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TECHNICAL REPORT

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

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FOREWORD

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. The main document types developed by IEC are described in greater detail at 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 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- withdrawn,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.

[SOURCE: IEC 60146-1-1:2009, 3.8.2, modified – The words "liquid (for example water) or gas (for example air)" have been replaced by "coolant", and the note to entry has been added.]

3.3
de-ionized water
purified water from which ionic species have been partially or completely removed, particularly by the use of ion-exchanger resins to achieve the least conductivity

3.4
main circuit
cooling circuit that exchanges heat with power electronic equipment (or with heat sink attached) by heat transfer agent

Note 1 to entry: Heat sink attached to power electronic equipment for heat transfer is considered as an integral part of power electronic equipment.

3.5
rated cooling capacity
cooling capacity of water cooling system at specified design conditions to cool the power electronic equipment

Note 1 to entry: Cooling capacity can be higher than the power dissipation of the equipment being cooled to cover pump losses, chiller losses, etc.

3.6
rated flow
specified flow through power electronic equipment at rated cooling capacity

Note 1 to entry: Flow from pump(s) can be higher than the flow through the equipment being cooled to cover flow into water treatment circuit, etc.

3.7
secondary circuit
cooling circuit that exchanges heat from the main circuit into a cooling medium in the liquid form and from there transports it to a further heat exchanger from where it is rejected to ambient

Note 1 to entry: Not all cooling systems use secondary circuit.

4 Service conditions

4.1 General

Service conditions can be divided into indoor conditions, outdoor conditions, and electrical supply conditions. All these conditions need to be subject to the specific requirement of purchasers or site location.

For indoor conditions, the specific requirement of indoor equipment, like pump motors and cabinets, needs to be included. The indoor conditions can be achieved by appropriate HVAC (heating ventilation and air-conditioning) system. The outdoor conditions and power conditions mostly depend on the site condition.

Some conditions, like altitude and seismic intensity, apply to all parts. Other environmental conditions, like corrosion, can differ when applied to indoor and outdoor equipment.

4.2 Indoor conditions

The following conditions need to be considered for indoor equipment:

a) the indoor temperature and humidity, which need to follow project requirements whilst complying with IEC 60654-1;

NOTE Local regulations can also exist.

b) condensation, which needs to be avoided for both mechanical equipment and control equipment;

c) explosive mixtures of dust or gases, corrosive gas or steam;

d) unusual mechanical stresses, for example shocks and vibrations;

e) exposure to strong electromagnetic interference.

4.3 Outdoor conditions

For outdoor equipment exposed to the environment, some conditions as follows need to be carefully considered:

a) corrosivity level at site, which is vital for life of steel structure and equipment structure, refers to ISO 12944-2, or needs to be subject to purchaser's requirement;

b) availability of raw water, which needs to be considered when evaporative cooling tower is included as heat exchanger;

c) special location, such as residential area or natural park, where operation noise of outdoor equipment is subject to local laws;

d) salty air (for example proximity to the sea), high humidity, dripping water or corrosive gases.

4.4 Electrical supply conditions

Voltage and frequency fluctuations of power supply and control power supply need to meet the requirement according to IEC 60038, or as specified by the purchaser. AC power for pumps, fans, etc. and control power for auxiliary equipment need to be configured separately. Redundancy of power supply (both AC and DC) as well as power quality of power supply (voltage fluctuations, frequency fluctuations, three-phase voltage unbalance, etc.) need to be considered and applied where feasible.

5 Technical performance

5.1 System functions

The main circuit is a continuous circulating loop filled with heat transfer agent. If required by the power electronic equipment, oxygen is prevented from entering the system. The design prevents dirt from entering the system as well. Figure 1 presents an example of typical flow chart of water cooling system application.

Circulation pump(s), heat exchanger, strainer, fine filter, expansion vessel(s), and de-ionization equipment need to be included. Refill equipment, electrical heater, and by-pass branch are optional but can be included as per power electronic equipment's or purchaser's requirement. Pressure meter and transducer, temperature transducer, conductivity transducer, flow transducer, and level meter and transducer need to be included in the loop to monitor the performance of the system. Oxygen meter, pH meter, or other kinds of meters and/or transducers are optional or can be installed as per requirement of purchaser and/or when specified.