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Special Documentation
Proline Promass 500 Modbus RS485

Petroleum 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 Petroleum software 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 **Petroleum** application package.

It provides detailed information on:
- 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
✓	**Permitted** Procedures, processes or actions that are permitted.
✓✓	**Preferred** Procedures, processes or actions that are preferred.
✗	**Forbidden** Procedures, processes or actions that are forbidden.
ℹ	**Tip** Indicates additional information.
📖	Reference to documentation
📄	Reference to page
🖼	Reference to graphic
▶	Notice or individual step to be observed

Symbol	Meaning
1., 2., 3....	Series of steps
	Result of a step
 A0028662	Operation via local display
 A0028663	Operation via operating tool
 A0028665	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:
- *Device Viewer* (www.endress.com/deviceviewer): Enter serial number from nameplate.
- *Endress+Hauser Operations app*: Enter serial number from nameplate or scan matrix code on nameplate.

This Special Documentation is available:
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
Promass E 500	BA01539D
Promass F 500	BA01540D
Promass O 500	BA01543D
Promass Q 500	BA01545D
Promass X 500	BA01547D

1.5 Registered trademarks

Modbus®
Registered trademark of SCHNEIDER AUTOMATION, INC.

TRI-CLAMP®
Registered trademark of Ladish & Co., Inc., Kenosha, USA

2 Product features and availability

2.1 Product features

The **Petroleum** application package delivers specific algorithms together with device variables and external inputs to calculate additional parameters, options and measured variables that are then available to the user.

The following three functions are available with the application package:

- **API referenced correction**
  Corrections for the corrected volume and reference density, calculated and based on the API MPMS, Chapter 11 Section 1 "Temperature and Pressure Volume Correction Factors for Generalized Crude Oils, Refined Products, and Lubricating Oils", and Chapter 11 Section 2 Part 4 "Temperature Correction for the Volume of NGL and LPG Tables 23E, 24E, 53E, 95E [sic], and 60E" . → 🖹 8
- **Net oil & water cut**
  Determines the net oil and water content based on the density values of the measuring device or on the oil/water contents measured by an external measuring device. Performed in accordance with API MPMS, Chapter 20 Section 1 "Allocation Measurement". All the corrections to the volume and density are performed in accordance with API MPMS, Chapter 11 Section 1 "Temperature and Pressure Volume Correction Factors for Generalized Crude Oils, Refined Products, and Lubricating Oils", and Chapter 11 Section 2 Part 4 "Temperature Correction for the Volume of NGL and LPG Tables 23E, 24E, 53E, 95E [sic], and 60E" → 🖹 17
- **Weighting of flow-related variables**
  Influence on density- and temperature-dependent measured variables through the use of weighted density and temperature mean values. Performed in accordance with API MPMS, Chapter 12 Section 2 Part 2 "Measurement Tickets" → 🖹 26

2.2 Availability

The **Petroleum** application package can be ordered directly with the device.

It is available subsequently via an activation code. Detailed information on the order code in question is available from your local Endress+Hauser sales center or on the product page of the Endress+Hauser website: www.endress.com.

The availability of the **Petroleum** application package with the **EJ** option can be checked as follows:

- Order code with breakdown of the device features on the delivery note
- In the W@M Device Viewer (www.endress.com/deviceviewer)
  Enter the serial number from the nameplate and check in the device information whether the option **EJ** "Petroleum" appears under the order code for "Application packages".
- In the operating menu:
  The software options currently enabled are displayed in the **Software option overview** parameter.
  Expert → System → Administration

2.2.1 Order code for

If ordering directly with the device or subsequently as a retrofit kit:
Order code for "Application packages", option **EJ** "Petroleum"

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 details, see Installation Instructions EA001164D

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.

3 API referenced correction

3.1 General principles

Using the API referenced correction of the "Petroleum" application package, the measuring device can calculate the corrected volume flow and reference density in compliance with the regulations in API MPMS, Chapter 11 Section 1 "Temperature and Pressure Volume Correction Factors for Generalized Crude Oils, Refined Products, and Lubricating Oils" and Chapter 11 Section 2 Part 4 "Temperature Correction for the Volume of NGL and LPG Tables 23E, 24E, 53E, 95E [sic], and 60E".

Promass measuring devices measure both the mass flow and the density of a fluid under controlled conditions. Using these measured values, the volume flow can be calculated by dividing the mass flow by the density.

When the fluid temperature changes, the density and volume also change. Therefore it is necessary to correct the volume flow back to standard conditions. Here, the temperature and pressure are corrected back to target values.

The fluid temperature must be known to be able to correct to standard or reference conditions. Given that all Promass measuring devices measure the temperature, this value can be used for the correction process. However, API MPMS Chapter 5 Section 6 explicitly advises against such an approach; it is also not the standard practice in many custody transfer applications and other applications. Therefore, an external source can provide a temperature to the measuring device in order to calculate the correction value. All users must understand the application and the requirements before they use the internal measured value and must know whether this is acceptable.

In order to correct volumes and densities from observed to standard or reference conditions based on the effect of pressure on the liquid (CPL) the meter must know the fluid pressure. As there is no internal pressure measurement, if a user wants to correct this effect the pressure must be either fixed statically in the meter or provided as an input from an external source.

Key parameters must be configured before the "Petroleum" application package is fully operational. In addition to configuring the pressure and temperature sources, it is necessary to select the API commodity group based on the process fluid as well as the API table number for which the reference or standard conditions should apply.

The options available in the **API commodity group** parameter and in the **API table selection** parameter are described below.

API commodity group parameter with the API commodity group and the associated process fluid:
- A - crude oil
- B - refined products
- C - special applications
- D - lubricating oils
- E – NGL/LPG

The following must be considered when selecting the option in the **API commodity group** parameter:
- The calculation and correction of the corrected volume and standard density depend on the process fluid selected.
- If the **C - special applications** option option is selected, the thermal expansion coefficient of the fluid must be specified.
- The calculations and corrections programmed into the device do not apply for the following media:
  - LNG
  - Ethylene
  - Butadiene
  - Cyclohexane
  - Aromas
  - Road tars

Options available in the "API table selection" parameter

API table selection	Unit	Standard conditions
API table 5/6	API°	60°F & 0 psi(g)
API table 23/24	SGU	60°F & 0 psi(g)
API table 53/54	kg/m³	15°C & 0 kPa(g)
API table 59/60	kg/m³	20°C & 0 kPa(g)
ASTM D4311/D4311M	kg/m³	15°C

3.2 System integration

Additional measured variables are available with the **Petroleum** application package and the **API referenced correction** option selected in the **Petroleum mode** parameter.

- Reference density alternative
- GSV flow
- GSV flow alternative
- NSV flow
- NSV flow alternative
- S&W volume flow

Overview of the extended range of measured variables available with the **Petroleum** application package: → 14

