SD01152D/06/EN/02.17
71378351

Special Documentation
Proline Promass 100, Proline Cubemass C 100

"Concentration Measurement" application package

Endress+Hauser
People for Process Automation

Table of contents

1 About this document 4
1.1 Document function 4
1.2 Using this document 4
1.3 Symbols used 4
1.4 Documentation 5

2 System integration 7
2.1 Output 4-20 mA HART 7
2.2 Protocol-specific data 7

3 Commissioning 8
3.1 Availability 8
3.2 Concentration measurement application package 9
3.3 4-20 mA HART 10
3.4 EtherNet/IP 13
3.5 Modbus RS485 15
3.6 Profibus DP 17

4 Operation 19
4.1 4-20 mA HART, EtherNet/IP, Profibus DP . . . 19
4.2 Modbus RS485 20

5 Concentration function in FieldCare 22
5.1 Starting the concentration function 22
5.2 User interface 23
5.3 Calculation base: "Defined liquids" 27
5.4 Calculation base: "Liquid properties" 30
5.5 Calculation base: "Fine tuning" 34
5.6 Error messages and troubleshooting 34

6 General principles and application examples 36
6.1 Principle of concentration measurement 36
6.2 Frequently used concentration calculations and examples 38

1 About this document

1.1 Document function

This document is part of the Operating Instructions and serves as a reference for application-specific parameters and notes.

It provides detailed information on:
- Every individual parameter in the operating menu
- Advanced technical specifications
- General principles and application tips

1.2 Using this document

1.2.1 Information on the document structure

For the arrangement of the parameters as per the **Operation** menu, **Setup** menu, **Diagnostics** menu, along with a short description, see the Operating Instructions for the device

For information about the operating philosophy, see the "Operating philosophy" chapter in the device's Operating Instructions

1.3 Symbols used

1.3.1 Symbols for certain types of information

Symbol	Meaning
A0011193	**Tip** Indicates additional information.
A0011194	**Reference to documentation** Refers to the corresponding device documentation.
A0011195	**Reference to page** Refers to the corresponding page number.
A0011196	**Reference to graphic** Refers to the corresponding graphic number and page number.
A0013140	**Operation via local display** Indicates navigation to the parameter via the local display.
A0013143	**Operation via operating tool** Indicates navigation to the parameter via the operating tool.
A0013144	**Write-protected parameter** Indicates a parameter that can be locked against changes by entering a user-specific code.

1.3.2 Symbols in graphics

Symbol	Meaning
1, 2, 3 ...	Item numbers
A, B, C, ...	Views
A-A, B-B, C-C, ...	Sections

1.4 Documentation

This manual is Special Documentation and is not a substitute for the Operating Instructions supplied with the device.

For detailed information, refer to the Operating Instructions and other documentation on the CD-ROM provided or visit "www.endress.com/deviceviewer".

The Special Documentation is an integral part of the following Operating Instructions:

	Documentation code				
Measuring device	HART	PROFIBUS DP	Modbus RS485	EtherNet/IP	PROFINET
Promass A 100	BA01187D	BA01246D	BA01179D	BA01182D	BA01424D
Cubemass C 100	BA01188D	BA01247D	BA01178D	BA01183D	BA01425D
Promass E 100 (8E1B**-...)	BA01167D	BA01248D	BA01056D	BA01064D	BA01426D
Promass E 100 (8E1C**-...)	BA01713D	BA01714D	BA01711D	BA01712D	BA01715D
Promass F 100	BA01168D	BA01249D	BA01057D	BA01065D	BA01427D
Promass H 100	BA01189D	BA01250D	BA01177D	BA01184D	BA01428D
Promass I 100	BA01190D	BA01251D	BA01058D	BA01066D	BA01429D
Promass O 100	BA01191D	BA01252D	BA01180D	BA01185D	BA01430D
Promass P 100	BA01192D	BA01253D	BA01059D	BA01067D	BA01431D
Promass S 100	BA01193D	BA01254D	BA01060D	BA01068D	BA01432D
Promass X 100	BA01194D	BA01255D	BA01181D	BA01186D	BA01437D

This Special Documentation is available:
- On the CD-ROM supplied with the device (depending on the device version ordered)
- In the Download Area of the Endress+Hauser Internet site: www.endress.com → Download

1.4.1 Content and scope

This Special Documentation contains a description of the additional parameters and technical data that are provided with the “Concentration Measurement” application package. All the parameters that are not relevant to concentration measurement are described in the Operating Instructions.

General information about concentration and concentration measurement can be found in the "General principles" section → 36.

1.4.2 Availability in FieldCare and other FDT-based asset management tools

FieldCare version 2.08 and higher supports the "Concentration" function for calculating the coefficients. More detailed information about calculating the coefficients and applying the results is provided in the "Calculating coefficients using FieldCare → 22" section.

Additional information about the "FieldCare" operating tool is available in the Operating Instructions for the device.

The "Concentration" DTM function is also available for other FDT-based asset management tools.

2 System integration

Extended options if the concentration application package is used

2.1 Output 4-20 mA HART

2.1.1 Output signal

Current output

Assignable measured variables	▪ ... ▪ Concentration ▪ ...

Pulse/frequency/switch output

Frequency output

Assignable measured variables	▪ ... ▪ Concentration ▪ ...

Switch output

Assignable functions	▪ ... ▪ Limit value – ... – Concentration – ...

2.2 Protocol-specific data

2.2.1 HART

Dynamic variables	The measured variables can be freely assigned to the dynamic variables. **Measured variables for SV, TV, QV (secondary, tertiary and quaternary dynamic variable)** ▪ ... ▪ Concentration ▪ ...

2.2.2 EtherNet/IP

Configurable Input

Configurable Input Assembly Input assembly position 1-10	▪ ... ▪ Concentration ▪ ...
Configurable Input Assembly Input assembly position 11-20	▪ ... ▪ Concentration unit ▪ ...

3 Commissioning

3.1 Availability

If the optional **concentration measurement** package was ordered for the flowmeter ex works, the function is available when the measuring device is delivered from the factory. The function is accessed via the operating interfaces of the measuring device, via the Web server or Endress+Hauser's FieldCare asset management software. No particular measures are required to put the function into operation.

Ways to check function availability in the measuring device:
- Using the serial number:
  W@M Device viewer [1] → order code option **ED** for "concentration", **EF** for "special density and concentration"
- In the operating menu:
  Check whether the function appears in the operating menu: Diagnostics → Measured values → Process variables → Concentration
  If the "Concentration" option is available the function is activated.

If the function cannot be opened in the measuring device, the optional package was not selected. It is then possible to upgrade to this function during the life cycle of the measuring device. On most flowmeters it is possible to activate the function without having to upgrade the firmware.

3.1.1 Enabling without upgrading the firmware

You require a conversion kit from Endress+Hauser to enable the function without upgrading the firmware. Among other things, this kit contains an activation code which must be entered via the operating menu to activate the "Concentration measurement" function.

The activation function is available under "Setup → Advanced setup → Enter access code".

Once activated the **Concentration measurement** application package is permanently available in the measuring device.

Activation without firmware upgrade is possible as of the following firmware versions:
- Modbus RS485: 01.02.zz
- EtherNet/IP: 01.01.zz
- HART: 01.00.zz
- PROFIBUS DP: 01.00.zz

3.1.2 Firmware upgrade before activation

If you have a measuring device that requires a firmware upgrade before the function can be activated, please contact your Endress+Hauser service organization.

This function requires service-level access to the device.

A firmware upgrade is required for measuring devices with earlier firmware versions (see → 8 "Enabling without upgrading the firmware").

Please contact your Endress+Hauser service or sales organization for further information regarding product availability and upgrades to existing measuring devices.

1) www.endress.com/deviceviewer

3.2 Concentration measurement application package

When the "Concentration measurement" application package is enabled, additional parameters and options are available in the device. On the basis of the measured fluid density, the device can calculate a concentration of a fluid using special algorithms.

If an FDT-based asset management tool (e.g. "FieldCare") is used the user has access to a concentration function. Apart from determining the concentration coefficients and transferring them to the measuring device, it is also possible to visualize the numerical uncertainty and document the results.

The device is configured in two steps:

1. Device configuration
   ↳ - Display (if present)
   - Units
   - Outputs
2. Calculation of coefficients → 22
   ↳ Transfer of coefficients to the device

NOTICE

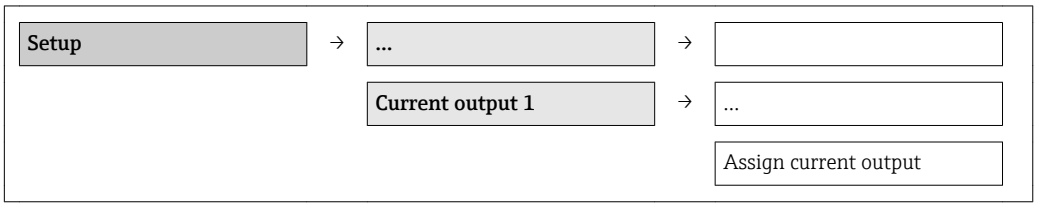
The calculation of the coefficients using the FieldCare concentration function is not related in any way to the configuration of the measuring device.

- The user must ensure that the coefficients are calculated on the basis of the same units as the device setting.

3.3 4-20 mA HART

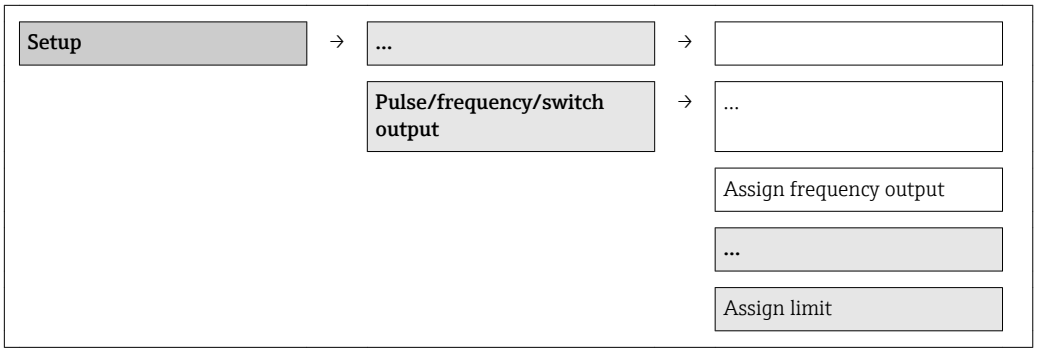
3.3.1 Configuring the measuring device

Configuring the current output



Parameter	Description	Selection/ User entry	Factory setting
Assign current output	Select process variable for current output.	▪ ... ▪ Target mass flow ▪ Carrier mass flow ▪ ... ▪ Concentration ▪ ...	Mass flow

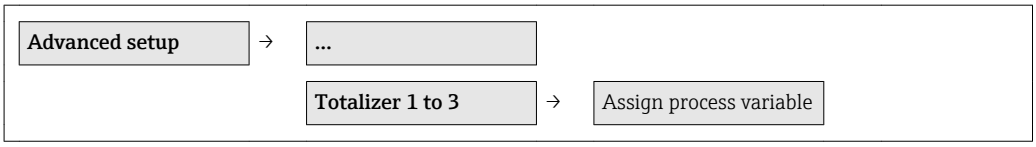
Configuring the pulse/frequency/switch output



Parameter	Description	Selection/ User entry	Factory setting
Assign frequency output	Select the process variable for the frequency output.	▪ ... ▪ Target mass flow ▪ Carrier mass flow ▪ ... ▪ Concentration ▪ ...	Off
Assign limit	Select the process variable for the limit function.	▪ ... ▪ Target mass flow ▪ Carrier mass flow ▪ ... ▪ Concentration ▪ ...	Mass flow

