Technical Information

Application Note | Liquid Cooling of Drive Controllers

File name	ti_dr_an-liquid-cooling-00004_en.pdf
Version	10/2022

1 Preface

The hardware and software described in this document are products of KEB. The information contained in this document is valid at the time of publishing. KEB reserves the right to update this document in response to misprints, mistakes or technical changes.

The application notes describe solved application cases. They serve designers and developers as an approach for designing their own applications. However, they are only valid as non-binding information. The selection with regard to their suitability for the intended application can only be made by the user.

The use of our devices in the target products is beyond our control and is therefore the sole responsibility of the machine manufacturer, system integrator or customer.

1.1 Signal words and symbols

The signal words and symbols used in this documentation have the following meaning:

⚠ DANGER	➢ Dangerous situation, which will cause death or serious injury if this safety warning is ignored.
⚠ WARNING	➢ Dangerous situation, which may cause death or serious injury if this safety warning is ignored.
⚠ CAUTION	➢ Dangerous situation, which may cause minor injury if this safety warning is ignored.
NOTICE	➢ Situation, which can cause damage to property if this safety warning is ignored.

RESTRICTION

Used when the following statements depend on certain conditions or are only valid for certain ranges of values.

i	➢ Used for informational messages or recommended procedures.

► This arrow starts an action step.

• / - Enumerations are marked with dots or indents.

=> Cross reference to another chapter or another page.

Content

Figures

Tables

2 Cooling of drive controllers

2.1 Cooling process

- Air-cooling
- **Liquid cooling (this manual supplement the installation manual)**
  - Water cooling
  - Oil Cooling

2.2 Application area

The use of water-cooled KEB COMBIVERT drive controllers is recommended for applications when coolant is present due to the process.

2.3 Safety instructions for the use of liquid heat sinks

⚠ CAUTION

High temperatures at heat sink and coolant!
Skin burns

- ➢ Cover hot surfaces safe-to-touch.
- ➢ If necessary, attach warning signs on the system.
- ➢ Before touching, check the surface and coolant pipes.
- ➢ Let the device cool down before starting any work.

2.4 Start-up

2.4.1 Flushing the cooling circuit

In order to vent the system beforehand, it is necessary to flush the cooling circuit. To do this beforehand

- Check the tightness of the cooling circuit.
- Check valves and pumps for function.
- Open shut-off valves, if available.
- Open the solenoid valve manually.

The times of the flushing process are shown in the table.

Volume flow [l/min]	Time [s]
5	10
10	5
15	2

Table 2-1 Flushing time for venting the heat sink

NOTICE

Observe flushing time!

- ➢ A flushing time of 10 seconds must not be exceeded. Exceeding the flushing time of 10s can lead to condensation (=> „*dew point* table water cooling“ / „*Dew point* table Oil Cooling“). If the entire cooling circuit must be flushed for more than 10s for venting, no voltage must be applied to the device as long as there is condensation.

2.5 Shutdown, storage and transport

In order to avoid deposits and corrosion, the cooling circuit must be emptied during longer shutdown or storage. If there is a risk of frost, the cooling circuit should be blown out with compressed air.

➢ Further information on storage and transport can be found in the corresponding power unit instructions.
=> F6 Power units

3 Water cooling

This chapter refers to the aluminium heat sink with stainless steel tubes.

3.1 Safety instructions for water cooling

NOTICE

Keep electrochemical processes low!

➢ In case of water cooling, make sure that the conductor cross-section for potential equalization is appropriate.

3.2 Coolant requirements

NOTICE

Corrosion on the heat sink!
Do not use pure water for cooling!

➢ The use of corrosion protection inhibitors is recommended.

➢ If used below 0°C, use an antifreeze/glycol mixture.

The requirements for the coolant depend on the ambient conditions as well as the used cooling system.

3.2.1 Corrosion protection

Additives can be used as corrosion protection. In connection with frost protection the antifreeze must have a concentration of min. 20%, max. 52%, in order to avoid a change of the additives.

3.2.2 Frost protection

An appropriate antifreeze must be used for applications when the heat sink or the coolant is exposed temperatures below zero. Use only products of one manufacturer for a better compatibility with other additives.

3.2.3 Others

In order to protect the materials or to avoid deposits, hard or soft water can be supplemented with appropriate additives.

