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Functional description

RTC-DAF

Implemented on
HACH measurement transmitter SC4500



Functional description
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Functional description of RTC-DAF

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Note: The description uses the color code below to distinguish between:

RTC menu structure: *purple, Italic*
Menu parameter: *blue, Italic*
RTC output parameter: *green, Italic*
RTC input parameter: *gold, Italic*

1. Product overview

The RTC-DAF (Dissolved Air Flotation) controller optimizes chemical dosing of coagulant and flocculant and adjusts the feed flow rate for dissolved air flotation processes in wastewater treatment.

Coagulant addition is based on dosing proportional to the actual solids load or flow into the process. This proportional coagulant dosing can be combined with feedback control of the TSS concentration in the clear effluent.

Flocculant concentration can be proportional to coagulant concentration or set to a fixed concentration.

In addition, the pH value can be monitored and controlled to a desired level by adjusting either the caustic or acid flow.

The feed flowrate to the DAF unit can be a manual adjustment or an automatic calculation maintaining a desired solids loading to the process based on solids concentration in the feed.

NOTICE
Under consideration of any limitation of liability set out in the Terms and conditions for Sale of Hach Products, with regard to the RTC Services, Hach will in particular not assume any liability for any damages, claims, penalties or expenses resulting from or connection with (1) any failure in or for operation by Buyer of the facility, equipment or plant, (2) any operational results, (Sensor) data, values, indicators of the facility, equipment or plant of the Buyer, (3) any faulty or incomplete integration concept (e.g. missing implementation of fallback levels in PLC programs processing RTC setpoints) of the RTC system into the Buyer's plant or equipment, (4) any unauthorized access of third parties regarding any Sensor Data, values, indicators or operation of the facility, equipment or plant of the Buyer.

2. Output and Input Signals

The RTC output and input signals are shown in Table 1 and illustrated in Figure 1.

RTC outputs / inputs	Unit Metric	Unit Imperial	Description
Calculated RTC output signals			provided via the standard SC4500 output modules
Coagulant set point	L/h	gal/h	Set point coagulant dosing rate
Flocculant set point	L/h	gal/h	Set point flocculant dosing rate
Coagulant concentration	mg/L		Calculated concentration of coagulant based on calculated *Coagulant set point* and *Feed flowrate measured*
Coagulant dosing factor	g/kg		Calculated specific coagulant dosing. Coagulant [g] per TSS feed [kg] based on calculated *Coagulant set point, Feed flowrate measured* and *TSS feed measured*
Flocculant concentration	mg/L		Calculated concentration of coagulant based on calculated *Flocculant setpoint* and *Feed flowrate*

Flocculant dosing factor	g/kg		Calculated specific flocculant dosing. Coagulant [g] per TSS feed [kg] based on calculated *Flocculant set point*, *Feed flowrate measured* and *TSS feed measured*
Coagulant pump ON/OFF	-		Digital output for dosing pump. Also used for pulsed pump operation (ON/OFF)
Flocculant pump ON/OFF	-		Digital output for dosing pump. Also used for pulsed pump operation (ON/OFF)
pH chemical set point	L/h		Set point for caustic or acid dosing rate
pH dosing pump ON/OFF	-		Digital output for dosing pump. Also used for pulsed pump operation (ON/OFF)
TSS clear set point	mg/L		Set point TSS concentration in clear water effluent
pH set point	-		Set point pH
Feed flow set point	L/s	gal/min	Calculated *Feed flow set point* based *TSS feed measured* and the maximum desired solids load fed to the machine
RTC input signals			provided via the standard SC4500 input modules
TSS feed measured	g/l		Measured TSS concentration in the feed
TSS clear measured	mg/l		Measured TSS concentration in clear water effluent
pH measured	-		Measured pH value
Feed flowrate measured	L/s	gal/min	Measured feed flow rate
Coagulant flow measured	L/h	gal/h	Coagulant flow measured
Flocculant flow measured	L/h	gal/h	Flocculant flow measured
pH chemical flow rate measured	L/h	gal/h	pH chemical flow rate measured
RTC Errors and Warnings			
Classified Error			
Classified Status 1			
Classified Status 2			
Classified Status 3			
Classified Status 4			
Device Error Condition			
Device Warning Condition			**Bit 5: RTC in Fallback**
Heartbeat			**Toggling each second**
Other RTC output signals			
Generic Spare 01			
…..			
Generic Spare 16			

Table 1: RTC-DAF output and input signals (Bold signals mandatory for RTC-DAF operation)

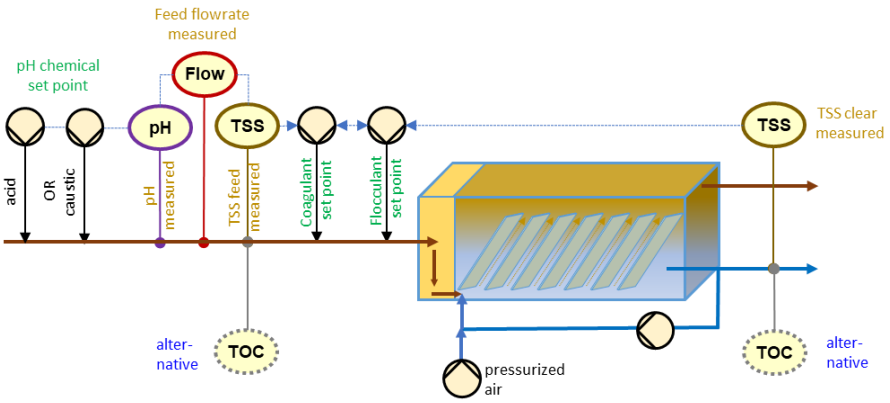


Figure 1: RTC-DAF input and output signals

2.1. Measurement Units

The RTC can be operated either in

- metric (e.g. L/s, m3/h, …. relevant for EU),
- imperial (MGD, gal/h, …. relevant for US) or
- free units.

Units for incoming signals are defined in the *In/Out configuration > Incoming* menu. Units for the outgoing signals are defined in the *In/Out configuration > outgoing* menu.

Note
The measurement unit selected for an input signal (e.g. mg/L for the TSS reading in clear water) must always be the same unit selected for the corresponding sensor.

IMPORTANT Notice
If the channel for input measurements is via a - digital communication channel (ModBus, Profibus, Profinet, Ethernet IP) the SC4500 has to receive a "NaN" signal (FFFF FFFF FFFF FFFF) in case the Signal transmitted is invalid (e.g. instrument error) - mA input card, the signal scaling must be 4…20 mA and the SC4500 has to receive 0 mA in case the Signal transmitted is invalid (e.g. instrument error)

Units for the RTC operating menu units and main display can be adjusted in the *System menu > Units* either in metric or in imperial units. This setting does not affect the units for the RTC inputs or outputs.

Whatever units are selected for inputs, outputs and the operating menu, the RTC algorithm is always calculating in defined metric units (base units).

2.2. Input Signal Setup

The RTC can receive measured input signals through analog and / or fieldbus communication. With the *In/Out configuration > Incoming* menu the measured input signals can be sourced and configured. The selection of a measured input signal source is completed by selecting the corresponding *Source*.

For each input parameter the measured unit can be selected by *Expected unit* (e.g. metric L/s, m3/h, … or imperial (MGD, gal/d, …). If *Expected unit* is selected to be a *Free unit*, *Offset* and *Gain* for this input reading must be defined to transform the input to the base unit used by the RTC.

