iE Convert

Cooling

Application notes

4189370008-A

Improve Tomorrow

1. Introduction

2. Design of liquid cooling

3. Design of air cooling

4. Safety and control

5. Examples

1. Introduction

1.1 Introduction to liquid cooling and air cooling

The iE Convert power converters require liquid cooling and air cooling. This application note discusses the requirements, design, safety, and control of these systems. It also includes examples. This application note is intended for system designers and switchboard builders.

For the converters, liquid cooling is the primary way to remove heat. That is, up to 90 % of the heat from the converter is removed by the liquid cooling. The liquid cooling is key to keeping the converters at the right temperature and operating efficiently. The remaining heat is removed by air cooling in the converter cabinet.

More information
See the **Data sheet** for the specifications for the relevant converter. The converter **Installation instructions** also include information on liquid cooling and air cooling.

Site conditions

Before you start to design the liquid cooling and air cooling for the power converters, identify the site conditions:

- Placement (indoors or outdoors)
- Air flow (how cool air comes in, and hot air leaves)
- Ambient temperature (maximum and minimum)
- Space restrictions
- Length of piping and elevations
- If applicable, pre-existing infrastructure for cooling
- Any other relevant information

Responsibilities

This application note does not replace any information from the maker of the liquid cooling and air cooling systems.

Party	Typical responsibility
DEIF	Converter requirements
System integrator	Cooling system design
Cooling system supplier	Cooling equipment specifications
Installer	Installation and commissioning
Operator	Operation and maintenance

1.2 Legal information

DEIF does not take responsibility for the design, installation, or operation of the liquid coolant system and the air cooling system. If there is any doubt about how to install or operate these systems, the company responsible for the installation or the operation of the system must be contacted.

1.2.1 Preliminary information

The product described in this document is still under development. All information is therefore preliminary.

1.2.2 Trademarks

DEIF and the DEIF logo are trademarks of DEIF A/S.
Modbus® is a registered trademark of Schneider Automation Inc.
Wolfspeed® is a registered trademark of Wolfspeed Inc.

All trademarks are the properties of their respective owners.

1.2.3 Copyright

1.2.4 Disclaimer

DEIF A/S reserves the right to change any of the contents of this document without prior notice.

The English version of this document always contains the most recent and up-to-date information about the product. DEIF does not take responsibility for the accuracy of translations, and translations might not be updated at the same time as the English document. If there is a discrepancy, the English version prevails.

2. Design of liquid cooling

2.1 Design requirements

You must make sure that the liquid cooling system meets these requirements.

Heat removal

The liquid cooling must be sized for 2 % of the converter's rated power. This value includes a safety margin.

For example, for a 500 kW converter, the liquid cooling must sized for 10 kW.

Temperature

The liquid cooling must be able to deliver the coolant at the temperature specified for the site, including when the ambient temperature is at its maximum. The coolant inlet temperature must be in the range specified for the converter.

Flow

The liquid cooling must be able to deliver the coolant flow required in the converter specification. A higher flow is acceptable as long as the maximum inlet pressure is not exceeded.

Pressure

The converter inlet pressure must be at least 3 bar (44 psi), but must not exceed 6 bar (88 psi).

To prevent excess pressure in the converter, pressure protection on the pipe to the converter inlet is recommend. For example, you can install a pressure relief valve.

Coolant tank

To accommodate the thermal expansion of the coolant, the system must have an coolant tank. The coolant tank also ensures stable operation and feeds the coolant pump.

During operation, the converter itself contains less than 0.5 litres of coolant. The total volume of coolant is:

- The coolant in the converter
- The coolant piping
- The coolant in the pump
- The coolant in the cooling equipment
- Extra coolant in the coolant tank

The coolant tank sizing considerations include:

- Filling the system
- Thermal expansion
- Air separation
- Pump suction stability

Coolant tank sizing example

A 50:50 Antifrogen N-water mix has an expansion coefficient of 57 x 10^{-5}/ K at 5 °C, and 82 x 10^{-5}/ K at 70 °C. For a system with 10 litres of coolant, and a temperature range of 5 to 70 °C, the coolant capacity required for thermal expansion is 0.5 litres.

Pipe and valve sizes

The liquid cooling system hydraulic design must ensure that the converter receives the required coolant flow and the converter inlet pressure is not exceeded.

Available pressure drop < Maximum pressure + Converter pressure drop + Safety margin (- Head)

The pipes and valves must be sized to avoid excessive pressure drop.

If the cooling system is installed above or below the converter, you also need to take the head (the pressure due to vertical differences) into account. The density of a 50:50 Antifrogen N-water mix is about 1070 kg/m^3. If the cooling system is 1 m above the conventer, that adds about 0.1 bar of pressure.

Vent and drain

The cooling system must include provisions to vent and drain the coolant.

2.2 Other design considerations

In addition to the design requirements, the following design considerations may also be important, depending on the site.

Cooling system efficiency

The energy required by the cooling system has an impact on the total power conversion energy efficiency. Depending on energy availability and price, it may be economical to use a more expensive cooling system that has a higher efficiency.

