IEC TR 63259

Edition 1.0 2022-03

TECHNICAL REPORT

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

IEC TR 63259:2022-03(en)

IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

IEC TR 63259

Edition 1.0 2022-03

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

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. 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.

– Main circuit

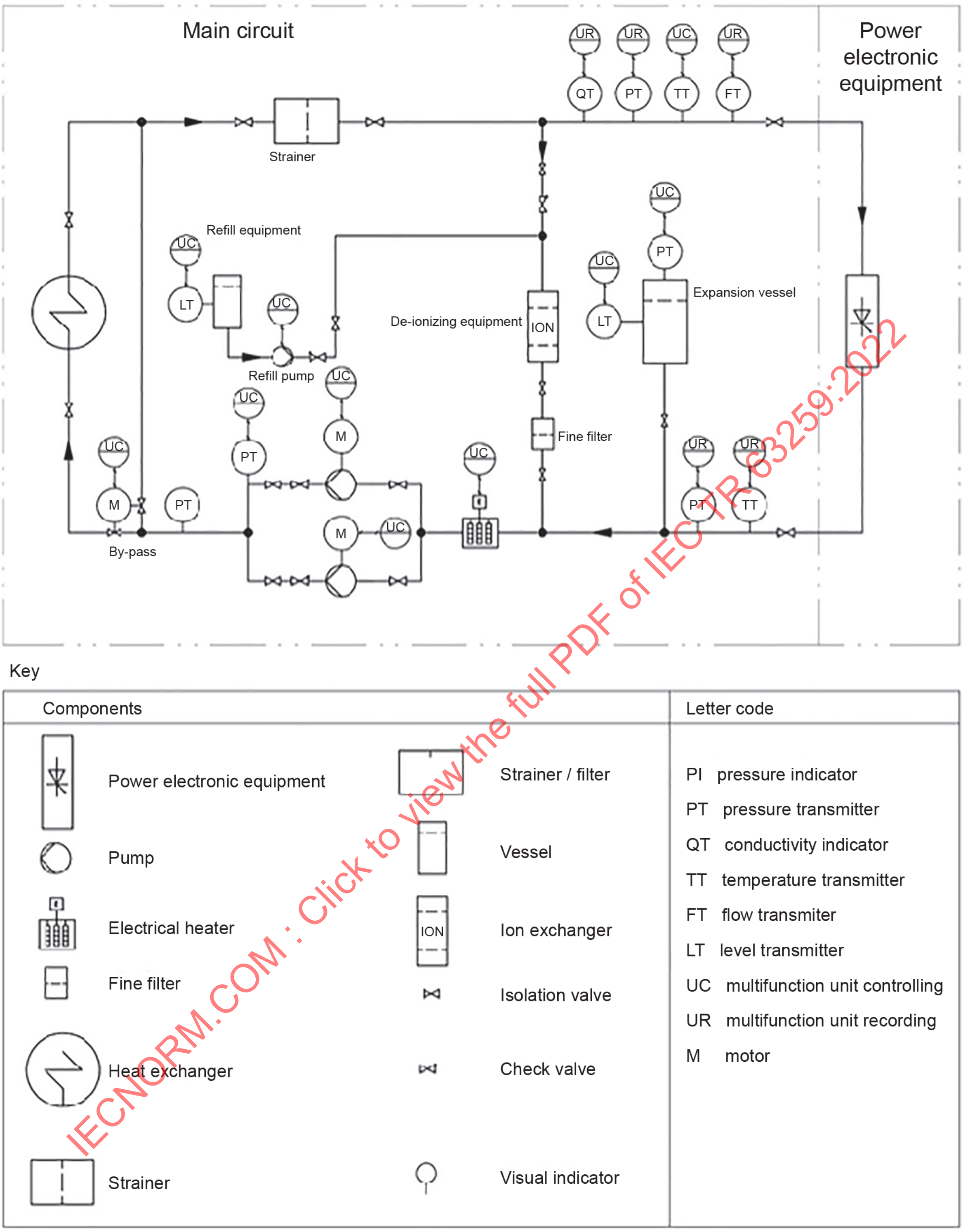
Main circuit directly exchanges heat with power electronic equipment, and transfers the heat which is emitted from the power electronic equipment, to heat exchanger. Indoor equipment can be mounted on frames, which is convenient for the testing and installation at site. The main circuit needs to be designed to meet the required pressure, flow, temperature, conductivity, and other requirements for power electronic equipment.

