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TECHNICAL SPECIFICATION

colour inside

Solar thermal electric plants –
Part 1-1: Terminology

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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SOLAR THERMAL ELECTRIC PLANTS –

Part 1-1: Terminology

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Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 62862-1-1, which is a technical specification, has been prepared by IEC technical committee 117: Solar thermal electric plants.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
117/75/DTS	117/85/RVDTS

Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

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SOLAR THERMAL ELECTRIC PLANTS –

Part 1-1: Terminology

1 Scope

This part of IEC 62862 contains the main terms and definitions used by the solar thermal electric (STE) industry and intends to be a reference for users of industry documents.

Since the components and configurations of STE plants depend on the concentrating solar thermal technology used (i.e., central *receiver*, *parabolic-trough collector*, parabolic-dish or linear Fresnel *concentrator*), some terms are not applicable to all types of STE plants and notes have been introduced in their definitions for clarification.

The reference STE plant configuration assumed is composed of three main subsystems: *solar field*, *power block* and (eventually) *thermal storage system*.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 9488:1999, *Solar energy – Vocabulary*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

3.1 SECTION 01: DESCRIPTION OF SYSTEMS, SUB-SYSTEMS AND COMPONENTS

3.1.1
absorber
element of the *receiver* absorbing *radiant solar energy* and transferring it to a fluid in the form of heat

3.1.2
absorber cover
transparent element that covers the *absorber* to reduce heat losses and provide weather protection

Note 1 to entry: When this element is made of glass it is usually referred to as a "glass cover".

3.1.3
active length of a linear receiver
length of the *absorber* exposed to concentrated solar radiation, at a reference temperature

Note 1 to entry: This temperature is 25 °C if not otherwise stated. The *absorber* length considered to be exposed is that where the radiation impinging normal to the *absorber*'s surface is not shadowed.

Note 2 to entry: Unit: the SI unit is m.

3.1.4
auxiliary heater
equipment in which thermal energy is transferred to the *heat transfer fluid* by means of *non-solar fuel consumption*

3.1.5
collector aperture normal
vector perpendicular to the *collector aperture plane*

3.1.6
collector aperture plane
plane, perpendicular to the *collector transversal plane*, that contains the *solar thermal collector aperture area*

3.1.7
collector axis
<*line-focus solar thermal collectors*> straight line resulting from the intersection of the *collector aperture plane* and a plane containing the *linear receiver* and perpendicular to the *collector aperture plane*

SEE: Figure 3.

3.1.8
collector longitudinal plane
plane defined by the *collector axis* and the *collector aperture normal*

SEE: Figure 2.

3.1.9
collector loop
set of *line-focus solar thermal collectors* assembled in series, in such a way that the same *heat transfer fluid* mass flow is circulating through the *absorber* tube of each

Note 1 to entry: A loop is composed of one or more *collector rows* connected in series.

3.1.10
collector row
set of *line-focus solar thermal collectors* assembled in series with the same *heat transfer fluid* mass flow and direction

3.1.11
collector transversal plane
plane perpendicular to the *collector axis*

SEE: Figure 2.

3.1.12
concentrator
reflecting or refracting elements that concentrate and redirect the *beam solar radiation* onto the *receiver*

3.1.13
dispatchability
capability of the *STE plant* to respond to the grid operator on demand, regardless of weather conditions

Note 1 to entry: The design of the plant and the availability of backup energy determine the degree on which grid operator demands can be fulfilled.

3.1.14
dispatchable STE plant
STE plant able to decouple the electricity production periods from the solar resource availability periods in order to satify the grid operator dispatch demands

3.1.15
effective length factor of a linear receiver
ratio of the *active length of a linear receiver* to its total length, at the specific temperature of the *receiver* tube

Note 1 to entry: Although the *effective length factor* can be given for any *absorber* temperature, its nominal reference temperature is 25 °C if not specified otherwise.

3.1.16
facet
smallest reflecting or refracting element composing a solar *concentrator*

3.1.17
heat transfer fluid
HTF
fluid used to carry heat from one system component to another in the *STE plant*

3.1.18
heliostat
system that reflects the *beam solar radiation* towards a predetermined fixed target by means of a single or a set of reflecting elements (*facets*) controlled by a 2-axis solar tracking system

3.1.19
linear collector incident plane
plane defined by the solar vector and the *collector axis*.

3.1.20
linear Fresnel collector
line-focus solar thermal collector that uses reflectors composed of at least two longitudinal segments with parallel axes to concentrate the solar radiation onto a fixed *receiver*

3.1.21
line-focus solar system
solar system using *line-focus solar thermal collectors.*

3.1.22
line-focus solar thermal collector
concentrating *solar thermal collector* that concentrates *solar radiation* in one plane only, producing a linear focus

[SOURCE: ISO 9488:1999, 7.7, modified – The term has been changed from "line-focus collector".]

3.1.23
line-focus solar thermal collector module
minimum subdivision of a *line-focus solar thermal collector* for which the *concentrator*, in its whole transversal extent, can be actuated independently

3.1.24
parabolic-dish collector
point-focus solar thermal collector using a parabolic-dish reflector

[SOURCE: ISO 9488:1999, 7.10.]

3.1.25
parabolic-trough collector
solar collector assembly
SCA
line-focus solar thermal collector that concentrates the solar radiation by means of a reflector with a parabolic cross section

Note 1 to entry: It is composed of a set of elements that altogether can track the sun as a single unit.

[SOURCE: ISO 9488:1999, 7.8, modified – Note 1 to entry added.]

3.1.26
parabolic-trough solar field circuit
linear Fresnel solar field circuit
parabolic-trough heat transfer fluid system
linear Fresnel heat transfer fluid sytem
system made up of the component parts through which the *solar field heat transfer fluid* flows from/to other sub-system of the plant (e.g. *power block*, *thermal storage* system, *auxiliary heater)*

3.1.27
point-focus solar system
solar system using *point-focus solar thermal collectors* or a *central receiver*

3.1.28
point-focus solar thermal collector
solar thermal collector that concentrates the solar radiation on a single point or non-linear focus

3.1.29
positive collector axis
defines the orientation of the *solar thermal collector*

Note 1 to entry: The alignment in space is described by the *collector axis azimuth angle*.

Note 2 to entry: The axis orientation is positive or there is a *positive collector axis* when the projection of the *collector axis* into the horizontal plane points towards the south in the northern hemisphere, and towards the north in the southern hemisphere. In the case of east-west aligned *solar thermal collectors*, the *positive collector axis* is when the projection points towards the west.

3.1.30
power block
STE plant equipment or components in which thermal-to-electric conversion takes place

Note 1 to entry: In those *STE plants* provided with steam generators fed by the *heat transfer fluid* used in the *solar field*, the steam-generating system is included in the *power block*. In STE plants with direct steam generation, the solar *receivers* are not included in the *power block*.

3.1.31
receiver
set of components (*absorbers*, glass cover, bellows, getters, etc.) that converts the concentrated solar radiation into thermal energy

Note 1 to entry: For solar tower plants, other plant components, required for the *receiver* to work, are included.

3.1.32
central receiver
single receiver used with *solar fields* composed of *heliostats*

3.1.33
linear receiver
receiver used in *line-focus solar thermal collectors*

3.1.34
solar field
part of the *STE plant* that collects and concentrates the *beam solar radiation*

Note 1 to entry: In *STE plants* with *parabolic-trough collector* or *Fresnel linear collectors*, the *solar field* is composed of a set of *solar thermal collectors* and their piping interconnections and headers. The *solar field* inlet is the last connecting point in the direction from the pumping equipment to the *solar thermal collectors* at which either the storage system, *auxiliary heater* or pumps are connected, while the *solar field* outlet is the first connecting point in the direction from the *solar thermal collectors* to the *power block* at which either the *thermal storage system* or *auxiliary heater* is connected. In a central *receiver* plant, the *solar field* is composed of the *heliostats*. In STE plants with parabolic dishes, the *solar field* is composed of the parabolic dishes.

3.1.35
solar thermal collector
device designed to absorb the solar radiation (concentrated or non-concentrated) and transfer the thermal energy thus generated to a *heat transfer fluid*

Note 1 to entry: For concentrating *solar thermal collectors*, the main components are: the *concentrator*, the *receiver* and the *supporting structure.*

3.1.36
solar thermal electricity plant
STE plant
solar thermal power plant
STP plant
facility, which applies solar concentration and thermodynamic processes, to convert direct solar radiation into electricity suitable for its distribution and consumption

Note 1 to entry: The facility can include further sources of thermal energy, such as fossil fuel or biomass, in parallel to solar radiation.

