Operating Instructions
DULCOMETER® D1C

Part 2: Adjustment and Operation,
Measured variable bromine

D1C2-Br-001-GB

Type D

Type W

D1C A	___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___

Please enter the identity code of your device here!

Please completely read through operating instructions! · Do not discard!
The warranty shall be invalidated by damage caused by operating errors!

Part No. 987353 **ProMinent Dosiertechnik GmbH · 69123 Heidelberg · Germany** BA DM 145 02/07 GB

1 Device Identification / Identity Code

D1C A	**DULCOMETER® Controller Series D1C / Version A**
	Type of mounting
D	Control panel installation 96 x 96 mm
W	Wall mounting
	Operating voltage
0	230 V 50/60 Hz
1	115 V 50/60 Hz
2	200 V 50/60 Hz (only with control panel installation)
3	100 V 50/60 Hz (only with control panel installation)
4	24 V AC/DC
	Measured variable
B	Bromine (0.02-2.00 ppm / 0.2-10 ppm)
	Connection of measured variable
1	Terminal, standard signal 0/4-20 mA
	Correction variable
0	None
	Feed forward control
0	None
1	Via standard signal 0/4-20 mA
2	Via frequency 0-500 Hz
3	Via frequency 0-10 Hz
	Control input
0	None
1	Pause
	Signal output
0	None
1	Standard signal 0/4-20 mA measured value
2	Standard signal 0/4-20 mA control variable
3	Standard signal 0/4-20 mA correction variable
4	2 standard signal outputs 0/4-20 mA, free programmable
	Power control
G	Alarm and 2 limit value/timer relays
M	Alarm and 2 solenoid valve relays
R	Alarm relay and servomotor with feedback
	Pump control
0	None
2	Two pumps
	Control characteristic
0	None
1	Proportional control
2	PID control
	Log output
0	None
	Language
D	German
E	English
F	French
I	Italian
N	Dutch
S	Spanish
P	Polish
A	Swedish
B	Portuguese
U	Hungarian
J	Japanese
G	Czech

D1C A ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___

Please enter the identity code of your device here!

2 Contents / General User Information

General User Information

These operating instructions describe the technical data and function of the series DULCOMETER® D1C controller, provide detailed safety information and are divided into clear steps.

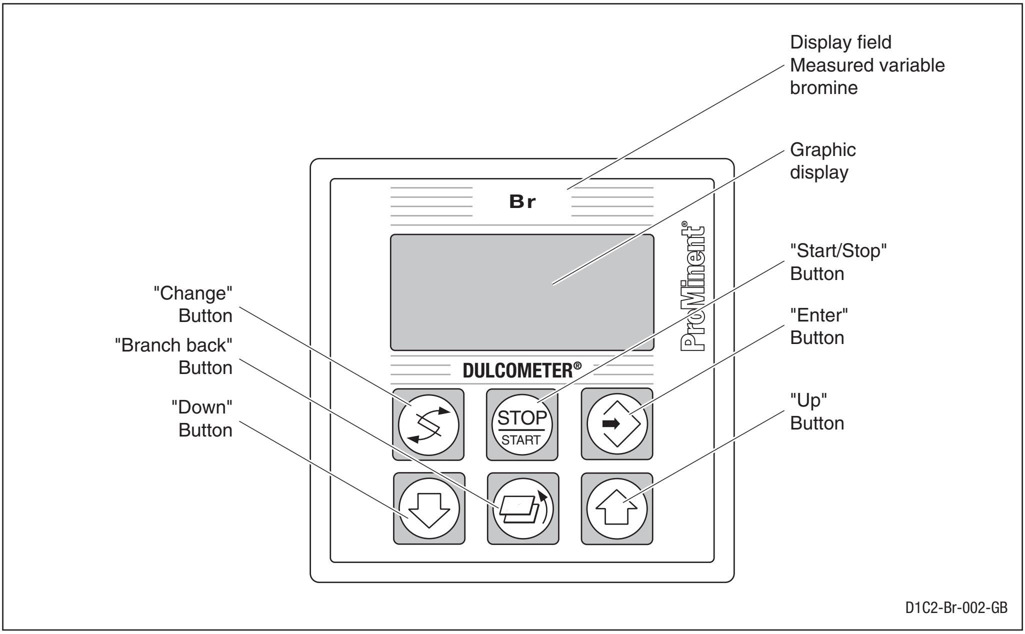
IMPORTANT

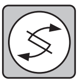
- ***Please observe the parts of these operating instructions applicable to your particular version! This is indicated in the Section "Device Identification / Identity Code"!***
- ***Correct measuring and dosing is only possible in the case of impeccable operation of the probe. The probe has to be calibrated / checked regularly!***

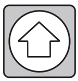
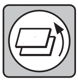
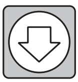
NOTE

A form "Documentation of controller settings Type D1C" is available under www.prominent.com/documentation_D1C for the purpose of documenting the controller settings.

3 Device Overview / Controls



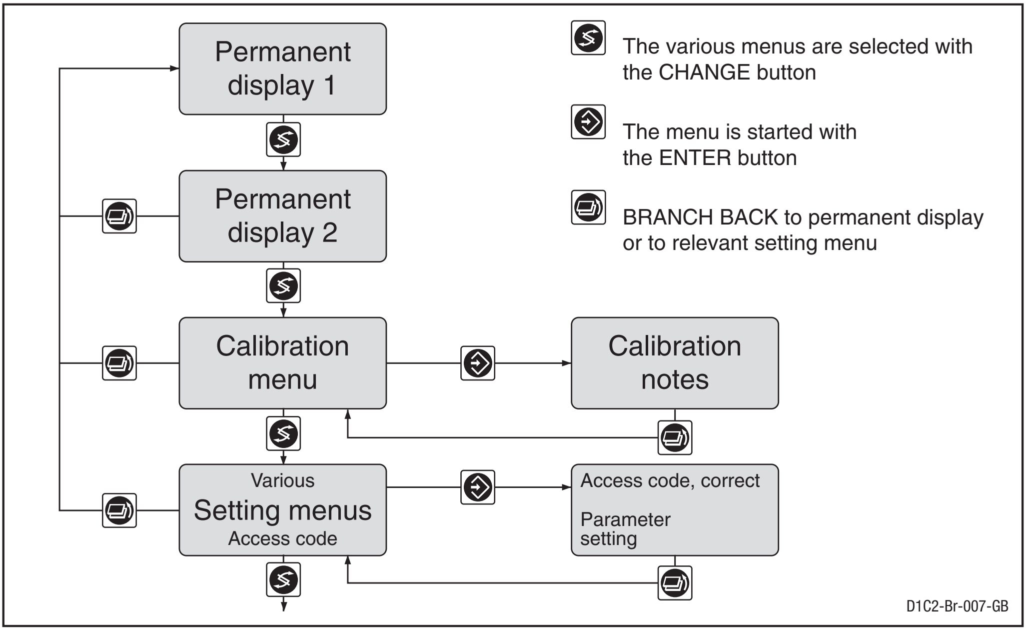
	CHANGE button To change over within a menu level and to change from one variable to another within a menu point.
	START/STOP button Start/stop of control and metering function.
	ENTER button To accept, confirm or save a displayed value or status. For alarm acknowledgement.

	UP button To increase a displayed numerical value and to change variables (flashing display).
	BRANCH BACK button Back to permanent display or to start of relevant setting menu.
	DOWN button To decrease a displayed numerical value and to change variables (flashing display).

4 Display Symbols

The display of the DULCOMETER® D1C controller uses the following symbols:

Description	Comment	Symbol
Limit value transgression Relay 1, upper	Symbol left	
Relay 1, lower	Symbol left	
Relay 2, upper	Symbol right	
Relay 2, lower	Symbol right	
Metering pump 1 (bromine) Control off	Symbol left	
Control on	Symbol left	
Metering pump 2 (De-bromine) Control off	Symbol right	
Controll on	Symbol right	
Solenoid valve 1 (bromine) Controll off	Symbol left	
Controll on	Symbol left	
Solenoid valve 2 (De-bromine) Controll off	Symbol right	
Control on	Symbol right	
Servomotor Control, open relay		
Control, close relay		
Without control		
Position feedback	Thickness of bar increases from left to right during opening	
Stop button pressed		O
Manual metering		M
Fault		Ɛ



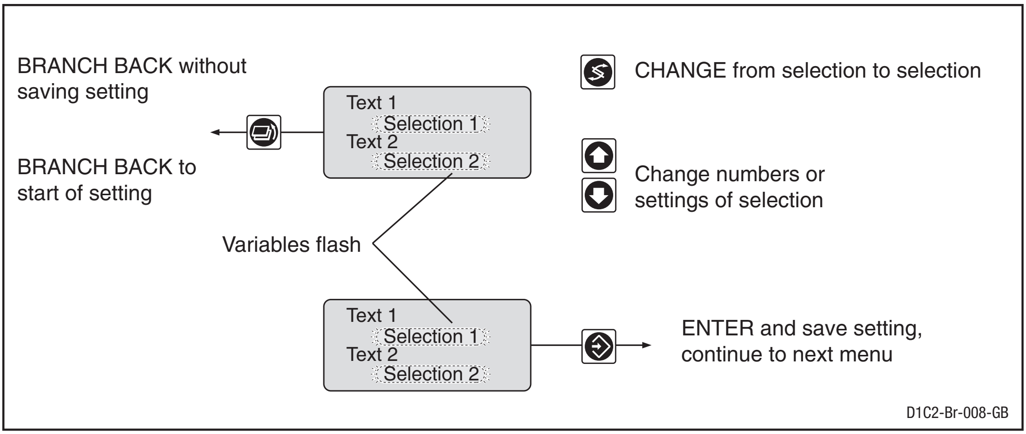
NOTE

Access to the setting menus can be barred with the access code!

The number and scope of setting menus is dependent on the device version!

If the access code is selected correctly in a setting menu, then the following setting menus are also accessible!