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

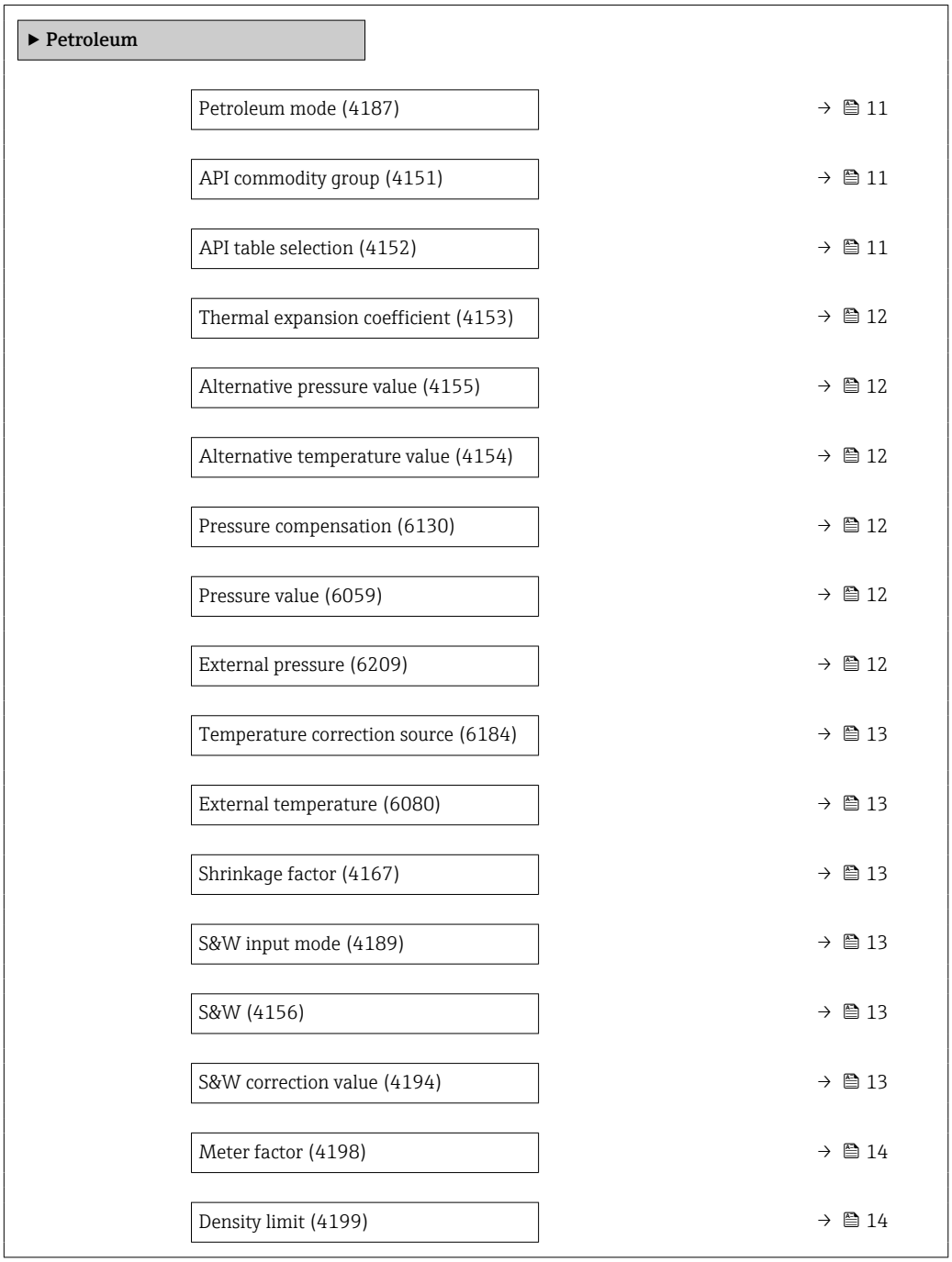
3.3 Commissioning

3.3.1 Configuring the measuring device

Configuration of the measuring device if the **API referenced correction** option is selected

1. Start with the **Petroleum** submenu→ 9
2. Configure the outputs → 14
3. Read out the measured values → 14

Navigation
"Setup" menu → Advanced setup → Petroleum



Parameter overview with brief description

Parameter	Prerequisite	Description	Selection / User entry / User interface	Factory setting
Petroleum mode	–	Select petroleum mode. If the **API referenced correction** option is selected, the **Corrected volume flow** parameter and the **Reference density unit** parameter are calculated in accordance with the guidelines in the API MPMS, Chapter 11 Section 1 "Temperature and Pressure Volume Correction Factors for Generalized Crude Oils, Refined Products, and Lubricating Oils", and Chapter 11 Section 2 Part 4 "Temperature Correction for the Volume of NGL and LPG Tables 23E, 24E, 53E, 95E [sic], and 60E".	▪ Off ▪ API referenced correction ▪ ASTM D4311	Off
API commodity group	–	Select API commodity group of the measured medium. For additional information, see the API MPMS, Chapter 11 Section 1 "Temperature and Pressure Volume Correction Factors for Generalized Crude Oils, Refined Products, and Lubricating Oils", and Chapter 11 Section 2 Part 4 "Temperature Correction for the Volume of NGL and LPG Tables 23E, 24E, 53E, 95E [sic], and 60E" .	▪ A - crude oil ▪ B - refined products * ▪ C - special applications ▪ D - lubricating oils * ▪ E - NGL / LPG *	A - crude oil
API table selection	–	Select reference density by API table. Use this function to select the API table according to the desired values for the reference temperature and pressure. For additional information, see the API MPMS, Chapter 11 Section 1 "Temperature and Pressure Volume Correction Factors for Generalized Crude Oils, Refined Products, and Lubricating Oils", and Chapter 11 Section 2 Part 4 "Temperature Correction for the Volume of NGL and LPG Tables 23E, 24E, 53E, 95E [sic], and 60E" .	▪ API table 5/6 * ▪ API table 23/24 ▪ API table 53/54 ▪ API table 59/60	API table 53/54

Parameter	Prerequisite	Description	Selection / User entry / User interface	Factory setting
Thermal expansion coefficient	The **C - special applications** option is selected in the **API commodity group** parameter parameter	Enter the thermal expansion coefficient of the measured medium.	$414 \cdot 10^{-6}$ to $1674 \cdot 10^{-6}$ 1/K	$414 \cdot 10^{-6}$ 1/K
Alternative pressure value	The **API referenced correction** option is selected in the **Petroleum mode** parameter parameter.	Enter an alternative user-defined pressure value. The volume and density are corrected with this value. The value specified is an alternative value to the reference pressure in the table selected in the **API table selection** parameter.	1.01325 to 104.434 60935 bar	1.01325 bar
Alternative temperature value	The **API referenced correction** option is selected in the **Petroleum mode** parameter parameter.	Enter an alternative user-defined temperature value. The volume and density are corrected with this value. The value specified is an alternative value to the reference temperature in the table selected in the **API table selection** parameter.	−46 to 93 °C	29.5 °C
Pressure compensation	–	Select pressure compensation type. If the effect of pressure on the volume and density of the fluid is to be corrected, the type of pressure compensation can be selected here. Pressure compensation can be deactivated if it is not needed for the application. If pressure compensation is deactivated, the measuring device continues to correct the effect of temperature on the volume and density.	▪ Off ▪ Fixed value ▪ External value ▪ Current input 1 * ▪ Current input 2 * ▪ Current input 3 *	Off
Pressure value	The **Fixed value** option or the **Current input 1...n** option is selected in the **Pressure compensation** parameter.	Enter process pressure to be used for pressure correction. The value entered corrects the effect of pressure on the volume and density of the fluid. The pressure is 0 bar(g) = 1.01325 bar under standard conditions.	Positive floating-point number	1.01325 bar
External pressure	In the **Pressure compensation** parameter, the **External value** option or the **Current input 1...n** option is selected.	Shows the external process pressure value.		–

Parameter	Prerequisite	Description	Selection / User entry / User interface	Factory setting
Temperature correction source	–	Select source for temperature correction. The effect of temperature on the volume and density of the fluid must be kept to a minimum. The setting requires detailed knowledge of the functioning of the device and application. It is not advisable to use the internal temperature value for correction purposes. According to the API MPMS, Chapter 5 Section 6 or other standards, and according to custody transfer guidelines, the use of the internal temperature value is not recommended. The value of a typical downstream external temperature measuring device should be used.	▪ Internal measured value ▪ External value ▪ Current input 1 * ▪ Current input 2 * ▪ Current input 3 *	Internal measured value
External temperature	In the **Temperature mode** parameter, the **External value** option or the **Current input 1…n** option is selected.	Shows the external process temperature read in from the external device.		–
Shrinkage factor	–	Enter shrinkage factor. The volume flow can decrease as a result of outgassing between the separation point and the storage tank. A reduction in the volume flow is taken into account by entering a shrinkage factor.	Positive floating-point number	1.0
S&W input mode	The **API referenced correction** option is selected in the **Petroleum mode** parameter parameter.	Select input mode for sediment and water. If the calculated volume flow should be reduced owing to the presence of sediment and water in the fluid, this can be done using a fixed value, a value from an external source or by entering a current value.	▪ Off ▪ Fixed value ▪ External value ▪ Current input 1 * ▪ Current input 2 * ▪ Current input 3 *	Off
S&W	The **Fixed value** option is selected in the **S&W input mode** parameter parameter	Enter a value for sediment and water in percent. Use this function to enter a percentage to factor in a reduction in the volume flow due to the presence of sediment and water in the fluid.	0 to 100 %	0 %
S&W correction value	In the **S&W input mode** parameter, the **External value** option or the **Current input 1…n** option is selected.	Shows the correction value for sediment and water.	Positive floating-point number	–

