KSB ServiceTool

Supplementary Operating Manual

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Supplementary Operating Manual KSB ServiceTool

Original operating manual

Contents

1 Supplementary Operating Manual

1.1 General

This supplementary operating manual accompanies the installation/operating manual. All information contained in the installation/operating manual must be observed.

Table 1: Relevant operating manuals

Type series	Reference number of the installation/operating manual
Calio	1157.821
Calio Z	1157.841

1.2 Menu

1.2.1 Operation

The Operation menu contains all information required for operating the pump set and its processes. This includes:

- Operating values and measured values for the motor, frequency inverter, pump set and system
- Setpoints
- Control values in open-loop control mode
- Control values in manual mode
- Energy meter
- Operating hours

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1.2.1.1 Menu number list

NOTE

Communication with the KSB ServiceTool is only possible if the Modbus function has been disabled.

Table 2: Menu overview

Menu number	Designation	Description	Unit
1-2 Operating Values			
1-2-1	Motor and Power Electronics	-	-
1-2-1-1	Speed	Current speed	[rpm]
1-2-1-2	Pump Set Input Power	Current effective power of pump set (pump set = pump, drive, components and accessories)	[W]
1-2-1-9	Pump Input Power	Mechanical power of pump	[W]
1-2-2 Pump			
1-2-2-1	Head	Current pump head	[m]
1-2-2-2	Flow rate	Current flow rate of the pump	[m^3/h]
1-2-2-3	Status	Current motor status	Locked / stopped / stopping / starting / running
1-2-4 Inputs / Outputs			
1-2-4-1	Analog Input Value	Current signal value present at analog input	[V]
1-2-4-2	RUN Terminal	Status of RUN terminal contact	Closed / Open
1-2-4-3	Function Relay 1	Function selected	Operation / alert
1-2-4-4	Status Relay 1	Status of relay	Enabled / disabled
1-2-4-5	Function Relay 2	Function selected	Operation / alert
1-2-4-6	Status Relay 2	Status of relay	Enabled / disabled
1-2-4-7	Status Control Panel	Status of control panel	Unlocked / locked
1-2-5 Temperatures			
1-2-5-1	Temperature Control Module	Temperature of control modules (HMI[1])	[°C]
1-2-5-2	Motor temperature	Current motor temperature	[°C]
1-2-5-3	Temperature PFC[2]	Temperature of reactive power compensation module	[°C]
1-2-5-4	Temperature Power Module[3]	Power module temperature	[°C]
1-2-5-5	Fluid temperature	Current fluid temperature	[°C]
1-3 Control			
1-3-1	Pump Start / Stop	-	-

1) Temperature measured on main control board
2) Power Factor Correction
3) Smart Power Module

Menu number	Designation	Description	Unit
1-3-2	Current Setpoint	Setpoint specification for operating modes: ▪ Constant-pressure Control ▪ Proportional-pressure Control ▪ Eco-Mode ▪ Open-loop Control	[%]
1-3-3	Status Night Setback	Mode currently detected for setback operation	Day / Night
1-3-4	Duty cycle	Operating mode of the pump set: ▪ Temperature-governed Differential Pressure Control ▪ Constant-pressure Control ▪ Proportional-pressure Control ▪ Eco-Mode ▪ Open-loop Control	-
1-3-5	HMI[1] Idle Mode Function	▪ Enabled: Switches to idle mode after 5 minutes without pressing a button. ▪ Disabled: Display remains permanently ON.	Enabled / disabled
1-3-6	HMI[1]Idle Mode Status	Idle mode status	Enabled / disabled
1-3-8	HMI[1]Setpoint	Display setpoint	[%]
1-3-9	Analog 0-10 V Active	Setpoint via analog input	[%]
1-3-10	Analog Control	Current status of analog input	Start / Stop
1-3-11	Modbus Control	Modbus status	Enabled / disabled
1-3-15	Dual-pump operation (DUAL)	Dual-pump operation status (DUAL)	Enabled / disabled
1-4 Counter			
1-4-1-1	kWh Counter	Energy meter	kWh
1-4-2-1	Operating Hours Counter	Number of pump operating hours	[h]
1-4-3-1	Water Volume Counter	Water volume pumped	[m]
2 Diagnosis			
2-1	Error Vector	Error vector for active alerts / warnings (bit-coded)	Bit mask
2-2	Clear History	Function for deleting the fault history	-
2-3	Test Alert	Check for functionality and/or correct wiring.	Enabled / disabled
3 Settings			
3-1	General Settings	-	-
3-1-2	Load Factory Settings	Loading factory-set defaults.	-
3-1-4	Load User Settings	Loading user settings. (Supplied = defaults)	-
3-1-5	Save User Settings	Saving pump set settings as user settings.	-
3-1-9	HMI[1]Function Reset to Factory / User Settings	Selection between factory-set defaults and user settings (HMI[1] function: Press control button > 30 seconds)	-
3-2 Modbus Settings			
3-2-1	Modbus Address	0 to 247 (default = 17)	-

Menu number	Designation	Description	Unit
3-2-2	Baud Rate	4.800, 9.600, 38.400, 57.600, 115.200 (19,200 = factory setting)	-
3-2-3	Parity	EVEN (Default), ODD, NONE	-
3-3 Motor Settings			
3-3-1	Motor Speed Limitation	Current speed limitation of motor	[rpm]
3-3-1-1	Minimum Motor Speed	-	[rpm]
3-3-1-2	Maximum Motor Speed	-	[rpm]
3-4 Pump Settings			
3-4-3-1	Integral Constant	-	[s^{-1}]
3-4-3-2	Anti-windup Limit	-	[rpm]
3-4-5	Controlled-operation Curves	-	-
3-4-5-4	Temperature-governed Differential Pressure Control	-	-
3-4-5-4-1	Reference Temperature T_1	1st temperature data point for describing the control curve	[°C]
3-4-5-4-2	Reference Temperature T_2	2nd temperature data point for describing the control curve	[°C]
3-4-5-4-3	Reference Head H_1	1st head data point for describing the control curve	[m]
3-4-5-4-4	Reference Head H_2	2nd head data point for describing the control curve	[m]
3-4-5-7 Ramps			
3-4-5-7-1	Threshold Value Start Ramp	-	[rpm]
3-4-5-7-2	Threshold Value Operating Ramp	-	[rpm]
3-4-5-7-3	Time Constant Start Ramp	-	[s]
3-4-5-7-4	Time Constant Stop Ramp	-	[s]
3-4-5-7-5	Time Constant Operating Ramp	-	[s]
3-4-5-7-6	Max Ramp	-	[s^{-1}]
3-4-5-7-7	Min Ramp	-	[s^{-1}]
3-4-5-7-8	Time Constant Common Ramp	-	[s]
3-5 Temperature Monitoring			
3-5-1	Temperature Control Module (HMI[1]) Warning Limit	-	[°C]
3-5-2	Temperature Control Module (HMI[1]) Alert Limit	-	[°C]
3-5-3	Motor Temperature Warning Limit	-	[°C]
3-5-4	Motor Temperature Alert Limit	-	[°C]
3-5-5	PFC[2] Temperature Warning Limit	-	[°C]
3-5-6	PFC[2] Temperature Alert Limit	-	[°C]
3-5-7	SPM[3] Temperature Warning Limit	-	[°C]
3-5-8	SPM[3] Temperature Alert Limit	-	[°C]
3-5-13	Speed Derating Percentage	-	[%]
3-5-14	Time Delay Before Next Derating	-	[s]
3-5-15	Time Constant For Mean Speed	-	[s]
3-6 DUAL Settings (Peak Load)			
3-6-1	DUAL Pump Changeover Time	-	[h]
3-6-2	DUAL Sleep Delay	-	[s]