Cooling system density and weight

If the site has space and weight restrictions, a compact, light cooling system should be selected. A cooling system that is delivered as a frame mounted system may provide the lightest and most compact solution.

Using the cooling system for multiple converters

If the cooling system is used for multiple converters, pay attention to the piping design to ensure that all of the converters get the required amount of coolant.

Cooling system materials

The materials of the cooling system (that is, the pump, pipes, valves, and seals) must be suitable for the coolant (Antifrogen N-water mix: 25:75 to 50:50).

Where metal components are used, make sure that the components are galvanically compatible.

Redundancy

Where the power converter is a critical system, all parts of the cooling must be designed so that a single failure (including fire and flooding) does not disable the critical system.

Filling and venting the cooling system

The piping design must include provision for filling and venting the cooling system.

Condensation

The coolant must be kept above the dew point (wet bulb) temperature of the converter room.

Leak prevention and containment

The coolant pipe design must consider thermal expansion, to ensure that there is no stress on any component (especially the connections to the converter).

The cooling system components and supports must be able to withstand vibration without leakage, fatigue failure, or loosening.

Use a separate, shielded compartment for the liquid coolant, with shielded routing away from the high voltage components, especially the DC busbars.

Route the coolant piping below the switchboard, to minimise the risk of liquid contact with electrical components.

The coolant pipe design must include a burst pressure safety factor that is at least 4 (four) times the design pressure.

Pressure test the coolant piping, and preserve the test documentation.

Use drip trays or other arrangements to ensure containment if there is a leak.

The cooling system design should include leak detection sensors.

Using the cooling system as a heater

The converter may need to be heated to remove possible condensation before operation. It can be helpful if the cooling system (for example, a chiller) includes a heating mode. If the cooling system cannot be used to heat the converter, it may be necessary to install a separate heater and/or dehumidifier in the converter cabinet.

2.3 Cooling solutions

A variety of configurations can provide the liquid cooling that the converter requires. The solution will depend on the site conditions and requirements.

Solution	Advantages	Limitations
Sea water exchanger	Low operating cost	Fouling risk
Radiator (that is, air cooling of the coolant)	Simple	Large footprint
Coolant as a utility	Minimal equipment	Site-dependent
Chiller	Suitable for high ambient temperatures	Higher energy use
Variable-speed chiller	Higher efficiency	Higher capital cost

More information
See Examples for drawings.

Water-coolant heat exchanger

If there is a reliable local water source (for example, sea water in a marine application), this can be used to deliver coolant at the required temperature.

Radiator (that is, air cooling of the coolant)

If there is a reliable local source of cool air, air cooling can be used to deliver the coolant at the required temperature. Since air cooling requires a large installation, it is not suitable where space is at a premium. However, it can be useful for smaller applications, for example, in a lab.

Coolant as a utility

On some sites, for example, a data center, coolant may already be available as a utility. If the coolant can be supplied at the required composition, temperature, pressure, and flow, it may be possible to simply connect it to the converter. Otherwise, local pumping, control, and/or heat exchange may be required.

Chiller

For sites with high ambient temperatures or space restrictions, a chiller may be required to deliver the coolant at the required temperature.

Variable-speed chiller

If a chiller is required, it may be possible to increase the system efficiency by using a variable speed chiller. This may be economical if the converter regularly operates over a wide range of loads.

3. Design of air cooling

3.1 Design requirements

You must make sure that the air cooling system meets these requirements.

Heat removal for the converter

The air cooling must be sized for 0.2 % of the converter's rated power. This value includes a safety margin.

For example, for a 500 kW converter, the air cooling for the converter must sized for 1 kW.

NOTICE

Include all heat sources in the cabinet

The design requirement of air cooling equivalent to 0.2 % of the converter's rated power is only for the converter. If there are other heat sources in the cabinet, for example, fuses, the load from these must also be included in the air cooling design.

Heat removal for other components

Integrators must also consider the heat generated from other components like fuses, busbars, and so on, while designing the switchboard cooling and calculating the temperature rise limits.

Flow

The air cooling must deliver a flow rate of 2 to 3 m/s.

Ambient temperature

The air flow must be designed to be effective when the ambient temperature is at its maximum.

The temperature inside the cabinet (including the temperature increase due to heating from the converter and other components) must be in the range specified for the converter. If the specified temperature is exceeded at full power, the converter power and current must be derated.

Flow path

The installation must ensure that the air is forced over all of the components that must be cooled. This includes the converter, the busbars, the AC fuses, the DC fuses, the power cables, the electrical components, and the terminals. There must be enough air flow in each section. An air deflector above the DC fuses may be required to ensure air flow over these fuses.

To direct the air flow to the areas that need cooling, block any gaps and alternative air paths.

If the enclosure includes multiple converters, these must not be directly in contact with each other. There must be a gap between them allows an air flow of 2 to 3 m/s (that is, the gap must be sized keep the air speed in the required range).

3.2 Other design considerations

In addition to the design requirements, the following design considerations may also be important, depending on the site.

Air inlet filters

Air inlet filters are recommended. In dirty environments, additional inlet air filtration may be required.

