Cooling systems for 90...800 kW inverters

All Altivar frequency inverters are characterized by high efficiency. The lost heat, due to the power size, from frequency inverters with more than 100kW is not irrelevant and needs careful attention especially regarding the protection degree.

This guide shows well proven solutions for an optimal integration of the Altivar 61 & 71 HHP (High Horse Power) inverter range into enclosures. These are the basic requirements to ensure operation without trouble resulting in a high customer satisfaction.
**IP23 „Basic design“**

**Typical applications**
- HHP frequency inverter in an enclosure for installation in electrical rooms
- HHP frequency inverter in an enclosure for installation in operating rooms with moderate dust exposure
- Ambient temperature: 0...+40°C
  (-10...+40°C with enclosure heating)
- Ambient temperature up to +50°C with derating

**Principle design**
The fan of the power part, which is inside the device, provides the forced cooling of the inverter and the heat abstraction of the enclosure. The cooling air is supplied by a grill in the enclosure door with large surface. For the air outlet, a cut-out in the roof sheet of the enclosure is provided and an air guidance hood is mounted onto it. The installation of the frequency inverter into the enclosure can be realized with a DCL box at the top side of the inverter or with a line reactor below the inverter.

1. Enclosure
2. Frequency inverter Altivar 61 or Altivar 71
3. DCL box (only available for 400V product lines)
4. Power part components (main switch, line contactor, chokes,…)
5. Air inlet grid (without filter mat) for control part and power part
6. Guided air flow (air channel) to avoid internal air short-cuts
7. Air guidance hood with splash water protection

Main parts of these cooling systems are the guided air flow inside the enclosure (air channel between inverter/DCL box and the roof sheet of the enclosure) and the air guidance hood mounted outside. On the one hand, an internal air short-cut is prevented and on the other hand the specifications for IP 23 are fulfilled.
The air exchange takes place by the inlet grill (without filter mat!) in the enclosure door and the cut-out in the roof sheet to the air guidance hood.

This cooling system does not need additional fans in the enclosure. The fan of the control part as well as the fan of the power part inside the inverter provide the required air flow.
The forced cooling of the power part components, which is built-in below the inverter, is also very advantageous.

*This cooling system is used for Altivar Plus - ATV61EXC2 and ATV71EXC2.*
**IP54 „Compact design“**

**Typical applications**
- HHP frequency inverter in an enclosure for installation outside of electrical operating rooms
- Ambient temperature: 0...+40°C
  (-10...+40°C with enclosure heating)
- Ambient temperature up to +50°C with derating

**Principle design**
At protection degree IP54 with filter mats the input of the cooling air takes place through the filters in the enclosure door and the output through a fan at the top of the enclosure.

1. Enclosure
2. Frequency inverter Altivar 61 or Altivar 71
3. Power part components (main switch, line contactor, chokes,...)
4. Air inlet grid (with filter mat) for control part and power part
5. Fan (with filter mat)

The pressure drop at the inlet- and outlet filter mats makes an additional fan in the enclosure necessary. It must provide at least the flow rate of the power part fans of the inverter and additionally it must overcome the pressure drop.

An additional air flow inside the enclosure is not necessary.

Advantages are the particular compactness and the economic design. High reliability in case of regular cleaning or exchanging the filter mats. Low pollution inside the enclosure. The dust of the cooling air is concentrated on the filter mats where it can be easily removed.

This cooling system is used for Altivar Plus - ATV61EXC5 and ATV71EXC5.
Typical applications

- HHP frequency inverter in an enclosure for installation outside of electrical operating rooms with increased dust exposure of cooling air
- Ambient temperature: 0...+40°C
  (-10...+40°C with enclosure heating)
- Ambient temperature up to +50°C with derating

Principle design

In case of protection degree IP54 with separate air channel the cooling air inlet for the power part takes place through the plinth and the air outlet through the enclosure roof. The control part is cooled by filter fans in the enclosure door.

1. Enclosure
2. Frequency inverter Altivar 61 or Altivar 71
3. DC choke (only available for 400V product lines)
4. Cooling air inlet for power part (via enclosure plinth)
5. Air guidance channel
6. Air outlet through air guidance hood with splash water protection
7. Air inlet (with filter mat) for control part
8. Air outlet (with filter fan and filter mat) for control part

For dimensioning the cooling circuit "control part”, consider the internal losses of the inverter and the losses of other components in the enclosure. The maximum difference of temperature is 10 K.

Clear internal separation of the cooling air for power part and control part. Only the cooling air for the control part is dissipated through filter mats. The cooling air of the power part does not require filter mats.

High reliability in case of regular cleaning or exchanging the filter mats. Low pollution inside the enclosure.

