".

3.4.5 transmittance transmission factor

τ
ratio of the *radiant flux* (3.2.3) passing through a body to that of the incident *radiation* (3.2.1)

Note 1 to entry: The transmittance may apply to either a single wavelength or a wavelength range.

3.4.6 selective surface

surface whose optical properties of *reflectance* (3.4.3), *absorptance* (3.4.1), *transmittance* (3.4.5) and *emittance* (3.4.2) are wavelength-dependent

Note 1 to entry: Surfaces with low *emittance* (3.4.2) in the longwave range and high *absorptance* (3.4.1) in the shortwave range are frequently used in *solar collector* (3.6.1) applications.

3.4.7 optical air mass

AM
measure of the length of the path through the atmosphere to sea level traversed by light rays from a celestial body, expressed with reference to the path length along the vertical

[SOURCE: WMO 00260^[4]]

Note 1 to entry: Optical air mass varies with the *solar altitude angle* (3.1.7) and the local barometric pressure, which changes with altitude. For a sun zenith angle, θ_z of 62° or less, and local atmospheric pressure, p , where p_0 is standard atmospheric pressure, $AM = p/(p_0 \cos \theta_z)$.

Note 2 to entry: Distinction should be made between optical air mass and the term *air mass* used in meteorology to designate an extensive body of the atmosphere whose physical properties, particularly temperature and humidity, exhibit only small and continuous differences in a horizontal plane.

3.4.8 atmospheric attenuation attenuation of solar radiation

decrease in the flux density of a beam of *radiation* (3.2.1) while propagating through the atmosphere, owing to absorption or *scattering* (3.4.9) by the atmospheric constituents

[SOURCE: WMO A2740^[4]]

3.4.9 scattering

wavelength-dependent interaction of *radiation* (3.2.1) with matter, by which the direction of the *radiation* (3.2.1) is changed, but the total energy and wavelength remain unaltered

3.4.10

atmospheric absorption

absorption of specific wavelengths of *solar energy* (3.2.14), due largely to moisture, atmospheric gases and pollutants

3.5 Indoor and outdoor climates

3.5.1

ambient air

air in the space (either indoors or outdoors) surrounding any object being considered

3.5.2

wind speed

W

<meteorology> air speed

Note 1 to entry: Wind speed is measured by an anemometer at a height of 10 m above the local ground level, the surrounding ground being flat and open, i.e. such that the horizontal distance between any obstacle and the anemometer is at least 10 times the height of the obstacle.

3.6 Collector types

3.6.1

solar collector

solar thermal collector

DEPRECATED: panel

DEPRECATED: solar panel

device designed to absorb *solar radiation* (3.2.13) and to transfer the thermal energy so produced to a fluid passing through it

Note 1 to entry: In addition to this function, a solar thermal collector can also be used for applications related to the exchange of thermal energy with the environment.

Note 2 to entry: The use of the term 'panel' is deprecated to avoid potential confusion with photovoltaic panels.

3.6.2

co-generating collector

hybrid device used to convert *solar radiation* (3.2.13) to thermal and electrical energy

3.6.3

photovoltaic thermal solar collector

PVT collector

co-generating collector (3.6.2) including photovoltaic panels

3.6.4

wind and infrared sensitive collector

WISC

DEPRECATED: Unglazed collector

solar thermal collector (3.6.1) that is particularly sensitive to wind and/or *infrared radiation* (3.2.10)

3.6.5

collector array

group of *solar collectors* (3.6.1) that are closely connected in series, in parallel or in combination of both modes, with one hydraulic input and one hydraulic output

3.6.6

liquid heating collector

liquid collector

solar collector (3.6.1) that uses a liquid as the *heat transfer fluid* (3.10.3)

3.6.7

air collector

air heating collector

solar collector (3.6.1) that uses air as the *heat transfer fluid* (3.10.3)

3.6.8

flat-plate collector

non-concentrating *solar collector* (3.6.1) in which the absorbing surface is essentially planar

3.6.9

concentrating collector

solar collector (3.6.1) that uses reflectors, lenses or other optical elements to redirect and concentrate the *solar radiation* (3.2.13) passing through the *aperture* (3.7.5) onto an *absorber* (3.7.1)

Note 1 to entry: A flat-plate collector provided with a mirror, or an evacuated tubular collector having a reflector behind the tubes, is a concentrating collector.

3.6.10

line-focus collector

concentrating collector (3.6.9) that concentrates *solar radiation* (3.2.13) in one plane only, producing a linear focus

3.6.11

parabolic-trough collector

line-focus collector (3.6.10) that focuses *solar radiation* (3.2.13) by means of a cylindrical reflector having a parabolic cross-section

Note 1 to entry: For parabolic-trough collectors, the irradiated surface is the *aperture area* (3.7.6) of the *solar thermal collector* (3.6.1).

