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Special Documentation
Proline Promass 500 HART

Concentration Measurement application package

HART
COMMUNICATION PROTOCOL

Endress+Hauser

People for Process Automation

Table of contents

1   About this document

1.1   Document function

This manual is a Special Documentation and does not replace the Operating Instructions included in the scope of supply. It is a part of the Operating Instructions and serves as a reference for using the Concentration Measurement function integrated in the measuring device.

1.2   Content and scope

This document contains descriptions of the additional parameters and technical data of the application package and detailed explanations regarding:

- Application-specific parameters
- Advanced technical specifications

1.3   Symbols

1.3.1   Safety symbols

⚠ DANGER

This symbol alerts you to a dangerous situation. Failure to avoid this situation will result in serious or fatal injury.

⚠ WARNING

This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in serious or fatal injury.

⚠ CAUTION

This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in minor or medium injury.

NOTICE

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:
- *W@M Device Viewer* (www.endress.com/deviceviewer): Enter the serial number from nameplate
- *Endress+Hauser Operations App*: Enter the serial number from the nameplate or scan the 2D matrix code (QR code) on the nameplate

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 → Downloads

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

Measuring device	Documentation code
Promass A 500 (8A5B**-…)	BA01526D
Promass A 500 (8A5C**-…)	BA01817D
Promass E 500	BA01528D
Promass F 500	BA01529D
Promass H 500	BA01530D
Promass I 500	BA01531D
Promass O 500	BA01532D
Promass P 500	BA01533D
Promass Q 500	BA01534D
Promass S 500	BA01535D
Promass X 500	BA01536D

1.5 Registered trademarks

HART®
Registered trademark of the FieldComm Group, Austin, Texas, USA

2 Product features and availability

2.1 Product features

The **Concentration Measurement** application package extends the functionality of the measuring device. The device can use the application package to calculate a concentration of a medium from the measured medium density.

Depending on the application, the configuration is performed via the local display or additionally with Endress+Hauser's FDT-based plant asset management software, FieldCare .

If the mixture to be measured is already saved in the measuring device, the configuration can be performed via the local display or the Web server.

If a concentration function has to be defined from user-defined table values, also use FieldCare.

Commissioning→ 🖺 9

2.2 Availability

The application package can be ordered together with the device or can be activated subsequently with an activation code. Detailed information on the order code is available via the Endress+Hauser website www.endress.com or from your local Endress+Hauser Sales Center.

2.2.1 Order code for

If ordering directly with the device or subsequently as a retrofit kit:
Order code for "Application package", option ED "Concentration"

The availability of the application package can be checked as follows:
• Order code with breakdown of the device features on the delivery note
• Call up the Device Viewer via the website www.endress.com/deviceviewer: enter the serial number from the nameplate and check whether the feature is displayed
• In the operating menu Expert → System → Administration : The **Software option overview** parameter indicates whether the application package is enabled

2.2.2 Activation

A retrofit kit is supplied if the application package is ordered subsequently. This kit includes a tag plate with device data and an activation code.

For detailed information on "Activating application packages via the software license code", see Installation Instructions EA01164D

2.2.3 Access

The application package is compatible with all the system integration options. Interfaces with digital communication are required to access the data saved in the device. The speed of data transmission depends on the type of communication interface used.

Availability in FieldCare and other FDT-based asset management tools

FieldCare version 2.08 and higher supports the "Concentration" function for calculating the coefficients. More detailed information about calculating the coefficients and applying the results is provided in the "Calculating coefficients using FieldCare → 🖺 21" section.

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

FieldCare is an FDT-based plant asset management tool from Endress+Hauser. It can configure all smart field units in a system and help you manage them. By using the status information, it is also a simple but effective way of checking their status and condition.

For additional information about FieldCare, see Operating Instructions BA00027S and BA00065S

3   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 → 🗎 10).
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 or **%ABV@20℃** option
        can be selected as the concentration unit (see Table → 🗎 10).

Overview of the extended range of measured variables available with the
Concentration application package: → 🗎 19

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

4   Commissioning

4.1   Configure the concentration

The measuring device can be configured for concentration measurement in two different ways:
- The mixture is already programmed into the measuring device as a predefined liquid
- The mixture must be saved in the device on the basis of user-defined table values

4.1.1   Mixture as a predefined liquid

Overview of the predefined liquids programmed into the measuring device → 🖥 10

If the mixture to be measured is already saved in the measuring device, the configuration can be performed via the local display or the Web server.

1. Select the predefined liquid in the **Liquid type** parameter→ 🖥 11
2. Select the units in the **Concentration unit** parameter→ 🖥 15
3. Configure the outputs → 🖥 17

4.1.2   Mixture from user-defined table values

If a concentration function has to be defined from user-defined table values, also use the FieldCare Concentration function→ 🖥 21.

Configuration via local display or Web server

1. Select the units in the **Concentration unit** parameter→ 🖥 15
2. Configure the outputs → 🖥 17

Additionally via FieldCare Concentration function

1. If necessary: calculate the coefficients from the values in the table→ 🖥 33
2. Adapt the coefficients and transfer them to the measuring device→ 🖥 37