Plausible minimum and *Plausible maximum* define the valid range of the measured values. Measured input signal values outside this range for longer than the *Hold time* will be considered invalid and the RTC will go into fallback mode.

For testing purposes or if a reading is not available there is also an option to assign a certain value to an input signal by putting the *Static* to "on" and input a desired *Static value*.

Input signal smoothing is recommended for spiking input signals. Adjustments can be made in the *Advanced settings > Input Value Filter* menu by selecting *Feed flowrate smoothing time*, *TSS feed smoothing time*, *TSS effluent smoothing time* and *pH smoothing time*.

2.3. Output Setup and Constraints

The calculated output variables from the RTC are sent to the PLC, SCADA or chemical feed pumps through analog and or fieldbus communication. The following section describes how the output signals are set up.

Unit selection

For each output signal the unit can be selected by *Expected unit* (e.g. metric L/s, m3/h, … or imperial MGD, gal/d, …). If *Expected unit* is selected to be a *Free unit*, *Offset* and *Gain* for this output value must be defined to transform the output value from the base to the expected unit transmitted to the RTC output.

The calculated RTC outputs can be restricted in *Advanced settings > Output value restrictions* menu for

- *Coagulant set point* by *Coagulant maximum concentration, Coagulant minimum concentration, Coagulant maximum dosing rate, Coagulant minimum dosing rate*
- *Flocculant set point* by *Flocculant maximum concentration, Flocculant minimum concentration, Flocculant maximum dosing rate, Flocculant minimum dosing rate*
- *pH chemical set point* by *Maximum pH dosing rate, Minimum pH dosing rate,*
- *Feed flow set point* by *Minimum feed flow limit, Maximum feed flow limit*

If calculated values are below the minimum or above the maximum limit for the output value, the output value is limited to the user defined minimum or maximum output value (Figure 2)

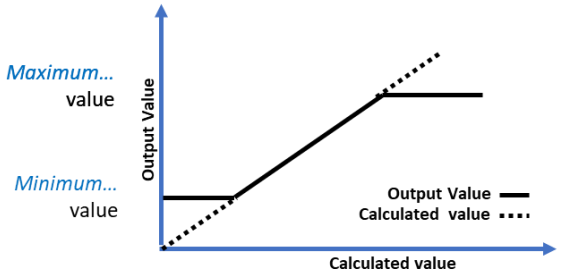


Figure 2: Restrictions of calculated output signals

The parameter *Maximum rate of change of dosing rate* limits how quickly the calculated *Coagulant set point* can change and is the percent per minute of the *Coagulant maximum dosing rate* value. A *Maximum rate of change of dosing rate* <= 0 adjusts to no limitation in the rate of change.

The parameter *Maximum rate of change of pH dosing rate* limits how quickly the calculated *pH chemical set point* can change and is the percent per minute of the *Maximum pH dosing rate* value. A *Maximum rate of change of dosing rate* <= 0 adjusts to no limitation in the rate of change.

2.4. Chemical Specification

The coagulant and flocculant concentration must be defined in the *Advanced settings > Chemical Specification* menu by setting a *Flocculant concentration* and a *Coagulant concentration* in g/L. The active concentration is specified by the manufacturer either in

- *g/kg:* This value needs to be multiplied by the density [kg/L] of the product to obtain the active content in g/L
- *%:* This value needs to be multiplied by 10 to obtain the concentration in g/kg, and then multiplied by the density of the product to obtain the active content in g/L.

If an on-site dilution unit is in use, *Flocculant concentration* and *Coagulant concentration* must be determined and adjusted accordingly.

2.5. Pump specification

On/Off operation mode for dosing pumps

If the calculated *Coagulant set point*, *Flocculant set point* or *pH chemical set point* is lower than the corresponding *Minimum pump rate* of the dosing pump adjusted in the corresponding pump specification menu, the RTC switches automatically to ON/OFF operation mode for the corresponding dosing pump. This operation mode can be defined with *Minimum pump rate*, *Control cycle* and *Minimum run time.* The *Control cycle* time defines the cycle time while the *Minimum run time* defines a minimum pumping time (Figure 3). Short cycle times increase the switch frequency but enable more precise dosing.

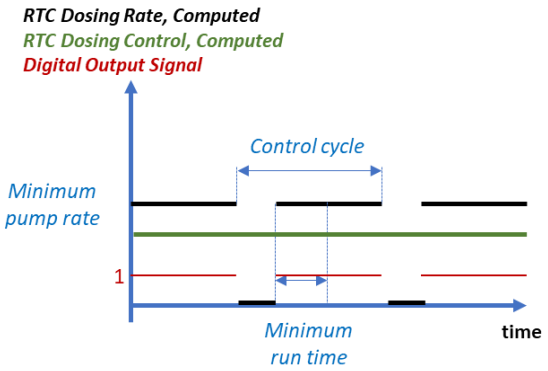


Figure 3: Impulse/pause operation mode for polymer dosing pump

3. RTC Operation modes

The RTC-DAF operation modes can be defined in the *Mode selection* menu:

- *Automatic* to select the
  - *Coagulant open loop type* operational modes (Figure 5) either
    - *Load based*: Mass ratio of coagulant to dry solids in the feed or
    - *Concentration based*: Coagulant feed concentration

    Each of the *Coagulant open loop type* must be combined with one of the feedback control modes listed in the *Coagulant mode selection* menu
    - *Open loop control only* (no closed loop control)
    - *Open w/ closed load based* control (Figure 6)
    - *Open w/ closed concentration based* control (Figure 6)

  - *Flocculant mode selection* which is applied in all control modes and must be adjusted either as a
    - *Static concentration* of flocculant in the feed or
    - *Flocculant/coagulant ratio*: Proportional dosing of coagulant and flocculant.

  - *pH dosing stop mode*: Defines if coagulant and / or the flocculant dosing shall be stopped, if the *pH measured* falls below a certain value.

  - *pH control mode*: Defines if a chemical for *pH measured* control is applied and if yes, if the chemical applied is either *Acid* or *Caustic*.

- *Semi Automatic* to define an operational mode with

- *Constant coagulant dosing rate*: If *On* is selected *Manual coagulant dosing rate* must be defined
- *Constant flocculant dosing rate*: If *On* is selected *Manual flocculant dosing rate* must be defined
- *Constant pH dosing rate*: If *On* is selected *Manual pH dosing rate* must be defined
- *Manual feed flow*: If *On* is selected *Manual feed flow* must be defined

Semi Automatic operating mode has higher priority than *Automatic* operating mode. Limits defined in the *Output value restrictions* menu are **not** applied in *Semi Automatic*.

Note:
The RTC operation menu displays only the setting relevant for the selected operating mode.

3.1. pH monitoring and control

Dosing stop due to low pH values

Coagulation (and flocculation) processes can be negatively affected by low pH values. Adding coagulants (and flocculants) might decrease the pH and due to this amplify the effect of low pH values on the DAF process. To avoid chemical dosing to the process at low pH values coagulant and flocculant dosing can be stopped if the *pH measured* falls below the adjustable value *Dosing stop due to low pH* defined in *Basic settings* menu. This functionality can be activated / deactivated independently for flocculant and coagulant in the *Mode selection > Automatic > pH dosing stop mode* menu.

pH control

The RTC DAF includes a controller maintaining the *pH measured* value at a *pH setpoint* defined in the *Basic settings* menu. In *Mode selection > Automatic > pH dosing chemical applied* it must be defined if a chemical is dosed and if yes, if either *Acid* or *Caustic* is dosed.