Menu number	Designation	Description	Unit
3-6-5	DUAL Pump Type	-	DUAL undefined (single pump) / DUAL left / DUAL right
3-6-7	Peak Load Operation	-	-
3-6-7-1	Activation Peak Load Operation	-	Enabled / disabled (default)
3-6-7-2	Hysteresis Reduction per Time	-	[(m³/h)/month]
3-6-7-3	Default Hysteresis	-	[m³/h]
3-6-7-4	Min Hysteresis	-	[m³/h]
3-6-7-5	Max Hysteresis	-	[m³/h]
3-6-7-6	Hysteresis Increase	-	[m³/h]
3-6-7-7	Time Window Excessive On/Off Detection	-	[s]
3-6-7-14	Peak Load Opt. Hysteresis	-	[m³/h]
3-7 Functions			
3-7-1	Setback Operation	-	-
3-7-1-1	Activation Night Setback	-	Enabled / disabled (default)
3-7-1-2	Status Night Setback	-	Day / Night
3-7-1-3	Threshold Value Time Night Mode	-	[min]
3-7-1-4	Minimum Fluid Temperature Gradient	-	[°C]
3-7-1-5	Time Window Fluid Temperature Reduction	-	[min]
3-7-1-6	Threshold Value Fluid Temperature Night Mode	-	[°C]
3-7-1-7	Maximum Duration Night Mode	-	[h]
3-7-1-8	Setpoint Reduction If Night Mode Detected	-	-
3-7-1-9	Threshold Value Fluid Temperature Daytime Mode	-	[°C]
3-7-3 Configuration of Analog Input			
3-7-3-1	Hysteresis Analog Input	-	[V]
3-7-3-2	Threshold Value Pump Start	2 V = setpoint 0 % Pump starts at voltage > 2 V.	[V]
3-7-3-3	Maximum Analog Voltage	10 V = setpoint 100 % Voltages > 10 V are interpreted as 10 V.	[V]
3-7-3-4	Minimum Change of Analog Signal	-	[V]
3-7-3-5	Analog Input Broken Wire Detection	-	Enabled / disabled (default)
3-7-3-6	Setpoint Threshold Value Broken Wire	If voltage < 1 V, a broken wire is detected and the E10 warning is output.	[V]
3-7-3-7	Setpoint Behaviour With Broken Wire	▪ Minimum speed ▪ Maximum speed ▪ Pump stops ▪ Last valid setpoint ▪ Last setpoint of HMI[1] or Modbus	-
3-7-3-8	Function Analog Input	▪ Setpoint (default) ▪ Actual value of temperature sensor ▪ Actual value of differential pressure	-
3-7-3-9	Actual Value Threshold Value Broken Wire	-	[V]

Menu number	Designation	Description	Unit
3-7-3-10	Delay Broken Wire Detection	-	[s]
3-7-3-12	Temperature Sensor Data Point T_1 for 2 V Input Signal	-	[°C]
3-7-3-13	Temperature Sensor Data Point T_2 for 10 V Input Signal	-	[°C]
3-7-3-16	Head Data Point P_1 for 2 V Input Signal	-	[m]
3-7-3-17	Head Data Point P_2 for 10 V Input Signal	-	[m]
3-7-4 Relays			
3-7-4-1	Relay 1: Function	-	-
3-7-4-1-1	Relay 1: Setting Function	-	Operation (default) / alert
3-7-4-1-2	Relay 1: Operation Bit Mask	List of operating states	-
3-7-4-1-3	Relay 1: Message Bit Mask	List of alerts, warnings and information	-
3-7-4-1-4	Relay 1: Inverted Logic	-	Disabled (default) / enabled
3-7-4-2	Relay 2: Function	-	-
3-7-4-2-1	Relay 2: Setting Function	-	Operation / alert (default)
3-7-4-2-2	Relay 2: Operation Bit Mask	List of operating states	-
3-7-4-2-3	Relay 2: Message Bit Mask	List of alerts, warnings and information	-
3-7-4-2-4	Relay 2: Inverted Logic	-	Disabled (default) / enabled
3-7-5 Flow Rate Limit (Flow Limit)			
3-7-5-1	Activation of Minimum Flow Monitoring	-	Enabled / disabled (default)
3-7-5-2	Threshold Value Minimum Flow	-	[m^3/h]
3-7-5-3	Hysteresis Minimum Flow	-	[m^3/h]
3-7-5-4	Activation of Maximum Flow Monitoring	-	Enabled / disabled (default)
3-7-5-5	Threshold Value Maximum Flow	-	[m^3/h]
3-7-5-6	Hysteresis Maximum Flow	-	[m^3/h]
3-7-5-7	Time Threshold: No Minimum/Maximum Flow Occurred	-	[s]
3-7-5-8	Minimum Duration of Minimum/Maximum Flow	-	[s]
3-7-6 High Fluid Temperature			
3-7-6-1	Activation Monitoring: High Fluid Temperature	-	Enabled / disabled (default)
3-7-6-2	Threshold Value Maximum Fluid Temperature	-	[°C]
3-7-6-3	Hysteresis Maximum Fluid Temperature	-	[°C]
3-7-6-4	Time Threshold: No High Fluid Temperature Occurred	-	[s]
3-7-6-5	Minimum Duration For High Fluid Temperature	-	[s]
3-7-8 Configuration of Digital Input			
3-7-8-1	Digital Input Function	▪ Starting / stopping the pump ▪ Switchover between normal operation and maximum setpoint ▪ Switchover between normal operation and minimum setpoint ▪ Switchover between normal operation and adjustable setpoint ▪ Switchover between day mode and night mode	-
3-7-8-2	Configurable Setpoint	-	[%]
3-7-9 Dynamic Control			
3-7-9-1	Delay	-	Enabled / disabled

Menu number	Designation	Description	Unit
3-7-9-2	Lowering Dynamic	-	[m/h]
3-7-9-3	Flow Rate Limits	-	[%]
3-7-9-4	Dynamic Control Active	-	Enabled (default) / disabled
4 Information			
4-1	Control panel	-	-
4-1-1	Serial number	-	Zxxxxxxxxxxxxxxxxx
4-1-2	Firmware Version	-	3.x.x
4-1-3	Firmware Revision	-	Xxxxxx
4-1-4	Hardware Revision	-	2
4-1-8	Factory Parameter Set Version	-	3.x.x
4-2 Motor Control System			
4-2-1	Serial number	-	Zxxxxxxxxxxxxxxxxx
4-2-2	Firmware Version	-	3.x.x
4-2-3	Firmware Revision	-	Xxxxxx
4-2-4	Hardware Revision	-	2
4-2-5	Hardware Variant	-	175 W, 350 W, 800 W
4-2-7	Pump type	Size of pump set	E.g. 50-120
4-3 Product Information			
4-3-1	Serial Number Product	-	xxxxxxx-201831-xxxxx
4-3-2	Product Version	-	3.x.x

1.2.2 Meter

NOTE

Communication with the KSB ServiceTool is only possible if the Modbus function has been disabled.

The pump set records the following values to evaluate and optimise system efficiency:

- Energy consumed
- Operating hours run
- Total volume of water pumped

Table 3: Counter menu

Menu number	Designation	Description	Unit
1-4-1-1	kWh Counter	Energy meter	[kWh]
1-4-2-1	Operating Hours Counter	Number of pump operating hours	[h]
1-4-3-1	Water Volume Counter	Water volume pumped	[m³]

1.2.3 Pump control settings

NOTE

Communication with the KSB ServiceTool is only possible if the Modbus function has been disabled.

The pump set continuously adjusts its speed to run at its best efficiency point.