If within a period of 10 minutes no button is pushed, the unit automatically branches back from the calibrating menu or a setting menu to the permanent display 1.

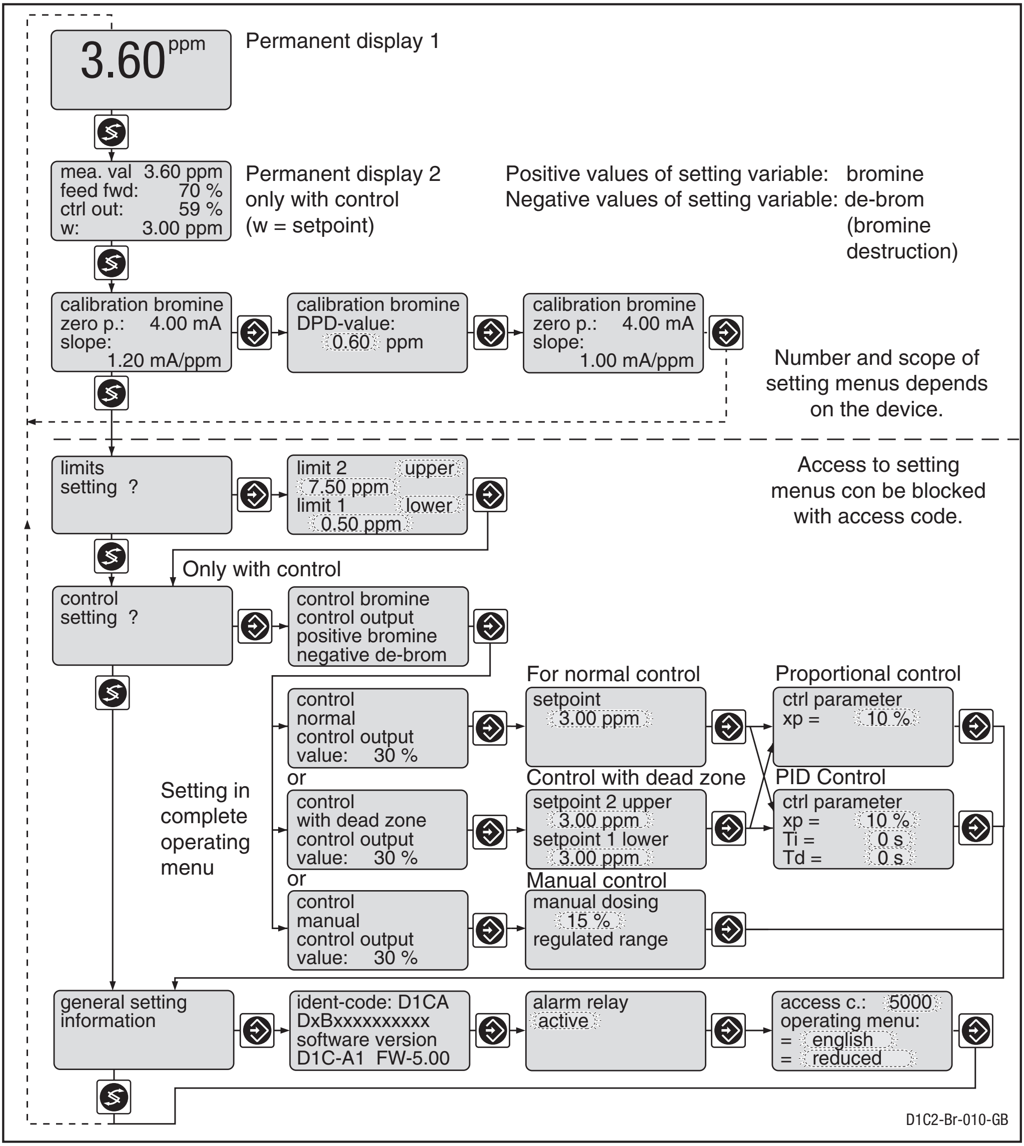


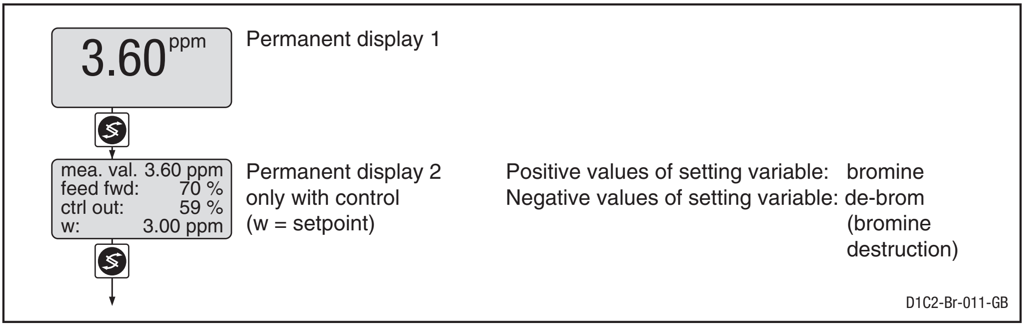
6 Restricted Operating Menu / Layout

Operating Menu

The DULCOMETER® D1C controller permits settings to be made in two different menus. All values are preset and can be changed in the **complete operating menu**.

The controller is delivered with a **restricted operating menu** so that the D1C controller can be used effectively in many applications from the very onset. If adaptations prove to be necessary, all relevant parameters can then be accessed by switching over to the complete operating menu (see “General settings”).



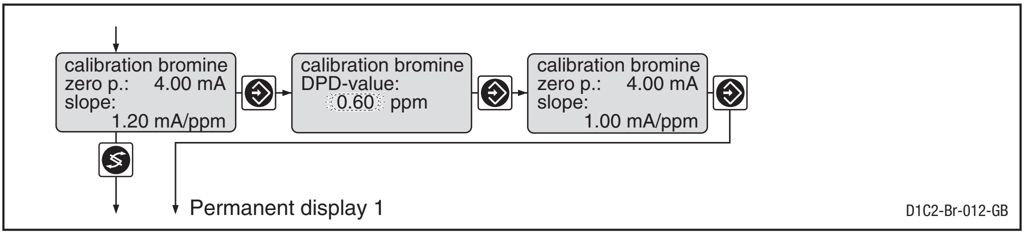


Error messages

Error messages and information are indicated on the bottom line in the permanent display 1. Errors to be acknowledged (acknowledgement switches off the alarm relay) are indicated by the "Ɛ". Errors/notes which still apply after acknowledgement are indicated alternately. During correction variable processing (temperature for correction of pH-value), the value is indicated in the same line as the error/note. Faults which are rectified of their own accord due to changed operating situations are removed from the permanent display without the need for acknowledgement.

IMPORTANT

The measuring range of the measuring cell must agree with the set measuring range (factory setting: 0.2 - 10 ppm). The measuring range must be reset prior to calibration (refer to page 16).



		Possible values			
	Initial value	Increment	Lower value	Upper value	Remarks
	Measured value	0.01 ppm	0 ppm	11 ppm	

Error message	Condition	Remarks
Calibration bromine not possible! Probe slope too low	Bromine slope too low (<25 % of norm slope)	Calibrate again
Calibration bromine not possible! Probe slope too high	Bromine slope too high (>300 % of norm slope)	Calibrate again
DPD value too low DPD > x.xx ppm	DPD <2 % of measuring range	Calibrate again after adding bromine

Calibrating the bromine sensor

During the calibration the DULCOMETER® D1C switches the control outputs to “0”. Exception: where a basic load or a manual control variable has been entered it is retained throughout the calibration.

The standard mA signal outputs (measured value or correction value) are frozen. The frozen measured value from the start of the calibration is suggested as the DPD value. The DPD values are variable (arrow keys). Calibration is possible only when the DPD value is ≥ 2 % of the measurement range.

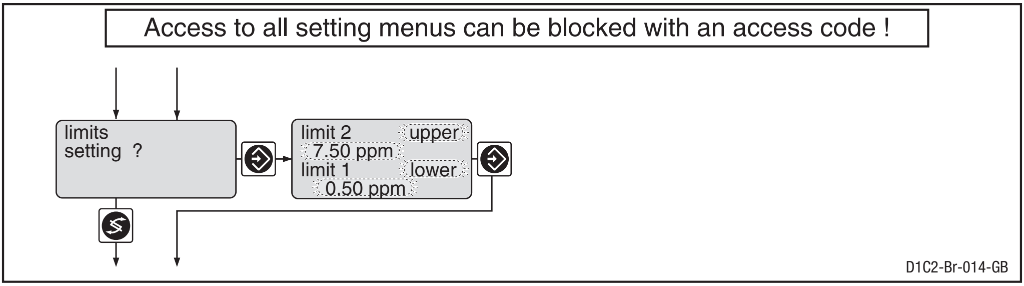
If the calibration is successful all fault-finding operations relating to the measured value start afresh.

In the limited-access operating menu: the DULCOMETER® D1C saves the detected slope values.

In the full operating menu: the DULCOMETER® D1C saves the detected slope and zero-point values.

The zero point calibration must be carried out under real conditions in bromide-free water. It is normally required only for the measurement range 0-0.5 ppm when measuring at the lower measurement range limit.

