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Special Documentation
Proline Promass 500 FOUNDATION Fieldbus

Concentration Measurement application package

Endress+Hauser
People for Process Automation

Table of contents

1 About this document

1.1 Document function

This manual is Special Documentation; it does not replace the Operating Instructions pertaining to the device. It serves as a reference for using the Concentration Measurement function integrated in the measuring device.

1.2 Content and scope

This documentation contains a description of the additional parameters and technical data that are provided with the **Concentration** application package.

It provides detailed information on:
- Application-specific parameters
- Advanced technical specifications

1.3 Symbols used

1.3.1 Safety symbols

Symbol	Meaning
DANGER	**DANGER!** This symbol alerts you to a dangerous situation. Failure to avoid this situation will result in serious or fatal injury.
WARNING	**WARNING!** This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in serious or fatal injury.
CAUTION	**CAUTION!** This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in minor or medium injury.
NOTICE	**NOTE!** This symbol contains information on procedures and other facts which do not result in personal injury.

1.3.2 Symbols for certain types of information

Symbol	Meaning
	Tip Indicates additional information.
	Reference to documentation
	Reference to page
	Reference to graphic
	Notice or individual step to be observed
1., 2., 3...	Series of steps
	Result of a step
	Operation via local display

Symbol	Meaning
	Operation via operating tool
	Write-protected parameter

1.3.3 Symbols in graphics

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

1.4 Documentation

For an overview of the scope of the associated Technical Documentation, refer to the following:
- The *W@M Device Viewer* (www.endress.com/deviceviewer): Enter serial number from nameplate
- The *Endress+Hauser Operations App*: Enter the serial number from the nameplate or scan the 2-D matrix code (QR code) on the nameplate.

This documentation is not a substitute for the Operating Instructions supplied with the device.

The Operating Instructions and additional documentation contain all detailed information on the device:
- Internet: www.endress.com/deviceviewer
- Smart phone/tablet: *Endress+Hauser Operations App*

This documentation is an integral part of the following Operating Instructions:

Measuring device	Documentation code
Promass A 500 (8A5B**-...)	BA01559D
Promass A 500 (8A5C**-...)	BA01883D
Promass E 500	BA01561D
Promass F 500	BA01562D
Promass H 500	BA01563D
Promass I 500	BA01564D
Promass O 500	BA01565D
Promass P 500	BA01566D
Promass Q 500	BA01567D
Promass S 500	BA01568D
Promass X 500	BA01569D

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

1.5 Registered trademarks

FOUNDATION™ Fieldbus
Registration-pending trademark of the FieldComm Group, Austin, Texas, USA

2 System integration

Extended options if the **Concentration** application package is used
- Target mass flow
- Carrier mass flow
- Target volume flow [1)]
- Carrier volume flow [1)]
- Target standard volume flow [2)]
- Carrier standard volume flow [2)]
- Concentration

1) These measured variables are only available for mixtures for which **%vol** option can be selected as the concentration unit (see Table → 9).
2) These measured variables are only available for the selected %mass / %volume in the **Liquid type** parameter or for mixtures in the **Liquid type** parameter for which **%StdVol** option can be selected as the concentration unit (see Table → 9).

Overview of the extended range of measured variables available with the Concentration application package: → 18

For detailed information on system integration, see the Operating Instructions for the device → 5

3 Commissioning

3.1 Configure the concentration

To configure the measuring device for concentration measurement, it is necessary to distinguish between the following two scenarios:
- The mixture is programmed into the measuring device as a predefined liquid.
- The mixture is to be saved in device on the basis of user-defined table values.

3.1.1 Mixture as a predefined liquid

Overview of the predefined liquids programmed into the measuring device → 9

If the mixture to be measured is already programmed into the device, the configuration can be performed exclusively at the device, e.g. via the display or Web server.

1. Select the predefined liquid in the **Liquid type** parameter→ 11
2. Select the units in the **Concentration unit** parameter→ 14
3. Configure the outputs → 16

3.1.2 Mixture from user-defined table values

If the mixture to be measured is saved in user-defined table values, these values can be used to create a concentration function in the measuring device. The function is created with the FieldCare → 20 concentration function.

The configuration is performed at the measuring device or in the Web server and also in the FieldCare concentration function.

Measuring device configuration

1. Select the units in the **Concentration unit** parameter→ 14
2. Configure the outputs → 16

Settings in the FieldCare concentration function

1. If necessary: calculate the coefficients from the values in the table→ 31
2. Adapt the coefficients and transfer them to the measuring device→ 35

3.2 Overview of defined liquids

Liquid type	Units	Temperature range Measuring range	Source / standard	Reconciliation of mineral content	Compressibility (pressure) considered
Ethanol in water	%Mass %vol %StdVol %ABV@20°C proof/vol	−20 to +40 °C 0 to 100 %	OIML IST-90 (Bettin, Spieweck 1990) [1]	☒	☑
Methanol in water	%Mass	0 to +50 °C 0 to 100 %	Coefficients from table data [2] [3]	☒	☒
Fructose in water	%Mass	0 to +80 °C 0 to 100 %	ICUMSA SPS-4 (1998)	☑	☑
Glucose in water	%Mass	0 to +80 °C 0 to 100 %	ICUMSA SPS-4 (1998)	☑	☑
Invert sugar in water	%Mass	0 to +80 °C 0 to 100 %	ICUMSA SPS-4 (1998)	☑	☑
Sucrose in water	%Mass °Brix SGU	0 to +80 °C 0 to 100 %	ICUMSA SPS-4 (1998)	☑	☑
Wort	%Mass °Plato °Balling SGU	0 to +80 °C 0 to 100 %	ICUMSA SPS-4 (1998) Sec. 2	☑	☑
Corn syrupHFCS42	%Mass	+15 to +60 °C 0 to 85 %	Coefficients from table data [4] [5]	☒	☒
Corn syrupHFCS55	%Mass	+15 to +60 °C 0 to 85 %			
Corn syrupHFCS90	%Mass	+15 to +60 °C 0 to 85 %			
Ammonium nitrate in water	%Mass mol/l	+5 to +95 °C 0.45 to 78.74 %	Density/concentration model according to [6]	☑	☑
Iron(III)chloride in water	%Mass mol/l	0 to +30 °C 1 to 50 %			
Hydrochloric acid	%Mass mol/l	−5 to +100 °C 0.04 to 40 %			
Sulfuric acid	%Mass mol/l	0 to +100 °C 0.01 to 77.06 %			
Nitric acid	%Mass mol/l	0 to +100 °C 0.1 to 80.11 %			
Phosphoric acid	%Mass mol/l	+15.85 to 81.4 °C 0.1 to 85 %			
Sodium hydroxide	%Mass mol/l	0 to 120 °C 0.05 to 70 %			
Potassium hydroxide	%Mass mol/l	0 to 100 °C 0.08 to 59.46 %			
Hydrogen peroxide in water	%Mass	0 to 100 °C 0 to 100 %	Coefficients from table data [7] [8]	☒	☒

Liquid type	Units	Temperature range Measuring range	Source / standard	Reconciliation of mineral content	Compressibility (pressure) considered
%mass / %volume	%Mass %vol			☑	☑
Concentration 3D	%Mass %vol User conc.			☒	☒

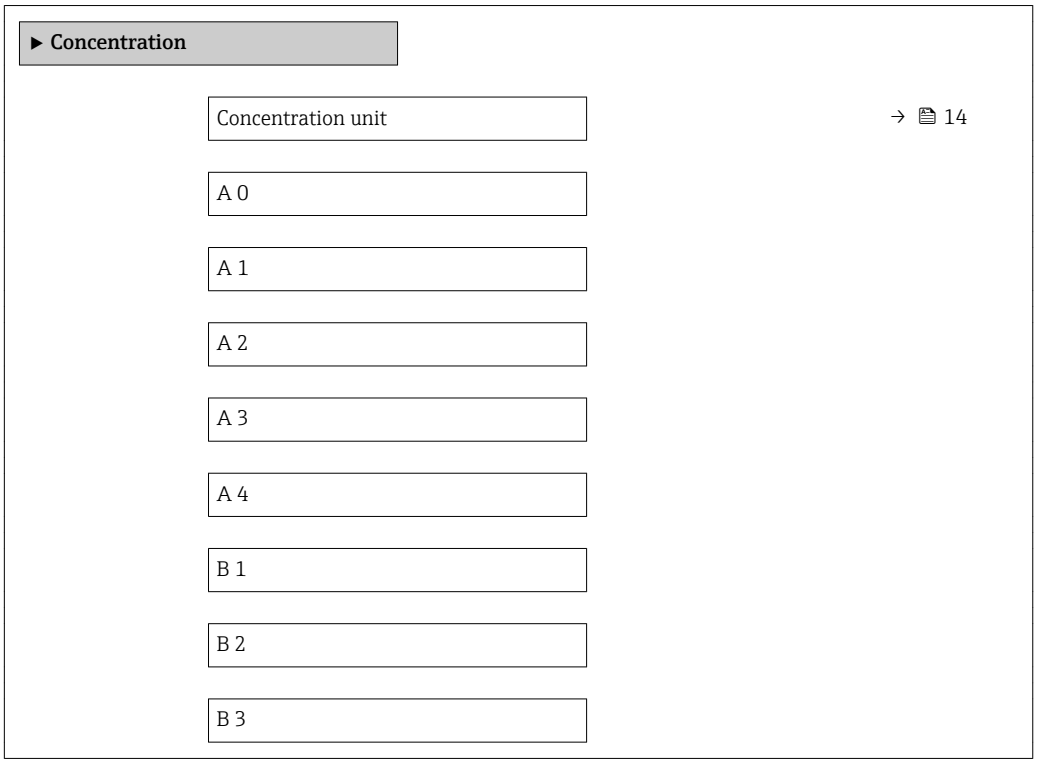
1) Horst Bettin and Frank Spieweck. A Revised Formula for the Calculation of Alcoholometric Tables. Physikalisch-Technische Bundesanstalt (PTB): PTB communications, Brunswick, 1990.
2) International Critical Tables of Numerical Data (1st electronic edition) Version 2003 (www.Knovel.com)
3) DEchema: Agaev et al. Experimental Determination of the Densities of Methanol..; Deposited Doc. VINITI.; 1975
4) Starch: Chemistry and Technology, 2009
5) DEchema: Relationship between Density, Temperature, and Dry Substance of Commercial Corn Syrups, High-Fructose Corn Syrups, and Blends with Sucrose and Invert Sugar; Wartman et al. J. Agric. Food Chem. 7984, 32, 971-974 3. Supporting information for J. Agric. Food Chem., 1984, 32(5), 971 – 974, DOI: 10.1021/jf00125a003
6) Journal of Chemical and Engineering Data, Vol. 49, No. 5, 2004
7) International Critical Tables of Numerical Data (1st electronic edition)
8) DEchema: DEchema: Easton et al. The Behaviour of Mixtures of Hydrogen Peroxide and Water. Trans. Faraday Soc., 1952

☑= is considered; ☒ = is not considered.

3.3 Overview of the "Concentration" submenu

The main settings for concentration measurement are made in the **Concentration** submenu. For example, users can choose from a range of predefined liquid mixtures and concentration units.

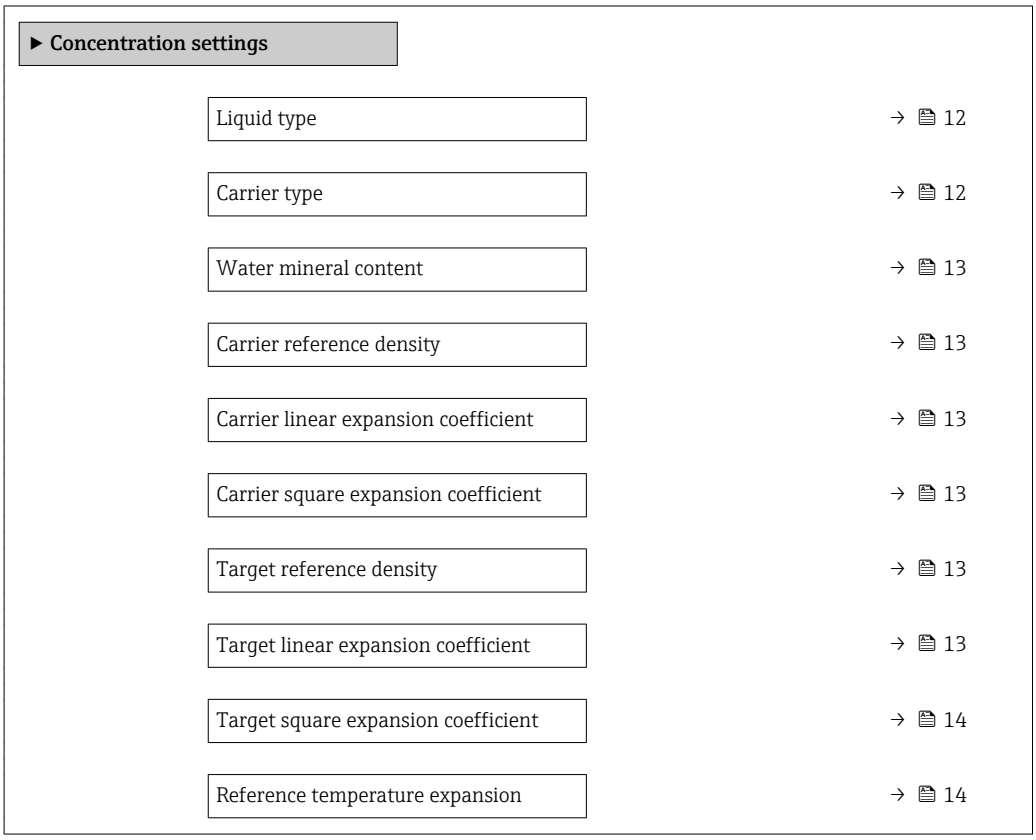
Navigation
"Advanced setup" submenu → Concentration



