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**Technical requirements for molten salt thermal storage system
of solar thermal electric plant**

太阳能光热发电站熔融盐储热系统技术要求

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1 Scope

This document specifies the system composition, the technical requirements and the corresponding test items for the molten salt thermal storage system of a solar thermal electric plant.

This document applies to two-tank thermal storage systems of solar thermal electric plants that use molten salt as the storage medium for sensible heat storage and whose largest tank volume is not less than 500 cubic metres, including direct storage systems in which molten salt is the heat transfer medium and indirect storage systems in which thermal oil is the heat transfer medium.

Note: a two-tank thermal storage system is a thermal storage system in which there are two kinds of tank, a high-temperature molten salt tank and a low-temperature molten salt tank; the number of tanks is two or more.

2 Normative references

The contents of the following documents constitute indispensable provisions of this document through the normative references made to them in the text. For dated references,

only the edition corresponding to that date applies to this document; for undated references, the latest edition (including all amendments) applies to this document.

GB/T 6075.7-2015 Mechanical vibration - Evaluation of machine vibration by measurements on non-rotating parts - Part 7: Rotodynamic pumps for industrial applications, including measurements on rotating shafts.

GB/T 16839.1-2018 Thermocouples - Part 1: EMF specifications and tolerances.

GB/T 29529-2013 Methods of measurement and evaluation of the noise of pumps.

GB/T 30121-2013 Industrial platinum resistance thermometers and platinum temperature sensors.

GB/T 40104 Solar thermal electric plants - Terminology.

GB/T 41087 Technical requirements for the heat exchange system of a solar thermal power plant.

GB/T 44800 Technical requirements for the working medium used for heat storage and heat transfer in solar thermal electric plants - Molten salt.

3 Terms and definitions

The terms and definitions given in GB/T 40104 and the following apply to this document.

3.1 effective heat storage capacity: The heat released by the thermal storage system from the fully charged state until the fully discharged state. Note 1: the fully charged state is the state in which the charged heat and the temperature of the thermal storage system have reached their design values and charging no longer continues. Note 2: the fully discharged state is the state in which the discharged heat and the temperature of the thermal storage system have reached their design values and no further discharge is possible.

3.2 thermal storage efficiency: The ratio, over one complete charge and discharge cycle in which charging and discharging follow one another, of the energy released by the thermal storage system through the heat transfer fluid to the energy it received through the heat transfer fluid.

3.3 rated charge power: The heat received by the thermal storage system through the heat transfer medium per unit of time at the rated temperature and rated flow rate.

3.4 rated discharge power: The heat released by the thermal storage system through the heat transfer medium per unit of time at the rated temperature and rated flow rate.

3.5 unavailable salt quantity ratio: The ratio of the total quantity of molten salt lying below the start-up level of the molten salt pumps in all the tanks to the total quantity of molten salt in the plant.

4 System composition

The molten salt direct thermal storage system of a solar thermal electric plant mainly comprises the storage tanks, the molten salt pumps, the molten salt piping and valves, the heat storage medium, the instrumentation and control, and the auxiliary systems.

The molten salt indirect thermal storage system of a solar thermal electric plant mainly comprises the storage tanks, the molten salt pumps, the oil-to-salt heat exchanger, the molten salt piping and valves, the heat storage medium, the instrumentation and control, and the auxiliary systems.

5.1 Normal service conditions

5.1.1 Ambient temperature: from minus 50 degrees Celsius to 60 degrees Celsius.

5.1.2 Altitude: below 5 000 m.

5.2 System functions and performance

5.2.1 The maximum charging power of the thermal storage system should be not less than 110 % of the rated charging power, and the maximum discharging power should be not less than 110 % of the rated discharging power.

5.2.2 The operating time of the effective heat storage capacity of the thermal storage system at rated discharging power shall meet the storage duration the plant requires of the thermal storage system.

5.2.3 The equipment of the thermal storage system shall be able to withstand fluctuations of temperature, pressure and load during charging and discharging, and its load-change capability shall be not less than 10 % of the rated charging or discharging power per minute.

5.2.4 The requirements for the unavailable salt quantity ratio are given in Table 1. Where the maximum tank volume is 500 cubic metres or more but less than 2 000 cubic metres the ratio shall be not more than 20 %; where it is 2 000 cubic metres or more but less than 5 000 cubic metres, not more than 18 %; where it is 5 000 cubic metres or more but less than 10 000 cubic metres, not more than 16 %; and where it is 10 000 cubic metres or more, not more than 13 %.

5.2.5 At the annual mean temperature and mean wind speed of the site, the requirements for the thermal storage efficiency of the system are given in Table 2, which fixes the efficiency required for three bands of maximum tank volume: 500 cubic metres or more but less than 2 000 cubic metres, 2 000 cubic metres or more but less than 5 000 cubic metres, and 5 000 cubic metres or more.

5.2.6 The number of complete charge and discharge cycles over the whole life of the

thermal storage system shall be not less than 12 000.

5.2.7 The design service life of the thermal storage system shall be not less than 25 years.

5.2.8 The materials of the equipment of the thermal storage system that is in contact with the molten salt shall resist molten salt corrosion, and the corrosion allowance shall meet the following requirements: a) not less than 1 mm where stainless steel is used; b) not less than 3 mm where carbon steel or alloy steel is used.

5.3 Molten salt storage tank

5.3.1 The molten salt storage tank shall be a vertical cylindrical welded steel tank. The stiffness and strength of the tank shell shall be able to carry the dead weight of the tank itself, the snow load, the dead load of the insulation and of maintenance work, the load of the fluctuating liquid level, the stresses produced by changes in the temperature of the medium, and other temporary loads. The insulation of the roof, the shell and the bottom of the tank shall meet the requirements for the temperature drop of the tank and for the thermal efficiency of the storage system.

5.3.2 At the annual mean temperature and mean wind speed of the site, the requirements for the maximum temperature drop of the tank are given in Table 3. Where the maximum tank volume is 500 cubic metres or more but less than 2 000 cubic metres, the maximum drop over 24 h shall be not more than 8 degrees Celsius for the hot salt tank and not more than 5 degrees Celsius for the cold salt tank; where it is 2 000 cubic metres or more but less than 5 000 cubic metres, not more than 5 degrees Celsius and not more than 3 degrees Celsius respectively; where it is 5 000 cubic metres or more but less than 10 000 cubic metres, not more than 3 degrees Celsius and not more than 2 degrees Celsius respectively; and where it is 10 000 cubic metres or more, not more than 2 degrees Celsius and not more than 1.5 degrees Celsius respectively.

5.3.3 A salt inlet distributor shall be fitted inside the molten salt storage tank, and the salt temperature inside the tank shall be evenly distributed in all directions. While salt is being admitted, the difference between the highest and the lowest salt temperature within the same tank should not exceed 56 degrees Celsius.

5.3.4 The molten salt storage tank should be provided with a salt drain outlet.

5.3.5 The molten salt storage tank shall be provided with facilities that prevent leaked molten salt from spreading; a sunken tank arrangement or a bund around the tank should be used.

5.3.6 Measures to distribute the load evenly shall be taken at the top of the insulating foundation of the molten salt storage tank.

5.3.7 Between the foundation and the shell of the molten salt storage tank there shall be thermal insulation measures such as an insulating layer and ventilation and heat dissipation