– Heat exchanger

Within heat exchanger, cooling medium (air or raw water at site) exchanges heat with heat transfer agent, which is heated in the power electronic equipment, and transfers the heat to atmosphere or other reliable sources to take over the heat energy from the system. The cooled heat transfer agent will flow back to be heated in power electronic equipment, then will be cooled again in the heat exchanger. The heat exchanger needs to have the cooling capacity no less than that required by power electronic equipment at the most severe performance condition.

– Control and protection system

Control and protection system needs to comprise following basic functions: protection of power electronic equipment related to water cooling system, and control, and monitoring and recording. The transducers which serve the protection system can be duplicated or triplicated as per the requirement of purchaser(s).



IEC

NOTE Symbols of the flow chart are designed according to ISO 3511-1, ISO 3511-2, ISO 14617-1, ISO 14617-3, ISO 14617-7, ISO 14617-8, ISO 14617-9, ISO 14617-11, and ISO 14617-12.

Figure 1 – Typical flow chart of water cooling system application

5.2 Main circuit

5.2.1 Design input parameters

Typical design input parameters of main circuit are listed in Table 1.

Table 1 – Typical design input parameters of water cooling system

Parameter of water cooling system	Unit	Description
Rated cooling capacity	kW	Refer to 3.5
Design inlet temperature of power electronic equipment	°C	Inlet temperature to power electronic equipment at design conditions
Maximum inlet temperature of power electronic equipment	°C	Used for the protection of power electronics
Minimum inlet temperature of power electronic equipment	°C	Used for the protection of power electronics
Rated flow of power electronic equipment	l/min	Refer to 3.6
Maximum design inlet pressure of power electronic equipment	kPa	Maximum allowed working pressure of power electronic equipment
Power electronic equipment pressure drop	kPa	Design pressure drop of power electronic equipment at rated flow
Maximum conductivity of main circuit	µS/cm	Maximum conductivity required by power electronic equipment
Maximum and minimum environmental temperature	°C	Maximum and minimum value of dry-bulb temperature or wet-bulb temperature of outdoor environment
Type and amount of antifreeze or other solutes in coolant (if any)	%	Water solute required by project or purchaser(s)

5.2.2 Components

5.2.2.1 Circulation pump

Circulation pump(s) needs to be provided to circulate heat transfer agent inside piping. Redundant pump(s), if required, needs to be installed in parallel with pump(s) in operation. The pump(s) in operation needs to be able to provide the required flow.

5.2.2.2 Filter

– Strainer

  Strainer needs to be included in the main circuit to filter solid particles and prevent them entering the pipe of power electronic equipment. The mesh size needs typically to be no larger than 250 µm, or less if required by the purchaser's requirements. Filter element inside can be either cleaned or changed when it is polluted.

– Fine filter

  Fine filter(s) needs to be included in the water treatment circuit to ensure that no deionizer resin and/or any other particles enter the main circuit. Mesh size of fine filter needs to be no larger than typical 25 µm or be subject to purchaser's requirement. Filter element inside can be either cleaned or changed when it is polluted.

5.2.2.3 De-ionizing equipment

To ensure the conductivity of heat transfer agent remains within an acceptable limit of the power electronic equipment, de-ionizing equipment needs to be included to remove ions continuously. A mixture of uniform granular particle sized polystyrene cation and anion resins needs to be used.