3.4 Concentration settings

Navigation
"Setup" menu → Advanced setup → Concentration → Concentration settings

Navigation
"Expert" menu → Application → Concentration → Concentration settings



Parameter overview with brief description

Parameter	Prerequisite	Description	Selection / User entry	Factory setting
Liquid type	–	Select liquid type. The measuring device already contains the density/ concentration correlation for a range of binary mixtures. Please refer to table → 🖹 29 for information on the validity ranges with regard to temperature and concentration and for standard deviations of the approximation model for converting density to concentration. 3 sets of coefficients are available for user-defined media. The coefficients are determined from table values via FieldCare → 🖹 20	▪ Off ▪ Sucrose in water ▪ Glucose in water ▪ Fructose in water ▪ Invert sugar in water ▪ HFCS42 ▪ HFCS55 ▪ HFCS90 ▪ Wort ▪ Ethanol in water ▪ Methanol in water ▪ Hydrogen peroxide in water ▪ Hydrochloric acid ▪ Sulfuric acid ▪ Nitric acid ▪ Phosphoric acid ▪ Sodium hydroxide ▪ Potassium hydroxide ▪ Ammonium nitrate in water ▪ Iron(III)chloride in water ▪ %mass / %volume ▪ Coef Set ▪ Coef Set ▪ Coef Set	Off
Carrier type	The **%mass / %volume** option is selected in the **Liquid type** parameter.	Select carrier medium type. For the **%mass / %volume** option, it is possible to choose whether the carrier medium is water. If "water-based" is selected, the **"Carrier reference density" parameter, Carrier linear expansion coefficient** and **Carrier square expansion coefficient** are not available. Instead, the density characteristic of water is determined using Kell's formula (ITS-90).	▪ Water based ▪ Not water based	Water based

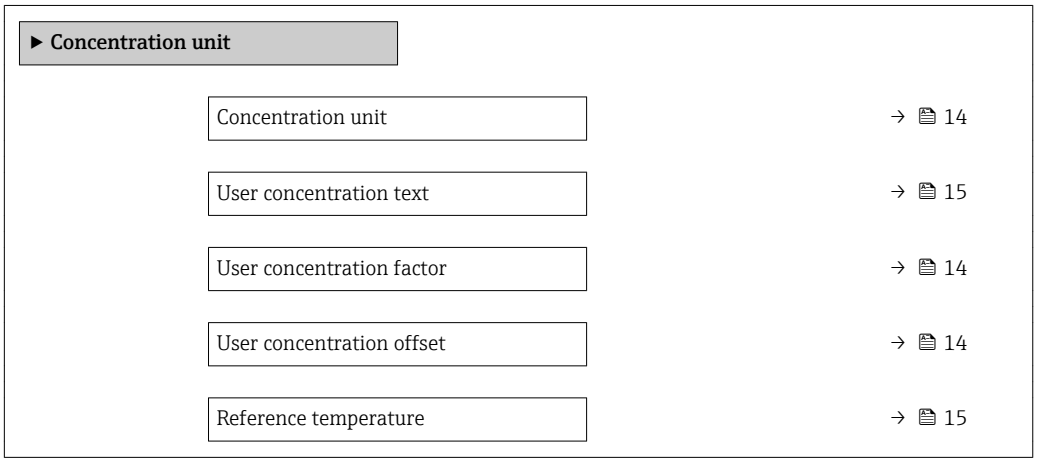
Parameter	Prerequisite	Description	Selection / User entry	Factory setting
Water mineral content	The following options are selected in the **Liquid type** parameter: One of the following options is selected in the **Liquid type** parameter: ▪ Sucrose in water ▪ Glucose in water ▪ Fructose in water ▪ Invert sugar in water ▪ HFCS42 ▪ HFCS55 ▪ HFCS90 ▪ Wort ▪ Methanol in water ▪ Hydrogen peroxide in water ▪ Hydrochloric acid ▪ Sulfuric acid ▪ Nitric acid ▪ Phosphoric acid ▪ Sodium hydroxide ▪ Ammonium nitrate in water ▪ Iron(III)chloride in water ▪ %mass / %volume	Enter mineral content for water based carriers. It is generally presumed that water is present as a carrier medium in pure form, i.e. fully demineralized. If the water contains minerals, these affect the density of the carrier medium and therefore the density of the mixture. This effect can be taken into consideration by entering the mineral content in the device. If the mineral content is to be calculated, this is performed in a separate menu → 17	Positive floating-point number	0 mg/l
Carrier reference density	The **%mass / %volume** option is selected in the **Liquid type** parameter and the **Not water based** option is selected in the **Carrier type** parameter.	Enter reference density for carrier. Density of the carrier medium at reference temperature if the **%mass / %volume** option is selected.	Positive floating-point number	1 kg/Nl
Carrier linear expansion coefficient	The **%mass / %volume** option is selected in the **Liquid type** parameter and the **Not water based** option is selected in the **Carrier type** parameter.	Enter linear expansion coefficient for the carrier. Coefficient of the linear term for approximating the thermal expansion of the carrier medium.	Signed floating-point number	0.0 1/K
Carrier square expansion coefficient	The **%mass / %volume** option is selected in the **Liquid type** parameter and the **Not water based** option is selected in the **Carrier type** parameter.	Enter square expansion coefficient for the carrier. Coefficient of the quadratic term for approximating the thermal expansion of the carrier medium.	Signed floating-point number	0.0 $1/K^2$
Target reference density	The **%mass / %volume** option is selected in the **Liquid type** parameter.	Enter reference density for target. Density of the target medium at reference temperature if the **%mass / %volume** option is selected.	Positive floating-point number	1 kg/Nl
Target linear expansion coefficient	The **%mass / %volume** option is selected in the **Liquid type** parameter.	Enter linear expansion coefficient for the target. Coefficient of the linear term for approximating the thermal expansion of the target medium.	Signed floating-point number	0.0 1/K

Parameter	Prerequisite	Description	Selection / User entry	Factory setting
Target square expansion coefficient	The **%mass / %volume** option is selected in the **Liquid type** parameter.	Enter square expansion coefficient for the targe. Coefficient of the quadratic term for approximating the thermal expansion of the target medium.	Signed floating-point number	0.0 1/K²
Reference temperature expansion	The **%mass / %volume** option is selected in the **Liquid type** parameter.	Enter the temperature at which the specified reference densities of the carrier and target media are valid.	−273.15 to 99 999 °C	20 °C

3.5 Concentration units

Navigation
"Setup" menu → Advanced setup → Concentration → Concentration unit

Navigation
"Expert" menu → Application → Concentration → Concentration unit



Parameter overview with brief description

Parameter	Prerequisite	Description	Selection / User entry	Factory setting
Concentration unit	–	Select concentration unit.	▪ °Balling ▪ °Baum (hv) ▪ °Baum (lt) ▪ °Brix ▪ °Plato	WT-%
User concentration factor	The **Coef Set 1...3** option is selected in the **Liquid type** parameter and the **User conc.** option is selected in the **Concentration unit** parameter.	With user-specific unit: Enter a factor which is multiplicated with the measured concentration value.	Signed floating-point number	1.0
User concentration offset	The **Coef Set 1...3** option is selected in the **Liquid type** parameter and the **User conc.** option is selected in the **Concentration unit** parameter.	With user-specific unit: Enter zero point shift which is added or subtracted to/from the measured concentration value.	Signed floating-point number	0

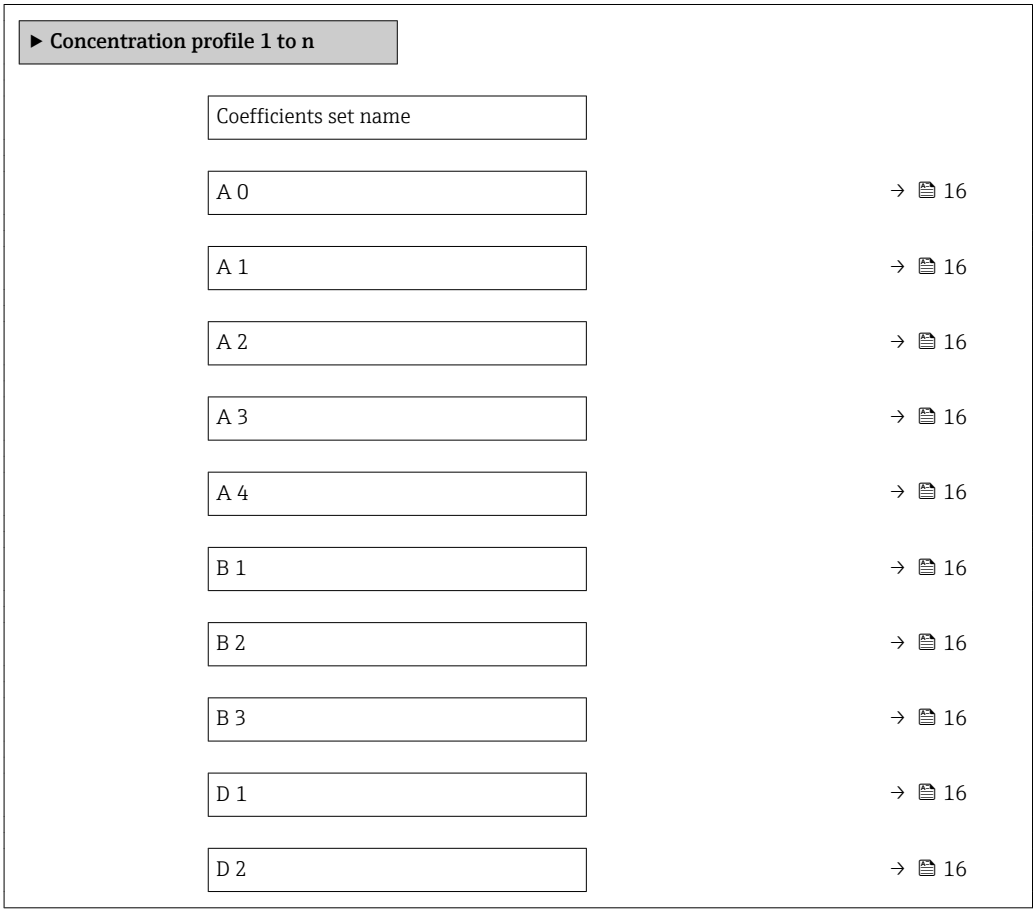
Parameter	Prerequisite	Description	Selection / User entry	Factory setting
User concentration text	The **Coef Set 1...3** option is selected in the **Liquid type** parameter and the **User conc.** option is selected in the **Concentration unit** parameter.	Enter text for the user specific unit of the concentration.		User conc.
Reference temperature	–	Enter reference temperature for calculating the reference density.	−273.15 to 99 999 °C	20 °C

3.6 Concentration coefficients

If the correlation between the concentration, density and temperature of a binary mixture is available in table form, the correlation of the variables is described by a polynomial. The relevant coefficients for the best data record are determined by FieldCare and transferred to the measuring device. Coefficients can be entered manually in the device, e.g. via Web server.

Navigation
"Setup" menu → Advanced setup → Concentration → Concentration profile 1 to n

Navigation
"Expert" menu → Application → Concentration → Concentration profile 1 to n



D 3	→ 16
D 4	→ 16

Parameter overview with brief description

Parameter	Description	User entry	Factory setting
A 0	Enter the coefficient.	Signed floating-point number	−7.2952
A 1	Enter the coefficient.	Signed floating-point number	15.1555
A 2	Enter the coefficient.	Signed floating-point number	−11.6756
A 3	Enter the coefficient.	Signed floating-point number	4.4759
A 4	Enter the coefficient.	Signed floating-point number	−0.6615
B 1	Enter the coefficient.	Signed floating-point number	0.7220 E-3
B 2	Enter the coefficient.	Signed floating-point number	38.9126 E-6
B 3	Enter the coefficient.	Signed floating-point number	−1.6739 E-9
D 1	Enter the coefficient.	Signed floating-point number	−0.0975 E-2
D 2	Enter the coefficient.	Signed floating-point number	−0.3731 E-4
D 3	Enter the coefficient.	Signed floating-point number	0.2957 E-3
D 4	Enter the coefficient.	Signed floating-point number	−0.1721 E-5

3.7 Configuring the measuring device

The following additional options are available for the outputs, the local display and the totalizer with the **Concentration** option package:
- Target mass flow
- Carrier mass flow
- Target volume flow [1)]
- Carrier volume flow [1)]
- Target standard volume flow [1)]
- Carrier standard volume flow [1)]
- Concentration [2)]

1) The availability of these measured variables depends on the mixture selected in the Liquid type parameter → 12
2) Available for the following measuring device outputs: current output, frequency output, switch output

The configuration of the measuring device outputs (current, pulse, frequency and switch output), the local display and the totalizer is described in the Operating Instructions for the device.

Operating Instructions for the measuring device → 5

4 Operation

After performing the first configuration for concentration measurement, it may be necessary to make adjustments to concentration calculations, e.g. by entering or determining the mineral content of the carrier medium water.

Before the process values and laboratory values are reconciled with one another, it is important to pay attention to the information provided in the "Unexpected concentration values and possible sources of error" section→ 🖹 55.