Note 2 to entry: Historically, "CSP" (concentrated solar power) universally referred only to, and was used in place of, "STE". Only in recent years has the term "STE" (solar thermal electricity) become widespread and have some organizations changed the definition of CSP to include both STE and concentrating photovoltaics (CPV). However, some organizations still use "CSP" to refer to, and in place of, "STE", and in these cases CSP does not include CPV. Therefore, the meaning of CSP varies between organizations without a clear definition and is not used herein. The term "CST" (concentrating solar thermal) is used to globally or individually refer to the technologies used to concentrate and convert solar radiation into thermal energy (i.e. CST technology or technologies).

3.1.37
supporting structure
structure that serves to support the components of the *solar thermal collector* with the required mechanical stiffness.

3.2 SECTION 02: ANGLE DEFINITIONS

3.2.1
acceptance angle of a concentrating solar thermal collector
$2\cdot\theta_c$
angular range ($2\cdot\theta_c$) over which all parallel rays intercepted by the *solar thermal collector* hit the *absorber* without moving all or part of the *collector*

Note 1 to entry: For nominal values, a perfect shape of the *concentrator* is assumed.

Note 2 to entry: Unit: the non-SI unit is °.

3.2.2
angle of acceptance of specular reflectance
ψ
polar angle defined by the direction of the ideal specular reflected beam and the direction of the admissible maximum dispersion of reflection on the surface

SEE: Figure 1.

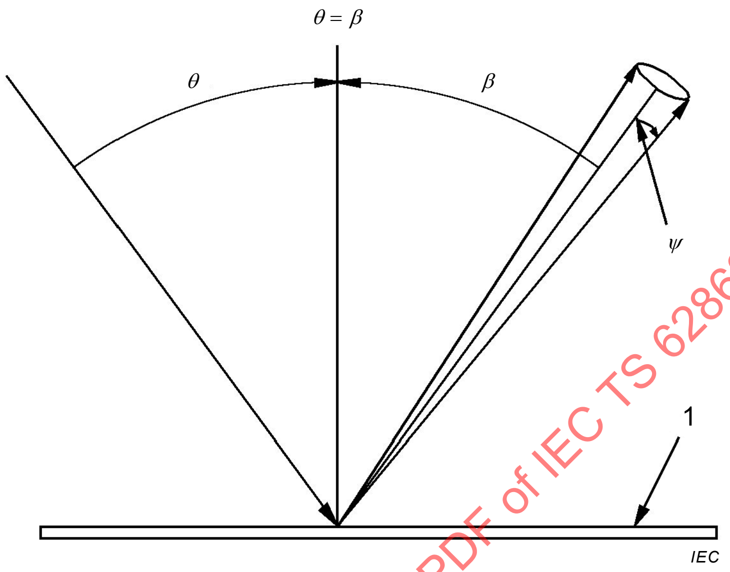


Figure 1 – Angle of acceptance of specular reflectance, *ψ*

Key:

θ Incidence angle

β Reflection angle

ψ *Angle of acceptance of specular reflectance*

1 Reflecting surface

Note 1 to entry: Unit: the non-SI unit is °.

3.2.3
angle of incidence of the beam solar radiation
incidence angle of the beam solar radiation
incident angle of the beam solar radiation
θ
angle between the straight line joining the centre of the solar disk to a point on an irradiated surface and the outward normal to the irradiated surface at that point

SEE: Figure 2.

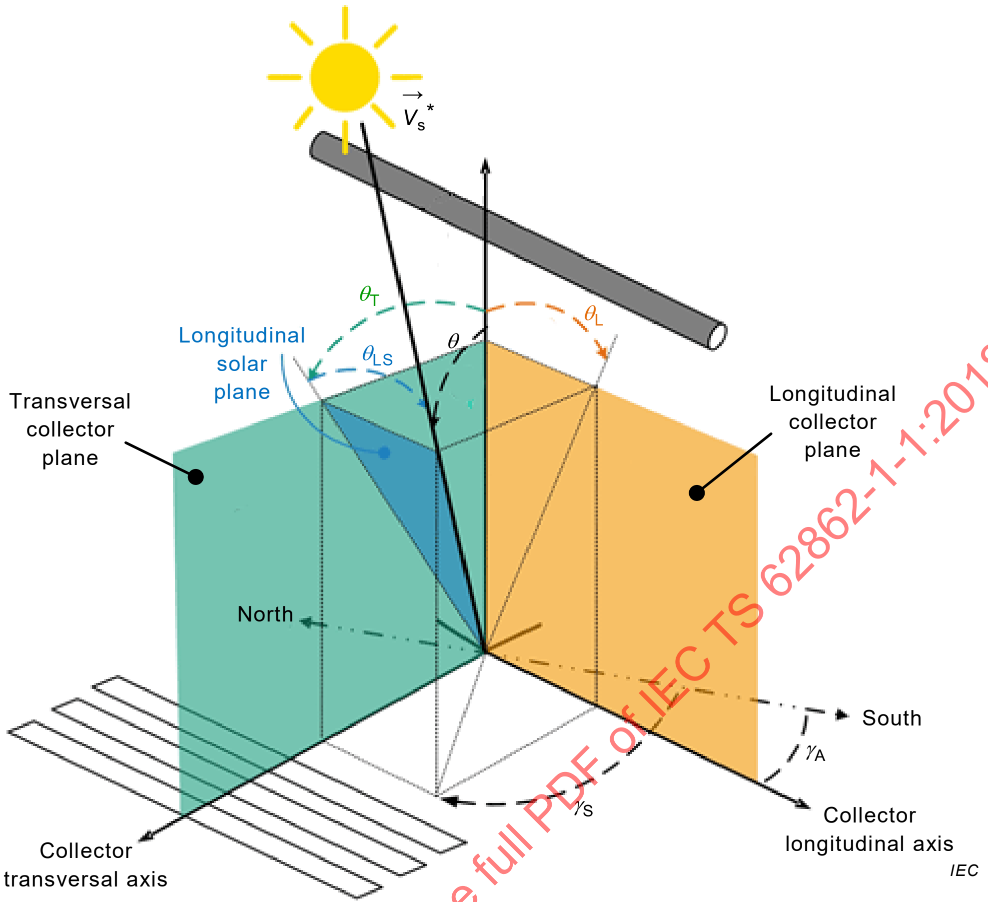


Figure 2 – Angles of incidence in *linear Fresnel collectors*

Note 1 to entry: For *parabolic-trough collectors* and *parabolic dishes*, the irradiated surface is the *solar thermal collector aperture area*. For *linear Fresnel collectors*, the irradiated surface is fixed in space and usually horizontal.

Note 2 to entry: Unit: the non-SI unit is °.

[SOURCE: ISO 9488:1999, 2.11, modified – Term changed to "angle of incidence of the beam solar radiation" and reference to Figure 2 added.]

3.2.4
transversal angle of incidence
$\boldsymbol{\theta_T}$
angle between the *collector aperture normal* and the projection of the sun beam into the transversal plane (plane perpendicular to the *collector axis*)

SEE: Figure 2.

Note 1 to entry: The *transversal angle of incidence* gets positive if the projection of the solar beam into the transversal plane rotates in clockwise direction from the vertical for an observer placed at the northern end of the *solar thermal collector*. For a collector exactly aligned east-west, the angle gets positive if the projection of the solar beam into the transversal plane rotates counter-clockwise from the vertical for an observer placed at the eastern end of the *solar thermal collector*.

Note 2 to entry: Unit: the non-SI unit is °.

3.2.5
longitudinal angle of incidence
$\boldsymbol{\theta_L}$
angle between the *collector aperture normal* and the projection of the sun beam into the longitudinal plane (plane defined by the *collector axis* and the *collector aperture normal*)

SEE: Figure 2.

Note 1 to entry: Usually, for symmetric *solar thermal collector* systems, it is sufficient to use the magnitude of the angle independent of the direction (0 ... 90°). For non-symmetric *solar thermal collectors*, the *longitudinal angle* is defined positive when the Sun is located in the *positive collector axis* direction; otherwise it is negative.

Note 2 to entry: The term "longitudinal" is more historical, while "axial" is more recent.

Note 3 to entry: Unit: the non-SI unit is °.

3.2.6
longitudinal solar angle
θ_{LS}
angle between the sun beam vector and the projection of the sun beam into the transversal plane

SEE: Figure 2.

Note 1 to entry: Only for ideally tracked *parabolic-trough collectors*, *the longitudinal solar angle* equals the *incidence angle*.

Note 2 to entry: Unit: the non-SI unit is °.

3.2.7
collector axis azimuth angle
γ_A
angle between the *positive collector axis* and due south (in the northern hemisphere) or due north (in the southern hemisphere), measured clockwise in the northern hemisphere and anticlockwise in the southern hemisphere, using the projections on the local horizontal plane

SEE: Figure 3.