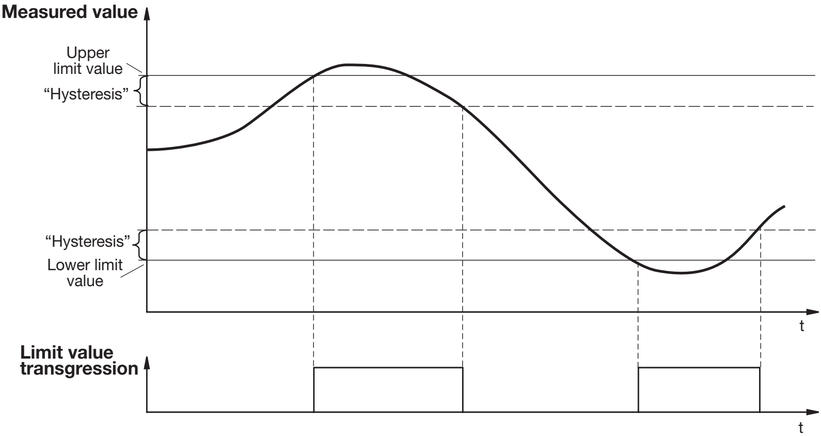
Limits



	Initial value	Possible values Increment	Lower value	Upper value	Remarks
Type of limit transgression Limit 1: Limit 2:	lower upper	upper lower off*			Limit transgression when exceeding or dropping below value *only with limit relays
Limit value Limit 1: Limit 2:	0.5 ppm 7.5 ppm	0.01 ppm 0.01 ppm	0.00 ppm 0.00 ppm	11.00 ppm 11.00 ppm	

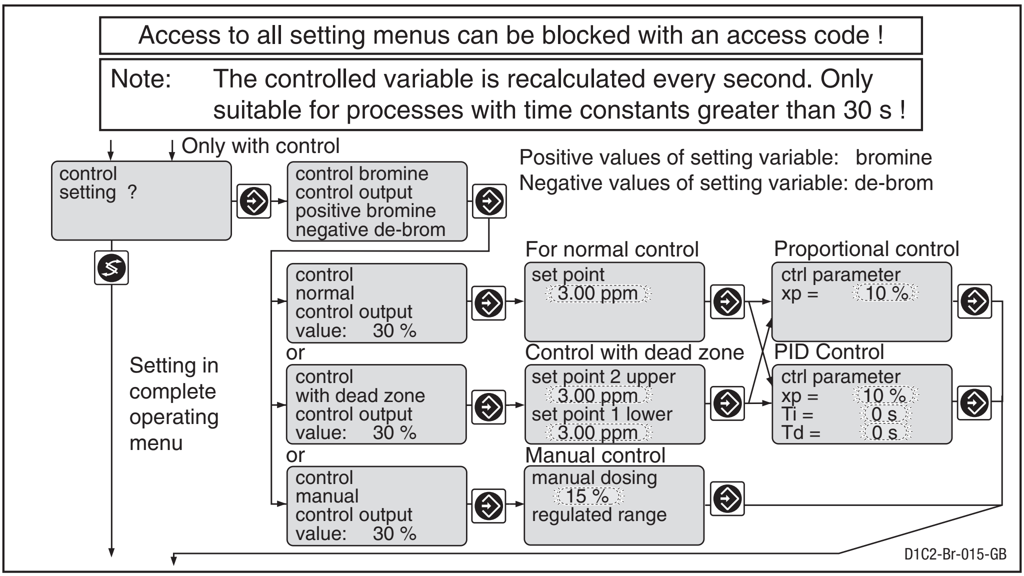
“Limit value 1, lower” means that the value has fallen below the lower limit value.
“Limit value 1, upper” means that the value has risen above the upper limit value.
The DULCOMETER® D1C can define a “Hysteresis limits”. Since “Hysteresis” acts in the direction of the removal of the limit value infringement, i.e. if the “Limit value 1, upper” of pH 7.5 is exceeded and the hysteresis limit value is set to pH 0.20, there is no longer a criterion for limit value infringement should values drop below pH 7.3 (see diagram below).
The hysteresis behaviour for a “Limit value, lower” functions in the same way (in this case the hysteresis value is added to the limit value). This eliminates the need for an external locking relay and does not affect the control behaviour.

Restricted Operating Menu / Description



If limit value relays are fitted and defined as such (see "Relays setting?") they will additionally switch to alarm relays if a limit value is infringed. The direction of the infringement is displayed by the symbols ↑ or ↓. It is also possible to set different response delays for the limit value relays for limit value 1 and limit value 2, respectively "Δt on" and "Δt off". These prevent the limit value relays from making and breaking circuits in response to brief dips or peaks in the values (damping function).
If there are no limit value relays, limit values can nevertheless be defined (as described above). The DULCOMETER® D1C can then display all the responses outlined above in the event of a limit value infringement.

Control



	Initial value	Possible values Increment	Lower value	Upper value	Remarks
Setpoint	3.00 ppm	0.01 ppm	lower limit measuring range	upper limit measuring range	2 setpoints necessary for control with dead zone. Setpoint 1 > setpoint 2
Control parameter xp	10 %	1 %	1 %	500 %	xp referred to measuring range
Control parameter Ti	off	1 s	1 s	9999 s	Function off = 0 s
Control parameter Td	off	1 s	1 s	2500 s	Function off = 0 s
Manual metering	0 %	1 %	-100 %	+100 %	

The DULCOMETER® D1C controller can be set to operate as a P, a PI or a PID controller. This depends on the device design (see identcode) and the control parameter settings.
The control variable is detected once per second.
This controller cannot be used in control circuits requiring rapid deviation control (less than approx. 30 sec.).
When actuating solenoid valves (pulse length) take account of the cycle times and when actuating servomotors (3-point) take account of their running times.
The pause control input can be used to switch off the control function (output of control variable). A new control variable is calculated when pause is cancelled and after the delay period t_d.

Abbreviations of controller-related values:

X: Control variable, actual value (e.g. pH value)
K_{PB}: Proportional secondary value
X_p: 100%/K_P (reciprocal proportional secondary value)
X_{max}: Maximum actual value of controller (e.g. pH 14)
y: Control variable (e.g. pulse frequency to pump)
Y_b: Control range (e.g. 180 pulses per minute)
y_p: P-controller control variable [%]
w: Guide value or set value (e.g. pH 7.2)
e: Control differential, $e = w-x$
x_w: Control deviation, $x_w = x-w$
T_i: Reset time of the I-controller [s]
T_d: Retaining time of the D-controller [s]

Controller equations:

$$x_p = \frac{100\ \%}{K_p} \qquad x_P = 100\ \% * \frac{e}{Y_h}$$

This formula determines the x_p at which the control variable is 100 % at a pre-determined control differential.

Control equation for P-controller:

$$y_p = 100\ \% * \frac{Y_h * (w-x)}{X_{max} * x_p}$$

Example for Y_p:
x_p = 10 %, control deviation 1.4 pH
(10 % of max. measurement range)

$$y_p = 100\ \% * \frac{180 \text{ strokes per minute} * (\text{pH } 7 - \text{pH } 5.6)}{10\ \% * 14 \text{ pH}}$$

= 180 strokes per minute

Controller equation for PID controller:

$$y = \underbrace{y_p}_{\text{P-proportion}} + \underbrace{\frac{1}{T_i}\int y_p dt}_{\text{I-proportion}} + \underbrace{T_d \frac{y_p}{dt}}_{\text{D-proportion}}$$

Normal

A measured value is compared with a set value. If there is a control differential (difference of set value minus actual value) a control variable is determined and this is offset against the control differential.

The following controller types are available:

P controller: used in control sections which are integrated operations (e.g. bath neutralisation)

PI controller: can be used in non-integrated control sections (e.g. in-flow neutralisation)

PID controller: used in control sections which are subject to peaks, which must be balanced out.

With dead zone

Dead zone control (neutral zone control) requires two set values. If the measured value is within the dead zone, no control variable is output.
Set value 2 must be greater than set value 1!

Manual

IMPORTANT

The controller does not automatically exit this operating mode.
The manual operating mode may be used only for commissioning and test purposes.

There is no control.
A manual control variable is specified
Control variable: 0...+100 % (control output “Raising” active)
Control variable: -100...0 % (control output “Lowering” active)

This function is used the check control elements.

Additive basic load

A basic load is added to the actual control variable.
The additive basic load is used e.g. to equalise constant decrease.

$Y_{tot} = Y_p + 15\ \%$ (additive basic load = 15 %)

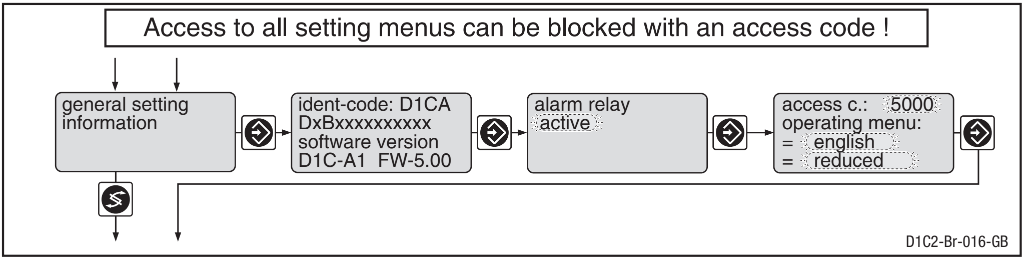
Example 1:

$Y_{tot} = 85\ \% + 15\ \%$
$Y_{tot} = 100\ \%$

Example 2:

