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INTERNATIONAL STANDARD

Solar thermal electric plants –
Part 4-1: General requirements for the design of solar power tower plants

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INTERNATIONAL
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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FOREWORD

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IEC 62862-4-1 has been prepared by IEC technical committee 117: Solar thermal electric plants. It is an International Standard.

The text of this International Standard is based on the following documents:

Draft	Report on voting
117/166/FDIS	117/169/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 62862 series, published under the general title *Solar thermal electric plants*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

SOLAR THERMAL ELECTRIC PLANTS –

Part 4-1: General requirements for the design of solar power tower plants

1 Scope

This part of IEC 62862 specifies the general requirements for the design of solar power tower plants and covers the electric power system requirements, the solar resource assessment, the site selection, the overall planning, the layout of the heliostat field and the receiver tower, the layout of the power block, the collector system, the heat transfer, the thermal energy storage and steam generation system, the steam turbine system, the water treatment system, the information system, instrumentation and control, the electrical equipment and system, occupational safety and occupational health.

This document is applicable to the design requirements of newly built, expanded or rebuilt solar power tower plants employing steam turbines with molten salt or water-steam as heat transfer fluid. If other heat transfer fluids are employed, it is possible that the provisions set out in this document will need to be adapted.

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.

IEC 60034-1, *Rotating electrical machines – Part 1: Rating and performance*

IEC 60034-3, *Rotating electrical machines – Part 3: Specific requirements for synchronous generators driven by steam turbines or combustion gas turbines and for synchronous compensators*

IEC 60034-16 (all parts), *Rotating electrical machines – Part 16: Excitation systems for synchronous machines*

IEC 60038, *IEC standard voltages*

IEC 60045-1, *Steam turbines – Part 1: Specifications*

IEC 60076-1, *Power transformers – Part 1: General*

IEC 60076-2, *Power transformers – Part 2: Temperature rise for liquid-immersed transformers*

IEC 60076-3, *Power transformers – Part 3: Insulation levels, dielectric tests and external clearances in air*

IEC 60076-4, *Power transformers – Part 4: Guide to the lightning impulse and switching impulse testing – Power transformers and reactors*

IEC 60076-5, *Power transformers – Part 5: Ability to withstand short circuit*

IEC 60076-7, *Power transformers – Part 7: Loading guide for mineral-oil-immersed power transformers*

IEC 60086-1, *Primary batteries – Part 1: General*

IEC 60183, *Guidance for the selection of high-voltage A.C. cable systems*

IEC 60255 (all parts), *Measuring relays and protection equipment*

IEC 60479 (all parts), *Effects of current on human beings and livestock*

IEC TS 60815 (all parts), *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 1: Definitions, information and general principles*

IEC 60839-11-2, *Alarm and electronic security systems – Part 11-2: Electronic access control systems – Application guidelines*

IEC 60870-5 (all parts), *Telecontrol equipment and systems – Part 5: Transmission protocols*

IEC 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety-related systems*

IEC 61511 (all parts), *Functional safety – Safety instrumented systems for the process industry sector*

IEC 61850 (all parts), *Communication networks and systems for power utility automation*

IEC 62040-1, *Uninterruptible power systems (UPS) – Part 1: Safety requirements*

IEC 62052-11, *Electricity metering equipment – General requirements, tests and test conditions – Part 11: Metering equipment*

IEC 62053 (all parts), *Electricity metering equipment – Particular requirements*

IEC 62053-21, *Electricity metering equipment – Particular requirements – Part 21: Static meters for AC active energy (classes 0,5, 1 and 2)*

IEC 62053-41, *Electricity metering equipment – Particular requirements – Part 41: Static meters for DC energy (classes 0,5 and 1)*

IEC 62271 (all parts), *High-voltage switchgear and controlgear*

IEC 62305-1, *Protection against lightning – Part 1: General principles*

IEC 62642-1, *Alarm systems – Intrusion and hold-up systems – Part 1: System requirements*

IEC 62676-1-1, *Video surveillance systems for use in security applications – Part 1-1: System requirements – General*

IEC TS 62749, *Assessment of power quality – Characteristics of electricity supplied by public networks*

IEC TS 62862-1-1, *Solar thermal electric plants – Part 1-1: Terminology*

IEC TS 62862-2-1, *Solar thermal electric plants – Part 2-1: Thermal energy storage systems – Characterization of active, sensible systems for direct and indirect configurations*

IEC 81346 (all parts), *Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations*

ISO/IEC 11801-3, *Information technology – Generic cabling for customer premises – Part 3: Industrial premises*

ISO 8995-1, *Lighting of workplaces – Part 1: Indoor*

ISO/CIE 8995-3, *Lighting of workplaces – Part 3: Lighting requirements for safety and security of outdoor workplaces*