Via *Basic settings* menu a *pH deadband* can be defined, where the PID controller is not active and *Acid* or *Caustic* dosing is fixed.

Via the menu *Advanced settings > pH closed loop parameters* the PID parameter *Concentration gain*, *Integral time* and *Derivative time* can be adjusted.

See 3.5 for PID control parameter adjustment.

3.2. Feed flow set point calculation

To ensure the solids process is working under optimum conditions, the RTC DAF allows to provide a defined *Solids loading target / maximum* to the DAF process, by calculating a *Feed flow set point* = (*Solids loading target / maximum)* / *TSS feed measured* (Figure 4).

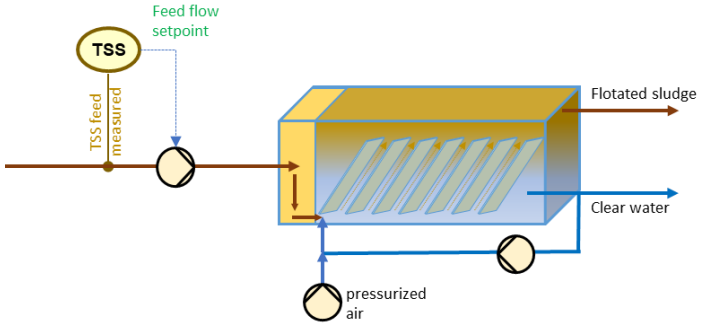


Figure 4: Adjustment of machine TSS loading

The *Feed flow set point* is calculated in any of the operational modes. It is overwritten by an activated *Manual feed flow* adjustable in the *Modes selection > Semi automatic > Feed flow* menu.

In each of the *Automatic* and *Semi Automatic* operating modes, the output signal *Feed flow set point* is calculated and output on the sc4500 RTC DAF detail page, even if it is not used to set the feed flow.

3.3. Open Loop Control Mode for Coagulant/Flocculant

The RTC DAF can be operated in an *Open loop control only* mode without a TSS measurement in the clear water (Figure 5). In the *Modes selection > Automatic > Coagulant open loop type* menu it can be chosen between

- *Load based:*
  The *Coagulant set point* output is based on the influent TSS loading (*Feed flowrate measured* x *TSS feed measured*) and the *Coagulant load factor*. The *Flocculant set point* is calculated either according to the adjusted *Flocculant/coagulant ratio* or based on a set *Flocculant concentration*.
- *Concentration based:*
  The *Coagulant set point* and the *Flocculant set point* outputs are based on the *Feed flowrate measured* and the *Coagulant concentration factor* and *Flocculant concentration factor*. In this control mode the *TSS feed measured* concentration is not required.

To operate in *Open loop control only* the corresponding setting must be chosen in the *Modes selection > Automatic > Coagulant mode selection* menu.

The operational mode *Open loop control only* allows immediate reaction to varying inflow conditions. However, the clear water quality has no impact on the dosing.

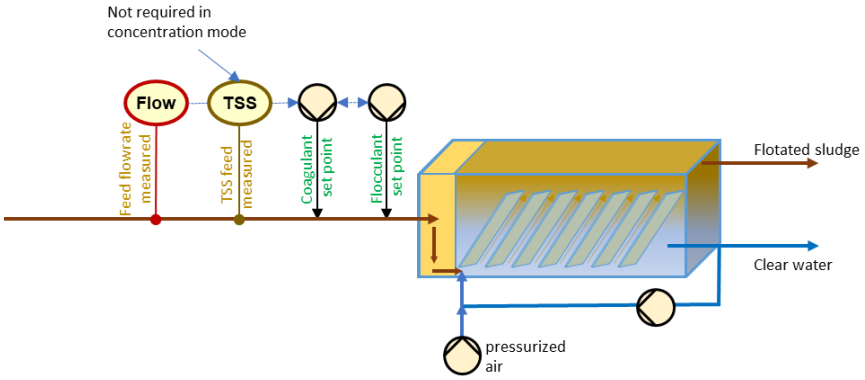


Figure 5: Open loop control

3.4. Closed Loop Control Modes for Coagulant/Flocculant

The open loop control modes described in 3.3 can be combined with a closed loop control of *TSS clear measured* (Figure 6).

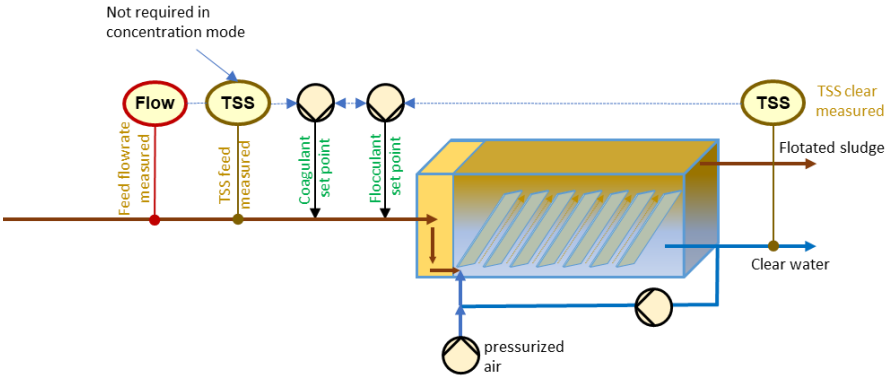


Figure 6: Closed loop control of TSS in clear water

In closed loop control the RTC DAF uses a specialized PID controller to calculate the *Coagulant set point* required to maintain the *TSS clear measured* concentration at the desired *TSS clear set point*. The *Flocculant set point* is calculated according either to the adjusted *Flocculant/coagulant ratio* or *Flocculant concentration*.

Three closed loop control options for the *TSS clear measured* are possible:

1)

Coagulant open loop type	*Concentration based*
Coagulant mode selection	*Open w/closed loop concentration based*

The control principle according to Figure 7 is applied. The PID controller output is a *concentration [mg/L]* which is added to the *Coagulant concentration factor*.

In this configuration there is no need for a *TSS feed measured* input signal.

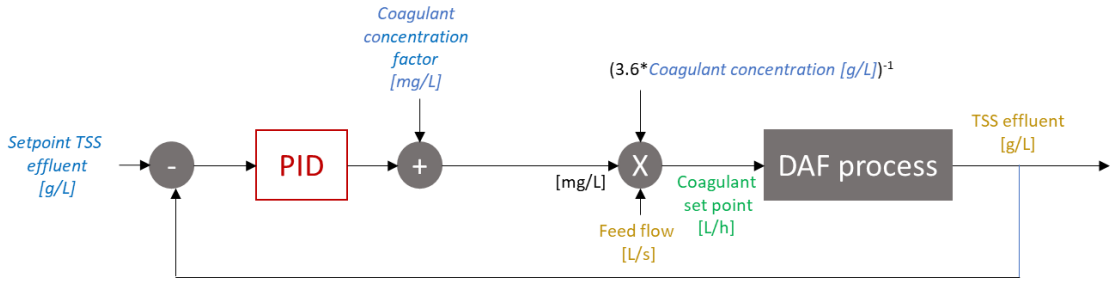


Figure 7: Closed loop control with concentration feedback [mg/L]

2)

Coagulant open loop type	*Load based*
Coagulant mode selection	*Open w/closed loop load based*

The control principle according to Figure 8 is applied. The PID output is a *load factor* which is added to the *Coagulant load factor.* In this configuration the *TSS feed measured* is impacting the PID feedback loop as a gain and by this making the control loop more reactive to changes in *TSS feed measured*.