4.2 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℃ proof/vol	−20 to +40 ℃ 0 to 100 %	OIML IST-90 (Bettin, Spieweck 1990) [1]	☒	☑
Methanol in water	%Mass	0 to +50 ℃ 0 to 100 %	Coefficients from table data [2] [3]	☒	☒
Fructose in water	%Mass	0 to +80 ℃ 0 to 100 %	ICUMSA SPS-4 (1998)	☑	☑
Glucose in water	%Mass	0 to +80 ℃ 0 to 100 %	ICUMSA SPS-4 (1998)	☑	☑
Invert sugar in water	%Mass	0 to +80 ℃ 0 to 100 %	ICUMSA SPS-4 (1998)	☑	☑
Sucrose in water	%Mass °Brix SGU	0 to +80 ℃ 0 to 100 %	ICUMSA SPS-4 (1998)	☑	☑
Wort	%Mass °Plato °Balling SGU	0 to +80 ℃ 0 to 100 %	ICUMSA SPS-4 (1998) Sec. 2	☑	☑
Corn syrupHFCS42	%Mass	+15 to +60 ℃ 0 to 85 %	Coefficients from table data [4] [5]	☒	☒
Corn syrupHFCS55	%Mass	+15 to +60 ℃ 0 to 85 %			
Corn syrupHFCS90	%Mass	+15 to +60 ℃ 0 to 85 %			
Ammonia	%Mass mol/l	0 to +100 ℃ 1.0 to 30.0 %	Density/concentration model according to [6]	☑	☑
Ammonium hydroxide	%Mass mol/l	0 to +100 ℃ 2.1 to 61.7 %			
Ammonium nitrate in water	%Mass mol/l	+5 to +95 ℃ 0.45 to 78.74 %			
Iron(III)chloride in water	%Mass mol/l	0 to +30 ℃ 1 to 50 %			
Potassium hydroxide	%Mass mol/l	0 to 100 ℃ 0.08 to 59.46 %			
Sodium chloride	%Mass mol/l	0 to 140 ℃ 0 to 26.0 %			
Sodium hydroxide	%Mass mol/l	0 to 120 ℃ 0.05 to 70 %			
Phosphoric acid	%Mass mol/l	+15.85 to 81.4 ℃ 0.1 to 85 %			
Nitric acid	%Mass mol/l	0 to +100 ℃ 0.1 to 80.11 %			
Hydrochloric acid	%Mass mol/l	−5 to +100 ℃ 0.04 to 40 %			
Sulfuric acid	%Mass mol/l	0 to +100 ℃ 0.01 to 77.06 %			
Hydrogen peroxide in water	%Mass	0 to +50 ℃ 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			If **Carrier type** parameter is water-based: ✅	If **Carrier type** parameter is water-based: ✅
Concentration 3D	%Mass %vol User conc.			❌	❌
Whey	%Mass	10 to +100 °C 6 to 65 %		❌	❌

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.

4.3   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

► Concentration	
► Concentration settings	→ 📖 11
► Concentration unit	→ 📖 15
► Concentration profile 1 to n	→ 📖 16

4.3.1   Concentration settings

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

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

‣ Concentration settings	
Liquid type	→ 🗎 13
Carrier type	→ 🗎 13
Water mineral content	→ 🗎 14
Carrier reference density	→ 🗎 14
Carrier linear expansion coefficient	→ 🗎 14
Carrier square expansion coefficient	→ 🗎 14
Target reference density	→ 🗎 14
Target linear expansion coefficient	→ 🗎 14
Target square expansion coefficient	→ 🗎 14
Reference temperature expansion	→ 🗎 15
Create coefficients for liquid type	→ 🗎 15

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 → 🕮 30 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 → 🕮 21	• Off • Sucrose in water • Glucose in water • Fructose in water • Invert sugar in water • HFCS42 • HFCS55 • HFCS90 • Wort • Whey (Total Solids) • Ethanol in water (OIML) • Methanol in water • Hydrogen peroxide in water • Hydrochloric acid • Sulfuric acid • Nitric acid • Phosphoric acid • Sodium hydroxide • Potassium hydroxide • Ammonia in water • Ammonium hydroxide in water • Ammonium nitrate in water • Iron(III)chloride in water • Sodium chloride in water • %mass / %volume • 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 → 🖺 18	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/K²
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
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

Parameter	Prerequisite	Description	Selection / User entry	Factory setting
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 ℃	20 ℃
Create coefficients for liquid type	–	Create coefficient set for selected liquid type. Adjust concentration values via user concentration factor and user concentration offset.	• Cancel • Coefficient set 1 • Coefficient set 2 • Coefficient set 3	Cancel

4.3.2   Concentration units

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

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

▶ Concentration unit	
Concentration unit	→ 🖺 15
User concentration text	→ 🖺 16
User concentration factor	→ 🖺 15
User concentration offset	→ 🖺 16
Reference temperature	→ 🖺 16

Parameter overview with brief description

Parameter	Prerequisite	Description	Selection / User entry	Factory setting
Concentration unit	–	Select concentration unit.	• mol/l • ˚Balling • ˚Brix • ˚Plato • %ABV@20℃ • proof/vol • %vol • %Mass • %StdVol • SGU • User conc.	˚Brix
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

Parameter	Prerequisite	Description	Selection / User entry	Factory setting
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
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 ℃	20 ℃

4.3.3   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

▶ Concentration profile 1 to n	
Coefficients set name	→ 🖺 17
A 0	→ 🖺 17
A 1	→ 🖺 17
A 2	→ 🖺 17
A 3	→ 🖺 17
A 4	→ 🖺 17
B 1	→ 🖺 17
B 2	→ 🖺 17
B 3	→ 🖺 17
D 1	→ 🖺 17

D 2	→ 🗎 17
D 3	→ 🗎 17
D 4	→ 🗎 17

Parameter overview with brief description

Parameter	Description	User entry	Factory setting
Coefficients set name	Enter name for coefficients set.		Coef Set No.
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	$0.7220 \cdot 10^{-3}$ E-3
B 2	Enter the coefficient.	Signed floating-point number	$38.9126 \cdot 10^{-6}$ E-6
B 3	Enter the coefficient.	Signed floating-point number	$−1.6739 \cdot 10^{-9}$ E-9
D 1	Enter the coefficient.	Signed floating-point number	$−0.0975 \cdot 10^{-2}$ E-2
D 2	Enter the coefficient.	Signed floating-point number	$−0.3731 \cdot 10^{-4}$ E-4
D 3	Enter the coefficient.	Signed floating-point number	$0.2957 \cdot 10^{-3}$ E-3
D 4	Enter the coefficient.	Signed floating-point number	$−0.1721 \cdot 10^{-5}$ E-5

4.4   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 → 🗎 13
[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

5 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→ 🖹 41.

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 → 🖹 21.

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

5.1 Determining the mineral content

Determination of the mineral content in water. This function is not available for all the predefined mixtures (see Table → 🖹 10).