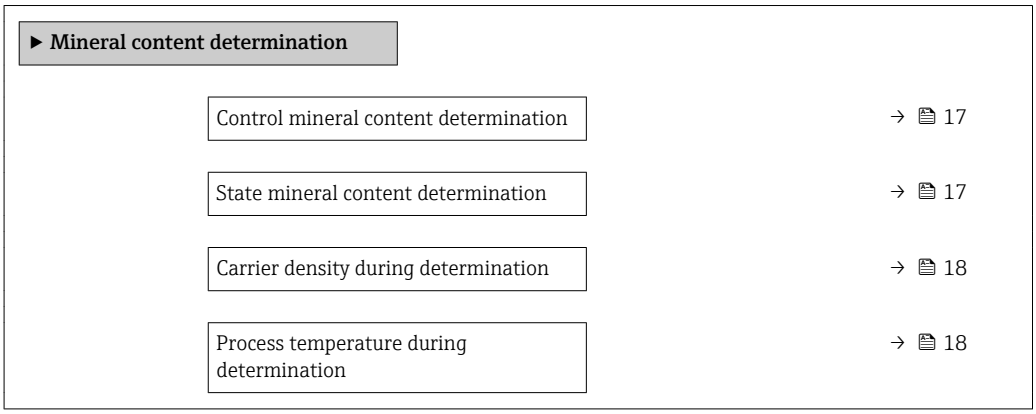
For some defined liquids, only the mineral content can be reconciled at the device level. To access the conversion of density to concentration at a deeper level, the formula for the selected mixture must first be transferred to one of the three user profiles on the basis of coefficients. This is done using FieldCare → 🖹 20.

Once the data have been adapted, the coefficients are recalculated and fed back into the device.

4.1 Determining the mineral content

Determination of the mineral content in water. This function is not available for all the predefined mixtures (see Table → 🖹 9).

Navigation
"Expert" menu → Application → Concentration → Mineral content determination



Parameter overview with brief description

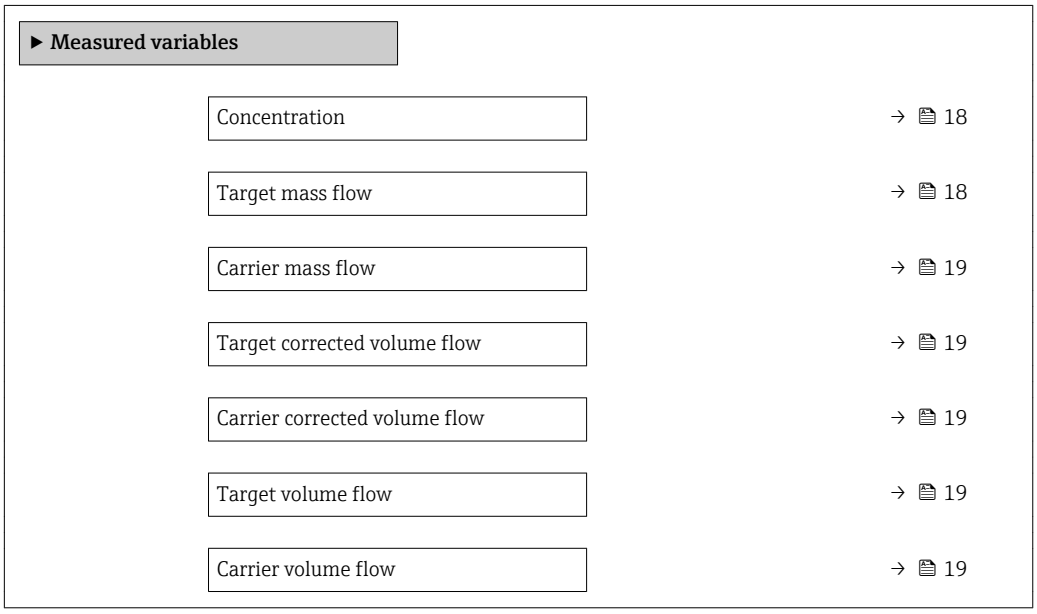
Parameter	Description	Selection / User interface	Factory setting
Control mineral content determination	Use this function to start or cancel mineral content determination. Select the **Use result** option to take the mineral content into consideration.	▪ Cancel ▪ Start ▪ Use result	Cancel
State mineral content determination	Displays the current status of mineral content determination.	▪ In progress ▪ Failed ▪ Not done ▪ Done	Not done

Parameter	Description	Selection / User interface	Factory setting
Carrier density during determination	Displays the current measured density of the water with minerals under process conditions. *Dependency* The unit is taken from the **Density unit** parameter.	Signed floating-point number	0 kg/l
Process temperature during determination	Displays the measured process temperature. *Dependency* The unit is taken from the **Temperature unit** parameter.	–273.15 to 99 726.8499 °C	–273.15 °C

4.2 Additional measured variables

Additional measured variables are available with the **Concentration** application package.

Navigation
"Diagnostics" menu → Measured values → Measured variables



Parameter overview with brief description

Parameter	Prerequisite	Description	User interface
Concentration	–	Displays the concentration currently calculated. *Dependency* The unit is taken from the **Concentration unit** parameter (→ 14).	Signed floating-point number
Target mass flow	–	Displays the mass flow currently measured for the target medium. *Dependency* The unit is taken from the **Mass flow unit** parameter.	Signed floating-point number

Parameter	Prerequisite	Description	User interface
Carrier mass flow	–	Displays the mass flow currently measured for the carrier medium. *Dependency* The unit is taken from the **Mass flow unit** parameter.	Signed floating-point number
Target corrected volume flow	With the following conditions: In the **Liquid type** parameter, the **Ethanol in water** option or **%mass / %volume** option is selected.	Displays the corrected volume flow currently measured for the target fluid. *Dependency* The unit is taken from the **Volume flow unit** parameter.	Signed floating-point number
Carrier corrected volume flow	With the following conditions: In the **Liquid type** parameter, the **Ethanol in water** option or **%mass / %volume** option is selected.	Displays the corrected volume flow currently measured for the carrier fluid. *Dependency* The unit is taken from the **Volume flow unit** parameter.	Signed floating-point number
Target volume flow	With the following conditions: ▪ The **Ethanol in water** option or **%mass / %volume** option is selected in the **Liquid type** parameter. ▪ The **%vol** option is selected in the **Concentration unit** parameter.	Displays the volume flow currently measured for the target medium. *Dependency* The unit is taken from the **Volume flow unit** parameter.	Signed floating-point number
Carrier volume flow	With the following conditions: ▪ The **Ethanol in water** option or **%mass / %volume** option is selected in the **Liquid type** parameter. ▪ The **%vol** option is selected in the **Concentration unit** parameter.	Displays the volume flow currently measured for the carrier medium. *Dependency* The unit is taken from the **Volume flow unit** parameter.	Signed floating-point number

4.3 Concentration function in FieldCare

Endress+Hauser provides a software function to calculate the concentration coefficients (A0 to A4, B1 to B3 and D1 to D4). 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 DeviceDTM 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

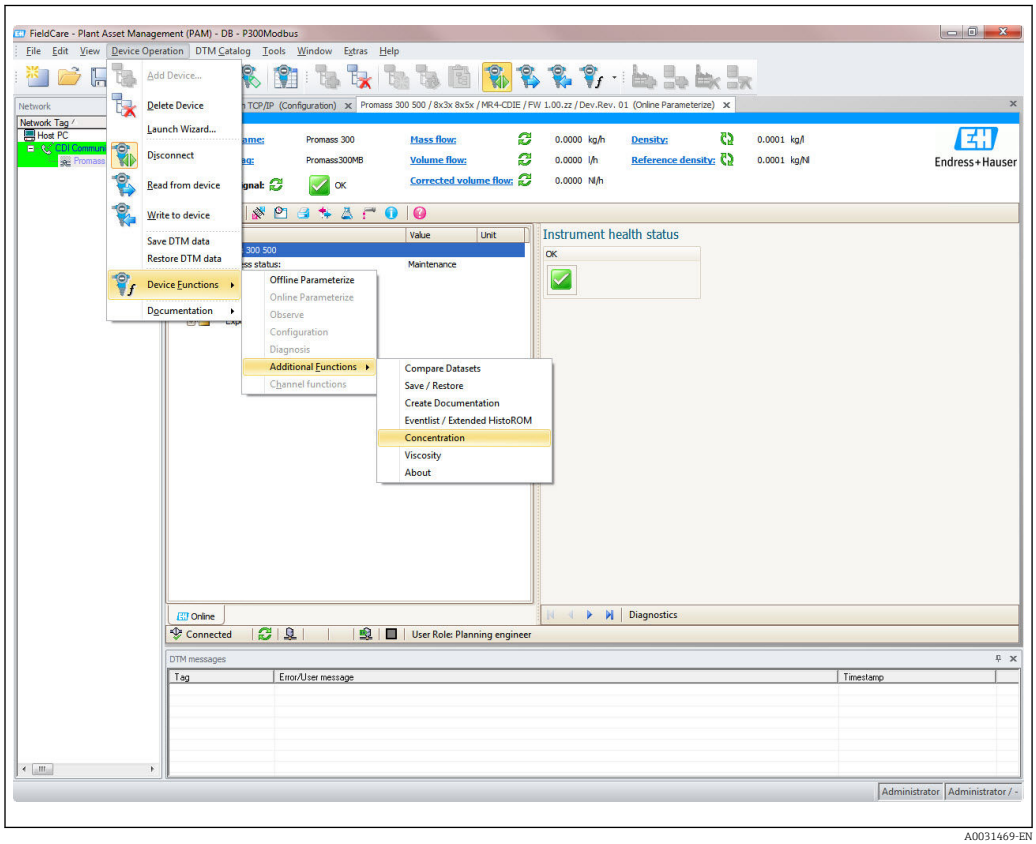
The functions, user interface and the necessary user entries are described in the following subsections.

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.

4.3.1 Starting the concentration function



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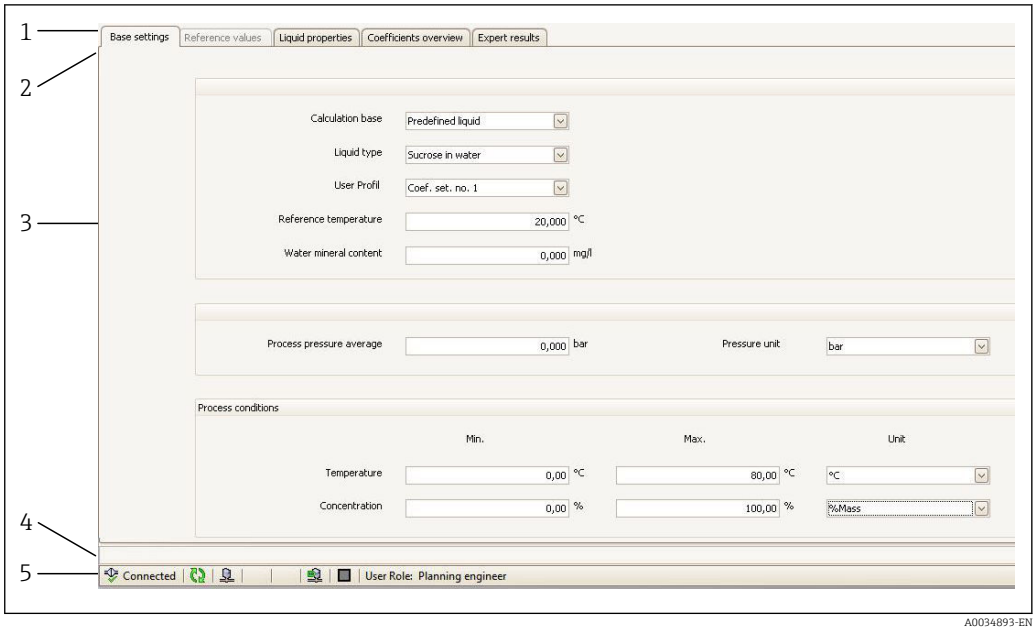
1. Open the "Device operation" menu in FieldCare.
2. Select the "Concentration" item under "Device function" and "Additional functions".

4.3.2 User interface



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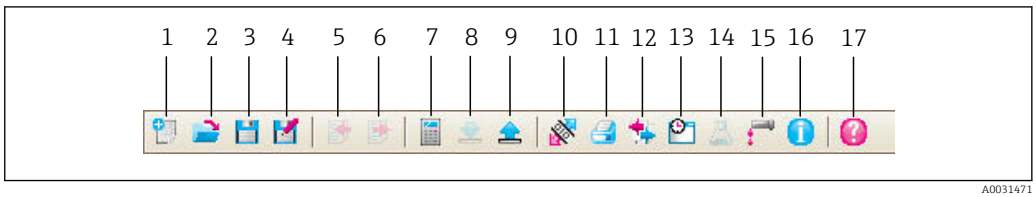
1 User interface of the concentration module

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

Title bar

DTM information about the device

Menu bar



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2 Commands in the menu bar

Position	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

Position	Name of the button	Short description	Explanation
7	Calculate	Calculate the concentration coefficients	Starts the calculation of the concentration coefficients. Pay attention to the messages in the info bar.
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.