$Y_{tot} = -75\ \% + 15\ \%$
$Y_{tot} = -60\ \%$

General Settings



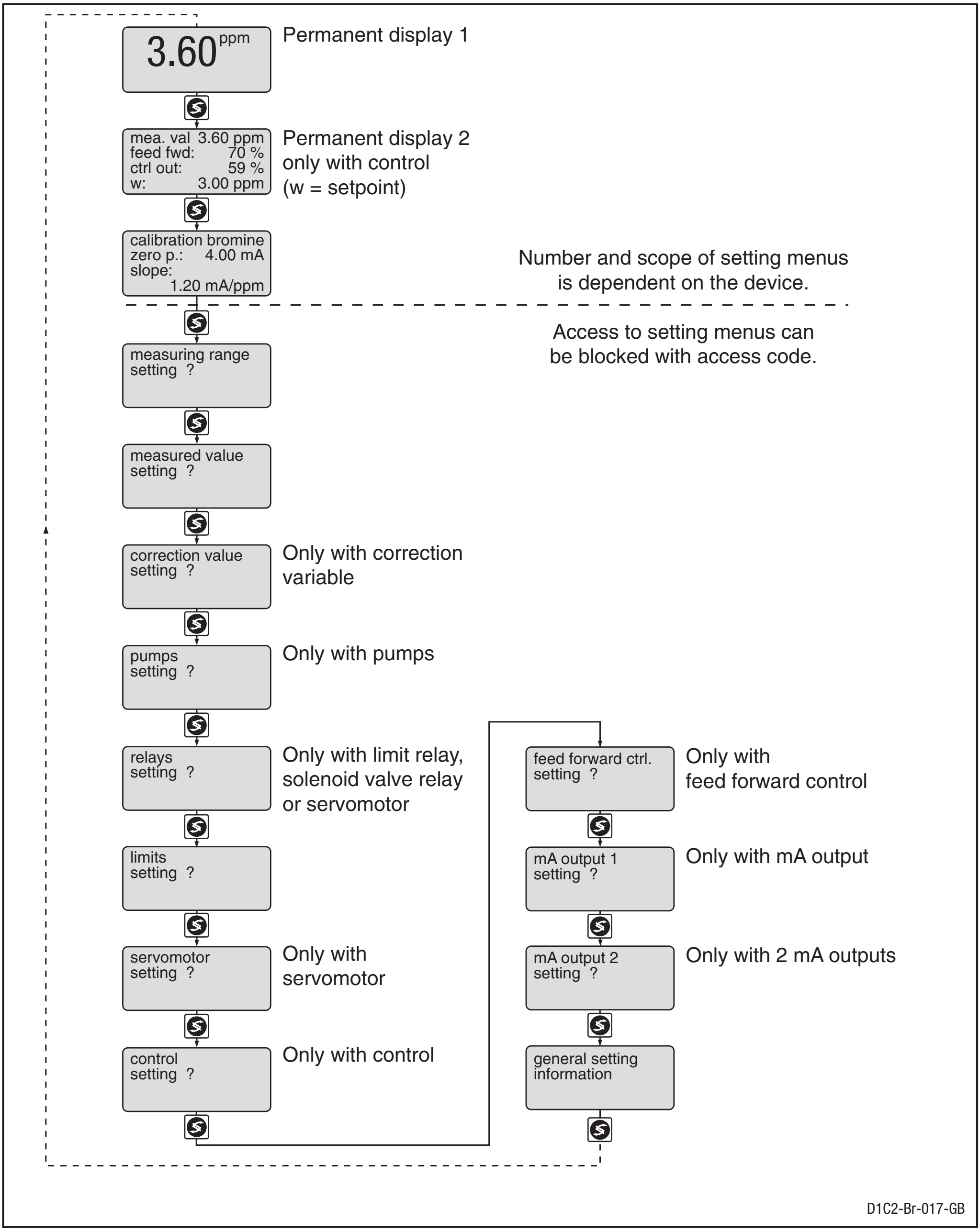
	Initial value	Possible values Increment	Lower value	Upper value	Remarks
Alarm relay	active	active not active			
Access code	5000	1	1	9999	
Language	as per identity code	German English French Spanish (as per identity code)			
Operating menu	restricted	restricted complete			

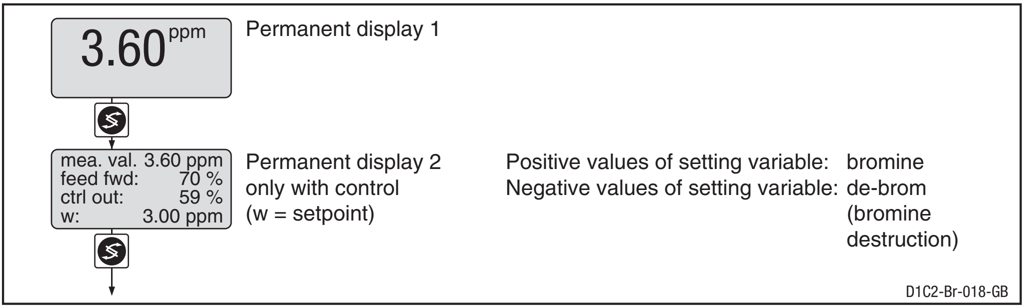
Access Code

Access to the setting menu can be prevented by setting up an access code. The DULCOMETER® D1C controller is supplied with the access code 5000 which permits free access to the setting menu. The calibration menu remains freely accessible even when access to the setting menu is blocked by the code.

7 Complete Operating Menu / Overview

All parameters of the controller can be set in the complete operating menu (access see previous page). The following overview shows the settings which can be selected:





Calibrating the bromine sensor

During the calibration the DULCOMETER® D1C switches the control outputs to “0”. Exception: where a basic load or a manual control variable has been entered it is retained throughout the calibration.

The standard mA signal outputs (measured value or correction value) are frozen. The frozen measured value from the start of the calibration is suggested as the DPD value. The DPD values are variable (arrow keys). Calibration is possible only when the DPD value is ≥ 2 % of the measurement range.

If the calibration is successful all fault-finding operations relating to the measured value start afresh.

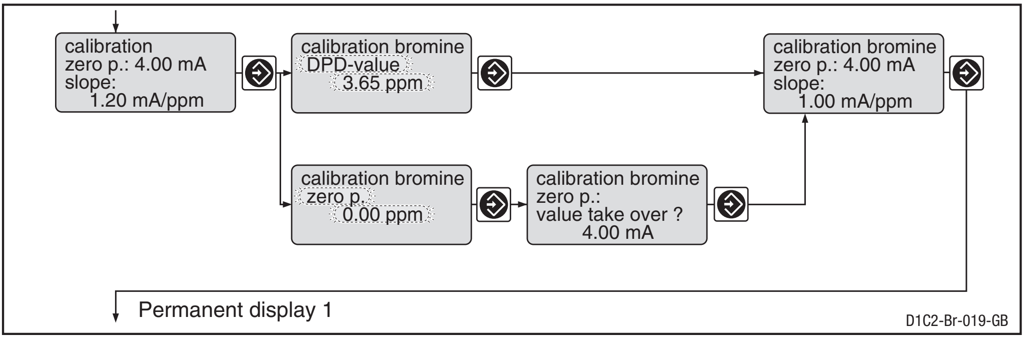
In the limited-access operating menu: the DULCOMETER® D1C saves the detected slope values.

In the full operating menu: the DULCOMETER® D1C saves the detected slope and zero-point values.

The zero point calibration must be carried out under real conditions in bromide-free water. It is normally required only for the measurement range 0-0.5 ppm when measuring at the lower measurement range limit.

IMPORTANT

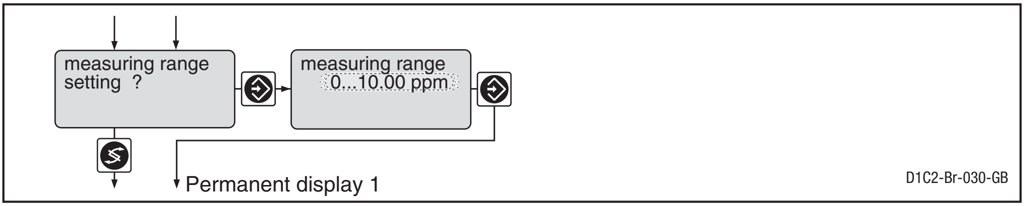
The measuring range of the measuring cell must agree with the set measuring range (factory setting: 0.2-10 ppm). The measuring range must be reset prior to calibration (refer to page 16).



		Possible values		
	Initial value	Increment	Lower value	Upper value
	Measured value	0.01 ppm	0 ppm	11 ppm (Measuring range up to 10 ppm) 2.2 ppm (Measuring range up to 2.0 ppm)

Error message	Condition	Remarks
Calibration bromine not possible! Probe slope too low	Bromine slope too low (<25 % of norm slope)	Calibrate again
Calibration bromine not possible! Probe slope too high	Bromine slope too high (>300 % of norm slope)	Calibrate again
DPD value too low DPD > x.xx ppm	DPD <2 % measuring range	Calibrate again after adding bromine
Zero point too low Zero point too high	< 3 mA > 5 mA	Check measuring cell/cable Repeat calibration in bromine-free water

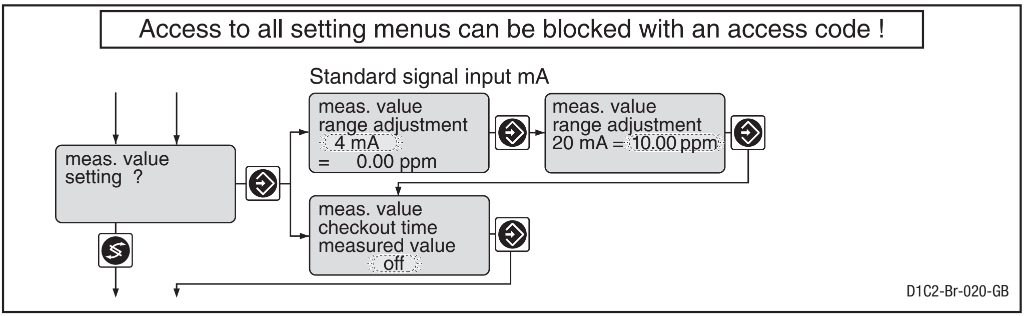
Measuring Range



		Possible values			
	Initial value	Increment	Lower value	Upper value	Remarks
Measured range	0...10 ppm	0...2 ppm 0...10 ppm			

IMPORTANT
If the range allocation is changed, check the settings in all menus.

Measured Value



IMPORTANT
If the area allocation is changed, the bromine measuring cell must be re-calibrated and all the menu settings must be checked!