NOTICE

Avoid abrasives and contaminations!
Do not use pure water for cooling!

➢ By using a water filter, abrasives and contamination can be avoided.

3.3 Coolant temperature

With liquid cooling (water), the inlet temperature may not exceed 40°C.

The maximum heat sink temperature is specified in the "Installation" section of the instructions for use in chapter => *"Switching frequency and temperature"*.

The flow temperature should be selected depending on the volume flow so that the heat sink temperature is always 10 K below the overtemperature level (OH) during rated operation. This avoids sporadic shutdown.

3.4 Volume flow

The minimum and maximum volume flow for cooling the drive controllers and the associated characteristic curves are described in the instructions for use, chapter "Installation" of the respective housing size.

➢ In order to monitor the volume flow in the cooling system, KEB recommends the use of a volume flow monitor.

3.5 Pressure drop

The pressure drop of the drive controller required to design the cooling circuit and the associated characteristics are described in the "Installation" section of the instructions for use for the respective housing size.

3.6 Power dissipation of the drive controllers

The maximum power dissipation of the drive controllers is specified in the instructions for use, chapter "Installation" for the respective housing size.

3.7 Coolant management (water)

Connections, pipe diameter and required screw connections are described in the instructions for use part "Installation“ for the respective housing size.

The connection to the cooling system can occur as closed or open cooling circuit. The connection to a closed cycle cooling circuit is recommended, because the danger of contamination of coolant is very small. Preferably also a monitoring of the pH value of the coolant should be installed.

Cooling liquid management is permissible for the following housing size. The largest device size for the respective housing size is listed:

Device size	Housing	Power dissipation P_D / W
20	3	700
22	4	1.082
23	6	2.074
28	7	3.550
30	8	5.300
33	9	7.000

Table 3-1 Valid devices for coolant management

3.7.1 Condensation protection

A temperature difference between drive controller and ambient temperature can lead to condensation at high humidity. The dew point table is used to determine the permissible temperature differences (=> *Table 3-2*). The table shows the coolant inlet temperature depending on the ambient temperature and air humidity.

The easiest way to avoid condensation is to supply an optimally tempered coolant. This is possible by using suitable cooling systems with heating in the cooling circuit to control the coolant temperature.The dew point table (=> *Table 3-2*) is available to determine the suitable flow temperature.

Air humidity [%] / Ambient temperature [°C]	10	20	30	40	50	60	70	80	90	100
-25	-45	-40	-36	-34	-32	-30	-29	-27	-26	-25
-20	-42	-36	-32	-29	-27	-25	-24	-22	-21	-20
-15	-37	-31	-27	-24	-22	-20	-18	-16	-15	-15
-10	-34	-26	-22	-19	-17	-15	-13	-11	-11	-10
-5	0	-22	-18	0	-13	-11	-8	-7	-6	-5
0	-26	-19	-14	-11	-8	-6	-4	-3	-2	0
5	-23	-15	-11	-7	-5	-2	0	2	3	5
10	-19	-11	-7	-3	0	1	4	6	8	9
15	-18	-7	-3	1	4	7	9	11	13	15
20	-12	-4	1	5	9	12	14	16	18	20
25	-8	0	5	10	13	16	19	21	23	25
30	-6	3	10	14	18	21	24	26	28	30
35	-2	8	14	18	22	25	28	31	33	35
40	1	11	18	22	27	31	33	36	38	40
45	4	15	22	27	32	36	38	41	43	45
50	8	19	28	32	36	40	43	45	48	50

Table 3-2 dew point table water cooling

NOTICE

Avoid moisture condensation!
Destruction of the drive controller due to short circuit!

➢ The user must guarantee that any moisture condensation is avoided!

To avoid condensation, the following prioritisation is proposed:

- Supply of optimally tempered cooling liquid
- Coolant control with circulating pump
- Coolant control with 2-way proportional valve
- Coolant control with 2/2-way proportional valve

3.7.2 Supply of temper coolant

The easiest way to avoid condensation is to supply an optimally tempered coolant. This can be achieved by using recooling systems

3.7.3 Coolant control with circulating pump

NOTICE

Observe the switching current of the valve!

➢ If switching current > output current of the digital output, then use a circuit breaker.