Parameter	Prerequisite	Description	Selection / User entry / User interface	Factory setting
Meter factor	The **Net oil & water cut** option is selected in the **Petroleum mode** parameter parameter.	Displays the current calibration factor for correcting the volume flow. The correction is required due to inaccuracies in the measuring device.	Signed floating-point number	1.0
Density limit	–	Enter limit value for the observed oil density. For higher °API values or lower kg/m³ values this limit value will be output.	Positive floating-point number	0 kg/l

* Visibility depends on order options or device settings

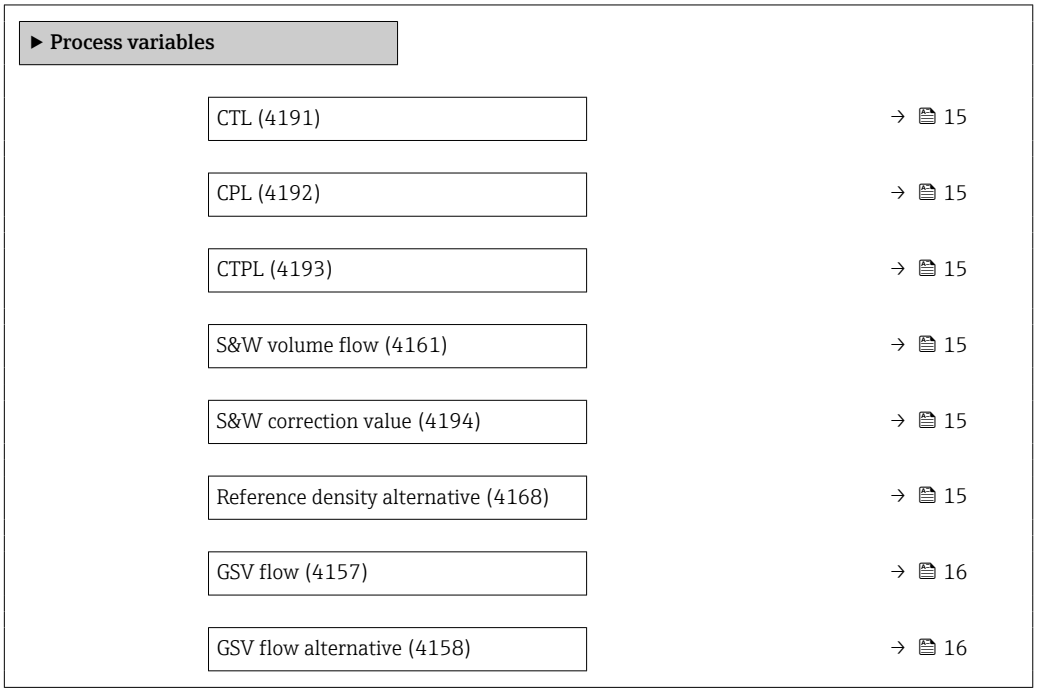
3.3.2 Configuration of the outputs

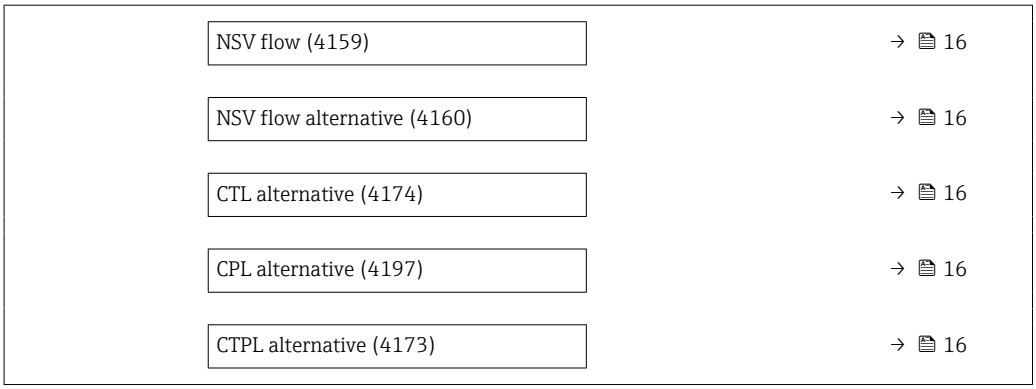
Additional measured variables are available for the outputs, the local display and the totalizer if the **API referenced correction** option is selected:
- Reference density
- Reference density alternative
- GSV flow
- GSV flow alternative
- NSV flow
- NSV flow alternative
- S&W volume flow

3.4 Additional measured variables

Additional measured variables are available with the **Petroleum** application package if the **API referenced corrections** option was selected in the **Petroleum mode** parameter.

Navigation
"Diagnostics" menu → Measured values → Measured variables





Parameter overview with brief description

Parameter	Prerequisite	Description	User interface	Factory setting
CTL	In the **Petroleum mode** parameter, the **API referenced correction** option is selected.	Displays the correction factor which represents the effect of temperature on the fluid. This is used to convert the measured volume flow and the measured density to values at reference temperature.	Positive floating-point number	–
CPL	In the **Petroleum mode** parameter, the **API referenced correction** option is selected.	Displays the correction factor which represents the effect of pressure on the fluid. This is used to convert the measured volume flow and the measured density to values at reference pressure.	Positive floating-point number	–
CTPL	In the **Petroleum mode** parameter, the **API referenced correction** option is selected.	Displays the combined correction factor which represents the effect of temperature and pressure on the fluid. This is used to convert the measured volume flow and the measured density to values at reference temperature and reference pressure.	Positive floating-point number	–
S&W volume flow	In the **Petroleum mode** parameter, the **API referenced correction** option is selected.	Displays the S&W volume flow which is calculated from the measured total volume flow minus the net volume flow. *Dependency* The unit is taken from: **Volume flow unit** parameter	Signed floating-point number	–
S&W correction value	In the **S&W input mode** parameter, the **External value** option or the **Current input 1…n** option is selected.	Shows the correction value for sediment and water.	Positive floating-point number	–
Reference density alternative	In the **Petroleum mode** parameter, the **API referenced correction** option is selected.	Displays the fluid density at the alternative reference temperature. *Dependency* The unit is taken from: **Reference density unit** parameter	Signed floating-point number	–

Parameter	Prerequisite	Description	User interface	Factory setting
GSV flow	In the **Petroleum mode** parameter, the **API referenced correction** option is selected.	Displays the measured total volume flow, corrected to the reference temperature and the reference pressure. *Dependency* The unit is taken from: **Corrected volume flow unit** parameter	Signed floating-point number	–
GSV flow alternative	In the **Petroleum mode** parameter, the **API referenced correction** option is selected.	Displays the measured total volume flow, corrected to the alternative reference temperature and the alternative reference pressure. *Dependency* The unit is taken from: **Corrected volume flow unit** parameter	Signed floating-point number	–
NSV flow	In the **Petroleum mode** parameter, the **API referenced correction** option is selected.	Displays the net volume flow which is calculated from the measured total volume flow minus the value for sediment & water and minus the shrinkage. *Dependency* The unit is taken from: **Corrected volume flow unit** parameter	Signed floating-point number	–
NSV flow alternative	In the **Petroleum mode** parameter, the **API referenced correction** option is selected.	Displays the net volume flow which is calculated from the measured alternative total volume minus the value for sediment & water and minus the shrinkage. *Dependency* The unit is taken from: **Corrected volume flow unit** parameter	Signed floating-point number	–
CTL alternative	In the **Petroleum mode** parameter, the **API referenced correction** option is selected.	Displays the correction factor which represents the effect of temperature on the fluid. This is used to convert the measured volume flow and the measured density to values at the alternative reference temperature.	Positive floating-point number	–
CPL alternative	In the **Petroleum mode** parameter, the **API referenced correction** option is selected.	Displays the correction factor which represents the effect of pressure on the fluid. This is used to convert the measured volume flow and the measured density to values at the alternative reference pressure.	Positive floating-point number	–
CTPL alternative	In the **Petroleum mode** parameter, the **API referenced correction** option is selected.	Displays the combined correction factor which represents the effect of temperature and pressure on the fluid. This is used to convert the measured volume flow and the measured density to values at the alternative reference temperature and the alternative reference pressure.	Positive floating-point number	1

