

# TECHNICAL SPECIFICATION



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



## THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2021 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

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

Tel.: +41 22 919 02 11  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://www.iec.ch)

### About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

### About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

#### IEC publications search - [webstore.iec.ch/advsearchform](http://webstore.iec.ch/advsearchform)

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, ...). It also gives information on projects, replaced and withdrawn publications.

#### IEC Just Published - [webstore.iec.ch/justpublished](http://webstore.iec.ch/justpublished)

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

#### IEC Customer Service Centre - [webstore.iec.ch/csc](http://webstore.iec.ch/csc)

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: [sales@iec.ch](mailto:sales@iec.ch).

#### IEC online collection - [oc.iec.ch](http://oc.iec.ch)

Discover our powerful search engine and read freely all the publications previews. With a subscription you will always have access to up to date content tailored to your needs.

#### Electropedia - [www.electropedia.org](http://www.electropedia.org)

The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 18 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

Preview generated by EVS

# TECHNICAL SPECIFICATION



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

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

ICS 27.160

ISBN 978-2-8322-9320-1

**Warning! Make sure that you obtained this publication from an authorized distributor.**

## CONTENTS

FOREWORD.....	5
INTRODUCTION.....	7
1 Scope.....	8
2 Normative references .....	8
3 Terms and definitions .....	8
4 Symbols and abbreviated terms.....	9
5 Thermal energy storage (TES) systems .....	10
5.1 Classification of TES systems .....	10
5.2 TES systems covered by this document.....	10
5.3 TES system limits .....	10
5.4 Key components .....	10
6 Instrumentation and measurement methods.....	11
6.1 General.....	11
6.2 Flow rate measurements.....	11
6.3 Temperature measurements .....	11
6.3.1 Heat transfer fluid temperatures .....	11
6.3.2 Wall temperatures .....	12
6.4 Level measurements .....	12
6.5 Meteorological signal measurements .....	12
6.5.1 Wind speed and direction .....	12
6.5.2 Ambient temperature .....	12
6.6 Data acquisition .....	13
7 General requirements on tests.....	13
7.1 General.....	13
7.2 Test procedure.....	13
7.2.1 General .....	13
7.2.2 Items to be included in the test procedure .....	14
7.2.3 Items to be agreed between the parties .....	14
7.3 Definition of the test included in this document .....	15
7.3.1 General .....	15
7.3.2 Test to determine the thermal efficiency of the storage system .....	15
7.3.3 Test to determine the heat capacity of the storage system.....	15
7.3.4 Test to determine the thermal losses of the storage system.....	16
7.3.5 Test to determine the global losses of the storage system .....	16
7.3.6 Test to determine the wall temperature .....	16
7.4 Test boundaries .....	17
8 Storage system characterization (storage thermal performance and capacity) .....	18
8.1 Thermal efficiency and storage capacity (storage thermal performance and capacity) .....	18
8.1.1 Test methodology .....	18
8.1.2 Calculation procedure.....	19
8.2 Thermal losses of the storage system .....	23
8.2.1 Test methodology .....	23
8.2.2 Calculation procedure.....	23
8.3 Global energy losses of the storage system .....	24
8.3.1 General .....	24

8.3.2	Test methodology .....	24
8.3.3	Calculation procedure .....	25
9	Verification procedure .....	25
10	Test report (results) .....	27
Annex A	(informative) Thermal energy storage system types .....	28
A.1	Thermal energy storage modes .....	28
A.1.1	General .....	28
A.1.2	Sensible heat storage .....	28
A.1.3	Latent heat storage .....	28
A.1.4	Thermochemical energy storage .....	29
A.2	TES configuration .....	29
A.3	Circulation of the storage medium .....	29
Annex B	(informative) Description of the main components of the active direct/indirect TES using molten salts .....	31
B.1	Storage media .....	31
B.2	Tanks and foundation .....	31
B.2.1	Tanks .....	31
B.2.2	Foundations .....	32
B.2.3	Insulation .....	32
B.3	Materials .....	32
B.4	Piping .....	33
B.5	Pumps .....	33
B.6	Heat exchanger .....	33
B.7	Safety and control system .....	34
B.7.1	General .....	34
B.7.2	HTF and MSF leak detection system .....	34
B.7.3	Instrumentation .....	34
B.7.4	Freeze protection system .....	34
B.7.5	Molten salt valves .....	36
B.7.6	Blanketing system .....	36
B.7.7	Welding control system .....	36
B.8	Melting system .....	36
Annex C	(normative) Data adquisition and treatment .....	38
C.1	Flow signal measurement .....	38
C.2	Temperature signals measurement .....	41
Annex D	(informative) Documentation to be provided by the TES manufacturer/supplier .....	44
Annex E	(normative) Test report .....	46
Bibliography	.....	48
Figure 1	– Agreed duration between two charges .....	16
Figure 2	– General typical diagram of the system and test boundaries for indirect TES systems .....	17
Figure 3	– General typical diagram of the system and test boundaries for direct TES systems .....	18
Figure 4	– Examples of criteria for comparison of the measurement (M) and the reference value (RV) .....	27