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	▪ Fine tuning settings ▪ Liquid properties ▪ Predefined liquid
Liquid type	This function is only available if the following option was selected in the **Calculation base** function: ▪ Fine tuning settings ▪ Liquid properties	Select a defined liquid	▪ Sucrose in water ▪ Glucose in water ▪ Fructose in water ▪ Invert sugar in water ▪ HFCS42 ▪ HFCS55 ▪ HFCS90 ▪ Wort ▪ Ethanol in water ▪ Methanol in water ▪ Hydrogen peroxide in water ▪ Hydrochloric acid ▪ Sulfuric acid ▪ Nitric acid ▪ Phosphoric acid ▪ Sodium hydroxide ▪ Potassium hydroxide ▪ Ammonium nitrate in water ▪ Iron(III)chloride in water ▪ %mass / %volume
Reference temperature	This function is only available if the following option was selected in the **Liquid type** function: %mass / %volume	Enter the temperature at which the specified reference densities of the carrier and target media are valid.	
Water mineral content	This function is **not** available if the following option was selected in the **Liquid type** function: Ethanol in water	Enter the mineral content for water-based carrier media.	
User profile			▪ Coef Set ▪ Coef Set 2 ▪ Coef Set 3
Process pressure average		Displays the average process pressure value The unit depends on the option selected in the **Pressure unit** function	
Pressure unit		Select the pressure unit for indicating the process pressure average	▪ bar ▪ bar g ▪ kPa a ▪ kPa g ▪ MPa a ▪ MPa g ▪ Pa a ▪ Pa g ▪ psi a ▪ psi g
Process conditions	This function is only available if the following option was selected in the **Calculation base** function: ▪ Fine tuning settings ▪ Liquid properties and the following option was selected in the **Liquid type** function: **%mass / %volume**	Enter the min/max values for temperature and concentration and select the unit	**Temperature** ▪ °C ▪ °F ▪ K ▪ °R **Concentration** ▪ %Mass ▪ %StdVol ▪ %vol

Reference properties tab

The Liquid properties tab is only available if the following option was selected in the **Liquid** function: **%mass / %volume**

Function	Prerequisite	Description	Selection/input
Carrier type		Select the carrier type. ▪ Yes: The carrier medium is water. The density characteristic of water is determined using Kell's formula (ITS-90). ▪ No: The carrier medium is not water-based. The density characteristic can be entered in the **Calculated** field.	▪ Yes ▪ No
Reference temperature expansion	This function is only available if the following option was selected in the **Liquid type** function: **%mass / %volume**	Enter the temperature at which the specified reference densities of the carrier and target media are valid.	–273.15 to 99 999 °C
Density unit	This function is only available if the following option was selected in the **Liquid type** function: **%mass / %volume**	Select the unit for the reference density of the target medium and/or the carrier medium	▪ g/cm³ ▪ g/m³ ▪ g/ml ▪ kg/l ▪ kg/m³ ▪ lb/bbl (us;beer) ▪ lb/bbl (us;liq.) ▪ lb/bbl (us;tank) ▪ lb/ft³ ▪ SD15°C ▪ SD20°C ▪ SD4°C ▪ SG15°C ▪ SG20°C ▪ SG4°C
Carrier linear expansion coefficient	This function is only available if the following option was selected in the **Carrier type** function: **No**	Coefficient of the linear term for approximating the thermal expansion of the carrier medium.	Unit 1/K
Carrier square expansion coefficient	This function is only available if the following option was selected in the **Carrier type** function: **No**	Coefficient of the quadratic term for approximating the thermal expansion of the carrier medium.	Unit 1/K²
Carrier reference density	This function is only available if the following option was selected in the **Carrier type** function: **No**	Enter the reference density of the carrier medium. Density of the carrier medium at reference temperature if the **%mass / %volume** function is selected.	The unit depends on the option selected in the **Density unit** function
Target linear expansion coefficient		Coefficient of the linear term for approximating the thermal expansion of the target medium.	Unit 1/K

Function	Prerequisite	Description	Selection/input
Target square expansion coefficient		Coefficient of the quadratic term for approximating the thermal expansion of the target medium.	Unit $1/K^2$
Target reference density		Enter the reference density of the target medium. Density of the target medium at reference temperature for the **%mass / %volume** function	The unit depends on the option selected in the **Density unit** function

Liquid properties tab

These functions are only available if the following option was selected in the **Calculation base** function:
Liquid properties

Coefficients can be imported, calculated or exported.

Function	Prerequisite	Description	Selection/input
Input format		Select the input format. The input table changes to suit the input format selected.	▪ Matrix ▪ List
Spreadsheet		Import/export the indicated table spreadsheet in .xls format via the Import/Export button in the menu bar. If there are gaps in the table with the liquid properties, use the CTRL+C (copy) and CTRL+V (paste) function for data import. Individual data pairs can shift if the data are imported via the "Import" button or the drag-and-drop function. Identical spreadsheet names are overwritten during export.	Enter the table name of the sheet

Function	Prerequisite	Description	Selection/input
Recalculate coefficients		Pressing the **Recalculate coefficients** function confirms the entry of user-defined table values and recalculates the coefficients in the table in the tab.	–
Define liquid properties		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

These functions are only available if the following option was selected in the **Calculation base** function:
Fine tuning

The measured values of the device are optimized by entering the control measurements (reference value)

Function	Prerequisite	Description	Selection/input
Spreadsheet		Import/export the indicated table spreadsheet in .xls format via the Import/Export button in the menu bar. If there are gaps in the table with the liquid properties, use the CTRL+C (copy) and CTRL+V (paste) function for data import. Individual data pairs can shift if the data are imported via the "Import" button or the drag-and-drop function. Identical spreadsheet names are overwritten during export.	Enter the table name of the sheet
Recalculate coefficients		Pressing the **Recalculate coefficients** function confirms the entry of user-defined table values and recalculates the coefficients in the table in the tab.	–
Unit selection	This function is only available if the following option was selected in the **Calculation base** function: Liquid properties	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 ▪ D1 · 10^{-2} ≙ E–2 ▪ D2 · 10^{-3} ≙ E–3 ▪ D3 · 10^{-4} ≙ E–4 ▪ D4 · 10^{-5} ≙ E–5
Coefficients from device	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 ▪ Entry of individual coefficients	

Expert results tab

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

Info bar

Information about the current processes and error messages.

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

Status bar

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

4.3.3 Calculation base: "Defined liquids"

Simple calculation method for predefined liquids.

Table of liquids that are predefined in the measuring device: → 9

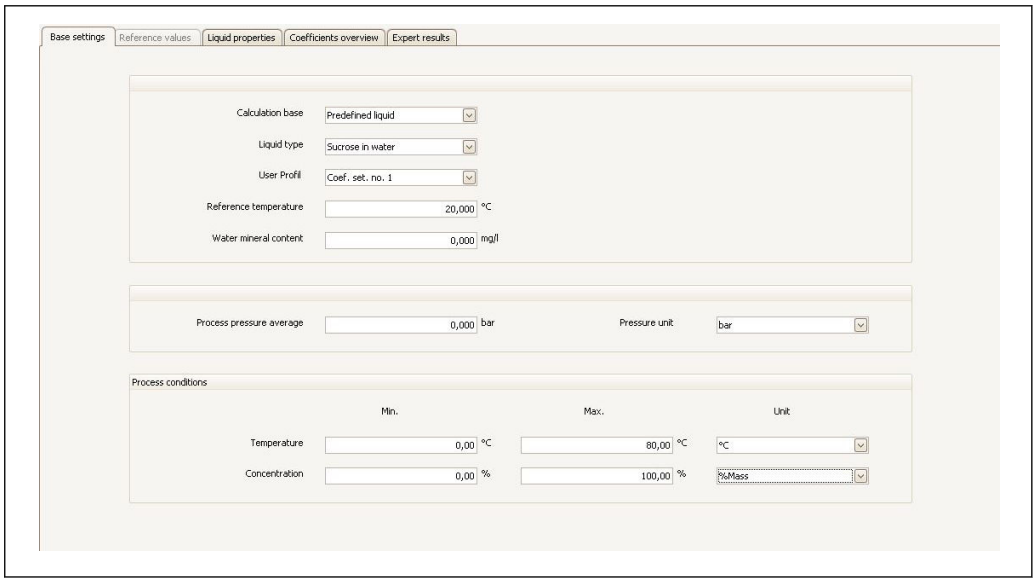
The table provides an overview of the liquids predefined in the measuring device with regard to:
- Available units
- Temperature and measuring ranges
- Sources used for calculation,
- Consideration of mineral content reconciliation
- Influence of pressure on density measurement

Calculation of coefficients for predefined liquids

Requirements

▶ Clarify information about the fluid:
  ↳ Can the indicated calculation sources (→ 9) be used for the medium?
  Is the process temperature within the permitted min./max. temperature range?

Calculation of coefficients for defined liquids



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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 %.

Specify the mineral content of the water.

1. Select the **Base settings** tab
2. In the **Calculation base** function select the following option: Predefined liquids
3. In the **Liquid type** function select a solution
4. In the **Water mineral content** function enter a value

5. 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
6. Click the **Calculate** button in the menu bar
   ↳ Pay attention to the information in the info bar
7. The calculated coefficients are displayed in the **Coefficients overview** tab.
8. The numerical uncertainty is graphically represented in the **Expert results** tab.
9. In the **Sensor** function select a sensor
   ↳ In the **Density adjustment** function, enter special density calibration if applicable (optionally available)
   The Field density adjustment option can also be selected.
10. Click the **Write** button in the menu bar
    ↳ The calculated, optimized concentration coefficients are written to the device or FieldCare

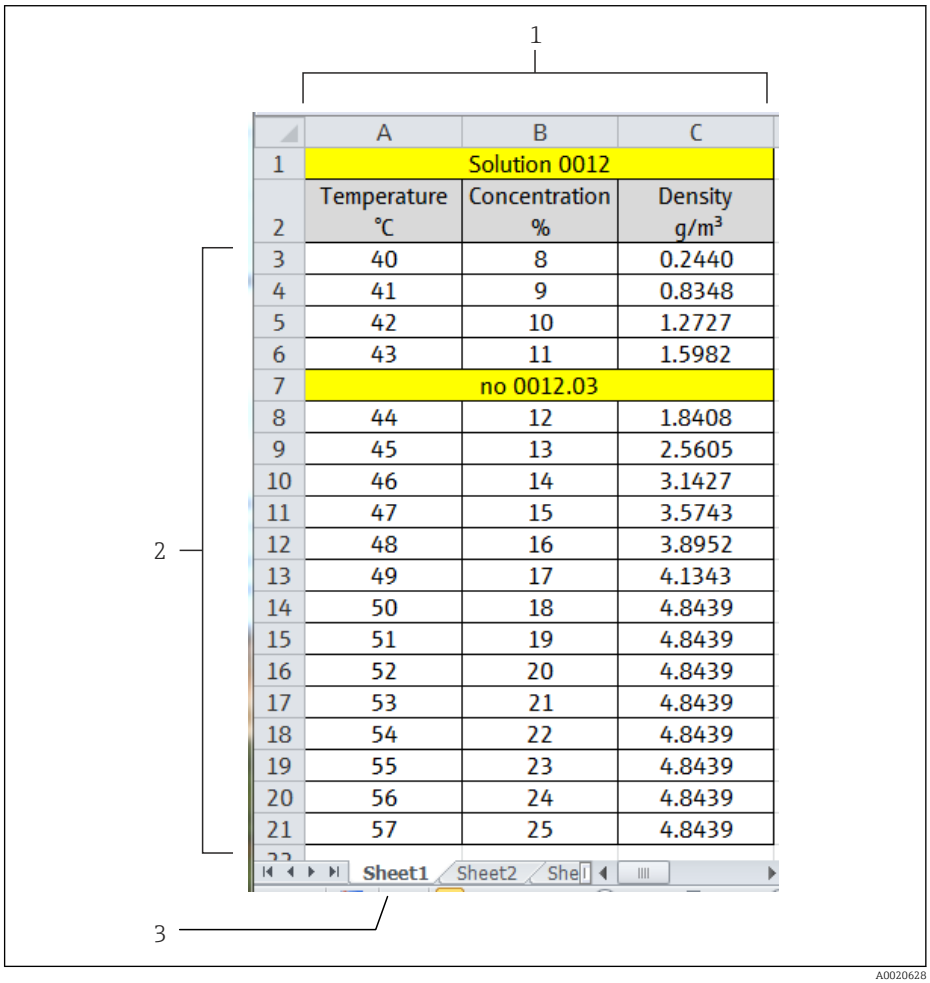
4.3.4 Calculation base: "Liquid properties"

Calculation method for user-defined liquids

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 15 (3 columns only in the following order: temperature, concentration, density, and with at least 15 rows)
   Decimal separator: period
   Import format: xls