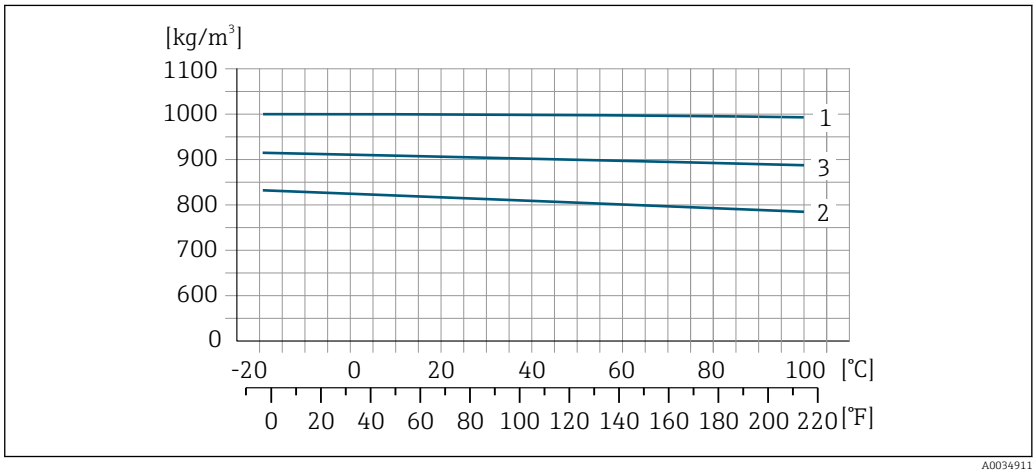
4 Net oil & water cut

4.1 General principles

The **Net oil & water cut** option is used to calculate the percentage of the water in the emulsion flow in proportion to the total volume. In this way, it is possible to display and totalize the volume flow for the oil part of the process only. The net oil volume refers directly to the oil volume minus the water volume. The calculation is performed in accordance with API standards MPMS, Chapter 20 Section 1 – Allocation Measurement.

If a fluid contains both water and oil, the measuring device measures the density of the overall mixture of water and oil. If the share of water in the mixture changes, the density of the overall mixture also changes.

If the density values of the pure oil and pure water are known, the density of the mixture is in the range between these two density values.



1 Example of an oil/water mixture: density as a function of the temperature

1 Density curve of pure water
2 Density curve of pure oil
3 Density curve of oil/water mixture

If this is the case, the share of the two components can be calculated using the following formula. This is also known as the density-based determination of the water cut.

$$W_C = \frac{\rho_e - \rho_o}{\rho_w - \rho_o}$$

A0034909

2 Density-based determination of the water cut

ρ_e *Emulsion density (density of the fluid) measured by the measuring device*
ρ_o *Density of the pure oil*
ρ_W *Density of the pure water*
W_C *Water cut (content of water in an oil/water mixture)*

To use this function, the density values of pure oil and pure water at a known temperature and pressure (oil only) must be known. The density values of pure oil and water for the temperature and pressure of the fluid are first calculated with the **Net oil & water cut** option. These values and the measured density of the fluid are then used to determine the water content of the mixture with using the formula above.

These values are usually taken from a sample of oil and water:
- Density of the oil sample
- Temperature of the oil sample
- Pressure of the oil sample
- Density of the water sample
- Temperature of the water sample

In addition to configuring the pressure and temperature sources, it is necessary to select the API commodity group based on the process fluid as well as the API table number for which the reference or standard conditions should apply.

If the percentage water content is known, the volume of the oil and the volume of the water can be totalized separately.

As soon as the net oil volume and the net water volume have been determined, they can be corrected back to the corrected volume using the properties of water and the API MPMS, Chapter 11 Section 1 "Temperature and Pressure Volume Correction Factors for Generalized Crude Oils, Refined Products, and Lubricating Oils", as already described under the **API referenced correction** option (→ 8).

Reading in the water content from an external measuring device
The **Net oil & water cut** option allows the user to read in the water content from an external measuring device.
- The percentage water content measured externally can be communicated directly to the measuring device by analog means or via fieldbus.
- The volume flow and corrected volume flow for water and oil are calculated with the external water content value.
- The density and temperature values of the samples also need to be specified with this method in order to calculate the standard variables.

4.2 System integration

Additional measured variables are available with the **Petroleum** application package and the **Net oil & water cut** option selected in the **Petroleum mode** parameter.

- Water cut
- Oil density
- Water density
- Oil mass flow
- Water mass flow
- Oil volume flow
- Water volume flow
- Oil corrected volume flow
- Water corrected volume flow

Overview of the extended range of measured variables available with the **Petroleum** application package: → 23