Table 1 – List of symbols and units .....	9
Table 2 – List of subscripts, superscripts and abbreviated terms.....	9
Table 3 – Levels of confidence and associated coverage factors (Gaussian distribution).....	26
Table C.1 – Critical range factor, $f(n_q)$ , depending on the number of sensors, $n_q$ , available .....	39
Table C.2 – Outline of the steps to be followed to calculate the representative flow rate (volumetric) for each time interval recorded .....	40
Table C.3 – Outline of steps to be followed to calculate the representative inlet heat transfer fluid temperature for each time interval recorded .....	43

This document is a preview generated by EVS

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**SOLAR THERMAL ELECTRIC PLANTS –****Part 2-1: Thermal energy storage systems –  
Characterization of active, sensible systems for  
direct and indirect configurations****FOREWORD**

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

IEC TS 62862-2-1 has been prepared by IEC technical committee 117: Solar thermal electric plants. It is a Technical Specification.

The text of this Technical Specification is based on the following documents:

Draft TS	Report on voting
117/119/DTS	117/127/RVDTS

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 Technical Specification 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](http://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/standardsdev/publications](http://www.iec.ch/standardsdev/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 "<http://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.

**IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.**



## INTRODUCTION

IEC TC 117 prepares International Standards (and other types of documents) for systems of solar thermal electric (STE) plants for the conversion of solar thermal energy into electrical energy and for all the elements (including all sub-systems and components) in the entire STE energy system. These documents would cover all current different types of systems in the STE field, as follows:

- Parabolic trough
- Solar tower
- Linear fresnel collectors
- Parabolic dish
- Any other type of system using thermal storage that is not connected to the grid.

The documents define terminology, design and installation requirements, performance measurement techniques and test methods, safety requirements, and "power quality" issues for each of the above systems.

In addition to those systems, there are several major components that require standardization, such as the storage media (oil, molten salt, ceramic, concrete, etc.).

## **SOLAR THERMAL ELECTRIC PLANTS –**

### **Part 2-1: Thermal energy storage systems – Characterization of active, sensible systems for direct and indirect configurations**

#### **1 Scope**

This document defines the requirements and the test methods for the characterization of thermal energy storage (TES) systems.

This document contains the information necessary for determining the performance and functional characteristics of active direct and indirect thermal energy storage systems based on sensible heat in solar thermal power plants using parabolic-trough collector, Fresnel collector or tower central receiver technology with liquid storage media.

This document includes characterization procedures for testing energy storage system charge and discharge, as well as reporting the results. Test performance requirements are given and the instrumentation necessary for them, as well as data acquisition and processing methods and methods for calculating the results and their uncertainties.

#### **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 TS 62862-1-1:2018, *Solar thermal electric plants – Part 1-1: Terminology*

IEC 60584-1:2013, *Thermocouples – Part 1: EMF specifications and tolerances*

IEC 60751:2008, *Industrial platinum resistance thermometers and platinum temperature sensors*

ISO 5725-3, *Accuracy (trueness and precision) of measurement methods and results – Part 3: Intermediate measures of the precision of a standard measurement method*

ISO 5725-6, *Accuracy (trueness and precision) of measurement methods and results – Part 6: Use in practice of accuracy values*

#### **3 Terms and definitions**

For the purposes of this document, the terms and definitions given in IEC TS 62862-1-1 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>