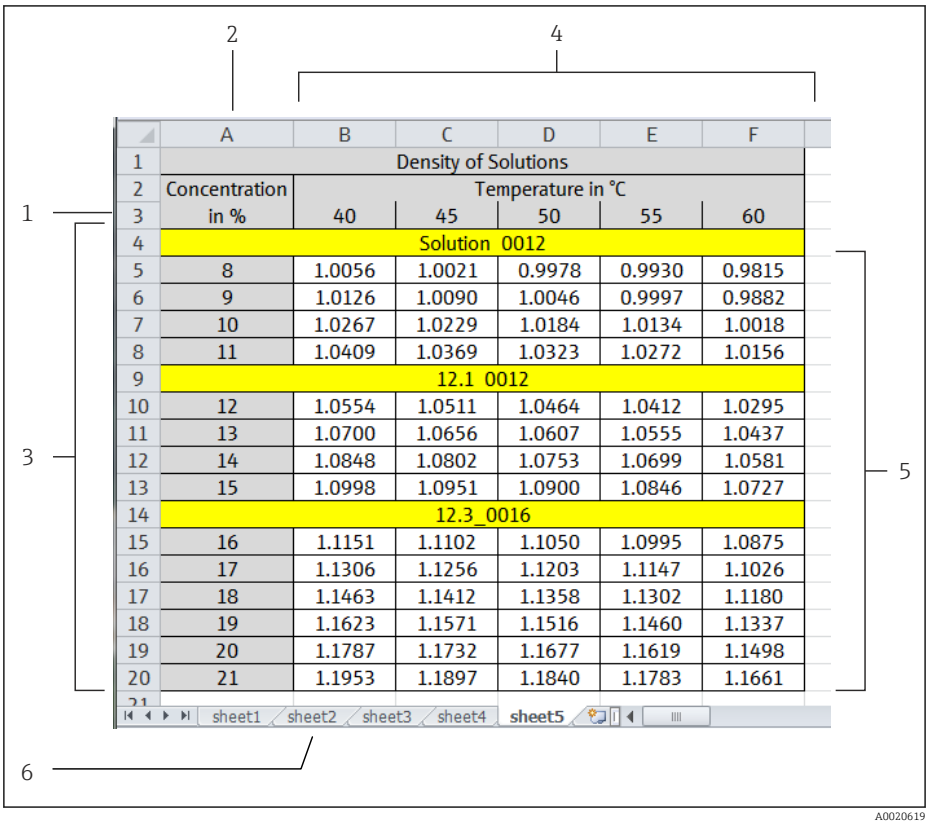


	A	B	C
1	Solution 0012		
2	Temperature °C	Concentration %	Density g/m³
3	40	8	0.2440
4	41	9	0.8348
5	42	10	1.2727
6	43	11	1.5982
7	no 0012.03		
8	44	12	1.8408
9	45	13	2.5605
10	46	14	3.1427
11	47	15	3.5743
12	48	16	3.8952
13	49	17	4.1343
14	50	18	4.8439
15	51	19	4.8439
16	52	20	4.8439
17	53	21	4.8439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

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 15 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 15 values (concentration X temperature or vice versa)
   Decimal separator: period
   Import format: xls



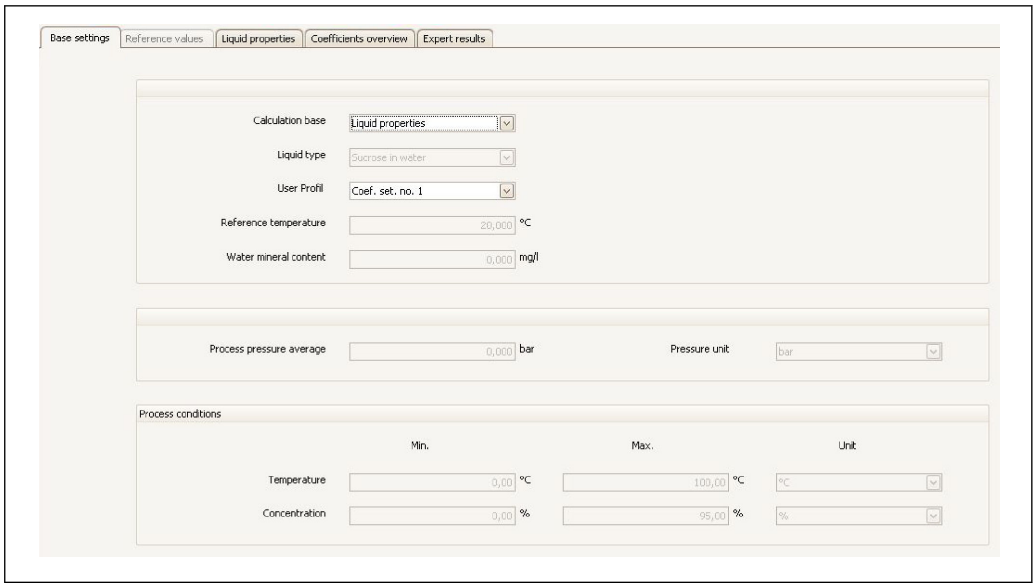
	A	B	C	D	E	F
1	Density of Solutions					
2	Concentration	Temperature in °C				
3	in %	40	45	50	55	60
4	Solution 0012					
5	8	1.0056	1.0021	0.9978	0.9930	0.9815
6	9	1.0126	1.0090	1.0046	0.9997	0.9882
7	10	1.0267	1.0229	1.0184	1.0134	1.0018
8	11	1.0409	1.0369	1.0323	1.0272	1.0156
9	12.1 0012					
10	12	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 → 🖹 8



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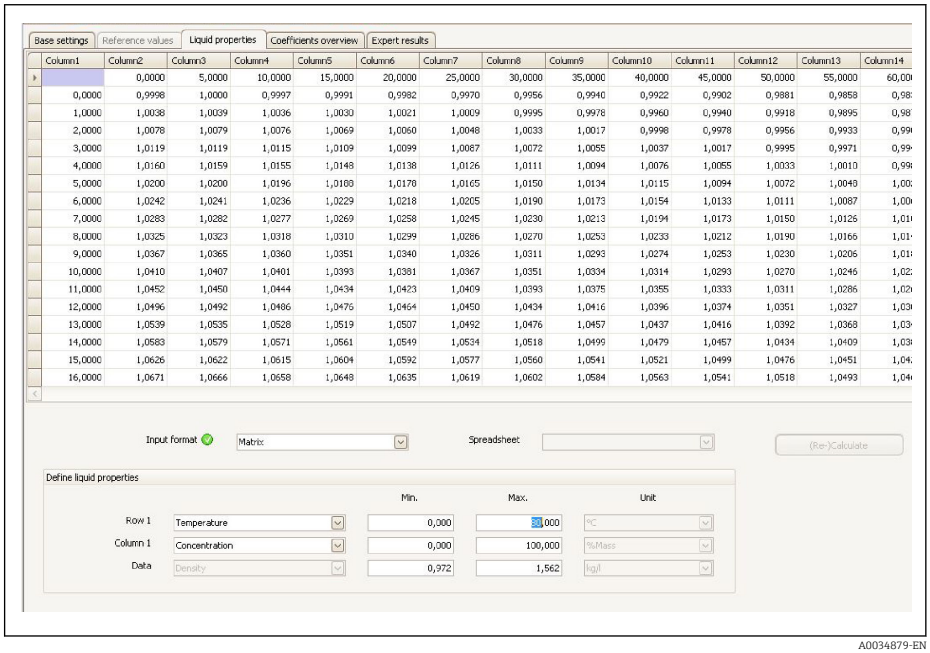
1. Select the **Base settings** tab
2. In the **Calculation base** function select the **Liquid properties** option
3. Select the Liquid properties tab



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4. In the **Input format** function, select list or matrix
5. Enter the density values as a function of the concentration and temperature
6. Select the temperature or concentration in the **Operating range** field in the **Row 1** or **Column 1** function
7. For temperature, concentration and density, enter the min/max range and select the unit

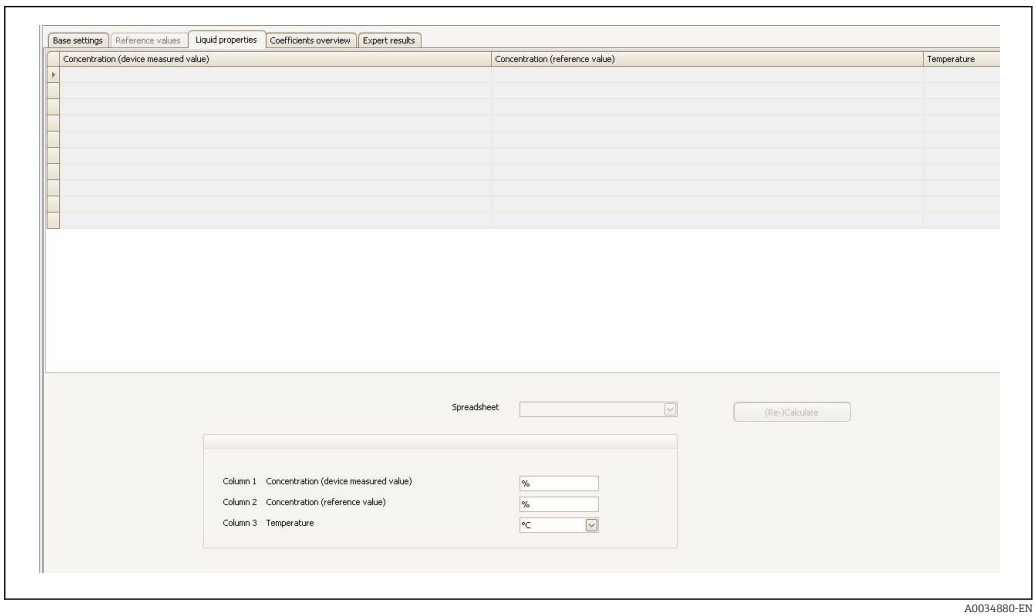
8. If the values should be imported from a table:
   ↳ Click the **Import** button in the menu bar.
   Select the file in .xls (Excel) format and import it.
   Pay attention to the information in the info bar

If there are gaps in the table with the liquid properties, use the CTRL+C (copy) and CTRL+V (paste) function for data import. Individual data pairs can shift if the data are imported via the "Import" button or the drag-and-drop function.

9. Press the **Recalculate coefficients** button to confirm your entries and recalculate the coefficients.
   ↳ Pay attention to the information in the info bar
10. The calculated coefficients are displayed and adjusted in the **Coefficients overview** tab
11. The numerical uncertainty is graphically represented in the **Expert results** tab.
12. In the **Sensor** function select a sensor
    ↳ In the **Density adjustment** function, enter special density calibration if applicable (optionally available)
    The Field density adjustment option can also be selected.
13. Click the **Write** button in the menu bar
    ↳ The calculated, optimized concentration coefficients are written to the device or FieldCare

4.3.5 "Fine-tuning" calculation base

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 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.



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Requirements

1. At least 11 concentration values from the measuring device (device measured value).
2. At least 11 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. Press the **Recalculate coefficients** button to confirm your entries and recalculate the coefficients.
   ↳ Pay attention to the information in the info bar
6. The calculated coefficients are displayed and adjusted in the **Coefficients overview** tab
7. The numerical uncertainty is graphically represented in the **Expert results** tab.

8. In the **Sensor** function select a sensor
   ↳ In the **Density adjustment** function, enter special density calibration if applicable (optionally available)
   The Field density adjustment option can also be selected.
9. Click the **Write** button in the menu bar
   ↳ The calculated, optimized concentration coefficients are written to the device or FieldCare

4.3.6 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.
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.

5 Concentration function in FieldCare

Endress+Hauser provides a software function to calculate the concentration coefficients (A0 to A4, B1 to B3 and D1 to D4). 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 DeviceDTM 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

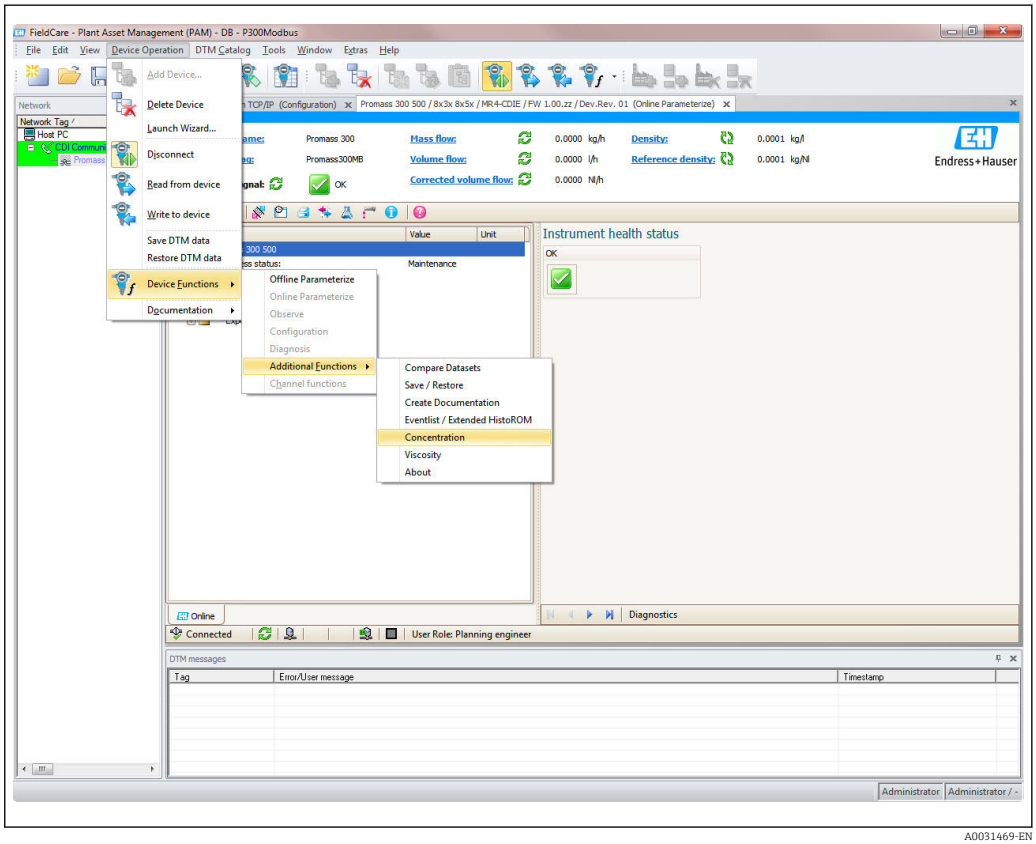
The functions, user interface and the necessary user entries are described in the following subsections.