To completely avoid the risk of condensation without tempered coolant, a hydraulic circuit with circulating pump can be accessed.

The cooling medium flows by means of an additional circulating pump in a circle through the drive controller, whereby the coolant heats up due to the power dissipation. After exceeding the set temperature limit, cold coolant is added by means of a 2/2-way control valve, e.g. Bürkert 6213-EV-A13 or similar. A check valve is absolutely necessary for the cooling flow direction. Make sure that the valves are working properly and do not clamp.

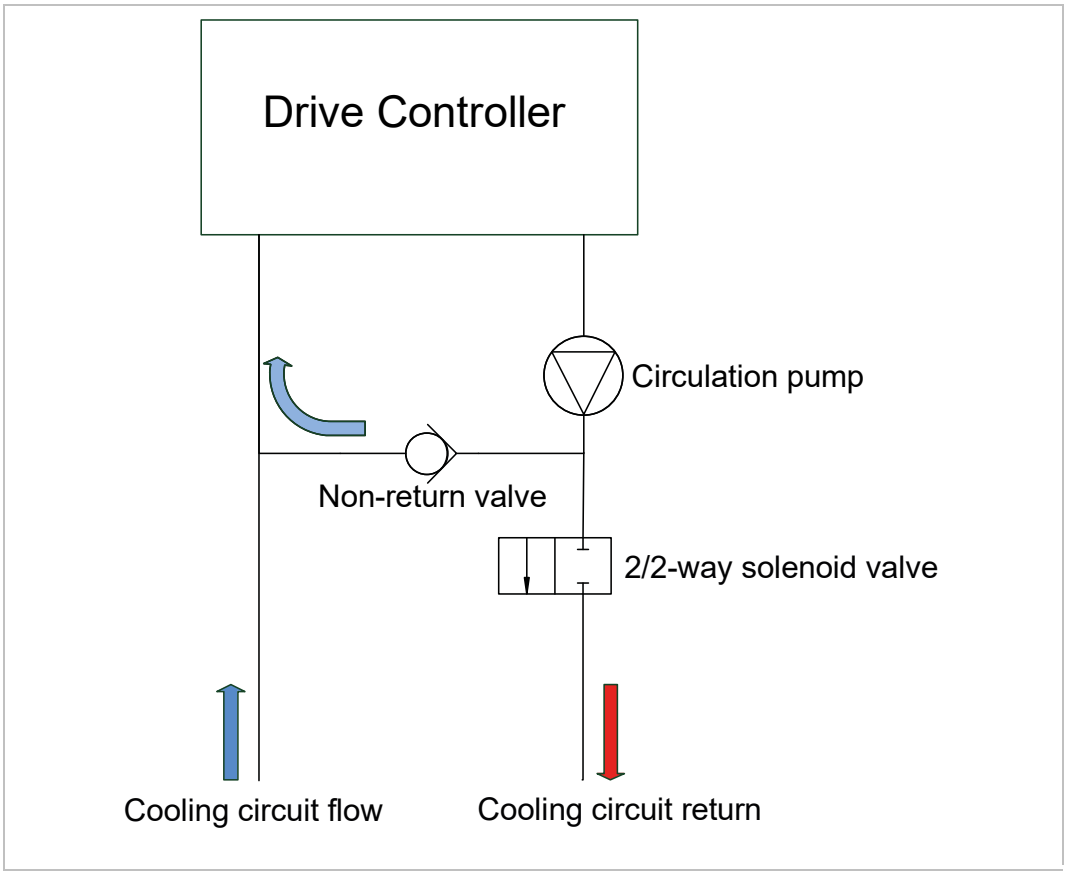

Figure 1 Coolant control with circulating pump

The cooling circuit must be flushed before commissioning (=> *Chapter 2.4.1 Flushing the cooling* circuit).

The valve is controlled via a PWM signal (=> *Chapter 3.8 Parameterization*). The cycle duration can be set in the software with max. 20s. For this hydraulic circuit we recommend 12s in order to increase the service life of the valve.

With this circuit, low heat sink temperatures can be avoided and safe operation is possible without the availability of tempered coolant.