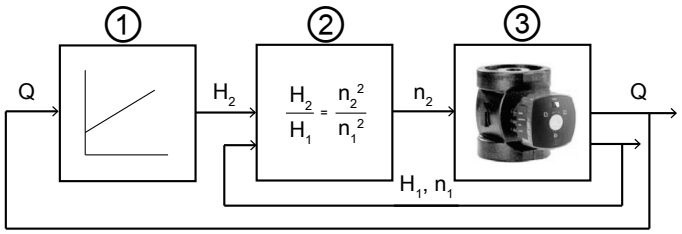

Fig. 1: Structure of the pump control system

①	Control mode to be used	②	Internal pressure controller
③	Pump set		

The operating point estimation integrated in the pump set ③ continuously determines the current flow rate and head. Based on the control mode set ① and setpoint, the internal pressure controller ② determines the required differential pressure H_2.
The internal pressure controller determines the required target speed n_2 based on the hydraulic principle that the ratio between 2 heads equals the ratio of the corresponding speeds squared.

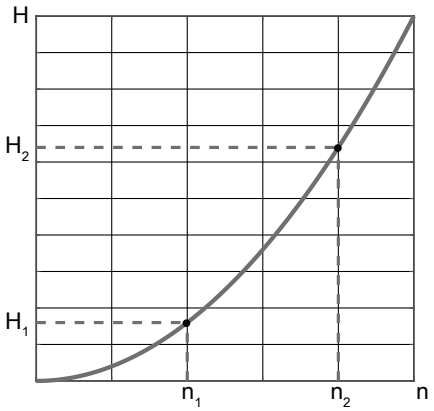

Fig. 2: Relationship between head and speed

The current operating point in this example is based on a known current speed n_1 and a known current head H_1. As all H/n value pairs are situated on a parabola, the formula for calculating any head setpoint H_2 and the corresponding target speed n_2 is as follows:

$n_2 = n_1 \times (H_2/H_1)^{0,5}$

Setting the speed setpoint n_2 results in the required head. The benefits compared to e.g. a PI controller[4)] are that there is no need to spend a great deal of time configuring the controller parameters and that maximum dynamic response is achieved without overshoots. An I controller[5)] with anti-windup limit is provided to prevent persistent control deviation in addition to the non-linear controller. The default values of the integral constant and the anti-windup limit are optimised for the entire operating range of the pump set. If the pump set is externally controlled, the integral constant can have a negative effect on the external control circuit in isolated cases. The parameters can be adapted via the KSB ServiceTool. If the integral constant is 0, this is equivalent to deactivating the integral constant.

Table 4: Pump control settings menu

Menu number	Designation	Default	Unit
3-4-3-1	Integral Constant	-10	[s^{-1}]
3-4-3-2	Anti-windup Limit	120	[rpm]

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4) Controller with proportional constant and integral constant
5) Controller with integral constant

1.2.4 Temperature-governed differential pressure control

NOTE

Communication with the KSB ServiceTool is only possible if the Modbus function has been disabled.

The temperature-governed differential pressure control increases (variant 1) or decreases (variant 2) the head linearly as a function of fluid temperature. It is activated via menu number 1-3-4.

Variant 1 Prerequisite: The pump set is installed in the supply line and the boiler is controlled by the outside temperature.

The fluid temperature is directly related to the outside temperature. If the outside temperature is low, the fluid temperature increases. This leads to elevated heating requirements and, thus, a higher volume flow rate required. To compensate for increased piping losses, the pump set must provide a higher head. When the outside temperature is higher, the fluid temperature is lower. The pump set then assumes a lower heating and volume flow requirement and reduces the head.

Variant 2 Prerequisite: The pump set is installed in the return line and the boiler features condensing boiler technology.

When gas or oil is combusted, condensation is generated in the process. The condensing boiler utilises the heat and thermal energy of this condensation. The cold required for this is taken from the heating medium, which is why the return temperature must be below the dew point (57 °C for natural gas, 47 °C for oil). A sufficiently low return temperature can be achieved via the temperature-governed differential pressure control.

The principle behind the temperature-governed differential pressure control is illustrated in the next figure. The progression of the curve is determined by data points H_1, T_1 and H_2, T_2. The data points can be set via the KSB ServiceTool.

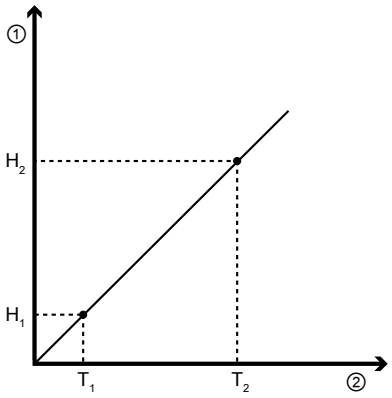

Fig. 3: Temperature-Governed Differential Pressure Control

①	Head	②	Fluid temperature

Table 5: Temperature-governed differential pressure control menu

Menu number	Designation	Unit
3-4-5-4-1	Reference Temperature T_1	[°C]
3-4-5-4-2	Reference Temperature T_2	[°C]
3-4-5-4-3	Reference Head H_1	[m]
3-4-5-4-4	Reference Head H_2	[m]

NOTE

The integrated estimation algorithm determines the fluid temperature. The estimation algorithm estimates temperatures between 40 °C and 90 °C and leads to a mean error of 4 K and a maximum error of up to 8 K. If higher accuracies or a higher temperature range are required, an external temperature sensor is recommended. (⇨ Section 1.2.9, Page 22)

1.2.5 Temperature monitoring

NOTE

Communication with the KSB ServiceTool is only possible if the Modbus function has been disabled.

To protect the motor against overheating a sensor monitors the winding temperature. If the temperature enters a critical range and exceeds the temperature limit (145 °C) ①, the motor outputs warning E05. In addition, the maximum speed is limited. The new maximum speed is 30 percent lower than the speed present when the warning is output.

If the temperature is still within the critical range after 4 minutes, the maximum speed is further reduced by another 30 percent. If the temperature exceeds the alert limit (155 °C) ②, the pump set switches off and alert E01 is displayed.

This procedure is explained in an example:

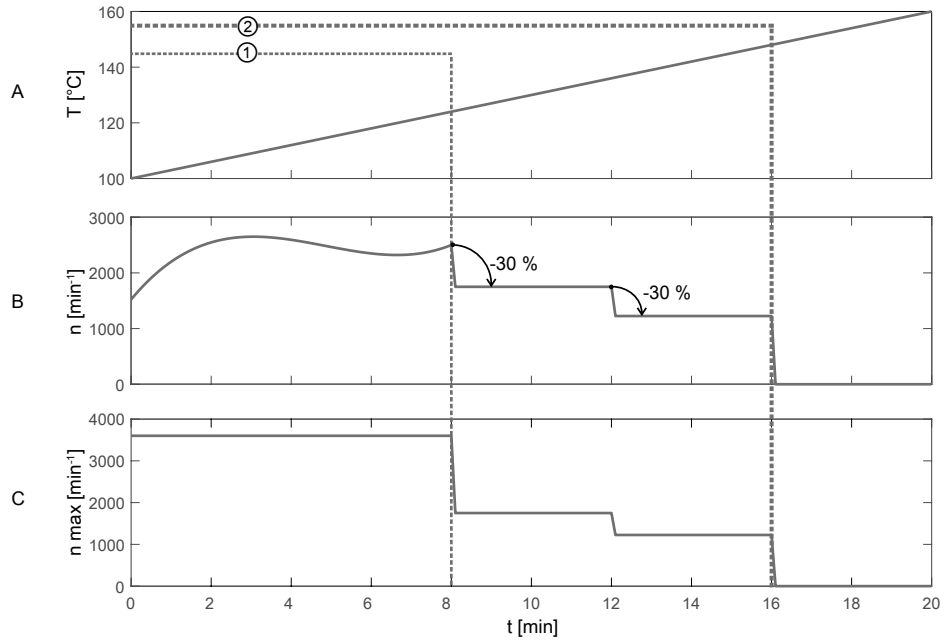

Fig. 4: Example diagram of protection against excessive temperature

①	Temperature limit (145 °C)	②	Alert limit (155 °C)

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Diagram A

- Example plotted curve of motor temperature

Diagram B

- Example plotted curve of speed

Diagram C

- Time progression of maximum permitted speed (in example: 3600 rpm)
  - In the time from 0 to 8 minutes, the temperature is below the warning limit. The pump set is in normal operation.
  - After 8 minutes, the motor temperature exceeds the warning limit (145 °C) ①. At this point of time the motor speed is 2500 rpm. This value – reduced by 30 percent – yields the new maximum speed of 1750 rpm.
  - After 12 minutes, the motor temperature is still in the critical range. The maximum speed is reduced by another 30 % to 1225 rpm.
  - After 16 minutes, the motor temperature exceeds the alert limit (155 °C) ②. The motor is switched off.