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



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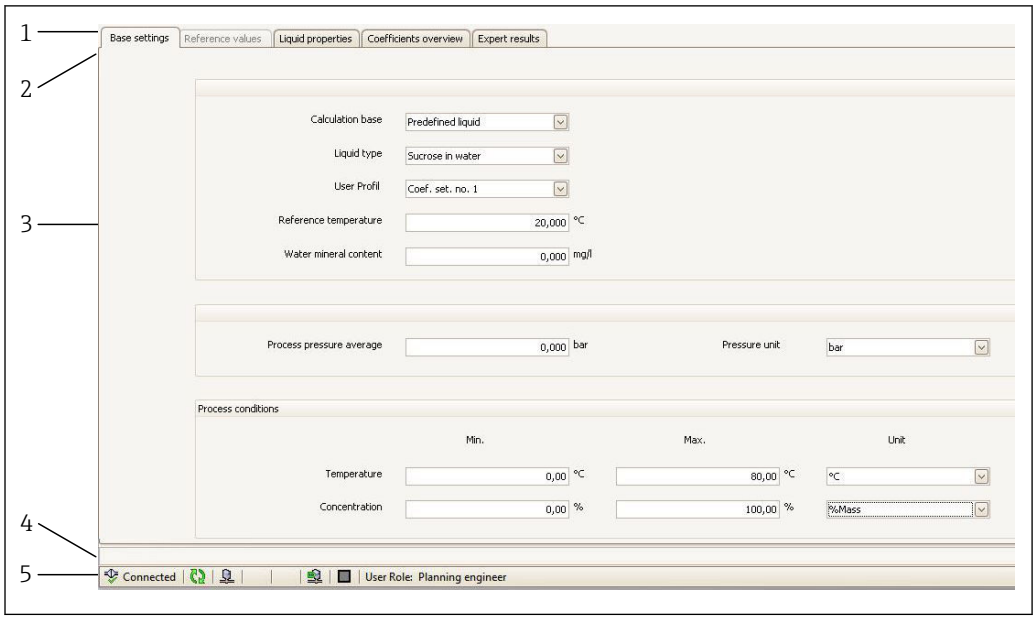
1. Open the "Device operation" menu in FieldCare.
2. Select the "Concentration" item under "Device function" and "Additional functions".

5.2 User interface



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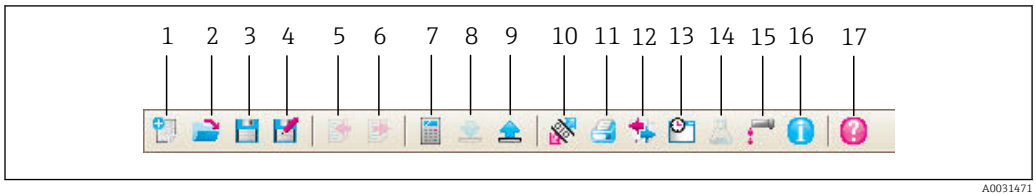
5 User interface of the concentration module

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



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6 Commands in the menu bar

Position	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

Position	Name of the button	Short description	Explanation
7	Calculate	Calculate the concentration coefficients	Starts the calculation of the concentration coefficients. Pay attention to the messages in the info bar.
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	▪ Fine tuning settings ▪ Liquid properties ▪ Predefined liquid
Liquid type	This function is only available if the following option was selected in the **Calculation base** function: ▪ Fine tuning settings ▪ Liquid properties	Select a defined liquid	▪ Sucrose in water ▪ Glucose in water ▪ Fructose in water ▪ Invert sugar in water ▪ HFCS42 ▪ HFCS55 ▪ HFCS90 ▪ Wort ▪ Ethanol in water ▪ Methanol in water ▪ Hydrogen peroxide in water ▪ Hydrochloric acid ▪ Sulfuric acid ▪ Nitric acid ▪ Phosphoric acid ▪ Sodium hydroxide ▪ Potassium hydroxide ▪ Ammonium nitrate in water ▪ Iron(III)chloride in water ▪ %mass / %volume
Reference temperature	This function is only available if the following option was selected in the **Liquid type** function: %mass / %volume	Enter the temperature at which the specified reference densities of the carrier and target media are valid.	
Water mineral content	This function is **not** available if the following option was selected in the **Liquid type** function: Ethanol in water	Enter the mineral content for water-based carrier media.	
User profile			▪ Coef Set ▪ Coef Set 2 ▪ Coef Set 3
Process pressure average		Displays the average process pressure value The unit depends on the option selected in the **Pressure unit** function	
Pressure unit		Select the pressure unit for indicating the process pressure average	▪ bar ▪ bar g ▪ kPa a ▪ kPa g ▪ MPa a ▪ MPa g ▪ Pa a ▪ Pa g ▪ psi a ▪ psi g
Process conditions	This function is only available if the following option was selected in the **Calculation base** function: ▪ Fine tuning settings ▪ Liquid properties and the following option was selected in the **Liquid type** function: **%mass / %volume**	Enter the min/max values for temperature and concentration and select the unit	**Temperature** ▪ °C ▪ °F ▪ K ▪ °R **Concentration** ▪ %Mass ▪ %StdVol ▪ %vol

Reference properties tab

The Liquid properties tab is only available if the following option was selected in the **Liquid** function: **%mass / %volume**

Function	Prerequisite	Description	Selection/input
Carrier type		Select the carrier type. ▪ Yes: The carrier medium is water. The density characteristic of water is determined using Kell's formula (ITS-90). ▪ No: The carrier medium is not water-based. The density characteristic can be entered in the **Calculated** field.	▪ Yes ▪ No
Reference temperature expansion	This function is only available if the following option was selected in the **Liquid type** function: **%mass / %volume**	Enter the temperature at which the specified reference densities of the carrier and target media are valid.	–273.15 to 99 999 °C
Density unit	This function is only available if the following option was selected in the **Liquid type** function: **%mass / %volume**	Select the unit for the reference density of the target medium and/or the carrier medium	▪ g/cm³ ▪ g/m³ ▪ g/ml ▪ kg/l ▪ kg/m³ ▪ lb/bbl (us;beer) ▪ lb/bbl (us;liq.) ▪ lb/bbl (us;tank) ▪ lb/ft³ ▪ SD15°C ▪ SD20°C ▪ SD4°C ▪ SG15°C ▪ SG20°C ▪ SG4°C
Carrier linear expansion coefficient	This function is only available if the following option was selected in the **Carrier type** function: **No**	Coefficient of the linear term for approximating the thermal expansion of the carrier medium.	Unit 1/K
Carrier square expansion coefficient	This function is only available if the following option was selected in the **Carrier type** function: **No**	Coefficient of the quadratic term for approximating the thermal expansion of the carrier medium.	Unit 1/K²
Carrier reference density	This function is only available if the following option was selected in the **Carrier type** function: **No**	Enter the reference density of the carrier medium. Density of the carrier medium at reference temperature if the **%mass / %volume** function is selected.	The unit depends on the option selected in the **Density unit** function
Target linear expansion coefficient		Coefficient of the linear term for approximating the thermal expansion of the target medium.	Unit 1/K

Function	Prerequisite	Description	Selection/input
Target square expansion coefficient		Coefficient of the quadratic term for approximating the thermal expansion of the target medium.	Unit $1/K^2$
Target reference density		Enter the reference density of the target medium. Density of the target medium at reference temperature for the **%mass / %volume** function	The unit depends on the option selected in the **Density unit** function

Liquid properties tab

These functions are only available if the following option was selected in the **Calculation base** function:
Liquid properties

Coefficients can be imported, calculated or exported.

Function	Prerequisite	Description	Selection/input
Input format		Select the input format. The input table changes to suit the input format selected.	▪ Matrix ▪ List
Spreadsheet		Import/export the indicated table spreadsheet in .xls format via the Import/Export button in the menu bar. If there are gaps in the table with the liquid properties, use the CTRL+C (copy) and CTRL+V (paste) function for data import. Individual data pairs can shift if the data are imported via the "Import" button or the drag-and-drop function. Identical spreadsheet names are overwritten during export.	Enter the table name of the sheet

Function	Prerequisite	Description	Selection/input
Recalculate coefficients		Pressing the **Recalculate coefficients** function confirms the entry of user-defined table values and recalculates the coefficients in the table in the tab.	–
Define liquid properties		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

These functions are only available if the following option was selected in the **Calculation base** function:
Fine tuning

The measured values of the device are optimized by entering the control measurements (reference value)

Function	Prerequisite	Description	Selection/input
Spreadsheet		Import/export the indicated table spreadsheet in .xls format via the Import/Export button in the menu bar. If there are gaps in the table with the liquid properties, use the CTRL+C (copy) and CTRL+V (paste) function for data import. Individual data pairs can shift if the data are imported via the "Import" button or the drag-and-drop function. Identical spreadsheet names are overwritten during export.	Enter the table name of the sheet
Recalculate coefficients		Pressing the **Recalculate coefficients** function confirms the entry of user-defined table values and recalculates the coefficients in the table in the tab.	–
Unit selection	This function is only available if the following option was selected in the **Calculation base** function: Liquid properties	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 ▪ D1 · 10^{-2} ≙ E–2 ▪ D2 · 10^{-3} ≙ E–3 ▪ D3 · 10^{-4} ≙ E–4 ▪ D4 · 10^{-5} ≙ E–5
Coefficients from device	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 ▪ Entry of individual coefficients	

Expert results tab

Graphic representation of the measured errors as a function of the sensor, 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.

Table of liquids that are predefined in the measuring device: → 9

The table provides an overview of the liquids predefined in the measuring device with regard to:

- Available units
- Temperature and measuring ranges
- Sources used for calculation,
- Consideration of mineral content reconciliation
- Influence of pressure on density measurement

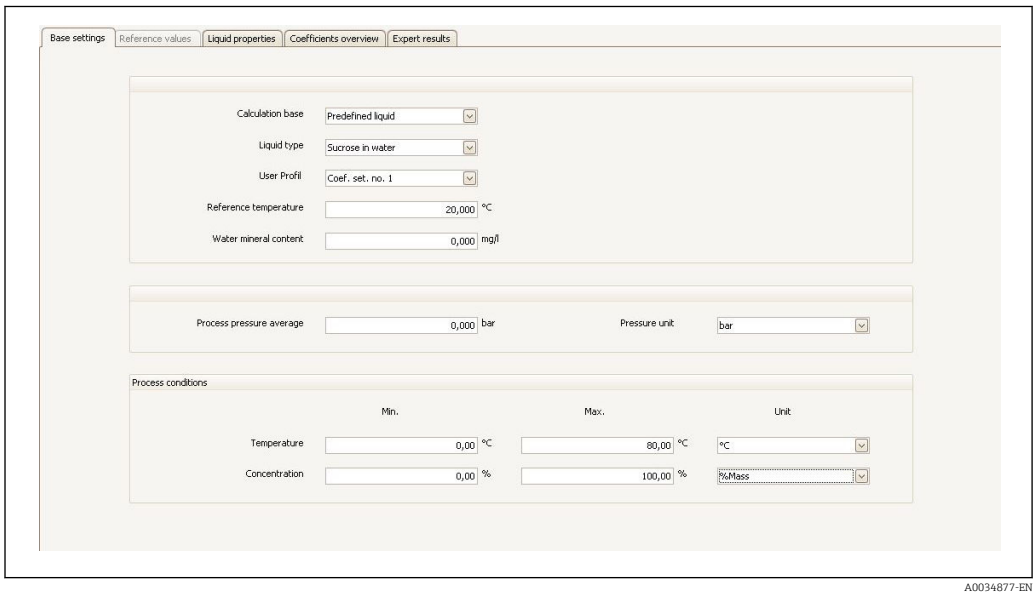
5.3.1 Calculation of coefficients for predefined liquids

Requirements

▶ Clarify information about the fluid:

↳ Can the indicated calculation sources (→ 9) be used for the medium?
Is the process temperature within the permitted min./max. temperature range?

Calculation of coefficients for defined liquids



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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 %.

Specify the mineral content of the water.