3.6.12

point-focus collector

concentrating collector (3.6.9) that focuses *solar radiation* (3.2.13) essentially to a point

3.6.13

parabolic-dish collector

point-focus collector (3.6.12) having a paraboloidal dish-shaped reflector

Note 1 to entry: For parabolic-dish collectors, the irradiated surface is the *aperture area* (3.7.6) of the *solar thermal collector* (3.6.1).

3.6.14

non-imaging collector

concentrating collector (3.6.9) that concentrates *solar radiation* (3.2.13) onto a relatively small *receiver* (3.7.3) without bringing the *solar radiation* (3.2.13) to focus, i.e. without creating an image of the sun on the *receiver* (3.7.3)

3.6.15

compound parabolic concentrator collector

CPC collector

non-imaging collector (3.6.14) that uses parabolic reflector segments

Note 1 to entry: The parabolic segments reflect all of the incident radiation on the *aperture* (3.7.5) over ranges of angles of incidence within wide limits; the limits define the acceptance angle of the concentrator.

Note 2 to entry: The term CPC is applied to many non-imaging concentrators even though their geometries may differ from parabolic.

3.6.16

Fresnel collector

line-focus solar thermal collector (3.6.10) that uses reflectors composed of at least two longitudinal segments with parallel axes to concentrate the *solar radiation* (3.2.13) onto a fixed *receiver* (3.7.3)

Note 1 to entry: The irradiated surface of a Fresnel collector is fixed in space and usually horizontal.

3.6.17

tracking collector

solar collector (3.6.1) that moves to follow the apparent motion of the sun during the day, rotating about one or two axes

Note 1 to entry: The type of tracking is termed single- or double-axis tracking.

3.6.18

evacuated collector

collector in which the space between the *absorber* (3.7.1) and the cover is evacuated

Note 1 to entry: The performance of this collector depends highly on the pressure in the evacuated space.

3.6.19

evacuated tube collector

evacuated tubular collector

evacuated collector (3.6.18) employing transparent tubing (usually glass) with an evacuated space between the tube wall and the *absorber* (3.7.1)

Note 1 to entry: The *absorber* (3.7.1) may consist of an inner tube or another shape, with means for removal of the thermal energy.

3.7 Collector components and related quantities

3.7.1

absorber

component of a *solar collector* (3.6.1) for absorbing *radiant energy* (3.2.2) and transferring this energy as heat into a fluid

3.7.2

absorber plate

absorber (3.7.1) of essentially planar shape

3.7.3

receiver

part to which the *solar radiation* (3.2.13) is finally directed or redirected, comprising the *absorber* (3.7.1) and any associated glazing through which the radiation passes

3.7.4

collector cover

transparent (or translucent) material or materials that cover the *absorber* (3.7.1) to reduce heat losses and provide weather protection, without being in direct contact with the *absorber* (3.7.1).

3.7.5

aperture

<*solar collector* (3.6.1)> opening through which unconcentrated *solar radiation* (3.2.13) is admitted

3.7.6

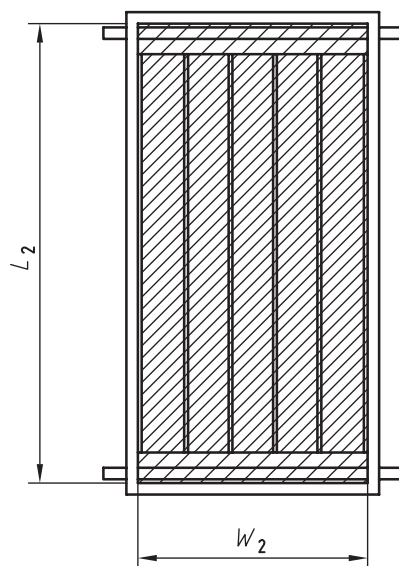
aperture area

A_a
<*solar collector* (3.6.1)> maximum projected area through which unconcentrated *solar radiation* (3.2.13) enters the collector

Note 1 to entry: See Figures 1 to 3 as examples.

Note 2 to entry: The aperture area does not include any transparent part screened from *solar radiation* (3.2.13) when this radiation is incident from the direction perpendicular to the projection plane defining the aperture area.

Note 3 to entry: Due to the variety of the designs there is only one example given at Figure 3 provided for *concentrating collectors* (3.6.9).