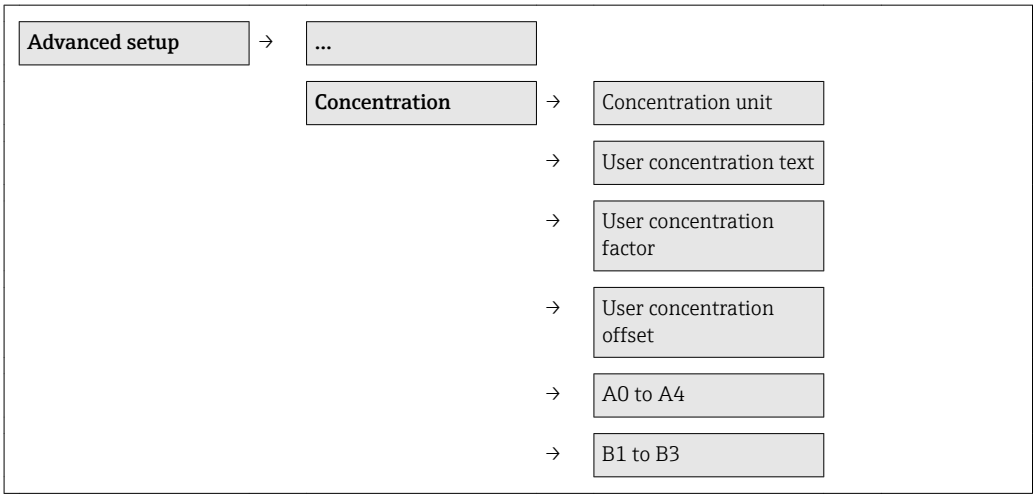
3.3.2 Advanced settings

Navigation path
Setup menu → Advanced setup



Parameter overview with brief description

Parameter	Prerequisite	Description	Selection/ input	Factory settings
Assign process variable	Target mass flow and carrier mass flow are available for selection if one of the following options is selected in the **Concentration** parameter in the **Advanced setup**→ menu: ▪ WT-% ▪ User conc. (user-defined)	Select process variable for totalizer. **Result** The selection determines the choose list of the **Unit** parameter.	Carrier target Carrier mass flow	Mass flow



Parameter overview with brief description

Parameter	Description	Selection/input	Factory settings
Concentration unit	Select the unit for concentration.	Unit choose list ▪ WT-% ▪ °API ▪ °Balling ▪ °Baumé (heavy) ▪ °Baumé (light) ▪ °Brix ▪ °Plato ▪ User conc. (user-defined)	WT-%
User concentration text	Use this function to enter a text for the user-defined unit.	Max. 4 characters such as letters, numbers or special characters (+, -, underscore, space)	"_ _ _ _" (no text)
User concentration factor	Use this function to enter the quantity factor for the user-defined unit. By entering a factor, the original measured value is scaled to the user-defined unit.	Floating point number with sign	1
User concentration offset	Enter an offset for the concentration measured value. The offset is added or subtracted, depending on the sign.	Floating point number with sign	0

Parameter	Description	Selection/input	Factory settings
A0 to A4	▪ Enter the coefficients A0 to A4 or ▪ Import or enter the calculated coefficients using the concentration function → 🖹 22	Floating point number with sign	0
B1 to B3	▪ Enter the coefficients B1 to B3 or ▪ Import or enter the calculated coefficients using the concentration function → 🖹 22	Floating point number with sign	0

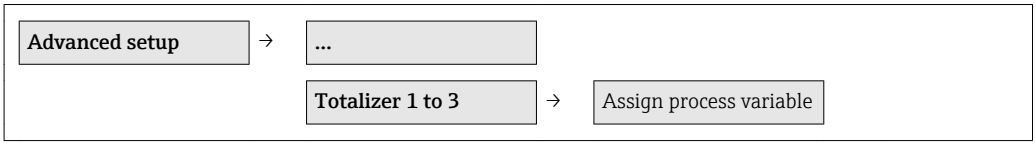
3.4 EtherNet/IP

3.4.1 Advanced settings

Navigation path
"Expert" menu → Communication → Configuration → Configurable Input Assembly 1-20

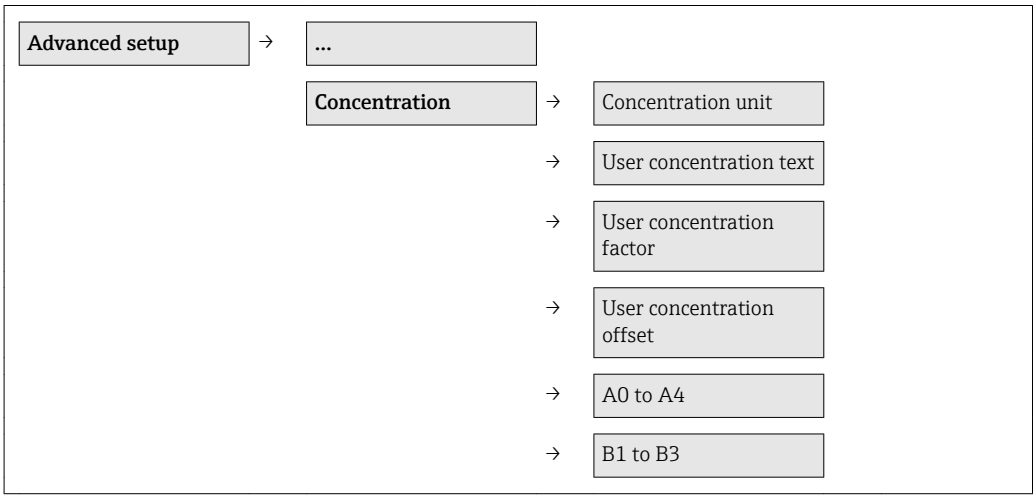
Configurable Input Assembly Input assembly position 1-10	▪ ... ▪ Target mass flow ▪ Carrier fluid ▪ ... ▪ Concentration ▪ ...
Configurable Input Assembly Input assembly position 11-20	▪ ... ▪ Concentration unit ▪ ...

Navigation path
Setup menu → Advanced setup



Parameter overview with brief description

Parameter	Prerequisite	Description	Selection/ input	Factory settings
Assign process variable	Target mass flow and carrier mass flow are available for selection if one of the following options is selected in the **Concentration** parameter in the **Advanced setup**→ menu: ▪ WT-% ▪ User conc. (user-defined)	Select process variable for totalizer. **Result** The selection determines the choose list of the **Unit** parameter.	Carrier target Carrier mass flow	Mass flow



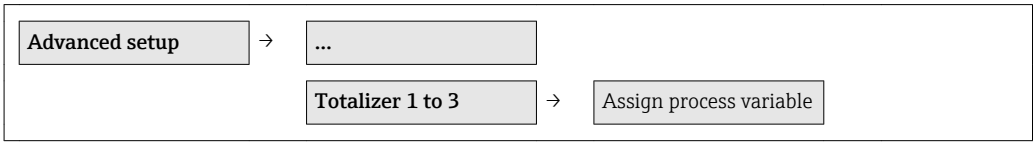
Parameter overview with brief description

Parameter	Description	Selection/input	Factory settings
Concentration unit	Select the unit for concentration.	Unit choose list ▪ WT-% ▪ °API ▪ °Balling ▪ °Baumé (heavy) ▪ °Baumé (light) ▪ °Brix ▪ °Plato ▪ User conc. (user-defined)	WT-%
User concentration text	Use this function to enter a text for the user-defined unit.	Max. 4 characters such as letters, numbers or special characters (+, -, underscore, space)	"_ _ _ _" (no text)
User concentration factor	Use this function to enter the quantity factor for the user-defined unit. By entering a factor, the original measured value is scaled to the user-defined unit.	Floating point number with sign	1
User concentration offset	Enter an offset for the concentration measured value. The offset is added or subtracted, depending on the sign.	Floating point number with sign	0
A0 to A4	▪ Enter the coefficients A0 to A4 or ▪ Import or enter the calculated coefficients using the concentration function → 🖹 22	Floating point number with sign	0
B1 to B3	▪ Enter the coefficients B1 to B3 or ▪ Import or enter the calculated coefficients using the concentration function → 🖹 22	Floating point number with sign	0

3.5 Modbus RS485

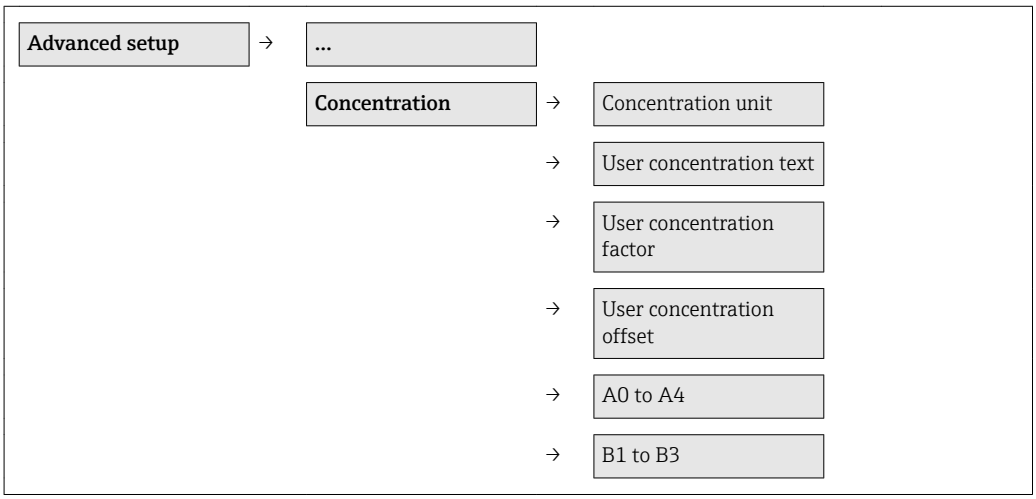
3.5.1 Advanced settings

Navigation path
Setup menu → Advanced setup



Parameter overview with brief description

Parameter	Prerequisite	Description	Selection/input	Factory settings
Assign process variable MODBUS register: 2601 Data type: integer Access: read/write	Target mass flow and carrier mass flow are available for selection if one of the following options is selected in the **Concentration** parameter in the **Advanced setup**→ menu: ▪ WT-% ▪ User conc. (user-defined)	Select process variable for totalizer. **Result** The selection determines the choose list of the **Unit** parameter.	74 = Carrier target 75 = Carrier mass flow	0 = Mass flow



Parameter overview with brief description

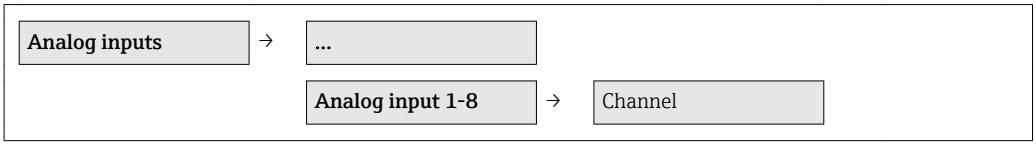
Parameter	Description	Selection/input	Factory settings
Concentration unit MODBUS register: 2439 Data type: integer Access: read/write	Select the unit for concentration.	Unit choose list Country-specific: ▪ 0 = WT-% ▪ 2 = °API ▪ 3 = °Balling ▪ 4 = °Baumé (heavy) ▪ 5 = °Baumé (light) ▪ 6 = °Brix ▪ 7 =°Plato ▪ 8 = User conc. (user-defined)	0 = WT-%

Parameter	Description	Selection/input	Factory settings
User concentration text MODBUS register: 2585 Data type: string Access: read/write	Use this function to enter a text for the user-defined unit.	Max. 4 characters such as letters, numbers or special characters (+, -, underscore, space)	"_ _ _ _" (no text)
User concentration factor MODBUS register: 2554 Data type: float Access: read/write	Use this function to enter the quantity factor for the user-defined unit. By entering a factor, the original measured value is scaled to the user-defined unit.	Floating point number with sign	1
User concentration offset MODBUS register: 2490 Data type: float Access: read/write	Enter an offset for the concentration measured value. The offset is added or subtracted, depending on the sign.	Floating point number with sign	0
A0 to A4 MODBUS register A0: 2099 MODBUS register A1: 2730 MODBUS register A2: 2972 MODBUS register A3: 2618 MODBUS register A4: 2670 Data type: float Access: read/write	▪ Enter the coefficients A0 to A4 or ▪ Import or enter the calculated coefficients using the concentration function → 🖹 22	Floating point number with sign	0
B1 to B3 MODBUS register B1: 2616 MODBUS register B1: 2656 MODBUS register B1: 2672 Data type: float Access: read/write	▪ Enter the coefficients B1 to B3 or ▪ Import or enter the calculated coefficients using the concentration function → 🖹 22	Floating point number with sign	0