1. Select the **Base settings** tab
2. In the **Calculation base** function select the following option: Predefined liquids
3. In the **Liquid type** function select a solution
4. In the **Water mineral content** function enter a value

5. 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
6. Click the **Calculate** button in the menu bar
   ↳ Pay attention to the information in the info bar
7. The calculated coefficients are displayed in the **Coefficients overview** tab.
8. The numerical uncertainty is graphically represented in the **Expert results** tab.
9. In the **Sensor** function select a sensor
   ↳ In the **Density adjustment** function, enter special density calibration if applicable (optionally available)
   The Field density adjustment option can also be selected.
10. Click the **Write** button in the menu bar
    ↳ The calculated, optimized concentration coefficients are written to the device or FieldCare

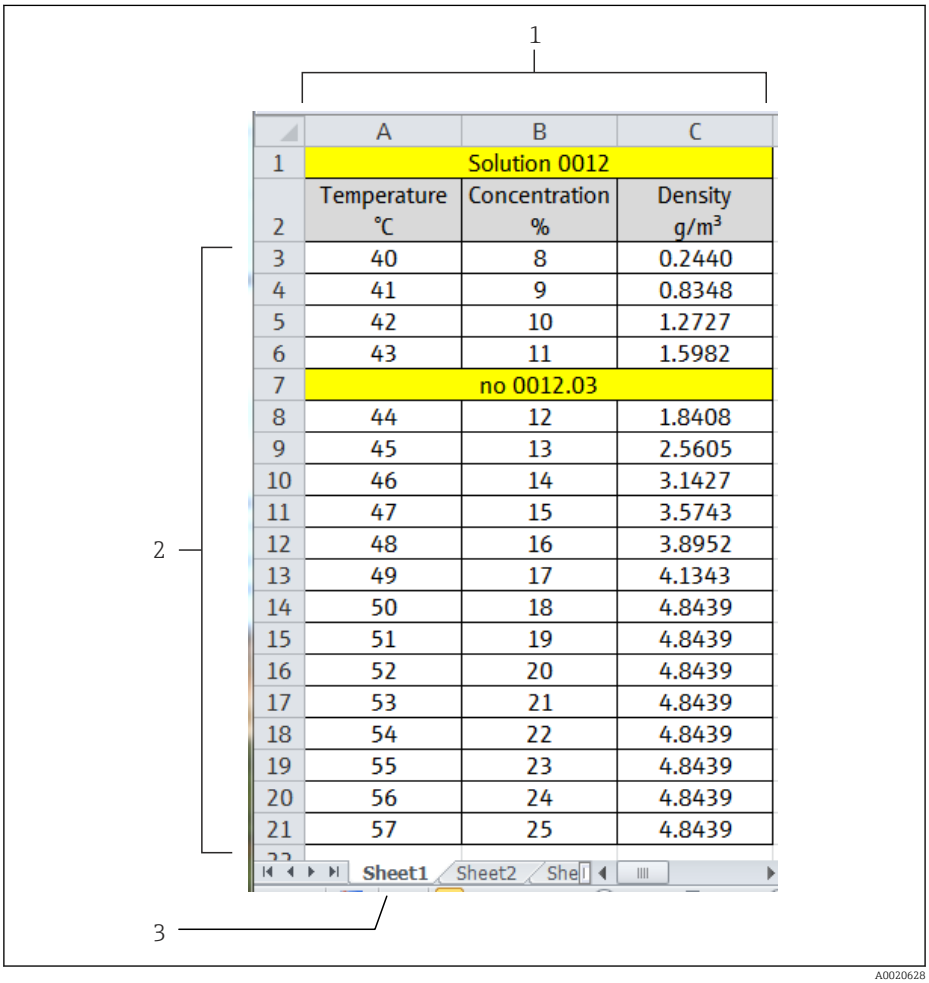
5.4 Calculation base: "Liquid properties"

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 15 (3 columns only in the following order: temperature, concentration, density, and with at least 15 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

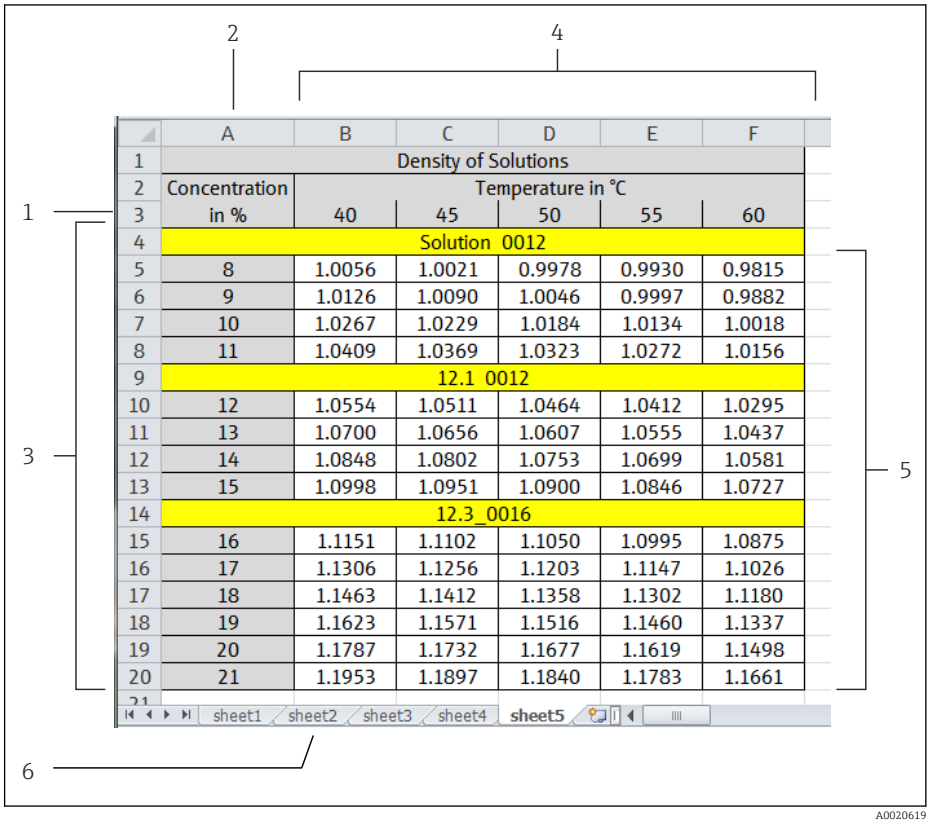
7 *Example of a table in the list input format*

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 15 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 15 values (concentration X temperature or vice versa)
   Decimal separator: period
   Import format: xls



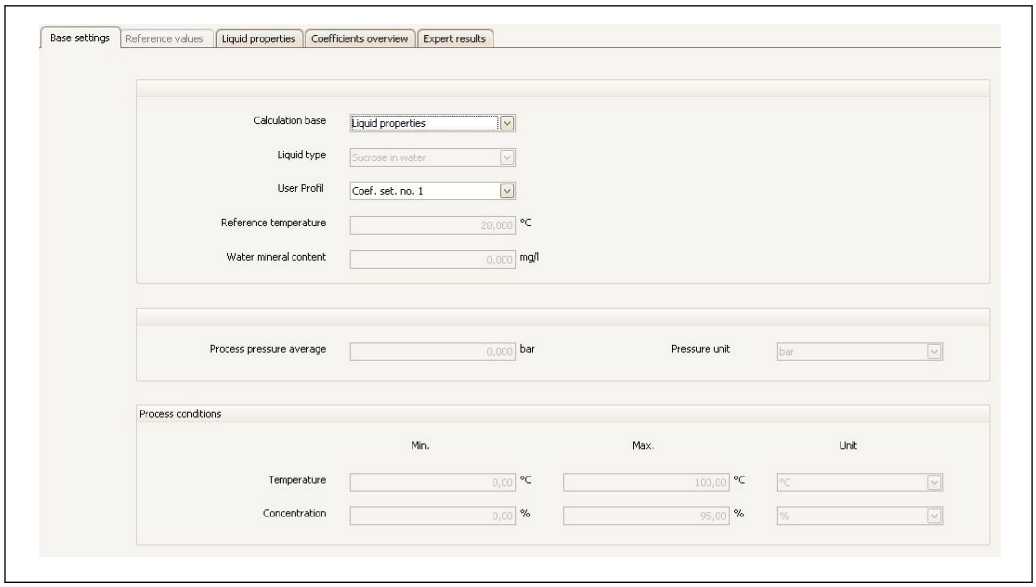
	A	B	C	D	E	F
1	Density of Solutions					
2	Concentration	Temperature in °C				
3	in %	40	45	50	55	60
4	Solution 0012					
5	8	1.0056	1.0021	0.9978	0.9930	0.9815
6	9	1.0126	1.0090	1.0046	0.9997	0.9882
7	10	1.0267	1.0229	1.0184	1.0134	1.0018
8	11	1.0409	1.0369	1.0323	1.0272	1.0156
9	12.1 0012					
10	12	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

8 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 → 8



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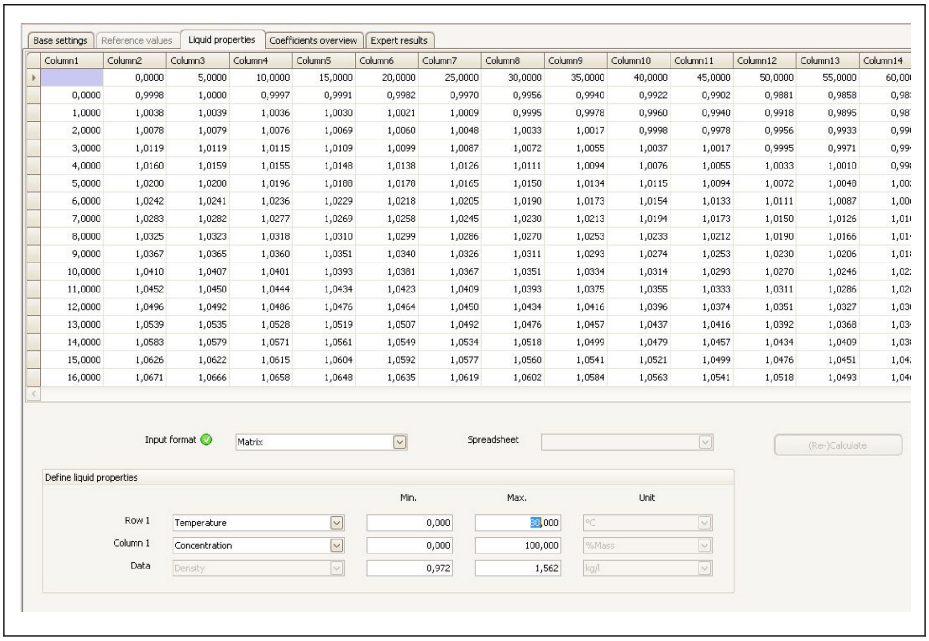
1. Select the **Base settings** tab
2. In the **Calculation base** function select the **Liquid properties** option
3. Select the Liquid properties tab



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4. In the **Input format** function, select list or matrix
5. Enter the density values as a function of the concentration and temperature
6. Select the temperature or concentration in the **Operating range** field in the **Row 1** or **Column 1** function
7. For temperature, concentration and density, enter the min/max range and select the unit

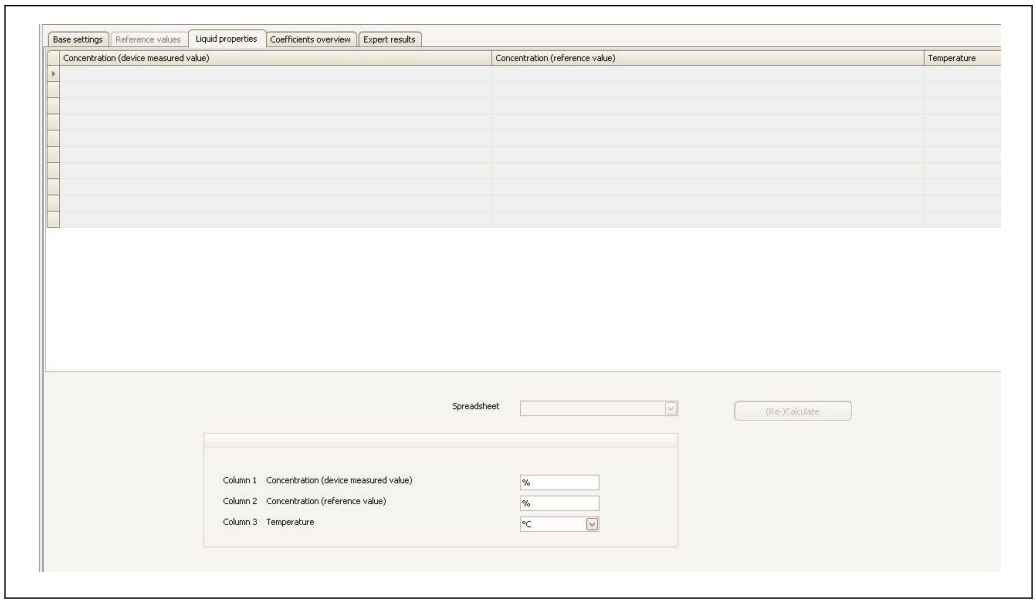
8. If the values should be imported from a table:
   ↳ Click the **Import** button in the menu bar.
   Select the file in .xls (Excel) format and import it.
   Pay attention to the information in the info bar

If there are gaps in the table with the liquid properties, use the CTRL+C (copy) and CTRL+V (paste) function for data import. Individual data pairs can shift if the data are imported via the "Import" button or the drag-and-drop function.

9. Press the **Recalculate coefficients** button to confirm your entries and recalculate the coefficients.
   ↳ Pay attention to the information in the info bar
10. The calculated coefficients are displayed and adjusted in the **Coefficients overview** tab
11. The numerical uncertainty is graphically represented in the **Expert results** tab.
12. In the **Sensor** function select a sensor
    ↳ In the **Density adjustment** function, enter special density calibration if applicable (optionally available)
    The Field density adjustment option can also be selected.
13. Click the **Write** button in the menu bar
    ↳ The calculated, optimized concentration coefficients are written to the device or FieldCare

5.5 "Fine-tuning" calculation base

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 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.



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Requirements

1. At least 11 concentration values from the measuring device (device measured value).
2. At least 11 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. Press the **Recalculate coefficients** button to confirm your entries and recalculate the coefficients.
   ↳ Pay attention to the information in the info bar
6. The calculated coefficients are displayed and adjusted in the **Coefficients overview** tab
7. The numerical uncertainty is graphically represented in the **Expert results** tab.

8. In the **Sensor** function select a sensor
   ↳ In the **Density adjustment** function, enter special density calibration if applicable (optionally available)
   The Field density adjustment option can also be selected.
9. Click the **Write** button in the menu bar
   ↳ The calculated, optimized concentration coefficients are written to the device or FieldCare

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.
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

In addition to measuring the mass flow and the temperature, a Coriolis flowmeter also measures the density of the medium in the measuring tube.

The density value is used to convert the mass flow to volume flow.

Density as a quality parameter: under defined ambient conditions (pressure, temperature) a pure medium has a precisely defined density. In the case of mixtures containing 2 media (binary mixtures), the concentration of the target medium in the carrier medium (e.g. water) can be determined from the density.

This process of converting density to concentration, while taking temperature into account, is performed using the "application package" for Promass.

6.1 Calculating the concentration from density and temperature

The dependency between concentration, density and temperature is substance-specific and must therefore be saved in the device.