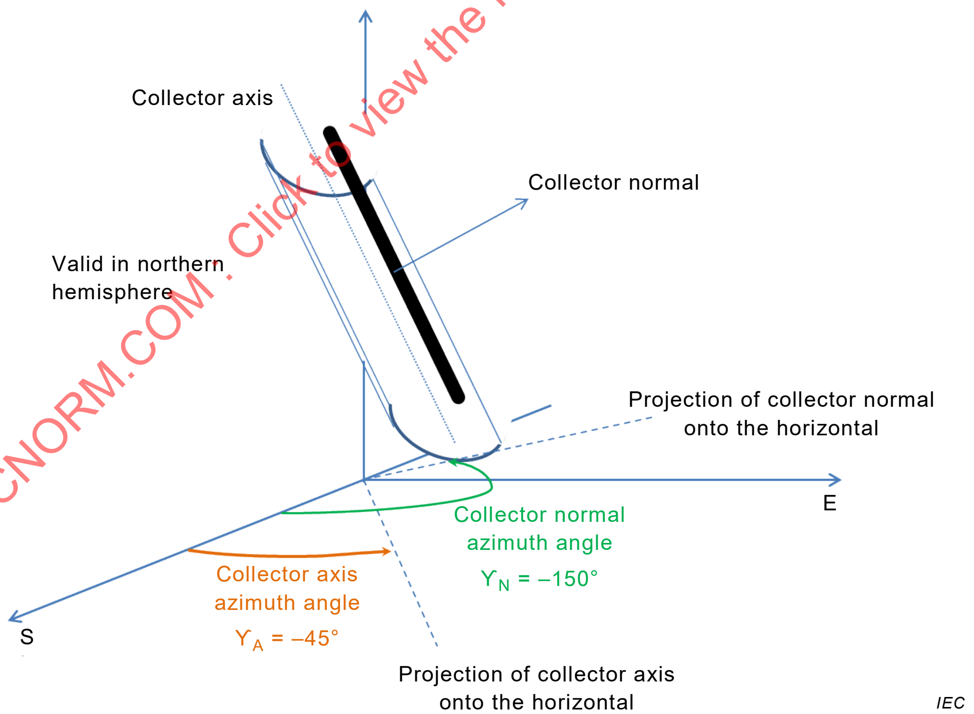


Figure 3 – Collector axis azimuth angle and collector normal azimuth angle (example for northern hemisphere)

Note 1 to entry: The same sign criteria used for *solar azimuth angle* is applied for *collector axis azimuth angle*.

Note 2 to entry: Unit: the non-SI unit is °.

3.2.8
collector axis tilt angle
β_A
angle between the horizontal plane and the *collector axis* (defined when looking in *positive collector axis*)

Note 1 to entry: Positive from horizon upwards and negative from horizon downwards.

Note 2 to entry: Unit: the non-SI unit is °.

3.2.9
collector normal azimuth angle
γ_N
direction that a *solar thermal collector* faces, expressed as the azimuth angle of the horizontal projection of the *collector aperture normal*

SEE: Figure 3.

Note 1 to entry: The angle definition is the same as for the *solar azimuth angle*.

Note 2 to entry: Unit: the non-SI unit is °.

3.2.10
collector normal tilt angle
β_N
angle between the horizontal plane and the plane of the specified surface

Note 1 to entry: Unit: the non-SI unit is °.

[SOURCE: ISO 9488:1999, 11.2, modified – The term has been changed from "tilt angle".]

3.2.11
rim angle of a solar thermal collector
φ
half of the angle defined by the lines connecting the centre of the *receiver* with the edge of the *concentrator*

Note 1 to entry: It is calculated as:

$$\tan(\varphi/2) = w/4f$$

Where

w is the aperture width of *solar thermal collector;*

f is the focal distance (see Figure 4).

[SOURCE: Rabl A., 1985, *Active solar thermal collectors and their applications*, New York: Oxford University Press.]

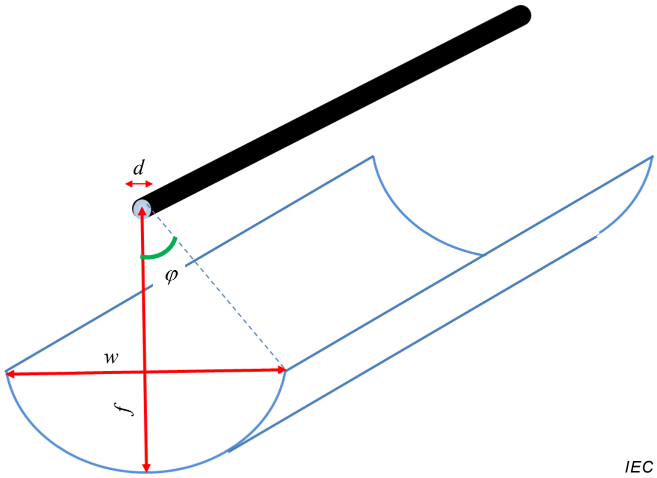


Figure 4 – Rim angle of a parabolic-trough collector

Note 1 to entry : Unit: the non-SI unit is °.

3.2.12
solar altitude angle
solar elevation angle
α_S
complement of the *solar zenith angle*

Note 1 to entry: Unit: the non-SI unit is °.

[SOURCE: ISO 9488:1999, 2.7, modified – A formula has been deleted and Note 1 to entry has been added.]

3.2.13
solar azimuth angle
Υ_s
projected angle between a straight line from the apparent position of the sun to the point of observation and due south (in the northern hemisphere) or due north (in the southern hemisphere), measured clockwise in the northern hemisphere and anticlockwise in the southern hemisphere, using the projections on the local horizontal plane

SEE: Figure 5 and Figure 6.

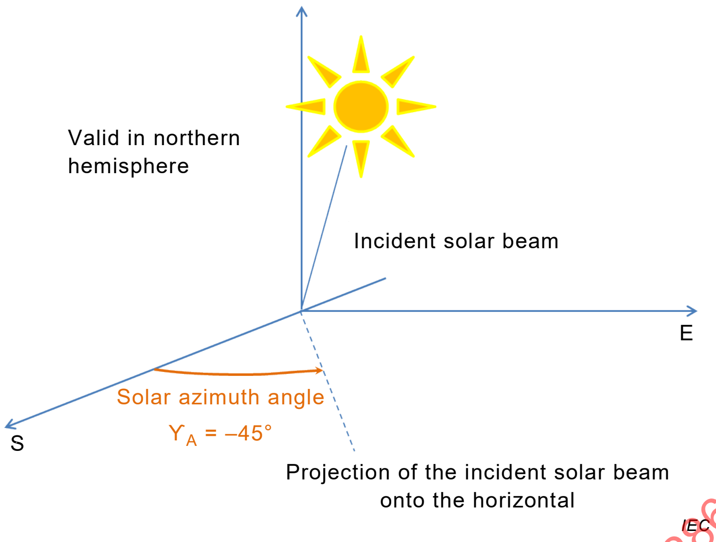


Figure 5 – Illustration of solar azimuth angle definition in the northern hemisphere

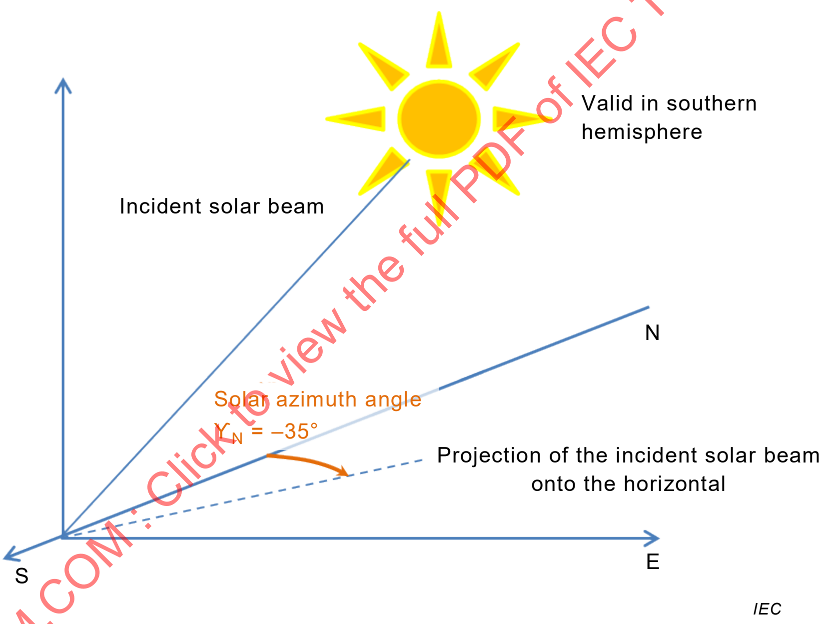


Figure 6 – Illustration of solar azimuth angle definition in the southern hemisphere

Note 1 to entry: The solar azimuth is negative in the morning (eastern directions), 0° or 180° at noon (depending on the relative values on solar declination and local latitude), and positive in the afternoon (western directions), over the whole globe. It diverges from the geographical azimuth, which is measured clockwise from due north, over the whole globe.