3.6 Profibus DP

3.6.1 Configuring the measuring device

Navigation path
Setup menu → Analog inputs

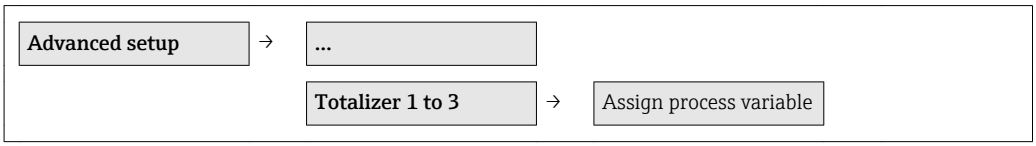


Parameter overview with brief description

Parameter	Description	Selection/input	Factory settings
Channel	Select the measured variable.	▪ Carrier target ▪ Carrier mass flow ▪ Concentration	Mass flow

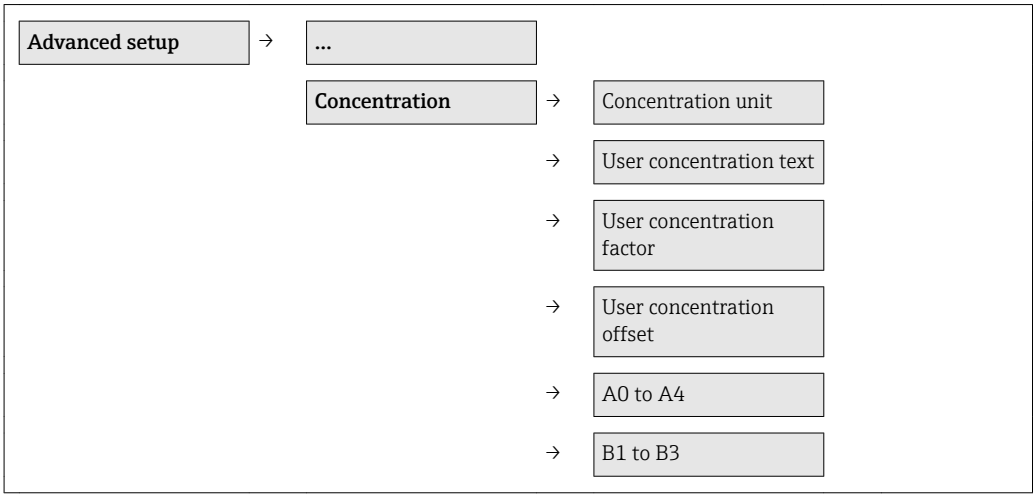
3.6.2 Advanced settings

Navigation path
Setup menu → Advanced setup



Parameter overview with brief description

Parameter	Prerequisite	Description	Selection/ input	Factory settings
Assign process variable	Target mass flow and carrier mass flow are available for selection if one of the following options is selected in the **Concentration** parameter in the **Advanced setup**→ menu: ▪ WT-% ▪ User conc. (user-defined)	Select process variable for totalizer. **Result** The selection determines the choose list of the **Unit** parameter.	Carrier target Carrier mass flow	Mass flow



Parameter overview with brief description

Parameter	Description	Selection/input	Factory settings
Concentration unit	Select the unit for concentration.	Unit choose list ▪ WT-% ▪ °API ▪ °Balling ▪ °Baumé (heavy) ▪ °Baumé (light) ▪ °Brix ▪ °Plato ▪ User conc. (user-defined)	WT-%
User concentration text	Use this function to enter a text for the user-defined unit.	Max. 4 characters such as letters, numbers or special characters (+, -, underscore, space)	"_ _ _ _" (no text)
User concentration factor	Use this function to enter the quantity factor for the user-defined unit. By entering a factor, the original measured value is scaled to the user-defined unit.	Floating point number with sign	1
User concentration offset	Enter an offset for the concentration measured value. The offset is added or subtracted, depending on the sign.	Floating point number with sign	0
A0 to A4	▪ Enter the coefficients A0 to A4 or ▪ Import or enter the calculated coefficients using the concentration function → 🖹 22	Floating point number with sign	0
B1 to B3	▪ Enter the coefficients B1 to B3 or ▪ Import or enter the calculated coefficients using the concentration function → 🖹 22	Floating point number with sign	0

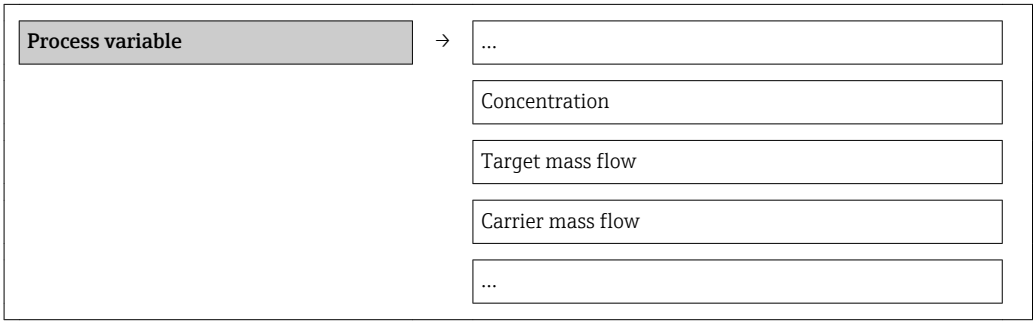
4 Operation

4.1 4-20 mA HART, EtherNet/IP, Profibus DP

4.1.1 Reading measured values

Process variables

Navigation path
"Diagnostics" menu → Measured values → Process variables



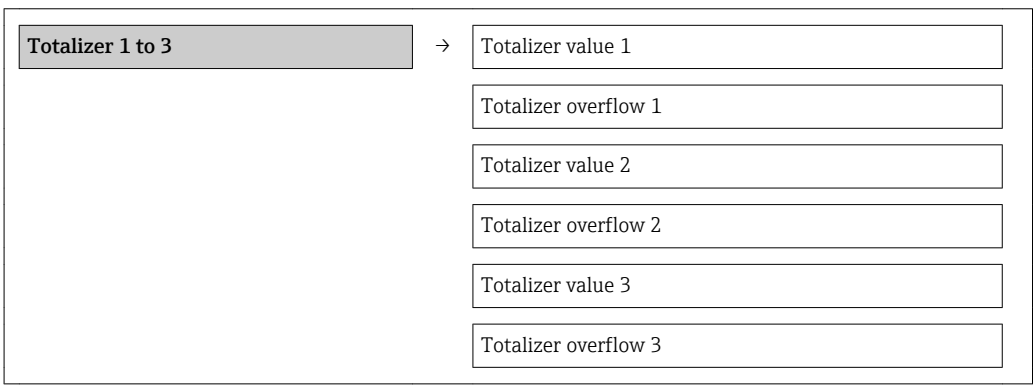
Parameter overview with brief description

Parameter	Description	User interface
Concentration	Displays the concentration currently calculated in weight by percent	Floating point number with sign, incl. unit (w) %
Target mass flow	Displays the flow of the target fluid in kilogram/hour	Floating point number with sign, incl. unit kg/h
Carrier mass flow	Displays the flow of the carrier fluid in kilogram/hour	Floating point number with sign, incl. unit kg/h

Navigation
"Diagnostics" menu → Measured values → Totalizer

Totalizer

Navigation path
"Diagnostics" menu → Measured values → Totalizer 1-3



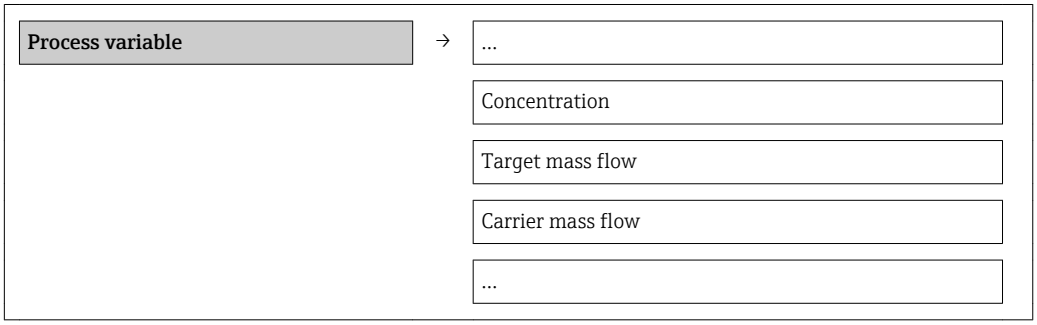
Parameter	Prerequisite	Description	User interface
Totalizer value 1-3	One of the following options is selected in the **Assign process variable** parameter of the **Totalizer 1-3** submenu: ▪ ... ▪ Target mass flow ▪ Carrier mass flow	Displays the current totalizer counter value.	Floating point number with sign
Totalizer overflow 1-3	One of the following options is selected in the **Assign process variable** parameter of the **Totalizer 1-3** submenu: ▪ ... ▪ Target mass flow ▪ Carrier mass flow	Displays the current totalizer overflow.	Integer

4.2 Modbus RS485

4.2.1 Reading measured values

Process variables

Navigation path
"Diagnostics" menu → Measured values → Process variables



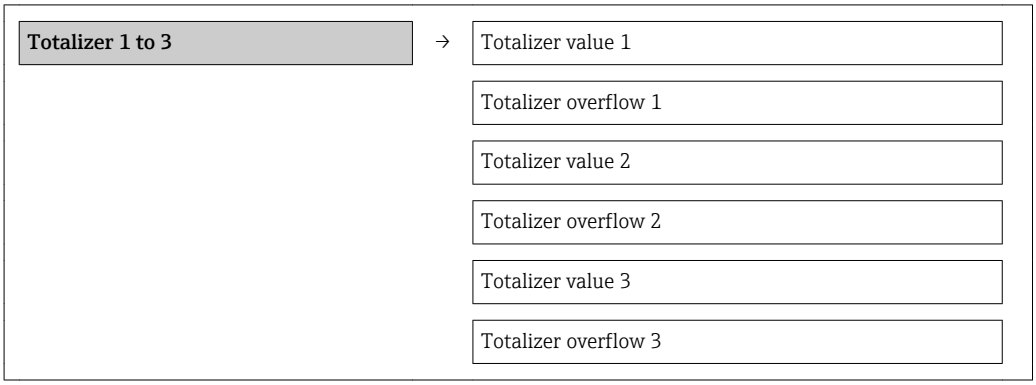
Parameter overview with brief description

Parameter	Description	User interface
Concentration MODBUS register: 2598 Data type: float Access: read	Displays the concentration currently calculated	Floating point number with sign
Target mass flow MODBUS register: 2797 Data type: float Access: read	Displays the flow of the target fluid in kilogram/hour	Floating point number with sign, incl. unit kg/h
Carrier mass flow MODBUS register: 2799 Data type: float Access: read	Displays the flow of the carrier fluid in kilogram/hour	Floating point number with sign, incl. unit kg/h

Totalizer

Navigation path

"Diagnostics" menu → Measured values → Totalizer 1-3



Parameter	Prerequisite	Description	User interface
Totalizer value 1-3 MODBUS register totalizer value 1: 2610 MODBUS register totalizer value 2: 2810 MODBUS register totalizer value 3: 3010 Data type: float Access: read	One of the following options is selected in the **Assign process variable** parameter of the **Totalizer 1-3** submenu: ▪ Mass flow ▪ Target mass flow ▪ Carrier mass flow	Displays the current totalizer counter value.	Floating point number with sign
Totalizer overflow 1-3 MODBUS register totalizer overflow 1: 2612 MODBUS register totalizer overflow 2: 2812 MODBUS register totalizer overflow 3: 3012 Data type: float Access: read	One of the following options is selected in the **Assign process variable** parameter of the **Totalizer 1-3** submenu: ▪ Mass flow ▪ Target mass flow ▪ Carrier mass flow	Displays the current totalizer overflow.	Integer

5 Concentration function in FieldCare

Endress+Hauser provides a software function to calculate the concentration coefficients (A0 to A4 and B1 to B3). This function supports the FDT interface and is therefore incorporated into any FDT frame, such as Endress+Hauser's FieldCare tool.

