AMKmotion
Projecting
Liquid cooling

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AMKmotion
MEMBER OF THE ARBURG FAMILY

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Change	**Letter symbol**
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For fast and reliable troubleshooting, you can help us by informing our Customer Service about the following:

- Type plate data for each unit
- Software version
- Device configuration and application
- Type of fault/problem and suspected cause
- Diagnostic messages (error messages)

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Content

1 About this documentation

1.1 Keeping this document

This document must permanently be available and readable at the place where the product is in use. If the product is used at another place or changed the owner, the document must be passed on.

1.2 Target group

Any person that is qualified and intends to work with this product must read, understand and follow this document:

- Projecting

1.3 Purpose

This document is addressed to any person who handles the product. It gives information about the following topics:

- Safety messages which are absolutely necessary to take care of during handling the product
- Projecting, planning and dimensioning of the application
- Assembly

1.4 Display conventions

Display	Meaning
	This symbol points to parts of the text to which particular attention should be paid!
See 'chapter name' on page x	Executable cross-reference in electronic output media

1.5 Appendant documents

Device descriptions

AMK part-no.	Title
28932	Servo drives KE/KW
200043	Liquid-cooled cold plate KW-CP
202276	Motors DD / DT / DTG / DTK / DP

2 For your safety

2.1 Basic notes for your safety

- At electrical drive systems, hazards are present in principle that can result in death or fatal injuries:
  - Electrical hazard (e. g. electric shock due to touch on electrical connections)
  - Mechanical hazard (e. g. crush, retract due to the rotation of the motor shaft)
  - Thermal hazard (e. g. burns due to touch on hot surfaces)
- These hazards are present while starting up and operating the unit, and also during servicing or maintenance work.
- Safety instructions in the documentation and on the product warn about the hazards.
- Personnel must have read and understood the safety instructions before installing and operating the product. In the documentation about the product the usage warnings pertain to direct hazards and must therefore be followed directly when operating or handling the product by the operator.
- AMKmotion products must be kept in their original order, that means it is not allowed to do a significant constructional change on hardware side and software is not allowed to be decompiled and change the source code.
- Damaged or faulty products are not allowed to be integrated or put into operation.
- Do not start the system in which the AMKmotion products are installed (begin of intended use) until you can determine that all relevant standards, laws, and directives have been complied with, e. g. low voltage directive, EMC directive, and the machinery directive, and possible further product standards. The plant manufacturer is responsible for the compliance with the laws, directives, and standards.
- The devices must be installed, electrically connected and operated as shown in the device description documentation. The technical data and the required environmental conditions must be observed at all times.

2.2 Presenting safety messages

Any safety information is configured as follows:

⚠ SIGNAL WORD	
	**Type and source of risk** Consequence(s) of non-observance **Steps to prevent:** • ...

2.3 Class of hazard

Safety and warning messages are graduated into classes of hazard (according to ANSI Z535). The class of hazard defines the potential risk of harm and is described by a single word, if the safety information is ignored. The signal word is followed by a safety alert symbol (ISO 3864, DIN EN ISO 7010). In accordance with ANSI Z535, the following signal words are used to define the class of hazard.

Safety alert symbol and signal word	Class of hazard and its meaning
⚠ DANGER	DANGER indicates a hazardous situation which, if not avoided, **will** result in death or serious injury
⚠ WARNING	WARNING indicates a hazardous situation which, if not avoided, **could** result in death or serious injury
⚠ CAUTION	CAUTION, used with the safety alert symbol, indicates a hazardous situation which, if not avoided, **could** result in minor or moderate injury
NOTICE	NOTICE is used to address preventions to avoid material damage, but not related to personal injury.

2.4 Safety alert symbols used

Safety symbol	Meaning
	Generic warning!
	Warning against crushing!

2.5 Intended use

The liquid cooling from AMK is specifically created for the individual AMK products in order to guide away the heat that is created during operation.

2.6 CE mark

AMKmotion products have been constructed using the "State of the Art" and are safe to operate. AMKmotion issues an EU declaration of conformity for each of its products in which the standards and guidelines relevant for the product are listed. AMKmotion also designates the products with the CE mark which signifies conformity to the standards. Since these standards are listed in the Official Journal of the EU, it can be assumed through their application that the product meets the basic safety and health requirements of the harmonization regulation, the so-called presumption of conformity applies.

2.7 Requirements for the personnel and their qualification

Only authorized and qualified personnel may work on and with the AMK drive systems.

Specialised personnel must:

- Perform mechanical and electrical work that is described in this documentation, such as mounting and connecting
- Observe all information in the documentation accompanying the product in order to work with the product safely and in an error-free manner
- Understand and know hazards that occur when handling the product
- Know connections and functions of the system
- Be familiar with the control concept in order to operate the drive system
- Be authorized to switch circuits and devices on and off, earth and label them
- Observe local specific safety requirements

3 Product overview

Despite a very high degree of efficiency of the power electronics and servo motors, there is a loss of heat during the conversion of energy. This heat influences the power density of the drives and may also have an influence on the production process. The liquid cooling is the most efficient procedure to guide the heat away from the sources of heat. This does not only save energy and space in the machine and system, but rather also increases the power density of the drive components significantly. The liquid cooling from AMK is specifically created for the individual components and keeps the heat load at the smallest possible level.

3.1 Comparison between convection cooling, air cooling and liquid cooling

The following example calculation shows that through the liquid cooling, more power can be derived with the same cooling surface than with air cooling or convection cooling. The efficiency is improved through liquid cooling.

Example:

Given:

- Motor with smooth casing
- Area of the motor: A = 0.01 m²
- Housing temperature increase: ΔT = 40 K
- Efficiency of the motor: η = 0,85
- Coolant: water

Searched for:

- Deriving power with the different cooling methods.

Calculation:

Convection cooling	Air cooling	Liquid cooling
Heat transfer number (Benchmarks):		
Deriving power:		
Output power of the motor:		

Legend

	Area
	Kelvin
	Active power motor
	Power loss
	Watt
	Heat transfer number
	Efficiency
	Permissible temperature increase of the coolant

3.1.1 Advantages liquid cooled AMK motors

Advantages in regards to the efficiency:

- Double torque compared to convection-cooled motors
- Quadruple power density compared to convection-cooled motors
- Less space needed in the machine
- Higher dynamics through less moved masses
- Lower weight through easier handling during installation

Advantages of the AMK design:

- Cost advantage for motors with great power
- Better utilization of the active part material being used
- No seal rings, but rather permanent, welded connections checked for leaks in regards to the liquid cooling
- All liquid leading parts made of stainless steel
- No restriction for the coolant with the exception of a filter
- Cost conscious construction with low material usage
- Very slim design
- Very light housing

Advantages for the application:

- Heat does not remain in the machine (no heat expansions, etc.)
- Motor surface is cold and there is no risk of burning with contact
- No cleaning of the surface needed
- Completely closed machine construction possible
- No noises or decontaminations through the fan
- No loss in performance when operating with dry heat.

