Hydrocarbon-Analyzer SmartFID mobile
Operating Instructions

Version 1.5.05 EN

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Document

Title:	Operating Instructions SmartFID mobile
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Product

Product name:	SmartFID
Components:	Completely portable
Software-Version:	V1.120605k

Manufacturer

ErsaTec GmbH
Reihekamp 17
30890 Barsinghausen

Telefon:	+49 5105 520 558
Telefax:	+49 5105 529 184
E-Mail:	info@ersatec.com
Web:	www.ersatec.com

Trademarks

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Warranty information

The described product properties and technical data provided do not represent a warrant.

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Subject to change.

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1 Notes for the reader

This manual contains Information on the safe Operation of the device. Please keep the instruction manual handy for future reference. First, it is discussed for whom this manual is binding. Then, the following topics are described:

- Service by the manufacturer
- Explanation of terms
- Units and tolerances
- Notes on figures
- Explanation of accentuations

1.1 Binding character of this manual

These operating instructions apply to the operator and all persons working on or with the device. Each such person is obliged to read the manual carefully and follow the instructions.

1.2 Service by the manufacture

After purchasing the device you can obtain the following benefits by ErsaTec:

- Technical Documents
- Training for maintenance and repair of the device
- Access to SmartFID-Online-Portal (Release planned at the end of 2013)

HINT	If you have any questions whatsoever, please do not hesitate to contact us.

1.3 Explanation of terms

In many places of the manual technical terms are used. These terms are explained below.

Overview of technical terms:

Fuel Gas	Fuel for the flame of the FID (generally hydrogen)
Combustion Air	Supply air for the flame of the FID
Adjustment	Process in which the device is modified so that it measures a known gas concentration correctly.
Calibration	Process in which the device settings are reviewed to determine whether zero point or endpoint have drifted or remained stable.
Full Scale	Final value of the active measurement range
Sample Gas	Gas, the hydrocarbon content should be measured.
Zero Gas	Gas with a concentration value of zero (hydrocarbon-free gas)
Zero Point	Initial value of scale (always 0)
Test Gas / Calibration Gas	Gas with a known hydrocarbon concentration
Calibration Gas Value	Known hydrocarbon concentration of the test gas

Table 1: Overview of technical terms

1.4 Units and tolerances

The units in the operating instructions are given in accordance with DIN 1301 to DIN 1304. All values have tolerances. These tolerances are not specified for reasons of simplification.

The described product properties and technical data provided do not represent a warrant.

1.5 Notes on illustrations and Screenshots

This manual shows some pictures of the equipment or screenshots in some simplified form. The Screenshots can differ slightly from the delivered (software-)version.
The measuring-values are shown in this manual largely in “ppm”. This representation can differ depending on the selected configuration.

1.6 Explanation of accentuations

DANGER

This identifies a warning of danger, which warns of personal injury.
Risk advice helps you to identify hazards to people and avoid adverse consequences.
→ The arrow indicates a precaution; you need to make to avert the threat.

WARNING

This identifies a warning of material damage.
Warnings help you to identify hazards of materials and avoid adverse consequences.
→ The arrow indicates a precaution; you need to make to avert the threat.

→ Single action, no further action will follow this step

1. First action step in a sequence of actions
2. Second action step in a sequence of actions

   Result of the previous action step

✓ **The action is complete, the goal is reached.**

HINT

This remarks a hint. Hints provide detailed information for you.

2 Description of device

In this chapter, you will find information about the device and its properties.

First, you will find information for the purpose of the device. Then, the following topics are described:

- Functional principle
- Assembly
- Technical characteristics

2.1 The purpose of the device

In this section you will find information about using the device. First, you will find information on the intended use of the device. Then, the following topics are described:

- Installation location
- Fields of application

2.1.1 Intended use

The unit is exclusively designed to measure the hydrocarbon content in gases within the stated limits. The result is a sum measurement of hydrocarbons. Any other use is considered as improper and is prohibited.

2.1.2 Installation location

The device is intended for mobile measurement. It can be used indoors and outdoors at ambient temperatures of -5 to 40° C. The device must be protected from moisture. For the continuous measurement in a 19 " cabinet or in a desktop case SmartFID ST is a more suitable device with its housing (19 " / 4U).

2.1.3 Fields of application

You can use the device for raw gas in industrial processes. Problems with condensation do not occur.

Possible applications:

- Measurement of immissions or emissions
- Measurement of the maximum allowable concentration (MAC)

2.2 Functional principle

The device operates on the basis of the comparison principle. The unknown concentration of a sample gas is compared with the known concentration of a test gas.

A flame ionization detector (FID) converts the measured values into electrical Signals. For this two electrodes generate an electric field around a flame. The flame is fed by the supply of fuel gas and combustion air.

During the analysis, the sample gas is ionized in the flame and then oxidized. If the sample gas contains hydrocarbon compounds, an ion current occurs in the electric field.

The device measures this flow of ions. The measurement signal is proportional to the number of fed and not pre-oxidized carbon atoms. Pre-oxidized carbon atoms in the measurement signal are only partially included. Carbon monoxide and carbon dioxide have no influence on the FID.

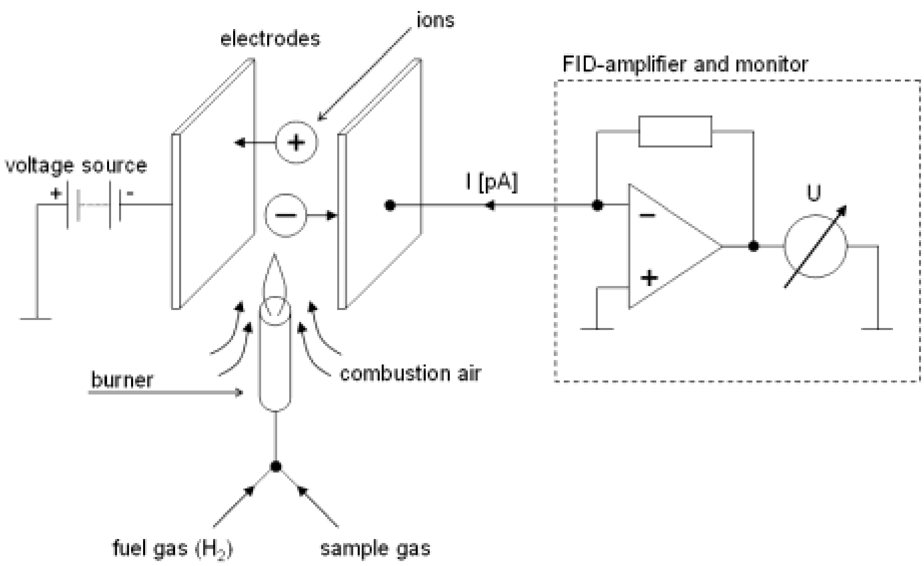


Figure 1: Principle sketch of the flame ionization detector

For more information on reaching correct results, see Appendix A “Measuring Hydrocarbon Concentrations Correctly”.

2.3 Assembly

This section provides information on the structure and the technical properties of the device.

First, you will find information on the label. Then, the following topics are described:

- Controls and top connectors
- Controls and sidewall connectors

2.3.1 Identification plate

Figure 2: Identification plate SmartFID mobile

The device is clearly marked by the identification plate. It is attached on the sidewall of the device.

The identification plate contains the following information:

- Name and address of manufacturer
- Model and type
- Article number
- Serial number
- Specification for power supply

HINT

If you contact ErsaTec regarding your device, you should know the serial number, so ErsaTec can view the service log of the unit.

2.3.2 Controls and top connectors

The following figure shows the top panel with numbering of the relevant controls. The table below illustrates them.

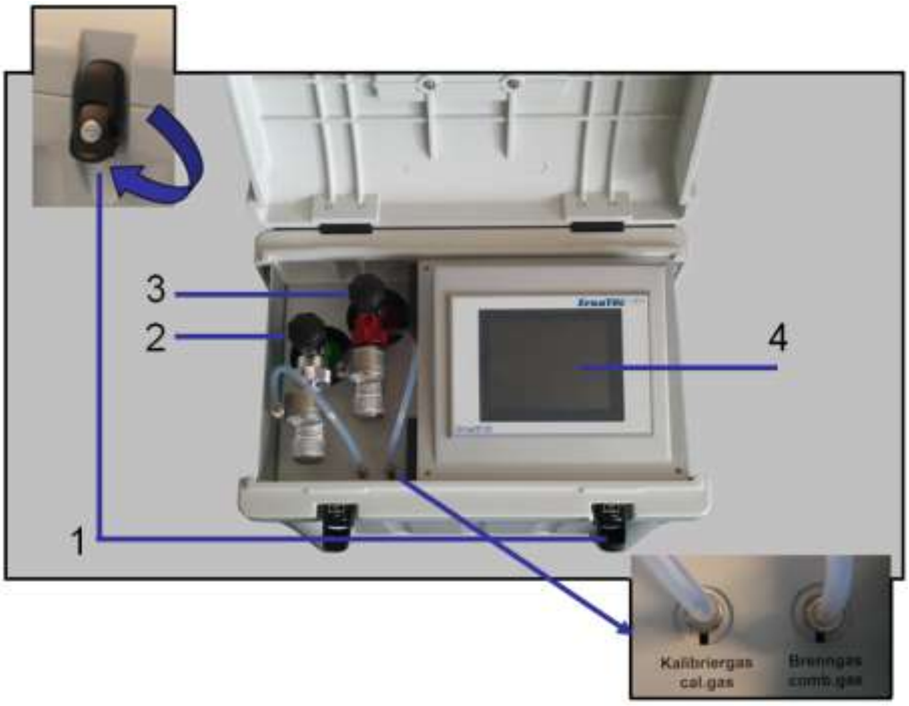


Figure 3: Top panel of SmartFID

Element	Description
1	Cap closures. Take notice that the locks are unlocked when opening the closures. Then pull the lockers at their bottom and lift them over the arrestor as shown above left.
2	Calibration gas cylinder with pressure reducer
3	Fuel gas cylinder with pressure reducer
4	Touch-panel for device Operation
	The correct connection of the calibration gas or fuel gas is supplied by quick coupling connections according to the labels (See Figure below right). Operating the unit with reversed connections leads to error messages, but is not a danger for operator or the device.

Table 2: Elements on top panel

Calibration gas and fuel gas (Nos. 2 and 3) are fed via two quick-coupling connections to the FID. With the fuel gas the flame of the FID is fed. The calibration gas (also test gas) is required to adjust the device. The requirements for these gases are described in the section 5.1 “Requirements for gases” on page 32).

2.3.3 Controls and side wall connectors

The following figure shows the side wall with numbering of the device interfaces. The table below illustrates them.

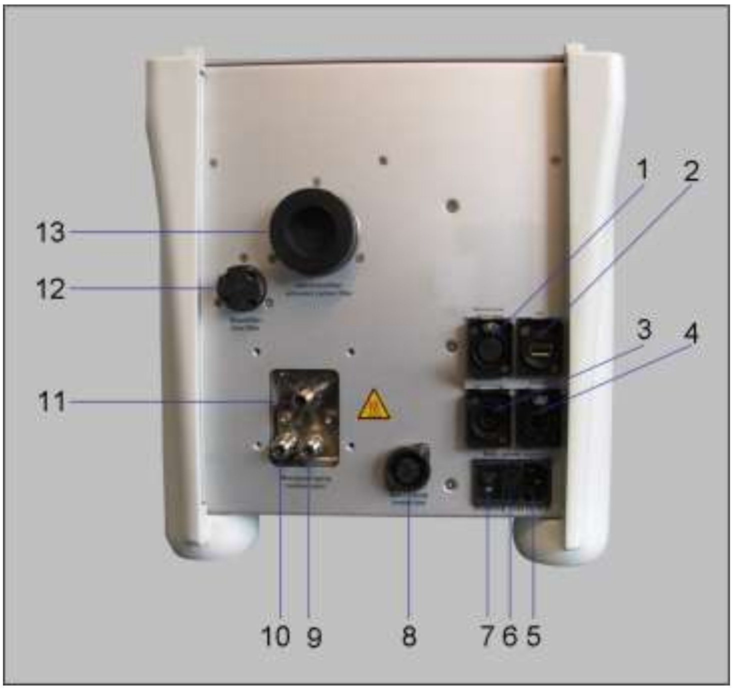


Figure 4: SmartFID's side wall

Element	Description
1	Measured value Output 2 x 0-20 mA or 4-20mA. Interface for the wire to evaluate the measured values. The electrical specifications and the assignment of individual contacts can be found in section 4.3.3 “Pin assignments” on page 29).
2	USB port for connecting a USB stick. When a USB flash drive is connected, data of the internal data logger can be transferred.
3	Alarm contacts: Interface for a wire to process messages externally. The electrical specifications and the assignment of individual contacts can be found in section 4.3.3 “Pin assignments” on page 29).
4	LAN interface for connecting the device to a network. This unit works with the TCP / IP protocol with static or dynamic IP addresses (DHCP). The setting can be done in the setup menu of the device - Refer to section 6.5.1.4 “Inputs and Outputs” on page 71.
5	Connection for the power cable. The specification for the electrical supply to the unit is shown on the identification plate. IEC power socket (according to EN 60320) with built-in fuses.
6	Holder for fuse (2 x M8 / 250D)

Element	Description
7	Power switch to power on and off the device
8	Connection for heated sample gas line
9	Bypass of the analyzer. Port for the discharge of excess sample gas. The line must be used free of pressure and with a slope away from the machine, to prevent condensation flowing in the unit.
10	Exhaust of the analyzer. Port for the discharge of exhaust gas and condensate. The cable used must also be used free of pressure and with a slope away from the machine run, to prevent condensate flowing in the unit.
11	Sample gas inlet
12	Dust filter for the purification of combustion air and zero gas before the measurement process. Instructions for maintenance can be found in section 5.7 “Notes on maintenance and repair” on page 56.
13	Activated carbon filter for removing hydrocarbons in combustion air and zero gas before the measurement process. Instructions for maintenance can be found in section 5.7 “Notes on maintenance and repair” on page 56. The activated carbon filter is usually only present if the device has no built-in catalyzer).

Table 3: side wall connectors

DANGER

Burn hazard!

The gas connections (9, 10 and 11) are heated during Operation of the analyzer up to 200 ° C. A contact should be avoided in this state.

→ Only work on these connections when the device is idle and cooled sufficiently.

2.4 Technical characteristics

The following is an overview of the technical data of the device.

Mechanical properties

Dimensions of the housing	Length: 470 mm
	Width: 320mm
	Height: 400mm
Weight	15,0 kg (version without catalyzer)
Protection	IP20, IP23
Materials:	The following materials are used for Measuring-gas-carrying parts: • Stainless steel 1 .4301 , 1 .4305 • Graphite • Quartz • Platinum
	The following materials are used for the measuring gas pump: • Teflon • Calrez • Viton

Table 4: Mechanical properties

Electrical properties

Supply voltage	For the specification for the electrical supply of your device please refer to the identification plate: • 115 V, 60 Hz or • 230 V, 50 … 60 Hz
	Voltage tolerance: -10% / +6%
Power consumption	100 W average in continuous Operation without catalyzer. 140 W average in continuous Operation when operating with a catalyzer. - about 365 W during the initial period, without a catalyzer. - about 560 W during the initial period, when operating with a catalyzer. + the appropriate performance of the heated sample gas line
Protection	2 x Fuse 5x20mm (M8/ 250D)

Table 5: Electrical properties

Temperature ranges

Permissible ambient temperature	-5 ... 40°C during Operation -20 ... 70°C during storage or transport
Allowable process temperature	0 ... 300°C

Table 6: Temperature ranges

Flow rates

Sample gas	1.2 liters per minute
Fuel gas	H_2: 1.15 ± 0.35 liters per hour (continuous supply)
Combustion air	about 1.0 liters per minute (continuous supply in measuring mode about 2.6 liters per minute (continuous supply) on zero-gas Opera-tion
Zero gas	about 2.2 liters per minute (flow only during the adjustment)
Calibration gas	about 1.6 liters per minute (flow only during the adjustment)

Table 7: Flow rates

Metrological characteristics

Lead time	Time between switching on and operational readiness: < 1 hour
Linearity	Linear range up to 100.000 ppm
Detection limit	< 1.5%of full scale value
Signal rise time	< 1 second (without prefilter)
	< 5 seconds (with prefilter)
Reproducibility	30...200
Influences on meas-ured signal	< 0.5 % of full scale per 10 hPa caused by barometric pressure fluctuations
	< 1.0 % of full scale per 10 hPa caused by sample-gas-pressure fluctuations.
Temperature dependence	Zero point: <2 % of full scale per 10 K
	Sensitivity: < 1 % of full scale per 10 K
Cross-sensitivity	< 0.25 % of full scale value against H_2O (saturated at 235 K)
	< 0.1 % of full scale value against CO (1.2 Vol.%)
	< 0.5 % of full scale value against CO_2 (15.2 Vol.%)
	< 0.2 % of full scale value against NO (127 mg/m^3)
	< 0.2 % of full scale value against SO_2 (2.767 mg/m^3)
Change of zero point	< 0.5 % of full scale value per month

Temporal change in sensitivity	< 0.5 % of full scale value per month
Relative Standard deviation of the evaluation factors	13.5 %

Table 8: Metrological characteristics

3 Security advices

In this chapter you will find information on the legal framework for the use of the device. First, you will find information on the safety of the device. Then, the following topics are described:

- Instructions for Operation
- Improper operating conditions
- Responsibilities of the operator
- Staff qualification
- Notes on transport

3.1 Information on the safety of the device

The device is safe to operate. It was constructed and manufactured on the current state of science and technology. The unit left the factory in perfect security-conditions.
Operating the device may still be dangerous in the following conditions:

- The device is not used as intended
- The device is used improperly
- The device is used outside the permitted specifications

3.2 Instructions for Operation

The case contains no parts that can be repaired. Only trained and authorized persons may open the case. Doing so may damage the unit.