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

▶ Mineral content determination	
Control mineral content determination	→ 🖹 18
State mineral content determination	→ 🖹 18
Carrier density during determination	→ 🖹 19
Process temperature during determination	→ 🖹 19

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 ℃	–273.15 ℃

*   Visibility depends on order options or device settings

5.2   Additional measured variables

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

Navigation
"Diagnostics" menu → Measured values → Measured variables

▸ Measured variables	
Concentration	→ 🖺 19
Target mass flow	→ 🖺 19
Carrier mass flow	→ 🖺 20
Target corrected volume flow	→ 🖺 20
Carrier corrected volume flow	→ 🖺 20
Target volume flow	→ 🖺 20
Carrier volume flow	→ 🖺 20

Parameter overview with brief description

Parameter	Prerequisite	Description	User interface
Concentration	–	Displays the concentration that is currently calculated. *Dependency* The unit is taken from the **Concentration unit** parameter (→ 🖺 15).	Signed floating-point number
Target mass flow	–	Displays the mass flow that is 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 that is 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: The **Ethanol in water** option or **%mass / %volume** option is selected in the **Liquid type** parameter.	Displays the corrected volume flow that is 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

5.3   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.

ℹ️ FieldCare is an FDT-based plant asset management tool from Endress+Hauser. It can configure all smart field units in a system and help you manage them. By using the status information, it is also a simple but effective way of checking their status and condition.

For additional information about FieldCare, see Operating Instructions BA00027S and BA00065S

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.

5.3.1   Starting the concentration function
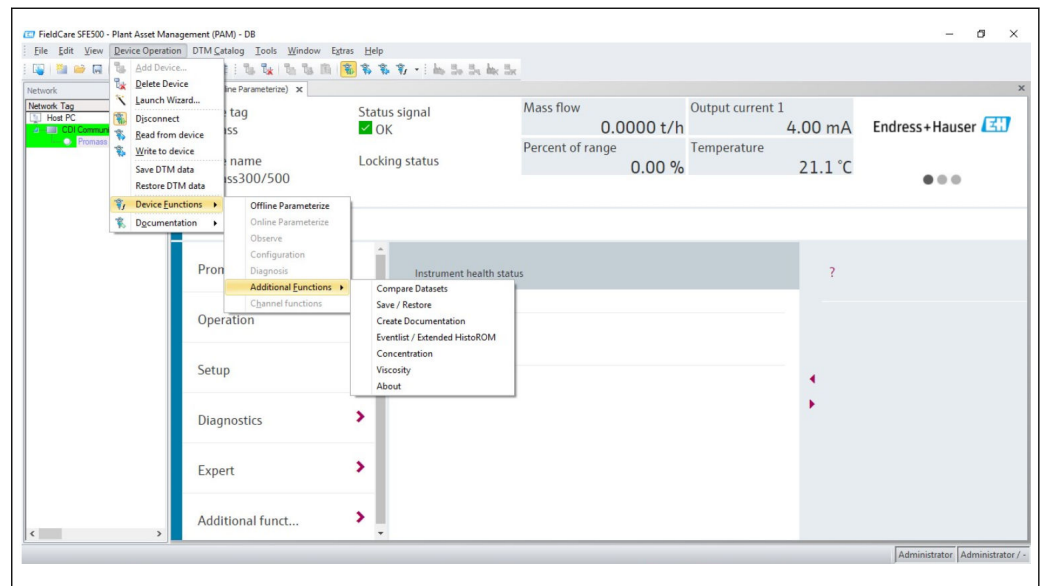
A0031469-EN

1. Open the "Device operation" menu in FieldCare.

2. Select the "Concentration" item under "Device function" and "Additional functions".

5.3.2   User interface
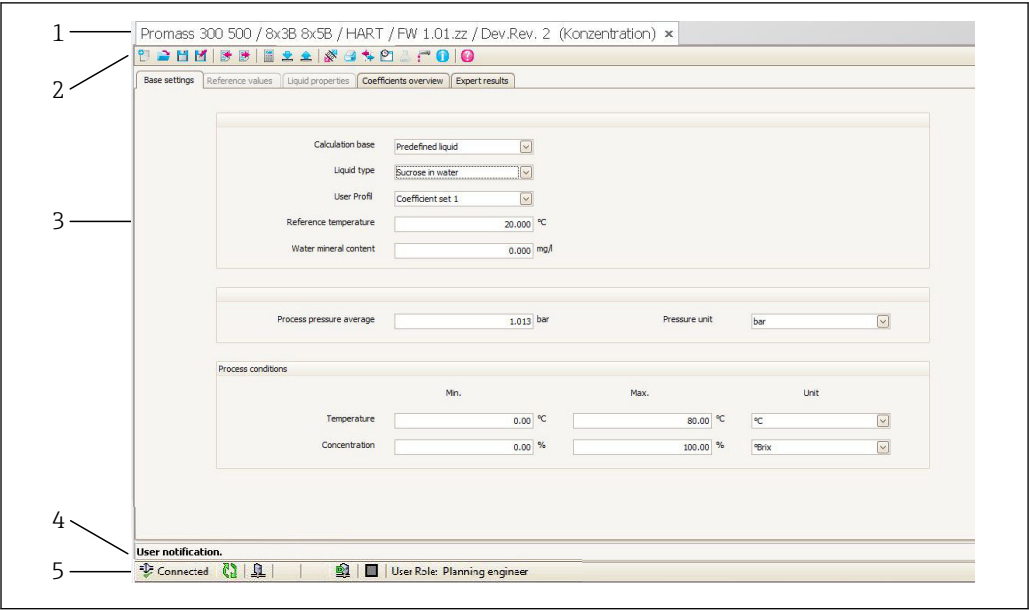
A0034893-EN

🖻 *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
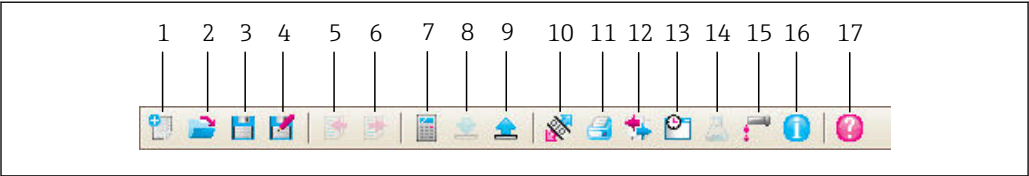
A0031471

🖻 *2   Commands in the menu bar*

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

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

Navigation

Five navigation tabs are available for the calculation and evaluation of the concentration coefficients:
- Base settings
- Reference properties
- Liquid properties
- Coefficients overview
- Expert results