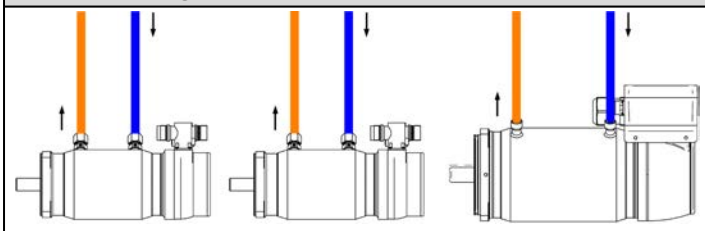
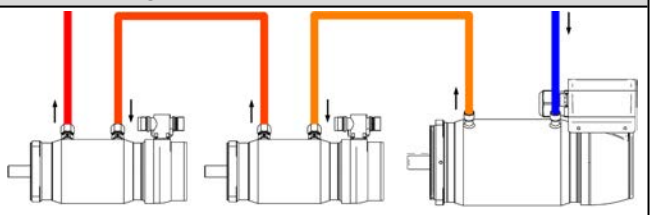
3.1.2 Advantages liquid cooled KE/KW module

Advantages compared to air cooled KE/KW module:

- Cost advantage compared to air cooled KE/KW module
- Heat does not remain in the switch cabinet, but rather is directly derived
- No loss in performance when operating with high ambient temperatures
- Less space needed in the switch cabinet, because there is no fan and thus, no open space needed for the entrance and exit of air
- Easier handling during installation, because no air canal is needed

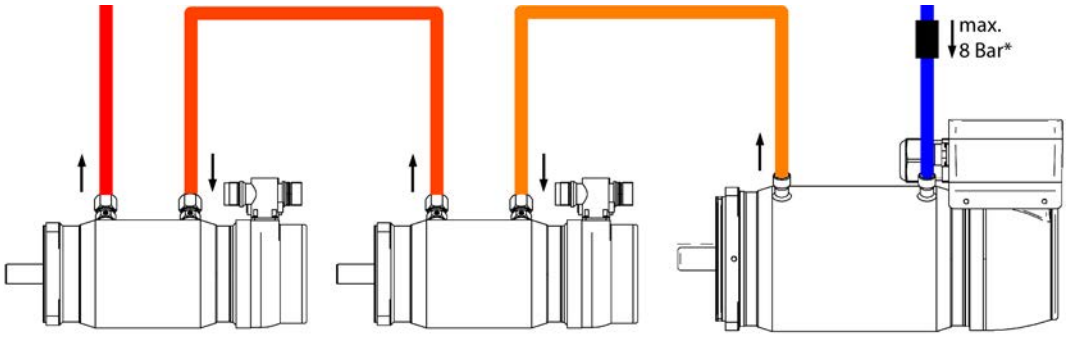
3.2 Comparison of parallel / suite cooling

Liquid cooled AMK motors can be operated in suite cooling or parallel cooling. A parallel cooling is recommended for an optimal cooling of the KE/KW module.

Parallel cooling	**Suite cooling**
	
Advantages: • Optimal cooling of the components • Sequence of the cooling components independent • Flow quantity can be optimally adjusted for each component through a flow regulator	Advantages: • Only one cooling circuit is needed • More cost-effective

3.2.1 Requirement for motors

Suite cooling

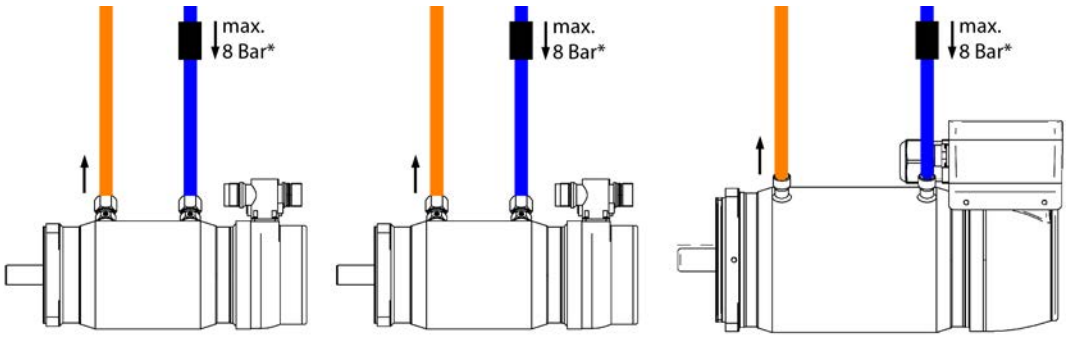


*flow controller

- The input pressure for the first component may not exceed 8 bar.
- The flow quantity must be determined for the largest power to be derived in the series.
- The pressure loss from the individual components is determined through the flow quantity of the largest power to be derived.
- The coolant temperature may not exceed the max. permissible inlet temperature of 40 °C.
- The max. coolant temperature increase from the motors must be < 10 K.
- A closed cooling circuit must be installed.
- The coolant temperature must be adjusted to the surrounding environment under consideration of the dew point table. A thawing of the motor surfaces is not permissible!
  (Siehe Dew point table auf Seite 22.)

See document Product description Motors DD / DT / DTG / DTK / DP (Part no. 202276), 'DYNASYN synchronous servo motors series DT, DTK, DTG and DP'

Parallel cooling



*flow controller

- The input pressure may not exceed 8 bar.
- The flow quantity must be set through a flow regulator for every motor.
- The coolant temperature may not exceed the max. permissible inlet temperature of 40 °C.
- The max. coolant temperature increase from the motors must be < 10 K.
- A closed cooling circuit must be installed.
- The coolant temperature must be adjusted to the surrounding environment under consideration of the dew point table. A thawing of the motor surfaces is not permissible!
  (Siehe Dew point table auf Seite 22.)

See document Product description Motors DD / DT / DTG / DTK / DP (Part no. 202276), 'DYNASYN synchronous servo motors series DT, DTK, DTG and DP'

3.2.2 Requirement for KE/KW modules

If the following points are fulfilled, the maximum permissible surface temperature of 40 °C while deriving the power loss from the KE/KW will not be exceeded

- The cooling wall consists of an aluminium alloy AlMgSi° 0.5. The same materials must be used for the cooling circuit. For components made of copper or other noble metals within the cooling circuit, cold plates with cast stainless steel pipes (KW-CP680x-V) must be used. The material from the coolant pipes of these plates is stainless steel X5CrNi1810 (1.4301)
- Before starting up the machine / system, the operator must check the cooling circuit for leaks in accordance with EN50178! (Test pressure from the aluminium cold plates: 8 bar, cold plates with stainless steel pipe: 3 bar)
- A closed cooling circuit must be installed.
- The flow quantity must amount to approximately 10 l/min.
- The coolant must have a temperature < 30 °C on the intake.
  The user must guarantee that the temperature of the cold plate is not lowered below the dew point. A thawing of the cold plate is not permissible!
  (Siehe Dew point table auf Seite 22.)

See document Product description Liquid-cooled cold plate KW-CP Part no. 200043), 'Cold plate KW-CPxxx'

4 Projecting

4.1 Design

Information that is needed for designing the cooling circuit:

1. Number of axes?
   Which motors are used?
2. Number of power supplies?
   Which power supplies are used?
3. Number of inverters?
   Which compact inverters are used?
4. Number of cold plates?
   Which cold plates are used for the respective KE/KW module?
5. Ambient temperature
6. Which coolant should be used for the cooling?