Note 2 to entry: Unit: the non-SI unit is °.

[SOURCE: ISO 9488:1999, 2.4, modified – Reference to figures and Note 2 to entry have been added.]

3.2.14
solar zenith angle
θ_Z
angular distance of the sun beam from the vertical

Note 1 to entry: Unit: the non-SI unit is °.

[SOURCE: ISO 9488:1999, 2.6, modified – Note 1 to entry has been added.]

3.2.15
tracking angle of a linear collector
ρ_{track}
<horizontal collectors> angle between the vertical and the normal to the *collector aperture plane*

Note 1 to entry: For tilted *solar thermal collectors*, it is the angle between the projection of the vertical onto the transversal plane and the normal to the *collector aperture plane*. For *linear Fresnel collector*, there is an individual angle for each mirror line of the *solar thermal collector*.

Note 2 to entry: The angle gets positive if the *collector aperture normal* rotates clockwise from the vertical for an observer placed at the northern end of the *solar thermal collector* (arbitrary aligned). For a *solar thermal collector* exactly aligned east-west, the angle gets positive if the *collector aperture normal* rotates anticlockwise from the vertical for an observer placed at the eastern end of the collector.

Note 3 to entry: Unit: the non-SI unit is °.

3.3 SECTION 03: AREA DEFINITIONS

3.3.1
absorber gross area
total area of the *absorber*

Note 1 to entry: For *receivers* without a secondary *concentrator* and composed of several parallel tubes, it is given by the sum of the products of the total length and the perimeter of each tube. For *receivers* with or without a secondary *concentrator* and composed of a single *absorber* tube, it is given by the products of the total length of the *absorber* tube and its perimeter.

3.3.2
net area factor
<*receiver*> ratio of the *receiver net collection area* to the *receiver aperture area*

3.3.3
net area factor
<*solar thermal collector*> ratio of the *solar thermal collectior net collection area* to the *solar termal collector aperture area*

3.3.4
receiver aperture area
maximum *receiver* flat area that accepts the concentrated *solar radiation*

Note 1 to entry: This is the area of the flat surface defined by the outer perimeter of the *receiver*, including non-active zones (if any) between adjacent absorber elements composing the *receiver*. For *receivers* without a secondary concentrator and composed of several parallel tubes, it is given by the product of the total length of each tube and the total width of the *receiver*. For *receivers* without secondary *concentrator* and composed by a single tube, it is given by the product of the total length and the diameter of the *absorber* tube (i.e. excluding the glass cover (if any)). For *receivers* with a secondary *concentrator*, it is given by the product of the total length of the receiver and the width of the aperture area of the secondary *concentrator*. For cavity *receivers*, it is the flat surface associated to the aperture of the cavity.

Note 2 to entry: Unit: the SI unit is m^2.

3.3.5
receiver net collection area
flat surface that accepts the concentrated *solar radiation*

Note 1 to entry: For *receivers* without a secondary concentrator and composed by several parallel tubes, it is given by the sum of the products of the *active length* and diameter of each tube. For *receivers* without a secondary *concentrator* and composed of a single tube, it is given by the products of the *active length* of the *receiver* tube and the arch length of the *receiver* tube that is defined by the double of the *rim angle*. For *linear receivers* with a secondary *concentrator*, it is given by the product of the *active length* of the *receiver* and the width of the flat area defined by the perimeter of the secondary *concentrator*. For cavity *receivers,* it is the flat surface associated with the perimeter of the cavity.

Note 1 to entry: Unit: the SI unit is m^2.

3.3.6
solar thermal collector aperture area
A
maximum projected area that accepts the solar radiation

Note 1 to entry: Unit: the SI unit is m^2.

3.3.7
solar thermal collector gross aperture area
A_{gross}
area of the flat surface defined by the outer perimeter of the *solar thermal collector*, including the gaps between adjacent reflectors

Note 1 to entry: This definition may be used for modules, *heliostats*, *heliostat* fields, *parabolic dishes*, linear Fresnel reflectors, etc., as well as complete *solar thermal collectors*.

3.3.8
solar thermal collector net aperture area
A_{net}
area of the perpendicular projection over the *collector aperture plane* of the *solar thermal collector* reflecting/refracting components

Note 1 to entry: In *line-focus solar system*, it is this surface plus the part of the perpendicular projection of the steel *receiver* tube onto the *collector aperture plane* that does not overlap, provided that the sun-oriented side of the *receiver* is absorbing radiation.

Note 2 to entry: The net aperture area of a *Linear Fresnel collector* or *heliostat* is defined as the sum of the *net aperture areas* of its mirror segment. The *net aperture area* of a mirror segment is the perpendicular projection of the reflective mirror area over its *collector aperture plane* when they are in the horizontal position.

3.3.9
solar thermal collector nominal aperture area
A_{nom}
flat aperture area, defined by product specifications, for example by the manufacturer

Note 1 to entry: The value should be between "net" and "gross". This term is necessary to have consistent definitions with efficiency and performance figures, as "gross" and "net" may include ambiguities resulting in invalid output characteristics. It may be used for modules, *heliostats*, *heliostat* fields, *parabolic dishes*, *linear Fresnel collector*, reflectors, etc., as well as complete *solar thermal collectors*.

3.3.10
solar thermal collector net collection area
area of the perpendicular projection over the *collector aperture plane* of the *solar thermal collector* reflecting/refracting components

Note 1 to entry: In a *parabolic-trough collector*, it is this surface plus the part of the perpendicular projection of the steel *receiver* tube onto the *collector aperture plane* that does not overlap.

Note 2 to entry: Unit: the SI unit is m^2.

3.4 SECTION 04: OPTICAL PROPERTIES

Table 1 – Optical terms and symbols

Absorptance, α	Emittance, ε	Reflectance, ρ	Transmittance, τ
		Hemispherical	Hemispherical
		Near specular	Direct
Spectral $\alpha_{\lambda}\ (\lambda,\ \theta_{i},\ T_{s})$	Spectral $\varepsilon_{\lambda}(\lambda,\ \theta_{i},\ T_{s})$	Spectral: • Hemispherical $\rho_{\lambda,h}(\lambda,\theta_{i},h,T_{s})$ • Near-specular $\rho_{\lambda,\varphi}(\lambda,\theta_{i},\ \psi,T_{s})$	Spectral: • Hemispherical $\tau_{\lambda,h}(\lambda,\theta_{i},h,T_{s})$ • Direct $\tau_{\lambda,d}(\lambda,\theta_{i},d,T_{s})$
Solar $\alpha_{S}([\lambda_{a},\ \lambda_{b}],\ \theta_{i},\ T_{s})$	Radiant $\varepsilon_{T}([\lambda_{a},\ \lambda_{b}],\theta_{i}\ ,T_{s})$	Solar: • Hemispherical $\rho_{S,h}([\lambda_{a},\lambda_{b}],\theta_{i},h,T_{s})$ • Near specular $\rho_{S,\varphi}([\lambda_{a},\lambda_{b}],\theta_{i},\ \psi,T_{s})$	Solar: • Hemispherical $\tau_{S,h}([\lambda_{a},\lambda_{b}],\theta_{i},h,T_{s})$ • Direct $\tau_{S,d}([\lambda_{a},\lambda_{b}],\theta_{i},d,T_{s})$

3.4.1
absorptance

α

ratio of the radiant flux absorbed by a surface element to the radiation incident on it

Note 1 to entry: The *absorptance* is a dimensionless variable ranging from 0 to 1, which depends on the wavelength, λ, the direction of the incident radiation, θ_{i}, and the nature, finish and temperature, T_{s}, of the surface which the incident radiation is impinging on.

Note 2 to entry: Unless otherwise specified, the temperature T_{s} taken into consideration is the ambient temperature. In this case, the symbol T_{s}, can be omitted.

Note 3 to entry: The terms "absorptivity" and "*absorptance*" are generally used interchangeably, as if they were synonymous. According to the National Bureau of Standards, the ending "-ivity" expresses the property of a material in general, for a homogeneous and semi-infinite sample, i.e. an intrinsic material property, (resistivity, thermal conductivity, etc.). The ending "-ance" expresses the property of a particular sample of material or a particular surface. In this case, the value depends on the specific conditions of the material (dirt, oxidation, grated, etc.) or even the thickness of the sample, i.e. strength or electrical conductance. Therefore, when talking about optical properties of materials used in solar applications *(reflectance, transmittance, absorptance* and *emittance*) the ending "-ance" shall be used, because such materials can be degraded by the thermal process, soiling, mechanical damage, etc.