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: Predefined liquid	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 **Calculation base** function: Predefined liquid	Displays the temperature (from the device) that is used to calculate the reference density.	
Water mineral content	This function is only available if the following option was selected in the **Calculation base** function: Predefined liquid	Enter the mineral content for water-based carrier media.	
User profile			• Coef Set 1 • 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: Predefined liquid	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. • Water-based: The carrier medium is water. The density characteristic of water is determined using Kell's formula (ITS-90). • Not water-based: The carrier medium is not water-based. The density characteristic can be entered in the **Calculated** field.	• Water-based • Not water-based
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 ℃
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℃ • SD20℃ • SD4℃ • SG15℃ • SG20℃ • SG4℃
Carrier linear expansion coefficient	This function is only available if the following option was selected in the **Carrier type** function: **Not water-based**	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: **Not water-based**	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: **Not water-based**	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 or .xlsx 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** • ℃ • ℉ • 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 ℃, 20℃, 4 ℃ • SG 15 ℃, 4℃, • SGU 20 ℃

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 or .xlsx 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 • $B1 \cdot 10^{-3} \hat{=} E-3$ • $B2 \cdot 10^{-6} \hat{=} E-6$ • $B3 \cdot 10^{-9} \hat{=} E-9$ • $D1 \cdot 10^{-2} \hat{=} E-2$ • $D2 \cdot 10^{-3} \hat{=} E-4$ • $D3 \cdot 10^{-4} \hat{=} E-3$ • $D4 \cdot 10^{-5} \hat{=} E-5$
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
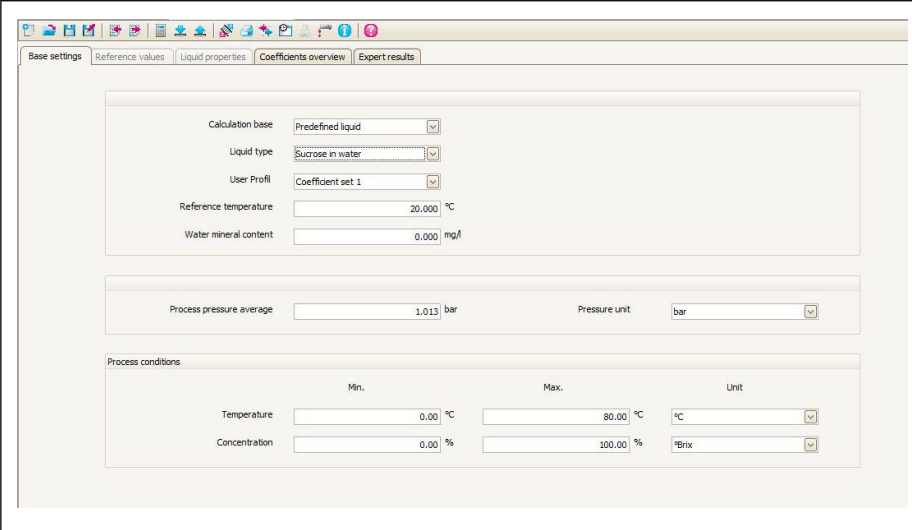
5.3.3   Calculation base: "Defined liquids"

Various liquids (mixtures) are predefined in the device for concentration measurement. These can be selected at the device level and used directly. In this case, the use of FieldCare to calculate coefficients is neither necessary nor practical.

For an adaptation of the concentration measurement (adjustment in relation to the reference measurement) that goes beyond the adaptation of the mineral content, it is necessary to convert the relevant concentration model into an approximation model (coefficient set). This can be performed with FieldCare.

🛈 Table of liquids that are predefined in the measuring device → 📄 10.

Calculation of coefficients for "Defined liquids"

1. Select the **Base settings** tab.

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2. In the **Calculation base** function, select the following option: Predefined liquids.

3. In the **Liquid type** function, select a defined liquid (mixture): e.g. sucrose in water, typically for °Brix measurements.

4. In the **User profile** function, select the coefficient set in which the coefficients for the selected defined liquids (mixtures) are written.

🛈 Three coefficient sets are available.

5. In the **Water mineral content** function, enter information regarding the mineral content of the water carrier medium (water mineral content).

6. In the **Process pressure average** function, enter the process pressure.

7. In the **Pressure unit** function, select the desired unit.

🛈 The effect of the mineral content and pressure on the density of the medium is taken into consideration when determining the coefficients. The data for the pure mixture under normal conditions can be obtained with the following setting:
- **Water mineral content**: 0 mg/l
- **Process pressure average**: 1.013 bar (14.7 psi)

8. In the **Temperature** function, enter the desired minimum and maximum value and select the unit.

9. In the **Concentration** function, enter the desired minimum and maximum value and select the unit.

ℹ️ Limiting the value range (min./max.) significantly improves the accuracy of the concentration model, as the approximation (coefficient) can then be better adapted to the data.

10. Click the **Calculate** button in the menu bar and pay attention to the information in the info bar.
    ↳ The performance of the calculation is confirmed in the info bar.