5.2.2.4 Refill equipment

Refill equipment can be included to replenish coolant in main circuit. The coolant needs to be filtered and preferably deionized before entering the main circuit. Refill pump(s) needs to be included as the major component. The working pressure of system and pressure loss through refill circuit need to be considered in the design of refill pump. The refill arrangement can be automatic or manual.

5.2.2.5 Expansion vessel

Expansion vessel(s) needs to be included to withstand the coolant's volume change due to the coolant's temperature change. The size of the vessel(s) needs to be carefully designed. Level meter and/or level transducer needs to be equipped to show the coolant level and/or level change. Expansion vessel(s) is mounted on wall or is installed on the skid. To ensure that coolant is fully filled at every spot of the circuit, the pressure inside the expansion vessel(s) needs to be large enough.

For expansion vessel(s) mounted on wall or positioned at height, it needs to be set at the highest spot of the main circuit. In such case, the vessel can be open to atmosphere.

If expansion vessel(s) is lower than the highest spot, an extra pressure control equipment needs to be provided. The following ways can be included for pressure control.

a) Connect expansion vessel(s) to vessel(s) with high compressed inert gas, decompressor, and solenoid valves. Increase the pressure by injecting inert gas. Decrease the pressure by emitting gas into atmosphere. Safety valve needs to be included in case of the pressure inside being too high.
b) Connect expansion vessel(s) to compressor and solenoid valve. Increase the pressure by starting compressor and injecting air. Decrease the pressure by opening solenoid valve and emitting air into atmosphere. Safety valve needs also to be included in case of the pressure inside being too high.
c) Connect a sealed expansion tank with diaphragm. The diaphragm separates a closed amount of gas and the coolant. The volume of the gas varies due to the coolant temperature as well as the pressure. Contact of the coolant to the vessel surface needs to be prevented due to corrosion issues.
d) Connect air filling pump to the connection point of the closed expansion vessel and pressurise the system to preferred initial pressure. Pressure in the tank can change during operation as coolant level in the tank varies. Safety valve needs to be included in case of the pressure inside being too high.

One type or a combination of different types of pressure control equipment can be applied with expansion vessel(s). Specific type(s) of pressure control equipment needs to be subject to purchaser's requirement or site condition.

5.2.2.6 Electrical heater

Electrical heater(s), when required, can be included to prevent freezing and/or keep the temperature of the coolant in main circuit above the requirements. Heater(s) can be installed in pipeline or on tank.

5.2.2.7 Measuring equipment

Measuring equipment installed in the main circuit needs to be able to monitor the required operation values like pressure, flow, temperature, conductivity, level, etc. Inspection or calibration of measuring instrument needs to be conducted within a fixed period. Measurement accuracy, repeatability and/or other characteristics need to be carefully considered or subject to purchaser's requirement.

5.2.2.8 Gas vent and drainage device

Deaerator(s) or degassing vessel(s) is usually included to vent gas dissolved in the coolant or existing in the pipe. At high spots or gas accumulation spots, natural, manual or automatic air vent(s) are installed. At the lowest spot(s), drainage device needs to be installed for maintenance.

5.3 Heat exchanger

5.3.1 General

Heat exchanger, as a component of main circuit, transfers the heat in main circuit to cooling medium. Four typical types of heat exchangers are as follows:

a) air cooler, which transfers the heat in the heat transfer agent via finned heat exchanger by forced air;

b) evaporative cooling tower, which transfers the heat in the coolant inside tubes to the air forced by fans and water forced by pump;

c) liquid-to-liquid heat exchanger, which transfers the heat in the coolant to the cooling medium (water commonly used) in secondary circuit;

d) chiller unit, which transfer the heat in the coolant to the refrigerant in another cooling circuit.