3.7.4 Coolant control with 2-way proportional valve

With coolant control by means of a 2-way proportional valve, dew-free operation cannot be completely guaranteed. Condensation can still occur at low flow temperatures, high ambient temperatures and high air humidity.

Whether the coolant control is suitable for safe operation must be checked according to the dew point table (Table 1).

For constant control to the temperature setpoint, a circuit with a 2-way proportional valve, e.g. Danfoss EV260B or similar, can be used. For this purpose the valve must be inserted in the flow line.

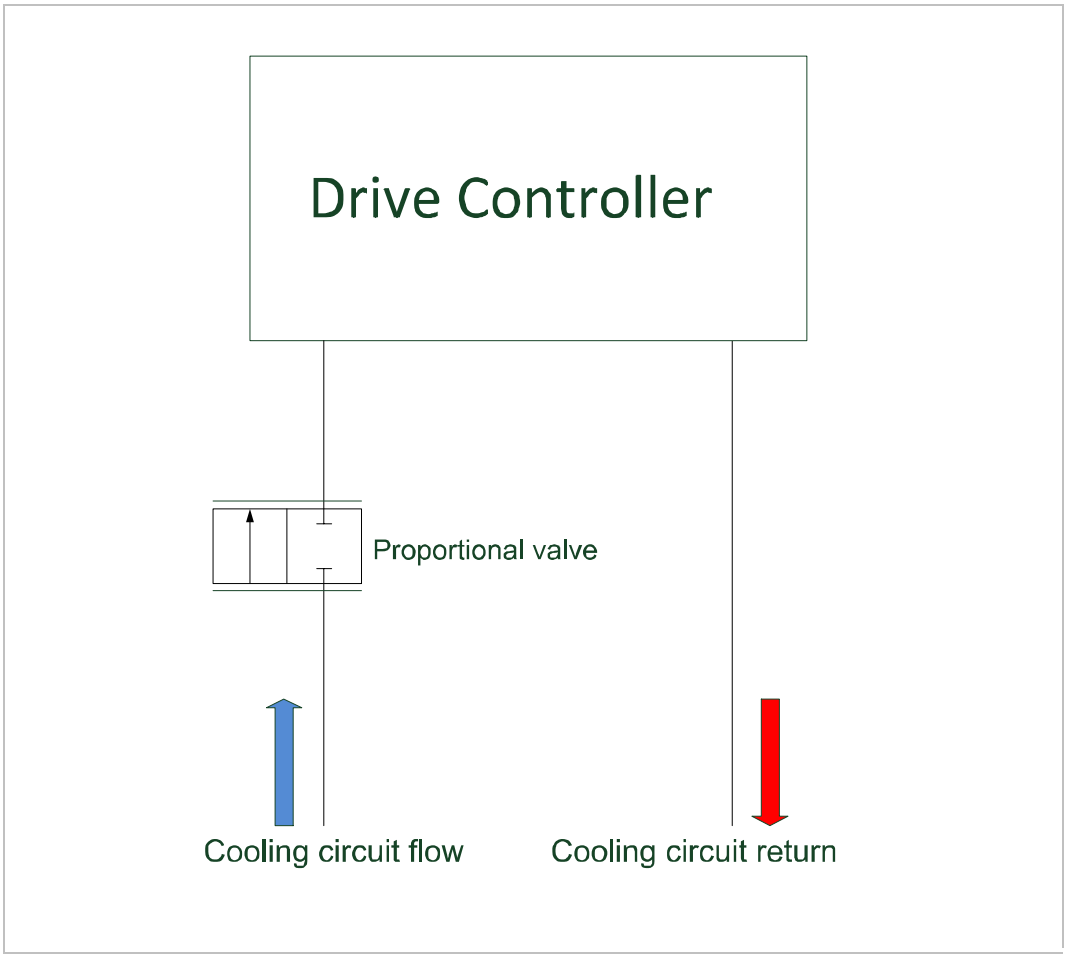

Figure 2 Coolant control with 2-way proportional valve

The cooling circuit must be flushed before commissioning (=> *Chapter 2.4.1 Flushing the cooling* circuit).

The temperature setpoint can be preset by software (=> *Chapter 3.8 Parameterization*).

Information on the switching currents at the analog outputs can be found in the respective control unit manual => *F6 Control units*.