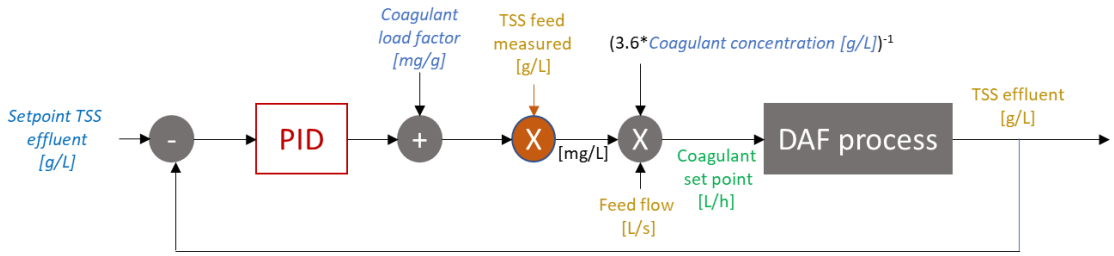


Figure 8: Closed loop control with load factor feedback

3)

Coagulant open loop type	*Load based*
Coagulant mode selection	*Open w/closed loop concentration based*

The control principle according to Figure 9 is applied. The PID output is a concentration. As indicated in Figure 9 in this configuration the *TSS feed measured* is not impacting the PID feedback loop as a gain and by this making the control loop less reactive to changes in *TSS feed measured*.

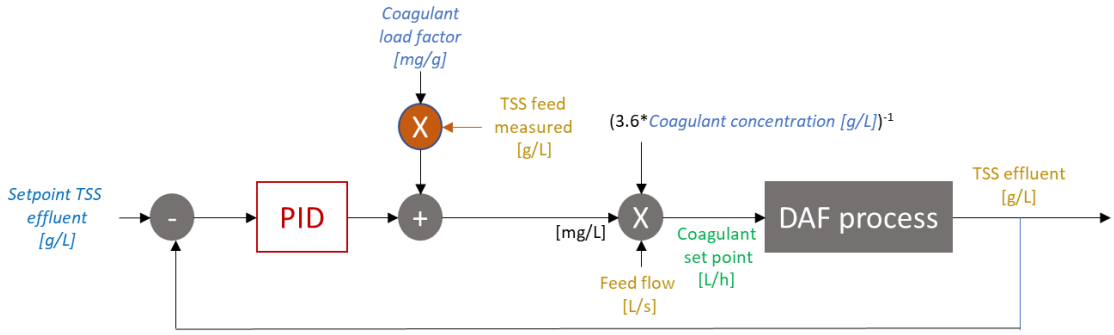


Figure 9: Closed loop control with concentration feedback

Control limitations

The PID controller changes either the adjusted *Coagulant load factor* or the *Coagulant concentration factor* depending on the control type selected.

In *Load based* mode the PID control output can be limited between

- *Maximum increase coagulant load factor* and
- *Max decrease coagulant load factor*

In *Concentration based* control mode the PID control output can be limited between

- *Max increase coagulant concentration*
- *Max decrease coagulant concentration*

Before switching from *Open w/closed loop load based* to *Open w/closed loop Concentration based* mode during operation and vice versa, it is recommended to adjust the *Coagulant concentration factor* to the actual *Coagulant concentration* and the *Coagulant load factor* to the actual *Coagulant dosing factor* respectively. This will allow a smooth transition between the control modes.

Difference and Ratio control

There are two closed loop control modes which can be adjusted in the *Coagulant closed loop parameters (load)* > *Control mode* resp. *Coagulant closed loop parameters (concentration)* > *Control mode* menu:

- *Difference*: The PID calculates a dosing rate targeting to achieve (*TSS clear set point*) – (*TSS clear measured*) = 0
- *Ratio*: The PID calculates a dosing rate targeting to achieve that (*TSS clear set point*) / (*TSS clear measured*) = 1

The *Ratio* control mode is recommended to control the *TSS clear set point* concentration between 150…300mg/L.

3.5. PID control adjustment

Depending on the *Mode selection* the PID controller for

- *TSS clear measured* can be adjusted either in the menu
  - *Coagulant closed loop parameters (load)* by *Load gain, Integral time* and *Derivative time* or
  - *Coagulant closed loop parameters (concentration)* by *Concentration gain, Integral time* and *Derivative time*.
- *pH measured* can be adjusted in the menu
  - *pH closed loop parameters* by *Concentration gain, Integral time* and *Derivative time*.

It is recommended to follow the steps below for PID controller adjustment:

- Step 1: Initial adjustment of *Load gain* respectively *Concentration gain* based on *TSS clear set point* or *pH setpoint*

If after a setpoint change the controlled variable (either *TSS clear measured* or *pH measured*) reading

- is oscillating, *Load gain* respectively *Concentration gain* needs to be reduced.
- is reacting very slow, *Load gain* respectively *Concentration gain* needs to be increased (Figure 10)

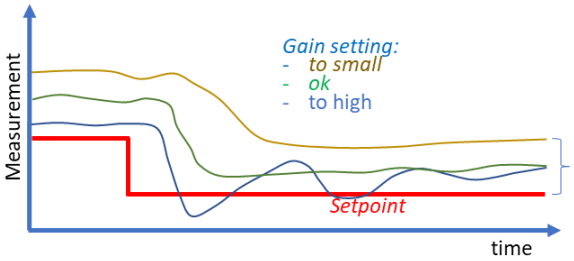


Figure 10: Adjustment of Gain setting

Note:

- There will always be a remaining control difference between the setpoint and the controlled variable (*TSS clear measured* or *pH measured*) if only *Load gain* respectively *Concentration gain* and no *Integral time* is applied (the higher *Load gain* respectively *Concentration gain* the lower the remaining control difference).

Step 2: Adjustment of *Integral time*
The *Integral time* ensures the desired *TSS clear set point* is reached.

If after a change in the TSS setpoint the TSS reading (Figure 11)

- is oscillating, the *Integral time* needs to be increased.
- is reacting very slow, the *Integral time* needs to be reduced.

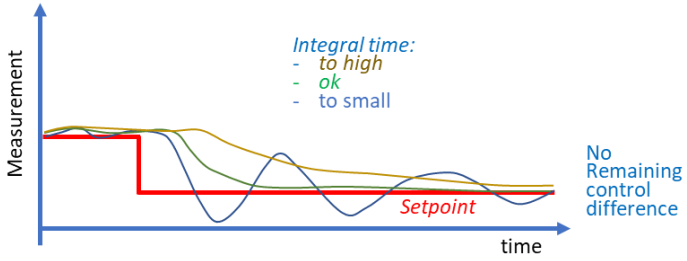


Figure 11: Adjustment of Integral time

- *Step 3*: Adjustment of *Derivative time*
  Using the *Derivative time* ensures to react to the rate of change of the controlled variable (*TSS clear measured* or *pH measured*). This might reduce the response time of the control but might also result in a more fluctuating profile of the controlled variable. That's why in most applications a *Derivative time* = 0 should be adjusted.

3.6. Semi Automatic

The *Semi automatic* operation mode allows to independently select

- *Constant coagulant dosing rate* (*On*/*Off*) and to adjust a *Manual coagulant dosing rate*
- *Constant flocculant dosing rate* (*On*/*Off*) and to adjust a *Manual flocculant dosing rate*
- *Constant pH dosing rate* (*On*/*Off*) and to adjust a *Manual pH Dosing rate*
- *Feed flow* (*On*/*Off*) and to adjust a *Manual feed flow*

Manual setpoints (dosing rates and feedflow) are not limited to the minimum and maximum dosing rates adjustable in the *Output value restrictions* menu.