ISO 11064-3, *Ergonomic design of control centres – Part 3: Control room layout*

ISO 11064-6, *Ergonomic design of control centres – Part 6: Environmental requirements for control centres*

ISO 12100, *Safety of machinery – General principles for design – Risk assessment and risk reduction*

ISO/TR 14121-2, *Safety of machinery – Risk assessment – Part 2: Practical guidance and examples of methods*

ISO 45001, *Occupational health and safety management systems – Requirements with guidance for use*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC TS 62862-1-1 and the following 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
receiver tower
tall structure which supports the receiver and auxiliary systems

3.2
solar power tower plant
solar thermal power plant consisting of a point-focus solar system that is composed of heliostats, a receiver system, and a receiver tower

3.3
heliostat field
area on which the heliostats are installed to concentrate the solar radiation onto the receiver

3.4
molten salt
inorganic salt in the liquid phase, usually composed of mixtures of alkali nitrates, carbonates or chlorides

3.5
annual efficiency of collector system
ratio of the thermal energy transferred to the heat transfer fluid from collector system to the total direct normal irradiation multiplied by the heliostat field aperture area over a year

3.6
shading loss
energy loss due to the reduction in the effective aperture of the heliostat caused by shadows cast by other heliostats or the tower

3.7
blocking loss
energy loss due to reflected rays being blocked by adjacent heliostats

3.8
capacity factor
ratio of the number of equivalent operating hours to the total number of hours in a year (8 760)
ratio of equivalent full-load operating hours to the total hours in a year

3.9
heliostat field efficiency
ratio of the solar radiant power incident in the receiver aperture from the heliostat field to the available radiant solar power over a given period (hourly, daily, weekly, etc.)

3.10
receiver efficiency
ratio of the thermal power transferred to the heat transfer fluid to the solar radiant power incident in the receiver aperture from the heliostat field over a given period

3.11
cosine loss
energy loss due to the incident direction of sunlight being not parallel to the normal direction of the mirror surface

3.12
atmospheric attenuation
energy loss due to the reflected rays from the heliostats being absorbed and scattered by the air before reaching the receiver

3.13
receiver spillage
energy that is reflected from the heliostats but fails to reach the receiver, after deduction of the blocking loss and the atmospheric attenuation

4 Basic requirements

4.1 For the design of a solar power tower plant, the site resource conditions should be evaluated considering long-term meteorological conditions at the proposed location of the plant. As a minimum, the evaluation of average yearly direct normal irradiance (DNI) values (P50 and P90), typical meteorological year series (P50), ambient temperature, ambient pressure, wind speed, wind gust and relative humidity should be performed.

4.2 The power block capacity, the storage capacity and the operation modes of solar power tower plants are determined by a techno-economic evaluation on the basis that the electric power system requirements are satisfied.

4.3 For the system capacity matching of solar power tower plants, the following provisions apply.

a) The overall optimization should be performed between the heliostat field, the receiver capacity, the steam generator capacity, the steam turbine capacity and the storage capacity.
b) The maximum continuous flow rate of the steam generation system shall match the maximum turbine inlet steam flow rate.
c) The maximum continuous capacity of the generator shall match the maximum continuous output of the steam turbine.

4.4 The annual electricity output may be estimated as specified in Annex A.

4.5 The design lifetime for solar power tower plants shall meet customer requirements.

4.6 A uniform identification system should be employed for the plant design and the uniform identification system employed shall meet the requirements of the IEC 81346 series.

4.7 All computer-based systems shall meet the local information technology requirements for security protection.

5 Electric power system requirements

5.1 General requirements

The main transformers, circuit breakers and other electric equipment connected to the power grid shall meet the frequent start-up/shutdown requirement for the plant.

5.2 Requirements for grid-connection

5.2.1 The grid-connection scheme for solar power tower plants shall meet the local grid-connection requirements.

5.2.2 The voltage class for grid-connection should be selected according to the power plant capacity, and there should be one or two voltage classes.

5.2.3 Off-load tap-changing transformers should be selected. On-load tap-changing transformers may be selected as main transformers if the voltage adjustment calculation is proved to be necessary.

5.2.4 The rated power factor of the generating units of the power plant should meet the local grid operation demands.

5.2.5 The power quality level at the point of common coupling shall meet the requirements of IEC TS 62749.

5.3 Relay protection and automatic safety device

5.3.1 The relay protection and the automatic safety device shall meet the requirements of IEC 60870-5 (all parts).

5.3.2 The configuration of the line protection shall meet the local grid requirements.

5.4 Dispatching automation

5.4.1 Telecontrol information shall meet the requirements of the IEC 60870-5 series.

5.4.2 The solar power prediction system should be installed at the power plants. The solar power prediction system should also have the function of upload the data on predicted power, the direct normal irradiance, the capacity of the thermal energy storage system and other real-time information to the dispatch.