The procedure is described by 3 parameters. The parameters can be read out via the KSB ServiceTool. KSB service technicians can adjust the factory defaults if they are not optimal for a specific system.

Table 6: Parameter functions

Parameter	Function
Speed Derating Percentage	Percentage-based reduction of maximum speed upon temperature warning
Time Delay	Time until next reduction in maximum speed. To compensate for momentary fluctuations in speed, the speeds are averaged within a time window of 10 minutes.
Time Constant For Mean Speed	Duration of averaging

Critical electronic elements are also monitored in addition to the winding temperature of the motor.

Table 7: Overtemperature protection menu

Menu number	Designation	Default	Unit
3-5-1	Temperature Control Module (HMI[6)]) Warning Limit	76	[°C]
3-5-2	Temperature Control Module (HMI[6)]) Alert Limit	79	[°C]
3-5-3	Motor Temperature Warning Limit	145	[°C]
3-5-4	Motor Temperature Alert Limit	155	[°C]
3-5-5	PFC[7)] Temperature Warning Limit	95	[°C]
3-5-6	PFC[7)] Temperature Alert Limit	100	[°C]
3-5-7	SPM[8)] Temperature Warning Limit	95	[°C]
3-5-8	SPM[8)] Temperature Alert Limit	100	[°C]
3-5-13	Speed Derating Percentage	30	[%]
3-5-14	Time Delay	180	[s]
3-5-15	Time Constant For Mean Speed	10	[s]

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6) Temperature measured on main control board
7) Power Factor Correction
8) Smart Power Module

1.2.6 Ramps

NOTE

Communication with the KSB ServiceTool is only possible if the Modbus function has been disabled.

Abrupt changes in speed promote pressure surges and high noise levels (not desired). A setpoint filter (ramp) limits speed changes. The ramp acts like a first-order low-pass filter with an adjustable time constant τ. The behaviour is depicted in the following graph:

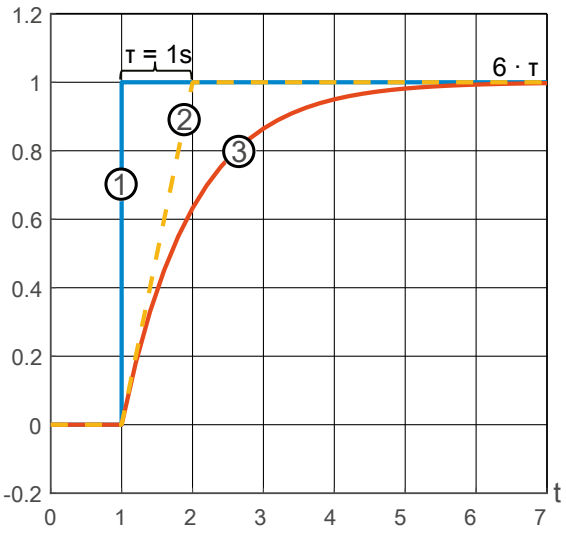

Fig. 5: Behaviour of a low pass

①	Setpoint jump	③	Jump response
②	Jump response tangent		

The intersection of the jump response tangent ② and the setpoint ① marks the time constant (τ). The jump response reaches its full value after a period of approx. 6 × τ.

The pump set distinguishes between 4 separate scenarios by using 4 different ramps. The ramp parameters are optimised for the respective pump set. If the pump set is externally controlled, the setpoint filter setting has a negative effect on the external control circuit. The parameters can be individually adjusted via the KSB ServiceTool.

Threshold value of start ramp

The start ramp is applied from the time the pump set is started up to the time at which the deviation between the speed setpoint and the actual speed is lower than this parameter.

Time constant of start ramp

The time constant defined here applies during the start ramp.

Time constant of stop ramp

The stop ramp engages when the pump set receives the stop command. The time constant defined here applies during the stop ramp.

Threshold value of operating ramp

The operating ramp is active when a large setpoint jump occurs during operation (start ramp and stop ramp inactive). A large setpoint jump is present if the deviation between the speed setpoint and the actual speed is greater than this parameter.

Time constant of operating ramp

The time constant defined here applies during the operating ramp.

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Time constant of standard ramp

If none of the 3 above ramps is active, the standard ramp applies. The time constant of the standard ramp is set with this parameter.

Minimum ramp / maximum ramp

Possible ramp values are limited at the top and bottom ends via this parameter.

Table 8: Operation menu

Menu number	Designation	Default	Unit
3-4-5-7-1	Threshold Value Start Ramp	200	[rpm]
3-4-5-7-2	Threshold Value Operating Ramp	200	[rpm]
3-4-5-7-3	Time Constant Start Ramp	0,1	[s]
3-4-5-7-4	Time Constant Stop Ramp	0,1	[s]
3-4-5-7-5	Time Constant Operating Ramp	0,1	[s]
3-4-5-7-6	Max Ramp	1000	[s^{-1}]
3-4-5-7-7	Min Ramp	10	[s^{-1}]
3-4-5-7-8	Time Constant Common Ramp	1	[s]

1.2.7 Peak load

NOTE

Communication with the KSB ServiceTool is only possible if the Modbus function has been disabled.

The peak load function allows 2 pump sets to work in parallel. The function is enabled via menu number 3-6-7-1. If open-loop control mode and peak load operation are activated at the same time, both pump sets always run together. For the proportional-pressure control, constant-pressure control and Eco operating modes, the control system automatically determines whether a second pump cuts in at the respective operating point. The starting and stopping behaviour are depicted in the following figure:

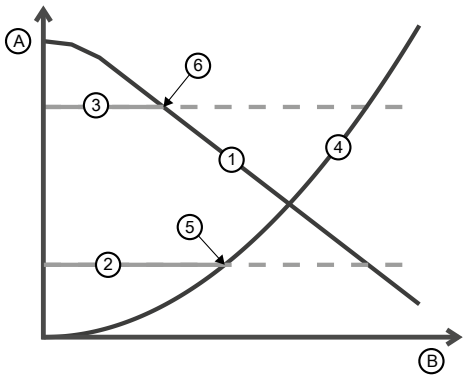

Fig. 6: Starting and stopping behaviour of a second pump set

Ⓐ	Head	Ⓑ	Flow rate
①	Operating range of single pump	②	Setpoint, constant pressure 20 %
③	Setpoint, constant pressure 80 %	④	Efficiency-optimised switching parabola
⑤	Cut-in point as per criterion 1	⑥	Cut-in point as per criterion 2

The switching parabola (4) is the curve along which the efficiency of the system is identical for single-pump and two-pump operation. To the left of the parabola, efficiency is higher if only one pump set is running. To the right of the parabola, efficiency is higher if 2 pump sets are running. The cut-in point is based on 2 criteria: efficiency (criterion 1) and the head required (criterion 2).

Criterion 1 If the operating point is to the right of the switching parabola, the control system starts up a second pump set. This increases the efficiency of the system.