When activating a closed loop control mode after the RTC was operating in the manual mode, the dosing setpoints will have a starting value equal to the manual dosing rates to allow for a smooth transition to the new control mode.

3.7. Minimum feed flow limit

If the input value *Feed flowrate measured* falls below *Feed flow rate low stop*, coagulant and flocculant dosing is stopped, i.e.

- Setpoint *Coagulant pump ON/OFF* = 0
- Setpoint *Coagulant set point* = 0
- Setpoint *Flocculant pump ON/OFF* = 0
- Setpoint *Flocculant set point* = 0
- Setpoint *pH chemical set point* = 0
- Setpoint *pH ….. pump ON/OFF* = 0

After the *Feed flowrate measured* exceeds the *Feed flowrate low stop*, the RTC is automatically activated again.

Note:

If the RTC *Feed flowrate measured* input signal is < *Feed flow rate low stop*, the input value *Feed flowrate measured* shown on the sc4500 =0.

4. Fallback Strategy

In case an input signal gets

- invalid
- **OR** is outside the plausible signal range *Plausible Minimum* and *Plausible Maximum*

for a time period > *Hold time*, the RTC switches to adjustable RTC outputs defined in the *Fallback* menu indicated in Table 2.

<table>
<tr><th>Fallback output
Failing input</th><th>Coagulant set point</th><th>Flocculant set point</th><th>Feed flow rate set point</th><th>pH chemical set point</th></tr>
<tr><td>Feed flowrate measured</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td rowspan="2">TSS feed measured</td><td rowspan="2">Fallback coagulant dosing rate</td><td>If Flocculant/coagulant ratio mode is selected: According to Fallback coagulant dosing rate and Flocculant/coagulant ratio</td><td rowspan="2">Fallback Feedflow setpoint</td><td rowspan="2">Not affected</td></tr>
<tr><td>If Static concentration mode is selected: Not affected</td></tr>
<tr><td>TSS Clear measured</td><td>Coagulant load factor or Coagulant concentration factor</td><td>According to Flocculant/coagulant ratio or Flocculant concentration factor</td><td>Not affected</td><td>Not affected</td></tr>
<tr><td rowspan="2">pH measured</td><td>pH dosing stop mode Applied to coagulant = Off : Not affected</td><td>pH dosing stop mode Applied to flocculant = Off : Not affected</td><td rowspan="2">Not affected</td><td rowspan="2">Fallback pH dosing rate</td></tr>
<tr><td>pH dosing stop mode Applied to coagulant = On :
- pH > pH min: Not affected
- pH < pH min: Limit on coagulant flow cancelled</td><td>pH dosing stop mode Applied to flocculant = On :
- pH > pH min: Not affected
- pH < pH min: Limit on coagulant flow cancelled</td></tr>
</table>

Table 2: RTC-DAF fallback strategy

Failing input signals

- *Coagulant flow measured*
- *Flocculant flow measured*
- *pH chemical flowrate measured*

are not activating a fallback.

5. Read / write operating menu parameter from SCADA/PLC

Optionally up to 10 SC4500 RTC menu parameters can be modified remotely through SCADA/PLC. For this feature the SC4500 must be connected to the SCADA/PLC via a digital SC4500 fieldbus.

The exchange of RTC menu parameters between the SC4500 and the PLC is based on up to 10 *Generic spare* tags *(Generic spare 1 …. Generic spare 10)* and equal number of *External measurement* tags.

The exchange process involves actions below (Figure 12):

- **RTC** continuously writes the *active RTC menu parameter value* currently applied to the RTC algorithm to the assigned *Generic spare*.
- **PLC** must read the *active RTC menu parameter value*, transmitted via the *Generic spare* tag and must display it on the *PLC/SCADA UI* as the *active RTC menu parameter*.
- **PLC** writing the *PLC/SCADA UI menu parameter* value to the RTC, using the assigned *External measurement* tag.
- **RTC** continuously reading *the External measurement* tag corresponding to a specified RTC menu parameter.
  If the
  - *External measurement* value changes
  - AND if the value of the *External measurement* tag is between *Plausible minimum* and *Plausible maximum*

  the RTC takes the value of the *External measurement* as the new *RTC menu parameter value* and writes the value to the corresponding *Generic Spare* tag. Otherwise the value of the *External measurement tag* received from the PLC is ignored.

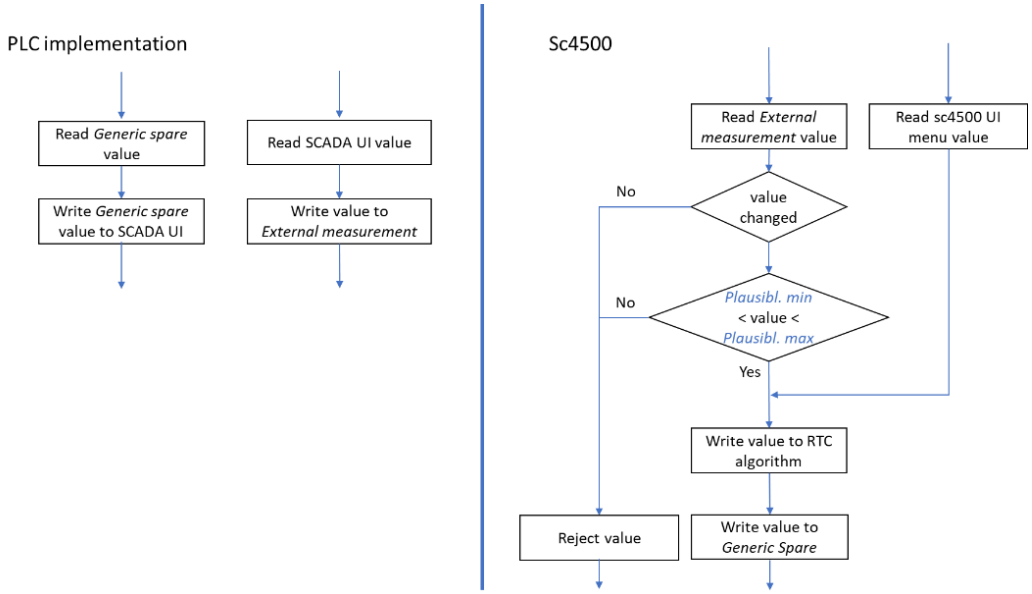


Figure 12: Principle Read / write operating menu parameter from SCADA/PLC functionality

Generic spare tags and *External measurement* tags must be integrated in the telegram of digital communication between RTC and PLC.

Note
For a Profibus card the number of *External measurement* tags = 8, for the other digital communication options the number of *External measurement* tags = 32. Those *External measurement* tags are also used to write measurement values (like flow) to the sc4500. So the

number of menu parameters which can be exchanged with SCADA might be limited, in particular if Profibus is used as the digital communication protocol.