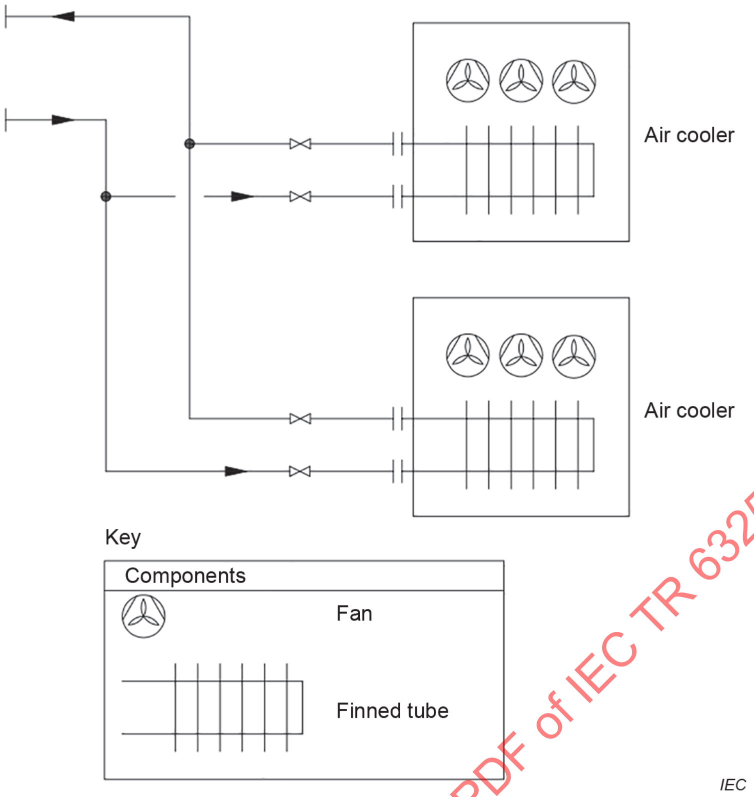
A single type or a combination of different types of heat exchangers can be applied. The selection of specific heat exchanger is relevant to environmental condition, site condition, or purchasers' requirement. As for environmental conditions, the maximum and minimum outdoor ambient temperature, availability of raw water, wind velocity, corrosion level need to be considered.

5.3.2 Air cooler

Air cooler can be used when maximum ambient dry-bulb temperature is below the maximum outlet temperature of heat exchanger. Forced by fans, air flows through finned tubes and removes the heat on the surface into ambient. Altitude above sea level needs to be considered for finned heat exchanger and fan design.

Redundancy in air cooler design needs to be defined by purchaser. Redundancy can be achieved by finned surface, bays or fans.

A typical flow chart of air cooler application is shown in Figure 2. Each of the air coolers is connected to shut-off valves so that each cooler can be isolated in case of maintenance. The air flow can be varied as per the need of cooling capacity.



NOTE Symbols of the flow chart are designed according to ISO 3511-1, ISO 3511-2, ISO 14617-1, ISO 14617-3, ISO 14617-7, ISO 14617-8, ISO 14617-9, ISO 14617-11, and ISO 14617-12.