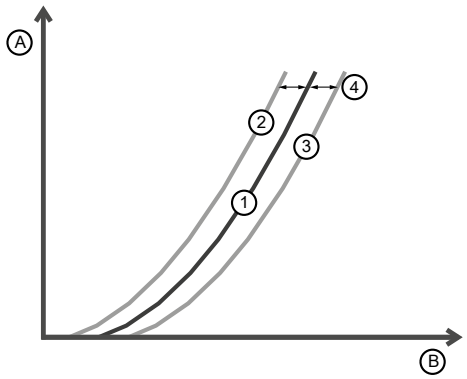

Fig. 7: Efficiency (criterion 1)

Ⓐ	Head	Ⓑ	Flow rate
①	Efficiency-optimised switching parabola	②	Stop limit
③	Cut-in limit	④	Hysteresis

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Criterion 2 If the head setpoint lies to the right of the maximum curve ①, the control system always starts up a second pump set. The setpoint cannot be attained with just one pump set.

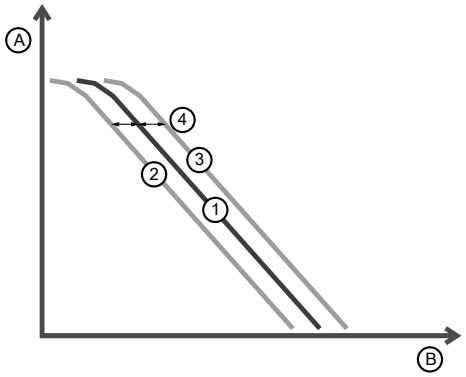

Fig. 8: Head required (criterion 2)

Ⓐ	Head	Ⓑ	Flow rate
①	Operating range of single pump	②	Stop limit
③	Cut-in limit	④	Hysteresis

If the operating point is very close to curve ①, excessive on/off cycling can be caused by measurement noise. Excessive on/off cycling refers to constant starting and stopping of the pump set within a set time window (menu number 3-6-7-7). To avoid excessive on/off cycling, starting and stopping are carried out with hysteresis. The graphs above plot starting and stopping via hysteresis according to criteria 1 and 2.

Learning procedure

Excessively high hysteresis increases energy consumption, while excessively low hysteresis does not sufficiently protect against excessive on/off cycling. The control system integrates a learning procedure that is leveraged to automatically optimise hysteresis. After commissioning, the hysteresis assumes its configurable start value (menu number 3-6-7-3) ①. If excessive on/off cycling is detected, the hysteresis is increased by a configurable value (menu number 3-6-7-6) ③. If user behaviour changes several times in short cycles, the control system will incorrectly interpret this as excessive on/off cycling and the hysteresis will increase as a result. To correct such incorrect decisions, the procedure is augmented by the forget function. This hysteresis is continually reduced at constant speed (menu number 3-6-7-2) ② until a minimum configurable hysteresis limit has been reached (menu number 3-6-7-4). The procedure is depicted in the following figure:

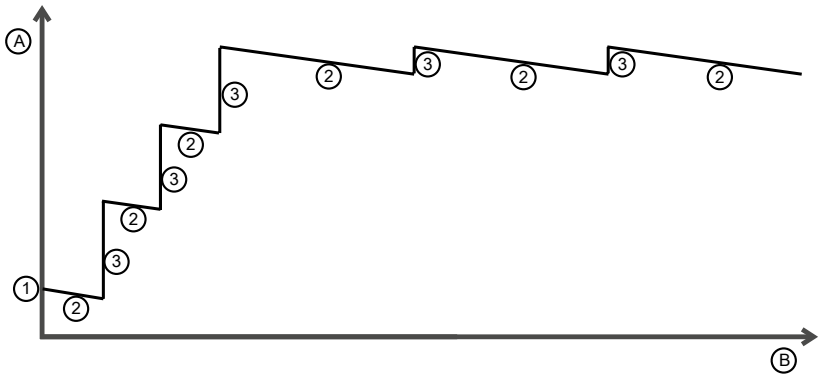

Fig. 9: Learning procedure

Ⓐ	$Q_{Hysteresis}$	Ⓑ	Time
①	Hysteresis at start	②	Reduction in hysteresis per time
③	Hysteresis		

When the system is switched on, the hysteresis is very small at first ①. Excessively low hysteresis results in e.g. excessive on/off cycling. The control system detects excessively low hysteresis and responds by increasing it ③. The hysteresis is

continuously reduced over the entire operating time to correct for a hysteresis setting that was set too high ②. The left side of the graph shows the learning phase as the hysteresis is incrementally increased to the optimum level. When the optimum level has been reached, the behaviour levels out (right-hand section of graph). The hysteresis does not exceed the configurable upper limit (menu number 3-6-7-5). The procedure can be deactivated by defining the same value for the minimum hysteresis (menu number 3-6-7-4) and the maximum hysteresis (menu number 3-6-7-5).

Table 9: Peak load menu

Menu number	Designation	Default	Unit
3-6-7-1	Activation Peak Load Operation	Disabled	Enabled / disabled
3-6-7-2	Hysteresis Reduction per Time	2	[(m³/h)/month]
3-6-7-3	Default Hysteresis	0,5	[m³/h]
3-6-7-4	Min Hysteresis	0	[m³/h]
3-6-7-5	Max Hysteresis	5	[m³/h]
3-6-7-6	Hysteresis Increase Excessive On/Off	0,2	[m³/h]
3-6-7-7	Time Window Excessive On/Off Detection	120	[s]
3-6-7-14	Peak Load Opt. Hysteresis	0	[m³/h]

1.2.8 Setback operation

NOTE

Communication with the KSB ServiceTool is only possible if the Modbus function has been disabled.

To save energy, the boiler in many buildings switches to a second (lower) heating curve in the night. This switchover lowers the room temperature and, thus, opens the thermostatic valves. If the pump set continues to operate using the same control curve, opening of the thermostatic valves increases the mass flow rate and leads to higher noise levels as well as increased energy consumption. To avoid this, we recommend enabling the setback operation function. When the setback operation function is enabled, the pump set uses the fluid temperature to detect when the boiler switches to night mode. The pump set switches to a lower control curve, and the unfavourable increase in mass flow rate in the night is avoided. The lower control curve is attained by reducing the setpoint (menu number 3-7-1-8).

Setback operation rules

Activation via digital input

If the configurable digital input is set to **Switchover between day mode and night mode** (menu number 3-7-8-1), the digital input has priority and automatic detection of setback operation is disabled.

Automatic activation

When the pump set is in night mode, it will automatically switch to day mode when the setpoint or operating mode is changed, when the configurable analog input is active, or – in the case of active dual-pump operation (DUAL) – when pump changeover takes place. The pump set will only switch back to night mode if the requirements for setback operation are fulfilled:

- The fluid temperature drops by 15 °C (menu number 3-7-1-6) within 120 minutes (menu number 3-7-1-5). During these 120 minutes, the fluid temperature drops by 0.1 °C (menu number 3-7-1-4) every 3 minutes (menu number 3-7-1-3).
- The pump set switches back to day mode based on the following criteria:
  - The fluid temperature increases by 3 °C (menu number 3-7-1-9) over the lowest temperature value measured during night mode.
  - The pump set has been in night mode for more than 7 hours (menu number 3-7-1-7). Even if the fluid temperature does not change, the pump set reverts to day mode.