The concentration function of the device DTM supports the following main functions:
- Calculation of the concentration coefficients
- Determination and visualization of the numerical uncertainty of the calculation model
- Documentation and printout of the results (creation of a PDF file)
- Transfer of the calculated concentration coefficients to the device

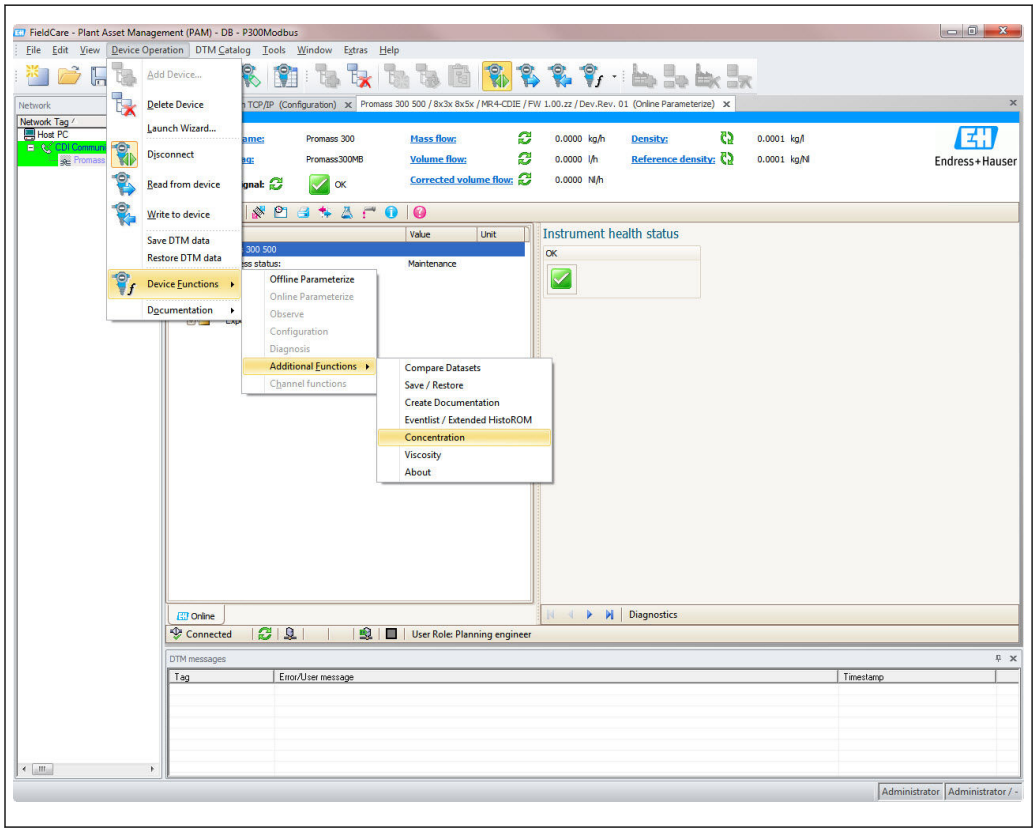
The functions, user interface and the necessary user entries are explained in the following subsections.

NOTICE

The calculation of the coefficients using the FieldCare concentration function is not related in any way to the configuration of the measuring device.

▶ The user must ensure that the coefficients are calculated on the basis of the same units as the device setting.

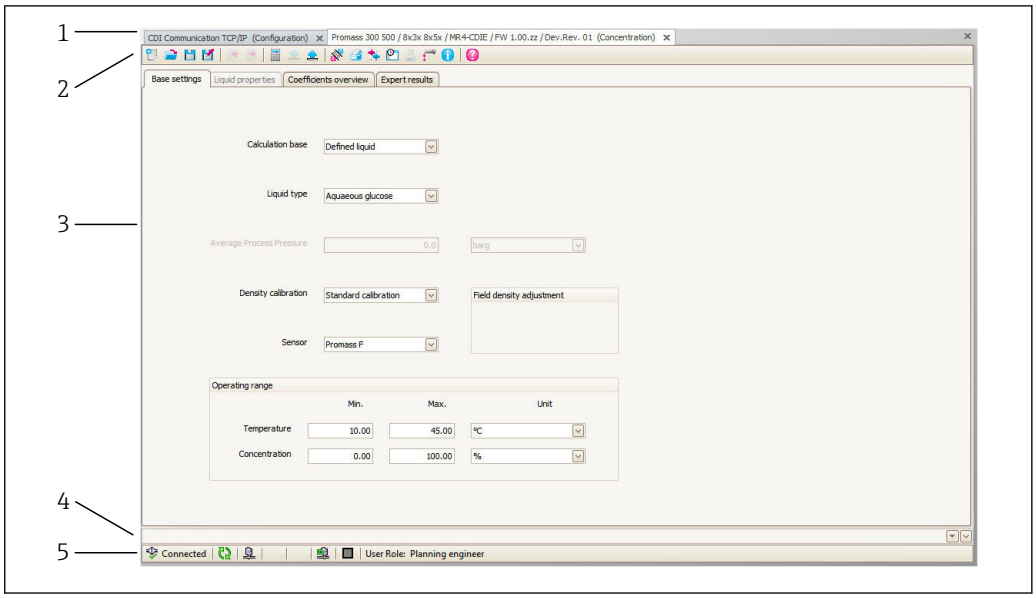
5.1 Starting the concentration function



A0031469-EN

1. Open the "Device operation" menu in FieldCare.
2. Select the "Concentration" item under "Device function" and "Additional functions".

5.2 User interface



A0031470-EN

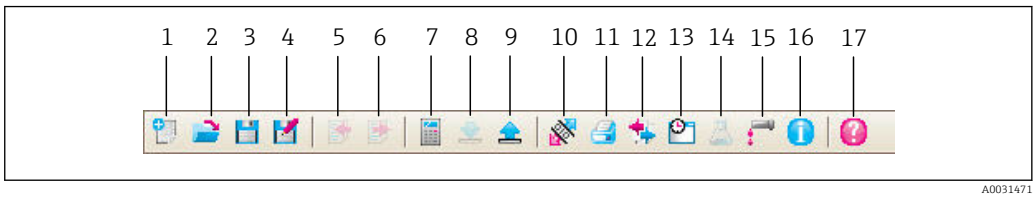
1 User interface of the concentration module

1 *Title bar*
2 *Menu bar*
3 *Navigation*
4 *Info bar*
5 *Status bar*

5.2.1 Title bar

DTM information about the device

5.2.2 Menu bar



A0031471

2 Commands in the menu bar

Item	Name of the button	Short description	Explanation
1	New	Reset DTM concentration data to their default settings	
2	Load	Load the saved concentration data	File format: .conc
3	Save	Save concentration data	File format: .conc
4	Save as	Save the concentration data under a new name	File format: .conc
5	Import	Import liquid properties from a file	Import format: xls
6	Export	Export liquid properties to a file	Export format: .xls
7	Calculate	Calculate the concentration coefficients	Starts the calculation of the concentration coefficients. Pay attention to the messages in the info bar.

Item	Name of the button	Short description	Explanation
8	Write	Write the concentration coefficients to the device	Transfer the calculated concentration coefficients to the device. In the offline mode the data are read into the FieldCare parameter set
9	Read	Read in concentration coefficients from the device	Read the concentration coefficients programmed into the device In the offline mode the data are read into the FieldCare parameter set
10	Save/restore	Save/restore the device configuration	Import/export format: .dhv In the offline mode the data are read into the FieldCare parameter set
11	Create documentation	Create documentation	Print out concentration coefficients and expert results. Only available in the online mode.
12	Compare datasets	Compare two data records	In the offline mode the data are read into the FieldCare parameter set
13	Event list	Show event list	Only available in the online mode.
14	Concentration	Open the concentration module	The concentration module is opened directly.
15	Viscosity	Open the viscosity module	The viscosity module is opened directly.
16	Information	Show version information	The FieldCare version information is displayed.
17	Help	Show help	Help text for various topics is displayed.

5.2.3 Navigation

Four navigation tabs are available for the calculation and evaluation of the concentration coefficients:

Base settings tab

Function	Prerequisite	Description	Selection/input
Calculation base	–	Select the calculation model	▪ Defined liquid ▪ Fine tuning ▪ Liquid properties
Liquid type	Liquid type is only available if the following option was selected in the **Calculation base** function: Defined liquid	Select a defined liquid	▪ Ethanol water ▪ Aqueous fructose ▪ Aqueous glucose ▪ Aqueous sugar ▪ Sucrose solution ▪ Crude oil (API) ▪ Gasoline (API) ▪ Transition zone (API) ▪ Jet fuel (API) ▪ Fuel oil (API) ▪ Ammonium nitrate NH4NO3 in water ▪ Ferric chloride solution in water ▪ Grape juice ▪ Hydrochloric acid solution in water ▪ Nitric acid solution in water ▪ Phosphoric acid solution in water ▪ Sodium hydroxide in water

Function	Prerequisite	Description	Selection/input
Sensor	–	Select the sensor	Cubemass C, Promass A, E, F, H, I, O, P, Q, S, X
Density calibration	The Field calibration option is only available if the following option was selected in the **Density calibration** function: Special density calibration	Select the density calibration	▪ Special density calibration: Highly accurate density measurement over a defined density and temperature range. ▪ Standard calibration: Density measurement over a defined density and temperature range
Operating range	In the **Calculation base** function the following option is selected: Defined liquid	Enter the Min/Max values for temperature and concentration	**Temperature** ▪ °C ▪ °F ▪ °R ▪ K **Concentration** ▪ % ▪ Mass

Liquid properties tab

The Liquid properties tab is only available if the following option was selected in the **Calculation base** function: Liquid properties

Function	Description	Selection/input
Input format	Select the input format. The input table changes to suit the input format selected.	▪ Matrix ▪ List
Operating range	Enter the Min/Max values for temperature and concentration By selecting temperature and concentration in the **Row1/Column1** function, temperature can be assigned to the row and concentration to the column or vice versa	**Temperature** ▪ °C ▪ °F ▪ °R ▪ K **Concentration** ▪ % ▪ Mass **Density** ▪ g/cm³, g/m³ ▪ kg/dm³, kg/l, kg/m³ ▪ lb/bbl (imp;oil), (imp;beer), (us;beer), (us;liq.), (us;oil), (us;tank) ▪ lb/ft³ ▪ lb/gal (imp), (us) ▪ SD 15 °C, 20°C, 4 °C ▪ SG 15 °C, 4°C, ▪ SGU 20 °C

Coefficients overview tab

Function	Prerequisite	Description	Display
Calculated coefficients	Calculation has been performed successfully (pay attention to the information in the info bar).	Displays the calculated coefficients.	Max. 15-digit floating-point number with sign ▪ A0, A1, A2, A3, A4 ▪ B1 · 10^{-3} ≙ E–3 ▪ B2 · 10^{-6} ≙ E–6 ▪ B3 · 10^{-9} ≙ E–9
Device coefficients	If the coefficients are to be read out of the device automatically, the "Read" button must be pressed in the menu bar	▪ Displays the coefficients read out of the device ▪ For entering the individual coefficients	

Expert results tab

Graphic representation of the measured errors as a function of the temperature, density and concentration.

5.2.4 Info bar

Information about the current processes and error messages.

History function: previous messages can be viewed at the side of the bar.

5.2.5 Status bar

Displays information about the device, such as online/offline or diagnostics status

5.3 Calculation base: "Defined liquids"

Simple calculation method for predefined liquids.