DANGER

Risk of explosion!
If you find a leakage loss of supply gas there may be danger of explosion.
→ Make sure that there's proper ventilation during Operation.
→ Turn off the power immediately if you notice any leakage of the supply gases.

DANGER

Risk of Burn!
Sample gas carrying parts are heated up to 240 °C. At these locations there is a risk of burn.
→ Wear protection gloves on all working.

Protect the unit from extreme environmental conditions (e.g., from temperatures outside the temperature information in the technical data and to prolonged direct sunlight).

Do not expose the machine to extremely strong magnetic fields, as can occur for example near induction furnaces and electric welding equipment!

To ensure the continuous Operation of the device, the following resources have to be continuously available:

- Electrical supply
- Fuel gas

In case of failure of fuel gas the flame of the FID extinguishes and the unit switches into fault mode. In this case the gas pump is turned off, so no sample gas is delivered anymore.

However by overpressure in the process, a certain amount of gas can enter the measuring device and condense there. This causes contaminations to sensitive parts. In this case, the device must be repaired. To avoid this Situation, you should disconnect the device immediately from the process when the flame extinguishes. Alternatively, you can set a parameter in the settings of the device, which will ensure that if the flame extinguishes zero gas is turned on automatically and rinses the sample gas line contrary to the suction direction.
This allows the device to avoid contamination by the process when it is unattended. You can find this parameter in the device options (Chapter 6.5.1.3 “Options” on page 70).

DANGER

Possible gas leak.
By turning off the device the supply of fuel gas is turned off automatically.
The pressure reducers on the bottles are no shut-off valves!
→ Close always the supply of test gas and fuel gas directly at the valve of each bottle if you turn off the device.

HINT

If you have any questions whatsoever, please do not hesitate to contact us. Our address can be found on page 2.

3.3 Improper operating conditions

If you do not use the device as intended, safety and Operation of the equipment is no longer guaranteed. Under the following conditions you must not operate the unit:

- The device is not set properly and horizontally on a solid surface.
- Malfunction has been detected.
- Damages to the device, electric lines or gas supply lines were detected.
- The device was modified.

The device may not be used outside the specified operating limits, see chapter 2 “Description of device” pp. 11).

Contaminated gas lines cause significant disturbances, for example measurement errors or failure of the measuring System. Cleaning internal lines of the device is not possible.

The device may not be used in processes that can lead to corrosion, deposits, or device damage:

- The sample gas must not contain any harsh ingredients that corrode the materials
- No corrosive substances must be created by oxidation that corrode the materials of measuring-gas-carrying parts.
- The components of the sample gas must not condense above the selected temperature.
- The sample gas must not lead to reactions in which solids are formed.

HINT	Information about the materials can be found in Chapter 2.4 “Technical characteristics” on page 17.

3.4 Responsibilities of the operator

The operator is responsible to plan security measures for handling the device and monitor their implementation. The operator of the device continues to monitor the following requirements:

- The relevant national laws and regulations must be obeyed.
- The operations manual must be kept complete, legible and readily available for anyone at the site of operation.
- Before starting work staff must be familiar with all controls and safety features of the device.
- Staff has to be is informed of the health hazards of the material and instructed in preventive measures.
- The device must only be used as intended. It must only operate in proper working conditions. Before starting up the device the state of safety has to be controlled.
- Processes, competencies and responsibilities concerning the unit should be established unambiguously. The behavior in case of incidents must be clear. The staff has to be taught in this regularly.
- Damage and scarcities to your equipment must be immediately removed by authorized personnel or the manufacturer.
- Warning signs must be complete and legible. For this reason they have to be regularly cleaned and replaced if necessary.
- The gas supply is in perfect condition. The current regulations are obeyed.

3.5 Staff qualification

All work on and with the device require special knowledge and skills of the staff. The device must be installed and operated only by suitably qualified persons. Each person working on or with the device must meet the following conditions:

- Personally suitable for the particular activity.
- Sufficiently qualified for the particular activity.
- Trained in the handling of the device.
- Familiar with the safety devices and their operation.
- Familiar with this manual, especially with safety instructions and the sections that are relevant to the operations.
- Familiar with basic rules for industrial safety and accident prevention.

In principle, any person working with the device must have the following minimum qualifications:

- Trained as a person in order to work on its own with the device.
- Adequate education to perform tasks with the device guided and supervised by a trained specialist.

3.6 Notes on transport

For transport to a measuring point, it is sufficient to seal the lid of the device. Avoid moving the unit in extreme rainfall.

Wrap the device separately to protect it from damage during transport before shipping it.

The device contains sensitive components. Place the unit during transport always gently.
Do not drop the unit or set it to any acceleration, shock or vibration. Check the equipment thoroughly after each transport before it is brought into operation again.

HINT	ErsaTec offers in its product range a suitable transport case with trolley function. Don't hesitate to contact us. Our address can be found on page 2.

4 Commissioning

The device is designed as a portable FID and not intended for permanent installation in a stationary measuring System.

HINT	A suitable device for stationary measurements of hydrocarbons is ErsaTec's model „SmartFID ST". Please address your inquiry to us. Our address can be found on page 2.

This chapter contains the following topics:

- Area requirements
- Pneumatic installation
- Electrical installation

4.1 Area requirements

The device is intended for use both indoors and outdoors. The site, however, must meet the following minimum requirements:

- The ambient air must be dust free and free of other contaminants.
- The device should be preferably placed at waist level during operation.
- The site must be freely accessible during measurement.

4.2 Pneumatic installation

In this section it is described how to connect the necessary gas lines to the device.

First learn about the gas lines requirements. After that it is described how to connect the gas lines to the device.

4.2.1 Gas lines requirements

SmartFID's required lines for fuel gas and calibration gas are pre-assembled. Please note the following instructions:

- The gas lines must not be contaminated.
- The gas lines and all connections must be tight. You can locate leaks using leak detection spray.
- When exhaust and bypass lines are used (optionally) they must be installed depressurized and sloping downward away from the device to prevent condensate running back into the unit.

If you are using a heated sample gas line, please note that older models on the market, have only one PT-100 temperature sensor, while modern versions have two temperature sensors.

HINT	ErsaTec recommends using a heated line with two PT-100 temperature sensors for safe Operation of the device.

With a double PT-100 sensor, the device is able to diagnose problems with the heated line:

The second temperature sensor is used to monitor the control System. If the temperatures differ by more than 5 °C from each other, the heating of the heated line gets disconnected and the unit switches to failure mode.

The type of heated line needs to be entered in the settings. Refer to the section parameters in the options menu in chapter 6.5.1.3 “Options” 70.

4.2.2 Connecting the gas lines

Conditions:

- The corresponding side wall of the unit is freely accessible
- The gas lines meet the requirements (see section 4.2.1 “Gas lines ” on page 26)
- The power switch is in position “0“

Required tools:

☑ 14mm / 15mm wrench

WARNING

Failure of the measuring System due to contaminated gas lines.
→ Rinse all gas lines with compressed air before connecting them to the device.
→ Never connect contaminated gas lines with the device.
→ Keep the gas ports clean and free of grease.

→ Follow these Steps:

1. If necessary connect the exhaust pipe (tube 4 mm inner diameter) on port “exhaust” (cp. No. 10 in Figure 4: SmartFID's side wall – page 15)
2. If necessary connect the bypass line (tube 4 mm inner diameter) on port “bypass” (cp. No. 9 in Figure 4: SmartFID's side wall – page 15)
3. Connect the fuel gas line to the quick coupling connection “fuel gas” (cp. Figure 3: Top panel of SmartFID – page 14)
4. Connect the calibration gas lint to quick coupling connection “calibration gas” (cp. Figure 3: Top panel of SmartFID – page 14)
5. Connect the sample gas line to the connection “sample gas” by using a clamp collar connection. (cp. No. 11 in Figure 4: SmartFID's side wall – page 15)
6. Check seals at all connected gas lines.

✓ **The gas lines are connected. The pneumatic installation is finished.**

WARNING

Safety measure.
When connecting the gas lines the device should be turned off and be cold for your own safety.
→ Turn the unit off before connecting the gas lines and let it cool down.

WARNING

If necessary select the Option “heated line".
If you are using a heated sample gas line, their presence must be configured in the device so that it is heated and its temperature is monitored.
→ Select the Option “Heated line” before the measurement Starts - cp. Section 6.5.1.3 “Options” 70.

4.3 Electrical Installation

During the electrical installation, you will connect all the necessary supply cables to the device.

First the requirements of the cables are described, that you need to connect to the device.
Then, the following topics are described:

- Connection of electrical cables
- Pin assignments

4.3.1 Requirements on electrical cable

The cable for the measurement Output must meet the following requirements:

- Depending on the application, 2-4 flexible wires, with a shared shield
- Outer diameter matching the connector

4.3.2 Connection of electrical cables

The electrical cord is plugged into the device. Optional cables can be connected by appropriate connectors on the device.

Requirements:

- The corresponding side wall of the unit is freely accessible
- The gas lines are connected (cp. section 4.2.2 “Connecting the gas lines” – page 26)
- The power switch is in position ”0”

Needs:

- Electrical connection (Specification see nameplate)
- Electric cable, heated line
- If necessary optional adapter cable (Measurement, signal contacts, Ethernet)

Follow these Steps:

1. Plug in the cables
2. Connect cord for the heated sample line with the port “heated line” (cp. No. 8 - Figure 4: SmartFID's side wall – Page 15)
3. If necessary connect cord for measuring Output with the port “measuring output” (cp. No. 1 - Figure 4: SmartFID's side wall – Page 15)
4. If necessary connect cord for signal contacts with the port “signal contacts” (cp. No. 3 - Figure 4: SmartFID's side wall – Page 15)
5. If necessary connect an Ethernet wire to connect the device to a LAN with the port “Ethernet” (cp. No. 4 - Figure 4: SmartFID's side wall – Page 15)
6. Connect the power supply cable to the port “power / fuse” link (cp. No. 5 / Figure 4: SmartFID's side wall – Page 15)

✓ **The electrical lines are connected and the electrical Installation is completed.**

4.3.3 Pin assignments

The electrical connections for measuring Output, heated sample gas line and signal contacts are wired as follows.

Figure 5: Assignment of the port “output value”

Legend

No.	**Description**	**Remark**
1	+ 0…4-20 mA (analog output #1)	not isolated
2	Ground	
3	+ 0…4-20 mA (analog output #2)	not isolated
4	Ground	
5	Not used	
6	Not used	
7	Shield	

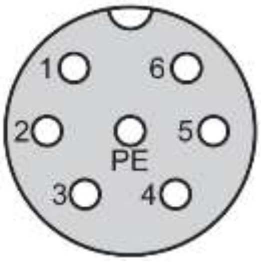


Figure 6: Assignment of the connector "heated sample gas line"

Legend

No.	Description	Remark
1	Voltage	
2	Voltage	
3	PT 100-1.1	Sensor for temperature monitoring
4	PT 100-1.2	
5	PT 100-2.1	Sensor for regularization
6	PT 100-2.2	
PE	Grounding conductor	

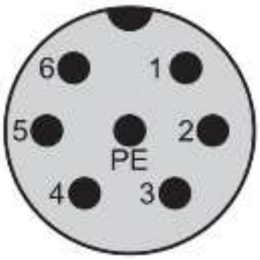


Figure 7: Assignment of the port "signal Output"

Legend

No.	Description	Remark
1	Signal contact 1 (a)	Maximum load:
2	Signal contact 1 (b)	100 V AC / 50 V DC / 0,5 A
3	Signal contact 2 (a)	Maximum load:
4	Signal contact 2 (b)	100 V AC / 50 V DC / 0,5 A
5	Signal contact 3 (a)	Maximum load:
6	Signal contact 3 (b)	100 V AC / 50 V DC / 0,5 A
PE	Grounding conductor	

The behavior of the signal contacts (NO or NC) and the related association (e.g., warning, alarm, Status message ...) are configured via the menu (cp. section 6.5.1.4 "Inputs and Outputs" – Page 71).

HINT For evaluation of the contacts use a measurement-cable of ErsaTec. This will ensure the correct allocation of the wires and get a consistent labeling of the 4-mm spring clip.

ErsaTec-measurement-cable assignments:

Color	Pin of connector	SmartFID function
white	1	Analog output 1 (+)
brown	2	Analog output 1 (ground)
green	3	Analog output 2 (+)
yellow	4	Analog output 2 (ground)
gray	5	Not used
Pink	6	Not used
black	7	Shield

Table 9: Assignments of ErsaTec's measurement-cable

5 Operation

In this chapter you will find all necessary Information on operating your SmartFID. First you are given some information for the operation gases before initial operation and the adjustment of the device are explained. Then measurement mode, main menu and alarms are described. Finally notes on maintenance and repair of your SmartFID are given. The topic "configuration" can be found in chapter 6 “Device configuration” on page 58.

5.1 Requirements for gases

All measurement readings should always be plausible and reproducible. To ensure the reliable operation of the device for a long time, the flowing operation gases meet the following requirements:

Gases and requirements

Fuel gas	The fuel gas has to meet the following requirements: • Composition: pure hydrogen (H2 5.0) -> If in your processes, greater demands on the O_2 quench are requested, we equip the device to operate with a hydrogen-helium mixture (40% H2, 60% He). • Residual hydrocarbon content, based on C1: <0.5 ppm when measuring low concentrations or <4 ppm in the measurement of higher concentrations. • The fuel gas is supplied from a pressure vessel suitable for SmartFID (aluminum cylinder 0.5 liter 200 bar fits in the SmartFID integrated bottle cage). • During Operation, this gas has to be continuously supplied. • The inlet pressure is controlled by the pressure regulator to the fuel gas cylinder and limited to 3 bar.

Combustion Air	The combustion air must meet the following requirements:
	• Residual hydrocarbon content, based on C1: <0.5 ppm when measuring low concentrations or <4 ppm in the measurement of higher concentrations (This goal is reached by the use of a catalyst or an activated carbon filter. For this reason there's no need to carry a Container with synthetic air).
	• During operation, the ambient air is drawn continuously.
	• If the combustion air is supplied by a compressed air line, in addition the following requirements must be met:
	  • Oil free.
	  • Condensate-free, dew point ≤ 20 °C.

	• Prepared by an upstream clean air supply
Zero gas	The zero gas must meet the following requirements: • Residual hydrocarbon content, based on C1: < 0.5 ppm when measuring low concentrations or <4 ppm in the measurement of higher concentrations (This goal is reached by the use of a catalyst or an activated carbon filter. For this reason there's no need to carry a Container with synthetic air). • During adjustment, the ambient air is drawn continuously.
Calibration gas	The calibration gas must meet the following requirements: • Hydrocarbon concentration of about 80% of the measuring range based on propane-equivalent in synthetic air. • The test gas is supplied from a pressure vessel suitable for SmartFID (aluminum cylinder 0.5 liter 200 bar fits in the Smart- FID integrated bottle cage). • During adjustment this gas has to be provided continuously. • The inlet pressure is controlled by the pressure regulator to the calibration gas cylinder and limited to 3 bar.

5.2 Start up the SmartFID

5.2.1 General operating instructions

The Operation of SmartFID is performed by a touch panel on the top of the unit (See Figure 3: Top panel of SmartFID on page 14). It realizes the input and Output interface simultaneously. That means that during the display of information the user sees defined areas to touch for input (called „Buttons"). By touching the designated areas the user controls the behavior of SmartFID.

WARNING

Avoid operating the touch panel with sharp or pointed objects.
→ When operating the device use your fingers or a blunt object (such as the rounded top of a pin) to do input. Otherwise you may damage the touch panel.

5.2.2 System start

In the following the boot process of SmartFID without special configuration settings and no errors will be described. Note that the behavior may vary when the above-named conditions are altered.