4.1.1 Procedure for designing the liquid cooling

Determine the following:

1. Power loss of the motors
   - Power to be derived during S1 operation and slow speeds
     (formula 1.1)
   - Power to be derived in the measuring point at operating temperature and during S1 operation
     (formula 1.2)

   → The required values are on the respective specifications from the motor.
2. Flow quantity of the motors

   (Formula 2)

   → Is calculated through the derived power and the permissible temperature increase.
3. Pressure drop with the desired flow quantity of the respective motors

   → May be taken from the diagram: Siehe 'Liquid cooled AMK motors' auf Seite 16.
4. Power loss of the electronic system

   → The power loss can be found in the table from the respective module: Siehe 'Liquid cooled AMK KE/KW module' auf Seite 17.
5. Power derived from the cold plate

   → Under consideration of the cooling surface, the derived power of the cold plate can be found in the table: Siehe 'Cold plate' auf Seite 18.
6. Pressure drop with the desired flow quantity of the respective cold plate

   → May be taken from the diagram: Siehe 'Determination the pressure loss from cold plates' auf Seite 20.
7. Pressure drop for the respective section of the suite cooling
   (formula 4)

   → Is the sum of the pressure drop for the respective component in this section.
8. Total volume current
   (formula 5)

   → Sum of the individual flow quantities in the respective section of the system.
9. Total pressure loss from the system
   (formula 6, 7, 8)

   →Is an operand and can be calculated through the formulas.

Formula:		
1.1	Power to be derived during S1 operation and slow speeds	
1.2	Power to be derived in the S1 operation and in the measuring point	'(rule of thumb)'
2	Flow quantity of the motors	
Suite cooling		
3	Volume current	
4	Pressure loss	
Parallel cooling/ system calculation		
5	Volume current	
6	Pressure loss	
7		
8		

Legend

Specific heat capacity of the coolant, for example, water: 4187 J/(kg K)

Permanent stop current from the motor specifications

Rated power

Power loss

Resistance

Clamp resistance from the motor specifications

Volume current

Pressure loss

Permissible temperature increase of the coolant

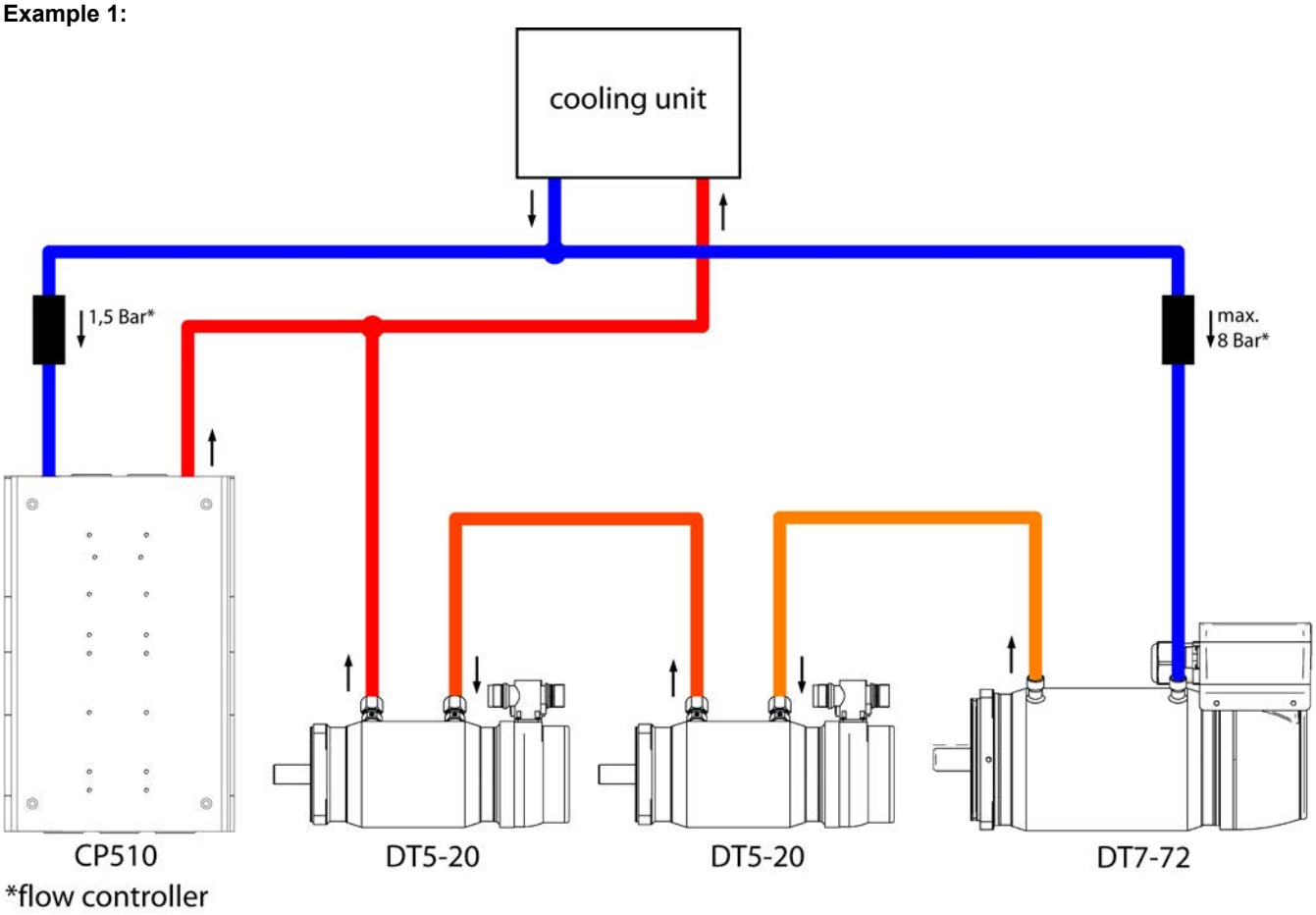
Temperature increase of motor coil from the motor specifications

Temperature coefficient of copper

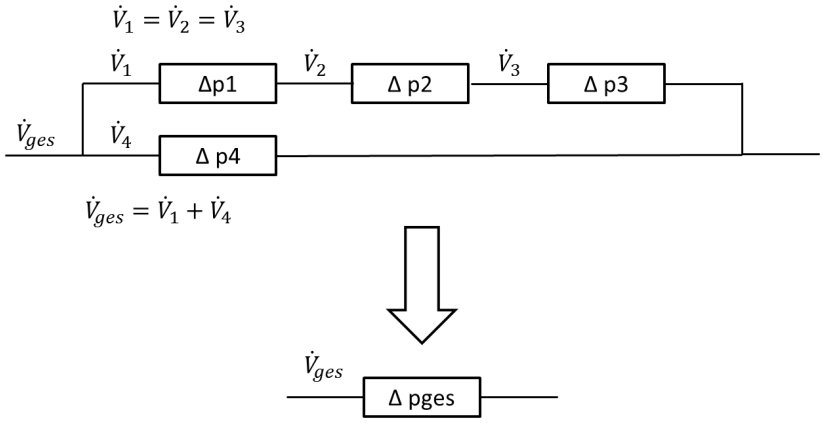
The pressure loss of the lines is not considered here!