11. Select the **Liquid properties** tab.
    ↳

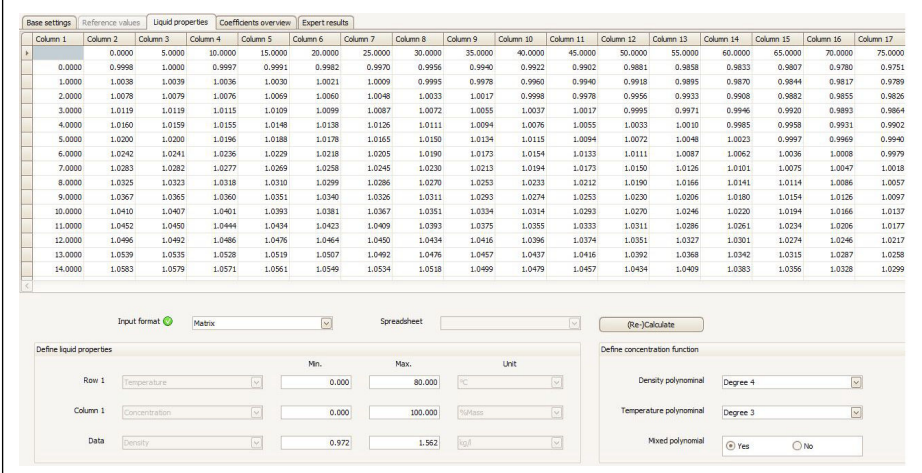| Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10	Column 11	Column 12	Column 13	Column 14	Column 15	Column 16	Column 17
	0.0000	5.0000	10.0000	15.0000	20.0000	25.0000	30.0000	35.0000	40.0000	45.0000	50.0000	55.0000	60.0000	65.0000	70.0000	75.0000
0.0000	0.9998	1.0000	0.9997	0.9991	0.9982	0.9970	0.9956	0.9940	0.9922	0.9902	0.9881	0.9858	0.9833	0.9807	0.9780	0.9751
1.0000	1.0038	1.0039	1.0036	1.0030	1.0021	1.0009	0.9995	0.9978	0.9960	0.9940	0.9918	0.9895	0.9870	0.9844	0.9817	0.9789
2.0000	1.0078	1.0079	1.0076	1.0069	1.0060	1.0048	1.0033	1.0017	0.9998	0.9978	0.9956	0.9933	0.9908	0.9882	0.9855	0.9826
3.0000	1.0119	1.0119	1.0115	1.0109	1.0099	1.0087	1.0072	1.0055	1.0037	1.0017	0.9995	0.9971	0.9946	0.9920	0.9893	0.9864
4.0000	1.0160	1.0159	1.0155	1.0148	1.0138	1.0126	1.0111	1.0094	1.0076	1.0055	1.0033	1.0010	0.9985	0.9958	0.9931	0.9902
5.0000	1.0200	1.0200	1.0196	1.0188	1.0178	1.0165	1.0150	1.0134	1.0115	1.0094	1.0072	1.0048	1.0023	0.9997	0.9969	0.9940
6.0000	1.0242	1.0241	1.0236	1.0229	1.0218	1.0205	1.0190	1.0173	1.0154	1.0133	1.0111	1.0087	1.0062	1.0036	1.0008	0.9979
7.0000	1.0283	1.0282	1.0277	1.0269	1.0258	1.0245	1.0230	1.0213	1.0194	1.0173	1.0150	1.0126	1.0101	1.0075	1.0047	1.0018
8.0000	1.0325	1.0323	1.0318	1.0310	1.0299	1.0286	1.0270	1.0253	1.0233	1.0212	1.0190	1.0166	1.0141	1.0114	1.0086	1.0057
9.0000	1.0367	1.0365	1.0360	1.0351	1.0340	1.0326	1.0311	1.0293	1.0274	1.0253	1.0230	1.0206	1.0180	1.0154	1.0126	1.0097
10.0000	1.0410	1.0407	1.0401	1.0393	1.0381	1.0367	1.0351	1.0334	1.0314	1.0293	1.0270	1.0246	1.0220	1.0194	1.0166	1.0137
11.0000	1.0452	1.0450	1.0444	1.0434	1.0423	1.0409	1.0393	1.0375	1.0355	1.0333	1.0311	1.0286	1.0261	1.0234	1.0206	1.0177
12.0000	1.0496	1.0492	1.0486	1.0476	1.0464	1.0450	1.0434	1.0416	1.0396	1.0374	1.0351	1.0327	1.0301	1.0274	1.0246	1.0217
13.0000	1.0539	1.0535	1.0528	1.0519	1.0507	1.0492	1.0476	1.0457	1.0437	1.0416	1.0392	1.0368	1.0342	1.0315	1.0287	1.0258
14.0000	1.0583	1.0579	1.0571	1.0561	1.0549	1.0534	1.0518	1.0499	1.0479	1.0457	1.0434	1.0409	1.0383	1.0356	1.0328	1.0299

Input format ⦿ Matrix   Spreadsheet   (Re-)Calculate

Define liquid properties

		Min.	Max.	Unit
Row 1	Temperature	0.000	80.000	°C
Column 1	Concentration	0.000	100.000	%Mass
Data	Density	0.972	1.562	kg/l

Define concentration function
Density polynominal   Degree 4
Temperature polynominal   Degree 3
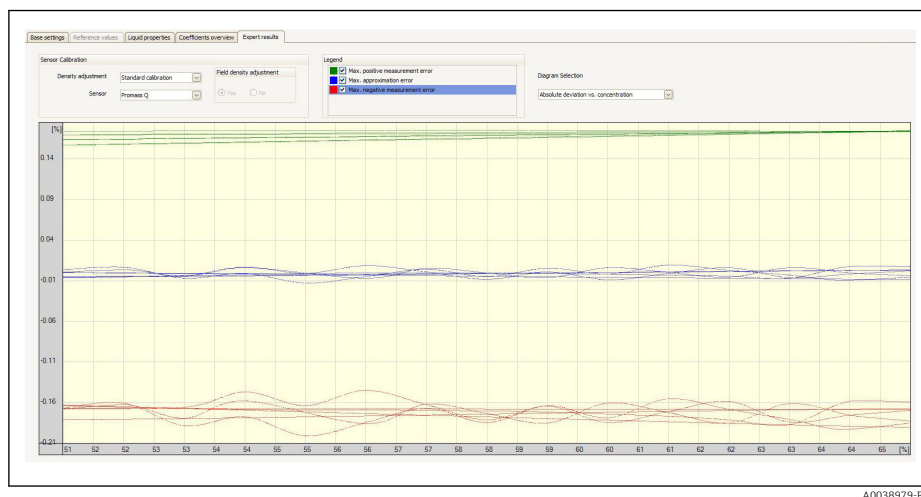Mixed polynominal   ⦿ Yes   ○ No

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The density of the defined liquid (with the pressure and mineral content factored in where necessary) is displayed as a function of the concentration and temperature in the **Liquid properties** tab.
The matrix can be edited. If changes are made, the coefficients can be recalculated using the **(Re-)calculate** button.