Complete Operating Menu / Description

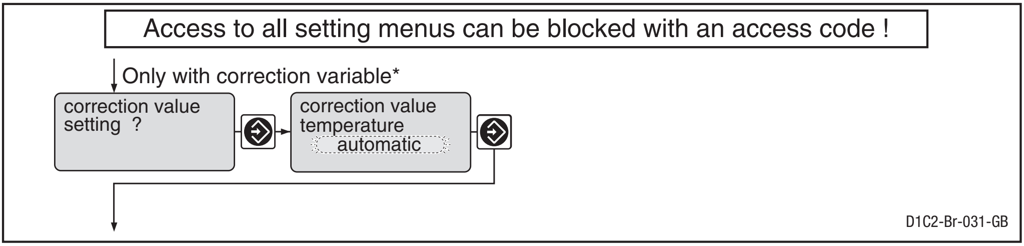
	Initial value	Possible values Increment	Lower value	Upper value	Remarks
Standard signal input lower signal limit	4 mA	0 mA 4 mA			
Allocated measured value lower upper	 0 ppm 10 ppm	 0.01 ppm	 0.00 ppm	 11.00 ppm	
Checkout time	off	1 s	1 s	9999 s	Constant measurement signal results in message and alarm. Function off = 0 s

Measured value control period

IMPORTANT

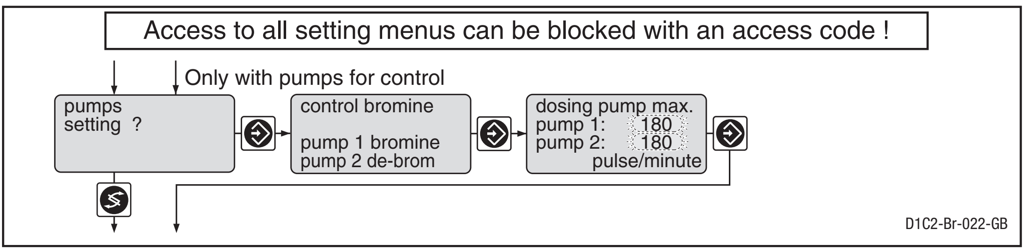
This function may not be activated for applications in which it can be assumed that the measured value will not change.

This function tests whether the measured value changes from that of the probe (at the measured value input) within the "Measured value control period". It is assumed that it will do so for an intact probe.
If the measured value does not change within this control period the DULCOMETER® D1C sets the control value to "0" and the alarm relay circuit is opened. The LCD displays the message, e.g. "Bromine limit".



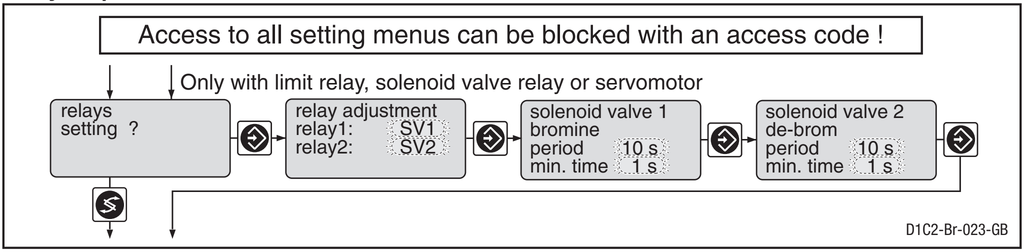
*In the setting menu "correction value" for this equipment enables you to display the temperature or to maintain an mA signal proportional to the temperature. No temperature adjustment is made to the measured variable!

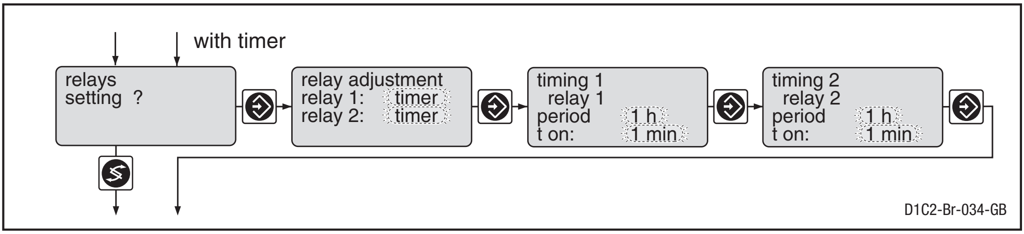
Pumps



	Initial value	Possible values Increment	Lower value	Upper value	Remarks
Max. stroke/minute of pumps 1 and 2	180	1	1	500	off = 0 strokes/min

Relay for power control

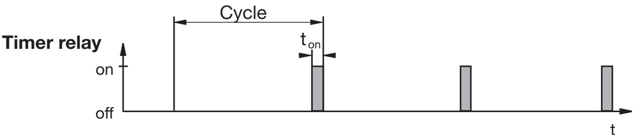




		Possible values			
	Initial value	Increment	Lower value	Upper value	Remarks
Relay adjustment	as per identity code				
Relay 1		Motor Solenoid valve 1 Limit value 1* Actuator 1 Timer 1 Servomotor off			*In the case of “Limit value” relays remain active even in the event of an error.
Relay 2		Motor 2 Solenoid valve 2 Limit value 2* Actuator 2 Timer 2 off			
Period (Cycle)	10 s	1 s	10 s	9999 s	for solenoid valve
min. time	1 s	1 s	1 s	period/2	for solenoid valve Set here the smallest permitted operating factor of the connnected device.
Period (Cycle)	off	1 h	1 h / off	240 h	for timer
t on	1 min	1 min	1 min	60 min	for timer

NOTE

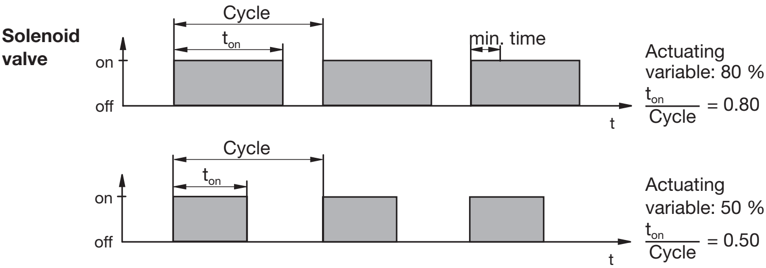
The limit value relay can be defined in such a way as to respond as a control element, i.e. if a limit value relay closes a circuit, it opens when a pause contact is activated and/or for a subsequent delay period t_d (if t_d is set to > 0 min in “General settings”).



IMPORTANT

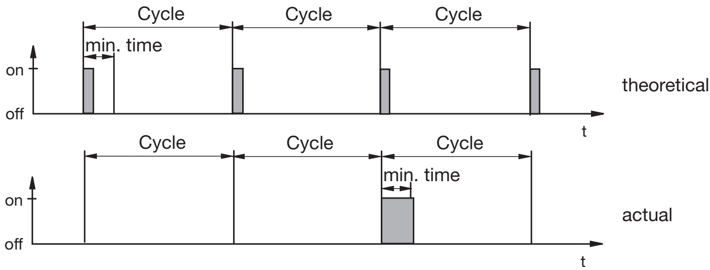
The timer will reset in the event of a power failure.

At the end of the (timer) cycle time the DULCOMETER® D1C closes the assigned relay for the duration of "t on" (timer). "Pause" interrupts the timer.
When the clock is shown in the LC display the timer can be reset to the start of the cycle at precisely this point using the enter button.
The % figure in the LC display indicates the progress of the current cycle.
Timer relays may be used, e.g. for shock metering or sensor cleaning.



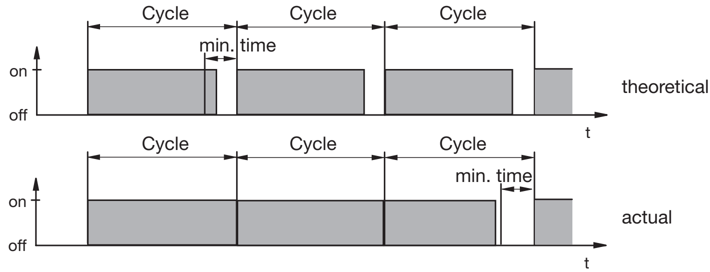
The switching time of the DULCOMETER® D1C (solenoid valve) depend on the actuating variable and the "min. time" (smallest permitted operating factor of the connected device).
The actuating variable determines the ratio t_{on}/cycle and thus the switching times (see fig. above).
The "min. time" influences the switching times in two situations:

a) theoretical switching time < min. time:



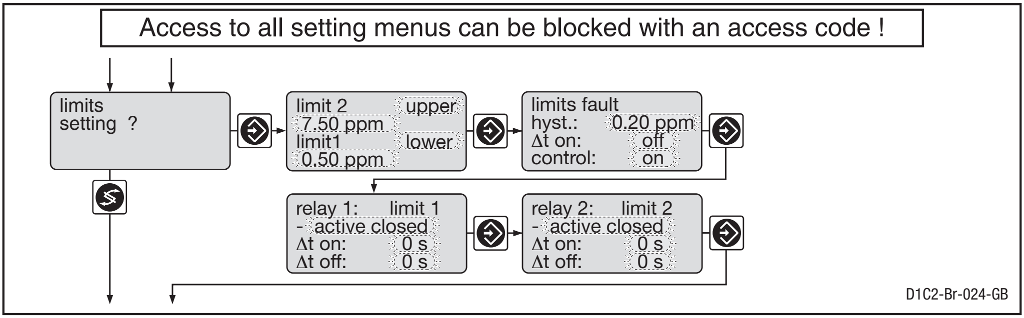
The DULCOMETER® D1C does not switch for a certain number of cycles until the sum of the theoretical switching times exceeds the "min. time". Then the DULCOMETER® D1C switches for the duration of this total time.

b) theoretical switching time > (cycle - min. time) and calculated switching time < cycle



The DULCOMETER® D1C does not deactivate for a certain number of cycles until the differences between cycle and theoretical switching time exceed the “min. time”.