A number of common mixtures are already preconfigured in the device, including various water-based sugar solutions, alcohol/water blends and various salts, acids and alkalis → 29. In addition, it is also possible to define the correlation between the concentration, temperature and density of any mixture in a table. This table can be created directly in the Endress+Hauser Fieldcare tool or be imported into Fieldcare in .xls format. A polynomial is used to approximate the values in the table. The coefficients determined by Fieldcare in this way can then be transferred to the measuring device → 31.

To ensure the concentration is determined correctly, ensure that the units in the table match the units in FieldCare and in the measuring device.

6.2 Concentration measurement accuracy

The accuracy of the process of determining the concentration depends on a number of parameters:
- Density accuracy
- Temperature accuracy
- Quality of the approximation to determine the concentration from the density and temperature

The standard deviations for the concentration calculations of predefined fluids are provided on → 29. If the concentration is determined on the basis of a table, this table should contain a particularly large number of high-quality values for the relevant measuring range. In addition, the value range for determining the coefficients should be defined as narrowly as possible, as this improves the quality of the approximation.

The best density accuracy is achieved with the optional special density calibration (wide-range density specification).

Promass Q sensors enable highly accurate density measurement without a special calibration.

The maximum deviation that can be expected during the concentration measurement can be visualized in FieldCare → 20.

6.3 Unexpected concentration values and possible sources of error

Unexpected concentration values can occur depending on the application. Such deviations are often revealed by comparing the concentration values against laboratory values, and can be caused by a number of factors.

The reason for the deviations should be checked, and rectified where applicable, before the measured values of the process device are adjusted to match laboratory values by adjusting or adapting the data via the fine-tuning function (→ 35).

Reasons for deviations in density measurement and remedial action

<table>
<tr><th>Possible reasons</th><th>Remedial measures</th></tr>
<tr><td>▪ The concentration measurement is conducted under different conditions in the process and the laboratory.
▪ Density measurements are conducted under different conditions in the process and the laboratory.</td><td>As density depends on temperature, the measurement must be taken at process temperature or the temperature dependency must be factored in accordingly.</td></tr>
<tr><td>Abrasion, corrosion or formation of buildup.</td><td>▪ Remove deposit buildup.
▪ In the event of abrasion or corrosion, check whether the material is compatible under process conditions.
Activate the Heartbeat Technology application package. Systematic errors caused by process influences, such as abrasion, corrosion or buildup, can be detected clearly without any ambiguity at an early stage with this application package.</td></tr>
<tr><td rowspan="5">▪ Error during field density adjustment or incorrectly configured concentration or density offset.
▪ Deposit buildup in the measuring tube: cleaning has not been performed.</td><td>▪ Ensure representative and stable process conditions during field adjustment.
▪ Intact measuring tube without deposit buildup, abrasion or corrosion.
▪ No air pockets that interfere with the measurement.
▪ Perform cleaning to remove the deposit buildup in the measuring tube.
▪ Factor in dependencies during density adjustment as indicated in the following table.</td></tr>
<tr><td>Influence of density adjustment or offset parameters on various output parameters.
☑= influence; ☒ = no influence.</td></tr>
<tr><td>
<table>
<tr><th></th><th>Density</th><th>Volume flow</th><th>Concentration</th></tr>
<tr><td>Execute density adjustment</td><td>☑</td><td>☑</td><td>☑</td></tr>
<tr><td>Density adjustment offset</td><td>☑</td><td>☒</td><td>☒</td></tr>
<tr><td>User concentration offset</td><td>☒</td><td>☒</td><td>☑</td></tr>
</table>
</td></tr>
<tr><td>Sample is not representative
▪ Sampling point was not near the measuring device
▪ Sample was not measured or analyzed swiftly in the laboratory
▪ Samples are contaminated
▪ Sedimentation</td><td>▪ Choose a sampling point as close as possible to the measuring device
▪ Measure and/or analyze the samples promptly in the laboratory
▪ Follow the basic rules for the prevention of contamination
▪ Ensure a sufficient suspension or slurry is maintained in the medium</td></tr>
<tr><td>The model for concentration measurement is not designed for the fluid mixture
▪ The fluid mixture is not a binary mixture
e.g. non-demineralized water was used or the density measurement was not corrected to factor in the mineral content
▪ Mixture modules are used for mixtures that are not described correctly
Brix: Models designed for sucrose and demineralized water are used as the model for syrup or diet beverages
▪ A different method is used in the laboratory to determine the concentration</td><td>▪ Use binary mixtures
▪ Adjust models for incorrectly described mixtures accordingly
▪ Agree on the method used for determining the concentration in the laboratory and field
e.g. refractometry</td></tr>
</table>

6.4 Application examples

6.4.1 Sugar solution and syrup

Media that can be selected in the measuring device
The user can choose from the following media in the **Liquid type** parameter:
- Sucrose in water
- Glucose in water
- Fructose in water
- Invert sugar in water
- Corn syrup HFCS42
- Corn syrup HFCS55
- Corn syrup HFCS90

Units
The following units are available in the **Concentration unit** parameter for measuring the concentration of water-based sugar solutions:
- %Mass
- °Brix

The concentration of the water-based sugar solutions is measured according to ICUMSA standard SPS-4 (1998). In accordance with the ICUMSA definition, the unit °Brix is only offered for water-based sucrose solutions and, in numerical terms, corresponds to the value in %mass.

The dry mass (%mass) of the corn syrup versions is determined based on table values provided in the literature (ref. XY), which were fitted with the approximation formula for coefficient determination.

Concentration measurement of water-based sugar solutions

1. In the **Assign current output** parameter in the Setup → Current output 1 to n menu, select the Concentration option
2. Parameter for concentration settings
   Call up the **Concentration settings** submenu in Setup → Advanced setup → Concentration
3. Select the liquid
   In the **Liquid type** parameter, select the **Sucrose in water** option
4. Select the carrier medium property
   Water-based is selected in the **#not yet translated#** parameter
5. Enter the mineral content of the carrier medium
   Enter the value 0 in the **Water mineral content** parameter
6. Parameter for selecting the unit
   Call up the **Concentration unit** submenu in Setup → Advanced setup → Concentration
7. Select the output unit
   Select *Brix in the **Concentration unit** parameter parameter

Reconciling the mineral content

When measuring the water-based sugar solutions, it is possible to factor in the mineral content (total dissolved solids TDS) of the water when determining the concentration. This can be done in one of two ways:

- Enter the mineral content in mg/l
  Setup → Advanced setup → Concentration → Concentration settings → Water mineral content
- Reconciliation by measuring the density of the mineralized water in the measuring device
  Expert → Application → Concentration → Mineral content determination → Carrier density during determination
  After successfully determining the mineral content in the **Control mineral content determination** parameter, select the **Use result** option to use the reconciled value during the measurement.
  Overview of the **Mineral content determination** submenu → 17

Fine tuning settings

The exact ICUMSA formula for water-based sugar solutions is saved in the device. If the selected binary mixture is actually measured, without any additional ingredients, there should be no need for fine-tuning. In this case, users should search for, and correct, the reason for the deviation.

The fine-tuning function is always performed based on the approximation formula with the coefficients A0 to A3, B1 to B3 and D1 to D4. This means that in the case of sugar solutions, for example, the ICUMSA formula is first converted to an approximate formula and is then written to a user profile. Consequently, the measuring range should also be limited here to keep the approximation error to a minimum. Fine-tuning is only possible using the FieldCare operating tool and cannot be performed at device level → 35.

6.4.2 Original wort

Units

The following units are available in the **Concentration unit** parameter for measuring the original wort:

- %Mass
- °Plato
- °Balling
- SGU

Measuring the original wort

The approximation of a water-based solution according to ICUMSA (sucrose/water) is used to measure the original wort. The numerical values for the units %mass, °Plato and °Balling correspond to the numerical value for °Brix when the sucrose/water mixture is selected. The measurement therefore represents the apparent extract, since a complex mixture (sugar/alcohol/water) - such as one that occurs during the fermentation process - cannot be captured by a single summation parameter such as density, for instance.

When the specific gravity (unit: SGU) is measured, the density of the medium is measured in relation to the density of water at the same reference temperature and output. The sucrose/water model is also used for this calculation.

6.4.3 Ethanol

Units
The following units are available in the **Concentration unit** parameter for determining the ethanol concentration:
- %Mass
- %vol
- %StdVol
- %ABV@20°C
- proof/vol

Determining the ethanol concentration

The concentration of ethanol is determined based on the model developed by Bettin and Spieweck (OIML ITS-90). The value is automatically converted to the alcohol content by volume at a reference temperature of 20°C by selecting the ABV unit (alcohol by volume). With the **Target corrected volume flow** option in the **Assign process variable** parameter, it is possible to determine the total amount of alcohol in a standard liter or standard cubic meter (at 20°C).

To set a user-defined reference temperature for volumetric concentration determination within the model's value range (-20 to +40°C), users can select the unit %StdVol and adjust the reference temperature accordingly.

The numerical value for ethanol proof is equivalent to twice the volume content at a reference temperature of 60°F (15.56°C).

6.4.4 %Mass/%vol – ideal mixtures

The %mass/%vol function treats a mixture of two substances as an ideal mixture. In this context, "ideal" means that there is no interaction between the two components of the mixture. The mass and volume of the ideal mixture result from the masses and volumes of the two substances. While the mass is preserved at all times in both ideal and real mixtures, in real mixtures the volume will normally expand or contract when the individual volumes are mixed due to the interaction between the substances.

The ideal mixture model is often used for solid/liquid mixtures (slurry or suspension). The following information is needed to determine the concentration of the target medium:
- Density of the target and carrier medium at a defined reference temperature ($T_{ref,exp}$)
- Reference temperature at which the aforementioned density was determined
- Thermal expansion coefficients of the target and carrier substance which describe the change in the density with the temperature.

The dependency of the density on temperature is mapped by a second-degree polynomial. For example, in the case of the target medium:

$$\rho_{Target}(T) = \frac{\rho_{Target}(T_{ref})}{[1 + \alpha_{Target}(T - T_{ref}) + \beta_{Target}(T - T_{ref})^2]}$$

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$\rho_{Target}(T)$	*Temperature-dependent reference density of the carrier medium*
$\rho_{Target}(T_{ref})$	*Reference density of the carrier medium that depends on the reference temperature*
T	*Medium temperature currently measured [°C] or [K]* [1)]
t_{ref}	*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

Variables α and β are linear and quadratic volume expansion coefficients, respectively, and must be determined from the density values of the target medium (or carrier medium) at different temperatures.

The carrier medium will be water in most cases. Water can be selected as the carrier at the device level or via FieldCare. It is not necessary to enter the reference density and expansion coefficients of water. The density characteristic of water as a function of temperature (and pressure) is calculated directly in the measuring device.

The mineral content of the water can be factored in by entering the value (TDS) or by reconciling the value with the carrier medium (cf. procedure for sugar solutions on → 56).

Concentration measurement of ideal mixtures

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 Setup → Advanced setup → Concentration select the **%Mass** option/**%vol**
3. In the **Carrier type** parameter, select the **Water based** option.
4. In the **Water mineral content** parameter, enter the mineral content if there are minerals in the water. Alternatively, perform mineral content reconciliation with water → 57. This function is only available for water-based media.
5. If the **Not water based** option was selected in the **Carrier type** parameter, enter the reference density and expansion coefficients of the carrier medium in the **Carrier reference density** parameter, **Carrier linear expansion coefficient** parameter and **Carrier square expansion coefficient** parameter.
6. In the **Reference temperature** parameter, enter the reference temperature at which the reference densities of the target and carrier media were measured.
7. In the **Target reference density** parameter, **Target linear expansion coefficient** parameter and **Target square expansion coefficient** parameter, specify the reference density and expansion coefficients of the target medium
8. In the **Concentration unit** parameter, select the **%vol** option, **%Mass** option or **%StdVol** option.
9. In the **Reference temperature** parameter in the **Concentration unit** submenu, enter the reference temperature for determining the reference density of the mixture or for calculating the corrected volume concentration.

6.4.5 Determining the reference density and corrected volume flow using the Concentration package

The functions for determining the reference density and corrected volume flow are available in the standard version by default. It is therefore not necessary to order the Concentration package to determine these variables. Nevertheless, specific points particular to these variables must be considered when the Concentration package is enabled.

Since the accuracy of determining the reference density and, consequently, of determining the corrected volume flow depends on the quality of the density measurement, the device should be ordered with a special density calibration (order code for "Application package", option EE "Special density") to obtain the best results. This is necessary for all devices except Promass Q, as the latter offers exceptionally good density measurement performance.

The reference density of a substance or mixture is the ratio of its mass to the volume adopted under reference conditions. The reference conditions (pressure and temperature)

are country-specific and therefore the reference temperature in the device can be configured as the user requires. The ability to output the reference density at reference conditions makes it easier to compare density values that have been measured at different temperatures. In addition, this makes it possible to output the corrected volume flow which can be calculated in the device from the reference density and the mass flow.

The corrected volume flow can also be determined without the Concentration package using Promass. The value for the reference density that is needed for this can either be saved in theSetup → Advanced setup → Calculated values → Corrected volume flow calculation as a fixed value or can be determined from the measured density by defining thermal expansion coefficients. In this context, the correlation between density and temperature is described by the following formula:

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

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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

If the Concentration package is used, there is no need to enter the expansion coefficients if the correlation between density and temperature has already been defined in a predefined formula (predefined fluids) or via the carrier- and target-specific expansion coefficients in the %mass/%vol function. In such cases, the device calculates the reference density automatically from the mixture characteristics. It is then only necessary to define the reference conditions (reference temperature)

If user-defined 3D tables are used, the expansion coefficients must still be entered to determine the reference density.

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