12. The calculated coefficients are displayed in the **Coefficients overview** tab.

13. Select the **Expert results** tab.

↳

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The accuracy of the concentration measurement that can be expected over the selected concentration range is displayed in the **Expert result** tab if the Diagram Selection: **Absolute Deviation vs. Concentration** option is selected.
The blue values indicate the maximum numerical deviation of the coefficient model from the table values (quality of the approximation). The maximum measured error is displayed in green and red (in the positive and negative direction). In addition to the approximation error, this also contains the density accuracy and therefore depends significantly on the choice of sensor and the quality of the density calibration.

ℹ The maximum numerical deviation shown in blue only applies to the calculation of the concentration using the coefficient model. Direct implementation in the measuring device offers better accuracy, particularly for ethanol measurement.

14. In the **Sensor** function, select the sensor.
    ↳ In the **Density adjustment** function, enter special density calibration if applicable (optionally available).
    The Field density adjustment option can also be selected.

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

ℹ • It is recommended to use the **Write** function instead of manually transmitting the coefficients to the device. This prevents any transcription and rounding errors.
  • The calculated coefficients can be compared with the coefficients from the device using the **Read** button.
  • The new coefficient set can be saved using the **Save** or **Save as** buttons. This makes it possible to restore any coefficient sets that may have been accidentally overwritten. The file has the extension ".conc".
  • A PDF document containing all the device parameters can be created using the **Print** button.

Performing measurements based on the coefficients

▶ In the **Coefficients set name** parameter in the Setup → Advanced setup → Concentration → Concentration profile 1 to n menu, select the coefficient set used for the calculation.

ℹ The choice of user-defined units makes it possible to set an offset and factor for a simple adjustment of the concentration measurement: Setup → Advanced setup → Concentration → Concentration unit

5.3.4   Calculation base: "Liquid properties"

This calculation method allows the creation of a concentration function for the device from user-defined data. The quality of the data forms the basis for a good-quality concentration measurement.

- The user-defined data (concentration, temperature and density) should cover the entire concentration and temperature range that typically occurs in the process.
  - If the density and concentration values are only available for a temperature of 20℃, this is not sufficient for concentration measurement with a process device.
  - The less data that is available, the greater the negative influence of individual outliers on the concentration function.
- The user-defined data can be entered or imported directly in FieldCare.
- For an assessment of the data, it is recommended to visualize the data in a spreadsheet program (density over concentration or density over temperature). This makes it easier to identify outliers - and remove them where necessary - and/or to repeat the measurement series in the laboratory.
- The most reliable way to create a concentration function is to specify the concentration in % mass, as mass is independent of temperature.

Formats for importing user-defined data

User-defined data in .xls or .xlsx Excel format can be imported via FieldCare. Two table layouts are permitted for this: the matrix format and the list format.

Structure of the matrix format

- First row: heading (the first row must never contain any values!)
- Second row: concentration values
- First column: temperature values
- Remaining rows and columns: density values

	A	B	C	D	E	F	G	H	I	J
1		Concentration/% mass								
2	T/℃	65	64	63	62	61	60	59	58	...
3	15	1.1703	1.1675	1.1648	1.162	1.1592	1.1565	1.1537	1.1509	...
4	20	1.1675	1.1647	1.1620	1.1593	1.1565	1.1545	1.1510	1.1483	...
5	25	1.1647	1.162	1.1592	1.1565	1.1538	1.1510	1.1483	1.1456	...
6	30	1.1619	1.1592	1.1565	1.1537	1.151	1.1483	1.1455	1.1428	...
7										

Structure of the list format

- First column: temperature values
- Second column: concentration values
- Third column: density values

	A	B	C
1	T/°C	Concentration/% mass	Density kg/l
2	15	51	1.1315
3	15	52	1.1355
4	15	53	1.13705
5	15	54	1.1398
6	15	55	1.1426
7	15	56	1.14535
8	15	57	1.14815
9	15	58	1.15095
10	15	59	1.1537
11	15	60	1.1565
12	15	61	1.15925
13	15	62	1.162
14	15	63	1.1648
15	15	64	1.16755
16	20	65	1.1703
17	20	51	1.12905
18	20	52	1.1318
19	20	53	1.13455
20	20	54	1.1373
21	20	55	1.14005
22	20	56	1.1428
23	20	57	1.14555
…	…	…	…

Calculation of the coefficients from user-defined data

1. Select the **Base settings** tab.

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2. In the **Calculation base** function, select the following option: Liquid properties.

3. In the **User profile** function, select the coefficient set in which the coefficients for the selected defined liquids (mixtures) are written.

   ℹ️ Three coefficient sets are available.

4. Select the **Liquid properties** tab.

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5. In the **Input format** function, select the list or matrix option.

6. In the **Row 1** function, select the temperature or concentration option (depending on the table that has been created), enter the range and select the unit.

7. In the **Column 1** function, select the temperature or concentration option (depending on the table that has been created), enter the range and select the unit.

   Import the data:

8. Click the **Import** button in the menu bar.

9. Select the file in .xls or .xlsx (Excel) format and confirm your choice.
   ↳ The data import is confirmed in the info bar.

10. Recalculate the coefficients using the **(Re-)calculate** button.
    ↳ The performance of the calculation is confirmed in the info bar.

11. The calculated coefficients are displayed in the **Coefficients overview** tab.

12. Select the **Expert results** tab.

↳

A0038979-EN

The accuracy of the concentration measurement that can be expected over the selected concentration range is displayed in the **Expert result** tab if the Diagram Selection: **Absolute Deviation vs. Concentration** option is selected.
The blue values indicate the maximum numerical deviation of the coefficient model from the table values (quality of the approximation). The maximum measured error is displayed in green and red (in the positive and negative direction). In addition to the approximation error, this also contains the density accuracy and therefore depends significantly on the choice of sensor and the quality of the density calibration.

ℹ The maximum numerical deviation shown in blue only applies to the calculation of the concentration using the coefficient model. Direct implementation in the measuring device offers better accuracy, particularly for ethanol measurement.

13. In the **Sensor** function, select the sensor.
    ↳ In the **Density adjustment** function, enter special density calibration if applicable (optionally available).
       The Field density adjustment option can also be selected.

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

ℹ • It is recommended to use the **Write** function instead of manually transmitting the coefficients to the device. This prevents any transcription and rounding errors.
   • The calculated coefficients can be compared with the coefficients from the device using the **Read** button.
   • The new coefficient set can be saved using the **Save** or **Save as** buttons. This makes it possible to restore any coefficient sets that may have been accidentally overwritten. The file has the extension ".conc".
   • A PDF document containing all the device parameters can be created using the **Print** button.