The selection of RTC menu parameters to be exchanged is done via the menu *In/Out configuration > RTC parameters.* For each of the up to 10 menu values to be exchanged select *Parameter 1* …. *Parameter 10* and configure:

> *RTC parameter*	> Select RTC menu parameter to be exchanged
> Current parameter value	> Indication of current parameter value
> Parameter tag write	> *Generic Spare* x
> *Source*	> Select input source for reading *External measurement*
> *Parameter*	> Select *External measurement x* for reading SCADA UI parameter
> *Plausible minimum*	> Plausible minimum > 0 in case PLC sends "0" during restart
> *Plausible maximum*	> Plausible maximum

Note

If there is a risk, that during a PLC restart a "0" is written to the *External measurement* the *Plausible minimum* setting must be adjusted to a value > "0" to avoid the "0" is accepted by the sc4500 as the new desired menu parameter.

6. Startup RTC

Commissioning of the SC4500:

- Installation and connection of the SC4500 should be performed in accordance with the complete SC4500 User Manual (DOC343.xx.90690).
- Configuration of the connected sensors should be done according to the supplied user manuals.

Note for analogue integration of DAF-RTC

The sum of analogue input signals and sensor input signals to the SC4500 is limited to 2. If more than 2 input signals are required, a second SC4500 must be networked via HCNB.

Figure 13 shows an example for analogue integration of the RTC-DAF. The 2 TSS measurements are connected to the SC4500 on the left side, while the SC4500 on the right picks up the pH Sensor and additionally via a 0/4…20mA input card the *Feed flowrate measured*. As the number of relays is limited to 2 in one SC4500 and the *System Error* for each SC4500 has to be transmitted, only the *Coagulant pump ON/OFF* and *Flocculant pump ON/OFF* signal is transmitted.

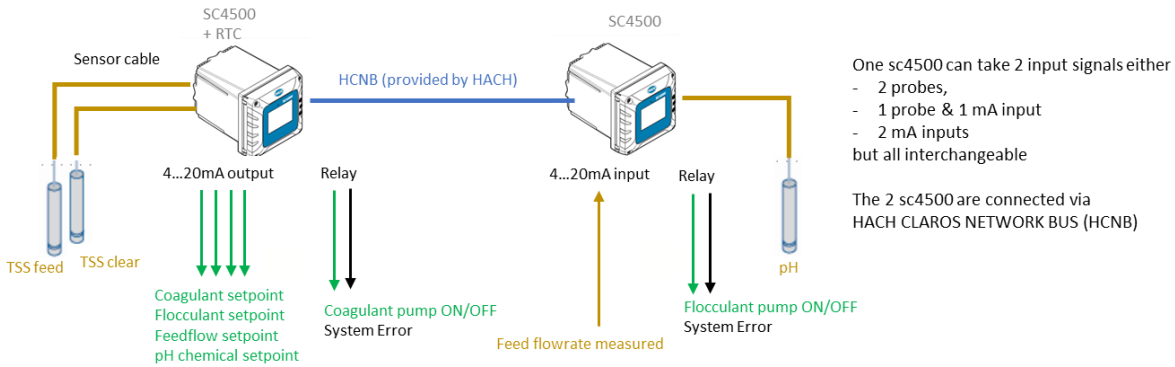


Figure 13: Example for analogue integration of DAF-RTC with 2 SC4500 controller

6.1. Configuration of input signals

For each of the 6 RTC input signals

- *TSS feed measured* not required for *Concentration based* mode

- *TSS clear measured* for closed loop control
- *pH measured* for pH monitoring / control
- *Feed flowrate measured* for *feed flowrate* monitoring / control
- *Coagulant flow measured* Optional
- *Flocculant flow measured* Optional
- *pH chemical flowrate measured* Optional

via the menu *Device Menu > In/Out configuration > Incoming* select for each input signal

- *Source*
- *Expected unit*
- *Plausible Minimum*
- *Plausible Maximum*
- *Hold time*

6.2. Configuration of output signals

Digital integration:

Configuration of output telegram

- *ModBus TCP* (or ProfiBus, ProfiNet, EthernetIP) > *Telegram* > *Add device* > *Select RTC DAF* > Select again > Select *Add Tag*

  Add the tags to be transmitted to PLC including:

  - *Coagulant set point*
  - *Flocculant set point*
  - *Coagulant concentration*
  - *Coagulant dosing factor*
  - *Flocculant concentration*
  - *Flocculant dosing factor*
  - *Coagulant pump ON/OFF*
  - *Flocculant pump ON/OFF*
  - *pH chemical set point*
  - *pH dosing pump ON/OFF*
  - *TSS clear set point*
  - *pH set point*
  - *Feed flow setpoint*
  - *Device warning condition* (Option)
  - *Heartbeat*

IMPORTANT Notice
PLC must receive the *Heartbeat* of RTC DAF changing every 6 sec. The entire Word (16 Bit) needs to be evaluated for a change. **If there is no *Heartbeat* change, the PLC must take over control**. RTC is not in operation.

Device warning condition Bit 5 indicates if a *fallback* is active.

Analogue integration:

The mA output needs to be configured for

- *Coagulant set point*, *Flocculant set point*, *pH chemical set point*, *Feed flow set point* (Option), *Coagulant concentration* (Option), *Coagulant dosing factor* (Option), *Flocculant concentration* (Option) and *Flocculant dosing factor* (Option)

  For each output select

  > *mA output* > *Device menu* > *System Set up* > *Channel x output value* >

  > *Source* > Select *RTC DAF*

  > *Parameter* > Select *corresponding output*

> *Data view* > Select *Input Value*
> *Function* > Select *Linear Control*
> *Transfer* > Select *0.0 mA*
> *Filter* > Select *10 s*
> *Filter unit* > Select *s*
> *Maximum* > Select *20.0 mA*
> *Scale* > Select *4-20mA*
> *Low value* > Select *0*
> *High value* > Select *100*
> *Error mode* > Select *Transfer*
> *Current* > Indication of current value
> *Data logger int…* > Select *Any selection possible*

Note:
Each SC4500 mA output card hosts 5 mA outputs which can be sourced from any signal available via the HACH Controller Network Bus (HCNB).

IMPORTANT Notice
If the mA output = 0mA, the PLC must take over control. RTC is not in operation.

- For *Coagulant pump ON/OFF* Select
>*High voltage relay* > *Device menu* > *System Set up* > *Relay 1*
> *Source* > Select *RTC DAF*
> *Parameter* > Select *Coagulant pump ON/OFF*
> *Data view* > Select *Relay contact status*
> *Function* > Select *Feeder control*
> *Transfer* > Select *Relay is energized*
> *Phase* > Select *Value above the limit*
> *Relay setpoint* > Select *+ 0,5*
> *Deadband* > Select *0*
> *OnMax timer* > Select *0*
> *Timer on delay* > Select *5s*
> *Timer off delay* > Select *5s*
> *Maximum timer expiration* > Select *….*
> *Input value* > Select *….*
> *Relay contact st..* > Select *….*
> *Data logger int…* > Select *off*

- ***Error / Warning***
>*High voltage relay* > *System Set up* > *Relay 2* >
> *Function* > Select *System Error*
> *Transfer* > Select *Relays are de-energized*
> *Warning list* > Select *Disabled*
> *Error list* > Select *Enabled*
> *Sensor is missing* > *Select Enabled*
> *Timer on delay* > Select *5s*
> *Timer off delay* > Select *5s*
> *Relay contact st..* > ….
> *Data logger int…* > Select *off*

Note:
Any further digital output *Coagulant pump ON/OFF* or *pH dosing pump ON/OFF* must be

routed through another SC4500 as the number of relay outputs per SC4500 is limited to 2 and one relay output per SC4500 is required to transmit *System Error*.