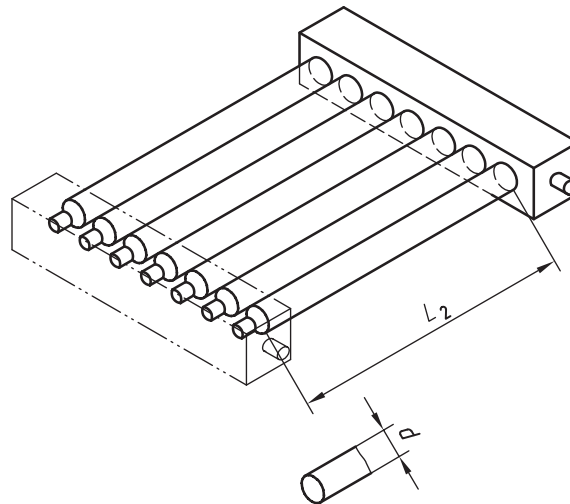
Key

L_2 length of unscreened maximum projected area

W_2 width of unscreened maximum projected area

$$A_a = L_2 \cdot W_2$$

Figure 1 — Aperture area of a flat-plate collector



Key

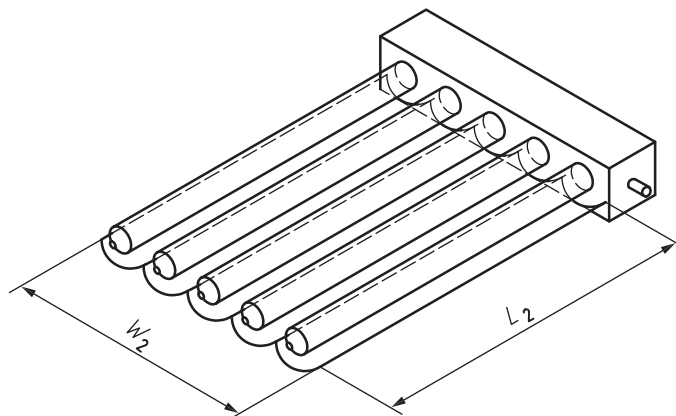
L_2 length of unscreened, parallel and transparent section of tube

d transparent tube inside diameter

N number of tubes

$$A_a = L_2 \cdot d \cdot N$$

Figure 2 — Aperture area of a tubular collector without reflector



Key

L_2 length of exposed reflector

W_2 width of exposed reflector

$$A_a = L_2 \cdot W_2$$

Figure 3 — Aperture area of a tubular collector with reflector (a concentrating collector)