This cooling system is used for Altivar Plus - ATV61EXS5 and ATV71EXS5.
IP54 “Separated air flow” with air/air heat exchanger

Typical applications
- HHP frequency inverter in an enclosure for installation outside of electrical operating rooms with increased dust exposure of cooling air
- Ambient temperature: 0...+45°C
  (-10...+45°C with enclosure heating)

Principle design
The cooling air inlet for the power part takes place through the plinth and the air outlet through the enclosure roof. The losses of the control part are dissipated via an air/air heat exchanger in the enclosure door. So no external air comes into the enclosure.

1. Enclosure
2. Frequency inverter Altivar 61 or Altivar 71
3. DC choke (only available for 400V product lines)
4. Cooling air inlet for power part (via enclosure plinth)
5. Air guidance channel
6. Air outlet through air guidance hood with splash water protection
7. Air/air heat exchanger for cooling the control part
8. Internal cooling air circuit for control part
9. External cooling air circuit

The air/air heat exchanger dissipates already the lost heat, occurring in the enclosure at a temperature difference of 5 K, to the ambient air. Its dimensioning is based on the “internal losses” of the inverter.

Additionally to the separated air flow of the power part, also the cooling air of the control part is completely separated in this case. Via the air/air heat exchanger the losses of the control part are dissipated without direct air exchange. So the entry of dust into the enclosure is nearly prevented.

This cooling system is used for the Altivar 61 & 71 mounting set for complete devices in an IP 54 housing (VW3 A9 541 to VW3 A9 549).
**IP54 „Separated air flow“ with air condition**

**Typical applications**
- HHP frequency inverter in an enclosure for installation outside of electrical operating rooms with increased dust exposure of cooling air and high ambient temperatures at the same time
- Ambient temperature: 0...+40°C
  (-10...+40°C with enclosure heating)
- Ambient temperature up to +55°C with derating

**Principle design**
In case of protection degree IP54 with air condition the cooling air inlet for the power part takes place through the plinth and the air outlet through the enclosure roof. The losses of the control part are dissipated by an active air condition which is arranged on the enclosure door.

1. Enclosure
2. Frequency inverter Altivar 61 or Altivar 71
3. DC choke (only available for 400V product lines)
4. Cooling air inlet for power part (via enclosure plinth)
5. Air guidance channel
6. Air outlet through air guidance hood with splash water protection
7. Active air condition for cooling the control part
8. Internal cooling air circuit for control part
9. External cooling air circuit

In contrast to the air/air heat exchanger the temperature of the internal cooling circuit is lowered in the air condition. The air condition requires a power supply (typically 230V, 50Hz) for operating the compressor and the two fans.

In case of this design variant higher ambient temperatures (with derating of the inverter at the same time) can be permitted.

This cooling system can be provided within the Altivar 61 Plus and ATV 71 Plus "Flexible offer".
Cooling systems for inverters with liquid cooling 90...800 kW

1st quarter 2011 available!
Altivar 61Q & Altivar 71Q

The today’s requirements of our customers as well as our knowledge from more than 20 years experience in manufacturing of liquid cooled power electronics were the specifications for developing the especially robust ATVQ inverters.

Heat sink:
- Cooling circuit completely made of stainless steel
- Continuously big flow channel
- Smooth internal walls
- Additional fans for reliable internal air circulation

Cooling circuit:
- Hydraulic and electrical connections are clearly separated
- High permitted temperature range of the cooling water
- Complete de-aerating
- High-quality, double-sealed connections

General technical data

<table>
<thead>
<tr>
<th>Voltage / frequency</th>
<th>380 V / 400 V / 440 V / 480 V ±10 %: 50/60 Hz ±5 %</th>
<th>500 V / 600 V / 690 V ±10 %: 50/60 Hz ±5 %</th>
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<td>ATV 61Q: -10...+45 °C</td>
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<td>Filling quantity / flow rate:</td>
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<td>ATV71QC16N4...C25N4, ATV71QC20Y...C31Y, ATV61QC20N4...C31N4, ATV61QC25Y...C40Y: 0.4 l / 24 l/min</td>
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<td>Standards</td>
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IP23 with external cooling circuit

Typical applications
- Liquid-cooled HHP frequency inverters in an enclosure for integration into a machine cooling system, e.g. at plastics machines
- Temperature of coolant: up to +55°C
- Ambient temperature up to +50°C

Principle design
The cooling circuit of the power part of the inverter is integrated into the cooling system of the drive. It provides the required flow and controls the temperature of the cooling water. The cooling of the control part as well as of other power part components is realized by the internal device fans.

1. Enclosure
2. Frequency inverter Altivar 61Q or Altivar 71Q
3. Power part components (main switch, line contactor, chokes,...)
4. Cooling water inlet / return
5. Air inlet grid in the enclosure door (without filter mat) for control part
6. Air guidance hood with splash water protection

The cooling circuit can be realized as open or closed cooling circuit, with industrial water, water-glycol-mixture or flowing water. In any case, you have to avoid condensation particularly.