Before you power on the SmartFID, please make sure that the Steps for pneumatic and electric Installation (see sections 4.2 “Pneumatic installation” and 4.3 “Electrical Installation” pp 25) have been completely done. For Operation open the valves on the fuel gas and the calibration gas cylinder (see Figure 3: Top panel of SmartFID on page 14). Press the power switch of the unit to turn it on (See No. 7 in Figure 4: SmartFID's side wall on page 15). The device is starting now. On the screen you first you see some system information followed by the "welcome screen". In addition, the following operating noises can be heard: the noise of the fan and the slightly louder hum of the internal pumps.

Figure 8: Welcome screen

When you touch the screen at this point of time, an adjustment of the touch panel is started. For this reason target crosses are displayed on the screen one after the other. You need to hit them in the center with a suitable object (such as closed-pen). After touching a target cross the following appears: After the contact of the fourth target cross this adjustment is completed and the device continues the boot up process.

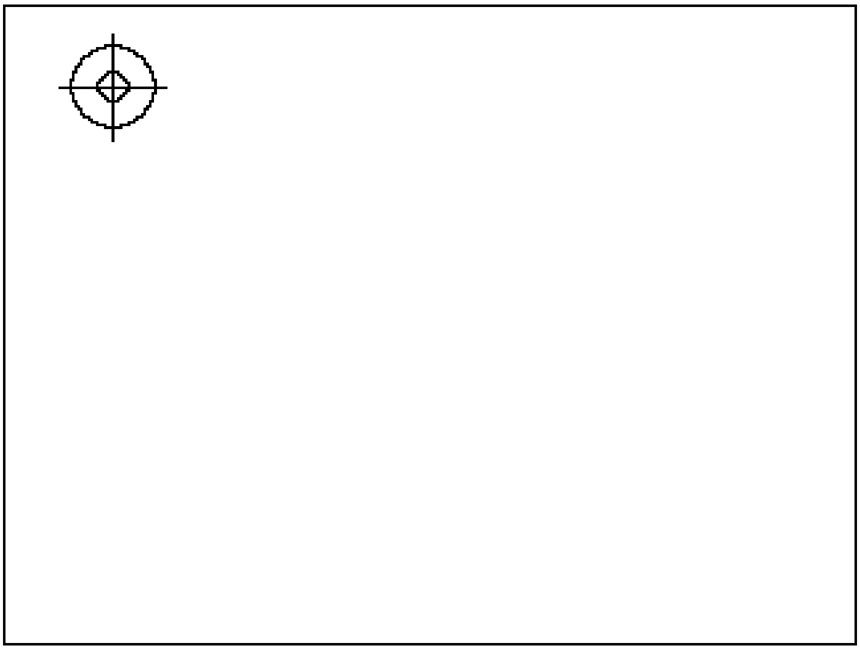


Figure 9: Adjustment of touch panel

After the welcome message appeared the unit begins to heat the analytic chamber. This process takes several minutes. A corresponding indicator provides information on the progress.

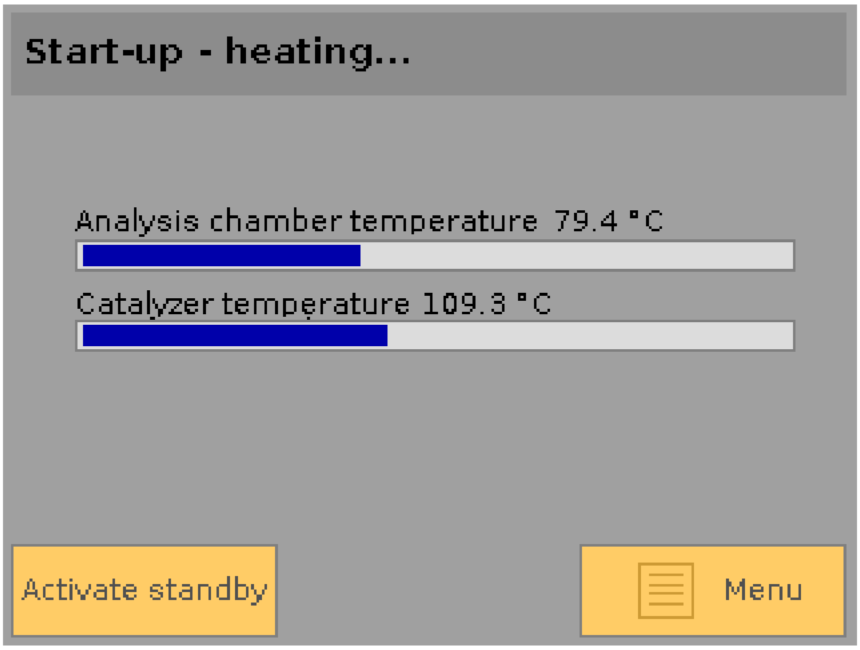


Figure 10: Status of the heating phase

Figure 10 shows the status of the heating for a device that is equipped with a catalyst. Since the catalyst is an optional feature, it is possible that the second progress bar on the screen is not present. The same may apply to a third progress bar that refers to the status of an optional heated line connected.

Theoretically, the device can be operated in this phase already by touching the "Standby" or "Menu" button at the bottom of the screen. In normal boot, it is not necessary to perform these actions. If the analysis chamber temperature has reached 80% of the nominal value, the device attempts to ignite the flame. A message informs the user about this action.

Figure 11: Ignition of detector flame

The unit is now trying to ignite the detector flame up to ten times. After the flame was ignited successfully, the system changes to measuring mode and switches on the meter.

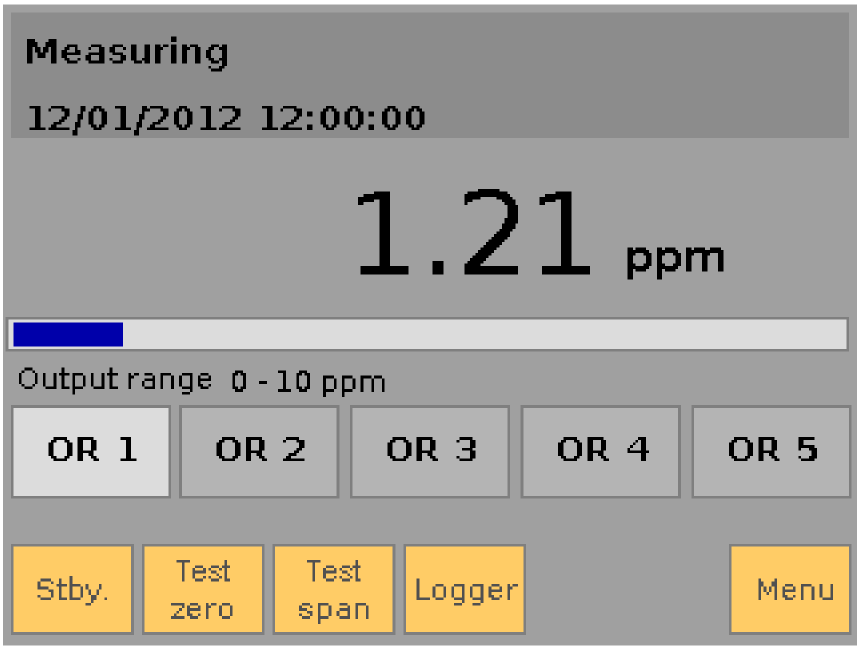


Figure 12: Measurement display

The following list shows problems and consequences that can sometimes occur at startup:

Problem	Consequence
A heated line could be connected, even though the Option in the device configuration is not enabled.	The line won't be heated.
A heated line is not connected or defective, although the option is enabled in the device configuration.	The device displays an error message.
The combustion air pressure cannot be achieved because the filters are congested or the fresh air pump is worn.	
The ignition fails.	
The sample gas pressure is not achieved because the pump is worn or the sample gas line is dirty.	
The analyzer chamber temperature is not reached.	

Table 10: Possible problems on system start

5.3 Calibration

The analyzer SmartFID operates on the principle of comparison. That means it compares a measured quantity to the characteristic curve from two well-known measurands. This is possible because the FID has a linear characteristic. The process to define a zero point and an end point is called the calibration.

The following chapter explains how the device is adjusted for the correct measurement mode. Please note that the calibration does not work if a test of zero point or end point has been initiated (see section 5.4.2 “User actions during the measuring Operation” on page 43 et. Seq.). It is also not possible to initiate a calibration when the calibration gas is not present.[1]

HINT	Background information on the need of calibration and any necessary conversions, see Appendix A "measure hydrocarbon concentrations correctly".

5.3.1 Basics - how to calibrate

First, the zero point of the analyzer is set. Purified ambient air is used as zero gas (Depending on equipment, purification is done either by an activated carbon filter or by an integrated catalytic Converter). The process of adjusting the zero point is done by the device automatically. In a second step, a gas with a known certain amount of organic compounds (calibration gas) is supplied. The exact concentration is determined by the gas supplier. The process of adjusting the end point is also done by the device automatically. Normally the supplier of calibration gas delivers a certificate of analysis stating the contents and its tolerance.

5.3.2 Calibrating the device

Before you start to calibrate the device, open the calibration gas cylinder of SmartFID to enable the menu item "Calibration". Then you can start the calibration by touching the appropriate button in the main menu. After that the first step of the calibration process will be shown (see Figure 13 on page 39). First you have to check and if necessary modify the field “Actual value cal.gas” referring to value of hydrocarbon concentration (in ppm) in the calibration gas from the gas manufacturer.
Below that value you can choose whether an automatic adjustment should be performed. In this case the device interprets independently the stable measurement values and continues the calibration automatically. Otherwise the user has to decide when the zero and the end point are sufficiently stable. The following example will describe the manual adjustment.

[1] Depending on the desired finish it may be that starting a calibration is made possible only by the proper confirmation of a password prompt.

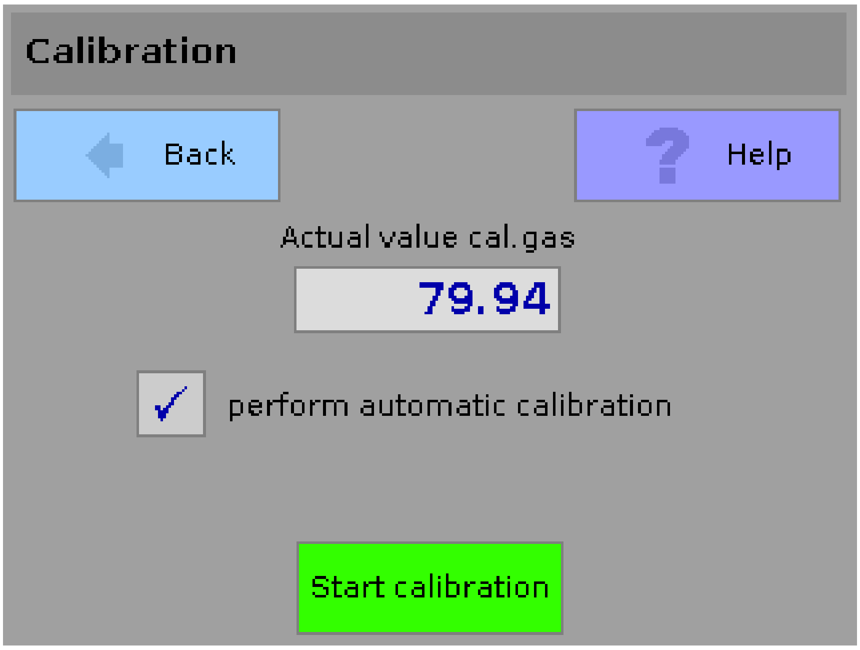


Figure 13: Start of Calibration

After the "Start calibration" button is touched, the device switches to zero gas supply and performs a short delay until the gas reaches the analysis chamber. During the calibration the user can at any time cancel the process by touching the red button down right.

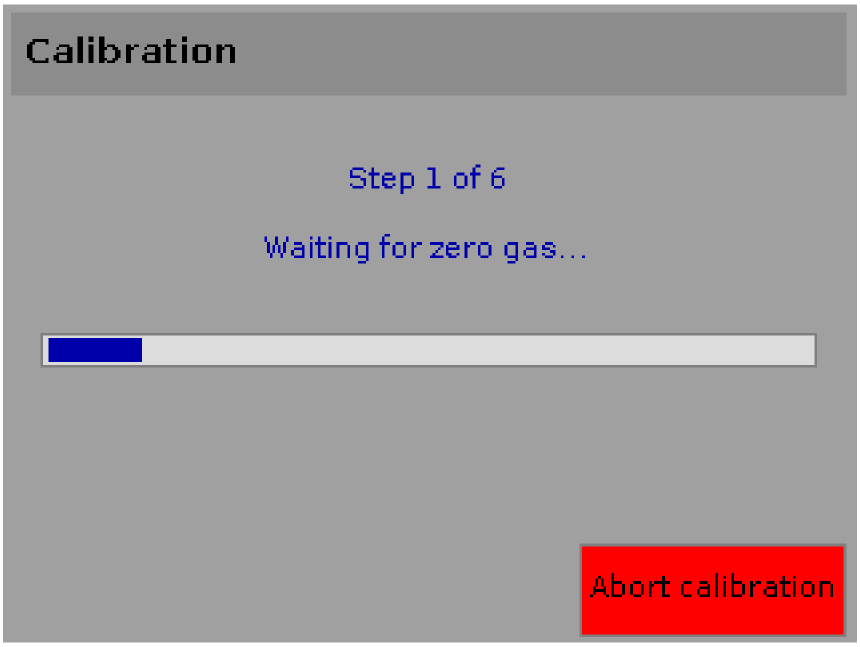


Figure 14: Waiting for zero gas

When the progress bar in Figure 14 has reached 100%, the System starts determining the zero point.

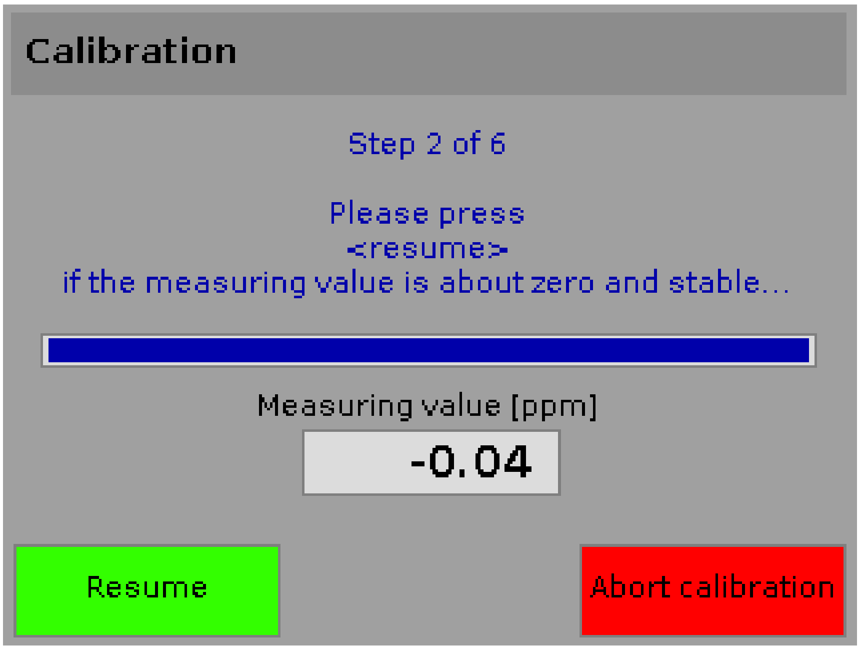


Figure 15: Waiting for a stable zero value

It can be observed that at first the measured value varies strongly, but it's getting increasingly more stable during the calibration. In case of automatic calibration the Instrument assesses the measuring value as sufficiently stable. In case of a manual adjustment a button appears. By touching it the user indicates the measured value as sufficiently stable and the calibration will proceed. As next step the device switches to calibration gas supply and waits until the gas reaches the analysis chamber.

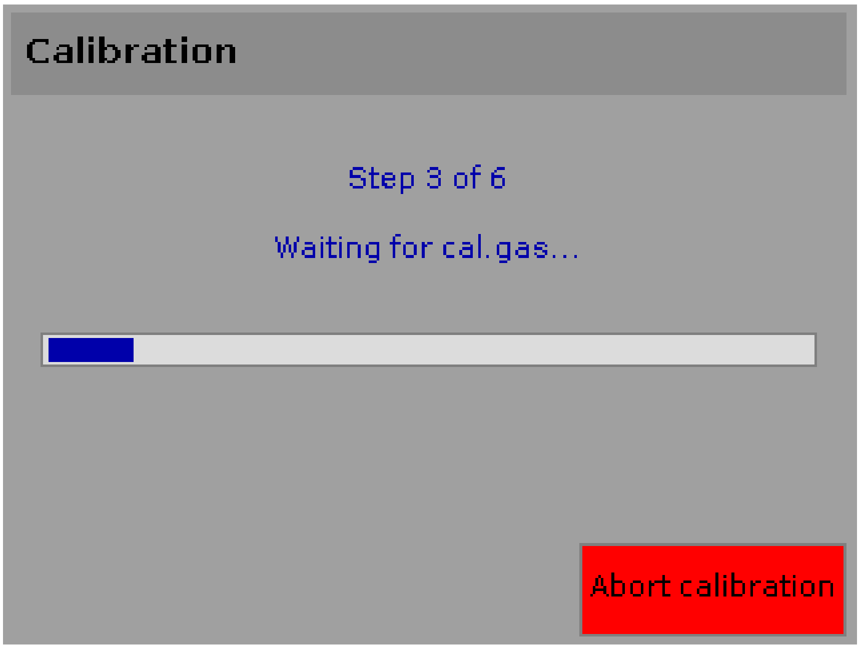


Figure 16: Waiting for calibration gas

After that the System determines the appropriate range for the gas.