5.3.1 Calculation sources and temperature ranges for defined liquids

Solution	Temperature range	Source / standard
Ethanol water	−20 to 40 °C (−4 to 104 °F)	OIML IST-90 (Bettin, Spieweck 1990) [1]
Aqueous fructose	10 to 50 °C (50 to 122 °F)	ICUMSA SPS-4 (1998) [2]
Aqueous glucose	10 to 45 °C (50 to 113 °F)	
Aqueous sugar	10 to 50 °C (50 to 122 °F)	
Sucrose solution	10 to 80 °C (50 to 176 °F)	
Crude oil (API)	0 to 80 °C (32 to 176 °F)	–
Gasoline (API)	0 to 80 °C (32 to 176 °F)	–
Transition zone (API)	0 to 80 °C (32 to 176 °F)	–
Jet fuel (API)	50 to 80 °C (68 to 176 °F)	–
Fuel oil (API)	50 to 80 °C (68 to 176 °F)	–
Ammonium nitrate NH4NO3 in water	50 to 80 °C (68 to 176 °F)	–
Ferric chloride solution in water	50 to 100 °C (68 to 212 °F)	–
Grape juice	20 to 80 °C (68 to 176 °F)	–
Hydrochloric acid solution in water	−5 to 100 °C (23 to 212 °F)	–
Nitric acid solution in water	0 to 100 °C (32 to 212 °F)	–
Phosphoric acid solution in water	0 to 40 °C (32 to 104 °F)	–
Sodium hydroxide in water	0 to 40 °C (32 to 104 °F)	–

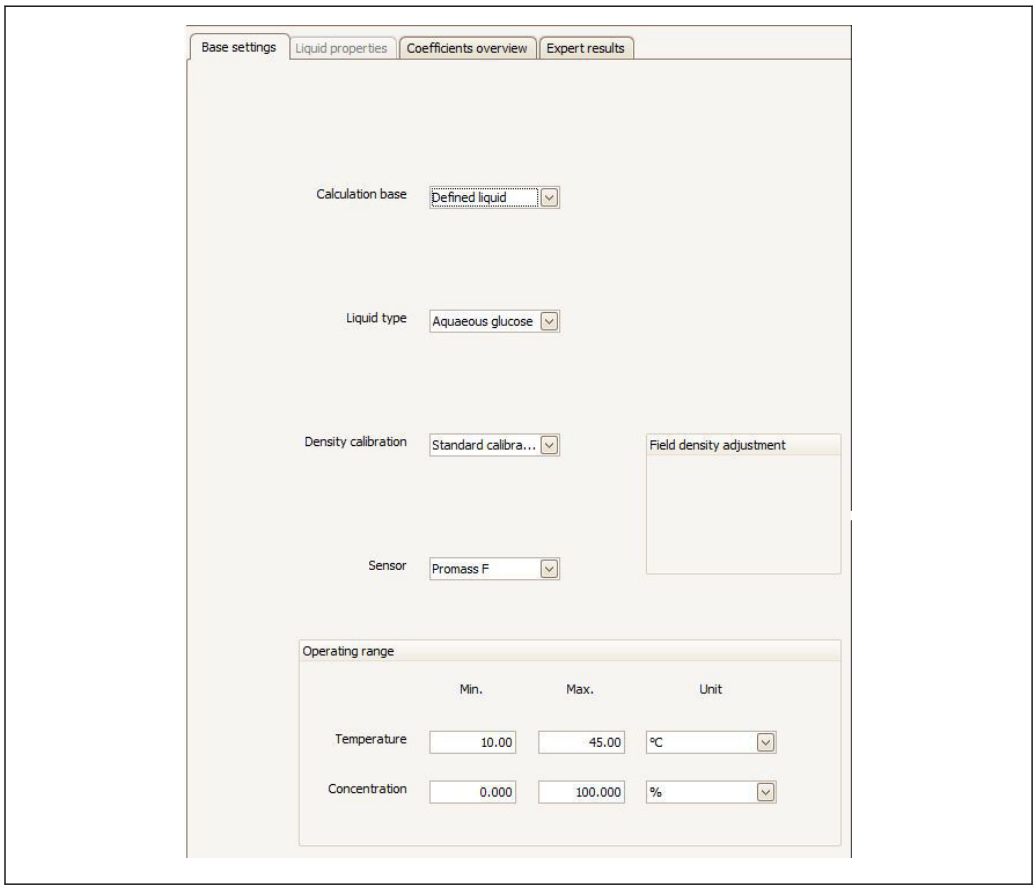
1) Horst Bettin and Frank Spieweck. A Revised Formula for the Calculation of Alcoholometric Tables. Physikalisch-Technische Bundesanstalt (PTB): PTB communications, Brunswick, 1990.
2) Densimetry and Tables: Sucrose, Glucose, Fructose and Invert Sugar. Publishing house: Dr. Albert Bartens KG, Berlin, 1998.

5.3.2 Calculation of coefficients for predefined liquids

Requirements

- Clarify information about the fluid:
  - Can the calculation sources provided (see table in the previous section) be used for the fluid?
    Is the process temperature within the permitted min./max. temperature range?

Calculation of coefficients for defined liquids



A0020373-EN

With this calculation method, the liquids available for selection, and the associated density values, are predefined.

The min./max. temperature values can only be modified within the defined temperature range (see the previous table).

The concentration range can be freely adjusted between 0 and 100 %.

1. Select the **Base settings** tab
2. In the **Calculation base** function select the following option: Defined liquids
3. In the **Liquid type** function select a solution
4. In the **Density calibration** function select one of the options provided
   ↳ The Field calibration option can also be selected.
5. In the **Sensor** function select a sensor
6. In the **Operating range** field enter the min./max. values for temperature and concentration.
   ↳ The density value is already defined - see the calculation sources in the previous section.
   The closer the min./max. values are to one another, the more accurate the concentration measurement
7. Click the **Calculate** button in the menu bar
   ↳ Pay attention to the information in the info bar
8. The calculated coefficients are displayed in the **Coefficients overview** tab.
9. The numerical uncertainty is graphically represented in the **Expert results** tab.

10. Click the **Write** button in the menu bar
    ↳ The calculated, optimized concentration coefficients are written to the device or FieldCare

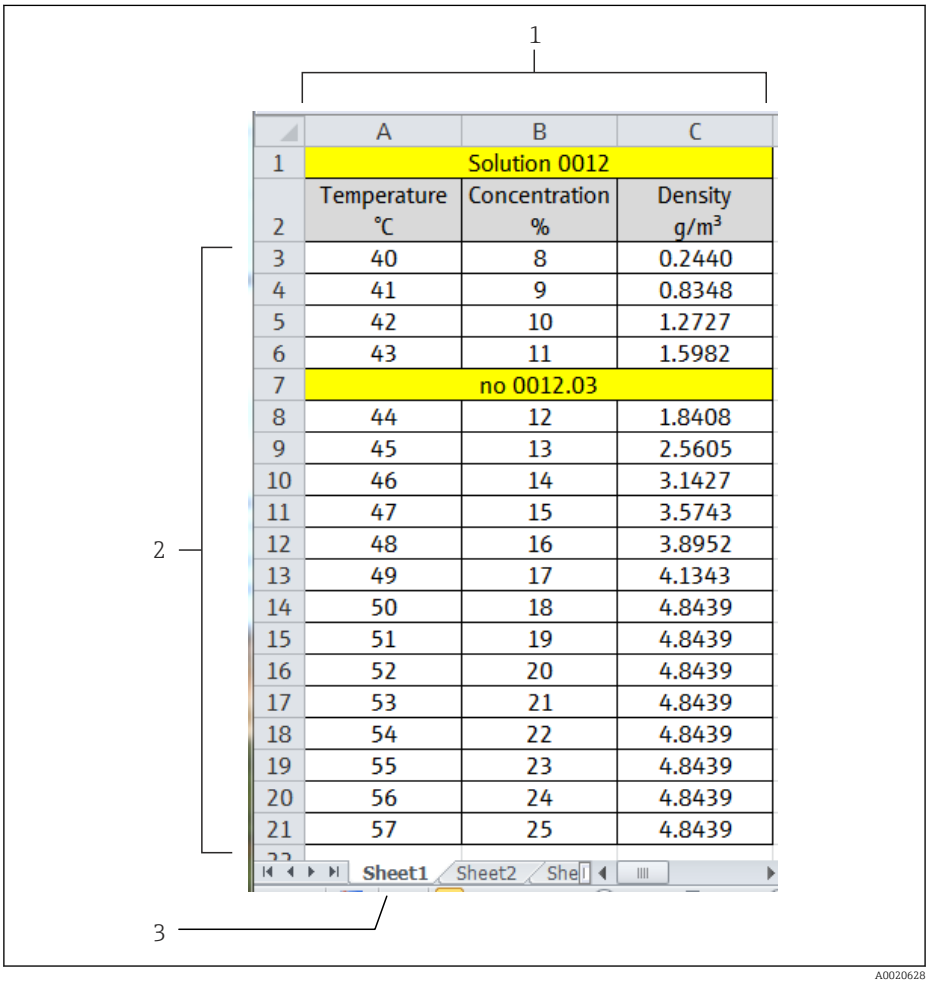
5.4 Calculation base: "Liquid properties"

Calculation method for user-defined liquids

5.4.1 Calculation of coefficients for user-defined liquids

Requirements

1. The density values are provided and specified as a function of the temperature and concentration.
2. Note the following if importing tables in the **List** input format:
   ↳ Matrix: 3 x 11 (3 columns only in the following order: temperature, concentration, density, and with at least 11 rows)
   Decimal separator: period
   Import format: xls



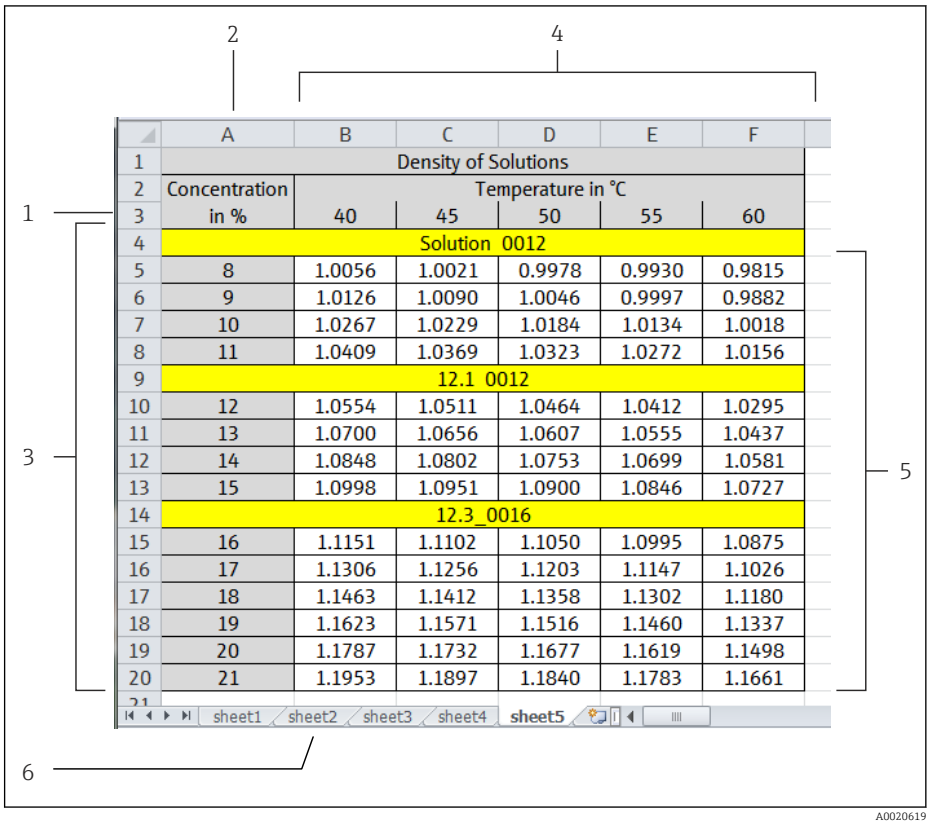
	A	B	C
1	Solution 0012		
2	Temperature °C	Concentration %	Density g/m³
3	40	8	0.2440
4	41	9	0.8348
5	42	10	1.2727
6	43	11	1.5982
7	no 0012.03		
8	44	12	1.8408
9	45	13	2.5605
10	46	14	3.1427
11	47	15	3.5743
12	48	16	3.8952
13	49	17	4.1343
14	50	18	4.8439
15	51	19	4.8439
16	52	20	4.8439
17	53	21	4.8439
18	54	22	4.8439
19	55	23	4.8439
20	56	24	4.8439
21	57	25	4.8439