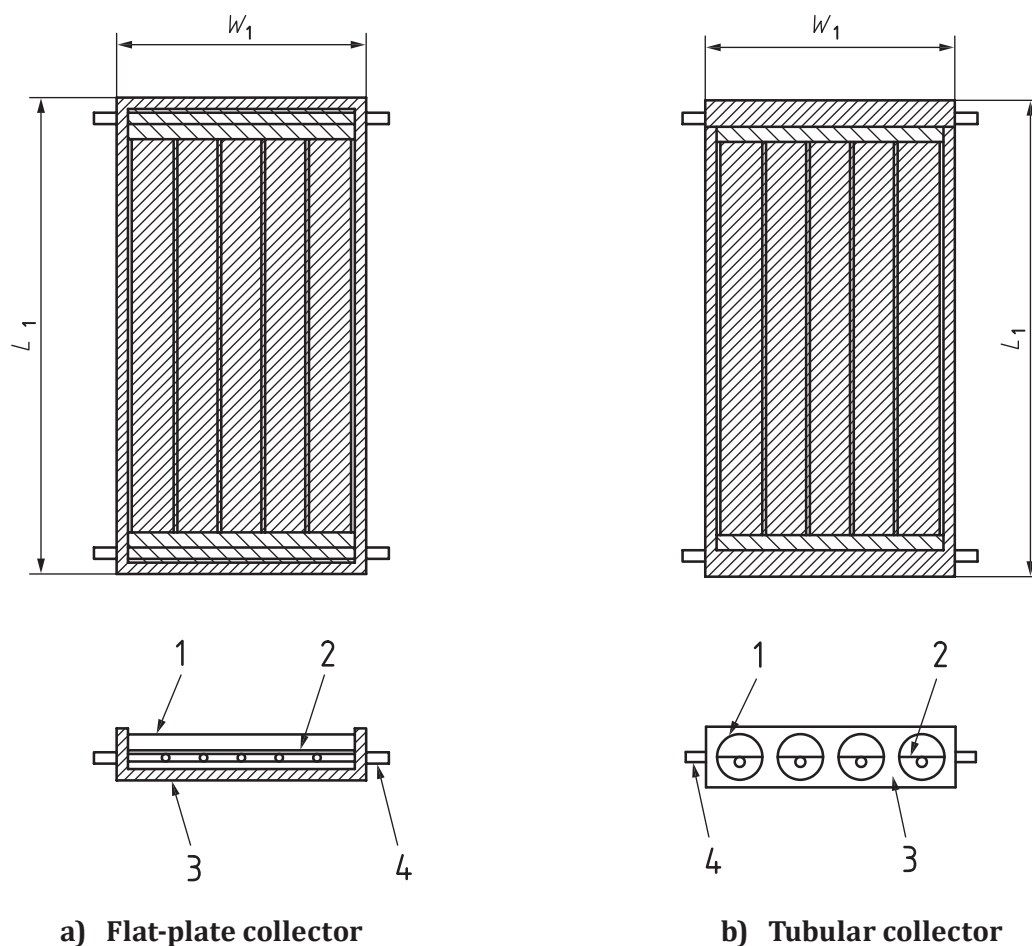
3.7.7

gross collector area

A_G
<solar collector (3.6.1)> maximum projected area of the complete collector, excluding any integral means of mounting and connecting fluid pipework.

Note 1 to entry: See Figure 4 as an example.

Note 2 to entry: In this clause, no example is given for concentrating *collectors* (3.6.6) as there is a great variety of designs.



Key

- 1 cover
- 2 absorber
- 3 box
- 4 inlet/outlet

L_1 maximum length excluding fixing brackets and tube connections

W_1 maximum width excluding fixing brackets and tube connections

$$A_G = L_1 \cdot W_1$$

Figure 4 — Gross collector area

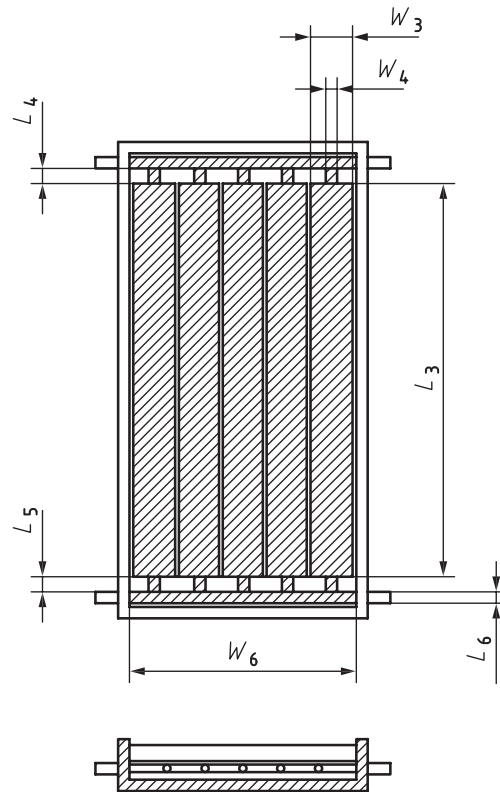
3.7.8 absorber area

A_A

<non-concentrating *solar collector* (3.6.1)> the maximum projected area of an *absorber* (3.7.1)

Note 1 to entry: See Figures 5 and 6.

Note 2 to entry: The absorber area does not include any absorbing part that is not reached by *solar radiation* (3.2.13), when this radiation is incident from the direction perpendicular to the projection plane defining the absorber area.



Key

Z number of absorber fins

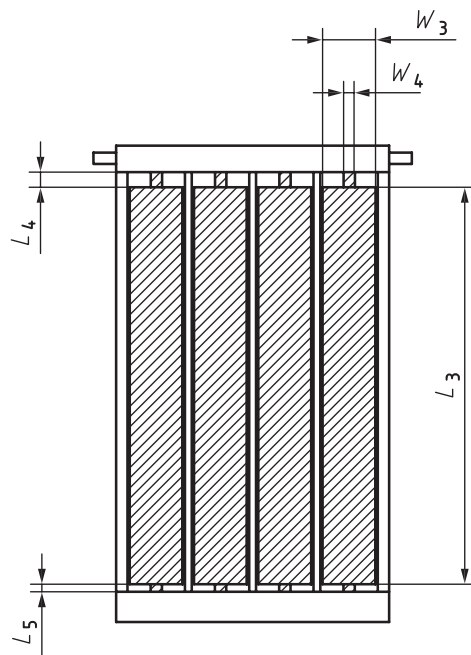
L_3 length of absorber fins

W_3 width of absorber fins

W_4, W_6, L_4, L_5, L_6 see figure

$$A_A = (Z \cdot L_3 \cdot W_3) + [Z \cdot W_4 \cdot (L_4 + L_5)] + (2 \cdot W_6 \cdot L_6)$$