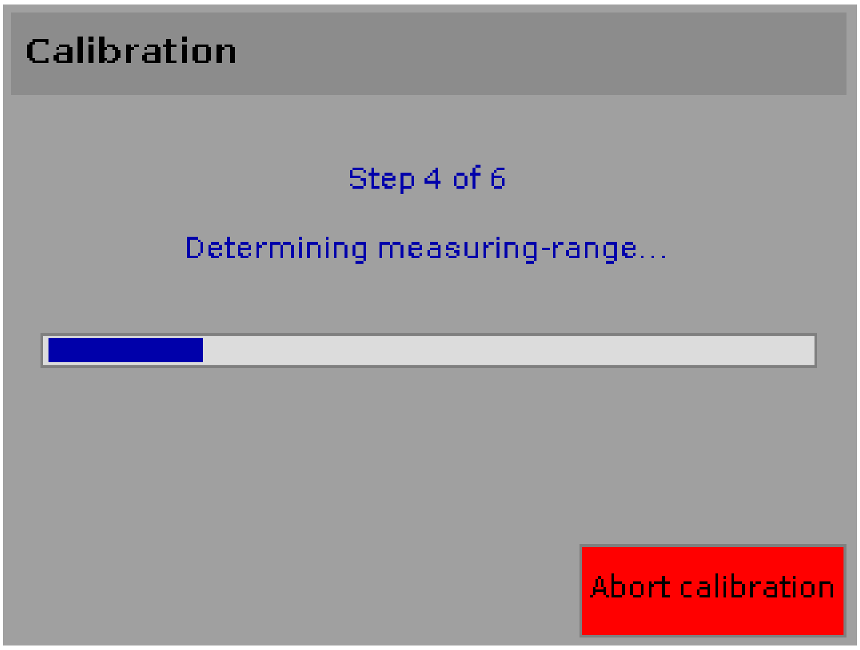


Figure 17: Determine the appropriate range

After the progress bar is completed, the System waits until the final value has stabilized. If the automatic adjustment was not selected the user has to confirm a stable value by touching the according button (step 5 of 6). Finally the measuring gas ways are flushed and the system switches to measuring mode.

WARNING

Risk of loss of gas.
If the user selects a manual calibration, he should not be distracted at this point (e.g. a by a phone call). The calibration gas will flow until the current value has been confirmed as stable by the user. If the user is distracted, too much calibration gas is burned in the analyzer at worst the entire gas in the accompanying cylinder.
→ When performing a manual adjustment it is necessary to ensure that the confirmation of the end point is carried out promptly in order to not unnecessarily consume calibration gas.

5.4 Measuring mode

The following section explains the possibilities for operating the device in measuring mode.

5.4.1 Display of measured value

If the device is in measuring mode it's possible to use the menu or to display the measured value on the screen. Displaying the measured value gives information about the current measured value and the device Status.

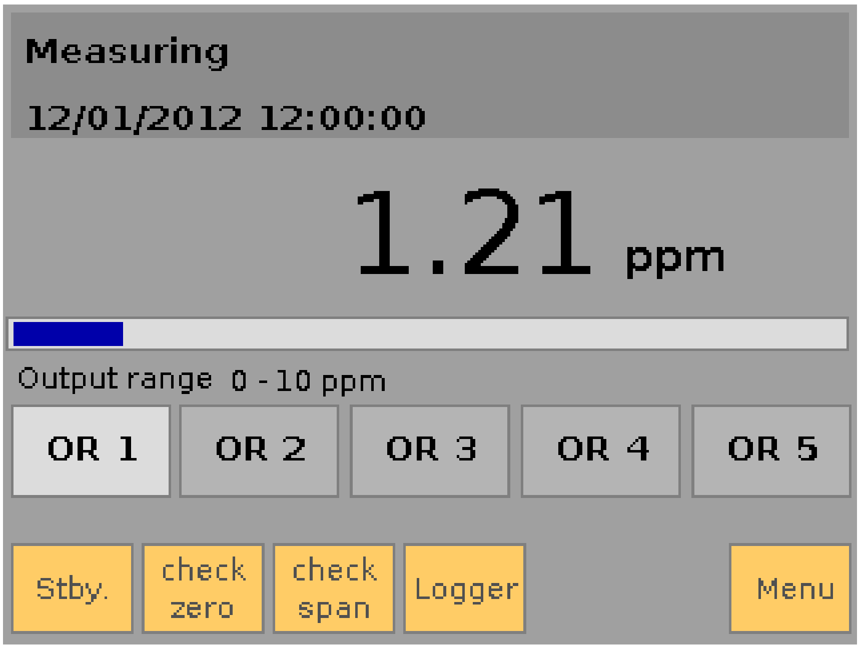


Figure 18: Measured value

The measured value is shown on Figure 18 without special Status messages. In the upper left area the current date and time are displayed. On the upper right area Status information are shown if necessary. Below the current measured value is shown in the configured unit. The bar-graph visualizes the part of the measured value (blue part) related to the complete current Output range (grey part). Below that the Start and end value of the currently selected Output range are shown (e.g. 0-10 ppm). Below that five gray buttons are displayed which offer the possibility to change the Output range. They are identified by the initials "OR". At the lower end there are further buttons that allow the user various actions.

5.4.2 User actions during the measuring Operation

In measurement mode the device allows the user to perform various operations. [2] In the following these actions are described on the basis of the display as mentioned in the previous section:

1. Decimals places

By touching the measured value the user is able to configure the displayed decimal places. By any new contact either one, two, or no decimal places will be indicated:

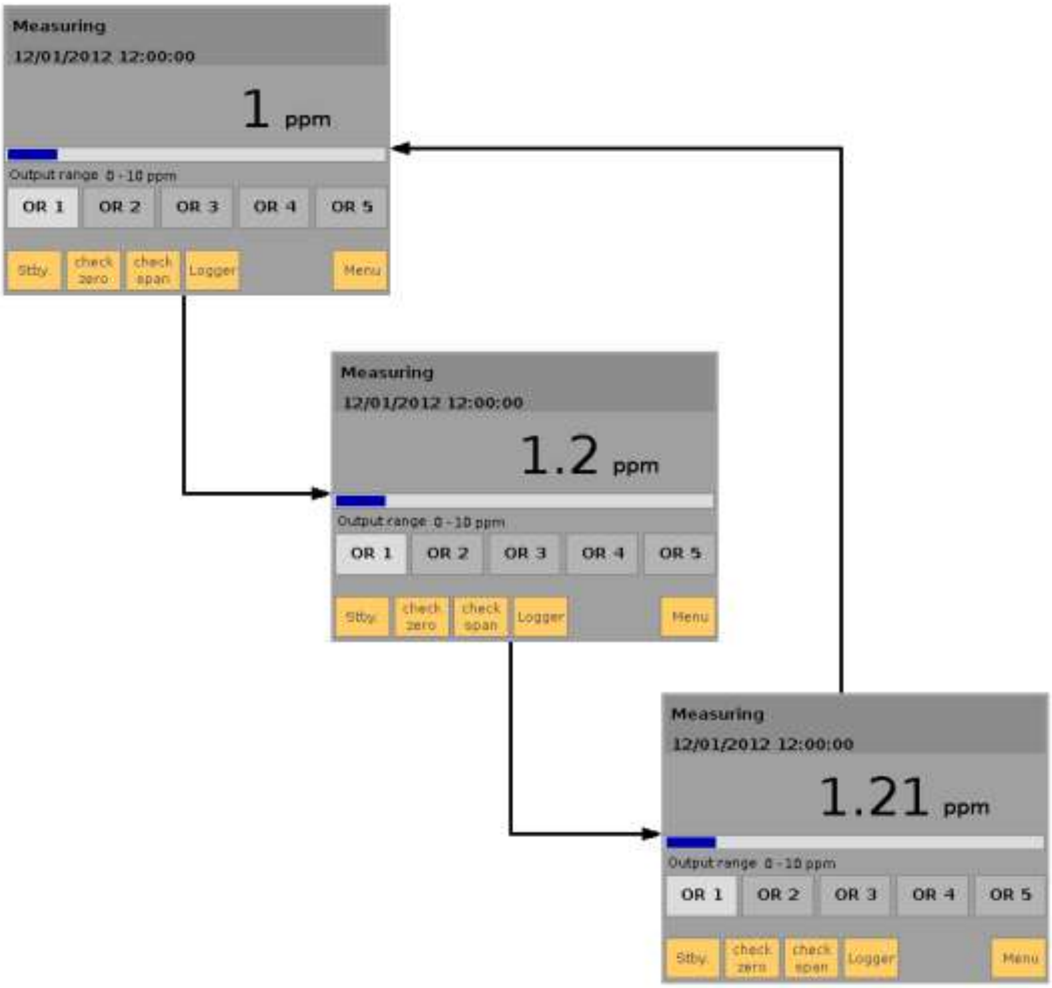


Figure 19: Configuration of decimal places

2. Output areas

The output areas are five scales. The final value of each scale can be defined by the user. The system automatically switches (if configured) to the next higher or lower Output range if a certain threshold is crossed for a certain time period. For this the value of the threshold and delay time are taken from the configuration settings of the device (see section

[2] Depending on the desired finish, it may be that the actions in the measuring operation are partially not available.

6.5.4.3 “Output ranges” on page 84).
The automatic switching of the Output areas can be turned off. This is done by touching one Output-range button to fix its range. The fixing is given to the user by a white frame drawn around the pushed range-button (see Figure 20). Touching the button again releases the fixing of the output-range. The white frame around the button disappears and the system selects the best fitting range for the current measured value.

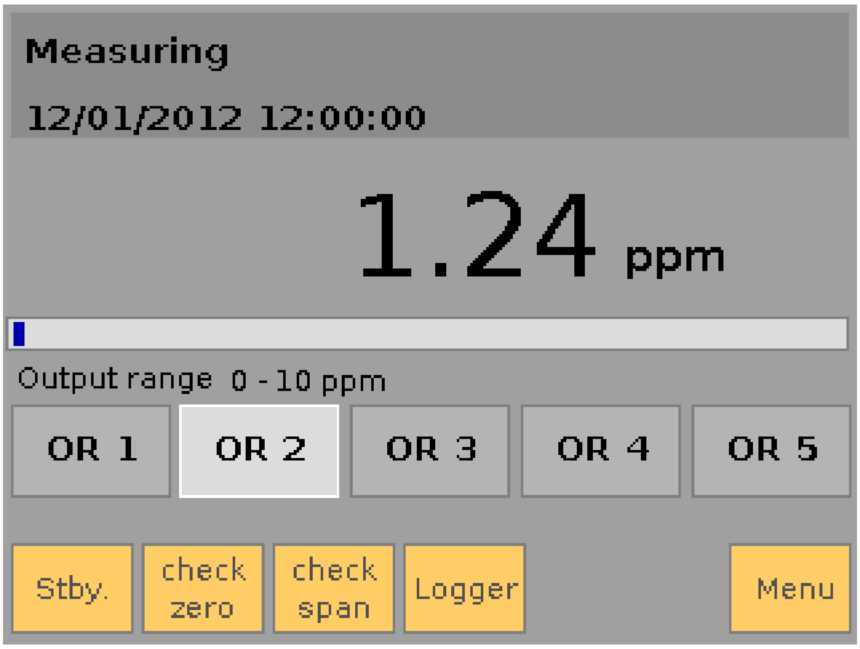


Figure 20: Fixed Output Range

3. The button “Stbv.”

This button puts the device into standby mode. In this mode, the device is continuously heated, however the measurement is interrupted. So the analyzer is using no hydrogen in this mode and it is disconnected from the process due to a cut-off of measuring gas supply. To ensure that the system is protected from streaming measuring gas into the analysis chamber, the user should take care that the SmartFID pumps zero gas through the measuring gas lines if the device is in stand-by mode. This Option can be found in section 6.5.1.3 “Options” on page 70.

4. The button “check zero”

Touching this button activates the flow of zero gas during the measurement. So a test of the zero point is triggered to visualize the drift of the zero value. Given this information the user can decide whether a further calibration is necessary. If this feature is enabled the button "check span" and the button "Calibrate device" in the main menu are disabled (See section 5.3 “Calibration” on page 38). The white frame drawn around the button tells the user that this feature is enabled. The zero point test is finished by touching the button "check zero" again or when the maximum calibration time is exceeded. This value can be set by the user (see section 6.5.2 “Waiting times” on page 80).

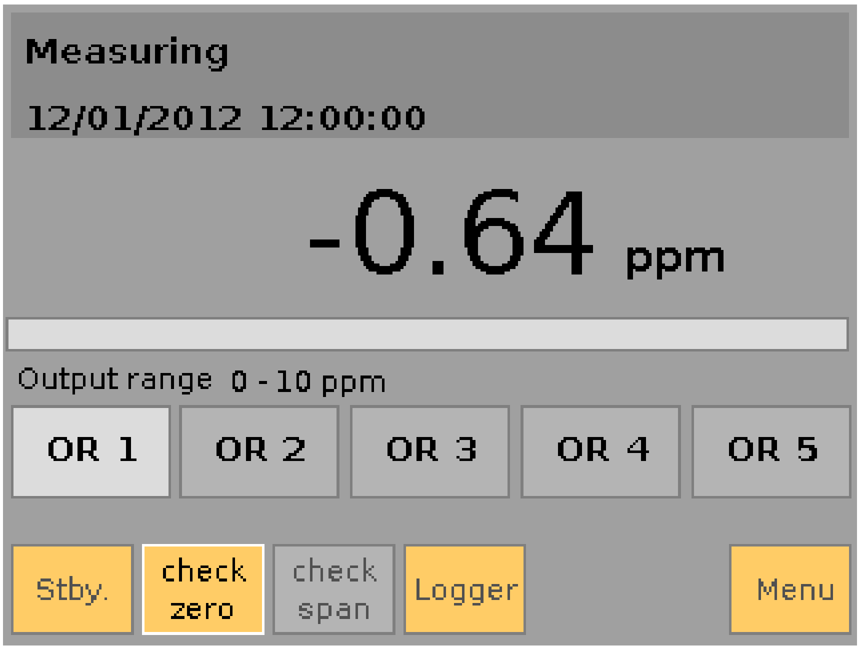


Figure 21: Test of zero point

5. The button “check span“

Similar to the previous section this button activates the flow of calibration gas in measuring mode. This empowers the user to check the endpoint and notice the drift. So a decision can be made if a calibration of the device is necessary. The white frame around the button shows the user the active function. The Option "check zero" is not available in this mode and disabled. The test is finished by pressing the button "check span" again or if the maximum calibration time is exceeded. This value can be set by the user (see section 6.5.2 “Waiting times” on page 80). After the test the sample gas lines are flushed with zero gas to remove test gas which was pressed into the sample gas line. During this time, the buttons “check zero” and “check span” are both disabled.

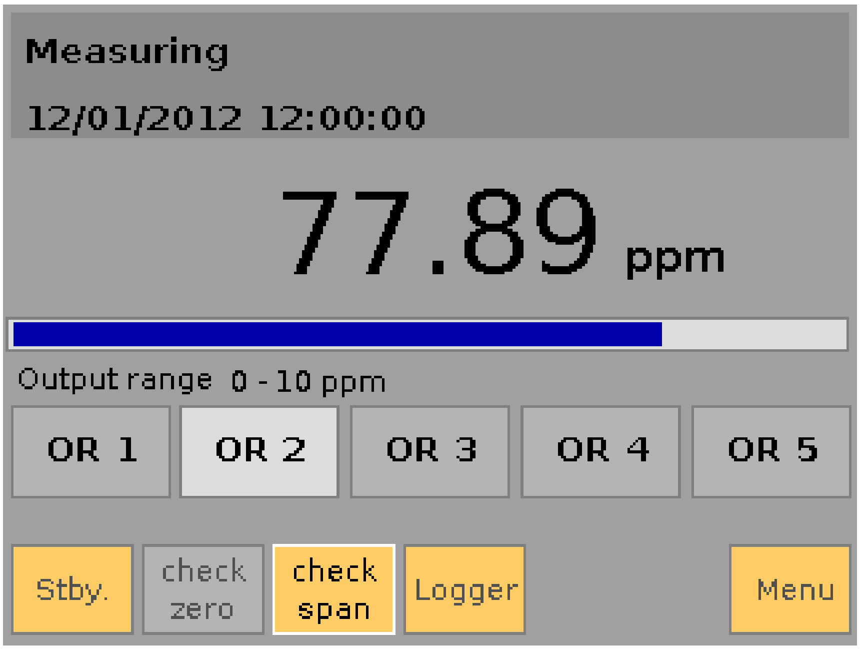


Figure 22: Check of endpoint

6. The button "Logger"

By touching this button the recording of sample data (data logging) is started or stopped. The state of activity is indicated by a red circle in the upper right area of the meter. If it is present the measured values are recorded. For more information on this feature, see the appropriate section 6.5.4.4 "Data-logger" on page 86).