[SOURCE: ISO 9488:1999, 5.1, modified – Notes to entry have been added.]

3.4.2
direct transmittance
near-direct transmittance

ratio of the radiant flux passing through a material within the solid angle 2·π· ψ (ψ is the *angle of acceptance* of the transmitted radiation) around the incident beam direction to the radiation incident on it

SEE: Table 1.

3.4.3
emittance
ε
ratio of the radiant energy flux emitted by a body from its surface to the radiant energy flux emitted by a perfect black body emitter at the same conditions

Note 1 to entry: The *emittance* is a dimensionless variable ranging from 0 to 1, which depends on wavelength, λ, direction of emission, θ_i, and nature, finish and temperature, T_s, of the surface emitting the radiant energy

Note 2 to entry: The terms "emissivity" and "*emittance*" are generally used interchangeably, as if they were synonymous. According to the National Bureau of Standards, the ending "-ivity" expresses the property of a material in general, for a homogeneous and semi-infinite sample i.e. an intrinsic material property (resistivity, thermal conductivity, etc.). The ending "-ance" expresses the property of a particular sample of material or a particular surface. In this case, the value depends on the specific conditions of the material (dirt, oxidation, grated, etc.) or even the thickness of the sample, i.e. strength or electrical conductance. Therefore, when talking about optical properties of materials used in solar applications (*reflectance, transmittance, absorptance* and *emittance*) the ending "-ance" shall be used, because such materials can be degraded by the thermal process, soiling, mechanical damage, etc.

3.4.4
hemispherical reflectance
ratio of the radiant flux reflected by a surface within the complete hemisphere over that surface, to the radiation incident on it

SEE: Table 1.

3.4.5
hemispherical transmittance
ratio of the radiant flux passing through a material within the complete hemisphere over its exit surface, to the radiation incident on it

SEE: Table 1.

3.4.6
near-normal incidence
situation where the *incidence angle* is below 15°

3.4.7
radiant emittance
ratio of the radiant energy flux emitted in all spatial directions by a material from its surface at a given temperature T_s to that emitted by a black body at the same temperature and the same wavelength range

Note 1 to entry: The *radiant emittance* is indicated with the subscript "T" after the *emittance* symbol, ε_T. The *radiant emittance* is represented as $\varepsilon_T([\lambda_a,\lambda_b],\theta_i,T_s)$, being $[\lambda_a,\lambda_b]$ the wavelength range, θ_i the *incidence angle* and T_s the temperature, which shall be indicated. It is expressed as in the next equation:

$$\varepsilon_T([\lambda_a,\lambda_b],\theta_i,T_S)=\frac{\int_{\lambda_a}^{\lambda_b}\varepsilon_\lambda(\lambda,\theta_i,T_S)\,i_{\lambda,bb}(\lambda,T_S)\,d\lambda}{\int_{\lambda_a}^{\lambda_b}i_{\lambda,bb}(\lambda,T_S)\,d\lambda}$$

As there is not a standard method for measuring a sample at different temperatures, an approximate value measured at room temperature can be used. In this case, the expression is:

$$\varepsilon_T([\lambda_a,\lambda_b],\theta_i,T_S)=\frac{\int_{\lambda_a}^{\lambda_b}\varepsilon_\lambda(\lambda,\theta_i,T_{S(room\ temperature)})\,i_{\lambda,bb}(\lambda,T_{S(operating\ temperature)})\,d\lambda}{\int_{\lambda_a}^{\lambda_b}i_{\lambda,bb}(\lambda,T_{S(operating\ temperature)})\,d\lambda}$$

Where:

$\varepsilon_\lambda(\lambda,\theta_i,T_s)$ is the *spectral emittance*;

$i_{\lambda,bb}$ (λ, T_s) is the emission intensity of a black body for every wavelength at a given temperature, calculated according to Planck's law where h is Planck's constant (6,626 × 10^{-34} J s), c is the light velocity (3,0 × 10^8 m/s) and k is Boltzmann's constant (1,380 648 52 × 10^{-23} J/K).

$$i_{\lambda,bb}(\lambda, T_S) = \frac{8\pi h d}{\lambda^5} \frac{1}{e^{(hc/\lambda k T)} - 1}$$

$\int_{\lambda_a}^{\lambda_b} i_{\lambda,bb}(\lambda, T_S) d\lambda$ is the Stefan-Boltzman law, giving the total power emitted per unit area at the surface of a black body.

The wavelength range within which the measuring and respective weighting is performed, [λ_a ,λ_b], will be determined according to the temperature T_s, so that it covers the emission spectrum of a black body at the temperature T_s, assessed in accordance with Planck's law.

SEE: Table 1.

3.4.8
reflectance

ρ

ratio of the radiant flux reflected from a surface to that of the incident radiation

Note 1 to entry: *Reflectance* is a dimensionless variable ranging from 0 to 1, which depends on wavelength, λ, direction of the incident radiation, θ_i, direction of the reflected radiation, θ_r, the nature, the finish and temperature of the surface which the radiation is falling on, T_s.

Note 2 to entry: Unless otherwise specified, the temperature T_s taken into consideration is the ambient temperature. In this case, the symbol T_s can be omitted.

Note 3 to entry: The terms "reflectivity" and "*reflectance*" are generally used interchangeably, as if they were synonymous. According to the National Bureau of Standards, the ending "-ivity" expresses the property of a material in general, for a homogeneous and semi-infinite sample, i.e. an intrinsic material property, (resistivity, thermal conductivity, etc.). The ending "-ance" expresses the property of a particular sample of material or a particular surface. In this case, the value depends on the specific conditions of the material (dirt, oxidation, grated, etc.) or even the thickness of the sample, i.e. strength or electrical conductance. Therefore, when talking about optical properties of materials used in solar applications *(reflectance, transmittance, absorptance* and *emittance*), the ending "-ance" shall be used, because such materials can be degraded due to the thermal process, soiling, mechanical damage, etc.

[SOURCE: ISO 9488:1999, 5.3, modified – Notes to entry have been added.]

3.4.9
solar absorptance

absorptance spectrum weighted over the solar spectral radiant distribution

Note 1 to entry: The *solar absorptance* is indicated with the subscript "s" after the *absorptance* symbol, α_s. The *solar absorptance* is represented as $\alpha_s([\lambda_a,\lambda_b],\theta_i,T_s)$, being [$\lambda_a$,$\lambda_b$] the wavelength range, θ_i the *incidence angle* and T_s the temperature. It is expressed as in the next equation:

$$\alpha_S([\lambda_a, \lambda_b], \theta_i, T_S) = \frac{\int_{\lambda_a}^{\lambda_b} \alpha_\lambda(\lambda, \theta_i, T_S) G_b(\lambda) d\lambda}{\int_{\lambda_a}^{\lambda_b} G_b(\lambda) d\lambda}$$

Where:

$\alpha_\lambda(\lambda, \theta_i, T_s)$ is the spectral absorptance;

$G_b(\lambda)$ is the spectral solar irradiance.

The range of wavelengths within which the weighting is performed, [λ_a,λ_b], shall be specified. The wavelength range should be between 300 nm and 2 500 nm, optionally between 320 nm and 2 500 nm.

The temperature T_s taken into consideration is the ambient temperature.

Note 2 to entry: T_s can be omitted if it is the ambient temperature.

Note 3 to entry: For applications using direct solar radiation, the AM (Air Mass) 1.5D spectrum is used to find the *direct solar absorptance*. The ASTM G173-03 (2012) AM 1.5 solar radiation spectrum shall be used to calculate the *solar absorptance*.

SEE: Table 1.