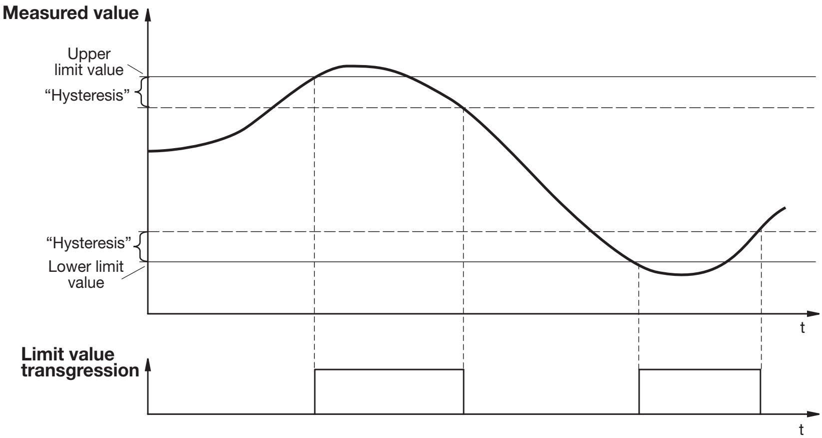
Limit values



	Initial value	Possible values Increment	Lower value	Upper value	Remarks
Type of limit transgression Limit 1: Limit 2:	lower upper	upper lower off*			Limit transgression when exceeding or dropping below value *only with limit relay
Limit value Limit 1: Limit 2:	0.1 ppm 1.5 ppm	0.01 ppm 0.01 ppm	0 ppm 0 ppm	11.00 ppm 11.00 ppm	
Hysteresis limits	0.04 ppm	0.01 ppm	0.02 ppm	11.00 ppm	Effective in direction of cancelling limit transgression
Checkout time limits Δt on	off	1 s	1 s	9999 s	Results in message and alarm. off = 0 s: Function switched off, no message, no alarm
Control	on	on off			
Switching direction Limit value 1	active closed	active closed			Acts as N/O
Limit value 2		active open			Acts as N/C
Switch-on delay Δt on	0 s	1 s	0 s	9999 s	
Switch-off delay Δt off	0 s	1 s	0 s	9999 s	

If the limit is exceeded for longer than the “Delay time - limit values” an error message is given, which must be acknowledged, and the alarm relay circuit is broken. If “Controller” is also set to “off” the control process stops.

“Limit value 1, lower” means that the value has fallen below the lower limit value.
“Limit value 1, upper” means that the value has risen above the upper limit value.
If “Control time limits” is set to >0 s, the alarm relay circuit is broken and the message “xx limit value 1 ↓ Ɛ” appears which means that the value has dropped below “Limit value 1”.
The DULCOMETER® D1C” can define a “Hysteresis limits”. Since “Hysteresis” acts in the direction of the removal of the limit value infringement, i.e. if the “Limit value 1, upper” of pH 7.5 is exceeded and the hysteresis limit value is set to pH 0.20, there is no longer a criterion for limit value infringement should values drop below pH 7.3 (see diagram below).
The hysteresis behaviour for a “Limit value, lower” functions in the same way (in this case the hysteresis value is added to the limit value). This eliminates the need for an external locking relay and does not affect the control behaviour.



If limit value relays are fitted and defined as such (see “Relay setting?”) they will additionally switch to alarm relays if a limit value is infringed. The direction of the infringement is displayed by the symbols ↿ or ⇂.
It is also possible to set different response delays for the limit value relays for limit value 1 and limit value 2, respectively “Δt on” and “Δt off”. These prevent the limit value relays from making and breaking circuits in response to brief dips or peaks in the values (damping function).
If there are no limit value relays, limit values can nevertheless be defined (as described above). The DULCOMETER® D1C can then display all the responses outlined above in the event of a limit value infringement.

Limit value relay as control element

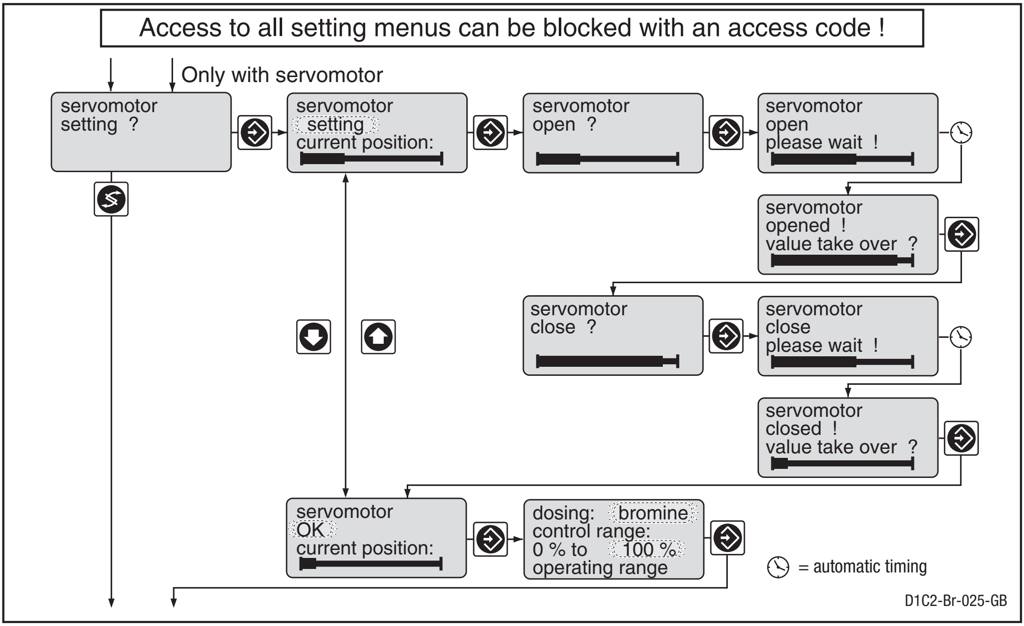
If the limit value relays are defined as control elements they respond in the same way as control outputs.

E.g. if pause is active or in the event of an alarm an actuated limit value relay opens.

Servomotor

ATTENTION

- ***To ensure correct operation, the activation time of the actuator used should not be less than 25 seconds for the control range from 0...100 %!***
- ***A servomotor must be actuated with same care as the calibration of a sensor.***



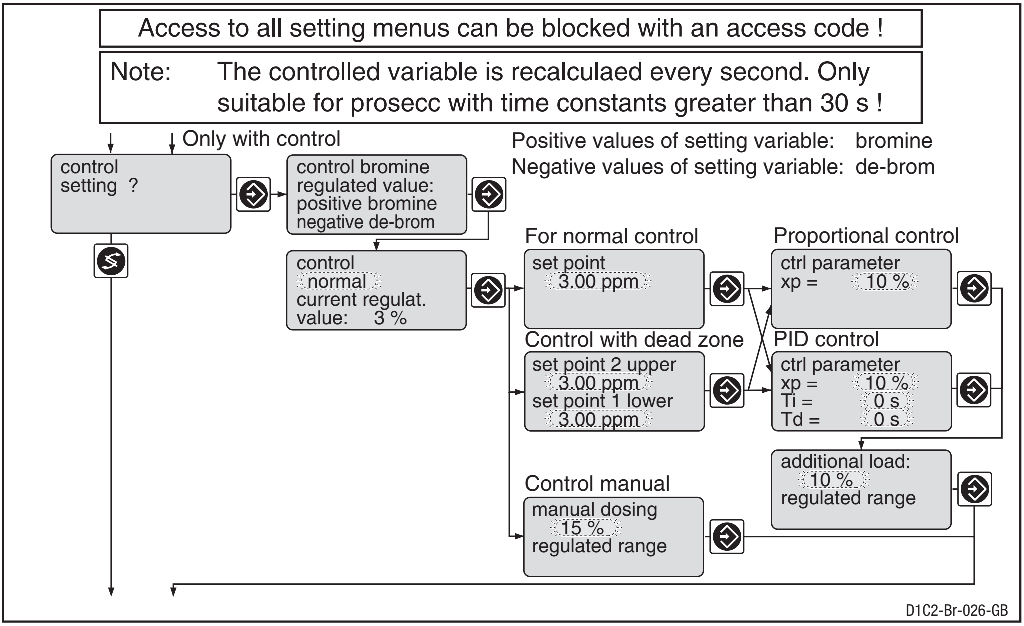
	Initial value	Possible values Increment	Lower value	Upper value	Remarks
Servomotor	setting	setting ok off			
Control direction	bromine	bromine de-brom			
Control range	100 %	1 %	10 %	100 %	in % of operating range

NOTE

- ***When the status bar reaches the right, the servo motor is open to its maximum extent.***
- ***The continuous display shows the opening rate in % (the greater the percentage, the further open the servomotor).***

The **operating range** is given by the overall resistance range of the feedback potentiometer. The maximum limit of the actual range used is determined when the **control range** is defined.

Control



	Initial value	Possible values Increment	Lower value	Upper value	Remarks
Control	normal	normal with dead zone manual			When controlling with dead zone, the feed forward control is not used for measured values within the dead zone.
Setpoint	0.60 ppm	0.01 ppm	Lower measuring range	Upper measuring range	2 setpoints necessary for control with dead zone. Setpoint 1 > setpoint 2
Control parameter xp	10 %	1 %	1 %	500 %	xp referred to measuring range
Control parameter Ti	off	1 s	1 s	9999 s	Function off = 0 s
Control parameter Td	off	1 s	1 s	2500 s	Function off = 0 s
Additional load	0 %	1 %	-100 %	+100 %	
Manual metering	0 %	1 %	-100 %	+100 %	

The DULCOMETER® D1C controller can be set to operate as a P, a PI or a PID controller. This depends on the device design (see identcode) and the control parameter settings.
The control variable is detected once per second.
This controller cannot be used in control circuits requiring rapid deviation control (less than approx. 30 sec.).
When actuating solenoid valves (pulse length) take account of the cycle times and when actuating servomotors (3-point) take account of their running times.
The pause control input can be used to switch off the control function (output of control variable). A new control variable is calculated when pause is cancelled and after the delay period t_d.