4.2 System representation of the suite cooling

Example 1:

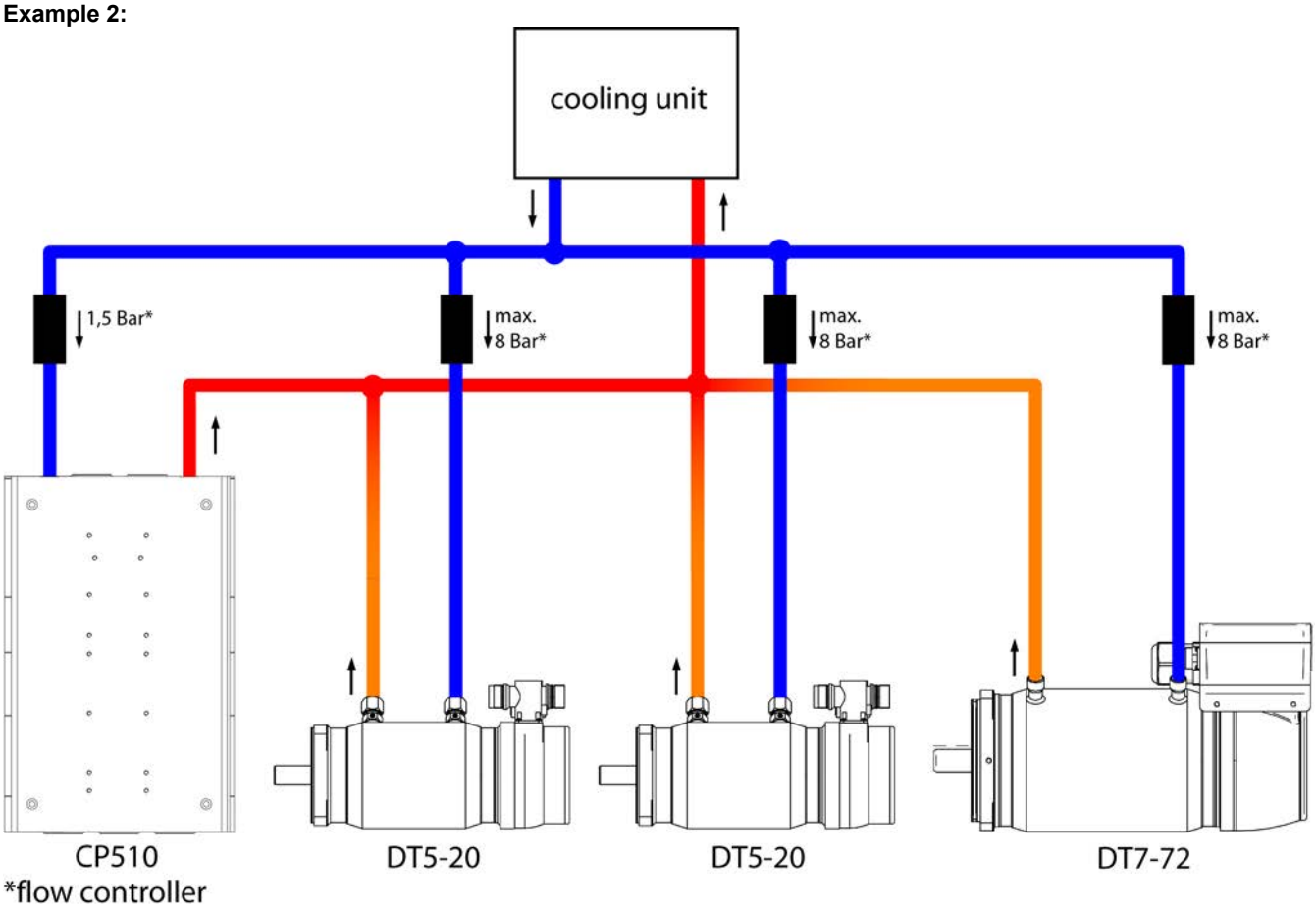


Abstract representation of the system

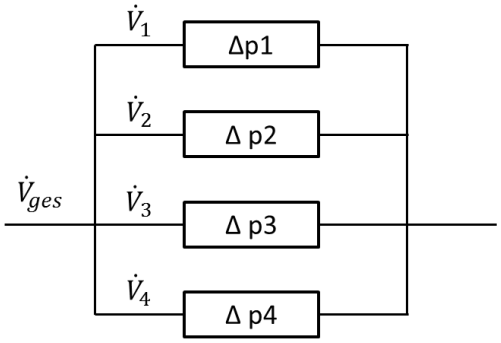


4.3 System representation of the parallel cooling

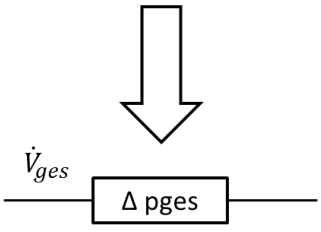
Example 2:



Abstract representation of the system



$$\dot{V}_{ges} = \dot{V}_1 + \dot{V}_2 + \dot{V}_3 + \dot{V}_4$$



4.4 Calculation examples

4.4.1 Prerequisites

Three axes are installed in a system. All axes are used in the measuring point and in permanent operation. The ambient temperature for the machine is 25 °C with a relative humidity of 70 %. The inside of the switch cabinet is cooled to 22 °C and also has a relative humidity of 70 %. The coolant should be water.

Under consideration of the dew point table, the temperature of the coolant is set to a minimum of 19.11 °C, even if a minimal temperature of 16.27 °C would be permissible inside the switch cabinet. The reason for this is that the motors would dew in the machine, which would then cause a failure of the motors.

The following motors with the KW and KE belonging to it are used:

Axis	Motor	Compact inverter	Compact power supply
1	DT7 - 72	KW 40	KE 60
2	DT5 - 20	KW 8	
3	DT5 - 20	KW 8	

4.4.2 General calculations

Power loss of the respective motors		
Flow quantity with a permissible temperature increase of 5 K		
Under consideration of the min flow quantity, for the DT5 - 20 motor a flow quantity results of: (Siehe 'Liquid cooled AMK motors' auf Seite 16.)		
Determination of the pressure loss of the individual motors: Siehe 'Liquid cooled AMK motors' auf Seite 16.	Suite cooling	
	Parallel cooling	
Determination of the power loss from the electronic system: Siehe 'Liquid cooled AMK KE/KW module' auf Seite 17.		
Total power loss of the electronic system		
The compact power supply and the compact inverter have a total power loss of 1166W. Based on the power loss and the dimensions of the module units, the required cold plate is determined.		
Power derived from the cold plate: Siehe 'Cold plate' auf Seite 18.		
In order to derive this power loss and to be able to guarantee a maximum surface temperature of < 40 °C, a flow of 10 l/min is required with a pressure drop of 0.7 bar: Siehe 'Determination the pressure loss from cold plates' auf Seite 20.		

Legend

Rated power

Power loss

Volume current

Pressure loss

Permissible temperature increase of the coolant

4.4.3 Calculations for suite cooling (example 1)

Siehe 'System representation of the suite cooling' auf Seite 13.

Pressure loss of the 3 axes	The input pressure for the first component is < 8 bar, and is therefore okay.
Total volume current	
Resistance value motor	
Resistance value cold plate	
Total resistance value from the system	
Total pressure loss of the system	

Legend

Rated power

Power loss

Resistance

Volume current

Pressure loss

Permissible temperature increase of the coolant

The system has a pressure loss of for a volume current of .

4.4.4 Calculations for parallel cooling (example 2)

Siehe 'System representation of the parallel cooling' auf Seite 14.

Total volume current	
Resistance value motor DT7	
Resistance values from the DT5 motors	
Resistance value cold plate	
Total resistance value from the system	
Total pressure loss of the system	

Legend

Rated power

Power loss

Resistance

Volume current

Pressure loss

Permissible temperature increase of the coolant

The system has a pressure loss of for a volume current of .