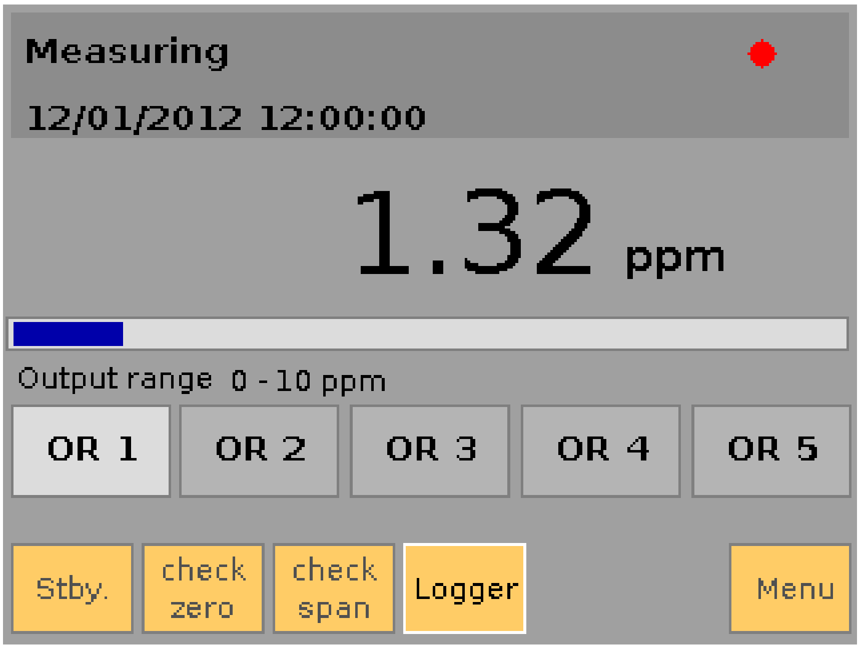


Figure 23: Activated data recording

7. The button “Menu”

Touching this button opens the main menu of the device that offers the user many options for device configuration of which many can be set in measurement mode. Please find the explanation of the main menu in the following section.

5.5 Main menu

The main menu is accessed by the corresponding button in the measurement mode or the standby mode. The back button takes the user back to the menu of which the main menu was called from. The other buttons are described in the following sections. The menu item "Setup" is explained due to its complexity in the section 6 "Device configuration" on page 59 et seq.

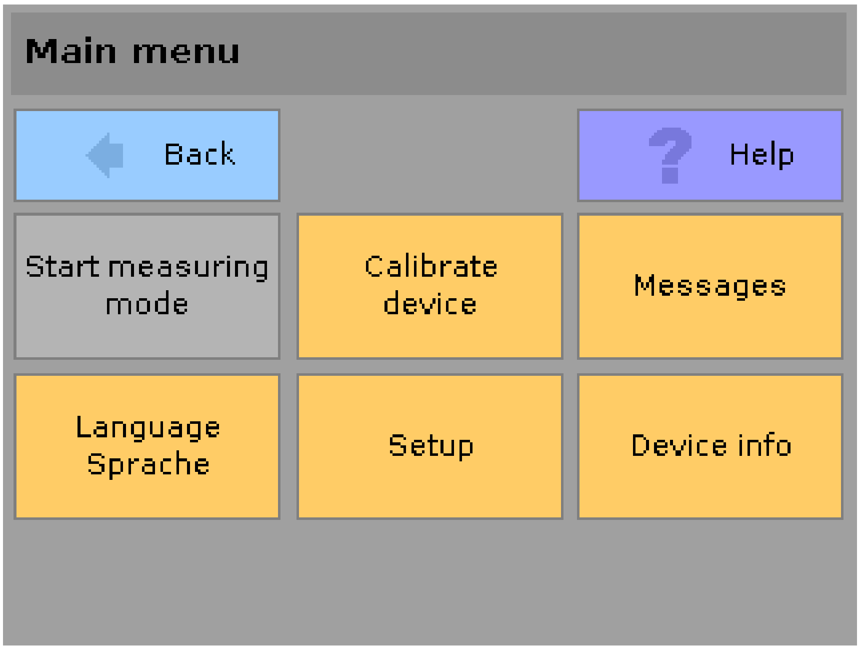


Figure 24: Main menu

5.5.1 Help

SmartFID provides the user extensive help screens on various menu items that are displayed by touching the “Help” button. The displayed text gives the user information. It can be scrolled by using the up and down buttons at the right edge of the text (See Figure 25 on page 48). Touching the back button takes the user back to the place in the menu system, the help screen was called from.

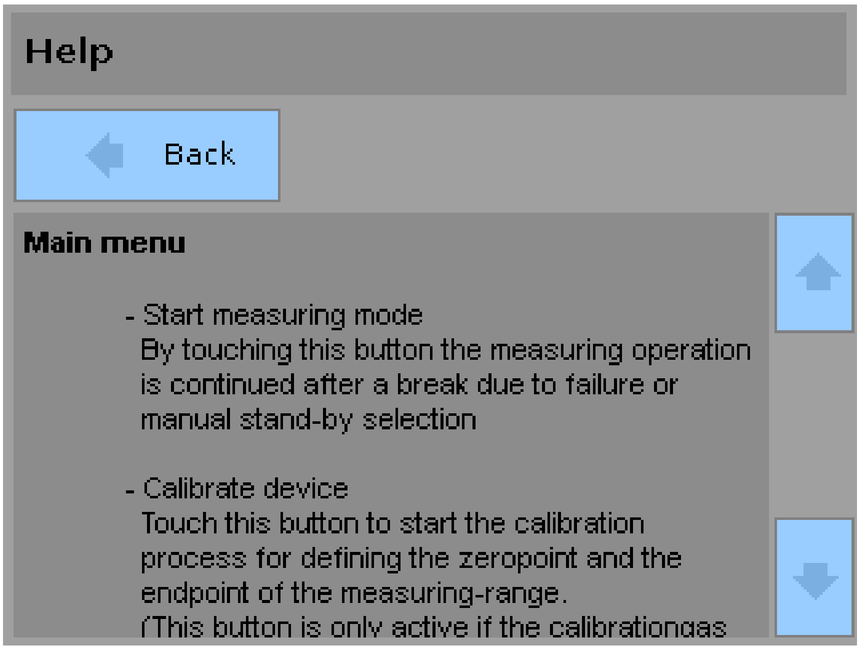


Figure 25: Help screen of main menu

5.5.2 Start measuring mode

By touching this button, the System will change after a disturbance or from standby mode to measuring mode if this is possible.

5.5.3 Calibrate device

Touching this button initiates the calibration of the SmartFID. The button is only active if:

- The calibration gas is available with enough pressure
- No check of zero point or endpoint is performed
- The calibration-blocker on Modbus-Controller is inactive.

For more Information on the process of calibration and the necessary conditions see section 5.3 “Calibration” on page 38.

5.5.4 Messages

In case of failures or exceptional states SmartFID generates status messages that are archived by the device. . Touching the Messages button displays the latest news of the device. Whether there are messages, shows a red or yellow flashing triangle in the upper right of the screen. The red symbol remarks a failure and a yellow triangle represents a note (failures override notes). If there are multiple messages, they can be sequentially displayed by using the buttons “Next” and “Back”. In the lower part of the screen the message is displayed. If the cause of a message is removed the user won't see the message anymore. It is then only visible in the message archive (See Figure 31 and Figure 32 on page 52), which logs all messages of the device for the Service.

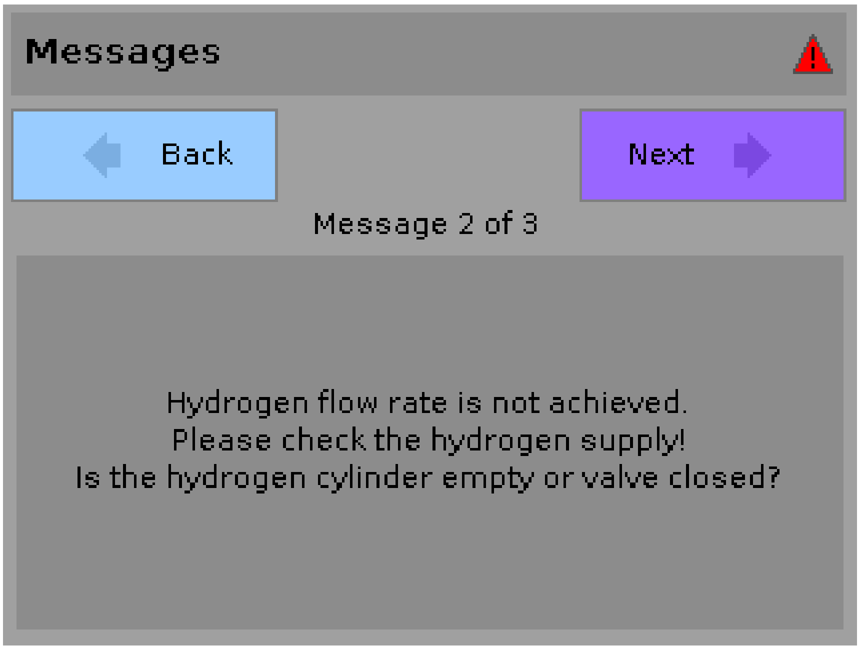


Figure 26: Example of a message

5.5.5 Language / Sprache

This button allows switching the user interface to a different language. After touching the button a list of the selectable languages will appear. When a language is selected, this language is used immediately. To reset the original language, the menu item has to be selected again.

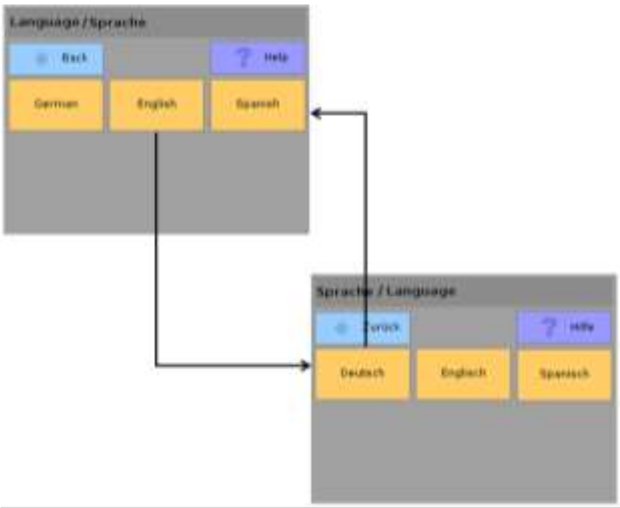


Figure 27: Language change

5.5.6 Device info

Using this button it is possible to obtain general Information about the device Status. The first page provides information on:

- serial number
- applied software version
- hours of operation
- next scheduled maintenance (calculated on real hours of operation)
- current processor temperature

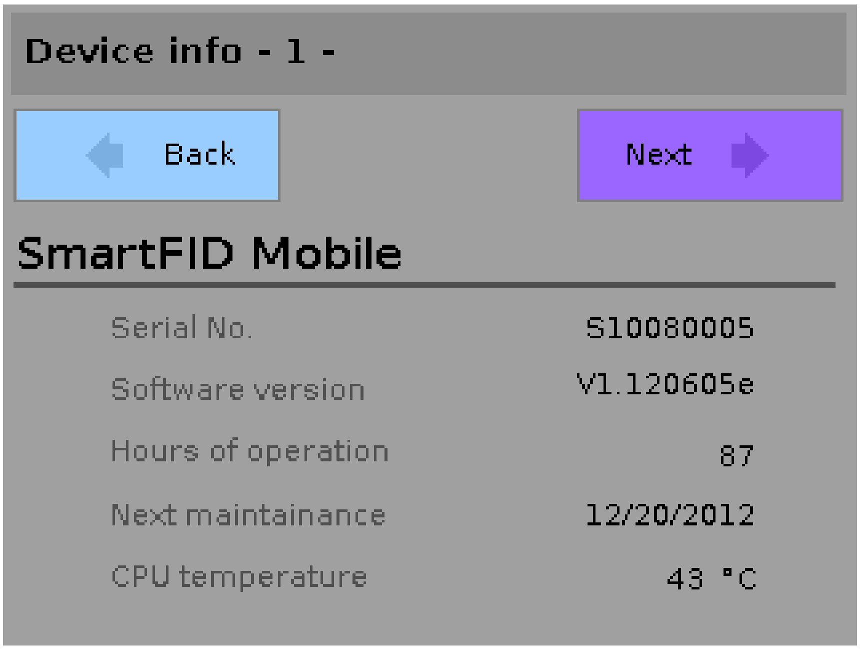


Figure 28: Device information - page 1

Using the button “Next” the second page of the device information is displayed. It provides information on:

- current temperature of the analysis chamber
- current temperature of the heated line (if connected)
- current temperature of the catalyzer (if installed)
- current pressure of sample gas
- current pressure of fresh air
- current flow of fuel gas

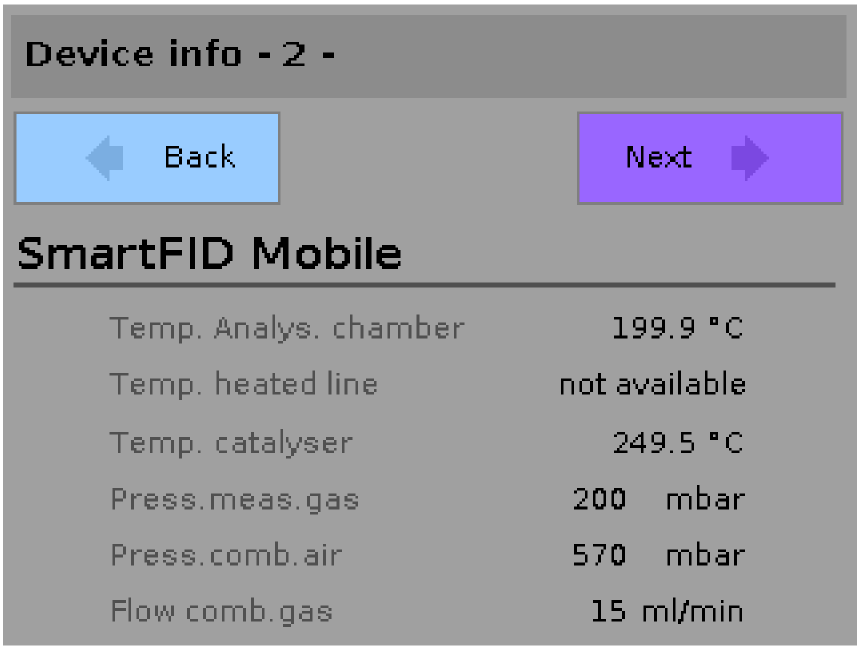


Figure 29: Device information - page 2

Using the button “Next” the third page of the device information is displayed. It provides information on:

- date of the last calibration
- sensitivity drift
- zero drift
- sensitivity drift in relation to the last calibration
- zero drift in relation to the last calibration

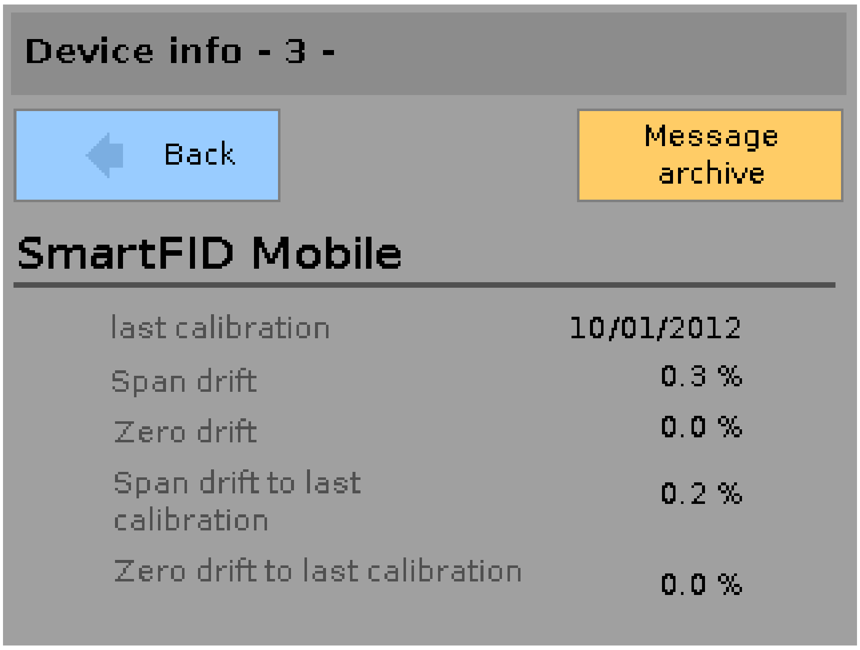


Figure 30: Device information - page 3

On the third page of the “device information” there is the button “message archive” which leads the user to the archived messages of the device:

Figure 31: Received message in the message archive

The message archive distinguishes between received messages (logged at the time of occurrence of a state) and outgoing messages (logged at the time of removal of a state). The distinction can be recognized by the user regarding the red icon symbolizing a coming message versus the green icon symbolizing an outgoing message in the right area of the screen. In the left area the number of the current message and the entire number of messages are displayed. In between this information the recorded timestamp of the message is shown.