The figure below illustrates an example of the criteria used by the boiler and pump set to switch between day mode and night mode:

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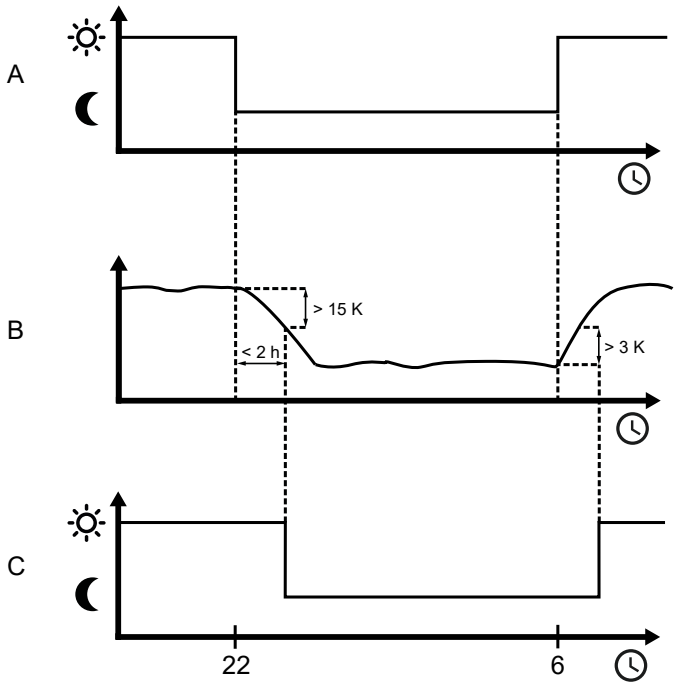

Fig. 10: Switchover between day mode and night mode

A	Boiler mode
B	Fluid temperature
C	Pump mode

The preset default values detect night mode for typical buildings. In special cases, the parameters must be adapted to the respective building and to the boiler control system.

Table 10: Setback operation menu

Menu number	Designation	Default	Unit
3-7-1-1	Activation Night Setback	Disabled	Enabled / disabled
3-7-1-2	Status Night Setback	Day	Day / Night
3-7-1-3	Threshold Value Time Night Mode	3	[min]
3-7-1-4	Minimum Fluid Temperature Gradient	0,1	[°C]
3-7-1-5	Time Window Fluid Temperature Reduction	120	[min]
3-7-1-6	Threshold Value Fluid Temperature Night Mode	15	[°C]
3-7-1-7	Maximum Duration Night Mode	7	[h]
3-7-1-8	Setpoint Reduction If Night Mode Detected	0,5	-
3-7-1-9	Threshold Value Fluid Temperature Daytime Mode	3	[°C]

1.2.9 Configuration of analog input

NOTE

Communication with the KSB ServiceTool is only possible if the Modbus function has been disabled.

The analog input can be configured and used to specify a setpoint (%) or actual value (sensor). It is configured via menu number 3-7-3-8.

Setpoint specification (broken wire)

The switchover between **start** and **stop**, and **broken wire detected** and **no broken wire detected** takes place after a hysteresis of 0.2 V has been exceeded or undershot (menu number 3-7-3-1). The setpoint only changes if the current voltage differs from the previous voltage by a minimum of 0.008 V (menu number 3-7-3-4). This avoids rapid setpoint changes as a result of interference.

To avoid a **broken wire detected** signal in the event of momentary power failures (e.g. caused by loose contacts at the analog input), a delay can be activated for broken wire detection.
If the delay is active, broken wire detection will only respond when the voltage has dropped below the **Threshold Value Broken Wire** for a parameterisable minimum period (menu number 3-7-3-10). To disable broken wire detection, set the minimum period to 0. The delay is set to 0.5 seconds by default.

The analog input is configured as a 0 - 10 V signal input. Broken wire detection can be enabled via menu item 3-7-3-5. If a broken wire is detected, menu number 3-7-3-7 can be used to select the following pump set responses:

- Minimum speed
- Maximum speed
- Maintain the last valid value.
- Last HMI[9]/Modbus value
- Pump stops (default).

To ensure redundancy in dual-pump operation (DUAL), connect the same voltage signal to both pump sets and enable broken wire detection. If a broken wire occurs on one of the pump sets, the voltage signal of the other pump continues to be available. If the voltage signal is connected on one pump set only, the conditions described in menu number 3-7-3-7 apply in the event of a broken wire.

The following graph shows the correlation between the voltage signal and setpoint:

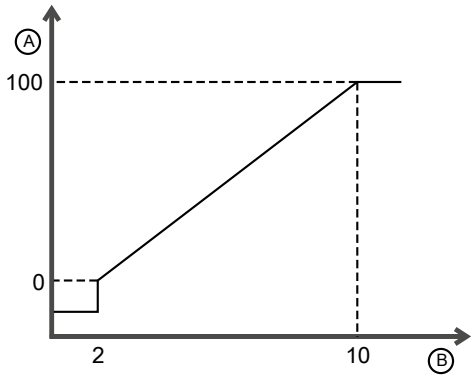

Fig. 11: Configuration of analog input

Ⓐ	Setpoint	Ⓑ	Voltage [V]

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9) Temperature measured on main control board

Fluid temperature as actual value (sensor)

The configuration is set via menu number 3-7-3-8. Scaling of the fluid temperature is linear. The temperature data points at 2 V and 10 V are defined via menu numbers 3-7-3-12 and 3-7-3-13. Broken wire detection (menu number 3-7-3-9) is realised as for setpoint specification. A start/stop command cannot be sent. If a broken wire is detected, the control system leverages the estimated temperature value.

Measured differential pressure

The differential pressure is specified as for the fluid temperature. Scaling occurs in linear fashion between the data points (menu numbers 3-7-3-16 and 3-7-3-17).

Table 11: Analog input configuration menu

Menu number	Designation	Description	Default	Unit
3-7-3-1	Hysteresis Analog Input	-	0,2	[V]
3-7-3-2	Threshold Value Pump Start	2 V = setpoint 0 % Pump starts at voltage > 2 V.	2	[V]
3-7-3-3	Maximum Analog Voltage	10 V = setpoint 100 % Voltages > 10 V are interpreted as 10 V.	10	[V]
3-7-3-4	Minimum Change of Analog Signal	-	0,008	[V]
3-7-3-5	Analog Input Broken Wire Detection	-	Disabled	Enabled / disabled
3-7-3-6	Setpoint Threshold Value Broken Wire	If voltage < 1 V, a broken wire is detected and the E10 warning is output.	1	[V]
3-7-3-7	Setpoint Behaviour With Broken Wire	▪ Minimum speed ▪ Maximum speed ▪ Pump stops ▪ Last valid setpoint ▪ Last setpoint of HMI[9] or Modbus	Pump stops	-
3-7-3-8	Function Analog Input	▪ Setpoint ▪ Actual value of temperature ▪ Actual value of differential pressure	Setpoint	-
3-7-3-9	Actual Value Threshold Value Broken Wire	-	1	[V]
3-7-3-10	Delay Broken Wire Detection	-	0,5	[s]
3-7-3-12	Temperature Sensor Data Point T_1 for 2 V Input Signal	-	0	[°C]
3-7-3-13	Temperature Sensor Data Point T_2 for 10 V Input Signal	-	0	[°C]
3-7-3-16	Head Data Point P_1 for 2 V Input Signal	-	0	[m]
3-7-3-17	Head Data Point P_2 for 10 V Input Signal	-	0	[m]

1.2.10 Configuration of digital input

NOTE

Communication with the KSB ServiceTool is only possible if the Modbus function has been disabled.

By default, the digital input is used for starting and stopping the pump set.
The digital input can also be configured. It is configured via menu number 3-7-8-1.

Starting / stopping the pump

- Digital input closed:
  - If the operating criteria as specified in the operating manual are met, the pump set will run.
- Digital input open:
  - Pump set stops.

Switchover between normal operation and maximum setpoint

- Digital input closed:
  - The pump set switches to maximum setpoint (100 %).
- Digital input open:
  - The pump set is in normal operation.

Switchover between normal operation and minimum setpoint

- Digital input closed:
  - The pump set switches to minimum setpoint (0 %).
- Digital input open:
  - The pump set is in normal operation.