As the air filters get dirty, the dirt will restrict the air flow. The maintenance plan should include regular air filter changes. If air filter changes are required more often than converter maintenance, it must be possible to change the air filters without opening the converter cabinet.

Cabinet air inlet and outlet

In general, the air inlet should be at the bottom of the cabinet, while the outlet is at the top. In this configuration, convection occurs in the same direction as the air flow, and the likelihood of hot spots is reduced.

Room air inlet and outlet

To avoid a build up of heat, the room should be designed so that cool air comes in, and the heated air leaves.

Placement of fan(s)

If the fan(s) are only installed at the air inlet, the cabinet will have slight positive pressure. This stops unfiltered air from leaking in.

If the fan(s) are only installed at the air outlet, the cabinet will have slight negative pressure. Unfiltered (dirty) air could potentially leak in.

If the pressure drop in the cabinet is high, you may need to install fans at both the inlet and the outlet.

Multiple converters

If the installation includes multiple converters, make sure that the hot air from the converters is not directed towards any of the other converters.

The cabinet has a heater

If the cabinet has a heater (to remove possible condensation before operation), you can use the air cooling ventilation to circulate the hot air from the heater effectively.

3.3 Cooling solutions

A variety of configurations can provide the air cooling that the converter requires. The solution will depend on the site conditions and requirements.

More information
See Examples for drawings.

Fans

If there is a reliable local source of cool air, you can use fans to deliver the air flow in the cabinet at the required temperature.

Coolant in a radiator

If the ambient temperature is high, you can design and size the coolant system so that some coolant is directed to a radiator. The air can then be directed to flow through the radiator, so that the air is available at the required temperature. If you use this solution, make sure that the air that enters the converter does not contain condensation.

Air conditioning

For sites with high ambient temperatures, high humidity, and/or a very dirty environment, air conditioning may be required to deliver the air at the required temperature and humidity.

4. Safety and control

4.1 Safety

For safe operation, the converter requires reliable cooling.

Condensation

The coolant must be kept above the dew point (wet bulb) temperature of the converter room.

The air at the converter inlet must not contain condensation.

Coolant pressure

The liquid cooling system must be designed to ensure that the pressure does not exceed the converter's maximum pressure. To achieve this, we recommend that there are no restrictions on the converter coolant outlet, and that a pressure relief valve is installed on the line to the converter coolant inlet.

Cooling system malfunctions

Liquid cooling system malfunctions include flow, pressure, and cooling failure. Even though the converter has high temperature protection, the converter controller can de-load and shut down faster if there is a signal from the liquid cooling system that there has been a failure. The cooling system can also send a shut down signal to the converter if a leak is detected.

Air cooling system malfunctions include flow restriction or failure, and high inlet temperature.

Redundancy

Where the power converter is a critical system, all parts of the cooling must be designed so that a single failure (including fire and flooding) does not disable the critical system.

4.2 Control

The liquid cooling system must control the pressure, flow, and temperature of the coolant so that these are always within the converter's specifications.

The liquid cooling control system can also be designed to use dynamic control to optimise its own energy use. For example, if a chiller has two compressors, at low load converter loads, the control system can turn off one of the compressors.

The air cooling system must run when the converter is running.

Both the liquid cooling and the air cooling must run for a while after the converter is stopped (to cool the converter down and prevent hot spots from forming).

4.3 Communication

The iE 250/iE 350 controller has a Modbus interface. The liquid cooling system could use this interface to send data to the controller. The controller could also send set points to the liquid cooling system.