Below the message itself is displayed. The message archive Stores 500 messages in a circular buffer and can be a useful source of Information in a case of Service due to a device failure.

Figure 32: Outbound message in the message archive

5.6 Alerts

SmartFID is able to trigger an alarm in two stages. This is a distinction between the prealarm and main alarm. The thresholds that must be exceeded for each alarm have to be configured (see section 6.5.1.6 “Alarm thresholds” on page 80).

In addition it's possible to activate the option, if the main alarm should be self-retaining. Whether an alarm is displayed on the digital outputs, depends on their configuration (see section 6.5.1.4 “Inputs and Outputs” on page 71). When crossing the pre-alarm threshold, the measurement value is shown in yellow.

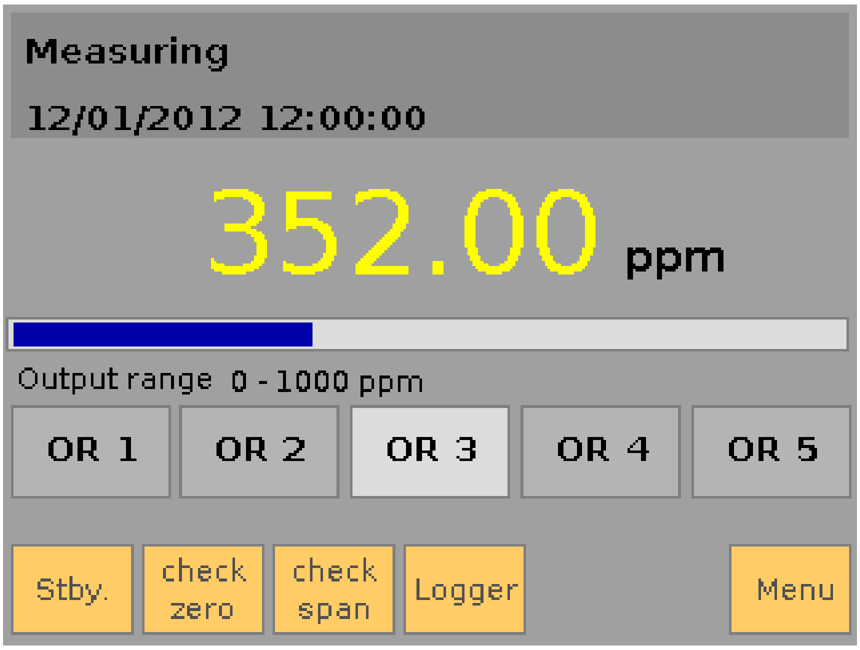


Figure 33: Visualization of the per-alarm

If the measurement value falls below the threshold after a pre-alarm, the meter changes back to black digits. When crossing the main alarm level, the measurement value display turns red. If the value falls slowly below the threshold it is again displayed in yellow (in the pre-alarm range) and turns to black if it falls below the per-alarm threshold. If the value falls very quickly, it's possible that the color might switch directly from red to black.

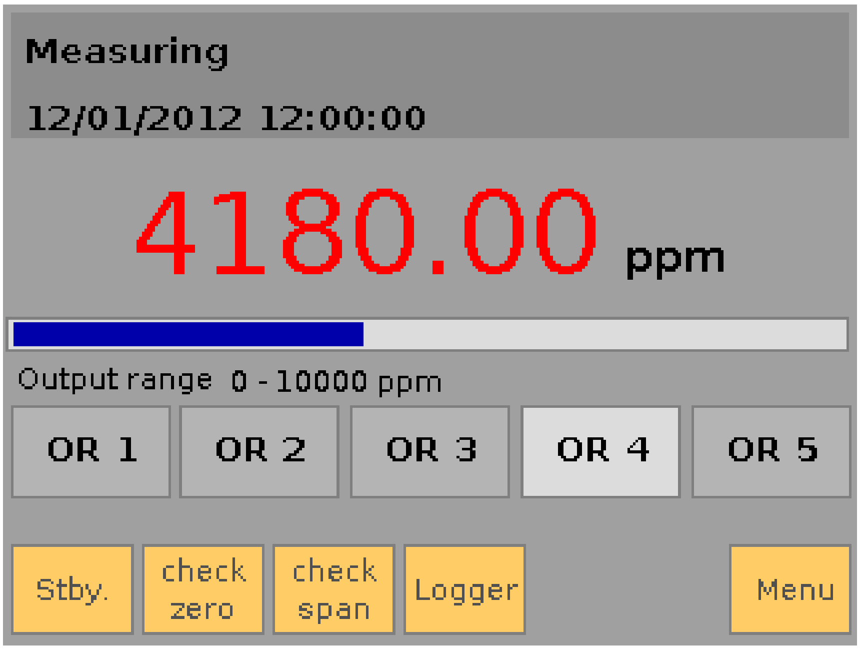


Figure 34: Visualisation of the main alarm

If the Option "self-keeping alert" is activated in the configuration an additional button appears on the meter to the right of the logger-button in case of a main alarm occurring.

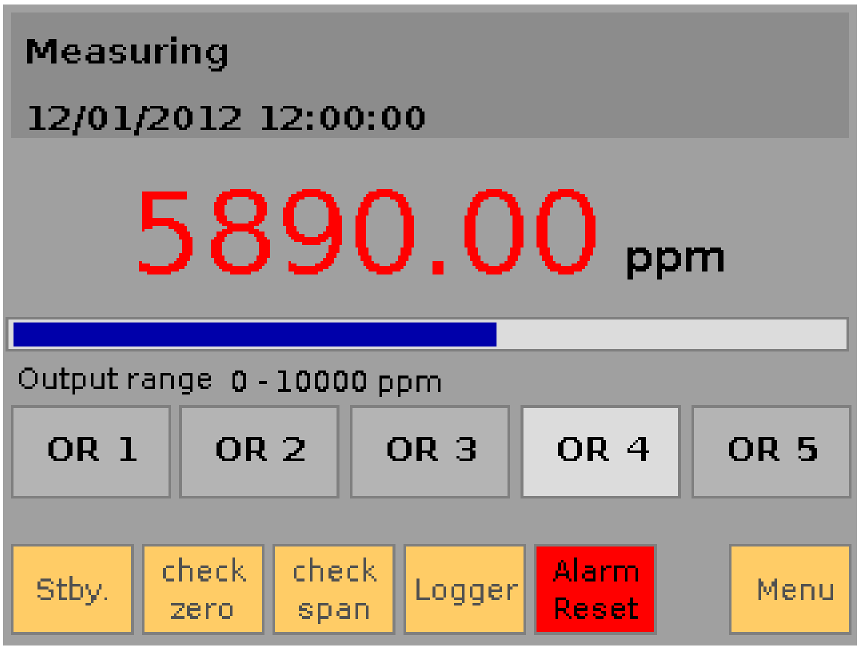


Figure 35: Main alarm self-keeping

The button "Alarm Reset" has to be touched to reset the alarm. It will no longer be displayed after this action. If the main alarm is given to an Output contact this is also activated until the user has acknowledged the alarm.

5.7 Notes on maintenance and repair

The following chapter provides Information on maintenance and repairs that you can perform. Please consider carefully all hints and notes in the following section:

WARNING

Use only original spare parts!
The usage of spare parts which are not delivered by ErsaTec may affect the device properties and shorten the life of the device.
→ Just use original spare parts.

DANGER

Precautions when working on the device.
To protect people and technology during maintenance work on SmartFID the following precautions have to been taken.
→ Turn the device power off before you Start working.
→ Unplug the main supply before you Start working.
→ Only work on a sufficiently cooled down device.

5.7.1 Maintenance of the dust filter

A blockage of the dust filter is probably given, if the device is not able to feed enough fresh air to the measuring process by the fresh air pump. The increased load of the pump is detected by SmartFID automatically and the device gives a message to the user. Moreover, a clogged filter can be identified by visible contamination. To replace the dust filter, open the appropriate cover on the side of the unit by screwing (see No. 12 - Figure 4: SmartFID's side wall on page 15), replace the filter tube and screw the cover back on.

5.7.2 Maintenance of activated carbon filter

The activated carbon filter frees combustion air and zero gas of hydrocarbons. This filter works depending on the ambient air and continuous operation for a limited period of time. The device does not detect aware of this filter. To check whether the proper function of the carbon filter is given, unscrew the facing of the filter at the side wall (see No. 13 - Figure 4: SmartFID's side wall on page 15) and remove it from the socket. Figure 36 shows the removed carbon filter (No. 1). Please check the white box indicated in the middle of the filter (No. 2) for discoloration. In case of a discoloration (3) the filter needs to be replaced.

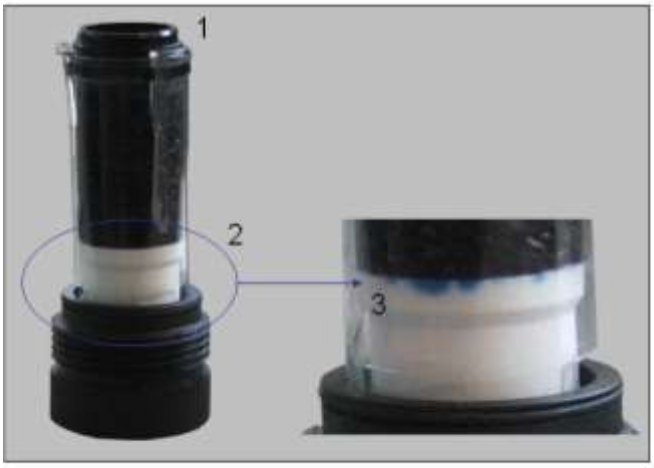


Figure 36: Activated carbon filter

6 Device configuration

The Setup button in the main menu (See Figure 24 on page 47) allows the configuration of SmartFID. By touching this button a warning appears which indicates that in some cases values may be applied without any acknowledgement when operating the setup. Also an interrupt of current measuring is possible. [3]

WARNING

First back up the current configuration.
As part of the configuration of many parameters can be changed. These changes affect in part directly or indirectly the measurement. It can be difficult to take back all changes, as if some parameters are ignored.
→ Ensure to back up the current configuration to be able performing a restore if necessary (see chapter 6.1 “Save settings” on page 59).

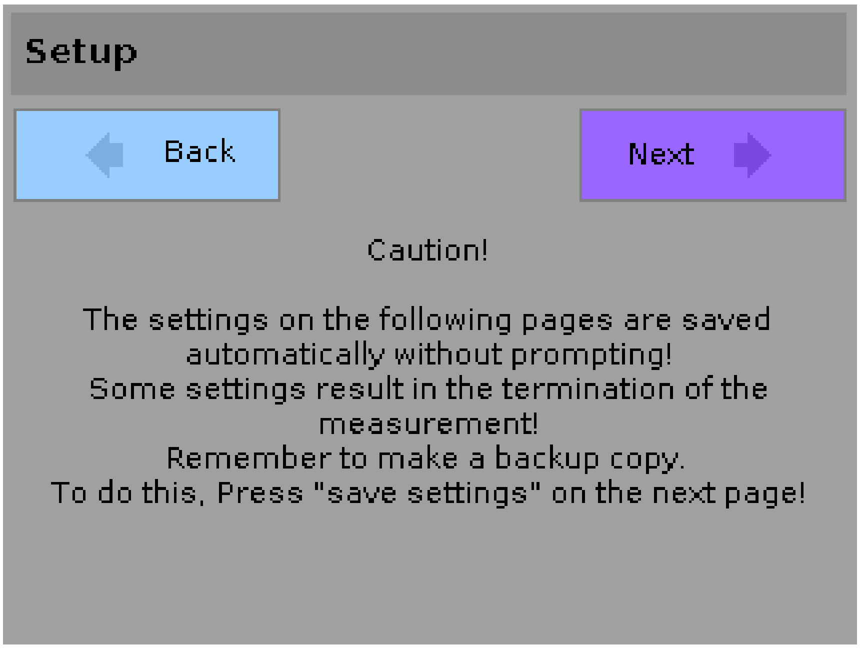


Figure 37: Warning-message when entering system configuration

[3] Depending on the desired finish it may be that starting the setup is made possible only by the proper confirmation of a password prompt.

After acknowledgement this warning by touching the button “next” the user gets to the setup-menu. The following illustration shows the basic options in this menu:

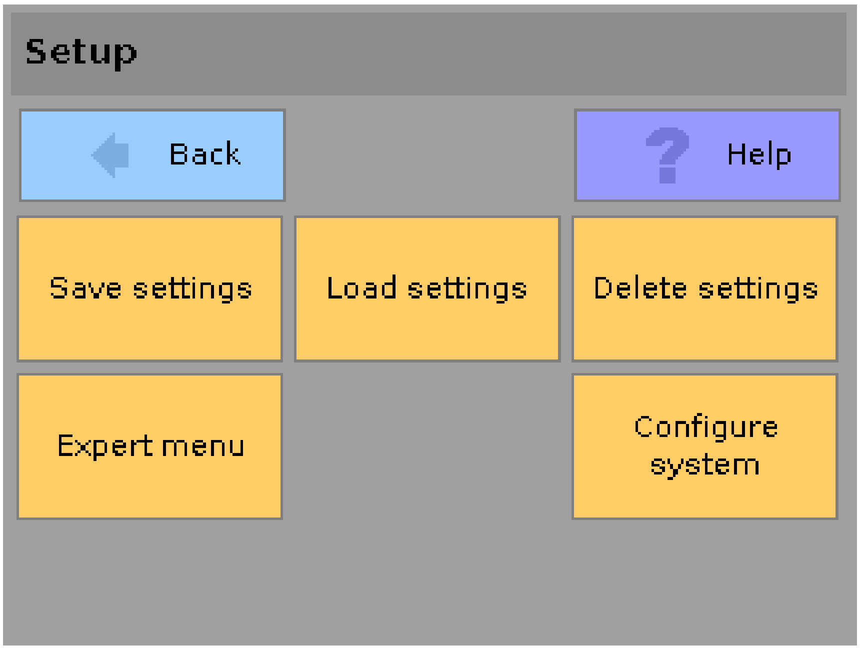


Figure 38: The setup menu

6.1 Save settings

Using this menu item the user can save the current System configuration in a configuration profile so that it can be restored at a later date. So the user gets empowered to hold six different configurations for different application scenarios and to activate them quickly if required.

If you touch this button, the System suggests a name for the file, in which the configuration profile is to be saved. This results from the current date (20121201 means 2012/12/01) and a continuous extension.

The green button "save" triggers the storage of device configuration using the specified caption. It's possible to modify the suggested filename by touching the text field where it's displayed. The System then presents an alphanumeric keyboard on the touch panel which allows the user to enter an individual file name (See Figure 39 on page 60).

