

# TECHNICAL REPORT

**Water cooling systems for power electronics used in electrical transmission and distribution systems**



## THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2022 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 Secretariat  
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 It also gives information on projects, replaced and withdrawn publications.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 Products & Services Portal - [products.iec.ch](http://products.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 22 300 terminological entries in English and French, with equivalent terms in 19 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

Preview generated by EVS

# TECHNICAL REPORT

---

**Water cooling systems for power electronics used in electrical transmission  
and distribution systems**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

ICS 29.240.99

ISBN 978-2-8322-1090-5

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

## CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	7
2 Normative references .....	7
3 Terms and definitions .....	7
4 Service conditions .....	8
4.1 General.....	8
4.2 Indoor conditions .....	9
4.3 Outdoor conditions.....	9
4.4 Electrical supply conditions.....	9
5 Technical performance .....	9
5.1 System functions .....	9
5.2 Main circuit .....	11
5.2.1 Design input parameters.....	11
5.2.2 Components .....	12
5.3 Heat exchanger .....	14
5.3.1 General .....	14
5.3.2 Air cooler.....	14
5.3.3 Evaporative cooling tower.....	15
5.3.4 Liquid-to-liquid heat exchanger.....	16
5.3.5 Chiller unit.....	17
5.4 Control and protection system.....	17
5.4.1 General .....	17
5.4.2 Control .....	18
5.4.3 Protection .....	18
5.4.4 Monitoring and recording .....	19
5.5 Freezing prevention .....	19
5.6 Rating plate .....	19
6 Documentation .....	19
7 Tests .....	20
7.1 Summary of tests .....	20
7.2 Description of tests .....	20
7.2.1 Visual inspection .....	20
7.2.2 Insulation test.....	21
7.2.3 Pressure and leakage test .....	21
7.2.4 Hydraulic performance test.....	21
7.2.5 Thermal performance test.....	21
7.2.6 Control and protection test.....	21
7.2.7 EMC test .....	21
7.2.8 Operation test.....	21
7.2.9 Inspection of internal cleanliness .....	21
7.2.10 Pump and motor alignment check .....	22
7.2.11 Coolant freezing point check.....	22
7.2.12 Vibration check.....	22
7.2.13 Audible noise check.....	22
7.2.14 Current check .....	22

7.2.15	Communication and interface test.....	22
8	Maintenance.....	22
9	Safety.....	22
10	Environmental impact.....	22
	Bibliography.....	24
	Figure 1 – Typical flow chart of water cooling system application.....	11
	Figure 2 – Typical flow chart of air cooler application.....	15
	Figure 3 – Typical flow chart of evaporative cooling tower application.....	16
	Figure 4 – Typical flow chart of water-to-water heat exchanger application.....	16
	Figure 5 – Typical flow chart of chiller unit application.....	17
	Table 1 – Typical design input parameters of water cooling system.....	12
	Table 2 – List of tests.....	20

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

# WATER COOLING SYSTEMS FOR POWER ELECTRONICS USED IN ELECTRICAL TRANSMISSION AND DISTRIBUTION SYSTEMS

## 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 TR 63259 has been prepared by subcommittee 22F: Power electronics for electrical transmission and distribution systems, of IEC technical committee 22: Power electronic systems and equipment. It is a Technical Report.

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

Draft	Report on voting
22F/650/DTR	22F/668/RVDTR

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 Report 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).

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](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.

## INTRODUCTION

In the power transmission and distribution systems, power electronic equipment, such as LCC-HVDC (line commutated converter high voltage direct current) converter valve, VSC-HVDC (voltage sourced converter high voltage direct current) converter valve, SVC (static var compensator), STATCOM (static synchronous compensator) and power distribution cabinets, are mainly used for the conversion and control of current. Heat emitted from power electronics, like thyristors, IGBTs or other kinds, needs to be removed continuously. Water cooling system is commonly used as an efficient way to remove the heat from power electronic equipment, especially when operation voltage of equipment reaches 1 000 V or above. To meet the insulation requirement, water needs to be deionized to have the property of least conductivity. De-ionized water can be mixed with antifreeze or other solutes to achieve lower freezing point or obtain other characteristics.

As one of the most important auxiliary parts of power transmission and distribution systems, a great deal of research and practices have been made in many countries and relevant national standards or enterprise standards have been established. This document collects experience of design, manufacturing, and testing in different fields and provides a guideline for further application. However, the supplier is not necessarily required to provide all functions that are included/described in this document, unless clearly specified/required by the purchaser.



# WATER COOLING SYSTEMS FOR POWER ELECTRONICS USED IN ELECTRICAL TRANSMISSION AND DISTRIBUTION SYSTEMS

## 1 Scope

This document provides guidelines for the application of water cooling systems for power electronics used in electrical transmission and distribution systems.

This document describes a kind of water cooling system, in which de-ionized water or de-ionized water mixed with other solutes is used as the heat transfer agent for the removal of heat from power electronic equipment. Water cooling system can be separated into main circuit, and control and protection system. Other cooling systems, in which de-ionized water is not the heat transfer agent, are excluded in this document.

This document provides guidance and supporting information for both purchaser(s) and potential supplier(s). It can be used as the basis for drafting a procurement specification and as a guide during project implementation.

**NOTE** Usually, the agreement between the purchaser and the supplier of the water cooling system includes specific requirements regarding contractual requirements of particular delivery. Such specific requirements will supersede the general/typical description mentioned in this document, and all functions mentioned in this document are not necessarily applicable/delivered for all systems.

## 2 Normative references

There are no normative references in this document.

## 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

#### **cooling medium**

liquid (for example water) and/or gas (for example air) which removes the heat that is generated by the equipment, from the heat exchanger

Note 1 to entry: A cooling medium is only used in the heat exchanger(s).

[SOURCE: IEC 60146-1-1:2009, 3.8.1, modified – The words "or gas" have been replaced by "and/or gas", the words "from the equipment" have been replaced by "that is generated by the equipment, from the heat exchanger", and the note to entry has been added.]

### 3.2

#### **heat transfer agent**

coolant within the equipment to transfer the heat from its source to a heat exchanger from where the heat is removed by the cooling medium

Note 1 to entry: In the context of this Technical Report, only de-ionized water and de-ionized water mixed with other solutes are considered as heat transfer agents.