Abbreviations of controller-related values:

X: Control variable, actual value (e.g. pH value)
K_{PB}: Proportional secondary value
X_p: 100%/K_P (reciprocal proportional secondary value)
X_{max}: Maximum actual value of controller (e.g. pH 14)
y: Control variable (e.g. pulse frequency to pump)
Y_b: Control range (e.g. 180 pulses per minute)
y_p: P-controller control variable [%]
w: Guide value or set value (e.g. pH 7.2)
e: Control differential, e = w-x
x_w: Control deviation, x_w = x-w
T_i: Reset time of the I-controller [s]
T_d: Retaining time of the D-controller [s]

Controller equations

$$x_p = \frac{100\ \%}{K_p} \qquad x_P = 100\ \% * \frac{e}{Y_h}$$

This formula determines the x_p at which the control variable is 100 % at a pre-determined control differential.

Control equation for P-controller:

$$y_p = 100\ \% * \frac{Y_h * (w-x)}{X_{max} * x_p}$$

Example for Y_p:
x_p = 10 %, control deviation 1.4 pH
(10 % of max. measurement range)

$$y_p = 100\ \% * \frac{180 \text{ strokes per minute} * (\text{pH } 7 - \text{pH } 5.6)}{10\ \% * 14 \text{ pH}}$$

= 180 strokes per minute

Controller equation for PID controller:

$$y = \underbrace{y_p}_{\text{P-proportion}} + \underbrace{\frac{1}{T_i}\int y_p dt}_{\text{I-proportion}} + \underbrace{T_d \frac{y_p}{dt}}_{\text{D-proportion}}$$

Normal

A measured value is compared with a set value. If there is a control differential (difference of set value minus actual value) a control variable is determined and this is offset against the control differential.

The following controller types are available:

P controller: used in control sections which are integrated operations (e.g. bath neutralisation)

PI controller: can be used in non-integrated control sections (e.g. in-flow neutralisation)

PID controller: used in control sections which are subject to peaks, which must be balanced out.

With dead zone

Dead zone control (neutral zone control) requires two set values. If the measured value is within the dead zone, no control variable is output.
Set value 2 must be greater than set value 1!

Manual

IMPORTANT

The controller does not automatically exit this operating mode.
The manual operating mode may be used only for commissioning and test purposes.

There is no control.
A manual control variable is specified
Control variable: 0...+100 % (control output “Raising” active)
Control variable: -100...0 % (control output “Lowering” active)

This function is used to check control elements.

Additive basic load

A basic load is added to the actual control variable.
The additive basic load is used e.g. to equalise constant decrease.

$Y_{tot} = Y_p + 15\ \%$ (additive basic load = 15 %)

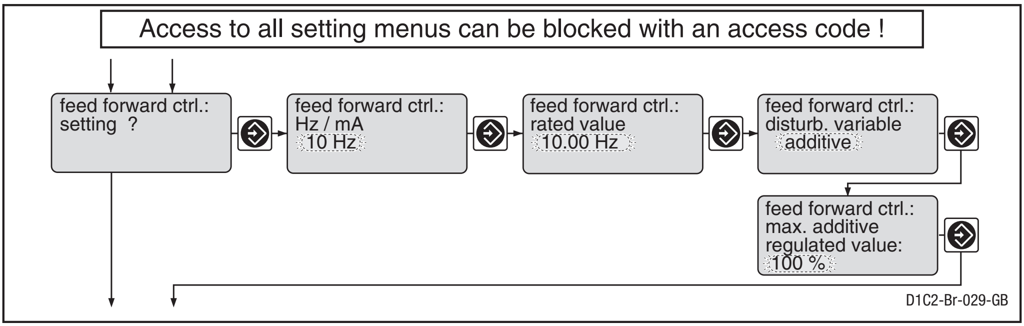
Example 1:

$Y_{tot} = 85\ \% + 15\ \%$
$Y_{tot} = 100\ \%$

Example 2:

$Y_{tot} = -75\ \% + 15\ \%$
$Y_{tot} = -60\ \%$

Feed forward control



	Initial value	Possible values Increment	Lower value	Upper value	Remarks
Feed forward control (Flow)	as per identity code Standard signal 4-20 mA	None 10 Hz 500 Hz 0…20 mA 4…20 mA			Signal processing: Signal <0.02 Hz = No flow Signal <0.2 Hz = No flow Signal <0.2 mA = No flow Signal <4.2 mA = No flow

	Initial value	Possible values Increment	Lower value	Upper value	Remarks
Feed forward control rated value	10 Hz 500 Hz 20 mA	0.01 Hz 1 Hz 0.1 mA	0.1 Hz 1 Hz 0/4 mA	10 Hz 500 Hz 20 mA	Depended on signal type. Maximum limitation of range used.
Feed forward control	multiplicative	multiplicative			
Feed forward effect		additive			
Max. add. regulated value	100 %	1 %	-500 %	+500 %	only with add. feed forward control

The DULCOMETER® D1C controller can, for instance, process a flow meter signal as a feed-forward control. This feed-forward control influences the control variables calculated by the controller depending on this external signal.
Depending on the type of influence on the control variable we speak of:

- multiplicative control variables (flow proportional influence)
- additive control variables (feed-forward control proportional influence)

This feed-forward control signal can exist in the form of a 0/4…20 mA standard signal or as a digital contact signal with the maximum frequencies up to 10 Hz and/or up to 500 Hz (depending on the identcode and settings).

“Commissioning”: the zero point signal of the flow meter must be checked without flow (must be ≥ 0).

Multiplicative feed-forward control

This type of feed-forward control is, e.g. used for flow neutralisation. The initial “control variable” determined by the controller is multiplied by a factor F. The factor lies within the range $0 \leq F \leq 1$ ($0 \cong 0$ %. $1 \cong 100$ %). The control variable can therefore be maximum 100%.

$$\text{Control element control variable [\%]} = \frac{\text{calculated control variable [\%]} * \text{actual feed forward control [mA]}}{\text{Nominal value of feed forward control [mA]}}$$

An “actual feed forward control” greater than or equal to the “nominal feed forward control value” has no influence on the control variable (see examples 2 and 3 in the table).

Examples:

Description	**Unit**	**1.**	**2.**	**3.**	**4.**
Calculated control variable	%	50	50	50	0
Actual feed forward control (for 0-20 mA)	mA	5	10	20	15
Nominal feed forward control value	mA	10	10	10	10
Factor F	-	0.5 (50%)	1 (100%)	1 (100%)	1 (100%)
Final control variable	%	25	50	50	0

Legend:
The calculated control variable is the control variable which the controller emits without feed forward control.

The nominal feed forward control limits the range used.

Example: A flow meter is used, for instance, which can measure a maximum flow of Q = 250 m^3/h. The analogue output of the flow meter gives a signal corresponding to 4 mA = 0 m^3/h, 20 mA = 250 m^3/h. However, the maximum achievable flow in the application is only 125 m^3/h. If the standard output signal of the flow meter is not adjusted to the 4 … 20 mA range of the DULCOMETER® D1C (this is possible with most flow meters), the standard signal at 125 m^3/h is only 12 mA. This value is entered in the “Feed forward control setting?” menu under the “Nominal feed forward control”.

The feed forward control is the actual system flow delivered by the flow meter. The control element control variable is transmitted to the control element.

Additive feed forward control

The actuation of the additive feed forward control is suitable for metering operations in which the dosage is primarily dependant on the feed forward control (e.g. flow) and requires minimal correction. This type of feed forward control processing is used, e.g. for chlorination of water with practically constant chlorine decrease.

A basic dose dependant on the feed forward control is added to or subtracted from the initial “control variable” determined by the controller. The control variable can be maximum 100 %.

Control element control variable [%] =

$$\text{Calculated control variable [\%]} + \left(\frac{\text{max. additive feed forward control [\%]} * \text{actual feed forward control [mA]}}{\text{Nominal feed forward control value [mA]}} \right)$$

Examples:

Description	Unit	1.	2.	3.	4.	5.	6.
Calculated control variable	%	40	90	50	50	50	0
Actual feed forward control (for 0-20 mA)	mA	5	5	2	10	20	5
Nominal feed forward control value	mA	10	10	10	10	0	10
Max. add. feed forward control	%	100	-100	200	200	200	100
Final control variable	%	90	40	90	100	50	50

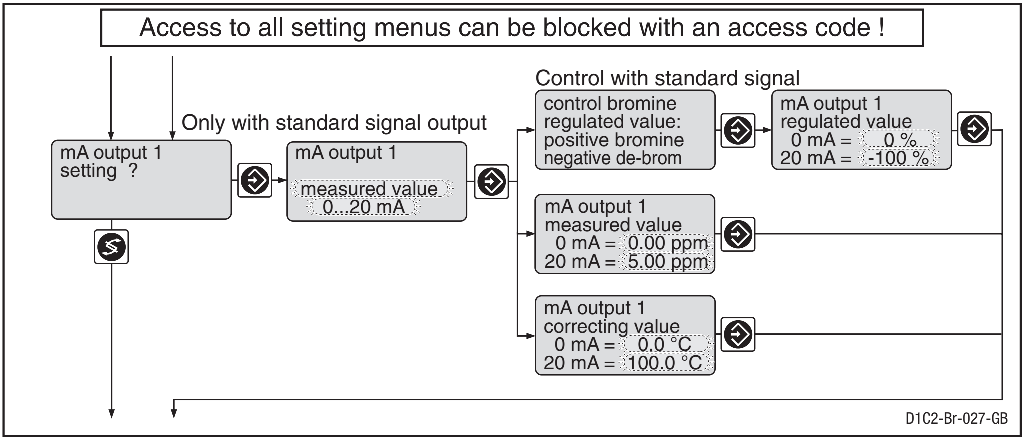
Legend:
The maximum additive feed forward control specifies the maximum feed forward control to be added (in case of actual feed forward control = nominal feed forward control)
Additional legend, see “multiplicative feed forward control”