4.5 Technical data

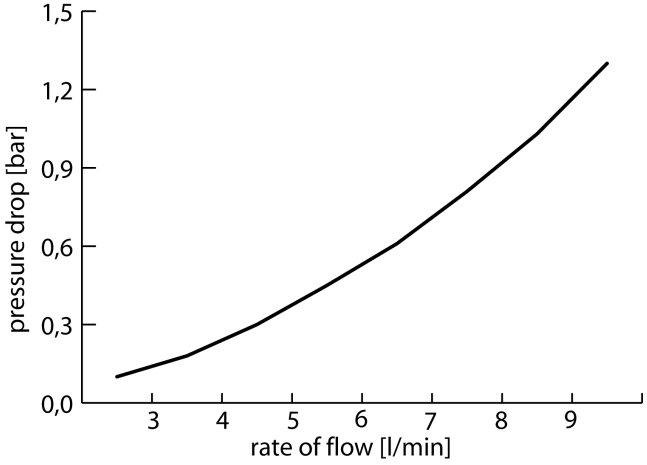
4.5.1 Liquid cooled AMK motors

Motor connection for liquid cooling (Ermeto water connection)	AS10-PL 10 mm pipe connection and 1/4" thread
Max. inlet pressure of the coolant (motor with welded stainless steel sheath)	8 bar
AMK test pressure	8 bar
Burst pressure	>50 bar
Pressure loss between inlet and outlet	See diagram [2)]
Flow temperature of the coolant	Flow temperature > ambient temperature [1)]
Temperature increase	<5 K

Max. inlet temperature of the coolant	40°C [3]
Typical min. flow rate [4)]	DD5 / DT5: 2,0 l/min DD7 / DT7 / DP7: 2,0 l/min DD10 / DT10 / DP10 / DA22: 4,0 l/min DT13 / DP13: 6,0 l/min

1) In case of flow temperature < ambient temperature: The cooling circuit has to be designed in such a way - using the dew point table - that the surface temperature of the cooled motors cannot fall below the dew point and no condensate can form.

2)



3) 60 °C > temperature > 40 °C: Loss of efficiency: approx. 1%/K

4) Flow rates on a specific motor data sheet are always valid, if different flow rates are specified on a motor data sheet.

4.5.2 Liquid cooled AMK KE/KW module

4.5.2.1 Power loss with cold plate modules

The power losses are based on the operating point:

KW, KWD, KWZ: $U_{DC\ bus}$ = 540 VDC, U_{Motor} = 3 x 350 VAC, f_{PWM} = 8 kHz

KE: $U_{power\ supply}$ = 3 x 400 VAC, U_Z = 540 VDC

KES: $U_{power\ supply}$ = 3 x 400 VAC, U_Z = 720 VDC, f_{PWM} = 8 kHz

Compact power supplies

Module	KEN 5	KEN 5-0N KEN 5-S10	KEN 10	KE 10	KEN 20-0N
Power loss at P_N [W]	25	25	40	70	75
Power loss of electronics [W]	25	10	25	15	15

Module	KE 20 KE 20-0EU	KES 20 KES 20-0EU	KE 40 KE 40-0EU	KES 40-0EU	KEN 60(KE 60-S4)
Power loss at P_N [W]	130	359	240	570	240
Power loss of electronics [W]	20	45	35	65	50

Module	KE 60 KE 60-0EU	KES 60 KES 60-0EU	KEN 120	KE 120 KE 120-0EU	KES 120 KES 120-0EU
Power loss at P_N [W]	350	876	520	780	1926
Power loss of electronics [W]	50	95	50	50	150

Module	KE 180-0EU	KES 180-0EU
Power loss at P_N [W]	1025	3500
Power loss of electronics [W]	110	280

Compact inverters

Module	KW 2	KW 3	KW 5	KW 8	KW 10
Power loss at P_N [W]	30	43	80	128	200
Power loss of electronics [W]	17	18	20	23	40

Module	KW 20	KW 40	KW 60
Power loss at P_N [W]	333	590	950
Power loss of electronics [W]	50	100	130

Module	KW 100	KW 150	KW 200
Power loss at P_N [W]	8 kHz: 1800 4 kHz: 1250	8 kHz: 2900 4 kHz: 1900	8 kHz: 4000 4 kHz: 2500
Power loss of electronics [W]	150	250	330

Module	KWD 1	KWD 2	KWD 5
Power loss at P_N [W]	2 x 13	2 x 30	2 x 75
Power loss of electronics [W]	25	28	37

For parallel cooling, flow controllers are required for the respective cooling cable in order to be able to guarantee the flow of 10 l/min from the individual plates. Furthermore, it is to be observed that the power loss of the electronic system must be discharged through the interior of the switch cabinet.

4.5.3 Cold plate

4.5.3.1 Cold plate with cooling connection on the side

Cold plate	KW-CP340	KW-CP510	KW-CP680	KW-CP680-V
AMK part no.	O704	O706	O708	O782
Maximum removable power	1500 W	2300 W	3000 W	3000 W
Ambient temperature	0 ... 40 °C	0 ... 40 °C	0 ... 40 °C	0 ... 40 °C
Coolant connection	sideways right	sideways right	sideways right	sideways right
	G 1/4 " internal thread			
Water flow	1.5 bar; 10 l/min			
Dimensions (B x T x H)	345 x 25 x 330 mm	515 x 25 x 330 mm	685 x 25 x 330 mm	680 x 25 x 330 mm
Material of the coolant pipe	AlMgSi 0.5	AlMgSi 0.5	AlMgSi 0.5	X5CrNi1810
Cooling surface (B x H)	340 x 320 mm	510 x 320 mm	680 x 320 mm	680 x 320 mm
Weight	approx. 6 kg	about 8 kg	about 11 kg	about 11 kg

Cold plate	KW-CP1000 *)
AMK part no.	O717
Maximum removable power	3000 W
Ambient temperature	0 ... 40 °C
Coolant connection	sideway left
	G 1/4 " internal thread
Water flow	1.5 bar; 10 l/min
Dimensions (B x T x H)	1005 x 25 x 330 mm
Material of the coolant pipe	AlMgSi 0.5
Cooling surface (B x H)	1000 x 320 mm
Weight	approx. 16 kg