3.4.10
solar reflectance
reflectance spectrum weighted over the solar spectral radiant distribution

Note 1 to entry: The *solar reflectance* is indicated with the subscript "s" after the reflectance symbol, ρ_S. This term can either refer to *near-specular* or *hemispherical reflectance*, which is indicated in a second subscript after the *reflectance* symbol with φ or h, respectively. The solar *hemispherical reflectance* is represented as $\rho_{s,h}([\lambda_a,\lambda_b],\theta_i,h,T_s)$, $[\lambda_a,\lambda_b]$ being the wavelength range, θ_i the *incidence angle*, h the symbol to express the hemispherical property and T_s the temperature. The *near-specular solar reflectance* is represented as $\rho_{s,\varphi}([\lambda_a,\lambda_b],\theta_i,\psi,T_s)$, being $[\lambda_a,\lambda_b]$ the wavelength range, θ_i the *incidence angle*, ψ the *angle of acceptance* and T_s the temperature. It is expressed as in Equation (1) for solar *hemispherical reflectance* and Equation (2) for solar *specular reflectance*:

$$\rho_{S,h}\left([\lambda_a,\lambda_b],\theta_i,h,T_S\right)=\frac{\int_{\lambda_a}^{\lambda_b}\rho_{\lambda,h}\left(\lambda,\theta_i,h,T_S\right)G_b\left(\lambda\right)d\lambda}{\int_{\lambda_a}^{\lambda_b}G_b\left(\lambda\right)d\lambda} \tag{1}$$

$$\rho_{S,\varphi}\left([\lambda_a,\lambda_b],\theta_i,\psi,T_S\right)=\frac{\int_{\lambda_a}^{\lambda_b}\rho_{\lambda,\varphi}\left(\lambda,\theta_i,\psi,T_S\right)G_b\left(\lambda\right)d\lambda}{\int_{\lambda_a}^{\lambda_b}G_b\left(\lambda\right)d\lambda} \tag{2}$$

Where:

$\rho_{\lambda,h}(\lambda,\theta_i,h,T_s)$	is the spectral hemispherical reflectance;
$\rho_{\lambda,\varphi}(\lambda,\theta_i,\psi,T_s)$	is the spectral near-specular reflectance;
$G_b(\lambda)$	is the spectral solar irradiance.

The range of wavelengths within which the weighting is performed, $[\lambda_a,\lambda_b]$, shall be specified. The wavelength range should be between 320 nm and 2 500 nm.

The temperature T_s taken into consideration is the ambient temperature.

Note 2 to entry: T_s can be omitted if it is the ambient temperature.

Note 3 to entry: For applications using direct solar radiation, the AM (Air Mass) 1.5D spectrum is used to find the direct *solar reflectance*. The ASTM G173-03 (2012) AM 1.5 solar radiation spectrum shall be used to calculate the *solar reflectance*.

SEE: Table 1.

3.4.11
solar transmittance
transmittance spectrum weighted over the solar spectral radiant distribution

Note 1 to entry: The *solar transmittance* is indicated with the subscript "s" after the transmittance symbol, τ_s. This term can either refer to *direct* or *hemispherical transmittance*, which is indicated in a second subscript after the *transmittance* symbol with d or h, respectively. The *solar hemispherical transmittance* is represented as $\tau_{s,h}([\lambda_a,\lambda_b],\theta_i,h,T_s)$, $[\lambda_a,\lambda_b]$ being the wavelength range, θ_i the *incidence angle*, h the symbol to express the hemispherical property and T_s the temperature. The *solar direct transmittance* is represented as $\tau_{s,d}([\lambda_a,\lambda_b],\theta_i,d,T_s)$, $[\lambda_a,\lambda_b]$ being the wavelength range, θ_i the *incidence angle*, d means direct and T_s the temperature. It is expressed as in Equation (3) for *solar hemispherical transmittance* and Equation (4) for *solar direct transmittance*:

$$\tau_{S,h}\left(\left[\lambda_a,\lambda_b\right],\theta_i,h,T_S\right)=\frac{\int_{\lambda_a}^{\lambda_b}\tau_{\lambda,h}\left(\lambda,\theta_i,h,T_S\right)G_b\left(\lambda\right)d\lambda}{\int_{\lambda_a}^{\lambda_b}G_b\left(\lambda\right)d\lambda} \tag{3}$$

$$\tau_{S,d}\left(\left[\lambda_a,\lambda_b\right],\theta_i,d,T_S\right)=\frac{\int_{\lambda_a}^{\lambda_b}\tau_{\lambda,d}\left(\lambda,\theta_i,d,T_S\right)G_b\left(\lambda\right)d\lambda}{\int_{\lambda_a}^{\lambda_b}G_b\left(\lambda\right)d\lambda} \tag{4}$$

Where:

$\tau_{\lambda,h}(\lambda,\theta_i,h,T_s)$ is the spectral hemispherical transmittance;

$\tau_{\lambda,d}(\lambda,\theta_i,d,T_s)$ is the spectral direct transmittance;

$G_b(\lambda)$ is the spectral solar irradiance.

The range of wavelengths within which the weighting is performed, $[\lambda_a,\lambda_b]$, shall be specified. The wavelength range should be between 300 nm and 2 500 nm, optionally between 320 nm and 2 500 nm.

The temperature T_s taken into consideration is the ambient temperature.

Note 2 to entry: T_s can be omitted if it is the ambient temperature.

Note 3 to entry: For applications using *direct solar radiation*, the AM (Air Mass) 1.5D spectrum is used to find the direct *solar transmittance*. The ASTM G173-03 (2012) AM 1.5 solar radiation spectrum shall be used to calculate the *solar transmittance*.

SEE: Table 1.

3.4.12
spectral absorptance

absorptance obtained at a given direction of the incident radiation, temperature and wavelength, λ, within a small wavelength interval, $\Delta\lambda$, centered at λ

Note 1 to entry: The *spectral absorptance* is indicated with the subscript λ after the *absorptance* symbol, α_λ, and is represented as, α_λ (λ, θ_i, T_s), being λ the wavelength, θ_i the *incidence angle* and T_s the temperature. The *spectral absorptance* for opaque materials is calculated as $1 - \rho_{\lambda h}(\lambda, \theta_i, h, T_s)$, where $\rho_{\lambda h}(\lambda, \theta_i, h, T_s)$ is the *spectral hemispherical reflectance*.

Note 2 to entry: T_s can be omitted if it is the ambient temperature.

SEE: Table 1.

3.4.13
spectral emittance
emittance spectrum

emittance obtained at a given wavelength, λ, within a small wavelength interval, $\Delta\lambda$, centered at λ

Note 1 to entry: The *spectral emittance* is indicated with the subscript λ after the *emittance* symbol, ε_λ, and is represented as, ε_λ (λ, θ_i, T_s), being λ the wavelength, θ_i the *incidence angle* and T the temperature. The *spectral emittance* is calculated from the corresponding total or hemispherical spectral reflectance: $\varepsilon_\lambda(\lambda, \theta_i, T_s) = 1 - \rho_{\lambda,h}(\lambda, \theta_i, h, T_s)$ where $\rho_{\lambda,h}(\lambda, \theta_i, h, T_s)$ is the *spectral hemispherical reflectance*. As there is not a standard method for measuring the *spectral hemispherical reflectance* of a sample at different temperatures, it is assumed to be constant with temperature, so the measured value at room temperature can be used as an approximation.

SEE: Table 1.

3.4.14
spectral reflectance

reflectance measured at a given direction of the incident radiation, temperature and wavelength, λ, within a small wavelength interval, $\Delta\,\lambda$, centered at λ

Note 1 to entry: The *spectral reflectance* is indicated with the subscript "λ" after the reflectance symbol, ρ_λ. This term can either refer to *near specular* or *hemispherical reflectance*, which is indicated in a second subscript after the reflectance symbol with φ or h, respectively. The *spectral hemispherical reflectance* is represented as $\rho_{\lambda,h}(\lambda,\theta_i,h,T_s)$, being λ the wavelength, θ_i the *incidence angle*, h the symbol to express the hemispherical property and T_s the temperature. The *spectral near-specular reflectance* is represented as $\rho_{\lambda,\varphi}(\lambda,\theta_i, \psi,T_s)$, being λ the wavelength, θ_i the *incidence angle*, ψ the *angle of acceptance* and T_s the temperature

Note 2 to entry: T_s can be omitted if it is the ambient temperature.

SEE: Table 1.

3.4.15
spectral transmittance
transmittance measured at a given direction of the incident radiation, temperature and wavelength, λ, within a small wavelength interval, $\Delta\lambda$, centered at λ

Note 1 to entry: The *spectral transmittance* is indicated with the subscript "λ", after the transmittance symbol, τ_λ. This term can either refer to *direct* or *hemispherical transmittance*, which is indicated in a second subscript after the transmittance symbol with d or h, respectively. The *spectral hemispherical transmittance* is represented as $\tau_{\lambda,h}(\lambda,\theta_i,h,T_s)$, being λ the wavelength, θ_i the *incidence angle*, h the symbol to express the hemispherical property and T_s the temperature. The *direct transmittance* is represented as $\tau_{\lambda,d}(\lambda,\theta_i,d,T_s)$, being λ the wavelength, θ_i the *incidence angle*, d means direct and T_s the temperature

Note 2 to entry: T_s can be omitted if it is the ambient temperature.

SEE: Table 1.

3.4.16
specular reflectance
near-specular reflectance
ratio of the radiant flux reflected by a surface within the solid angle 2·π· ψ (ψ is the *angle of acceptance* of the reflected radiation) around the specular direction, to the radiation incident on it

Note 1 to entry: The specular direction is the one forming an angle with the normal to the surface equal to the *angle of incidence* of the incident radiation. The specular direction is on the same plane as the incident radiation and the normal to the surface and symmetric to the direction of incidence in relation to the surface normal. *Near-specular reflectance* depends on φ, which shall be given.