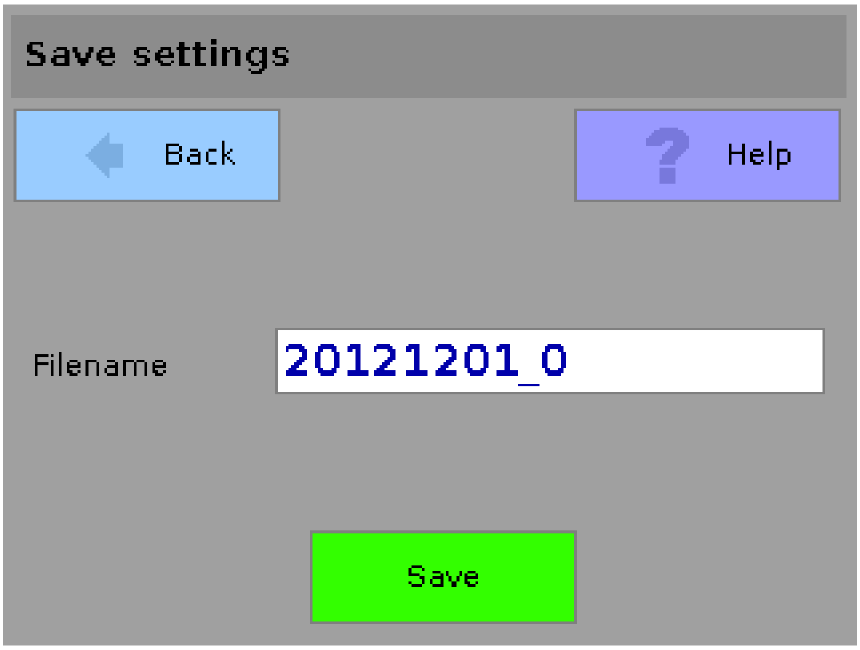


Figure 39: Dialog to enter a profile file name

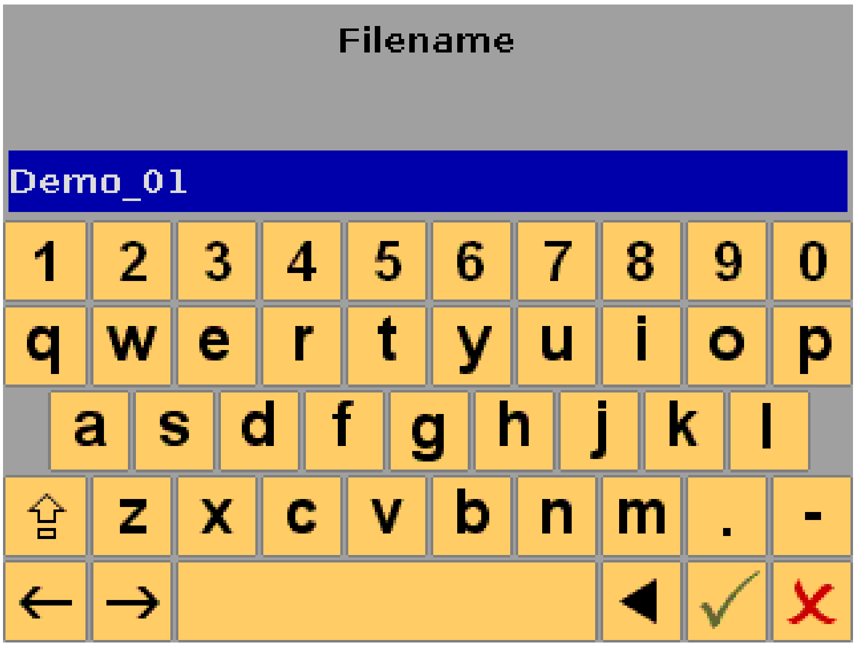


Figure 40: Input of an individual file name

By pressing the appropriate letters and numbers an alternate file name can be specified and be confirmed by the green check mark. Touching the cross button discards the changes and the System returns to the previous screen without applying changes.
Using the back-button at the bottom left (◄) typing errors can be corrected. The arrows on the left (← / →) are used for cursor navigation. After confirmation the System returns to the save-dialog applying the new filename. Remark that the usage of special characters (e.g. /) is not possible. In this case you will get an error-message. However special character may be applied in other cases (e.g. setting measuring units).

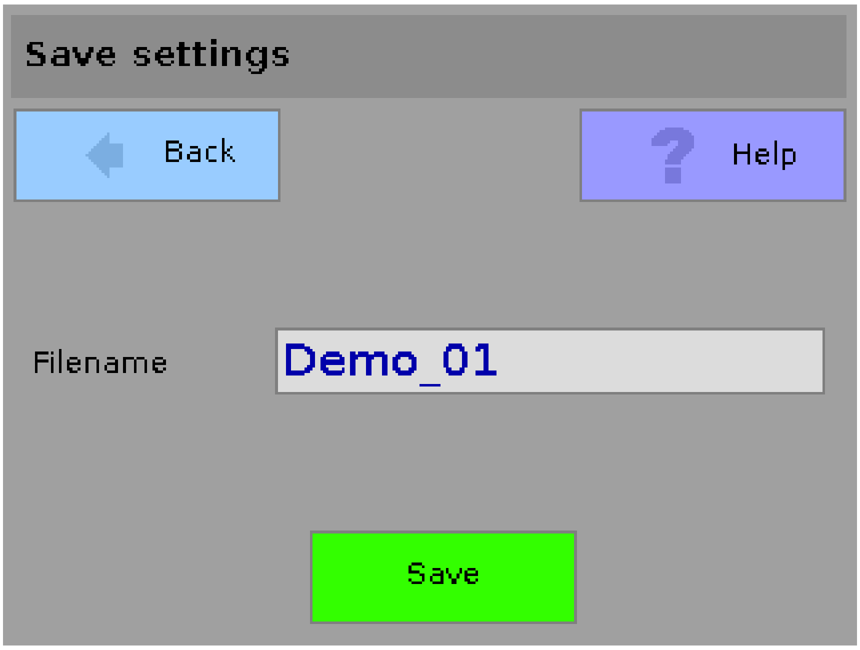


Figure 41: Save profile with an individual file name

By touching the “Save” button, the configuration is saved. A message informs the user about the successful backup of the configuration. Touching the “Next” button takes the user back to the setup menu.

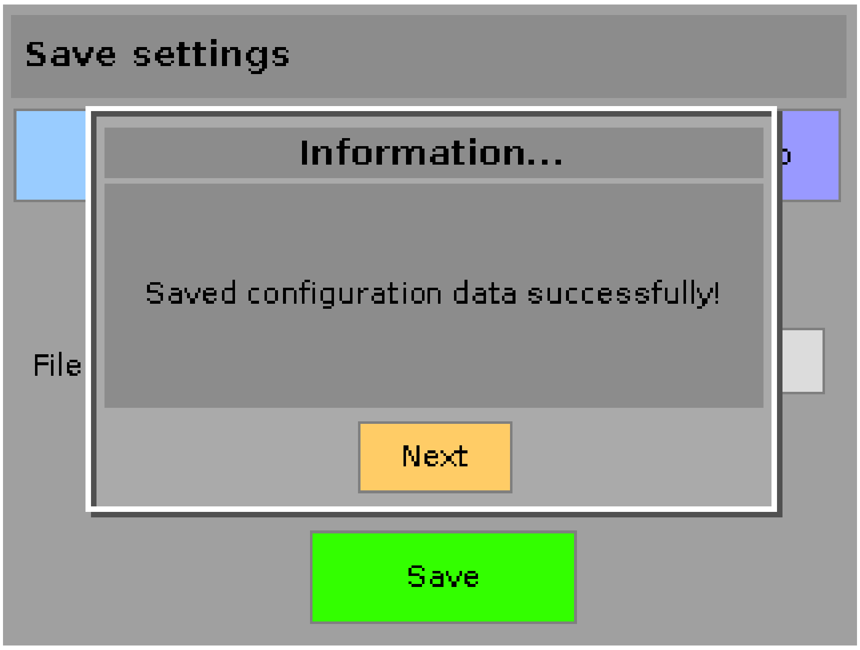


Figure 42: Successful backup of the configuration

6.2 Load Settings

Using this menu item it is possible to restore a previously saved settings-configuration. After touching the button the restorable configurations are displayed. The user selects a profile by touching the corresponding button, then the procedure of restoring data begins after confirming a security notice.

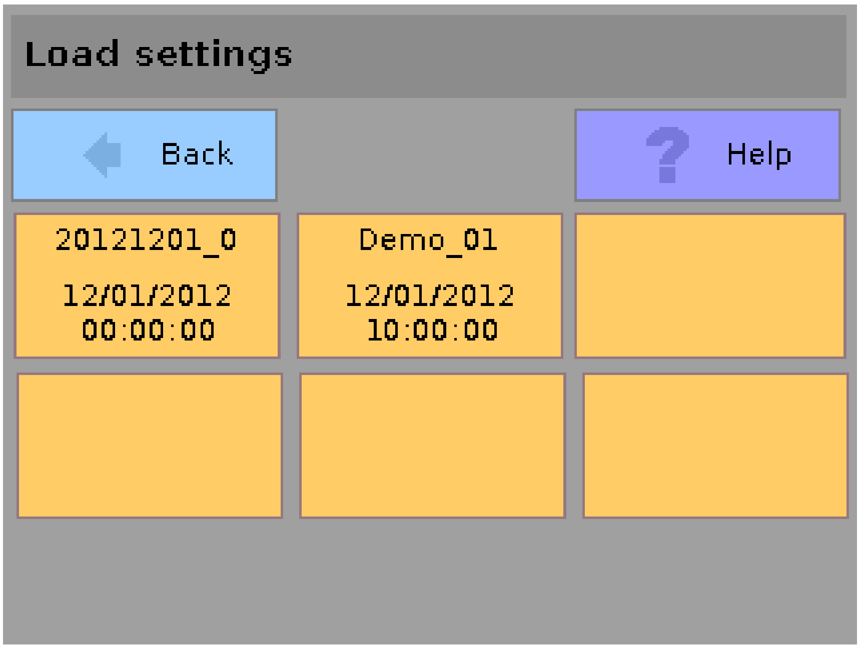


Figure 43: Load a previous configuration

After a successful loading process there is an indication that the configuration is now active and the unit has to be calibrated again. The hint is indicated by a flashing yellow triangle in the upper left corner.

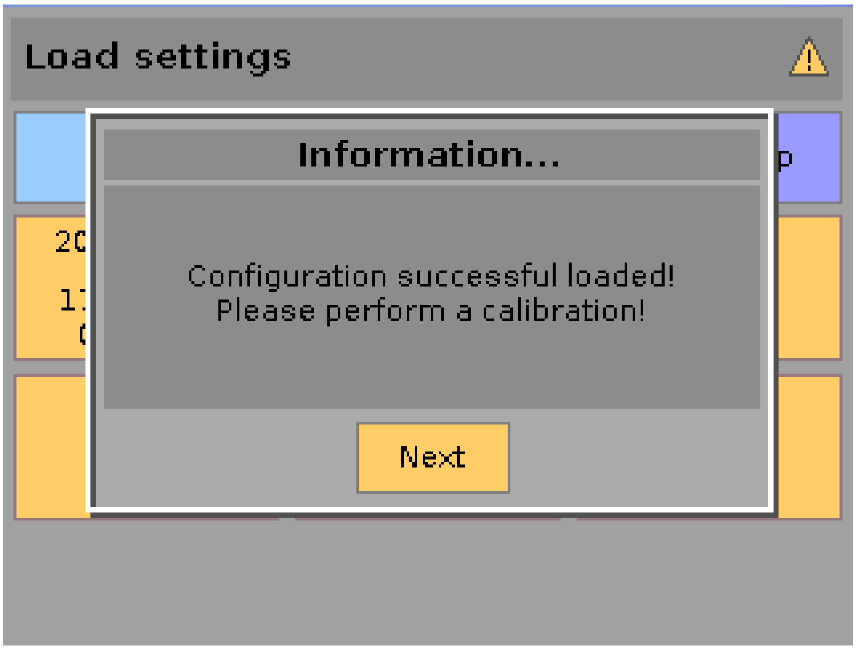


Figure 44: Report of a successful restore

6.3 Delete settings

This menu allows the user to delete one of six possible profiles from the System to provide space for a future saving of settings. After touching the button the System will display the six presets. The user selects by touching the appropriate button which configuration should be deleted.

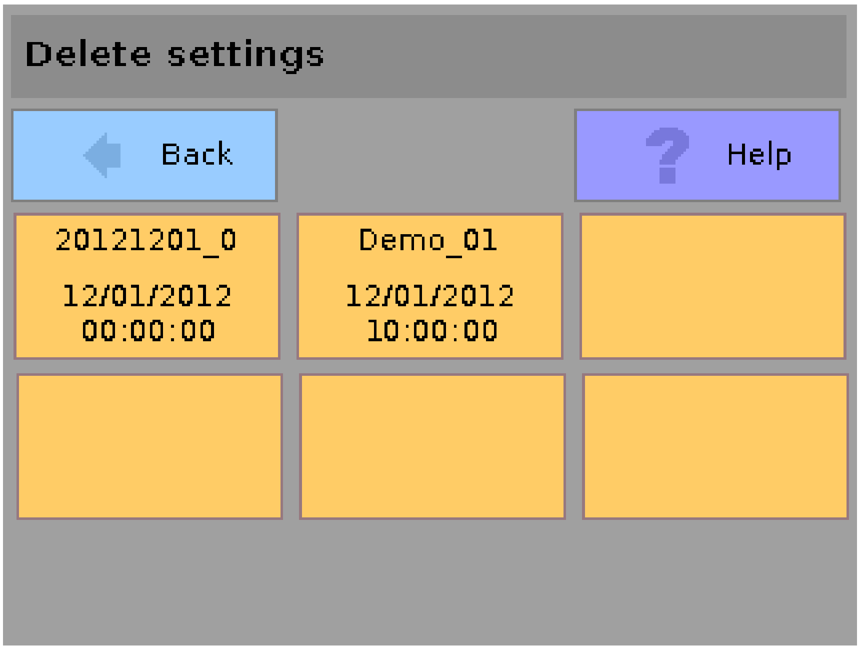


Figure 45: Selection of the configuration to be deleted

After that the removal of the selected configuration has to be confirmed by the user in a separate step by touching the "Yes"-Button. Alternatively the user can cancel the deletion process by touching the "No"- button.

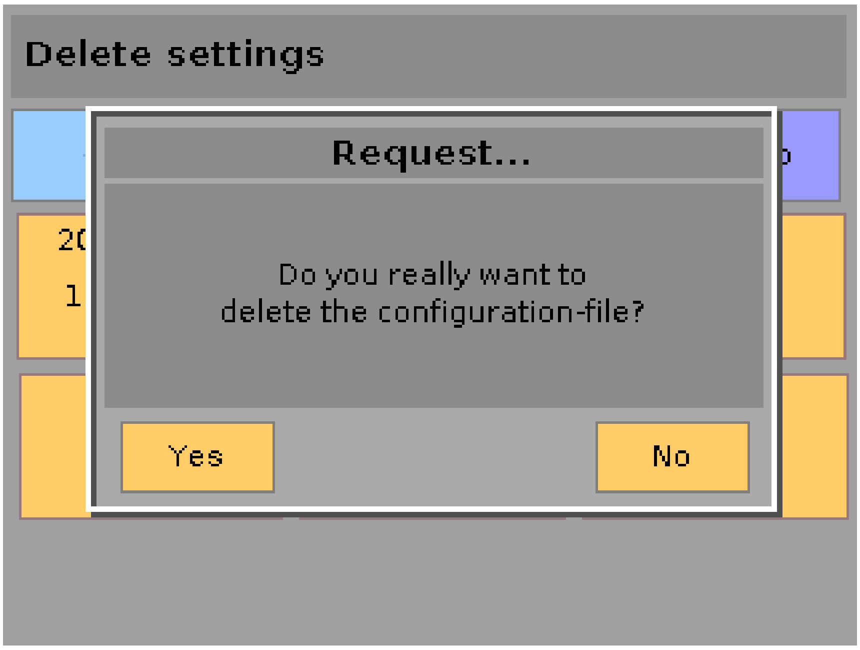


Figure 46: Confirmation of deletion of a configuration

6.4 Workshop menu

This special menu allows the user to perform specific diagnostic and service activities. It is only required in case of a Service call and generally locked for users when trying this menu item a message appears including a service code. To access the menu this code has to be transferred to ErsaTec and the user receives in return a service key, which needs to be input in the appropriate field to unlock the menu temporarily. After that an on-site service or a remote controlled service can be performed.

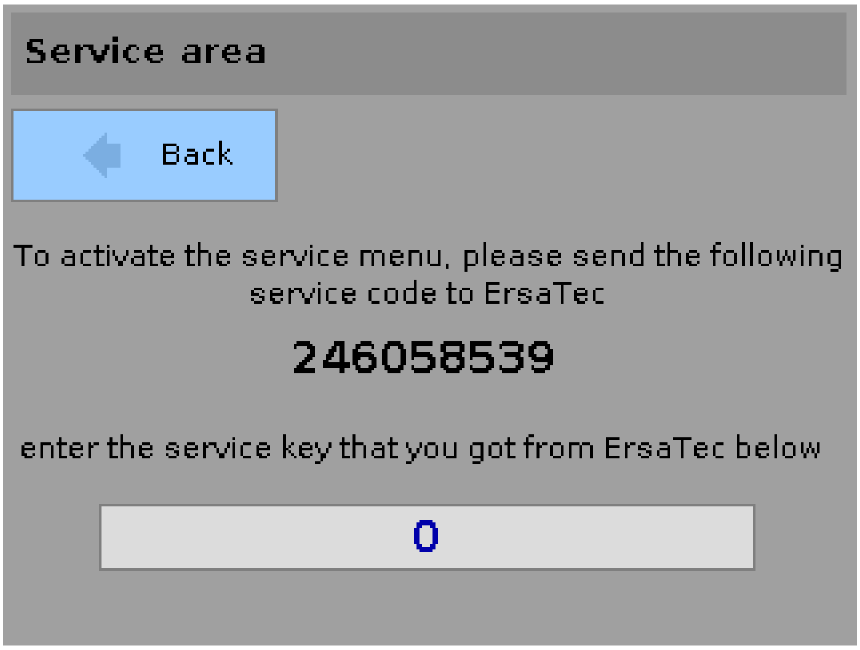


Figure 47: Key request for workshop menu

WARNING

Ask for the key only if you received a technical training on SmartFID.
The configuration options in the workshop menu are manifold and complex. The overview can be easily lost.
→ Request the key only if you have attended service training for SmartFID at ErsaTec. Alternatively you can order a service technician at ErsaTec if necessary.