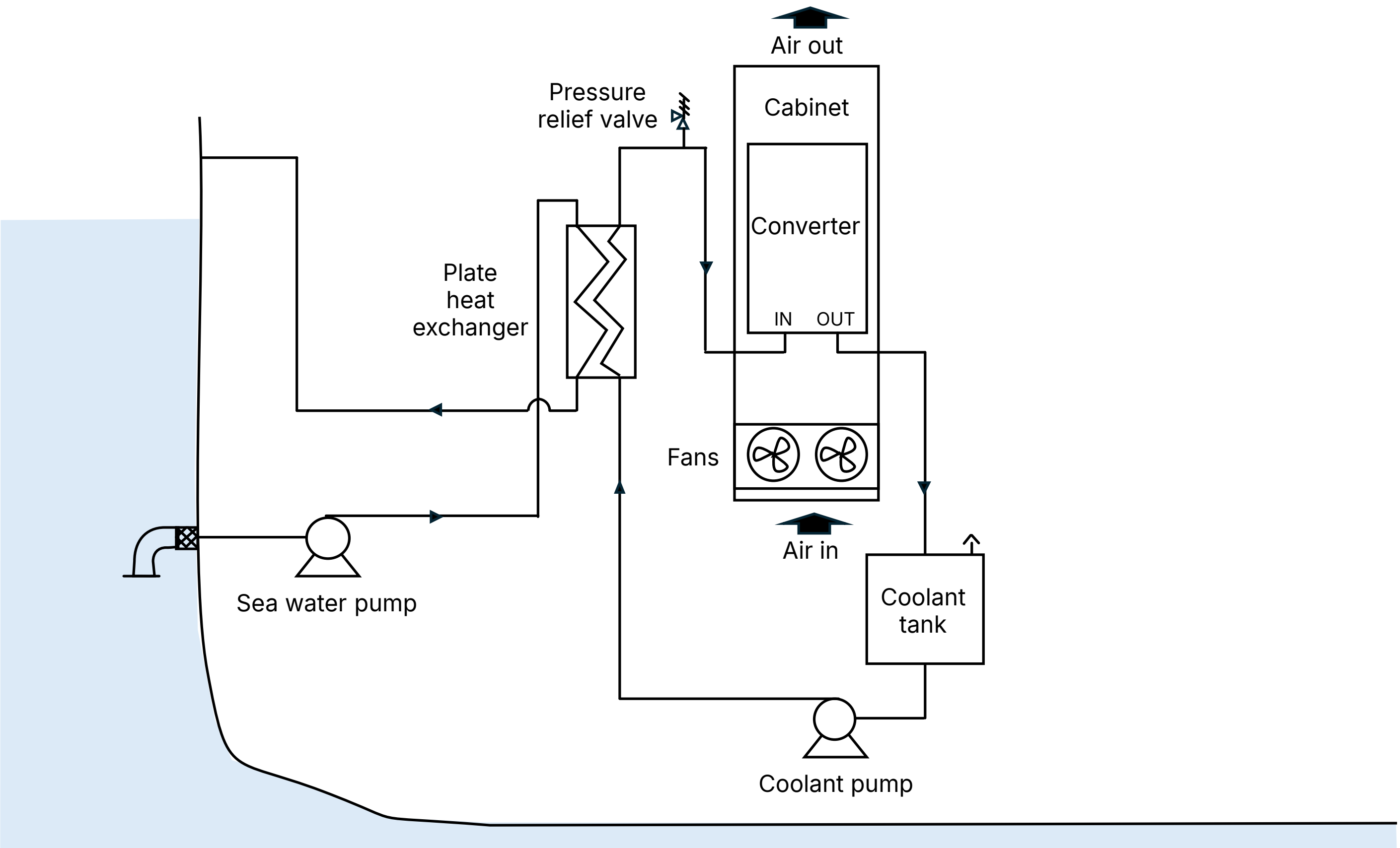
Getting a set point from the controller can allow the liquid cooling system to respond faster to load changes, as well as operate more efficiently at low loads.

Sending data from the cooling systems to the controller can simplify fault finding. Operating data can also be useful for monitoring effectiveness and scheduling maintenance.

5. Examples

5.1 Cooling in a marine application

For marine applications, sea water can be used to cool the coolant for the converter. If the ambient air is cool enough, it can be used as it is for air cooling.



Marine converter cooling example

Liquid cooling sizing

	iE Convert 150	iE Convert 500	iE Convert 1000
Heat exchanger duty	3 kW	10 kW	20 kW
Coolant flow	10 litres/minute	16 litres/minute	30 litres/minute
Coolant inlet temperature*	30 °C	30 °C	30 °C
Coolant outlet temperature**	35 °C	40 °C	41 °C
Sea water inlet temperature*	20 °C	20 °C	20 °C
Sea water outlet temperature*	25 °C	25 °C	25 °C
Sea water flow**	9 litres/minute	29 litres/minute	58 litres/minute

NOTE * These numbers are examples.
NOTE ** This value is based on the example numbers.

Air cooling sizing

	iE Convert 150	iE Convert 500	iE Convert 1000
Air cooling duty	300 W	1 kW	2 kW
Air speed	2 to 3 m/s	2 to 3 m/s	2 to 3 m/s
Air inlet temperature*	30 °C	30 °C	30 °C
Air outlet temperature*	35 °C	35 °C	35 °C
Air flow required to cool the converter**	180 m^3/h	600 m^3/h	1200 m^3/h
Air flow required to cool the other components***			
Total air flow required***			

NOTE * These numbers are examples.
NOTE ** This value is based on the example numbers.
NOTE *** The system integrator must calculate these values.

Issues for attention

Sea water quality: Polluted sea water can quickly foul the plate heat exchanger, which would reduce its effectiveness.

Spare plate exchanger: This may be needed due to the potential for rapid fouling by polluted sea water, or slow fouling over time. With salty water, corrosion is also a concern. To prevent sea water leaks into the coolant, monitoring and regular replacement of the plate exchanger may be required.