Note 2 to entry: The usual *angle of acceptance* is 12,5 mrad or 23 mrad.

SEE: Table 1.

3.4.17
transmittance
τ
ratio of the radiant flux passing through a body to the incident radiation on it (ISO 9488)

Note 1 to entry: The *transmittance* is a dimensionless variable ranging from 0 to 1, which depends on the wavelength, λ, the direction of the incident radiation, θ_i, the direction of the transmitted radiation, θ_t and the nature, finish and temperature, T_s, of the material surface which the incident radiation is impinging on

Note 2 to entry: Unless otherwise specified, the temperature T_s taken into consideration is the ambient temperature. In this case, the symbol T_s can be omitted.

Note 3 to entry: The terms "transmissivity" and "*transmittance*" are generally used interchangeably, as if they were synonymous. According to the National Bureau of Standards, the ending "-ivity" expresses the property of a material in general, for a homogeneous and semi-infinite sample, i.e. an intrinsic material property (resistivity, thermal conductivity, etc.). The ending "-ance" expresses the property of a particular sample of material or a particular surface. In this case, the value depends on the specific conditions of the material (dirt, oxidation, grated, etc.) or even the thickness of the sample, i.e. strength or electrical conductance. Therefore, when talking about optical properties of materials used in solar applications (*reflectance, transmittance, absorptance* and *emittance*), the ending "-ance" shall be used, because such materials can be degraded by the thermal process, soiling, mechanical damage, etc.

[SOURCE: ISO 9488:1999, 5.5, modified – Notes to entry have been added.]

3.5 SECTION 05: SOLAR IRRADIANCE

3.5.1
annual solar radiation data sets
ASR
<solar thermal power plant production and feasibility studies> complete standardized set of solar irradiance data, which can be accompanied by other meteorological variables considered of interest, and which attempts to establish a reference for radiometric evolution in a specific place during the year

Note 1 to entry: This dataset shall have a solar radiation sum close to a normal annual value (among an estimation of all possible annual values).

3.5.2
data from meteorological model
data from numerical weather prediction models
any data found from models that include numerical solutions of differential equations defining the behaviour of the atmosphere based on given initial conditions

Note 1 to entry: This document distinguishes between high- and low-quality *data from meteorological models*. High-quality *data from meteorological models* refers to *data from meteorological models* with a temporal resolution of one hour or less, and a maximum spatial resolution of 20 km. ASR data sets could be formed by high-quality *data from meteorological models*.

3.5.3
derived data
data found from a statistical function that relates a set of simultaneous data for different variables at the same place

Note 1 to entry: For example, data found from regression models, such as some models for calculating direct normal irradiance from global horizontal irradiance, are *derived data*.

3.5.4
direct measurements
value of a certain variable found with a measurement instrument on the surface at the specific site

Note 1 to entry: Direct measurement data shall be considered to be any statistic derived from values of the same variable that meet the above definition for a given period of time. For example, those found by the arithmetic mean of values recorded by the corresponding measurement instrument (sensor and data acquisition system) for a given period of time are *direct measurements*.

3.5.5
direct solar irradiance
beam solar irradiance
G_b
rate between the solar radiant flux incident on a given plane, originating from a small solid angle centered on (and including) the Sun's disk, and the area of the surface

Note 1 to entry: *Direct solar irradiance* is usually measured at normal incidence (angle of incidence = 0°) and in this case is called *Direct Normal Solar Irradiance*.

Note 2 to entry: In general, *direct normal solar irradiance* is measured by instruments with field-of-view angles of up to 6°. Therefore, a part of the scattered radiation around the Sun's disk [circumsolar radiation] is included, as the solar disk itself has a field-of-view angle of about 0,5°.

Note 3 to entry: Approximately 99 % of the *direct solar radiation* received at ground level is contained within the 0,3 µm to 3 µm wavelength range.

Note 4 to entry: Unit: the SI unit is W/m^2.

[SOURCE: ISO 9488:1999, 3.25, modified – Notes to entry have been added.]

3.5.6
indirect measurements
value of one variable found by combining *direct measurements* of other variables

Note 1 to entry: For example, measurement of *direct solar irradiance* with a pyrheliometer directed at the Sun is a direct measurement process. On the other hand, its determination from the direct measurement of global solar irradiance and diffuse solar irradiance is an *indirect measurement* involving two previous *direct measurements*.

Note 2 to entry: Finding *direct solar irradiance* from a numerical model, for example, a regression equation cannot be considered either direct or *indirect measurement*.

3.5.7
infrared radiation
electromagnetic radiation covering the range from 780 nm to 1 mm (approximately)

[SOURCE: ISO 9488:1999, 3.9]

3.5.8
satellite data
satellite image data
data found from information collected by a measurement instrument on board a satellite

Note 1 to entry: This document distinguishes between high- and low-quality *satellite data*. High-quality *satellite data* refers to *satellite data* with a temporal resolution of one hour or less, and a maximum spatial resolution of 20 km. ASR data sets could be formed by high-quality *satellite data*.

3.5.9
synthetic
synthetic generation of a series
data that is the interpolated data of the same variable recorded in another space and/or time frequency

Note 1 to entry: For example, all data found from spatial or temporal interpolation are *synthetic* data.

3.6 SECTION 06: ENERGIES DEFINITION (SOLAR FIELD PART)

3.6.1
available radiant solar power
product of the *solar thermal collector net collection area* and the direct normal solar irradiance

Note 1 to entry: Unit: the SI units are kW, MW.

3.6.2
available solar irradiation
integral of the *available radiant solar power* over the time interval considered

Note 1 to entry: Unit: the non-SI unit is kWh (1 kWh = 3 600 kJ).

3.6.3
net thermal energy of the receiver
Q_{net}
<*point-focus solar systems*> thermal energy from the *direct solar radiation* that is transferred to the *heat transfer fluid* circulating through the *receiver* for a given period of time

Note 1 to entry: It is calculated as the time integral of the difference between the product of the *heat transfer fluid* mass flow and specific enthalpy at the outlet and inlet of the receiver

$$Q_{net} = \int_t m(t)\left[h_{out}(t) - h_{in}(t)\right]dt$$

Note 2 to entry: Unit: the non-SI unit is kWh.

3.6.4
net thermal energy of the solar field
$Q_{\text{net,SF}}$
<*line-focus solar systems*> *net thermal energy* delivered by the *beam solar radiation* and transferred to the *heat transfer fluid* of the *STE plant* as it circulates through the *solar field circuit* over a given period of time

Note 1 to entry: It is calculated as the time integral of the difference between the product of the *heat transfer fluid* mass flow and the specific enthalpy of the *heat transfer fluid* at the outlet and inlet of the *solar field circuit.*

$$Q_{net,SF} = \int_t m_{SF}(t)\left[h_{out,SF}(t) - h_{in,SF}(t)\right]dt$$

Note 2 to entry: Unit: the non-SI unit is kWh.

3.6.5
net thermal power of the solar field
net thermal power delivered by the beam solar radiation and transferred to the *heat transfer fluid* of the *STE plant* as it circulates through the *solar field circuit* (or the *receiver* of the *point-focus solar system*)

3.6.6
radiant solar energy
energy emitted by the Sun in the form of photons or electromagnetic waves

[SOURCE: ISO 9488:1999, 3.14]

3.6.7
solar radiant power absorbed by a line-focus solar field
sum of the *solar radiant power absorbed by the receivers* included in the *solar field* circuit

Note 1 to entry: Unit: the SI units are kW, MW.

3.6.8
solar radiant power absorbed by the receiver
sum of the net thermal power transferred to the *heat transfer fluid* from the *receiver* inlet to the *receiver* outlet, and the thermal power lost in the *receiver*

Note 1 to entry: Unit: the SI units are kW, MW.

3.6.9
useful radiant solar power
product of the *solar thermal collector net collection area*, the direct normal solar irradiance and the cosine of the incidence angle

Note 1 to entry: Unit: the SI units are kW, MW.

3.6.10
useful solar irradiation
integral of the *useful radiant solar power* over the time interval considered

Note 1 to entry: Unit: the non-SI unit is kWh (1 kWh = 3 600 kJ).