Switchover between normal operation and adjustable setpoint

- Digital input closed:
  - The pump set switches to adjustable setpoint (menu number 3-7-8-2).
- Digital input open:
  - The pump set is in normal operation.

Switchover between day mode and night mode

- Digital input closed:
  - Pump set is in night mode. The digital input has priority and automatic detection of setback operation is disabled.
- Digital input open:
  - Pump set is in day mode.

Table 12: Digital input configuration menu

Menu number	Designation	Description	Default	Unit
3-7-8-1	Digital Input Function	▪ Starting / stopping the pump ▪ Switchover between normal operation and maximum setpoint ▪ Switchover between normal operation and minimum setpoint ▪ Switchover between normal operation and adjustable setpoint ▪ Switchover between day mode and night mode	Pump ON	-
3-7-8-2	Configurable setpoint	-	0	[%]

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Behaviour in dual-pump operation (DUAL)

If dual-pump operation (DUAL) is enabled, each pump set can be started and stopped individually via the digital input.

For all other functions the input signal at the digital input applies to both pump sets. If the signals applied differ, the control system uses the information as follows:

Table 13: Control system response if signals differ

Signal for pump set 1	Signal for pump set 2	Signal used
Closed	Closed	Closed
Closed	Open	Closed
Open	Closed	Closed
Open	Open	Open

1.2.11 Dynamic control

NOTE

Communication with the KSB ServiceTool is only possible if the Modbus function has been disabled.

Principle

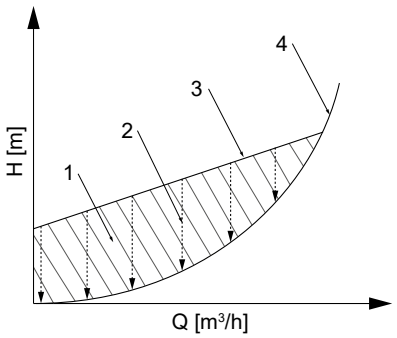

Fig. 12: Principle of dynamic control

1	Excess energy input	3	Control curve
2	Dynamic Control	4	Minimum characteristic curve[10)]

The dynamic control (2) system detects when the selected control curve (3) is higher than the minimum characteristic curve[10)] (4). The control system shifts the control curve downward, and power input is reduced automatically. To ensure sufficient supply the pump set switches to a higher control curve when the minimum characteristic curve is reached. The energy input is reduced (1) without any negative impact on the supply of the building. The function is enabled via menu number 3-4-5-6-4.

Function

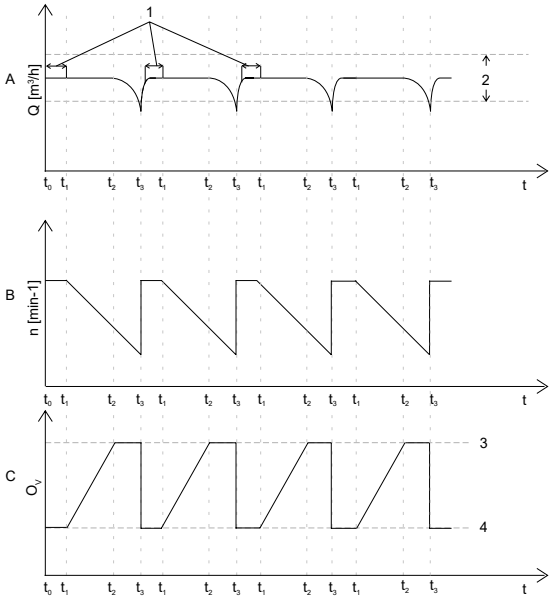

Fig. 13: Dynamic control function plotted over time

1	Delay	n	Speed [rpm]
2	Flow rate limit	O_V	Degree of valve opening
3	Open	Q	Flow rate [m³/h]
4	Closed		

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10) Characteristic curve at fully open thermostatic valves

Diagram A

When the pump set starts (t0), a static control curve is applied. The pump set checks whether the flow rate is within the permissible flow rate limits (2) (menu number 3-4-5-6-3). If flow rate Q remains constant for a certain period of time (delay, menu number 3-4-5-6-1), the operating point is stable (t1).

Diagram B

If the flow rate remains constant for a certain period of time and the operating point is stable, the pump set slowly but steadily reduces speed.

Diagram C

When the pump set reduces speed, the thermostat valves open while the room temperature remains constant. When the thermostat valves are fully open (t2), the flow rate decreases and falls below the permissible flow rate limit (t3) (menu number 3-4-5-6-3). As soon as the flow rate limit is undershot, the algorithm switches back to the static control curve (the speed increases to its original level) to prevent undersupply.

The function is shown in the H/Q diagram:

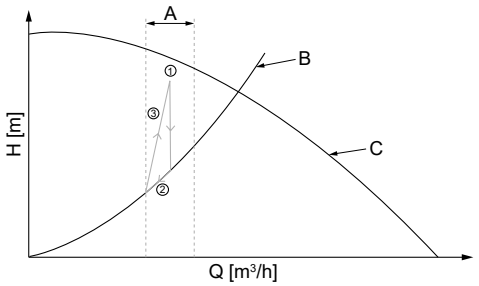

Fig. 14: Dynamic control function in H/Q diagram

①	Start	A	Flow rate limit
②	Flow rate reduction	B	Minimum characteristic curve
③	Return to static control curve	C	Operating range of pump set

The algorithm starts at point ①. If the flow rate stays within the permissible flow rate limits (A), the speed and the head H are reduced and the thermostat valves open. The reduction dynamic (rate of reduction) can be set via menu number 3-4-5-6-2.
The flow rate remains constant until the thermostat valves are fully open. When the thermostat valves are fully open, the flow rate decreases and falls below the permissible flow rate limit ②. As soon as the flow rate limit is undershot, the algorithm switches back to the static control curve ③ and the process is repeated.

Table 14: Dynamic control menu

Menu number	Description	default	Unit
3-7-9-1	Delay	7200	Enabled / disabled
3-7-9-2	Lowering Dynamic	0,05	[m/h]
3-7-9-3	Flow Rate Limits	15	[%]
3-7-9-4	Dynamic Control Active	Active	Enabled / disabled

1.2.12 Flow rate limit

NOTE

Communication with the KSB ServiceTool is only possible if the Modbus function has been disabled.

This function monitors flow rate changes within the adjustable limits. Should the flow rate exceed the limits, a warning is output.

Minimum flow rate

Monitoring of the minimum flow rate limit can be activated in menu number 3-7-5-1.

- If the actual flow rate undershoots the threshold value (menu number 3-7-5-2), warning E15 is output.
- If the flow rate subsequently exceeds the threshold value (menu number 3-7-5-2) and the configurable hysteresis (menu number 3-7-5-3), the E15 warning is deactivated.

Maximum flow rate

Monitoring of the maximum flow rate limit can be activated in menu number 3-7-5-4.

- If the actual flow rate overshoots the threshold value (menu number 3-7-5-5), warning E16 is output.
- If the flow rate subsequently undershoots the threshold value (menu number 3-7-5-5) minus the configurable hysteresis (menu number 3-7-5-6), the E16 warning is deactivated.

Warnings E15 and E16 appear if the excessively low or high flow rate is maintained for a minimum period set in menu number 3-7-5-7. If the flow rate transitions back to the permissible range over the minimum time frame defined (menu number 3-7-5-8), the warning deactivates. Monitoring of the minimum and maximum flow rate can be simultaneously activated.