Figure 5 — Absorber area of a flat-plate collector



a) Projection of the collector



b) Cross section of variant with tubular absorber on the inner tube surface



c) Cross section of variant with flat fin absorber in the tube

Key

N number of tubes

L_3 length of absorber

W_3 width or diameter of absorber

W_4, L_4, L_5 see figure

$$A_A = N \cdot (L_3 \cdot W_3) + N \cdot W_4 \cdot (L_4 + L_5)$$

Figure 6 — Absorber area of a tubular collector

3.7.9 absorber area

A_A

<concentrating solar collector (3.6.9)> surface area of the *absorber* (3.7.1) which is designed to absorb *solar radiation* (3.2.13)

Note 1 to entry: The absorber area of the *concentrating collector* (3.6.9) displayed in Figure 3 is equal to that of the corresponding non-concentrating collector obtained by removing the mirrors. Accordingly, it is calculated as indicated in Figure 6. However, in the case of a tubular collector with tubular *absorbers* (3.7.1) (see Figure 6b), the projected area to be considered is the one of the whole tubes.

Note 2 to entry: The absorber area does not include any absorbing part permanently screened from *solar radiation* (3.2.13).

3.7.10 fluid inlet temperature

ϑ_i

<heat transfer fluid (3.10.3)> temperature at the inlet to the collector

3.7.11 fluid outlet temperature

ϑ_e

<heat transfer fluid (3.10.3)> temperature at the outlet of the collector

3.7.12 stagnation

stable status of a collector or system when no heat is being removed by a *heat transfer fluid* (3.10.3)

3.7.13 steady state

<solar collector (3.6.1)> status of a collector when the rate of heat removal plus heat losses is equal to the *solar flux* (3.2.15)

3.7.14 active overheating protection

<solar collector (3.6.1)> controller activated mechanism to avoid overdesign temperatures

3.7.15 fail-safe design

collector design, where collector protection functions will continue under all collector and system failure modes, including controller failures

3.7.16 collector efficiency

η

<solar thermal collector> ratio of the thermal power removed by the *heat transfer fluid* (3.10.3), to the product of a defined collector area (gross, absorber or aperture) and the *solar irradiance* (3.2.5) on the collector

3.7.17 peak collector efficiency

DEPRECATED: zero-loss collector efficiency

η_0

efficiency of the collector, when the mean fluid temperature is equal to the *ambient air* (3.5.1) temperature

Note 1 to entry: The peak collector efficiency is indicated by $\eta_{0,b}$ or $\eta_{0,hem}$ depending on whether the *direct irradiance* (3.2.28) or the *hemispherical irradiance* (3.2.29) is considered.

3.7.18

incidence angle modifier

IAM

ratio of *peak efficiency* (3.7.17) at the given *angle of incidence* (3.1.11) to the *peak efficiency* (3.7.17) at normal incidence

3.7.19

concentration ratio

ratio of the *aperture area* (3.7.6) of a *concentrating collector* (3.6.9) to the *absorber area* (3.7.8)

3.7.20

tracking mechanism

mechanism used to adjust the collector *azimuth* (3.10.2) and *tilt angle* (3.10.1) in a *tracking collector* (3.6.17) system

3.7.21

tracking error

<single-axis *tracking collector* (3.6.17)> angular deviation between the actual position of the collector and the desired position relative to the sun, measured in a plane perpendicular to the axis of rotation

3.7.22

tracking error

<double-axis *tracking collector* (3.6.17)> angle between the normal vector to the *aperture* (3.7.5) and the collector-to-sun vector

3.8 Types of solar heating systems

3.8.1

solar heating system

solar thermal system

system using *solar energy* (3.2.14) for the delivery of thermal energy

3.8.2

solar-only system

solar heating system (3.8.1) without any other heat source

3.8.3

solar-plus-supplementary system

solar heating system (3.8.1) which utilizes both solar and any other energy sources to provide a heating service independent of *solar energy* (3.2.14) availability

3.8.4

solar preheat system

solar heating system (3.8.1) to preheat a fluid prior to its entry into any other type of heater

3.8.5

integral collector-storage system

ICS system

solar heating system (3.8.1) in which the *solar collector* (3.6.1) also functions as a heat storage device

3.8.6

circulating system

system in which *heat transfer fluid* (3.10.3) circulates between the collector(s) and a storage device or heat exchanger during operating periods

Note 1 to entry: Circulation is carried out by means of a pump or fan or by natural convection.

3.8.7

forced-circulation system

system which utilizes a pump or a fan to circulate the *heat transfer fluid* (3.10.3) through the collector(s)