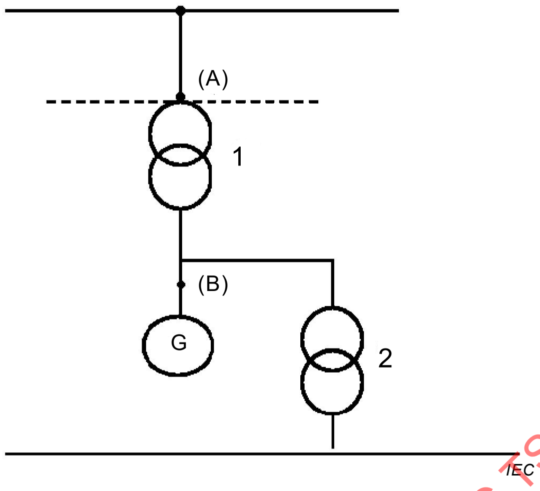
3.7 SECTION 07: ENERGIES DEFINITION (POWER BLOCK PART)

3.7.1
gross plant electricity production over a given period of time
electricity produced by the plant's generating equipment during a given production period, as measured at the equipment outlet (point B in Figure 7)

Note 1 to entry: Only active electricity will be taken into account.

Note 2 to entry: Unit: the non-SI units are kWh, MWh.

3.7.2
gross plant power
electrical power measured at the generator terminals (point B in Figure 7)



Key

1 Main power transformer

2 Auxiliary transformer

Figure 7 – Typical interconnection of the power generation (G), the auxiliary power transformer and the main power transformer in a solar thermal electricity plant

Note 1 to entry: Unit: the SI units are kW, MW.

3.7.3
net plant electricity production over a given period of time
E_{net}
electricity delivered to the grid by the *STE plant* during a given production period as measured at a point located as close as possible to the side of the main plant power transformer connected to the external grid (point A in Figure 7)

Note 1 to entry: Only the active electrical energy will be taken into account.

Note 2 to entry: Loss in the transmission line from the *STE plant* to the nearest sub-station of the grid does not belong to this term.

Note 3 to entry: Unit: the non-SI units are kWh, MWh.

3.7.4
net plant power
P_{net}
electrical power delivered to the grid and measured at a point located as close as possible to the side of the main plant power transformer connected to the external grid (point A in Figure 7)

Note 1 to entry: Unit: the SI units are kW, MW.

3.7.5
nominal plant power
power block rated power
electrical power specified on the generator nameplate

Note 1 to entry: It takes the smaller value between the sum of the powers indicated in the turbine's low- and high-pressure stages nameplates and the power indicated on the electrical generator nameplate.

Note 2 to entry: Unit: the SI units are kW, MW.

3.7.6
plant electricity consumption over a given period of time
electricity consumed by the *solar thermal electricity plant* over a period of time

Note 1 to entry: It comprises:

- consumption of electricity from its own production by the *solar thermal electricity plant* at generating conditions (electricity self-consumption);
- consumption of electricity imported from the grid by the solar *thermal electricity plant*.

Note 2 to entry: Unit: the non-SI unit is kWh (1 kWh = 3 600 kJ).

3.8 SECTION 08: EFFICIENCY NUMBERS

3.8.1
collector optical efficiency
η_{opt}
ratio of the *solar radiant power absorbed by the receiver* to the *useful radiant solar power* at the *solar thermal collector*

3.8.2
equivalent net plant efficiency
η_{net}
net plant efficiency for one year

3.8.3
global collector efficiency of parabolic-trough collectors
global collector efficiency of Fresnel linear collectors
η
ratio of the thermal power transferred to the *heat transfer fluid* between the *solar thermal collector* inlet and outlet to the *available radiant solar power*, both integrated over a given period of time

Note 1 to entry: The *useful radiant solar power* may be used instead of the *available radiant solar power* provided that it is expressly stated when providing the value.

3.8.4
gross plant efficiency
η_{gross}
ratio of *gross plant electricity production* to the total *available solar irradiation* and *non-solar fuel consumption* over a given period of time

Note 1 to entry: This term is equivalent to the *gross plant solar efficiency* in solar-only plants.

3.8.5
gross plant solar efficiency
$\eta_{gross,solar}$
ratio of the *gross plant electricity production* from solar energy to the *available solar irradiation* over a given period of time

Note 1 to entry: This term is equivalent to the *gross plant efficiency* in solar-only plants.

3.8.6
gross power block efficiency
$\eta_{PB,gross}$
ratio of the *gross plant electricity production* to the thermal energy delivered to the *power block* in the same period of time

3.8.7
net plant efficiency

η_{net}
ratio of *net plant electricity production* to the total *available solar irradiation* and the *non-solar fuel consumption* over a given period of time

Note 1 to entry: This term is equivalent to the *net plant solar efficiency* in solar-only plants.

3.8.8
net plant solar efficiency

$\eta_{net,solar}$
ratio of *net plant electricity production* from solar energy to the *available solar irradiation* over a given period of time

Note 1 to entry: This term is equivalent to the *net plant efficiency* in solar-only plants.

3.8.9
net power block efficiency

$\eta_{PB,net}$
ratio of *net plant electricity production* to the thermal energy input to the *power block* in the same period of time

3.8.10
plant availability factor

$f_{avail,plant}$
ratio of the number of hours in a given period of time during which the *STE plant* is able to produce electricity (i.e. all the systems required for electricity generation are ready to work) to the total number of theoretical hours, defined as the number of days in the period of time considered multiplied by 24

3.8.11
power block availability factor
ratio of the hours the *power block* is able to produce power, in a given period of time, to the total number of theoretical hours available to the power block, defined as the number of days in the given period multiplied by 24

3.8.12
solar field availability factor
ratio of the hours, in a given period of time, during which the *solar field* is able to operate (weighted by the percentage of the *solar field* that is able to produce net thermal power) during hours of sunlight, to the total hours of sunlight

Note 1 to entry: Sunlight hours are accounted as the time period between sunrise and sunset.

3.8.13
solar field efficiency for parabolic-trough collectors and Fresnel linear concentrators

η_{SF}
ratio of the *solar radiant power* absorbed by the *solar field* to the *available radiant solar power*, both integrated over a given period of time

Note 1 to entry: The *useful radiant solar power* may be used instead of the *available radiant solar power* provided that it is expressly stated when providing the value.

3.8.14
theoretical peak collector optical efficiency

$\eta_{opt,0}$
collector optical efficiency when direct solar radiation is perpendicular to the *collector aperture plane*, with a perfectly clean *solar thermal collector* and no shadows on the *collector aperture plane* other than those due to the components of the *solar thermal collector* itself

Note 1 to entry: For *solar thermal collectors* whose *receivers* do not comprise a secondary reflector, and if there are no tracking errors and no structural torsions, the *theoretical peak collector efficiency* can be calculated as the product of reflector *solar reflectance* (or refractor *solar transmittance*), cover *solar transmittance* if any, *absorber solar absorptance*, *intercept factor* and the *effective length factor*, all at an *angle of incidence* of the *solar thermal collector* equal to zero.

Note 2 to entry: Definition valid for *line-focus solar thermal collectors*. For *parabolic-dish solar thermal collectors*, *the effective length factor* has to be replaced by the *net area factor of the receiver*.

Note 3 to entry: This variable is not used for solar tower systems.

3.9 SECTION 09: THERMAL STORAGE SYSTEM

3.9.1
charge
process during which energy is transferred or supplied to the *thermal storage system*

Note 1 to entry: This definition can be qualified depending on the acquired *storage level*:

– full *charge*: charging ends when the *storage level* is 100 %;

– partial *charge*: charging ends when the *storage level* is below 100 %.

3.9.2
discharge
process during which energy is transferred or extracted from the *thermal storage system*

Note 1 à l'article: This definition can be qualified depending on acquired *storage level*:

– full *discharge:* discharging ends when the *storage level* is 0 %;

– partial *discharge:* discharging ends when the *storage level* is above 0 %.

3.9.3
latent heat thermal storage
storage in which the *thermal storage medium* changes phase when thermal energy is charged or discharged

3.9.4
minimum charge power
minimum thermal power required to transfer energy to the *thermal storage system*

3.9.5
multi-media storage system
thermal storage system in which the energy is stored in different substances or media

3.9.6
nominal conditions
rated conditions
characteristic conditions established when a *thermal storage system* is designed

Note 1 to entry: These conditions can be associated with:

- *Heat transfer fluid* (HTF), referring, in this case, to the flow or flow rate (mass or volumetric) and its inlet and outlet enthalphy during *charge* and *discharge*. The *nominal conditions* of the *heat transfer fluid* are the process conditions and can be the same or different during charging and discharging.
- The storage tanks, referring, in this case, to the state of such tanks, which shall be determined by the temperature of the hot tank and the cold tank in a two-tank system or by the maximum and minimum temperatures in a thermocline tank, and by the useful or usable volume for generating electricity from the storage medium in the corresponding tank.

3.9.7
rated charge power
thermal power supplied to the *thermal storage system* under rated charging conditions (flow rates and temperatures)

Note 1 to entry: Unit: the SI unit is MW.