Sheet1 Sheet2 Shee

3 Example of a table in the list input format

1 *Column section. 3 columns only in the following order: temperature, concentration, density. Other columns can be inserted provided that the cells do not contain a numerical value. Cells are not recognized as a numerical value if the string contains spaces, letters or special characters.*
2 *Row section. At least 11 rows. Other rows (e.g. row 7) can be inserted provided that the cells do not start with a numerical value (a date is permitted). Cells are not recognized as a numerical value if the string contains spaces, letters or special characters.*
3 *Worksheets can be given an individual name. The names should always start with a letter. Do not use special characters (+, -, (,), _ etc.). Select the table sheet in the "Operating range" tab, "Working sheet" function.*

3. Note the following if importing tables in the **Matrix** input format:
   ↳ Matrix: at least 11 values (concentration X temperature or vice versa)
   Decimal separator: period
   Import format: xls



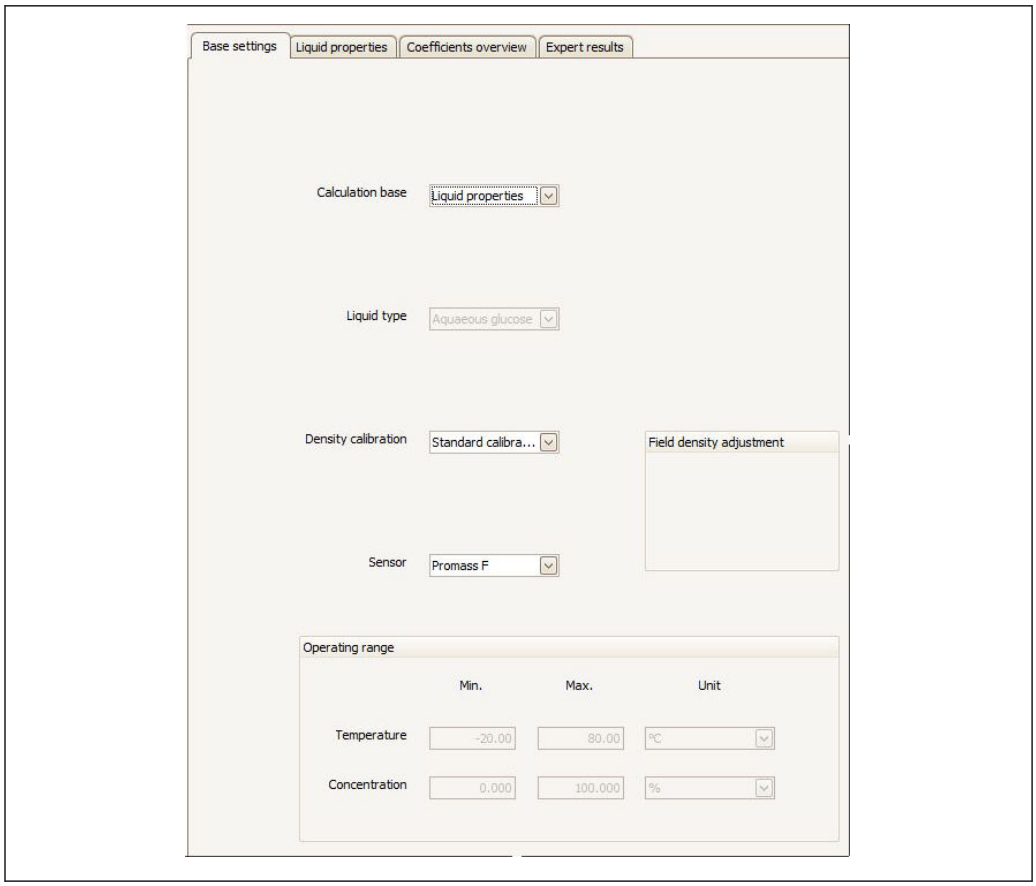
	A	B	C	D	E	F
1	Density of Solutions					
2	Concentration	Temperature in °C				
3	in %	40	45	50	55	60
4	Solution 0012					
5	8	1.0056	1.0021	0.9978	0.9930	0.9815
6	9	1.0126	1.0090	1.0046	0.9997	0.9882
7	10	1.0267	1.0229	1.0184	1.0134	1.0018
8	11	1.0409	1.0369	1.0323	1.0272	1.0156
9	12.1 0012					
10	12	1.0554	1.0511	1.0464	1.0412	1.0295
11	13	1.0700	1.0656	1.0607	1.0555	1.0437
12	14	1.0848	1.0802	1.0753	1.0699	1.0581
13	15	1.0998	1.0951	1.0900	1.0846	1.0727
14	12.3_0016					
15	16	1.1151	1.1102	1.1050	1.0995	1.0875
16	17	1.1306	1.1256	1.1203	1.1147	1.1026
17	18	1.1463	1.1412	1.1358	1.1302	1.1180
18	19	1.1623	1.1571	1.1516	1.1460	1.1337
19	20	1.1787	1.1732	1.1677	1.1619	1.1498
20	21	1.1953	1.1897	1.1840	1.1783	1.1661
21						

sheet1 sheet2 sheet3 sheet4 sheet5

4 *Example of a table in the matrix input format*

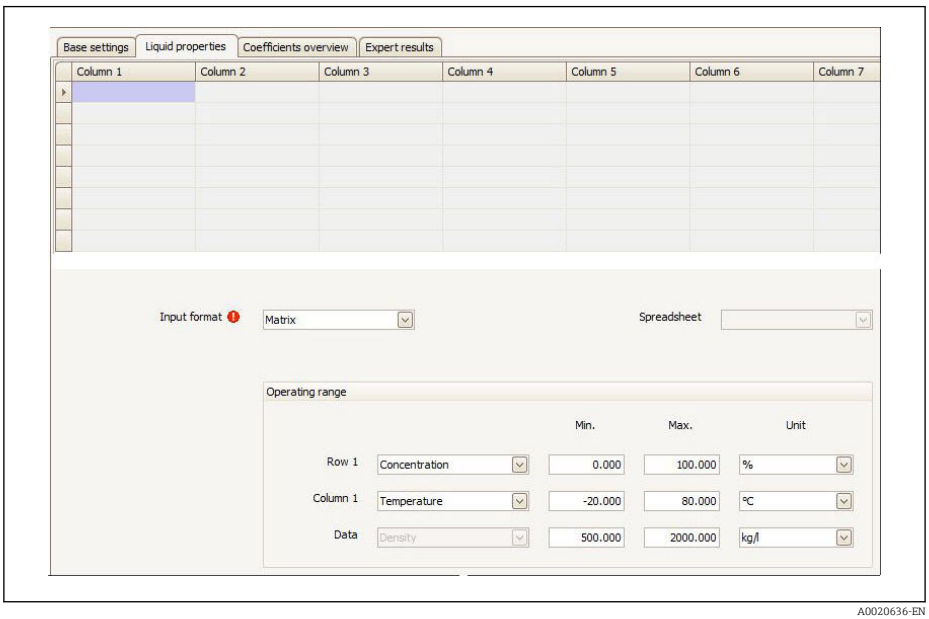
1 *First row. Temperature or concentration values. Assign in the "Operating range" tab, "Row 1" function.*
2 *First column. Temperature or concentration values. Assign in the "Operating range" tab, "Column 1" function.*
3 *Row section. Other rows (e.g. rows 4, 9 and 14) can be inserted provided that the cells do not contain a purely numerical value. Cells are not recognized as a numerical value if the string contains spaces, letters or special characters.*
4 *Column section. Other columns can be inserted provided that the cells do not contain a purely numerical value. Cells are not recognized as a numerical value if the string contains spaces, letters or special characters.*
5 *Result section. Only use numerical values. Invalid or empty cells are replaced by the cells on the right. "n.def" (not defined) is in the cell on the extreme right. Accordingly the cells around the entire number section may not contain individual numerical values.*
6 *Worksheets can be given an individual name. The names should always start with a letter. Do not use special characters (+, -, (,), _ etc.). Select the table sheet in the "Operating range" tab, "Working sheet" function.*

4. Data entry for concentration-related parameters



A0020530-EN

1. Select the **Base settings** tab
2. In the **Calculation base** function select the **Liquid properties** option
3. In the **Density calibration** function select one of the options provided
   ↳ The Field calibration option can also be selected.
4. In the **Sensor** function select a sensor
5. Select the Liquid properties tab
   ↳



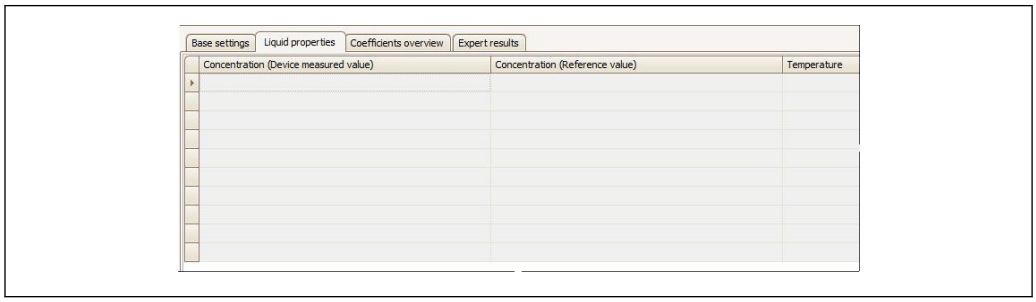
A0020636-EN

6. In the **Input format** function, select list or matrix.
7. Enter the density values as a function of the concentration and temperature

8. Select the temperature or concentration in the **Operating range** field in the **Row 1** or **Column 1** function
9. For temperature, concentration and density, enter the min/max range and select the unit
10. If the values should be imported from a table:
    ↳ Click the **Import** button in the menu bar.
    Select the file in .xls (Excel) format and import it.
    Pay attention to the information in the info bar
11. Click the **Calculate** button in the menu bar
    ↳ Pay attention to the information in the info bar
12. The calculated coefficients are displayed in the **Coefficients overview** tab.
13. The numerical uncertainty is graphically represented in the **Expert results** tab.
14. Click the **Write** button in the menu bar
    ↳ The calculated, optimized concentration coefficients are written to the device

5.5 Calculation base: "Fine tuning"

The calculated coefficients are already programmed into the device. The results of control measurements performed with a hydrometer found discrepancies between the measured value and the value displayed in the device. The fine tuning function is used to correct this. The measured values of the device are optimized by entering the reference values and recalculating the coefficients. Once the new coefficients are imported or entered into the device, the concentration values are adapted to the control measurements.



A0020683-EN

Requirements

1. At least 7 concentration values from the measuring device (device measured value).
2. At least 7 concentration values from control measurements (reference value).
3. Device measured value and reference value at the same temperature value.
4. The higher the number of measured values and the smaller the temperature range the higher the accuracy.
5. Connect the measuring device to export the old coefficients or enter them manually.

Calculation of coefficients for fine tuning

1. Select the **Base settings** tab
2. In the **Calculation base** function select the following option: Fine tuning
3. In the **Liquid properties** tab, enter the device measured value, reference value and temperature value
4. Click the **Read** button in the menu bar
   ↳ Concentration coefficients are read in from the device
5. Click the **Calculate** button in the menu bar
   ↳ Pay attention to the information in the info bar
6. The calculated coefficients are displayed in the **Coefficients overview** tab.
7. The numerical uncertainty is graphically represented in the **Expert results** tab.
8. Click the **Write** button in the menu bar
   ↳ The calculated, optimized concentration coefficients are written to the device

5.6 Error messages and troubleshooting

List of information messages, error messages and remedial measures

Index	Message
1	User messages
2	Operating range: min. value > max. value.
3	Operating range: max. value < min.value.
4	Input out of operating range.

Index	Message
5	Calculation failed. Input data not correct.
6	Function failed. Only executable via "calc. type - table".
7	
8	Imported data not correct.
9	Calculation failed. Data not usable.
	Calculation successful. For coefficients, see the "Coefficients overview" tab.
10	No device coefficients are available.
11	Not enough triple data are available.
12	Matrix incomplete.
13	List incomplete.
14	Calculation is running....
15	Negative density measured value(s).
16	
17	Contains redundant data.
18	MatrixValid
19	ListValid
20	NegativeConcData
21	NotEnoughTripleDataInTheRang
22	ExcelImportSuccessful
23	
24	Excel Export was successful
25	Data loaded successfully.
26	Data not loaded successfully.
27	Coefficients written successfully to the device.
28	Coefficients not written successfully to the device.
29	Save not successful.
30	Save successful.