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

4.3 Commissioning

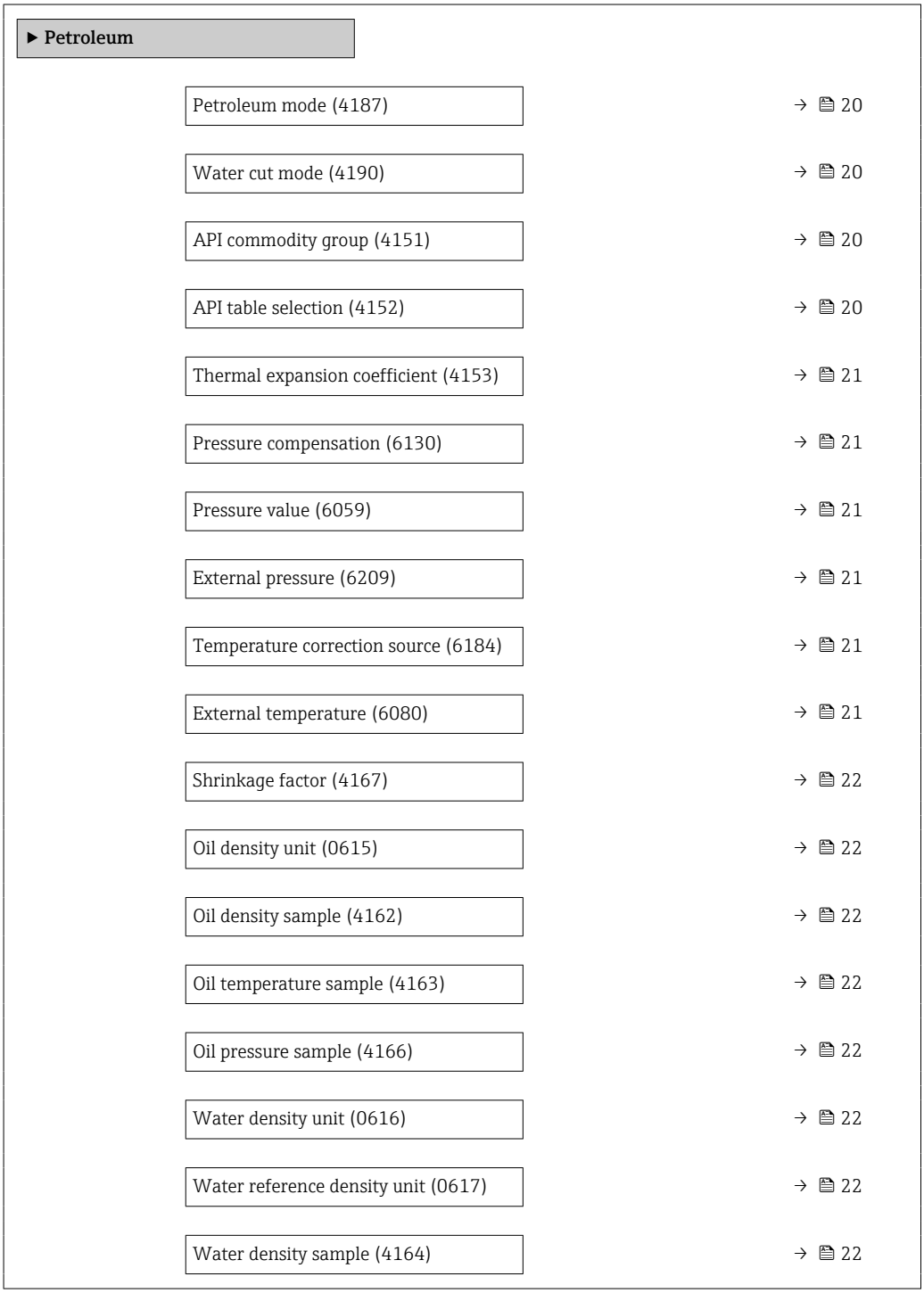
4.3.1 Configuring the measuring device

Configuration of the measuring device if the **Net oil & water cut** option is selected.

1. Start with the **Petroleum** submenu→ 18

2. The density, temperature and pressure values of an oil and water sample are always needed to determine the standard density and corrected volume flow of the water content. Start making your entries with the **Oil density unit** parameter and subsequent parameters.
3. Configure the outputs → 22
4. Read out the measured values → 23

Navigation
"Setup" menu → Advanced setup → Petroleum



Water temperature sample (4165)	→ 22
Meter factor (4198)	→ 22

Parameter overview with brief description

Parameter	Prerequisite	Description	Selection / User entry	Factory setting
Petroleum mode	–	Select petroleum mode. If the **Net oil & water cut** option is selected, the water in the emulsion flow is calculated in proportion to the total volume in order to determine the net oil content.	▪ Off ▪ Net oil & water cut	Off
Water cut mode	The **Net oil & water cut** option is selected in the **Petroleum mode** parameter parameter.	Select water cut mode.	▪ Calculated value ▪ External value ▪ Current input 1 * ▪ Current input 2 * ▪ Current input 3 *	Calculated value
API commodity group	–	Select API commodity group of the measured medium. For additional information, see the API MPMS, Chapter 11 Section 1 "Temperature and Pressure Volume Correction Factors for Generalized Crude Oils, Refined Products, and Lubricating Oils", and Chapter 11 Section 2 Part 4 "Temperature Correction for the Volume of NGL and LPG Tables 23E, 24E, 53E, 95E [sic], and 60E" .	▪ A - crude oil ▪ C - special applications ▪ E - NGL / LPG *	A - crude oil
API table selection	–	Select reference density by API table. Use this function to select the API table according to the desired values for the reference temperature and pressure. For additional information, see the API MPMS, Chapter 11 Section 1 "Temperature and Pressure Volume Correction Factors for Generalized Crude Oils, Refined Products, and Lubricating Oils", and Chapter 11 Section 2 Part 4 "Temperature Correction for the Volume of NGL and LPG Tables 23E, 24E, 53E, 95E [sic], and 60E" .	▪ API table 5/6 * ▪ API table 23/24 ▪ API table 53/54 ▪ API table 59/60	API table 53/54

Parameter	Prerequisite	Description	Selection / User entry	Factory setting
Thermal expansion coefficient	The **C - special applications** option is selected in the **API commodity group** parameter parameter	Enter the thermal expansion coefficient of the measured medium.	$414 \cdot 10^{-6}$ to $1\,674 \cdot 10^{-6}$ 1/K	$414 \cdot 10^{-6}$ 1/K
Pressure compensation	–	Select pressure compensation type. If the effect of pressure on the volume and density of the fluid is to be corrected, the type of pressure compensation can be selected here. Pressure compensation can be deactivated if it is not needed for the application. If pressure compensation is deactivated, the measuring device continues to correct the effect of temperature on the volume and density.	▪ Off ▪ Fixed value ▪ External value ▪ Current input 1 * ▪ Current input 2 * ▪ Current input 3 *	Off
Pressure value	The **Fixed value** option or the **Current input 1...n** option is selected in the **Pressure compensation** parameter.	Enter process pressure to be used for pressure correction. The value entered corrects the effect of pressure on the volume and density of the fluid. The pressure is 0 bar(g) = 1.01325 bar under standard conditions.	Positive floating-point number	1.01325 bar
External pressure	In the **Pressure compensation** parameter, the **External value** option or the **Current input 1...n** option is selected.	Shows the external process pressure value.		–
Temperature correction source	–	Select source for temperature correction. The effect of temperature on the volume and density of the fluid must be kept to a minimum. The setting requires detailed knowledge of the functioning of the device and application. It is not advisable to use the internal temperature value for correction purposes. According to the API MPMS, Chapter 5 Section 6 or other standards, and according to custody transfer guidelines, the use of the internal temperature value is not recommended. The value of a typical downstream external temperature measuring device should be used.	▪ Internal measured value ▪ External value ▪ Current input 1 * ▪ Current input 2 * ▪ Current input 3 *	Internal measured value
External temperature	In the **Temperature mode** parameter, the **External value** option or the **Current input 1...n** option is selected.	Shows the external process temperature read in from the external device.		–

Parameter	Prerequisite	Description	Selection / User entry	Factory setting
Shrinkage factor	–	Enter shrinkage factor. The volume flow can decrease as a result of outgassing between the separation point and the storage tank. A reduction in the volume flow is taken into account by entering a shrinkage factor.	Positive floating-point number	1.0
Oil density unit	The **Net oil & water cut** option is selected in the **Petroleum mode** parameter parameter.	Select unit for the density of oil.	Unit choose list	kg/m³
Oil sample density	The **Net oil & water cut** option is selected in the **Petroleum mode** parameter parameter.	Enter the value for the density of the oil sample.	470 to 1 210 kg/m³	850 kg/m³
Oil sample temperature	The **Net oil & water cut** option is selected in the **Petroleum mode** parameter parameter.	Enter the value for the temperature of the oil sample.	– 273.15 to 99 726.84 99 °C	15 °C
Oil sample pressure	The **Net oil & water cut** option is selected in the **Petroleum mode** parameter parameter.	Enter the value for the pressure of the oil sample.	Positive floating-point number	1.01325 bar
Water density unit	The **Net oil & water cut** option is selected in the **Petroleum mode** parameter parameter.	Select unit for the density of the water.	Unit choose list	kg/m³
Water reference density unit	The **Net oil & water cut** option is selected in the **Petroleum mode** parameter parameter.	Select unit for reference density of the water.	Unit choose list	kg/Nm³
Water sample density	The **Net oil & water cut** option is selected in the **Petroleum mode** parameter parameter.	Enter the value for the density of the water sample.	900 to 1 200 kg/m³	999.2 kg/m³
Water sample temperature	The **Net oil & water cut** option is selected in the **Petroleum mode** parameter parameter.	Enter the value for the temperature of the water sample.	– 273.15 to 99 726.84 99 °C	15 °C
Meter factor	The **Net oil & water cut** option is selected in the **Petroleum mode** parameter parameter.	Displays the current calibration factor for correcting the volume flow. The correction is required due to inaccuracies in the measuring device.	Signed floating-point number	1.0