3.7.5 Coolant control with 2/2-way proportional valve

NOTICE

Observe the switching current of the valve!

➢ If switching current > output current of the digital output, then use a circuit breaker.

With the coolant control by means of a 2/2-way proportional valve, dew-free operation cannot be completely guaranteed. Condensation can still occur at low flow temperatures, at high ambient temperatures and high air humidity.

Whether the coolant control is suitable for safe operation must be checked according to the dew point table (=> *Table 3-2 dew* point table).

As a simplified version, a coolant control by means of a 2/2-way control valve can be used, e.g. Bürkert 6213-EV-A13 or similar. For this purpose the valve must also be inserted in the flow line.The coolant is without circulation in the drive controller. After the preset setpoint temperature has been exceeded, cold coolant is added by opening the valve. Make sure that the valves are working properly and do not clamp.

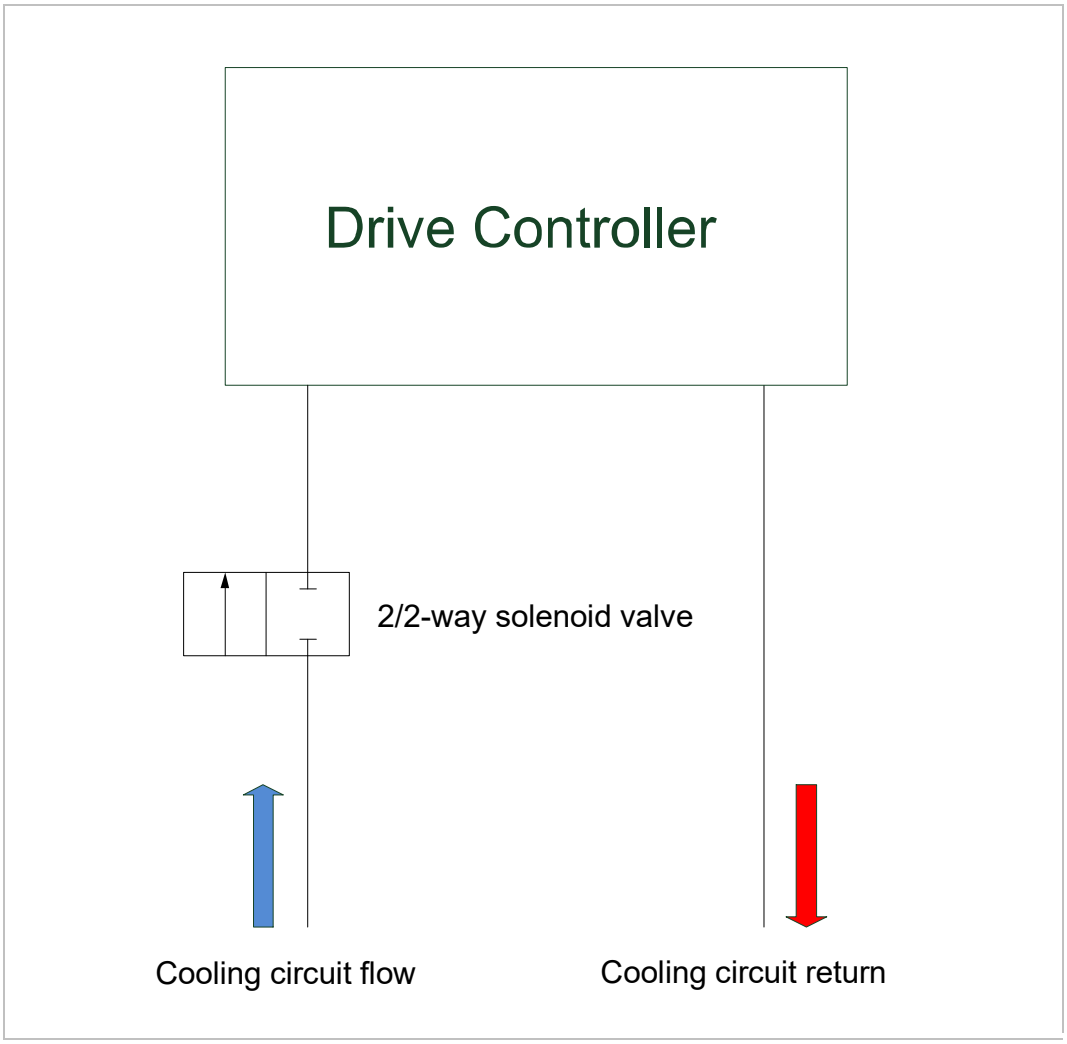

Figure 3 Coolant control with 2/2-way solenoid valve

The valve is also controlled by the PWM signal. A typical value for 2/2-way valves is 20 million switching cycles. However, this is always dependent on the operating point and