6 General principles and application examples

Concentration is an important value in many processes. This value indicates how much of a substance is in a mixture or solution. The concentration is always a relative amount. The amount can be measured in units of mass or volume.

6.1 Principle of concentration measurement

The measuring device measures 3 primary measured variables simultaneously:
- Mass flow
- Density
- Medium temperature

With these measured variables, it is possible to calculate other process variables such as volume flow, reference density etc. The concentration of a fluid can be calculated from the known fluid data (fluid, density, temperature).

If a solution is made up of two fluids (e.g. sugar in water) the percentage concentration of the individual fluids (sugar and water) can be calculated. Here one part is known as the "carrier fluid" (water) and the other is called the "target fluid" (sugar). How these two fluids depend on one another must be known and defined. For each density/temperature value a corresponding concentration value is calculated.

Furthermore the application package has a function to perform customer-specific concentration calculations. For this purpose it is essential to know either the dependency of concentration and density/temperature or the dependency of the concentration on the reference density. The user usually has this information in the form of a table, as is the case for alcohol tables for instance. By using customer-specific tables it is possible to define the parameters which the Promass device then uses to calculate the concentration value of the fluid from the primary measured variables.

6.1.1 Preliminary information about the fluid and the process

Concentration calculations depend on the fluid properties. Therefore it is very important to have this information in advance.

The correlation between the density, temperature and quantity of fluid (%mass, %volume, %solids, etc.) must be known. If this information is available in table format (.xls), this table can be imported into the concentration function. The coefficients defined for the measuring device are then calculated.

The more values that are saved in the table the better the values can be linearized and the more accurate the results. It is advisable to only calculate the coefficients for the actual application window (density/temperature range). The reason is that the larger the window the more linearization has to be applied and therefore the overall accuracy will suffer.

6.1.2 Effects on the accuracy

The accuracy of the concentration measurement depends heavily on the sensor and the process conditions. This includes the following factors:
- The density measuring accuracy of the sensor
- The temperature measuring accuracy of the sensor
- The quality of the information available about the fluid
- The size of the application window (density/temperature range)

Furthermore it must be considered how much the density change equals a certain change in concentration.

For example let us say that a specific density accuracy is 1 g/l. If 1 % concentration corresponds to 2 g/l it is possible to calculate the concentration with an accuracy of 0.5 %. If insufficient fluid data are available, or if these data are inaccurate, the computing accuracy will suffer accordingly.

6.1.3 Density measurement

The best accuracy is achieved with the optional wide-range density specification. For applications in which the process temperatures vary, the special density calibration offers the highest level of accuracy over a wide temperature range (+5 °C to 80 °C). Even more accurate readings can be obtained with a field calibration which should be performed under "real" process conditions in the field.

6.1.4 Measurement method

The concentration is calculated using the following equation:

$$C = A0 + A1 \cdot \rho + A2 \cdot \rho^2 + A3 \cdot \rho^3 + A4 \cdot \rho^4 + B1 \cdot T + B2 \cdot T^2 + B3 \cdot T^3$$

C	Concentration
ρ	Density currently measured
A0 to A4	Density coefficient
B1 to B3	Temperature coefficient
T	Temperature currently measured in °C

Three-dimensional concentration calculation

This type of concentration measurement has proven to be the most practical option. Here, the operating density and the temperature are factored into the calculation of the concentration, thereby compensating for all the variables that influence the density.

6.2 Frequently used concentration calculations and examples

This section describes frequently used concentration calculations and explains how such concentrations can be calculated.

6.2.1 Mass fraction (percent by weight)

Units: wt%, w%, % (w/w), mass%, Ma%, m%, G%

Indicates the mass (g, kg, etc.) of the target fluid $m_{target\ fluid}$ as a percentage of the total mass of the solution $m_{solution}$:

$m_{target\ fluid} + m_{carrier\ fluid} = m_{solution}$

Mass fraction of the target fluid: $\omega_{target\ fluid} = m_{target\ fluid} / m_{solution}$

Mass fraction in % of target fluid: $c_{M/M} = \omega_{target\ fluid} \cdot 100\ \%$

Example: a mixture contains 40 grams of ethanol and 60 grams of water. The mass fraction of ethanol is 0.4 or 40 percent by weight

In the case of commercially available concentrated aqueous reagents such as acids and bases, the concentration is often still indicated in w% (weight percentage) with the specific weight.

Example: measuring the mass fraction (percent by weight)

Prerequisites

1. The concentration measurement application package must be enabled
2. The best measurement results are achieved using devices with a special density calibration (application package order code, option **ED** "concentration")
3. The concentration values are provided and specified as a function of the temperature and density.

Configure the concentration

1. In the **Assign current output** parameter in the **Setup** → **Current output 1** menu select the concentration option
2. In the **Concentration unit** parameter in the **Setup** → **Advanced setup** → **Concentration** menu select the WT-% option
3. Calculate the coefficients using the concentration function in the FieldCare operating tool → 📄 22
   ↳ In the FieldCare operating tool open the **Concentration** function
4. Select the **Base settings** tab
5. In the **Calculation base** function select the following option: Liquid properties
6. In the **Sensor** function select a sensor
7. In the **Density calibration** function select the Special density calibration option.
   ↳ Only available if the **ED** option was selected in the application package order code.
8. In the **Liquid properties** tab enter or import density values as a function of the temperature and concentration. Detailed information is provided in the section entitled "Calculation base: Liquid properties" → 📄 30
9. Click the **Calculate** button in the menu bar
   ↳ Pay attention to the information in the info bar
   The calculated coefficients are displayed in the **Coefficients overview** tab
   The calculated coefficients are represented graphically in the **Expert results** tab

10. Click the **Write** button in the menu bar
    ↳ The calculated coefficients are uploaded to the device

6.2.2 Reference density

The reference density of a substance is the ratio of its mass to volume under reference conditions. Generally (in Europe), these are measured at 0 °C and 101.325 kPa (1.01325 bar). In many cases density values are derived from the reference density. The reference density can be used to calculate the density at a specific reference temperature. This makes it possible to compare density measurements at different temperatures. For this purpose certain properties of the fluid must be known before calculations can be undertaken (e.g. the volume expansion coefficient).

Reference density calculation

$$\rho_n = \rho \cdot (1 + \alpha \cdot \Delta t + \beta \cdot \Delta t^2)$$

A0023403

ρ_n	*Reference density*
ρ	*Medium density currently measured [°C] or [K]* [1]
Δt	$t - t_N$
t	*Medium temperature currently measured [°C] or [K]* [1]
t_N	*Reference temperature at which the reference density can be calculated (e.g. 15 °C or 288.15 K)*
α	*Linear thermal volume expansion coefficient of the medium concerned [1/K]* [1]
β	*Quadratic thermal volume expansion coefficient of the medium concerned [1/K²]* [1]

1) K = Kelvin

Example: Measuring the reference density

Prerequisites

1. The best measurement results are achieved using devices with a special density calibration ("application package" order code, option **ED** "concentration")
2. The reference density function is already available in the device. The concentration measurement application package is not absolutely essential.

Configuring the current output

1. In the **Assign current output** parameter in the **Setup** → **Current output 1** menu select the following option: Reference density
2. In the **Reference density unit** parameter in the **Setup** → **Advanced setup** → **System units** menu select the following option: Unit

Configuring corrected volume flow calculation

In the **Setup** → **Advanced setup** → **Calculated values** → **Corrected volume flow calculation** menu configure the following parameters:

1. In the **Corrected volume flow calculation** parameter select the following option: Calculated reference density
2. In the **Reference temperature** parameter enter the reference temperature for the density functions (e.g. 20 °C)
3. In the **Linear expansion coefficient** parameter enter the fluid-specific expansion coefficient for linear temperature curves
4. In the **Square expansion coefficient** parameter enter the fluid-specific expansion coefficient for non-linear temperature curves

6.2.3 Degrees Plato (Balling)

Units: °Plato, °Pl, Balling

Tables were constructed by Bohemian chemist Karl Balling, and later improved upon by German chemist Fritz Plato. Balling, Plato and Brix (→ 43) tables are generally interchangeable. They differ at the 5th and 6th decimal place when converting from percent by weight to specific gravity. While the Balling scale can still be found on older saccharimeters and is still used in the South African wine industry, the Plato scale is primarily used in the brewing industry.

The brewing industry uses the specific gravity to determine the original wort of beer.

A wort of n-degrees Plato has the same specific gravity as a water-sucrose solution containing n percent sucrose by weight. Both tables are used to measure sucrose solutions in water - each solution contains different percentages by weight - and to weigh a known volume of the resulting solutions in order to determine their density. Stating that the original wort is 10° Plato means that in a 100% sucrose solution it would be 10% of the total weight.

In the typical wort only a small fraction of the extract is actually sucrose. In Germany, for example, most beers are brewed from a wort with 1° to 16 ° Plato and have an alcohol content of 4.5 to 5.5 Vol.%.

As the quality of the original wort is density-dependent, a Coriolis flowmeter can calculate the original density and output a corresponding signal.

Laboratory measurements are usually given in specific gravity. Plato refers to a specific gravity of 20/20 °C. The indicator 20/20 °C means that the ratio of the mass of a certain volume of a liquid to the mass of the same volume of water is 20 at 20 °C (68 °F). The specific gravity is the measure for the density of a medium. It is dimensionless and is equivalent to the density of the medium divided by the density of water. The density of water at 20 °C is 998.2041 kg/m^3

Example: Measuring °Plato or Balling

Prerequisites

1. The concentration measurement application package must be enabled
2. The best measurement results are achieved using devices with a special density calibration ("application package" order code, option **ED** "concentration")
3. Remove CO_2 gases with a de-aerator or other method
4. To compare the laboratory value (SG) the device measured value is divided by the density of water at 20 °C (998.2041 kg/m^3)
5. The varying amounts of CO_2 and yeast in the process must be factored into the calculation as they affect the accuracy.
   ↳ This is done by taking sample measurements with a hydrometer. Before measuring with the hydrometer, the sample must be well shaken to reduce the CO_2 content. Then it is left to rest so that the yeast settles. The measured reference values are noted down and used during the subsequent fine tuning process.

Configure the concentration for the current output

1. In the **Assign current output** parameter in the **Setup** → **Current output 1** menu select the concentration option
2. In the **Concentration unit** parameter in the **Setup** → **Advanced setup** → **Concentration** menu select the °Plato oder °Balling option
3. Calculate the coefficients using the concentration function in the FieldCare operating tool → 22
   ↳ In the FieldCare operating tool open the **Concentration** function

4. Select the **Base settings** tab
5. In the **Calculation base** function select the following option: Defined liquid
6. In the **Liquid type** function select the following option: Sucrose solution
7. In the **Sensor** function select a sensor
8. In the **Density calibration** function select the following option: Special density calibration (only available if the **ED** option was selected in the application package order code)
9. In the **Operating range** function enter the min./max. values for temperature and concentration.
   ↳ The density value is already defined as explained in the reference → 22
   The closer the min./max. values are to one another, the more accurate the subsequent measurement result
10. Click the **Calculate** button in the menu bar
    ↳ Pay attention to the information in the info bar
    The calculated coefficients are displayed in the **Coefficients overview** tab
    The calculated coefficients are represented graphically in the **Expert results** tab
11. Click the **Write** button in the menu bar
    ↳ The calculated coefficients are uploaded to the device

Fine tuning

1. Select the **Base settings** tab
2. In the **Calculation base** function select the following option: Fine tuning
3. In the **Liquid properties** tab, enter the device measured values, reference values and temperature values
4. Click the **Read** button in the menu bar
   ↳ Concentration coefficients are read in from the device
5. Click the **Calculate** button in the menu bar
   ↳ Pay attention to the information in the info bar
6. The calculated coefficients are displayed in the **Coefficients overview** tab.
7. The numerical uncertainty is graphically represented in the **Expert results** tab.
8. Click the **Write** button in the menu bar
   ↳ The calculated, optimized concentration coefficients are written to the device

6.2.4 Degrees Brix

Units: °Brix, °Bx

The sugar-processing industry uses various standard densities roughly in the range of 1.00 to 1.45 kg/l to determine the sugar content of liquids such as fruit juices.