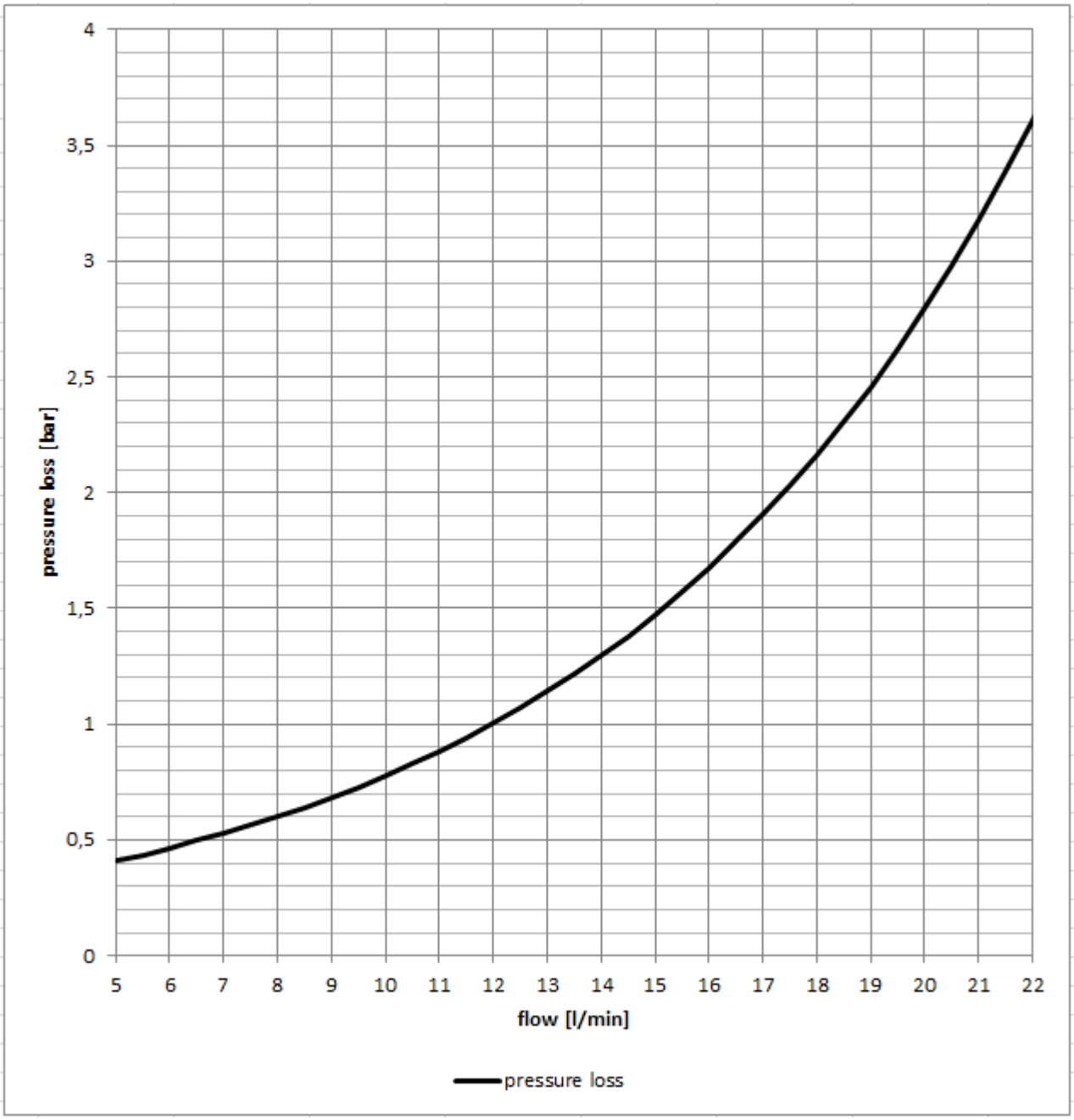
*) Not for new applications

4.5.3.2 Cold plate with cooling connection on the rear side

Cold plate	KW-CP340R	KW-CP420R	KW-CP510R	KW-CP680R
AMK part no.	O705	O710	O707	O709
Maximum removable power	1500 W	1900 W	2300 W	3000 W
Ambient temperature	0 ... 40 °C	0 ... 40 °C	0 ... 40 °C	0 ... 40 °C
Coolant connection	rear	rear	rear	rear
	G 1/4 " internal thread			
Water flow	1.5 bar; 10 l/min			
Dimensions incl. coolant connection (B x T x H)	345 x 40 x 330 mm	421 x 40 x 330 mm	515 x 40 x 330 mm	685 x 40 x 330 mm
Material of the coolant pipe	AlMgSi 0.5	AlMgSi 0.5	AlMgSi 0.5	AlMgSi 0.5
Cooling surface (B x H)	340 x 320 mm	416 x 320 mm	510 x 320 mm	680 x 320 mm
Weight	approx. 6 kg	about 7 kg	about 8 kg	about 11 kg

Cold plate	KW-CP680R-V	KW-CP1035R
AMK part no.	O783	O734
Maximum removable power	3000 W	3000 W
Ambient temperature	0 ... 40 °C	0 ... 40 °C
Coolant connection	rear	rear
	G 1/4 " internal thread	
Water flow	1.5 bar; 10 l/min	
Dimensions incl. coolant connection (B x T x H)	680 x 40 x 330 mm	1040 x 40 x 330 mm
Material of the coolant pipe	X5CrNi1810	AlMgSi 0.5
Cooling surface (B x H)	680 x 320 mm	1035 x 320 mm
Weight	about 11 kg	about 18 kg

4.5.3.3 Determination the pressure loss from cold plates



4.5.4 Coolant

Requirements to the quality of the water used as coolant

Components	Quantities
Chloride ions	< 40 ppm[1)]
Sulphate ions	< 50 ppm
Nitrate ions	< 50 ppm
pH value	6...12
Electrical conductivity	< 500 µS/cm
Total hardness	< 170 ppm

1) 1 mmol/l (alkaline earth ions) = 100 ppm (part per million)
1 °dH = 17.8 ppm
Drinking water can have a chloride ion count of up to 2500 ppm. Add deionised water with reduced conductivity (5...10 µS/cm). Ask your water supplier about the composition of your drinking water.

Requirements to the coolant

Components	Quantities
Frost protection	If necessary: 20-30% Antifrogen N (manufacturer: Clariant) or Tyfocor L (manufacturer: Tyfocorp)[1)]
Solutes	< 340 ppm
Size of particles in the coolant	< 100 µm

1) The antifreeze protection quantity has to be < 30 %, else derating is required. Consult the AMK customer service.

4.5.5 Cooling circuit

Requirements for the cooling circuit

NOTICE	
Material Damage!	**Damage to the cooling plate due to electrolysis** The cooling plate is made of an AlMgSi 0.5 aluminium alloy. If components such as supply line pipes and heat exchangers that are made of more precious materials (e.g. copper) are used within the cooling circuit, they can be affected and damaged due to electrolytic processes. **Steps to prevent:** • Only use components made of the same or a comparable aluminium alloy within the cooling circuit • Use cold plates with a moulded stainless steel pipe (KW-CP680x-V) in components made of copper or other high-grade metals within the cooling circuit. The material of the coolant pipe of these plates is X5CrNi1810 (stainless steel 1.4301)

Siehe 'Requirement for KE/KW modules' auf Seite 10.

The installation of a closed cooling circuit with the following properties is recommended:

- No constant addition of freshwater, through this the water quality is controllable and consistent
- Light-proof cooling system in order to hinder the growth of algae
- Negligible loss through evaporation

If there are critical water circumstances, an expert institute should be contacted for a water analysis.

4.5.6 Measures to protect the cooling circuit

In cooling circuits with water, measures must be taken through additives[1)] against the following topics:

1) The dosing and further data about the water quality can be found in the product specifications from the supplier of the inhibitor. In general, the guidelines from the heat exchanger manufacturer apply.

Corrosion

A corrosion protection for the complete cooling circuit must be guaranteed with the usage of mixed material.

The material may vary according to the arrangement (aluminium, steel, copper, brass, plastic, ...) and according to its composition of the selected cooling components (observe manufacturer's guideline).

When using aluminium in the cooling circuit, it must be guaranteed that there is no direct contact of the aluminium with the copper parts. In order to avoid selective corrosion, the possible copper decontamination must be removed carefully through customer handling or through miscellaneous modifications (for example, by flushing out the cooling canal).