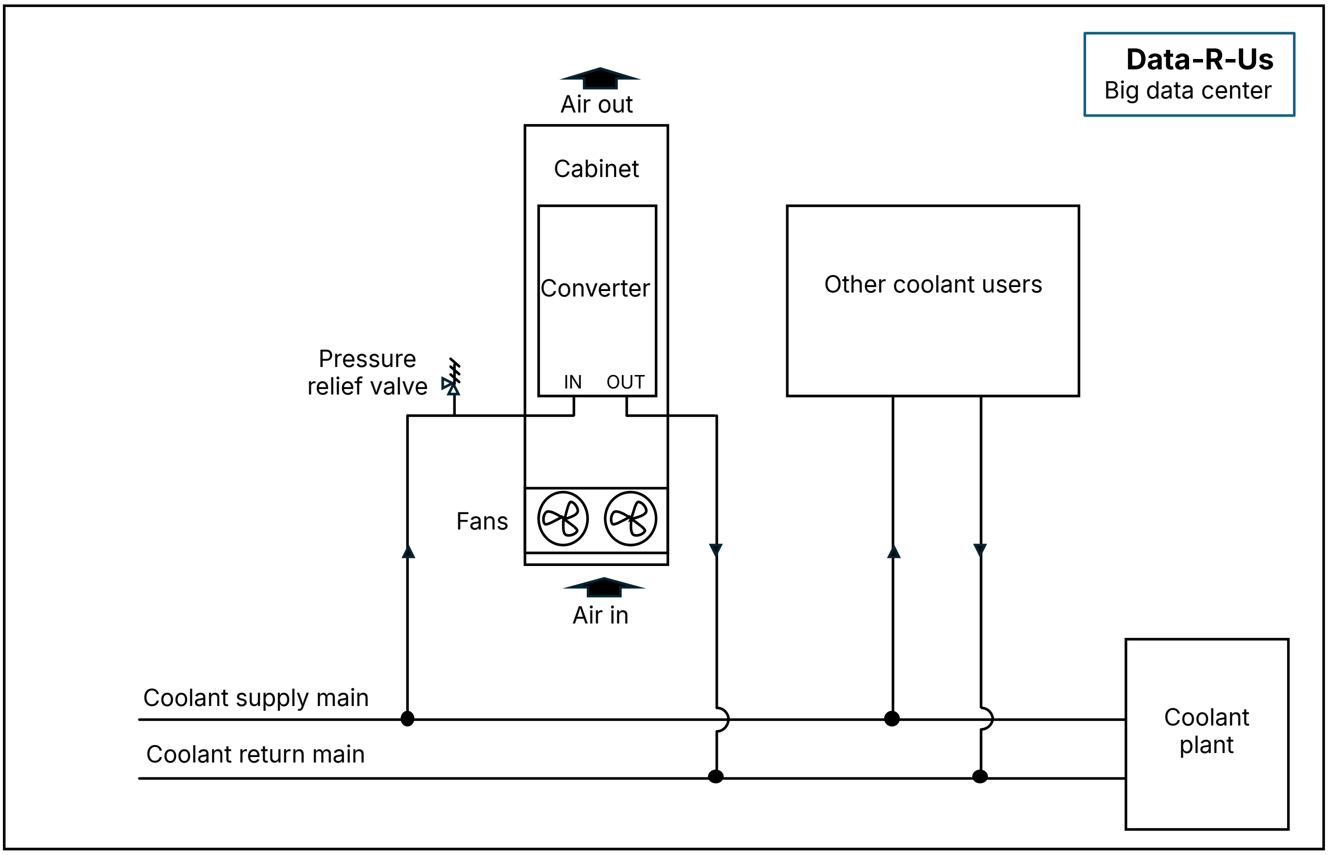
Tropical sea water: This can be up to 30 °C. A higher coolant temperature (which may require power and current derating for the converter), and/or a larger heat exchanger, may be required.

Cold sea water at low loads: The converter minimum inlet temperature is 5 °C. When the sea water is very cold, at low converter loads, you may need to use a heat exchanger bypass.

Condensation: Take measures to avoid condensation build up on the liquid cooling pipes. Make sure that there is no condensation in the converter air inlet.