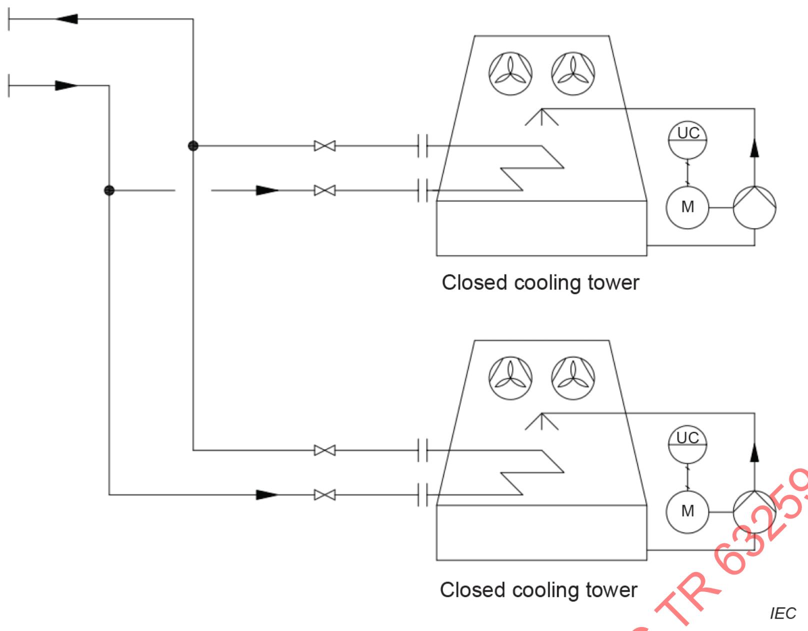
Figure 2 – Typical flow chart of air cooler application

5.3.3 Evaporative cooling tower

Evaporative cooling tower can be used when the maximum wet-bulb temperature is below the maximum outlet temperature of heat exchanger and raw water is easily available at site. To maintain the quality of heat transfer agent, cooling circuit inside the tower is closed.

Redundancy in cooling tower design is defined by purchaser. Redundancy can be achieved by cooling coils or fans.

A typical flow chart of evaporative cooling tower application is shown in Figure 3. Both fans and spraying pump are working together to get the maximum cooling capacity. The air flow can be varied as per the need of cooling capacity. To get a usable spray water, the raw water is treated by desalting and dosing to avoid scaling on the cooling coils.



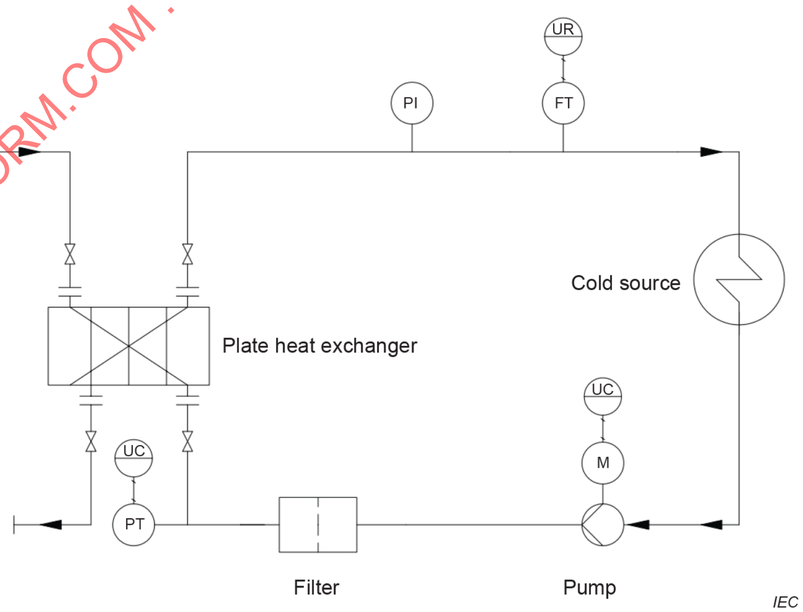
NOTE Symbols of the flow chart are designed according to ISO 3511-1, ISO 3511-2, ISO 14617-1, ISO 14617-3, ISO 14617-7, ISO 14617-8, ISO 14617-9, ISO 14617-11, and ISO 14617-12.

Figure 3 – Typical flow chart of evaporative cooling tower application

5.3.4 Liquid-to-liquid heat exchanger

Liquid-to-liquid heat exchanger is used when the heat exchange between heat transfer agent and cooling medium occurs indoor or where there is a suitable liquid coolant supply readily available. Heat exchangers can be of two types: plate type or shell-and-tube type.

A typical flow chart of plate heat exchanger application and use of secondary circuit is shown in Figure 4. All components, including plate heat exchanger, and pipes of main circuit are installed indoor.