* Visibility depends on order options or device settings

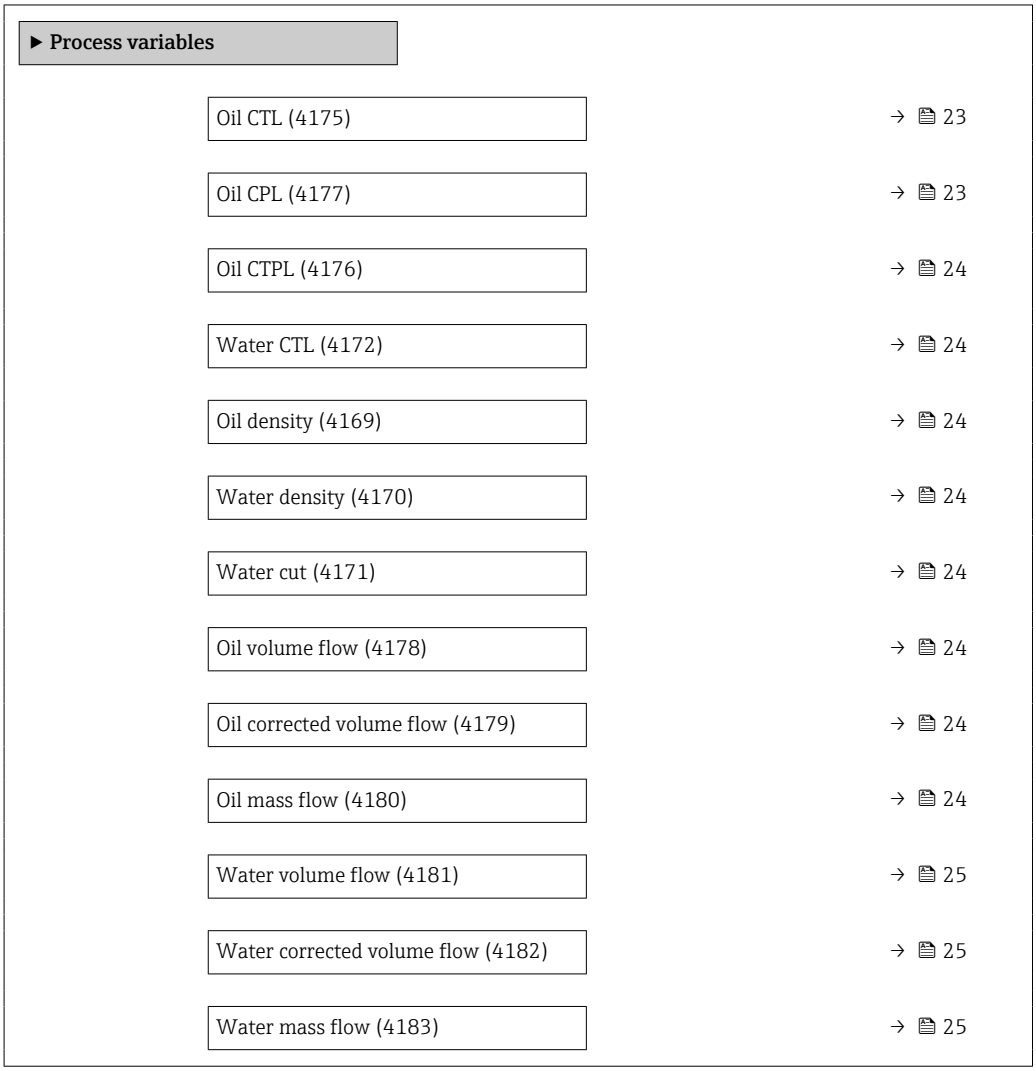
4.3.2 Configuration of the outputs

Additional measured variables are available for the outputs, the local display and the totalizer if the **Net oil & water cut** option is selected:
- Water cut
- Oil density
- Water density
- Oil mass flow
- Water mass flow
- Oil volume flow
- Water volume flow
- Oil corrected volume flow
- Water corrected volume flow

4.4 Additional measured variables

Additional measured variables are available with the **Petroleum** application package if the **Net oil & water cut** option was selected in the **Petroleum mode** parameter.

Navigation
"Diagnostics" menu → Measured values → Measured variables



Parameter overview with brief description

Parameter	Prerequisite	Description	User interface	Factory setting
Oil CTL	In the **Petroleum mode** parameter, the **Net oil & water cut** option is selected.	Displays the correction factor which represents the effect of temperature on the oil. This is used to convert the measured oil volume flow and the measured oil density to values at reference temperature.	Positive floating-point number	–
Oil CPL	In the **Petroleum mode** parameter, the **Net oil & water cut** option is selected.	Displays the correction factor which represents the effect of pressure on the oil. This is used to convert the measured oil volume flow and the measured oil density to values at reference pressure.	Positive floating-point number	–

Parameter	Prerequisite	Description	User interface	Factory setting
Oil CTPL	In the **Petroleum mode** parameter, the **Net oil & water cut** option is selected.	Displays the combined correction factor which represents the effect of temperature and pressure on the oil. This is used to convert the measured oil volume flow and the measured oil density to values at reference temperature and reference pressure.	Positive floating-point number	–
Water CTL	In the **Petroleum mode** parameter, the **Net oil & water cut** option is selected.	Displays the correction factor which represents the effect of temperature on the water. This is used to convert the measured water volume flow and the measured water density to values at reference temperature.	Positive floating-point number	–
Oil density	In the **Petroleum mode** parameter, the **Net oil & water cut** option is selected.	Displays the density of the oil currently measured.	Signed floating-point number	–
Water density	In the **Petroleum mode** parameter, the **Net oil & water cut** option is selected.	Displays the density of the water currently measured.	Signed floating-point number	–
Water cut	In the **Petroleum mode** parameter, the **Net oil & water cut** option is selected.	Displays the percentage water volume flow in relation to the total volume flow of the fluid.	0 to 100 %	–
Oil volume flow	In the **Petroleum mode** parameter, the **Net oil & water cut** option is selected.	Displays the currently calculated volume flow of the oil. Dependency: ▪ Based on the value displayed in the **Water cut** parameter ▪ The unit is taken from: **Volume flow unit** parameter	Signed floating-point number	–
Oil corrected volume flow	In the **Petroleum mode** parameter, the **Net oil & water cut** option is selected.	Displays the currently calculated volume flow of the oil, calculated to values at reference temperature and reference pressure. Dependency: ▪ Based on the value displayed in the **Water cut** parameter ▪ The unit is taken from: **Corrected volume flow unit** parameter	Signed floating-point number	–
Oil mass flow	In the **Petroleum mode** parameter, the **Net oil & water cut** option is selected.	Displays the currently calculated mass flow of the oil. Dependency: ▪ Based on the value displayed in the **Water cut** parameter ▪ The unit is taken from: **Mass flow unit** parameter	Signed floating-point number	–

Parameter	Prerequisite	Description	User interface	Factory setting
Water volume flow	In the **Petroleum mode** parameter, the **Net oil & water cut** option is selected.	Displays the currently calculated volume flow of the water. Dependency: ▪ Based on the value displayed in the **Water cut** parameter ▪ The unit is taken from: **Volume flow unit** parameter	Signed floating-point number	–
Water corrected volume flow	In the **Petroleum mode** parameter, the **Net oil & water cut** option is selected.	Displays the currently calculated volume flow of the water, calculated to values at reference temperature and reference pressure. Dependency: ▪ Based on the value displayed in the **Water cut** parameter ▪ The unit is taken from: **Corrected volume flow unit** parameter	Signed floating-point number	–
Water mass flow	In the **Petroleum mode** parameter, the **Net oil & water cut** option is selected.	Displays the currently calculated mass flow of the water. Dependency: ▪ Based on the value displayed in the **Water cut** parameter ▪ The unit is taken from: **Mass flow unit** parameter	Signed floating-point number	–

5 Weighting of flow-related factors

Certain applications in the oil and gas industry may require an average density or temperature to be provided for a batch.