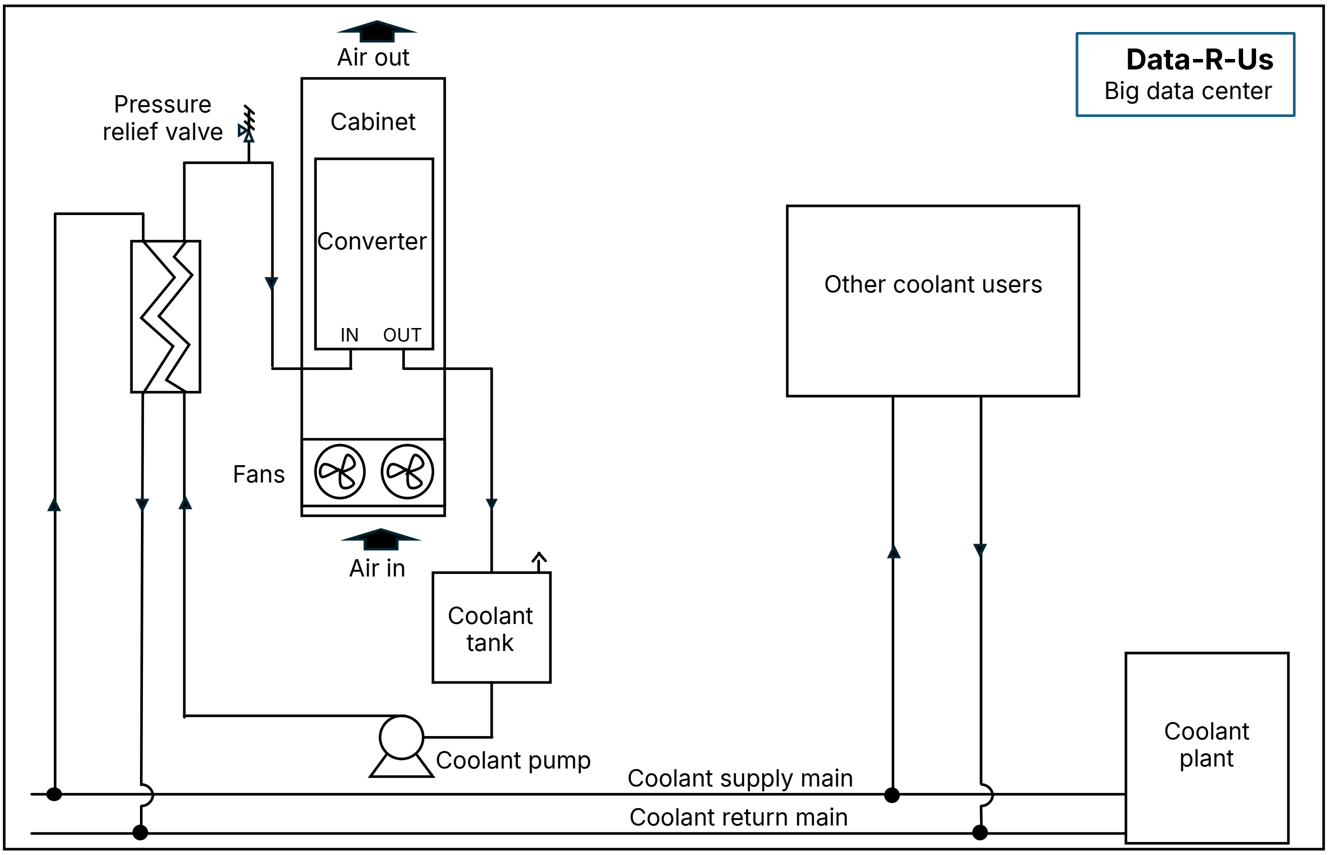
5.2 Site cooling for converters

For sites that have coolant available as a utility, this can be used for the converter. To use the site coolant directly, the site coolant composition, pressure, flow, and temperature must meet the converter specifications. The example below shows site coolant as a utility used directly in the converter, with ambient air used for the air cooling. Note that the coolant flow control is not shown.



Data center coolant as a utility - used directly - example

If the site coolant composition, pressure, flow, or temperature do not meet the converter specifications, the site coolant can be used in a plate heat exchanger to cool the converter coolant. The example below shows site coolant used to cool the converter coolant, with ambient air used for the air cooling. Note that the coolant flow control is not shown.



Data center coolant as a utility - used indirectly - example

Liquid cooling sizing

	iE Convert 150	iE Convert 500	iE Convert 1000
Duty	3 kW	10 kW	20 kW
Coolant flow	10 litres/minute	16 litres/minute	30 litres/minute
Coolant inlet temperature*	30 °C	30 °C	30 °C
Coolant outlet temperature**	35 °C	40 °C	41 °C

NOTE * These numbers are examples.
NOTE ** This value is based on the example numbers.

Air cooling sizing

	iE Convert 150	iE Convert 500	iE Convert 1000
Air cooling duty	300 W	1 kW	2 kW
Air speed	2 to 3 m/s	2 to 3 m/s	2 to 3 m/s
Air inlet temperature*	30 °C	30 °C	30 °C
Air outlet temperature*	35 °C	35 °C	35 °C
Air flow required to cool the converter**	180 m^3/h	600 m^3/h	1200 m^3/h
Air flow required to cool the other components***			
Total air flow required***			

NOTE * These numbers are examples.
NOTE ** This value is based on the example numbers.

NOTE *** The system integrator must calculate these values.

Issues for attention

Coolant composition, pressure, flow, and temperature: If coolant is available on site, it must meet all the converter specifications to be used directly. If the coolant is the wrong composition, it could still be used as a source of cooling, like the sea water in the marine example. If the composition is right, but the pressure is too high, then pressure protection with an accumulator at atmospheric pressure and return pump may be required.

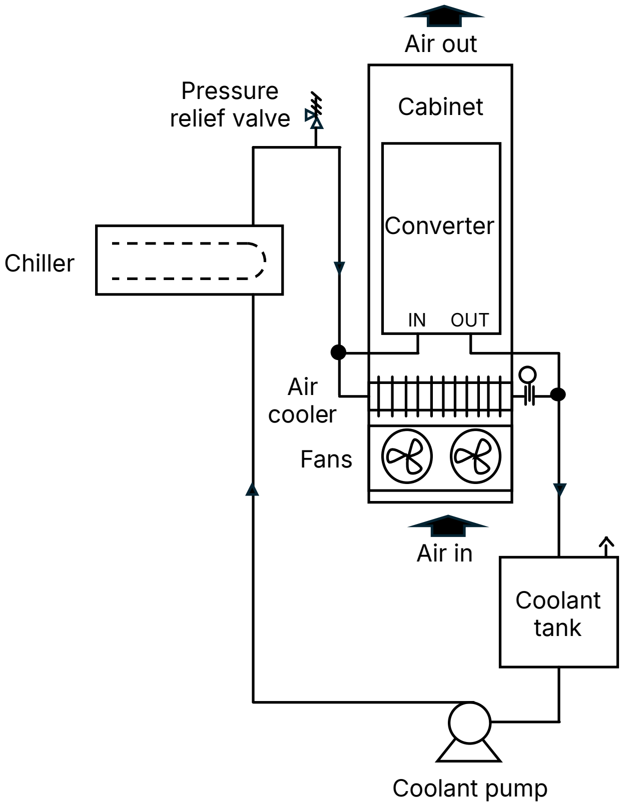
Start-up issues: The coolant must be available when the converter starts.