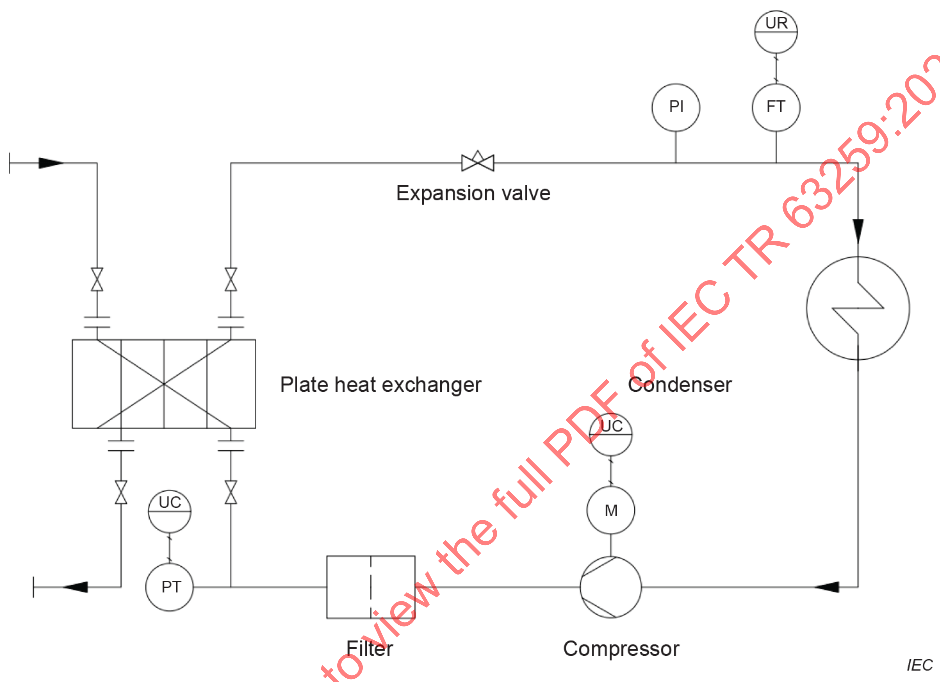
NOTE Symbols of the flow chart are designed according to ISO 3511-1, ISO 3511-2, ISO 14617-1, ISO 14617-3, ISO 14617-7, ISO 14617-8, ISO 14617-9, ISO 14617-11, and ISO 14617-12.

Figure 4 – Typical flow chart of water-to-water heat exchanger application

5.3.5 Chiller unit

Chiller unit(s) is used in the region with high dry bulb temperature and lack of raw water. By the heat transfer of phase change, chiller can reduce the water outlet temperature below the ambient temperature.

A typical flow chart of chiller unit(s) application is shown in Figure 5. A typical chiller is mainly composed of compressor, condenser, expansion valve, dry filter, and evaporator. Evaporative condenser, air-cooled condenser and a combination of these two types can be applied as per site condition, or purchaser's requirement.



NOTE Symbols of the flow chart are designed according to ISO 3511-1, ISO 3511-2, ISO 14617-1, ISO 14617-3, ISO 14617-7, ISO 14617-8, ISO 14617-9, ISO 14617-11, and ISO 14617-12.

Figure 5 – Typical flow chart of chiller unit application

5.4 Control and protection system

5.4.1 General

Control and protection system needs to be included with function of control, protection, monitoring and recording of the operation of water cooling system.

Redundant design can be included according to reliability, availability and maintainability, or other requirements of purchaser. When a redundant system is provided, the two systems need to be set with different states – one in active state and the other in stand-by state. If system in active state fails or any fault be detected, it is automatically switched to stand-by state, and the other system, which is in stand-by state, is switched to active state. Failure of single component does not cause tripping of the control system. Control and protection system sends signals to power electronic control system and also receives the signals sent by the power electronic control system.