Note
If "Relay 2" is *open* (System Error) one of the below occurred: - Sensor error (disconnected or broken) OR - SC4500 general error OR - RTC program error OR - Cable breakage If the mA output signal *Dosing Rate* is still valid and between 4….20mA, RTC operates in ***fallback*** mode and the PLC can continue to use *Dosing Rate*, *Dosing pump ON/OFF* and *Feed flow set point* to control the process.

7. Operating menu

RTC menu		
Mode selection		
Automatic		
Coagulant open loop type		
Load based		Sets coagulant open loop to load based control
Concentration based		Sets coagulant open loop to concentration based control
Coagulant mode selection		
Open loop control only		Sets coagulant control to open loop only
Open w/closed loop load based		Sets coagulant control to open loop with closed loop load based
Open w/closed loop concentration based		Sets coagulant control to open loop with closed loop concentration based
Flocculant mode selection		
Static concentration		Sets the flocculant control to static concentration
Flocculant/coagulant ratio		Sets the flocculant control to flocculant/coagulant ratio
pH control mode		
Off		No dosing
Acid		Acid dosing
Caustic		Caustic dosing
pH dosing stop mode		
Applied to coagulant (On / Off)		Turns pH dosing stop mode on or off for coagulant
Applied to flocculant (On / Off)		Turns pH dosing stop mode on or off for flocculant
Semi automatic		
Constant coagulant dosing rate (On / Off)		Constant coagulant dosing rate
Manual coagulant dosing rate	[L/h]	Sets the constant coagulant dosing rate
Constant flocculant dosing rate (On / Off)		Turns constant flocculant dosing rate (On / Off)
Manual flocculant dosing rate	[L/h]	Sets the constant flocculant dosing rate
Constant pH dosing rate	[L/h]	Turns on constant pH dosing rate
Manual pH Dosing rate	[L/h]	Sets the constant pHdosing rate
Feed flow		
Manual feed flow	[L/s]	Sets the constant feed flow rate
In/Out configuration		
Incoming		
TSS feed measured	[g/L]	
Value		Indicates the current reading for this parameter, as received by the RTC
Source		Select source for incoming parameter
Parameter		Select source for incoming parameter

Static		Select a static input value for the signal. This feature supports RTC commissioning
Static value		
Plausible minimum		Set the minimum plausible input value. If the reading is lower than this value for a time longer than the Hold time, the signal is assigned to be invalid and the RTC goes into a fallback mode. During the hold time the RTC continues to operate with the last valid reading (higher than the minimum value).
Plausible maximum		Set the maximum plausible input value. If the reading is higher than this value for a time longer than the hold time, the signal is assigned to be invalid and the RTC goes into a fallback mode. During the hold time the RTC continues to operate with the last valid reading (lower than the maximum value).
Same setting for all other incoming variables *TSS clear measured, pH measured, Feed flowrate measured, Coagulant flow measured, Flocculant flow measured, pH chemical flowrate measured*		
Outgoing		
Coagulant set point	[L/h]	
Value		
Expected unit		
Raw value		
Offset		
Gain		
RTC parameters		Configuration of parameter exchange with PLC/SCADA
Parameter 1		Select parameter
RTC parameter		To be selected from the list of available parameters
Current parameter value		Shows the current value of the parameter
Parameter tag write		Shows the assigned Generic Spare tag for parameter Read
Source		Select the digital used communication option (Modbus TCP, ProfiBus, Ethernet IP or Profinet)
Parameter		Select the used Measurement 1-10 tag for parameter value Write
Plausible minimum		Values below minimum will be rejected
Plausible maximum		Values above maximum will be rejected
Same setting for 10 selectable parameter for SCADA exchange		
Basic settings		
Coagulant load factor	mg/g	Coagulant load factor
Coagulant concentration factor	mg/l	Coagulant concentration factor
Flocculant/coagulant ratio	-	Flocculant/coagulant ratio
Flocculant concentration factor	mg/l	Flocculant concentration factor
TSS clear set point	mg/l	Sets the effluent solids concentration setpoint
Dosing reduction start due to low pH	-	Sets the low pH value when coagulant dose should start to reduce
Dosing stop due to low pH		Sets the low pH value when coagulant dose should stop
pH setpoint	-	Sets the pH setpoint
pH deadband	-	Dosing does not change in this range around the setpoint
Solids loading target / maximum	kg/hr	Sets the solids loading target to the DAF
Advanced settings		
Setpoints		
Coagulant load factor	mg/g	Defines the load-based coagulation dosing rate
Coagulant concentration factor	mg/l	Sets the dosing concentration of coagulant
Flocculant/coagulant ratio	-	Sets the flocculant to coagulant ratio
Flocculant concentration factor	mg/l	Sets the dosing concentration of flocculant
TSS clear set point	mg/l	Sets the effluent solids concentration setpoint

Dosing reduction start due to low pH	-	Sets the low pH value when coagulant dose should start to reduce
Dosing stop due to low pH		Sets the low pH value when coagulant dose should stop
pH setpoint	-	Sets the pH setpoint
pH deadband	-	Dosing does not change in this range around the setpoint
Solids loading target / maximum	kg/hr	Sets the solids loading target to the DAF
Coagulant closed loop parameters (load)		
Load gain	[mg/g] / [g/L]	Load gain
Integral time	[min]	Integral time
Derivative time	[min]	Derivative time
Maximum increase coagulant load factor	mg/g	Sets the maximum increaese in coagulant load factor for the effluent solids feedback loop
Maximum decrease coagulant load factor	mg/g	Sets the minimum increaese in coagulant load factor for the effluent solids feedback loop
Control mode		Sets the control mode for the closed loop
Difference		Closed loop uses the difference between the measured value and setpoint
Ratio		Closed loop uses a ratio between the measured value and setpoint
Coagulant closed loop parameters (concentration)		
Concentration gain	[mg/l] / [g/L]	Concentration gain
Integral time	[min]	Integral time
Derivative time	[min]	Derivative time
Maximum increase coagulant concentration	mg/L	Sets the maximum increase in coagulant concentration factor for the effluent solids feedback loop
Maximum decrease coagulant concentration	mg/L	Sets the minimum increase in coagulant concentration factor for the effluent solids feedback loop
Control mode		Sets the control mode for the closed loop
Difference		Closed loop uses the difference between measured value and setpoint
Ratio		Closed loop uses a ratio between measured value and setpoint
pH closed loop parameters		
Concentration gain	[L/h] / [L/s]/pH	Concentration gain
Integral time	[min]	Integral time
Derivative time	[min]	Derivative time
Input Value Filter		
Feed flowrate smoothing time	min	Sets moving average time window to smooth the Feed Flow input signal
TSS feed smoothing time	min	Sets moving average time window to smooth the TSS feed input signal
TSS effluent smoothing time	min	Sets moving average time window to smooth the TSS clear measured input signal
pH smoothing time	min	Sets moving average time window to smooth the pH input signal
Output Value Restrictions		
Coagulant minimum dosing rate	L/h	Sets the minimum coagulant concentration output from the RTC
Coagulant maximum dosing rate	L/h	Sets the maximum coagulant concentration output from the RTC
Coagulant minimum concentration	mg/l	Sets the minimum coagulant concentration output from the RTC
Coagulant maximum concentration	mg/l	Sets the maximum coagulant concentration output from the RTC