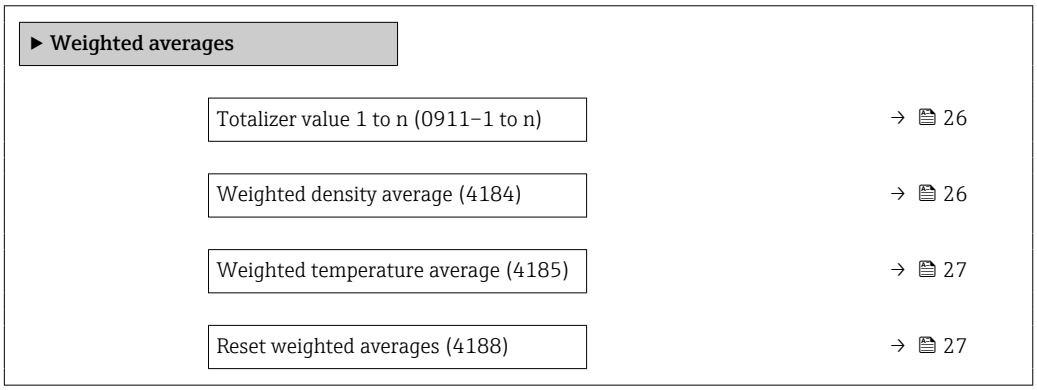
An average value for the density and an average value for the temperature have been provided for this purpose. These values are volume-weighted and can be reset. Both values can be reset at the start of a batch and then read at the end of the batch. They are calculated as described in the API MPMS, Chapter 12, Section 2, Part 2 – Calculation of Petroleum Quantities.

5.1 "Weighted averages" submenu

The temperature and density averages can be read and reset in the **Weighted averages** submenu.

Navigation

"Operation" menu → Weighted averages



Parameter overview with brief description

Parameter	Prerequisite	Description	User interface / Selection	Factory setting
Totalizer value 1 to n	A process variable is selected in the **Assign process variable** parameter of the **Totalizer 1 to n** submenu.	Displays the current totalizer counter value.	Signed floating-point number	–
Weighted density average	–	Displays the weighted average for the density since the last time the density averages were reset. Dependency: ▪ The unit is taken from: **Density unit** parameter ▪ The value is reset to NaN (Not a Number) via the **Reset weighted averages** parameter	Signed floating-point number	–

Parameter	Prerequisite	Description	User interface / Selection	Factory setting
Weighted temperature average	–	Displays the weighted average for the temperature since the last time the temperature averages were reset. Dependency: ▪ The unit is taken from: **Temperature unit** parameter ▪ The value is reset to NaN (Not a Number) via the **Reset weighted averages** parameter	Signed floating-point number	–
Reset weighted averages	The values can only be reset at zero flow. For the following order code: "Application package", option **EJ** "Petroleum" The software options currently enabled are displayed in the **Software option overview** parameter.	Resets the weighted averages for density and temperature to NaN (Not a Number) and then starts determining the weighted averages.	▪ Totalize ▪ Reset weighted averages ▪ Reset weighted averages + totalizer 3	Totalize

6 Software locking

Software locking is only available if the Petroleum application package is ordered with an option for custody transfer.

If software locking is activated, the "Custody transfer" and "Custody transfer logbook" menus are hidden and the associated parameters locked.

Neither an authorized user login nor the use of the DIP switch are required for the software locking described here.

Depending on your region, the software locking described here may not be recognized as an approved mechanism for custody transfer locking according to local metrological standards and requirements.

Information on activation and deactivation for legal custody transfer is provided in the "Custody transfer" Special Documentation

6.1 Activating software locking

1. In the **Define Software Lock code** parameter, define the software locking code (lower-/upper-case letters, numbers or special characters).
2. In the **Software Lock login** parameter, enter the defined software locking code.
3. In the **Software lock** parameter, activate software locking (**On** option).
   ↳ Software locking is active and a lock symbol appears at the top right of the local display.

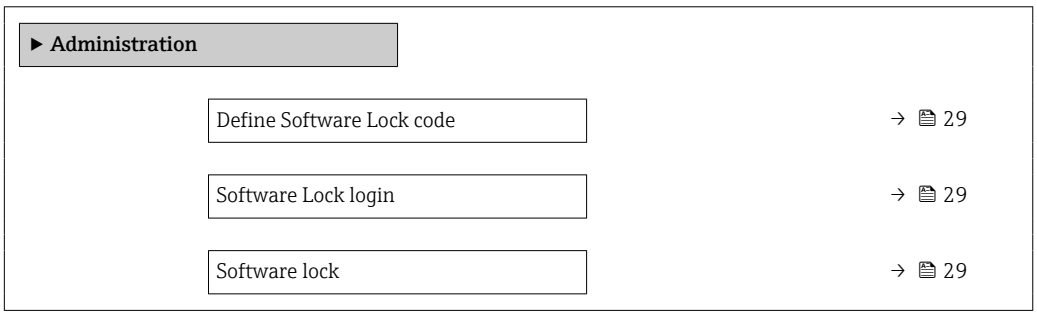
6.2 Deactivating software locking

1. In the **Software Lock login** parameter, enter the software locking code.
   ↳ The **Software lock** parameter can be edited.
2. In the **Software lock** parameter, deactivate the software locking code (**Off** option).
   ↳ Software locking is no longer active.

If the software locking code is lost or misplaced, contact your Endress+Hauser service organization.

6.3 Software locking parameters

Navigation
"Expert" menu → System → Administration



Parameter overview with brief description

Parameter	Description	User entry / Selection	Factory setting
Define Software Lock code	Specify an access code that is required to obtain write access to the 'Software lock' parameter.	Character string comprising numbers, letters and special characters (16)	0000
Software Lock login	Enter Software Lock code to obtain write access to the 'Software lock' parameter.	Character string comprising numbers, letters and special characters (16)	–
Software lock	Activate or deactivate the software lock (Software Lock access rights required).	▪ Off ▪ On	Off

7 Workflow

The workflow below provides a schematic representation of the configuration procedure in the **Petroleum** application package if the **"API referenced correction" option** or **"Net oil & water cut" option** is selected.

Start	
Select the petroleum mode: API referenced correction or Net oil & water cut	
Select the API commodity group: A, B, C, D or E .	
Select the API table: API table 5/6, API table 23/24, API table 53/54 or API table 59/60.	
Enter the Thermal expansion coefficient if the C - special applications option is selected	
↓	↓
API referenced correction is selected	**Net oil & water cut is selected**
↓	↓
Enter the alternative user-specific pressure value if applicable	Select the type of pressure compensation: Off, Fixed value, External value or Current input 1…n
Enter the alternative user-specific temperature value, if applicable	Select the source for temperature correction: Internal measured value, External value or Current input 1…n
Select the type of pressure compensation: Off, Fixed value, External value or Current input 1… n	Enter the shrinkage factor
Select the source for temperature correction: Internal measured value, External value or Current input 1…n	If the water cut value is read in directly via the Current input 1…n, the process variables listed below can be read. If the water cut value has to be calculated, the following entries must be made.
Enter the shrinkage factor.	Enter the value for the density of the oil sample.
Select the entry mode for sediment and water: Off, Fixed value, External value or Current input 1…n	Enter the value for the temperature of the oil sample.
Enter the value for sediment and water, if applicable.	Enter the value for the pressure of the oil sample.
	Enter the value for the density of the water sample.
	Enter the value for the temperature of the water sample.
You can choose from the following process variables: ▪ CTL ▪ CPL ▪ CTPL ▪ S&W volume flow ▪ S&W correction value ▪ GSV flow ▪ NSV flow ▪ CTL alternative ▪ CPL alternative ▪ CTPL alternative ▪ GSV flow alternative ▪ NSV flow alternative ▪ Reference density alternative	You can choose from the following process variables: ▪ Oil CTL ▪ Oil CPL ▪ Oil CTPL ▪ Oil density ▪ Oil mass flow ▪ Oil volume flow ▪ Oil corrected volume flow ▪ Water cut ▪ Water CTL ▪ Water density ▪ Water mass flow ▪ Water volume flow ▪ Water corrected volume flow

8 Modbus RS485 register information

8.1 Notes

8.1.1 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**	**User interface/ Selection/User entry**	**→**
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 (+) (+) = Factory setting depends on country, order options or device settings **User entry** Specific value or 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.