Coolant return temperature: The site may have requirements for the coolant return temperature. The converter design and control would need to meet these requirements.

Air cooling: If the ambient air is too hot, then some of the coolant can be used for air cooling, as shown in the chiller example.

5.3 Chiller for cooling

For sites that have a high ambient temperature, and no access to cooling water, a chiller may be required. The example below shows the chiller cooling the coolant, with some of the coolant used in to cool the air used for the air cooling.



Example of chiller used to cool the coolant, with some coolant used to cool the air

Liquid cooling sizing

	iE Convert 150	iE Convert 500	iE Convert 1000
Duty	3.3 kW	11 kW	22 kW
Coolant flow to converter	10 litres/minute	16 litres/minute	30 litres/minute
Coolant flow to air cooler**	1.5 litres/minute	2.7 litres/minute	4.5 litres/minute
Total coolant flow	11.5 litres/minute	19 litres/minute	35 litres/minute
Coolant inlet temperature*	20 °C	20 °C	20 °C
Coolant outlet temperature**	25 °C	30 °C	31 °C

NOTE * These numbers are examples.
NOTE ** This value is based on the example numbers.

Air cooling sizing

	iE Convert 150	iE Convert 500	iE Convert 1000
Converter cooling duty	300 W	1 kW	2 kW
Air speed in cabinet	2 to 3 m/s	2 to 3 m/s	2 to 3 m/s
Ambient air temperature*	45 °C	45 °C	45 °C

	iE Convert 150	iE Convert 500	iE Convert 1000
Cabinet air inlet temperature*	30 °C	30 °C	30 °C
Ambient air cooling duty**	450 W	1.5 kW	3 kW
Cabinet air outlet temperature*	35 °C	35 °C	35 °C
Air flow required to cool the converter**	180 m^3/h	600 m^3/h	1200 m^3/h
Air flow required to cool the other components***			
Total air flow required***			

NOTE * These numbers are examples.
NOTE ** This value is based on the example numbers.
NOTE *** The system integrator must calculate these values.

Issues for attention

Efficiency: If the converter regularly runs at lower loads, for higher efficiency, you may want to consider using a variable speed chiller.

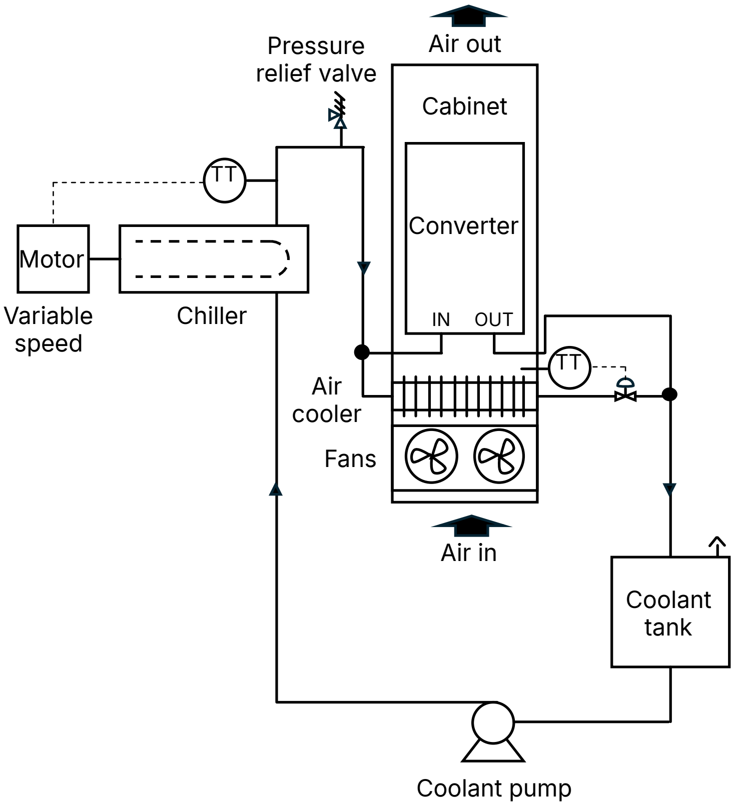
Temperature at low loads: The converter minimum inlet temperature is 5 °C. At low converter loads, you may need to use a bypass.