Flocculant minimum dosing rate	L/h	Sets the minimum flocculant concentration output from the RTC
Flocculant maximum dosing rate	L/h	Sets the maximum flocculant concentration output from the RTC
Flocculant minimum concentration	mg/l	Sets the minimum flocculant concentration output from the RTC
Flocculant maximum concentration	mg/l	Sets the maximum flocculant concentration output from the RTC
Minimum pH dosing rate	L/h	Sets the minimum output for the dosing rate of the pH chemical
Maximum pH dosing rate	L/h	Sets the maximum output for the dosing rate of the pH chemical
Minimum feed flow limit	[L/s]	Sets the minimum feed flow output from the RTC
Maximum feed flow limit	[L/s]	Sets the maximum feed flow output from the RTC
Feed flow rate low stop	L/s	Sets the value of feed flow that is considered as no flow
Chemical specification		
Flocculant concentration	[g/L]	Sets the active concentration of flocculant
Coagulant concentration	[g/L]	Sets the active concentration of coagulant
Coagulant pump specification		
Minimum pump rate	[L/h]	Sets the minimum pumping rate output from RTC, control will start pump cycle control
Control cycle	sec	Sets the time a single cycle will run
Minimum run time	sec	Sets the minimum run time of the pump
Flocculant pump specification		
Minimum pump rate	[L/h]	Sets the minimum pumping rate output from RTC, control will start pump cycle control
Control cycle	sec	Sets the time a single cycle will run
Minimum run time	sec	Sets the minimum run time of the pump
pH Chemical pump specification		
Minimum pump rate	[L/h]	Sets the minimum pumping rate output from RTC, control will start pump cycle control
Control cycle	sec	Sets the time a single cycle will run
Minimum run time	sec	Sets the minimum run time of the pump
Fallback		
Fallback coagulant dosing rate	[L/h]	Sets coagulant fallback dosing rate to be used during RTC Error
Fallback flocculant dosing rate	[L/h]	Sets flocculant fallback dosing rate to be used during RTC Error
Fallback pH dosing rate	[L/h]	Sets pH fallback dosing rate to be used during RTC Error
Fallback feed flow rate	[L/s]	Sets feed flow rate to be used during RTC Error
Diagnostic		
P term load	[mg/g]	
I term load	[mg/g]	
D term load	[mg/g]	
P term concentration	[mg/L]	
I term concentration	[mg/L]	
D term concentration	[mg/L]	
P term pH	%	
I term pH	%	
D term pH	%	
Actual coagulant dose factor	mg/g	
Actual coagulant dose concentration	mg/L	
24h average coagulant dosing rate	l/h	
24h average Coagulant concentration	mg/L	
24h average TSS feed	g/l	
Actual flocculant dose factor	mg/g	
Actual flocculant dose concentration	mg/L	
24h average flocculant dosing rate	l/h	
24h average Flocculant concentration	mg/L	
24h average TSS effluent	mg/L	

Volume coagulant in the last 24h based on set point	L	
Volume coagulant in the last 24h based on measurement	kg	
Totalized coagulant based on measurement (day)	kg	
Volume flocculant in the last 24h based on set point	L	
Volume flocculant in the last 24h based on measurement	kg	
Totalized flocculant based on measurement (day)	kg	
Volume pH chemical in the last 24h based on set point	L	
Volume pH chemical in the last 24h based on measurement	kg	
Totalized pH chemical based on measurement (day)	kg	
Feed flow in the last 24h	L	
System		
Location		
Units		
Metric		
Imperial		
Data logger interval		
Version		

8. Diagnostic data log

The Diagnostic data log can be downloaded from the SC4500 via a USB stick.
> *Controller* > *USB transfer* > *Logs*
It contains the SP-RTC input parameter as well as the P-RTC calculated parameter as described in Table 3.

Paramter	Unit	Explaination
Feedflow_m 1 SI	L/s	smoothed/filtered feed flow
TSS feed_m 1	g/L	smoothed/filtered feed solids concentration
TSS_m 1	mg/L	smoothed/filtered solids concentration in clear water
pHcontrol_m 1		smoothed/filtered pH value
QCoag_SP SI 1	L/h	QCoag_SP SI 1 (calculated (mean if pump is in pulse mode)
QFloc_SP SI 1	L/h	QFloc_SP SI 1 (calculated (mean if pump is in pulse mode)
Caustic_reg 1	L/h	Caustic_reg 1 (calculated (mean if pump is in pulse mode)
Coag SP 1	L/h	Coagulant set point as sent to output
Coag Digi 1		Coagulant pump ON/OFF
Floc SP 1	L/h	Flocculant set point as sent to output
Floc Digi 1		Flocculant pump ON/OFF
pHDos SP	L/h	pH chemical set point as sent to output
pHPump RQ		pH dosing pump ON/OFF
Feed 1_SI	L/s	Feed flow setpoint
FCoag_fin_L 1	g/kg	Coagulant dosing factor (based on Coagulant set point)
FCoag_fin_Q 1	mg/L	Coagulant concentration (based on Coagulant set point)
FFloc_fin_Q 1	mg/L	Flocculant concentration (based on Flocculant set point)
LTSSinl 1	kg/h	LTSSinl 1 (current solids feed load)
pH_Factor 1		value 0….1: 1 ---> no impact; 0….1 --> factor for coagulant dosing
LTSSinl_m 1	kg/h	smoothed/filtered solids feed load
LFeed_SP 1	kg/h	solids feed load setpoint
QFeed_SP_unl 1	L/s	Calculated feed flow result without considering Maximum feed flow limit

Deadband Mode 1		Deadband Mode (1: pH below deadband, 2: pH in deadband, 3 pH above deadband)
pH dev 1		pH Deviation
pH_I Caust 1	%	pH_I Caust 1
pH_Result Caust 1	%	pH_Result as percentage of maximum dosing rate
pH_Reg Caust 1	L/h	pH result without considering maximum pH dosing rate
dev_Clear 1	mg/L	absolute deviation/error of solids concentration in clear water (MV - SP)
FB_Result L 1	g/kg	Feedback result (potentially limited by Max increase/Max decrease) for dosing factor
FB_Result Q 1	mg/L	Feedback result (potentially limited by Max increase/Max decrease) for dosing concentration
I_Term L 1	g/kg	Calculated I term for load based feeback calculation
I_Term Q 1	mg/L	Calculated I term for concentration based feeback calculation
rDev_Clear 1		relative deviation/error of solids concentration in thickened sludge: 1 - SP/MV resp. -(1 - SP/MV)
P_Term L 1	g/kg	Calculated P term for load based feeback calculation
TSS feed 1	g/L	TSS feed 1
D_Term L 1	g/kg	Calculated D term for load based feeback calculation
P_Term Q 1	mg/L	Calculated P term for concentration based feeback calculation
D_Term Q 1	mg/L	Calculated D term for concentration based feeback calculation
mAgent1_req_L 1	g/h	mAgent1_req_L 1
mAgent1_req_Q 1	g/h	mAgent1_req_Q 1
FactCoag_act SI	g/kg	Actual Coagulant dosing factor based on measured coagulant flow
FactCoag_Q_act 1	mg/L	Actual Coagulant concentration based on measured coagulant flow
Coag_FF L 1	L/h	Coagulant dosing feed forward result from load based calculation (ignoring feeback)
Coag_FF Q 1	L/h	Coagulant dosing feed forward result from concentration based calculation (ignoring feedback)
mAgent2_req_Q 1	g/h	mAgent2_req_Q 1
FactCoag_Q_act 1	g/kg	Actual dosing concentration based on measured flocculant flow

Table 3: Content and description of Diagnostic data log

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