IMPORTANT

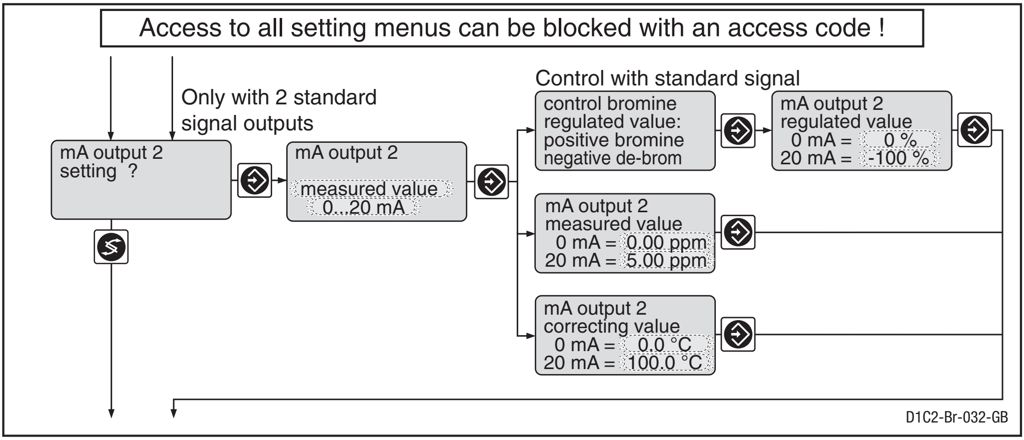
If there is no actual feed forward control (flow = 0) but there is a calculated control variable from the PID controller, the final control variable is the calculated control variable from the PID controller. If there is an actual feed forward control (flow > 0) and the calculated control variable from the PID controller = “0”, the final control variable is the second term from the formula above:

$$\frac{\text{max. additive feed forward control [\%]} * \text{actual feed forward control [mA]}}{\text{Nominal feed forward control value}}$$

Standard Signal Output 1



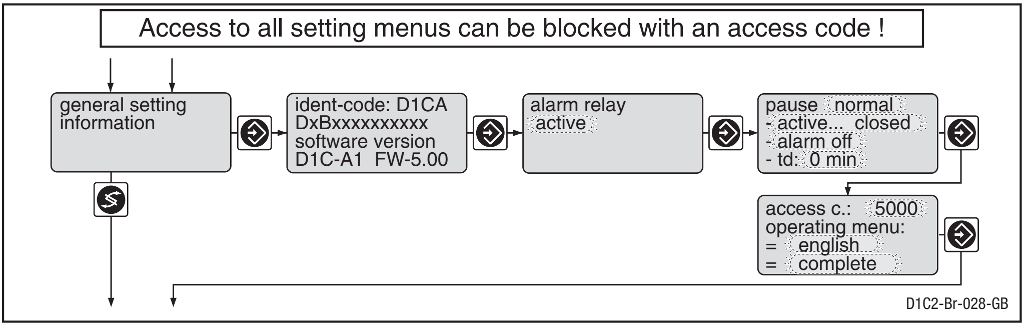
Standard Signal Output 2



	Initial value	Possible values Increment	Lower value	Upper value	Remarks
Variable allocation	as per identity code	Measured value Actuating variable Correction value			If control is present, only with adjustment variable
Output range	0…20 mA	0…20 mA 4…20 mA 3.6/4-20mA			Reduction to 3.6 mA when alarm relay switches (not limit value violation)
Range measured value	0…5 ppm	0.01 ppm	0 ppm	11 ppm	Minimum range 0.1 ppm
Range controlled variable	-100 %...0 %	1 %	-100 %	+100 %	Minimum range 1 %
Range correction value	0...100 °C	0.1 °C	0 °C	100 °C	Minimum range 1 °C

Complete Operating Menu / Description

General setting



	Initial value	Possible values Increment	Lower value	Upper value	Remarks
Alarm relay	active	active not active			
Pause	normal	normal Hold*			*If Pause/Hold is activated, the last valid set output signal is held
Control input pause	closed	closed open			Alarm relay can be activated through pause contact.
Alarm pause	alarm off	alarm off alarm on			
td	0 min.	1 min.	0 min.	60 min.	
Access code	5000	1	1	9999	
Language	as per identity code	German English French Spanish (as per identity code)			
Operating menu	complete	restricted complete			

Standard Pause

If the pause-switch is off, the DULCOMETER® D1C sets the operating outputs to “0” for as long as the pause-switch is off or for a set time-delay t_d (if t_d is set to > 0 min). Whilst the pause-switch is off, the D1C establishes the P-proportion in the background.
With PID-control (Identity code characteristics “control characteristic” = 2): the I-proportion is stored when the pause is switched off (I-proportion then usually only present if Ti > 0 has been selected in the “Control setting?” setting menu).
Exception: the standard signal outputs mA for the measured value or correction value are not affected by the pause.
After pause is activated the operating outputs remain at “0” for the length of the time-delay t_d. The time-delay t_d must be set up in such a way that, in this time e.g. sample water (process-specific current concentration) flows to the sensor.
With PID-control (Identity code characteristics “control characteristic” = 2): The control variable output resulting from the pause and the expiry of the time-delay t_d is reconciled jointly with the current P-component and (if Ti is set > 0) with the stored I-component.

Pause Hold

If the pause-switch is off, the DULCOMETER® D1C freezes the operating output at the most recent value for as long as the pause-switch is off or for a set time-delay t_d (if t_d is set to > 0 min). Whilst the pause-switch is off, the DULCOMETER® D1C establishes the P-proportion in the background.
With PID-control (Identity code characteristics “control characteristic” = 2):
Even the mA standard signal outputs for measured value or correction value are frozen.
After pause is activated the operating outputs remain frozen for the length of the time delay t_d. The time delay t_d must be set up in such a way that, in this time e.g. sample water (process-specific current concentration) flows to the sensor.
With PID-control (Identity code characteristics “control characteristic” = 2): The control variable output resulting from the pause and the expiry of the time-delay t_d is reconciled jointly with the current P-proportion and (if Ti is set > 0) with the newly established I-proportion.

Access Code

Access to the setting menu can be prevented by setting up an access code. The DULCOMETER® D1C controller is supplied with the access code 5000 which permits free access to the setting menu. The calibration menu remains freely accessible even when access to the setting menu is blocked by the code.

8 Fault/Remarks/Troubleshooting

Fault	Fault text	Symbol	Effect on metering	Effect on control	Alarm with acknowledgement	Remarks	Remedy
Measured value Checkout time measured value exceeded	*Check Bromine measuring cell*	ε	Basic load	Stop	Yes	Function can be switched off	Check function of measuring cell, exceed checkout time
Signal exceeded/drops below value	*Check Bromine input*	ε	Basic load	Stop	Yes	Signal <3.0 ±0.2 mA or >23 ±0.2 mA	Check measuring cell, transducer and cable connection
Calibration measuring cell with error	*Check Bromine calibration*	ε	Basic load	Stop	No	Metering continues in case of error with unsteady measured values	Check measuring cell, replace if necessary, recalibrate if necessary
Correction variable Signal exceeded/drops below value	*Check te-input*	ε			yes	Pt100-signal >138,5 Ω Signal <3,0 ±0,2 mA or >23 ±0,2 mA Value last valid is used	Check probe, transducer and cable connection
Feed forward control Signal exceeded/ drops below value Signal drops below value, multiplicative	*Check feed forward input*	ε ε		 Stop	Yes	Signal <3.0 ±0.2 mA or >23 ±0.2 mA Value last valid is used.	Check measuring cell, transducer and cable connection
Limit transgression after checkout time limit value Control "on" Control "off"	*Bromine limit 1* *Bromine limit 2*	ε ε	Stop or Basic load	Stop	Yes Yes	Function can be switched off	Define cause, reset values if necessary
Servomotor Position not reached	*Servomotor defective*	ε			Yes	Servomotor closes	Check servomotor
Electronics error	*System error*	ε O	Stop	Stop	Yes	Elektronic data defective	Call in service

Operation	Note text	Symbol	Effect on metering	Effect on control	Alarm with acknowledgement	Remarks	Remedy
Pause contact	*Pause*	Ɛ O	Stop	Stop	No/Yes*	No further fault check	–
	Pause/Hold	Ɛ		PI-part frozen			
Stop button	*Stop*	Ɛ O	Stop	Stop	No	Relay drops out	–
During calibration measuring cell			Basic load	Stop	No	No error processing of measured variable	–
Measuring cell slope too low Measuring cell slope too high	*Bromine slope low* *Bromine slope high*	Ɛ	Basic load	Stop	No	25% > slope > 300% norm slope	Check measuring cell, replace if necessary
DPD-value <2 % measuring range	*DPD too low*						Recalibrate after adding bromine
Zero point	*Zero point low* *Zero point high*	Ɛ	Basic load	Stop	No	Signal < 3 mA Signal > 5 mA	Check measuring cell/cable Repeat calibration in bromine-free water
During servomotor setting Position feed back wrong Upper position <40 % max. value Lower position >30 % range	*Direction check* *Final value too small* *Final value too big*					Without correct adjustment the last valid values are still used	Check connection of relay and potentiometer. Adjust the operation region of the servomotor correctly.

*depending on whether "Alarm on" or "Alarm off" set in "General settings"

Error messages

Error messages and information are indicated on the bottom line in the permanent display 1. Errors to be acknowledged (acknowledgement switches off the alarm relay) are indicated by the "Ɛ". Errors/notes which still apply after acknowledgement are indicated alternately. During correction variable processing (temperature for correction of pH-value), the value is indicated in the same line as the error/note. Faults which are rectified of their own accord due to changed operating situations are removed from the permanent display without the need for acknowledgement.

Operating Instructions DULCOMETER® D1C, Part 2/Bromine
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