5.5 Electric power system communication

Electric power system communication shall meet the requirements of the IEC 61850 series.

5.6 Electric energy metering

The electric energy metering device shall meet the requirements of the IEC 62053 series.

6 Solar resource assessment

The solar resource at the site should be assessed according to IEC TS 62862-1-2 and IEC TS 62862-1-3.

7 Site selection

7.1 When selecting a site for a plant, the following factors should be considered: the power grid structure and the electric power system planning, the auxiliary energy supply, the water source, the traffic and large equipment transportation, the environmental impact assessment, the outgoing line corridor, the landform, geology, the seismicity, the hydrology, the meteorology, the construction, the effect of surrounding companies on the solar power tower plant, etc.

7.2 When the site of a solar power tower plant is selected, the following provisions for the water supply apply.

a) The water source should be stable and reliable. The water supply should meet requirements of the long-term water consumption of the power station.

b) If river water is used as water source, the water intake point should be located in the riverbed section which is stable all year around, so that the impact of mud, sand, vegetation, ice, drifting sundries and drained water backflow can be avoided.

c) If underground water is used as water source, a hydro-geological investigation report shall be completed, and it can be subject to local requirements.

7.3 The following provisions for the site's natural conditions apply.

a) The proposed site should be selected in areas with abundant and stable direct normal irradiance.

b) The site should not be set in a dangerous rock, landslide, karst development, mudslide section, seismogenic fault or goaf zone. If a geological disaster-prone area cannot be avoided, in the site selection stage, a geological disaster risk assessment should be conducted and comprehensively assessed.

c) In the site selection, suspended particulate matter, airport runways and routes, high wind speed areas, and surroundings with tall and wide trees, mountains, buildings and other factors should be taken into consideration.

d) Bird habitats and migration routes should be avoided.

e) The proposed site should be located in a flat region.

f) The buildings (structures) inside and outside the power plant should not cast shadow on the collector during the majority of daytime hours.

g) The proposed site should be away from important, protected cultural relics. The site should not be located in an open mineral resources area or underground shallow layer mining area with exploitation value.

7.4 During the site selection process, essential data on the geological conditions in the site area should be obtained, to determine the foundation design scheme of buildings (structures) in the site.

7.5 The seismic fortification intensity of the site should be determined based on the local seismic fortification intensity or design ground motion parameters.

8 Overall planning

8.1 General requirements

8.1.1 According to the environmental conditions of sites and the environmental conditions in the vicinity of sites, an overall planning for the land use, sites and construction area, water source, water supply and drainage pipelines, auxiliary fuel pipelines, transportation, and outgoing line corridor, etc. shall be considered in the overall planning.

8.1.2 The overall planning shall minimize the land use to the extent possible. Buildings in the plant should be grouped into a complex. Construction land shall make full use of interspaces between plants and the reserved land.

8.2 Off-site planning

8.2.1 The off-site planning shall be based on site location and the main plant processes, considering the transportation, water supply and drainage, auxiliary energy supply and the outgoing line corridor according to the plant design capacity and the environmental conditions.

8.2.2 For the transportation planning, the following provisions apply.

a) The transportation planning of the power plant shall be consistent with the environmental conditions and with the layout design. Local legal requirements can also apply.
b) The access roads shall connect to the existing roads. Access roads should be short and easy for driving. The access road shall be negotiable for the maximal size and weight of the equipment supplied.
c) The existing roads should be used for maintenance and inspections of the off-site water supply and the drainage facility.

8.2.3 The overall planning of the water supply and drainage shall be done according to the design capacity of the power plant, construction capacity of the current stage, water source, landform, geology, and environmental protection, etc. The following provisions apply.

a) The feedwater pump rooms, and the feedwater pipelines of the off-site feedwater system shall be located in reasonably close proximity to the water source. Space should be reserved for future expansion.
b) The supply and the drainage pipelines should be arranged alongside the existing roads or planned roads.

8.2.4 The outgoing line corridor of the power plant shall be planned according to the design capacity of the power plant and the construction capacity of the current stage. The urban and rural general planning, transmission line directions, voltage classes and loop numbers shall also be considered.

8.2.5 The auxiliary fuel supply, if required, shall be reliable and stable. And the transportation method of any such auxiliary fuel supply should be determined after a techno-economic evaluation of nearby transportation and coordination conditions. The auxiliary fuel pipelines should be reasonably planned according to the local fuel supply, transportation, and environmental protection requirements.