Performing measurements based on the coefficients

▶ In the **Coefficients set name** parameter in the Setup → Advanced setup → Concentration → Concentration profile 1 to n menu, select the coefficient set used for the calculation.

ℹ The choice of user-defined units makes it possible to set an offset and factor for a simple adjustment of the concentration measurement: Setup → Advanced setup → Concentration → Concentration unit

5.3.5   "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

5.3.6 Information and error messages

List of information and error messages

Message
Calculation failed. Data are not usable.
Calculation failed. Input data are incorrect.
Calculation successful. For coefficients, see "Coefficient overview" tab.
Coefficients were loaded successfully from device.
Coefficients were not loaded successfully from device.
Coefficients were not written successfully to device.
Coefficients were written successfully to device.
Concentration (device measured value).
Concentration modul is not activated.
Concentration (reference value).
Contains redundant data.
Data loaded and converted successfully.
Data loaded successfully.
Data saved successfully.
Data saved unsuccessfully.
Define liquid properties.
Density measured error.
Excel file loaded successfully.
Excel file loaded unsuccessfully.
Field density adjustment performed or planned.
For liquid properties not enough value pairs entered. Expand the limits of the process conditions.
Input values out of process conditions range. Input were undone.
Legend.
Load coefficients from device.
Load concentration data from the saved file.
Loaded data from saved file incorrect.
Loading not successful.
Load the calculated coefficients from device.
Matrix incomplete.
Max. approximation error.
Max. negative measured error.
Max. positive measured error.
Negative concentration value not possible.

Message
Negative process pressure not possible. Input were undone.
No device coefficients available.
Not enough value pairs entered.
Process conditions incorrect. Min. value > max. value. Input was undone.
Select base for the coefficient calculation.
Select data view for the liquid properties input.
Select density calibration which were performed ex works.
Select spreadsheet with required liquid properties from loaded excel file.
Software option 'Concentration' is not activated.
Temperature measured error.
Value(s) not correct. Change was undone.
Write coefficients to device.
Write the calculated coefficients to device.

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 → 🖹 30. 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 → 🖹 33.

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 → 🖹 30. 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 → 🖹 21.

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 (→ 🕮 37).

Reasons for deviations in density measurement and remedial action

Possible reasons	Remedial measures
• 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.	As density depends on temperature, the measurement must be taken at process temperature or the temperature dependency must be factored in accordingly.
Abrasion, corrosion or formation of buildup.	• Remove deposit buildup. • In the event of abrasion or corrosion, check whether the material is compatible under process conditions. ℹ️ 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.
• Error during field density adjustment or incorrectly configured concentration or density offset. • Deposit buildup in the measuring tube: cleaning has not been performed.	• 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. Influence of density adjustment or offset parameters on various output parameters. ✅= influence; ❌ = no influence.

	Density	Volume flow	Concentration
Execute density adjustment	✅	✅	✅
Density adjustment offset	✅	❌	❌
User concentration offset	❌	❌	✅

Possible reasons	Remedial measures
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	• 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
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	• 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

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. Enter the mineral content of the carrier medium
   Enter the value 0 in the **Water mineral content** parameter

5. Parameter for selecting the unit
   Call up the **Concentration unit** submenu in Setup → Advanced setup → Concentration

6. 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 → 🖺 18

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 → 🖺 37.

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℃
- 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℃ 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℃).

To set a user-defined reference temperature for volumetric concentration determination within the model's value range (-20 to +40℃), 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℉ (15.56℃).

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:

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

A0034832

$\rho_{Target}(T)$	*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 [℃] or [K] [1]*
t_{ref}	*Reference temperature at which the reference density can be calculated (e.g. 15 ℃ 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 → 🖺 42).

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 → 🖺 43. This function is only available for water-based media.

5. If the **Not water based** option was selected in the **Carrier type** parameter, specify 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 application package

🄰 The quality of the density measurement determines how accurately the reference density and corrected volume flow are determined. For the best possible results, the device should be ordered with a special density calibration (order code for "Application package", option EE "Special density"). However, this is not necessary for the 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 is calculated in the device from the reference density and the mass flow.

The corrected volume flow can also be determined with a Promass without the Concentration application package. The value for the reference density that is needed for this can either be saved in the Setup → 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:

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

<div align="right">A0023403</div>

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/K^2]* [1]

1)   K = Kelvin

If the Concentration application package is used, there is no need to enter the expansion coefficients if the dependency of density and temperature can already be specified via a predefined formula (predefined fluids) or via the carrier- and target-specific expansion coefficients for the **%mass / %volume** option. 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.

If the Concentration application package is used, the reference density is only calculated if one of the following options is selected in the **Liquid type** parameter:
- Ethanol in water
- Fructose in water
- Glucose in water
- Invert sugar in water
- Sucrose in water
- Wort
- Ammonium nitrate in water
- Iron(III)chloride in water
- Hydrochloric acid
- Sulfuric acid
- Nitric acid
- Phosphoric acid
- Sodium hydroxide
- Potassium hydroxide
- %mass / %volume

In the case of the other options, the calculation uses the coefficients in the **Corrected volume flow calculation** submenu.

7 Modbus RS485 register information

7.1 Notes

7.1.1 Structure of the register information

The individual parts of a parameter description are described in the following section:

Navigation: navigation path to the parameter					
Parameter	Register	Data type	Access type	Selection/input	→ 🖹
Name of parameter	Indicated in decimal numerical format	• Float length = 4 byte • Integer length = 2 byte • String length, depending on parameter	Possible type of access to parameter: • Read access via function codes 03, 04 or 23 • Write access via function codes 06, 16 or 23	**Options** List of the individual options for the parameter • Option 1 • **Option 2** • Option 3 (+) ℹ️ • Factory setting highlighted in bold • (+) = Factory setting depends on country, order options or device settings **User entry** Input range for the parameter	Page number information and cross-reference to the standard parameter description

> **NOTICE**
>
> **If non-volatile device parameters are modified via the MODBUS RS485 function codes 06, 16 or 23, the change is saved in the EEPROM of the measuring device.**
> The number of writes to the EEPROM is technically restricted to a maximum of 1 million.
> ▶ Make sure to comply with this limit since, if it is exceeded, data loss and measuring device failure will result.
> ▶ Avoid constantly writing non-volatile device parameters via the MODBUS RS485.