must be clarified with the manufacturer accordingly. In order to achieve a moderate service life with the typical value (up to 5 years), the valve must not switch below 8s. This is expected to result in a significant reduction in service life and thus longer maintenance intervals.

NOTICE

Observe cycle duration!

- The cxcle duration must not exceed 20s.
- With high cycle duration, the semiconductor modules are thermally overstressed, which leads to a reduction in service life.
- A cycle duration of less than 8s reduces the service life of the valve.

The cooling circuit must be flushed before commissioning (=> *Chapter 2.4.1 Flushing the cooling* circuit).

3.8 Parameterization

The section Parameterization contains only an extract of the parameter description. Further information can be found under the following link:

=> *Programming manual F6/S6 from version 2.8 – Liquid Cooling Management*

- The default values should be retained if possible. A flushing process and activation only need to be started in the case of initial start-up (=> *Chapter 2.4.1 Flushing the cooling* circuit).

Parameterization of the liquid cooling occurs with parameter "ud53 liquid cooling ctrl.". The parameter consists of 11 indices and is structured as follows:

ud53	liquid cooling ctrl.			0x3035
Sub-Index	Function	Default	Value range	Plaintext
1	source select	Exception: Activation (1) and flushing procedure (32)	**1**	Activation of the controller
			2	Actual value heat sink temperature sensor 1
			4	Actual value heat sink temperature sensor 2
			8	Actual value heat sink temperature sensor 3
			16	0: The maximum difference between the selected temperatures and the setpoint ud53[2] ref value is the input value Xd of the PI controller.
				16: OH temperature – ud53[2] ref value is the setpoint of the respective heat sink temperature. The largest difference between setpoint and actual value is input Xd of the PI controller.
			32	Manual setting The PWM control setting is set manually. For output via analog output, the analog value must be preset directly via the an parameters. The setting of ud53 has no effect
2	ref value	50°C	0…100 °C	Temperature setpoint heat sink **Setting under consideration of the dewing protection**

ud53	liquid cooling ctrl.			0x3035
Sub-Index	Function	Default	Value range	Plaintext
3	Kp	5	0…100	P-controller, proportional component **(preferably default value)**
4	Tn	300000 ms	0…500000 ms	Reset time of the controller, 0=off **(preferably default value)**
5	PI control out	-	0…100 %	Initial value controller (**display parameter)**
6	manual setting	0%	0…100 %	Control setting of the PWM, if ud53[1] is manually selected (subindex 1 = 32) **(set to 100% during the flushing process)**
7	PWM period	12s	4…20 s	Cycle duration of the PWM signal.
8	PWM start value	0 %	0…100 %	Minimum PWM on-pulse.
9	PWM end value	100 %	0…100 %	Maximum PWM pulse control setting.
10	PWM minimum pulse length	0.01s	0…5 s	Set-on-pulse **Preferably default value**
11	actual load	-	0…100 %	Pulse control factor of the PWM (**display parameter)**

3.8.1 Temperature setpoint setting

The temperature setpoint is preset under ud53[2].

Minimum temperature setpoint

The minimum temperature setpoint must be determined according to the dew point table (=> *Table 3-2*) depending on the ambient temperature and air humidity, considering the protection against condensation.

Maximum temperature setpoint

The maximum temperature setpoint must be at least 10K below the OH temperature limit.

3.8.2 Cycle duration

The cycle duration must be set under ud53[7]. This is important for coolant control with 2/2-way solenoid valve, => *3.7.3 Coolant control with* circulating pump and *3.7.5 Coolant control with 2*/2-way proportional valve.

Note on the cycle duration on page 14. The default value of 12 s should preferably be used.