5.4.2 Control

The major control functions can be applied as follows.

a) The control of inlet temperature of power electronic equipment is achieved by switching on and off heat exchanger(s), i.e., start/stop of fans and/or spraying pumps, and/or changing the speed of cooling fans. Use of heater(s) or bypass could also be included to ensure robust temperature control.

b) The control of circulation pump(s) is achieved by switching on/off pump(s) according to abnormal pressure at its inlet or outlet, outdoor ambient temperature, abnormal flow, or other failings. Pump speed control can also be achieved by means of variable frequency drives. In case of pump(s) failure, the redundant pump(s) are started, and an alarm is generated. To achieve equal wear and tear of each pump, a routine (e.g., weekly) change of pump(s) is usually carried out, when there is no failure indication for the stand-by pump(s).

c) The control of water refill, when applicable, can be achieved by switching on/off the refill pump, when level of expansion vessel(s) decreases below or increases above set point.

d) The pressure control of expansion vessel(s) to be included depends on the pressure equipment connected to expansion vessel(s). Only the inert gas capping, compressor and air filling pump can be controlled. To increase pressure, the solenoid valve in the gas pipe is opened to inject gas into vessel(s), the compressor is started, or the air filling pump is started. To decrease pressure, the solenoid valve connected to the atmosphere will be opened to vent gases from the expansion vessel(s).

e) Heater(s), when applicable, will be switched on to keep the coolant in electronics equipment above the minimum allowed temperature, below which condensation can occur or there is possibility of freezing. If necessary, bypass valves will start operation to support heaters to keep inlet temperature of power electronics above the limit. A minimum flow will always be circulated through outdoor heat exchanger(s) to prevent coolant freezing as well as to prevent an increase of conductivity in outdoor part of circuit. Alternatively, the temperature of the coolant can be maintained above the minimum temperature allowed by recirculation through the by-pass of the main circuit if present.

5.4.3 Protection

The major protection functions can be applied as follows.

a) Temperature protection can be achieved by detecting abnormal inlet temperature of power electronic equipment. If the inlet temperature, which can be measured with temperature transducer, is higher than a certain reference value for alarm or trip, a high temperature alarm, or a trip signal, will be generated to protect power electronics. When the temperature is lower than a certain reference value, an alarm or trip is generated.

b) Flow protection can be achieved by detecting abnormal flow or pressure characteristics in main circuit. If the flow, which can be measured with flow transducer or pressure sensors, is lower than a certain reference value for alarm or trip, a low flow alarm, or a trip signal is generated.

c) Conductivity protection can be achieved by detecting abnormal conductivity in main circuit and/or outlet of de-ionizing equipment. If the conductivity, which can be measured with conductivity transducer, is higher than a certain value for alarm or trip, a high conductivity alarm or a trip signal is generated.

d) Level protection can be achieved by detecting abnormal level in the expansion vessel(s). If the level, which can be measured with level transducer, is lower than a certain value for alarm or trip, a low-level alarm or a trip signal needs to be generated.

e) Pressure protection can be achieved by detecting abnormal pressure in the components or piping in main circuit. If the pressure, which can be measured with pressure transducer, is higher or lower than the limit, an alarm of high pressure or low pressure is generated.

f) Leakage protection can be achieved by detecting abnormal loss of coolant in the main circuit. If the leakage, which can be detected by measuring of level changing or pressure changing in the expansion vessel(s), is above the limit, an alarm or a trip signal is generated.

Or if refill pump is started more times than allowed within a period, an alarm is also generated.

5.4.4 Monitoring and recording

The major functions of monitoring and recording can be applied as follows.

a) The operation of control and protection system and various components needs to be monitored. The major indications are available at the HMI (human machine interface), when applicable.

b) The indications within a particular period can be recorded for the further analysis when disturbance or fault happens.

c) The control and protection system has the function of self-checking, which can be achieved by comparing the operation data with the reference. If the data is higher or lower than the reference, it can be used to indicate the malfunction of the system.