7.1.2 Address model

The Modbus RS485 register addresses of the measuring device are implemented in accordance with the "Modbus Applications Protocol Specification V1.1".

In addition, systems are used that work with the register address model "Modicon Modbus Protocol Reference Guide (PI-MBUS-300 Rev. J)".

Depending on the function code used, a number is added at the start of the register address with this specification:
• "3" → "Read" access
• "4" → "Write" access

Function code	Access type	Register in accordance with "Modbus Applications Protocol Specification"	Register in accordance with "Modicon Modbus Protocol Reference Guide"
03 04 23	Read	XXXX Example: mass flow = 2007	3XXXX Example: mass flow = 32007
06 16 23	Write	XXXX Example: reset totalizer = 6401	4XXXX Example: reset totalizer = 46401

7.2   Overview of the operating menu

The following table provides an overview of the structure of the operating menu with its parameters specific to the concentration. The page reference indicates where the associated description of the submenu or parameter can be found.

Navigation
"Setup" menu → Advanced setup → Concentration

▶ Concentration		
▶ Concentration settings	→ 🖹 50	
Liquid type	→ 🖹 50	
Carrier type	→ 🖹 50	
Water mineral content	→ 🖹 50	
Carrier reference density	→ 🖹 50	
Carrier linear expansion coefficient	→ 🖹 50	
Carrier square expansion coefficient	→ 🖹 50	
Target reference density	→ 🖹 50	
Target linear expansion coefficient	→ 🖹 50	
Target square expansion coefficient	→ 🖹 50	
Reference temperature expansion	→ 🖹 50	
Create coefficients for liquid type	→ 🖹 50	
▶ Concentration unit	→ 🖹 51	
Concentration unit	→ 🖹 51	
User concentration text	→ 🖹 51	

User concentration factor	→ 🖺 51
User concentration offset	→ 🖺 51
Reference temperature	→ 🖺 51
▶ Concentration profile 1 to n	→ 🖺 51
Coefficients set name	→ 🖺 51
A 0	→ 🖺 51
A 1	→ 🖺 51
A 2	→ 🖺 51
A 3	→ 🖺 51
A 4	→ 🖺 51
B 1	→ 🖺 51
B 2	→ 🖺 51
B 3	→ 🖺 51
D 1	→ 🖺 51
D 2	→ 🖺 51
D 3	→ 🖺 51
D 4	→ 🖺 51

7.3   Register information

7.3.1   "Concentration settings" submenu

Navigation: Concentration → Concentration settings					
Parameter	Register	Data type	Access	Selection / User entry / User interface	→ 🖹
Liquid type		Integer	Read / Write	**0 = Off** 1 = Fructose in water 2 = Glucose in water 4 = Hydrogen peroxide in water 5 = Sucrose in water 6 = Invert sugar in water 7 = Nitric acid 8 = Phosphoric acid 9 = Potassium hydroxide 10 = Sodium hydroxide 11 = Ethanol in water (OIML) 12 = Methanol in water 13 = Ammonium nitrate in water 14 = Iron(III)chloride in water 15 = HFCS42 16 = HFCS55 17 = HFCS90 18 = Wort 19 = %mass / %volume 23 = Coef Set 24 = Hydrochloric acid 25 = Sulfuric acid 26 = Whey (Total Solids) 27 = Ammonia in water 28 = Ammonium hydroxide in water 29 = Sodium chloride in water	13
Carrier type		Integer	Read / Write	**0 = Water based** 0 = Not water based	13
Water mineral content		Float	Read / Write	Positive floating-point number	14
Carrier reference density		Float	Read / Write	Positive floating-point number	14
Carrier linear expansion coefficient		Float	Read / Write	Signed floating-point number	14
Carrier square expansion coefficient		Float	Read / Write	Signed floating-point number	14
Target reference density		Float	Read / Write	Positive floating-point number	14
Target linear expansion coefficient		Float	Read / Write	Signed floating-point number	14
Target square expansion coefficient		Float	Read / Write	Signed floating-point number	14
Reference temperature expansion		Float	Read / Write	−273.15 to 99 999 ℃	15
Create coefficients for liquid type		Integer	Read / Write	**0 = Cancel** 1 = Coefficient set 1 2 = Coefficient set 2 3 = Coefficient set 3	15

7.3.2   "Concentration unit" submenu

Navigation: Concentration → Concentration unit					
Parameter	Register	Data type	Access	Selection / User entry / User interface	→ 🖺
Concentration unit		Integer	Read / Write	90 = SGU **101 = °Brix** 107 = °Balling 108 = proof/vol 149 = %vol 160 = °Plato 240 = mol/l 240 = %ABV@20℃ 240 = %Mass 240 = %StdVol 240 = User conc.	15
User concentration text		String	Read / Write		16
User concentration factor		Float	Read / Write	Signed floating-point number	15
User concentration offset		Float	Read / Write	Signed floating-point number	16
Reference temperature		Float	Read / Write	−273.15 to 99 999 ℃	16

7.3.3   "Concentration profile 1 to n" submenu

Navigation: Concentration → Concentration profile 1 to n					
Parameter	Register	Data type	Access	Selection / User entry / User interface	→ 🖺
Coefficients set name		String	Read / Write		17
A 0		Float	Read / Write	Signed floating-point number	17
A 1		Float	Read / Write	Signed floating-point number	17
A 2		Float	Read / Write	Signed floating-point number	17
A 3		Float	Read / Write	Signed floating-point number	17
A 4		Float	Read / Write	Signed floating-point number	17
B 1		Float	Read / Write	Signed floating-point number	17
B 2		Float	Read / Write	Signed floating-point number	17
B 3		Float	Read / Write	Signed floating-point number	17
D 1		Float	Read / Write	Signed floating-point number	17
D 2		Float	Read / Write	Signed floating-point number	17
D 3		Float	Read / Write	Signed floating-point number	17
D 4		Float	Read / Write	Signed floating-point number	17

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