Liquid cooling of electrical and mechanical units is already best-proven in the area of plastics machines, for example. Due to their robust cooling system, the Altivar 61Q & Altivar 71Q frequency inverters can be particularly integrated into existing cooling concepts.

Within the Altivar 61 Plus and Altivar 71 Plus "Flexible offer", we can provide water-cooled frequency inverters as a solution for installation into an enclosure.
IP23 with an external air heat exchanger

Typical applications
- Liquid cooled HHP frequency inverter in an enclosure with an external air heat exchanger
- Cooling air temperature for heat exchanger: up to +40°C
- Ambient temperature in the electrical room: up to +50°C

Principle design
The coolant will be cooled in an external heat exchanger. Thereby results a separation of the frequency inverter to the cooling air flow. The cooling of the control part as well as of other power part components is realized by the internal device fans.

1. Enclosure
2. Frequency inverter Altivar 61Q or Altivar 71Q
3. Power part components (main switch, line contactor, chokes, …)
4. Internal cooling circuit
5. Water/water heat exchanger
6. External cooling circuit
7. External air/water heat exchanger
8. Air inlet grid in the enclosure door (without filter mat) for control part
9. Air guidance hood with splash water protection

The 2 stage cooling circuit enables the installation of the air/water heat exchanger at distances further away. With the corresponding efficiency of the circulation pump large distances and large height differences are possible.

To install the heat exchanger within immediate distance of the frequency inverter (for example on the roof of the container) the design can also be in the form of a simple cooling circuit. This system is recommended if the heat exchanger and the frequency inverter are to be delivered as one ready-for-use unit.

The lost heat of several inverters with high power in an electrical room can easily lead to overheating of the operating room. On the other hand, when the main losses of the inverters are dissipated to a liquid coolant, the installation of an expensive air conditioning can be avoided.

With their internal liquid cooling the Altivar 61Q & Altivar 71Q frequency inverter are optimally prepared for these applications. In this concept about 85% of the inverter losses are dissipated from the electrical room by means of the cooling water.

Within the Altivar 61 Plus and Altivar 71 Plus "Flexible offer", we can provide water-cooled frequency inverters as a solution for installation into an enclosure.
**IP55 with external water cooling**

**Typical applications**
- Liquid cooled HHP frequency inverters in a closed enclosure
- Very harsh environmental conditions e.g. mining and tunneling
- Cooling water inlet temperature: +5 ... +35°C
- Ambient temperature: up to +60°C

**Principle design**
With this design the total losses of control part and power part are conducted via the cooling water. In order to transfer the control part losses into the cooling water, an air/water heat exchanger is built-in additionally.

1. Enclosure IP55
2. Frequency inverter Altivar 61Q or Altivar 71Q
3. Power part components (main switch, line contactor, chokes,...)
4. Air/water heat exchanger
5. Internal cooling circuit
6. Water/water heat exchanger
7. External cooling water

Enclosures in protection degree IP55 or higher, closed containers or also pressure-resistant encapsulation require a complete heat abstraction of the whole electrical drive unit. Therefore 100 % of the losses must be dissipated by the cooling water. This can be done easily with an additional air/water heat exchanger. Thereby the monitored fans in the inverter provide the required air circulation inside the enclosure.

The completely closed enclosure system prevents a penetration of dust and aggressive ambient air. Likewise "low noise" requirements are optimally fulfilled due to the completely closed inverter unit.

Within the Altivar 61 Plus and Altivar 71 Plus "Flexible offer", we can provide water-cooled frequency inverters as a solution for installation into an enclosure.
IP55 with air cooling

Typical applications
- Liquid cooled HHP frequency inverters in a closed enclosure with air cooling
- For environments with conductive dust e.g. shredders
- Ambient temperature: up to +40°C

Principle design
Due to the integrated air/water heat exchanger and the highly efficient heat exchanger, a complete sealing of the inverter enclosure is possible. The total losses of control part and power part are dissipated via the cooling water. The heat exchange occurs in the air/water heat exchanger.

1. Enclosure with frequency inverter IP55
2. Incoming enclosure with control components
3. Cooling enclosure with heat exchanger
4. Frequency inverter Altivar 61Q or Altivar 71Q
5. Power part components (line contactor, chokes, ...)
6. Internal air/water heat exchanger
7. Internal cooling circuit
8. Air/water heat exchanger

A dust loading even with conductive particles cannot be prevented around shredder drives, especially in case of recycling processes. As a result, special requirements regarding the protection degree are needed for the electrical installation. In a perfectly adapted drive system, sealing walls between the accessible connecting area, the inverter enclosure and the cooling enclosure prevent intrusion of dangerous particles.

The inverter enclosure is securely closed and must not be opened for connection or start-up. The monitored fans in the inverter as well as the air/water heat exchanger reliably provide the required cooling inside the inverter enclosure.

Within the Altivar 61 Plus and Altivar 71 Plus "Flexible offer", we can provide water-cooled frequency inverters as a solution for installation into an enclosure

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