Soluble solids, such as sugars, are measured according to the Brix scale, a hydrometer scale for sugar solutions introduced in the nineteenth-century by Austrian chemist Adolf F. Brix. Degrees Brix is a measured variable for a sugar/water solution. A 25 °Brix solution is 25 grams of dry solids in 100 grams of liquid. Or to put it another way there are 25 grams of dry solids and 75 grams of water.

The sugar content of an aqueous solution that does not contain solids is represented on a scale from 0 to 100 °Brix. Degrees Brix is a measurement of the specific gravity of liquids, also because the specific gravity is well known for sucrose solutions. Calculations in the measuring device are based on ICUMSA formulas and tables (ICUMSA = International Commission for Uniform Methods of Sugar Analysis).

The degrees Brix unit is used primarily in the food and beverage industry to measure the approximate amount of sugar in fruit juices, wine, and soft drinks, and is also used in the sugar production industry. For fruit juices, 1 °Brix is about 1–2% sugar by weight of the fruit juice and correlates well with perceived sweetness.

Most wineries require a minimum °Brix level to be reached before they accept grapes for processing, as the amount of sugar in a grape is one of the key measures of its maturity. Therefore °Brix is an important indicator of the proper time to harvest. Most wineries seek readings ranging from 21 to 23 °Brix for white grapes and 23 to 25 °Brix for reds. Red wines have a higher Brix and thus higher alcohol levels.

In pure sugar solutions, dissolved solids correspond exactly to the sugar concentration, and are a fairly accurate approximation of harvest time.

Predefined liquids are saved as a template for the following Brix calculations: fructose, glucose, cane sugar and sucrose. A data record with 3-D table values (correlation between density/concentration/temperature) must be used for other sugar solutions that are not listed, such as fluids with other ingredients that affect the density (e.g. fibrous content like ketchup).

Example: Measuring °Brix

Prerequisites

1. The concentration measurement application package must be enabled
2. The best measurement results are achieved using devices with a special density calibration (application package order code, option **ED** "concentration")
3. The density values are provided and specified as a function of the temperature and concentration.

Configure the concentration

1. In the **Assign current output** parameter in the **Setup** → **Current output 1** menu select the concentration option
2. In the **Concentration unit** parameter in the **Setup** → **Advanced setup** → **Concentration** menu select the User conc. option and enter °Brix
3. Calculate the coefficients using the concentration function in the FieldCare operating tool → 🖹 22
   ↳ In the FieldCare operating tool open the **Concentration** function
4. Select the **Base settings** tab
5. In the **Calculation base** function select the following option: Defined liquids
6. In the **Liquid type** function select a solution

7. In the **Density calibration** function select one of the options provided
   ↳ The Field calibration option can also be selected.
8. In the **Sensor** function select a sensor
9. In the **Operating range** field enter the min./max. values for temperature and concentration.
   ↳ The density value is already defined - see the calculation sources in the previous section.
   The closer the min./max. values are to one another, the more accurate the concentration measurement
10. Click the **Calculate** button in the menu bar
    ↳ Pay attention to the information in the info bar
11. The calculated coefficients are displayed in the **Coefficients overview** tab.
12. The numerical uncertainty is graphically represented in the **Expert results** tab.
13. Click the **Write** button in the menu bar
    ↳ The calculated, optimized concentration coefficients are written to the device or FieldCare

Example: Configuring totalizers

Configure totalizer 1

In the **Setup** → **Advanced setup** → **Totalizer 1** menu configure the following parameters:

1. In the **Assign process variable** parameter select the following option: Target mass flow
2. In the **Unit totalizer** parameter select a unit (e.g. kg)
3. In the **Operating mode** parameter select the following option: e.g. Net flow total
4. In the **Failsafe mode** parameter specify the output behavior in the event of a device alarm

6.2.5 Degrees Baumé

Units: °Baumé, °Bé

Density can also be measured on the Baumé scale, which reads from 0° to 100 °Baumé. The formula is derived from the specific gravity. The Baumé scale was devised to correlate to the percentage concentration (weight-weight percentage) of a brine solution (salt in water). The Baumé scale is a measure used to ascertain the specific gravity of a solution, not its concentration. To get the molarity of HCl, you need to convert the degrees Baumé value to the specific gravity, and then use the specific gravity to look up the concentration of HCl from a table.

This mode of expressing density is used primarily for acidic solutions such as iron chloride. In fact, two different Baumé scales are used to determine the density of acids:

- °BAUME > 1 kg/l → for solutions heavier than water
- °BAUME < 1 kg/l → for solutions lighter than water

For liquids that are heavier than water, 0 °Bé marks the water level in pure water, and 15 °Bé corresponds to the water level in a solution that is 15% HCl by mass.

For liquids that are lighter than water, 10 °Bé marks the level for pure water and 0 °Bé corresponds to a solution that is 10% HCl by mass.

Although the Baumé scale is almost never mentioned, it is a convenient way to check solution concentration.

For example, U.S. Grade A honey must have a Baumé reading of at least 42.49 °Bé at 60 °F. A recipe for lowering the pH of pool water calls for 20 °Bé HCl. The Baumé scale is also used by brewers to check the density of sugar solutions before fermentation. The Baumé scale is traditionally used in industries where hydrometer readings have long been used to determine the concentration of a solution. Examples include brewing, wine-making, honey production, and acid production.

Example: Measuring °Baumé

Prerequisites

1. The concentration measurement application package must be enabled
2. The best measurement results are achieved using devices with a special density calibration (application package order code, option **ED** "concentration")
3. The density values are provided and specified as a function of the temperature and concentration.

Configure the concentration

1. In the **Assign current output** parameter in the **Setup** → **Current output 1** menu select the concentration option
2. In the **Concentration unit** parameter in the **Setup** → **Advanced setup** → **Concentration** menu select the °Baume (heavy) or °Baume (light) option
3. Calculate the coefficients using the concentration function in the FieldCare operating tool → 📄 22
   ↳ In the FieldCare operating tool open the **Concentration** function
4. Select the **Base settings** tab
5. In the **Calculation base** function select the following option: Liquid properties
6. In the **Sensor** function select a sensor
7. In the **Density calibration** function select the Special density calibration option
   ↳ Only available if the **ED** option was selected in the application package order code
8. In the **Liquid properties** tab enter or import the concentration as a function of the temperature and density values. Detailed information is provided in the section entitled "Calculation base: Liquid properties" → 📄 30

9. Click the **Calculate** button in the menu bar
   ↳ Pay attention to the information in the info bar
   The calculated coefficients are displayed in the **Coefficients overview** tab
   The calculated coefficients are represented graphically in the **Expert results** tab
10. Click the **Write** button in the menu bar
    ↳ The calculated coefficients are uploaded to the device

6.2.6 Alcohol concentration and percent by volume

In many practical cases, tables have been produced relating fluid properties to each other. One example is the concentration of the fluid as a function of the operating temperature and density.

Ethyl alcohol, also known as ethanol or grain alcohol, is a flammable, colorless chemical compound and is found in alcoholic beverages such as beer, wine and spirits. It can be prepared by the fermentation of sugar (e.g. from molasses), and yeast acts as the enzyme catalyst. If it is to be prepared by the fermentation of starch (e.g. from corn, rice, rye, or potatoes), enzymes present in an extract of malt are also required in addition to yeast enzymes. The concentration of alcohol obtained by fermentation is limited to about 10% due to the reduced catalytic effect of the yeast enzyme.

For non-beverage uses, ethanol is more commonly prepared by passing ethylene gas at high pressure into sulphuric or phosphoric acid to form the corresponding ester. The acid-ester mixture is diluted with water and heated. Ethanol is formed by hydrolysis. The alcohol is removed from the mixture by distillation.

The concentration of alcohol in an alcoholic beverage may be specified in percent alcohol by volume (ABV), in percent by weight (sometimes abbreviated w/w for weight for weight), or in “proof". The conversion factor from proof to percent by volume is 1/2 (e.g. 80 proof is equivalent to 40% ABV at 20 °C).

Example: Measuring the alcohol concentration

Prerequisites

1. The concentration measurement application package must be enabled
2. The best measurement results are achieved using devices with a special density calibration (application package order code, option **ED** "concentration")

Configure the concentration

1. In the **Assign current output** parameter in the **Setup** → **Current output 1** menu select the concentration option
2. In the **Concentration unit** parameter in the **Setup** → **Advanced setup** → **Concentration** menu select the WT-% option
3. Calculate the coefficients using the concentration function in the FieldCare operating tool → 🖹 22
   ↳ In the FieldCare operating tool open the **Concentration** function
4. Select the **Base settings** tab
5. In the **Calculation base** function select the following option: Defined liquids
6. In the **Liquid type** function select ethanol
7. In the **Density calibration** function select one of the options provided
   ↳ The Field calibration option can also be selected.
8. In the **Sensor** function select a sensor
9. In the **Operating range** field enter the min./max. values for temperature and concentration.
   ↳ The density value is already defined - see the calculation sources in the previous section.
   The closer the min./max. values are to one another, the more accurate the concentration measurement
10. Click the **Calculate** button in the menu bar
    ↳ Pay attention to the information in the info bar
11. The calculated coefficients are displayed in the **Coefficients overview** tab.
12. The numerical uncertainty is graphically represented in the **Expert results** tab.

13. Click the **Write** button in the menu bar
    ↳ The calculated, optimized concentration coefficients are written to the device or FieldCare

Example: Configuring totalizers

Configure totalizer 1

In the **Setup** → **Advanced setup** → **Totalizer 1** menu configure the following parameters:

1. In the **Assign process variable** parameter select the following option: Target mass flow
2. In the **Unit totalizer** parameter select the following option: WT-%
3. In the **Operating mode** parameter select the following option: e.g. Net flow total
4. In the **Failsafe mode** parameter specify the output behavior in the event of a device alarm

6.2.7 Black liquor

Units: % mass, m%, % black liquor

Black liquor is a byproduct of paper production. In paper production, caustic soda, sodium sulfide, sodium sulfate and sodium carbonate are added to cook wood (white liquor). This removes organic lignin in the wood. Lignin determines a wood's strength and its lignification (woody structure). Black liquor is what is left over after pulpwood is digested into paper pulp. It is a high-energy aqueous mixture whose primary ingredient is lignin.

Because of this lignin the black liquor has a very high net calorific value. Following a concentration process the thickened black liquor has a dry matter content of up to 75%. In the subsequent combustion process, the lignin is burned. Electricity is generated and the entrained chemicals are reduced. The melt produced (lignin-free and chemically reduced) is discharged and collected. Diluted white liquor is added to the melt to produce green liquor. This is then filtered and calcium hydroxide ($Ca(OH)_2$) is added to form white liquor, which is fed back into the paper production process.

As black liquor is made up of many organic and inorganic parts, it is not possible to use one single formula or table. Customer-specific data are needed to calculate the concentration.

Example: Measuring °black liquor

Prerequisites

1. The concentration measurement application package must be enabled
2. The best measurement results are achieved using devices with a special density calibration (application package order code, option **ED** "concentration")
3. The density values are provided and specified as a function of the temperature and concentration.

Configure the concentration

In the **Setup** → **Advanced setup** → **Concentration** menu configure the following parameters:

1. In the **Concentration unit** parameter select the following unit: User conc.
2. In the **User concentration text** enter text for the user-defined unit, e.g. %BL
3. In the **User concentration factor** parameter enter the factor for calculating the user-defined unit.
4. Calculate the coefficients using the concentration function in the FieldCare operating tool → 🖹 22
   ↳ In the FieldCare operating tool open the **Concentration** function
5. Select the **Base settings** tab
6. In the **Calculation base** function select the following option: Liquid properties
7. In the **Sensor** function select a sensor
8. In the **Density calibration** function select the following option: Special density calibration
   ↳ Only available if the **ED** option was selected in the application package order code
9. In the **Liquid properties** tab enter or import density values as a function of the temperature and concentration. Detailed information is provided in the section entitled "Calculation base: Liquid properties" → 🖹 30
10. Click the **Calculate** button in the menu bar
    ↳ Pay attention to the information in the info bar
    The calculated coefficients are displayed in the **Coefficients overview** tab
    The calculated coefficients are represented graphically in the **Expert results** tab

11. Click the **Write** button in the menu bar
    ↳ The calculated coefficients are uploaded to the device

www.addresses.endress.com

Endress+Hauser

People for Process Automation