Scale formation

In order to avoid to formation of scale, for example, the hardness of the water should be limited or the use of hardness stabilizers may make sense.

Algae growth

In closed systems without the addition of oxygen or with light-proof installations not critical, otherwise it must be worked with suitable biocides.

Biological attack, formation of mucus bacteria

An attack, or the constant addition of materials promoting the growth of bacteria must be avoided.

Frost

If there are possible temperatures below the freezing point (transport, storage....), measures against frost damage must be taken.

Environment tolerability

The environment tolerability of the protective material used must received special value.

4.5.7 Dew point table

NOTICE	
Material Damage!	**Material damage when dew forms!** Dew may result in electrical shorts. **Steps to prevent:** • Observe the dew point table! • Switch off the cooling circuit when the systems are idle! • Check the temperature of the coolant after longer downtimes! • At high levels of humidity, it is recommended to use a dehumidifier!

The dew point table specifies at which surface temperature condensate forms. This depends on the temperature of the air and the relative humidity.

Dew point table in °C

Example: Ambient temperature: 32 °C, humidity: 60 %
The temperature of the cooling circuit may not be less than 23 °C, else condensate will form!

Ambient air temperature in °C	Dew point in °C at a relative humidity of										
	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
2	-7.70	-6.26	-5.43	-4.40	-3.16	-2.48	-1.77	-0.98	-0.26	0.47	1.20
4	-6.11	-4.88	-3.69	-2.61	-1.79	-0.88	-0.09	0.78	1.62	2.44	3.20
6	-4.49	-3.07	-2.10	-1.05	-0.08	0.85	1.86	2.72	3.62	4.48	5.38
8	-2.69	-1.61	-0.44	0.67	1.80	2.83	3.82	4.77	5.66	6.48	7.32
10	-1.26	0.02	1.31	2.53	3.74	4.79	5.82	6.79	7.65	8.45	9.31
12	0.35	1.84	3.19	4.46	5.63	6.74	7.75	8.69	9.60	10.48	11.33
14	2.20	3.76	5.10	6.40	7.58	8.67	9.70	10.71	11.64	12.55	13.36
15	3.12	4.65	6.07	7.36	8.52	9.63	10.70	11.69	12.62	13.52	14.42
16	4.07	5.59	6.98	8.29	9.47	10.61	11.68	12.66	13.63	14.58	15.54
17	5.00	6.48	7.62	9.18	10.39	11.48	12.54	13.57	14.50	15.36	16.19
18	5.90	7.43	8.83	10.12	11.33	12.44	13.48	14.56	15.41	16.31	17.25
19	6.80	8.33	9.75	11.09	12.26	13.37	14.49	15.47	16.40	17.37	18.22
20	7.73	9.30	10.72	12.00	13.22	14.40	15.48	16.46	17.44	18.36	19.18
21	8.60	10.22	11.59	12.92	14.21	15.36	16.40	17.44	18.41	19.27	20.19
22	9.54	11.16	12.52	13.89	15.19	16.27	17.41	18.42	19.39	20.28	21.22
23	10.44	12.02	13.47	14.87	16.04	17.29	18.37	19.37	20.37	21.34	22.23
24	11.34	12.93	14.44	15.73	17.06	18.21	19.22	20.33	21.37	22.32	23.18
25	12.20	13.83	15.37	16.69	17.99	19.11	20.24	21.35	22.27	23.30	24.22
26	13.15	14.84	16.26	17.67	18.90	20.09	21.29	22.32	23.32	24.31	25.16
27	14.08	15.68	17.24	18.57	19.83	21.11	22.23	23.31	24.32	25.22	26.10
28	14.96	16.61	18.14	19.38	20.86	22.07	23.18	24.28	25.25	26.20	27.18
29	15.85	17.58	19.04	20.48	21.83	22.97	24.20	25.23	26.21	27.26	28.18
30	16.79	18.44	19.96	21.44	23.71	23.94	25.11	26.10	27.21	28.19	29.09
32	18.62	20.28	21.90	23.26	24.65	25.79	27.08	28.24	29.23	30.16	31.17
34	20.42	22.19	23.77	25.19	26.54	27.85	28.94	30.09	31.19	32.13	33.11
36	22.23	24.08	25.50	27.00	28.41	29.65	30.88	31.97	33.05	34.23	35.06
38	23.97	25.74	27.44	28.87	30.31	31.62	32.78	33.96	35.01	36.05	37.03
40	25.79	27.66	29.22	30.81	32.16	33.48	34.69	35.86	36.98	38.05	39.11
45	30.29	32.17	33.86	35.38	36.85	38.24	39.54	40.74	41.87	42.91	44.03
50	34.76	36.63	38.46	40.09	41.58	42.99	44.33	45.55	46.75	47.90	48.98

The use of a dehumidifier in the switch cabinet is recommended in case of high levels of humidity.

5 Assembly

5.1 For your safety

⚠ DANGER	
	**Risk of injury from crushing, cutting and hitting.** When transporting and mounting sharp-edged and / or heavy components, there is a risk of crushing, cutting and bruising of the persons involved. Suspended loads can fall down and people suffer fatal injuries. **Steps to prevent:** • Utilize suitable assembly and transport equipment, such as hoists and carriages. • Wear protective clothing, e.g. safety gloves and boots, during the assembly. • Use only appropriate tools during the assembly. • Make sure that there are no persons or body parts located under suspended loads during the transport or assembly. • Prevent catching and crushing by mechanical devices.

⚠ WARNING	
	**Warning against pressurised lines!** Closed cooling circuits are under high pressure. Opening the circuit while it is under high pressure can result in injuries from escaping coolant. The sudden pressure change can cause lines to rip loose or make uncontrolled movements. **Steps to prevent:** • Never open a line system that is under high pressure! • Drain the coolant at the provided point, e.g. drain valve. Pay attention to the instructions of the manufacturer of the cooling device. • Collect the cooling liquid in a proper containment. Store or dispose it according to the local instructions. • Wear adequate protective clothing, e.g. goggles, gloves, safety shoes.

NOTICE	
Material Damage!	**Short circuit due to penetrating foreign objects or water** Foreign objects such as metal shavings, screws, etc. cause short circuits. In particular it needs to be prevented that water, e.g. condensation water, seeps in through the cooling units. A temporary forming of dew may only occur as long as the devices are out of operation. **Steps to prevent:** • The modules need to be protected against penetrating foreign objects or water. • When applying mains voltage, no dew may be present any longer.

5.2 KW-CPxx cold plates

The cold plate is fitted on the mounting plate in the switch cabinet.

Fastening: 4 screws M8 (KW-CP340 / 420 / 510 / 680(R)) or 8 screws M8 (KW-CP1000 / -CP1035R).

The assembly must be carried out on a flat surface (flatness ≤ 0.3 mm). The cold plate must not be braced during the assembly.

If several cold plates are assembled on top of each other, an upward and downward minimum distance of 100 mm each must be observed. The distances between signal and power cables must be complied with. Furthermore, please take note of the fact that the electronic components are cooled by internal fans, and that the air inlet temperature must not exceed 40 °C even in the top row.

The cold plates can be placed seamlessly next to each other on the sides, provided that the coolant connection is on the back. In case of a connection on the side, an according distance for the installation of the coolant circuit must be provided.