3.8.3 Flushing process

For the start-up of the drive controller it is necessary to flush the system beforehand (=> *Chapter 2.4.1 Flushing the cooling* circuit*).*

For coolant controls, the valve for the flushing process must be opened. To be able to control the valve manually, bit 5 is activated in parameter ud53[1].

Then the control setting is set to 100% under ud53[6] and the valve is opened.

After the flushing process, parameter ud53[1] must be reset to default setting.

A more detailed software description can be found in the technical information under "PWM control".

4 Oil Cooling

This chapter refers to the aluminium heat sink.

4.1 Coolant requirements

The requirements for the coolant depend on the ambient conditions as well as the used cooling system.

General requirements:

Requirement	Description
Characteristic of the oil	Hydraulic oil HLP 46 (ISO VG 46)
Oils with appropriate properties	Mobil DTE 25 Shell Tellus Oil 46 Castrol Hyspin ZZ 46 Or similar oils

Table 4-1 Requirements for the oil

Requirements for open and half-open cooling systems:

Impurities	Mechanical impurities in half-open cooling systems can be counteracted by using appropriate filters.
Organic materials	The contamination with organic materials must be kept as small as possible, because separate slime can be caused by this.

Table 4-2 Requirements for open and semi-open cooling systems for oil coolers

4.2 Coolant temperature

With oil cooling the inlet temperature must not exceed 55°C.

The maximum heat sink temperature is specified in the "Installation" section of the instructions for use in chapter => *"Switching frequency and temperature"* of the respective housing size.

To prevent overtemperature shutdown, the coolant outlet temperature should be 10K below the heat sink temperature.

4.3 Volume flow

The minimum and maximum volume flow for cooling the drive controllers and the associated characteristic curves are described in the instructions for use, chapter "Installation" of the respective housing size.

➢ KEB recommends the use of a volume flow monitor in order to monitor the volume flow in the cooling system.

4.4 Pressure drop

The pressure drop of the drive controller required to design the cooling circuit and the associated characteristics are described in the "Installation" section of the instructions for use for the respective housing size.

4.5 Power dissipation of the drive controllers

The maximum power dissipation of the drive controllers is specified in the instructions for use, chapter "Installation" for the respective housing size.

4.6 Coolant management (oil)

4.6.1 Condensation protection

A temperature difference between drive controller and ambient temperature can lead to condensation at high humidity. The dew point table is used to determine the permissible temperature differences (=> *Table 4-3*). The table shows the coolant inlet temperature depending on the ambient temperature and air humidity.

The easiest way to avoid condensation is to supply an optimally tempered coolant. This is possible by using suitable cooling systems with heating in the cooling circuit to control the coolant temperature.The dew point table (=> *Table 4-3*) is available to determine the suitable flow temperature.

Air humidity [%] / Ambient temperature [°C]	10	20	30	40	50	60	70	80	90	100
-25	-45	-40	-36	-34	-32	-30	-29	-27	-26	-25
-20	-42	-36	-32	-29	-27	-25	-24	-22	-21	-20
-15	-37	-31	-27	-24	-22	-20	-18	-16	-15	-15
-10	-34	-26	-22	-19	-17	-15	-13	-11	-11	-10
-5	0	-22	-18	0	-13	-11	-8	-7	-6	-5
0	-26	-19	-14	-11	-8	-6	-4	-3	-2	0
5	-23	-15	-11	-7	-5	-2	0	2	3	5
10	-19	-11	-7	-3	0	1	4	6	8	9
15	-18	-7	-3	1	4	7	9	11	13	15
20	-12	-4	1	5	9	12	14	16	18	20
25	-8	0	5	10	13	16	19	21	23	25
30	-6	3	10	14	18	21	24	26	28	30
35	-2	8	14	18	22	25	28	31	33	35
40	1	11	18	22	27	31	33	36	38	40
45	4	15	22	27	32	36	38	41	43	45
50	8	19	28	32	36	40	43	45	48	50

Table 4-3 Dew point table Oil Cooling

NOTICE

Avoid moisture condensation!

Destruction of the drive controller due to short circuit!

➢ The user must guarantee that any moisture condensation is avoided!

Automation **mit Drive**

www.keb.de

KEB Automation KG Südstsraße 38 32683 Barntrup Tel. +49 5263 401-0 E-Mail: info@keb.de