Table 15: Operation menu

Menu number	Designation	Unit
3-7-5-1	Activation of Minimum Flow Monitoring	Enabled / disabled
3-7-5-2	Threshold Value Minimum Flow	[m³/h]
3-7-5-3	Hysteresis Minimum Flow	[m³/h]
3-7-5-4	Activation of Maximum Flow Monitoring	Enabled / disabled
3-7-5-5	Threshold Value Maximum Flow	[m³/h]
3-7-5-6	Hysteresis Maximum Flow	[m³/h]
3-7-5-7	Time Threshold: No Minimum / Maximum Flow Occurred	[s]
3-7-5-8	Minimum Duration of Minimum/Maximum Flow	[s]

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1.2.13 High fluid temperature

NOTE

Communication with the KSB ServiceTool is only possible if the Modbus function has been disabled.

The function monitors whether the fluid temperature exceeds a configurable limit. The function can be activated via menu number 3-7-6-1.

- If the fluid temperature exceeds the threshold value (menu number 3-7-6-2), warning E09 is output.
- If the fluid temperature subsequently undershoots the threshold value minus the configurable hysteresis (menu number 3-7-6-3), warning E09 is deactivated.

Warning E09 appears if the excessively high fluid temperature persists for at least the time delay set (menu number 3-7-3-5). If the fluid temperature transitions back to the permissible range over the minimum time frame defined (menu number 3-7-6-4), the E09 warning is deactivated.

Table 16: High fluid temperature menu

Menu number	Designation	Unit
3-7-6-1	Activation Monitoring: High Fluid Temperature	Enabled / disabled
3-7-6-2	Threshold Value Maximum Fluid Temperature	[°C]
3-7-6-3	Hysteresis Maximum Fluid Temperature	[°C]
3-7-6-4	Time Threshold: No High Fluid Temperature Occurred	[s]
3-7-6-5	Minimum Duration For High Fluid Temperature	[s]

NOTE

The integrated estimation algorithm determines the fluid temperature. The estimation algorithm estimates temperatures between 40 °C and 90 °C and leads to a mean error of 4 K and a maximum error of up to 8 K. If higher accuracies or a higher temperature range are required, an external temperature sensor is recommended. (⇨ Section 1.2.9, Page 22)

1.2.14 Relays

NOTE

Communication with the KSB ServiceTool is only possible if the Modbus function has been disabled.

The pump set has 2 relay outputs. The relays are configured as alarm and operation relays, respectively, at the factory. The configuration can be adapted via menu number 3-7-4-1-1 or 3-7-4-2-1.

Adapting pick-up behaviour for pump conditions

By default, the alarm relay picks up when the pump set is in one of the following conditions:

- Pump running (normal operation).
- Speed reduced due to NTC sensor failure (failure of motor temperature sensor)
- Speed reduced due to temperature monitoring (temperature limit exceeded) (⇨ Section 1.2.5, Page 14)).
- The pump is in night mode.

The relay can also be configured to not pick up for one or more of the criteria mentioned via menu number 3-7-4-1-2 or 3-7-4-2-2:

1. Click Edit button (next to menu number 3-7-4-1-2 / 3-7-4-2-2).
   ⇨ A window listing the 4 conditions opens.
2. Select condition.
3. Remove checkmark.
4. Confirm with OK button.
   ⇨ The relay no longer picks up for the condition selected.

Adapting pick-up behaviour for alerts, warnings and information

If there is an alert, the alarm relay picks up by default. If a warning or information is present, the relay does not pick up. The behaviour can be adapted via menu number 3-7-4-1-3 or 3-7-4-2-3:

1. Click Edit button (next to menu number 3-7-4-1-3 / 3-7-4-2-3).
   ⇨ A window listing alerts, warnings and information opens.
2. Select alert and/or warning.
3. Set or remove checkmark.
4. Confirm with OK button.
   ⇨ Alert and/or warning is added to or removed from the relay responses.

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Relay inversion

The relay logic can be inverted via menu number 3-7-4-1-4 or 3-7-4-2-4. The inverted logic is deactivated by default:

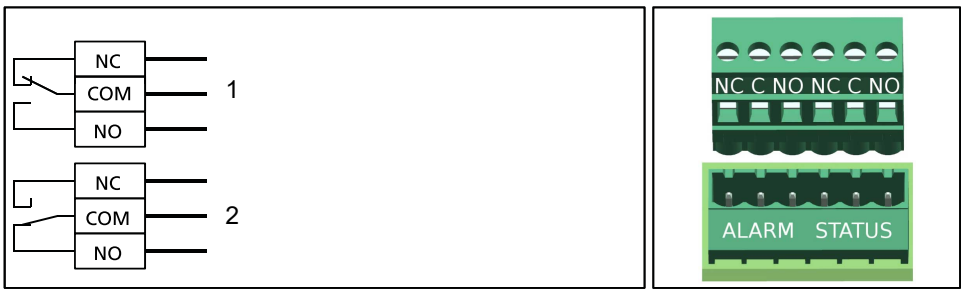

Fig. 15: Wiring diagram (inverted logic deactivated)

1	Pump not in operation (rotor not rotating) / alert active
2	Pump in operation (rotor rotating) / alert not active
NC	NC contact, normally closed and electrically conductive connection to COM
COM	Reference potential for either contact that is closed
NO	NO contact, normally open and not electrically conductive connection to COM

If menu number 3-7-4-1-4 or 3-7-4-2-4 is active, the relay inverts:

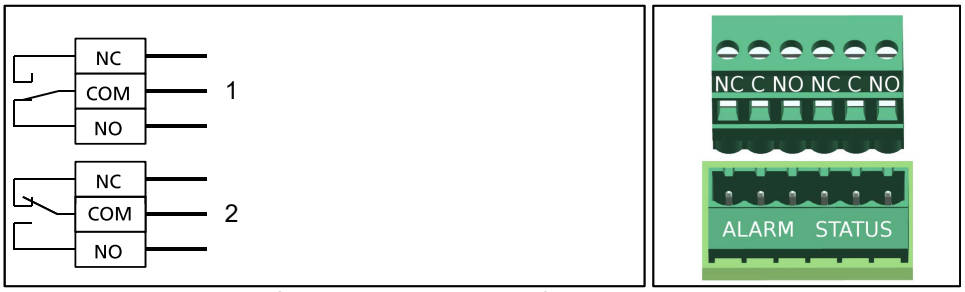

Fig. 16: Wiring diagram (inverted logic activated)

1	Pump not in operation (rotor not rotating) / alert active
2	Pump in operation (rotor rotating) / alert not active
NC	NC contact, normally closed and electrically conductive connection to COM
COM	Reference potential for either contact that is closed
NO	NO contact, normally open and not electrically conductive connection to COM

Table 17: Relay menu

Menu number	Designation	Default	Unit
3-7-4-1 Relay 1: Function			
3-7-4-1-1	Relay 1: Setting Function	Operation	Operation / alert
3-7-4-1-2	Relay 1: Operation Bit Mask (list of operating states)	All operating states are set.	-
3-7-4-1-3	Relay 1: Message Bit Mask (list of alerts, warnings and information)	All alerts are set.	-
3-7-4-1-4	Relay 1: Inverted Logic	Disabled	Enabled / disabled
3-7-4-2-1 Relay 2: Function			
3-7-4-2-1	Relay 2: Setting Function	Alert	Operation / alert
3-7-4-2-2	Relay 2: Operation Bit Mask (list of operating states)	All operating states are set.	-
3-7-4-2-3	Relay 2: Message Bit Mask (list of alerts, warnings and information)	All alerts are set.	-
3-7-4-2-4	Relay 2: Inverted Logic	Disabled	Enabled / disabled

Test alert

The relays can be triggered by setting a test alert to verify functionality and/or correct wiring.

✓ The relay has been configured as an alarm relay (menu number 3-7-4-1-4 or 3-7-4-2-4).

✓ Test alert has been set in the list (menu number 3-7-4-1-3 or 3-7-4-2-3).

1. Enable test alert via menu item 2-3.

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