5.3 Installation of the cooling circuit

Depending on the cold plate, the coolant is connected either on the right or left side, or on the back through two G 1/4" internal threads and the matching conduit fittings.

The coolant input is connected at the lower fitting. The coolant output is connected at the upper fitting.

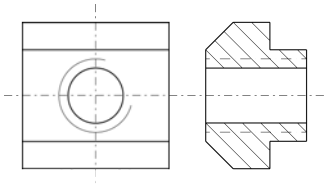
Tightening torque for G 1/4": max. 20 Nm

5.4 KE/KW modules

The KE/KW modules are mounted directly on the cold plate without heat transfer paste.

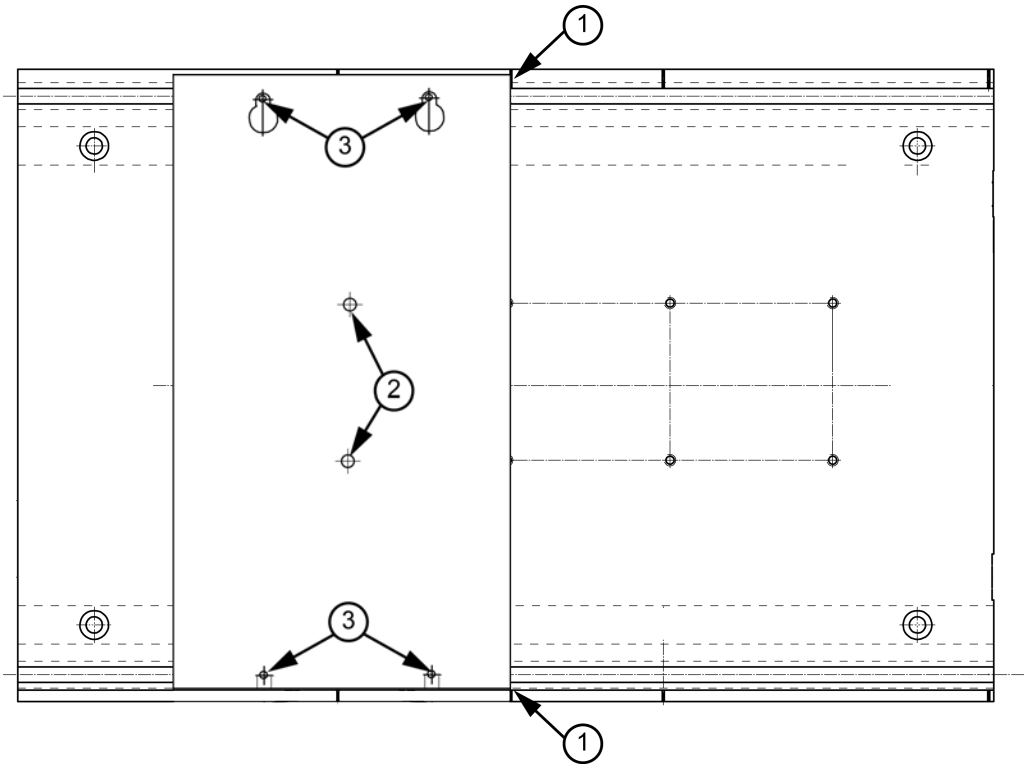
Note the following during assembly:

- The protective cardboard on the bearing face of the modules needs to be removed.
- Both the assembly surface of the cold plate as well as the bearing faces of the modules must be clean and scratch-free.
- The bearing faces of the KE and KW modules are arched by 0.3 mm so that a fully covered surface between module and cold plate is ensured after assembly.
- The cold plates have one T-slot on top and bottom, respectively, according to DIN 508 for the fastening of the KE/KW modules. The required number of slot nuts must be inserted into the slot through the mounting hole. The slot nuts have an M6 internal thread M6 x 20 fastening screws.



The fastening set for the assembly of the KE/KW modules, which consists of 20 slot nuts and 20 cylinder screws, can be ordered separately (AMK part no. 49994)

- The slot nuts are aligned according to the module position and width. Markings that identify the module position are located on the upper and lower edges of the cold plates (1).
- Threaded bores for the assembly of KE and KW modules with centre screw connections (170 mm / 255 mm / 425 mm width) are located in the cold plate.
- If available, the **centre screws** (2) must be tightened first during assembly: Tightening torque 5 Nm (Tool: Allen size 4).
- Afterwards, the fastening screws (3) of the modules are tightened: Tightening torque 8 Nm (Tool: Allen size 5).



The KW-CP420R cold plate does not contain threaded bores for centre screw connections. It is suitable solely for the use of use of the KE/KW modules with a width of 55 mm and 85 mm.

For compact power supplies and compact inverters with a module width of 425 mm, cold plates KW-CP680 (AMK part no. O708), KW-CP510 (AMK part no. O706) respectively KW-CP510R (AMK part no. O707) must be exclusively used with a **revision from 2.03 on**!

6 Accessories

6.1 Liquid cooling system

All KE/KW series modules are designed for mounting on a cold plate with liquid cooling.
The coolant line is connected either on the right side (on the left side only at KW-CP 1000) or on the back using two G1/4" inner threads and the matching hose connections.

Cold plate	Technical Data
KW-CP 340(R)	Effective width 340 mm removable power approx. 1.5 kW
KW-CP 420R	Effective width 416 mm removable power approx. 1.9 kW
KW-CP 510(R)	Effective width 510 mm removable power approx. 2.3 kW
KW-CP 680(R) KW-CP 680(R)-V	Effective width 680 mm removable power approx. 3.0 kW
KW-CP 1000 *)	Effective width 1000 mm removable power approx. 3.0 kW
KW-CP 1035R	Effective width 1035 mm removable power approx. 3.0 kW

R coolant connection on the back
-V integrated stainless steel piping
*) not to be used for new applications

Depending on the module width, the KE/KW cold plate modules can be mounted on the cold plates according to the following table.
When you select the cold plate, you have to take into account the power losses to be removed.

Cold plate	AMK part no.	Module width / mm				
		55	85	170	255	425
KW-CP 340	O704	■	■	■	-	-
KW-CP 340R	O705	■	■	■	-	-
KW-CP 420R	O710	■	■	-	-	-
KW-CP 510	O706	■	■	■	■	■
KW-CP 510R	O707	■	■	■	■	■
KW-CP 680	O708	■	■	■	■	■
KW-CP 680R	O709	■	■	■	■	-
KW-CP 680-V	O782	■	■	■	■	-
KW-CP 680R-V	O783	■	■	■	■	-
KW-CP 1000	O717	■	■	■	■	-
KW-CP 1035R	O734	■	■	■	-	-

For compact power supplies and compact inverters with a module width of 425 mm, cold plates KW-CP680 (AMK part no. O708), KW-CP510 (AMK part no. O706) respectively KW-CP510R (AMK part no. O707) must be exclusively used with a **revision from 2.03 on**!

For more information: see device description Liquid-cooled cold plate KW-CP (AMK part no. 200043)

Use of own cold plates

Requirements on surface when using own cold plate with liquid cooling.

- Plate flatness: 0.1 mm
- Surface finish: 0.02 mm
- Ridges and bore holes should be carefully deburred.
- To make assembly easier, the threads M6 for the clamping bolts must in the centre for devices with a width of 170/255 mm must feature an inner bevel of approx. 45°/2 mm.

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