5.5 Freezing prevention

In the region of low temperature, there is a risk that pure water would be frozen. Volume expansion from water to ice can cause the burst of pipes, pumps and other components, and it will severely influence the operation of water cooling system. The methods listed below are examples applied in the freezing prevention. One kind or a combination of the following kinds of methods can be applied according to specific requirement of the project or purchaser.

a) Antifreeze agent can be added into water to decrease the freezing point of coolant, so that coolant will not freeze when used intermittently. Ethylene glycol or propylene glycol can be used. The specific antifreeze needs to be subject to requirements of purchaser or project.

   NOTE Local laws can also exist.

b) During outdoor cold ambient conditions, part or all the coolant circulating to outside heat exchangers can be by-passed with a by-pass valve arrangement. This is to prevent temperature of the heat transfer agent in the indoor circulation getting too low for the power electronics and other indoor equipment. An additional important function of the bypass valve is to prevent condensation resulting from a too-low value of coolant temperature entering the power electronic equipment.

c) Electrical heater(s) can be equipped to warm the system when it is cold.

d) Electric tracing ribbon and insulating barrier can be wrapped outside the pipes open to atmosphere. Electric tracing is started and kept working when coolant stops circulating in the freezing temperature.

5.6 Rating plate

A rating plate of the cooling system needs to be fixed to the equipment. Additional information can be defined by the purchaser.

Components are equipped with their own rating plates.

6 Documentation

A detailed documentation describing the whole lifecycle of the water-cooling system needs to be provided to ensure that the system is operated within its performance limits to drive the required reliability and availability as defined by the purchaser.

Beside the instructions for use in accordance with IEC 82079-1, the following documents are part of the documentation:

a) pipe and instrumentation diagram (P+ID);

b) system drawings;

c) main component drawings;

d) electrical drawings (circuit diagrams);

e) component list;

f) test certificates.

7 Tests

7.1 Summary of tests

Clause 7 provides guidelines for testing of water cooling system. To verify the performance of water cooling system and/or its subsystems, three different stages of tests can be performed.

– Type tests are performed to validate a specific design or component. Type tests can be conducted to verify new types of design or effectiveness of design modification or can be performed according to the requirement of purchaser(s).

– Factory tests are performed to prove that equipment meets the design criteria before delivery. Factory tests need to be subject to the requirements of purchaser(s) or can be eliminated if type tests are accepted by purchasers.

– Site tests are performed to verify final assembly and interface connection after the installation of equipment at site. It might not be necessary to repeat tests previously performed as factory tests if the site tests can verify performance of the equipment under site conditions.

A summary of test items of type tests, factory tests and site tests of water cooling system is listed in Table 2 from which purchaser can specify required tests as applicable.

Table 2 – List of tests

Test items	Subclause		
	Type tests	Factory tests	Site tests
Visual inspection	7.2.1	7.2.1	7.2.1
Insulation test	7.2.2	7.2.2	7.2.2
Pressure and leakage test	7.2.3	7.2.3	7.2.3
Hydraulic performance test	7.2.4	7.2.4	7.2.4
Thermal performance test	7.2.5		
Control and protection test	7.2.6	7.2.6	7.2.6
EMC test	7.2.7		
Operation test	7.2.8	7.2.8	7.2.8
Inspection of internal cleanliness		7.2.9	7.2.9
Pump and motor alignment check		7.2.10	7.2.10
Coolant freezing point check			7.2.11
Vibration check		7.2.12	7.2.12
Audible noise check	7.2.13	7.2.13	7.2.13
Current check	7.2.14	7.2.14	7.2.14
Communication and interface test		7.2.15	7.2.15

7.2 Description of tests

7.2.1 Visual inspection

This test is purposed to