8.1.2 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

8.2 Overview of the operating menu

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

	Oil pressure sample	→ 35
	Water density unit	→ 35
	Water reference density unit	→ 36
	Water density sample	→ 36
	Water temperature sample	→ 36
	Meter factor	→ 36
Diagnostics		→ 36
▶ **Measured values**		→ 36
▶ **Measured variables**		→ 36
	CTL	→ 36
	CPL	→ 36
	CTPL	→ 36
	S&W volume flow	→ 36
	S&W correction value	→ 36
	Reference density alternative	→ 36
	GSV flow	→ 36
	GSV flow alternative	→ 36
	NSV flow	→ 36
	NSV flow alternative	→ 36
	Oil CTL	→ 36
	Oil CPL	→ 36
	Oil CTPL	→ 36
	Water CTL	→ 36
	CTL alternative	→ 36
	CPL alternative	→ 36

	CTPL alternative	→ 36
	Oil density	→ 36
	Water density	→ 36
	Water cut	→ 36
	Oil volume flow	→ 36
	Oil corrected volume flow	→ 36
	Oil mass flow	→ 36
	Water volume flow	→ 36
	Water corrected volume flow	→ 37
	Water mass flow	→ 37
	Weighted density average	→ 37
	Weighted temperature average	→ 37

8.3 Register information

8.3.1 "Setup" menu

"Advanced setup" submenu

"Petroleum" submenu

Navigation: Setup → Advanced setup → Petroleum					
Parameter	**Register**	**Data type**	**Access**	**Selection / User entry / User interface**	**→**
Petroleum mode	26563	Integer	Read / Write	**0 = Off** 2 = API referenced correction 3 = ASTM D4311	11
Water cut mode	26568	Integer	Read / Write	**0 = Calculated value** 2 = External value 11 = Current input 1 * 12 = Current input 2 * 13 = Current input 3 *	20
API commodity group	26225	Integer	Read / Write	**0 = A - crude oil** 1 = B - refined products * 2 = C - special applications 3 = D - lubricating oils * 4 = E - NGL / LPG *	11
API table selection	26226	Integer	Read / Write	0 = API table 23/24 1 = API table 59/60 2 = API table 5/6 * **3 = API table 53/54**	11
Thermal expansion coefficient	26276 to 26277	Float	Read / Write	$414 \cdot 10^{-6}$ to $1\,674 \cdot 10^{-6}$ 1/K	12

Navigation: Setup → Advanced setup → Petroleum					
Parameter	**Register**	**Data type**	**Access**	**Selection / User entry / User interface**	**→**
Alternative pressure value	26295 to 26296	Float	Read / Write	1.01325 to 104.43460935 bar	12
Alternative temperature value	26287 to 26288	Float	Read / Write	−46 to 93 °C	12
Pressure compensation	5184	Integer	Read / Write	**0 = Off** 1 = Fixed value 2 = External value 11 = Current input 1 * 12 = Current input 2 * 13 = Current input 3 *	12
Pressure value	5185 to 5186	Float	Read / Write	Positive floating-point number	12
External pressure	2440 to 2441	Float	Read / Write		12
Temperature correction source	5515	Integer	Read / Write	**0 = Internal measured value** 1 = External value 11 = Current input 1 * 12 = Current input 2 * 13 = Current input 3 *	13
External temperature	2507 to 2508	Float	Read / Write		13
Shrinkage factor	26511 to 26512	Float	Read / Write	Positive floating-point number	13
S&W input mode	26567	Integer	Read / Write	**0 = Off** 1 = Fixed value 2 = External value 11 = Current input 1 * 12 = Current input 2 * 13 = Current input 3 *	13
S&W	26303 to 26304	Float	Read / Write	0 to 100 %	13
S&W correction value	26939 to 26940	Float	Read	Positive floating-point number	13
Oil density unit	26433	Integer	Read / Write	0 = g/cm³ 3 = kg/l **4 = kg/m³** 9 = SG15°C 10 = SG20°C 11 = lb/ft³ 12 = lb/gal (us) 15 = lb/bbl (us;oil) 17 = lb/gal (imp) 19 = lb/bbl (imp;oil) 23 = °API 24 = SG60°F 97 = g/l 98 = lb/in³ 99 = STon/yd³	22
Oil density sample	26497 to 26498	Float	Read / Write	470 to 1 210 kg/m³	22
Oil temperature sample	26499 to 26500	Float	Read / Write	−273.15 to 99 726.8499 °C	22
Oil pressure sample	26507 to 26508	Float	Read / Write	Positive floating-point number	22
Water density unit	26434	Integer	Read / Write	0 = g/cm³ 3 = kg/l **4 = kg/m³** 9 = SG15°C 10 = SG20°C 11 = lb/ft³ 12 = lb/gal (us) 17 = lb/gal (imp) 23 = °API 24 = SG60°F 97 = g/l 98 = lb/in³ 99 = STon/yd³	22

Navigation: Setup → Advanced setup → Petroleum					
Parameter	**Register**	**Data type**	**Access**	**Selection / User entry / User interface**	**→**
Water reference density unit	26481	Integer	Read / Write	0 = g/Scm³ 1 = kg/Nl **2 = kg/Nm³** 3 = kg/Sm³ 4 = lb/Sft³ 6 = RD15°C 7 = RD20°C 8 = RD60°F	22
Water density sample	26503 to 26504	Float	Read / Write	900 to 1 200 kg/m³	22
Water temperature sample	26505 to 26506	Float	Read / Write	−273.15 to 99 726.8499 °C	22
Meter factor	29295 to 29296	Float	Read / Write	Signed floating-point number	14

* Visibility depends on order options or device settings
* Visibility depends on order options or device settings

8.3.2 "Diagnostics" menu

"Measured values" submenu

"Measured variables" submenu

Navigation: Diagnostics → Measured values → Measured variables					
Parameter	**Register**	**Data type**	**Access**	**Selection / User entry / User interface**	**→**
CTL	26569 to 26570	Float	Read	Positive floating-point number	15
CPL	26571 to 26572	Float	Read	Positive floating-point number	15
CTPL	26869 to 26870	Float	Read	Positive floating-point number	15
S&W volume flow	26495 to 26496	Float	Read	Signed floating-point number	15
S&W correction value	26939 to 26940	Float	Read	Positive floating-point number	13
Reference density alternative	26513 to 26514	Float	Read	Signed floating-point number	15
GSV flow	26311 to 26312	Float	Read	Signed floating-point number	16
GSV flow alternative	26319 to 26320	Float	Read	Signed floating-point number	16
NSV flow	26483 to 26484	Float	Read	Signed floating-point number	16
NSV flow alternative	26490 to 26491	Float	Read	Signed floating-point number	16
Oil CTL	26531 to 26532	Float	Read	Positive floating-point number	23
Oil CPL	26537 to 26538	Float	Read	Positive floating-point number	23
Oil CTPL	26535 to 26536	Float	Read	Positive floating-point number	24
Water CTL	26523 to 26524	Float	Read	Positive floating-point number	24
CTL alternative	26529 to 26530	Float	Read	Positive floating-point number	16
CPL alternative	29199 to 29200	Float	Read	Positive floating-point number	16
CTPL alternative	26527 to 26528	Float	Read	Positive floating-point number	16
Oil density	26515 to 26516	Float	Read	Signed floating-point number	24
Water density	26519 to 26520	Float	Read	Signed floating-point number	24
Water cut	26521 to 26522	Float	Read	0 to 100 %	24
Oil volume flow	26539 to 26540	Float	Read	Signed floating-point number	24
Oil corrected volume flow	26543 to 26544	Float	Read	Signed floating-point number	24
Oil mass flow	26545 to 26546	Float	Read	Signed floating-point number	24
Water volume flow	26547 to 26548	Float	Read	Signed floating-point number	25

Navigation: Diagnostics → Measured values → Measured variables					
Parameter	**Register**	**Data type**	**Access**	**Selection / User entry / User interface**	**→**
Water corrected volume flow	26551 to 26552	Float	Read	Signed floating-point number	25
Water mass flow	26553 to 26554	Float	Read	Signed floating-point number	25
Weighted density average	26555 to 26556	Float	Read	Signed floating-point number	26
Weighted temperature average	26559 to 26560	Float	Read	Signed floating-point number	27

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