Condensation: Take measures to avoid condensation build up on the liquid cooling pipes. Make sure that there is no condensation after the air cooler.

Control of air cooling coolant flow: For a fixed coolant flow for the air cooling, you can use a restriction orifice (RO) plate (as shown in the drawing).

5.4 Variable speed chiller for cooling

For sites that have a high ambient temperature, and no access to cooling water, a chiller may be required. If it is likely that there will be significant periods with a low converter load, you can consider using a variable speed chiller to increase the efficiency. The example below shows a variable speed chiller cooling the coolant. Some of the coolant is used to cool the air for the air cooling. At low loads, the chiller detects the lower outlet temperature, and reduces its speed. This saves energy and increases the system efficiency.



Example of a variable speed chiller used to cool the coolant, with some coolant used to cool the air

Liquid cooling sizing

	iE Convert 150	iE Convert 500	iE Convert 1000
Duty	3.3 kW	11 kW	22 kW
Coolant flow to converter	10 litres/minute	16 litres/minute	30 litres/minute
Coolant flow to air cooler**	1.5 litres/minute	2.7 litres/minute	4.5 litres/minute
Total coolant flow	11.5 litres/minute	19 litres/minute	35 litres/minute
Coolant inlet temperature*	20 °C	20 °C	20 °C
Coolant outlet temperature**	25 °C	30 °C	31 °C

NOTE * These numbers are examples.
NOTE ** This value is based on the example numbers.

Air cooling sizing

	iE Convert 150	iE Convert 500	iE Convert 1000
Converter cooling duty	300 W	1 kW	2 kW
Air speed in cabinet	2 to 3 m/s	2 to 3 m/s	2 to 3 m/s
Ambient air temperature*	45 °C	45 °C	45 °C
Cabinet air inlet temperature*	30 °C	30 °C	30 °C
Ambient air cooling duty**	450 W	1.5 kW	3 kW
Cabinet air outlet temperature*	35 °C	35 °C	35 °C
Air flow required to cool the converter**	180 m^3/h	600 m^3/h	1200 m^3/h
Air flow required to cool the other components***			
Total air flow required***			

NOTE * These numbers are examples.
NOTE ** This value is based on the example numbers.
NOTE *** The system integrator must calculate these values.

Efficiency effect of a variable speed chiller

Variable speed chiller example

At 100 % of the load, the chiller must remove 11 kW of heat (10 kW for liquid cooling, and 1 kW to cool the air). At 50 % of the load, the chiller must remove 6 kW of heat (10 kW for liquid cooling, and 1 kW to cool the air).

For a modern variable-speed air-cooled chiller, the coefficient of performance may be 3.0 to 4.0 at 100 % load, and 4.0 to 6.0 at 50 % load. The chiller then requires about 3.1 kW for 11 kW of cooling, and 1.2 kW for 6 kW of cooling. That is, the load drops to 55 %, but the power drops to 39 %.

Assuming that all other variables are constant, if the chiller runs at full (100 %) load continuously for a year, it will require about 28 MWh of electrical power. At half (50 %) load for a year, it will require about 11 MWh. If the chiller runs at full load 90 % of the time, and at half load 10 % of the time, the variable speed chiller will save about 1.7 MWh of electrical power per year. If the chiller runs at full load half the time, and at half load the rest of the time, the variable speed chiller will save about 8.5 MWh of electrical power per year.

In reality, the variable speed chiller will run more effectively (at lower loads) when the ambient temperature is lower. In addition, the load can be reduced by using a control loop to optimise the cabinet air cooling.

Issues for attention

Condensation: Take measures to avoid condensation build up on the liquid cooling pipes. Make sure that there is no condensation after the air cooler.

Control of the coolant flow for air cooling: For a fixed coolant flow for the air cooling, you can use a restriction orifice (RO) plate (as shown in the Chiller for cooling drawing). However, operate more effectively at lower loads, use a coolant valve that is controlled by the air temperature after the air cooler, as shown above.

5.5 Cooling system vendors

To help you select the equipment that is right for you, here is a list of vendors for liquid and air cooling. DEIF is however not responsible for the products and services from these vendors.

NOTE The links are only for guidance. They do not belong to DEIF, and could be changed at any time.

5.5.1 Adwatec

Main website: adwatec.com/

Marine: adwatec.com/industries/marine/

Other applications: adwatec.com/industries/other-applications/

5.5.2 AKG

Main website: www.akg-group.com/akg-group/

5.5.3 Envicool

Main website: en.envicool.net/

5.5.4 HydraSpecma

Main website: www.hydraspecma.com/store/dk/en

5.5.5 Pfannenberg

Main website: www.pfannenberg.com/en/

Liquid cooling: www.pfannenberg.com/en/liquid-cooling/

Thermal management: www.pfannenberg.com/en/thermal-management/

5.5.6 Rittal

Main website: www.rittal.com

Fans, filter fans, air/air heat exchangers: www.rittal.com/com-en/products/PG20231215KLI101/PG20231215KLI102

Air-water heat exchangers, chillers: www.rittal.com/com-en/products/PG20231215KLI101/PG20231215KLI104