6.5 Configure the System

Within this menu the device's settings can be changed. The Options of each menu item are described in the following sections.

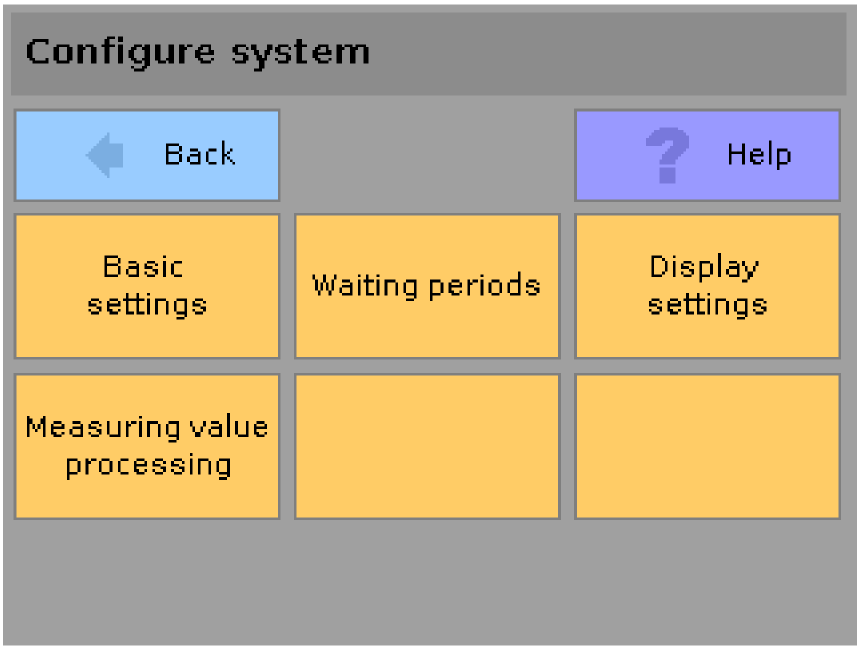


Figure 48: Main menu of system configuration

6.5.1 Basic settings

By touching this button, the menu for setting the basic parameters of the SmartFID is called. The following menu combines them in six areas (temperature, date and time options, inputs and outputs, automatic calibration and alarm thresholds).

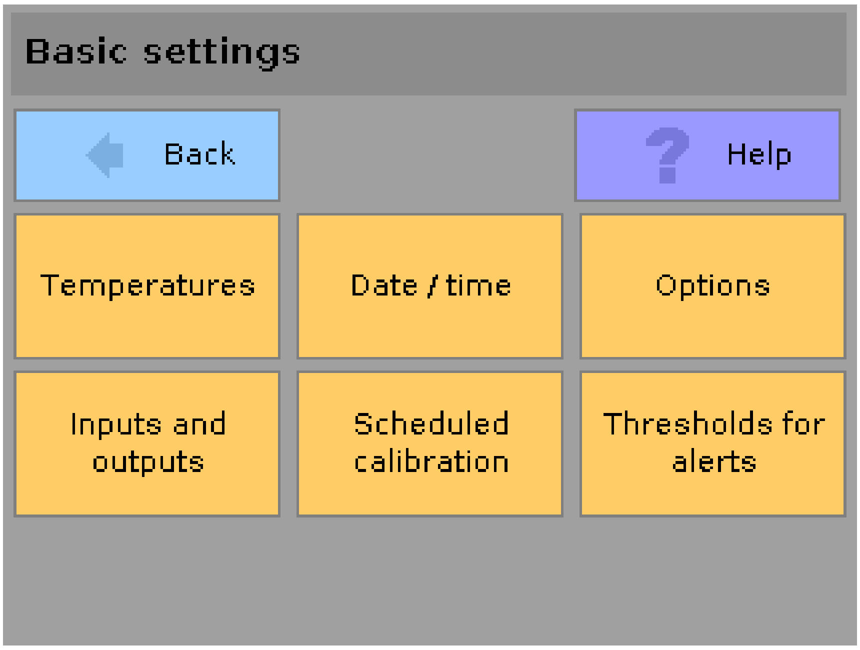


Figure 49: Configuration of the basic settings

6.5.1.1 Temperatures

This menu allows to set the target temperatures for the analysis chamber and if installed for the heated sample gas line and the optional integrated catalyst. If SmartFID is in measurement mode, modifying these values may lead the System to the heating phase to restore the operating state. The following warning is displayed to the user before fading in the menu.

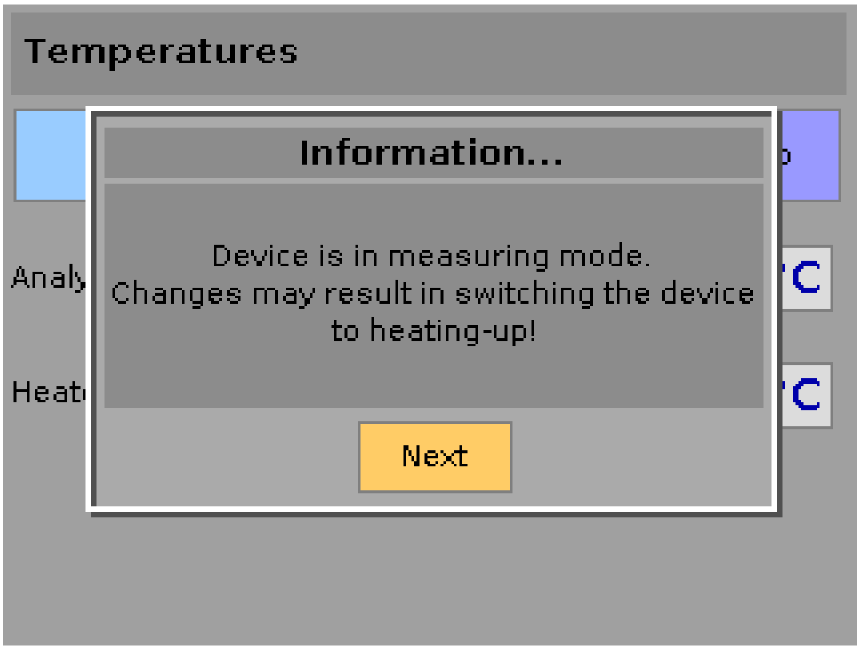


Figure 50: Hint before changing the set temperatures

After confirmation of the note by touching the “Next”-button the menu to configure the temperature is shown.

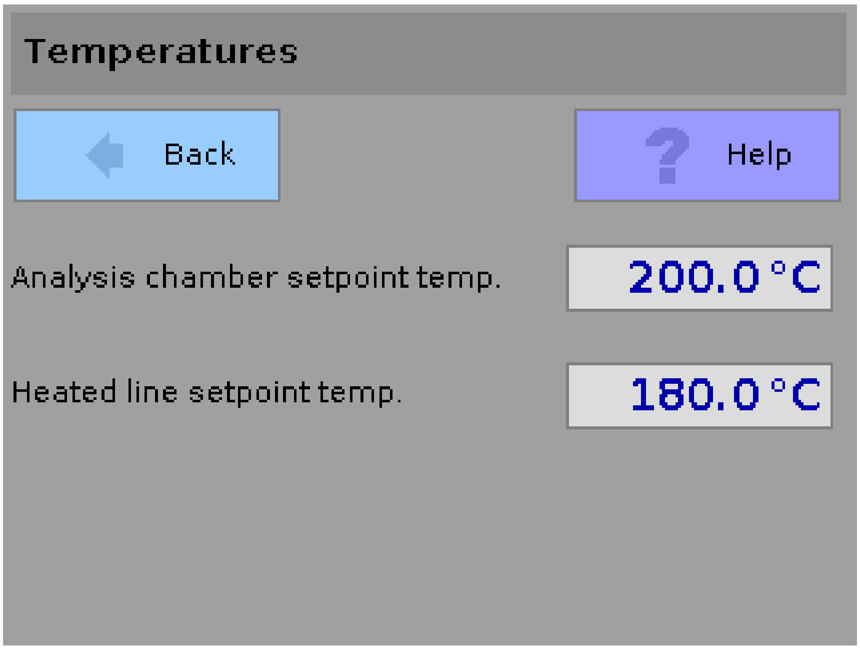


Figure 51: Configuration - set temperatures

In the shown example the nominal values for the analysis chamber and the heated sample gas can be modified. If your SmartFID has a catalyst installed it's also possible to modify its nominal temperature at this point.
To execute a change of a set temperature of a component the value shown has to be touched by the user.
By that an input-field in combination with an alphanumeric keyboard is shown where a new set point can be entered. In the upper section of the screen on the left side the minimum possible value is displayed while on the right side the maximum value is displayed (in the example below 50 °C and 200 °C – see Figure 52 on page 68).
By confirming the button containing the green check mark on the lower right of the visual keyboard the new value is applied. Similarly, a touch of the button containing the red cross leads back to the previous menu discarding changes. In the former case, the new nominal value for the target temperatures is set and displayed in the configuration menu immediately (See Figure 53 on page 69).

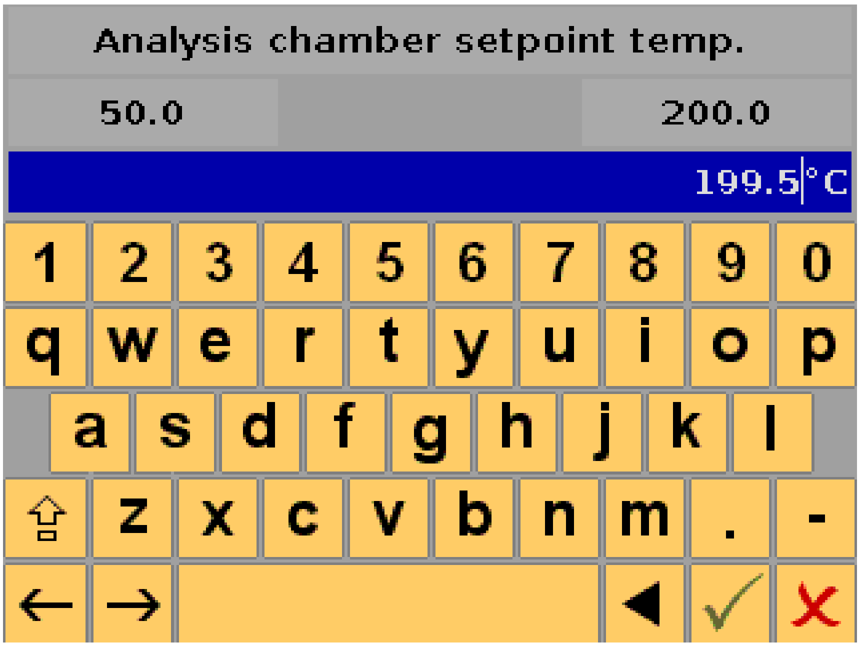


Figure 52: Input a desired temperature

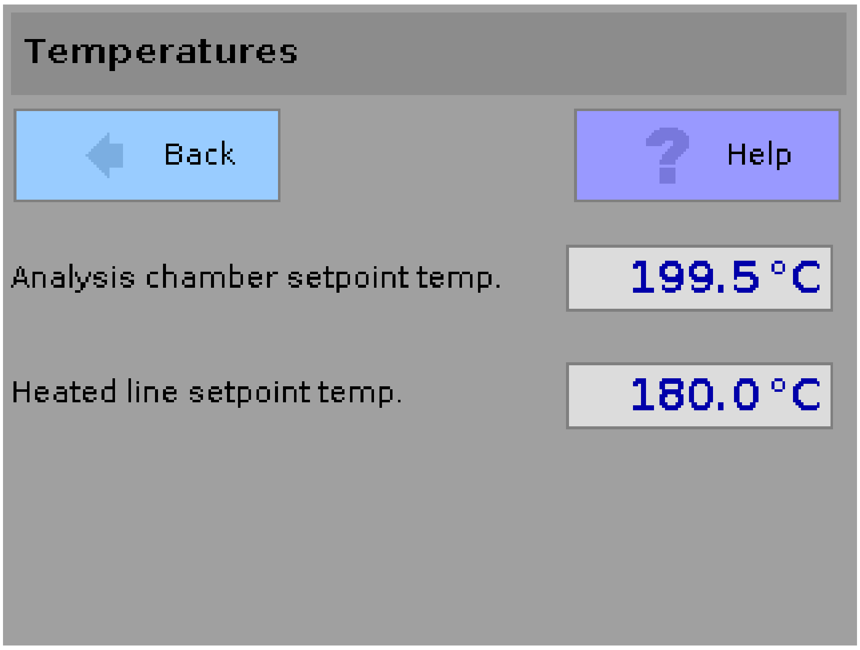


Figure 53: Acquired new set point

6.5.1.2 Date and time

By calling this menu it's possible to change settings concerning the System date and System time (See Figure 54 on page 69). Using the list the time zone can be selected in which the machine is located. The list is opened by touching the down arrow to the right. Below that it's possible to modify the values for day, month, year, hour and minute. Activate the underlying Option to switch automatically between summer and winter time on (as shown in the picture - check mark is present) or off (no check mark is present).

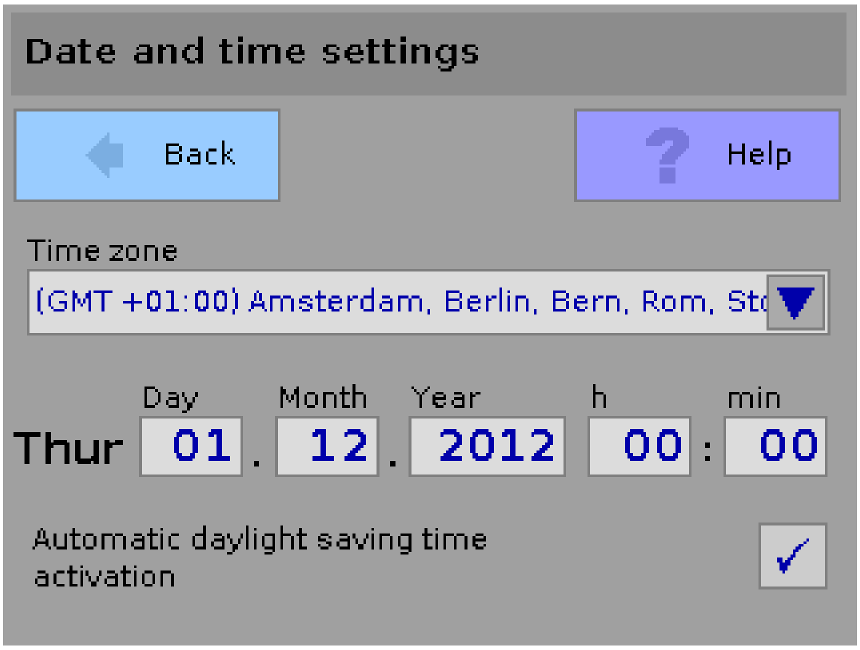


Figure 54: Configuring the system date and time

WARNING

Note the correct setting of these values.
For automatic switching between winter and summer time or for the correct recording of measuring-values the correct setting of time zone and the correct System time are essential.
→ Make sure that these values are set correctly.

6.5.1.3 Options

When invoking this menu the user can enable or disable the following device options.

Option	Description
heated line / probe connected	Enabling this Option tells the System that a heated sample gas line is connected to the device and the monitoring of its temperature is activated.
zero gas ON if not in measuring mode	If this Option is active sample gas lines are flushed reverse to the suction direction with zero gas if the flame lapses or when the device is leaving the measuring mode. This avoids contamination in measuring-mode of the device if the process is operated unattended, because no process gas is fed into the device.
heated line with double Pt 100	This Option tells the system whether a heated line with two Pt-100 sensors is connected. Only such a heated line ensures the secure function of the temperature control (see also section 4.2.1 “Gas lines ” on page 26).
start in standby-mode	If this Option is activated, the system Switches to standby mode at the end of the heating phase, which is triggered when powering SmartFID on. There is no automatic ignition of the flame.
blank value during calibration.	By enabling this Option during the adjustment, no measurement Signal Output is given on the analog Output 1. So the Signal is 0 or 4 mA during the calibration. Analog Output 2 is not affected.

Table 11: Options

WARNING

If necessary activate Option for heated line.
If you are using a heated sample gas line, its presence must be configured in the device, so that it gets heated and its temperature will be monitored.
→ Activate the Option "heated line / probe attached" before starting a measurement.

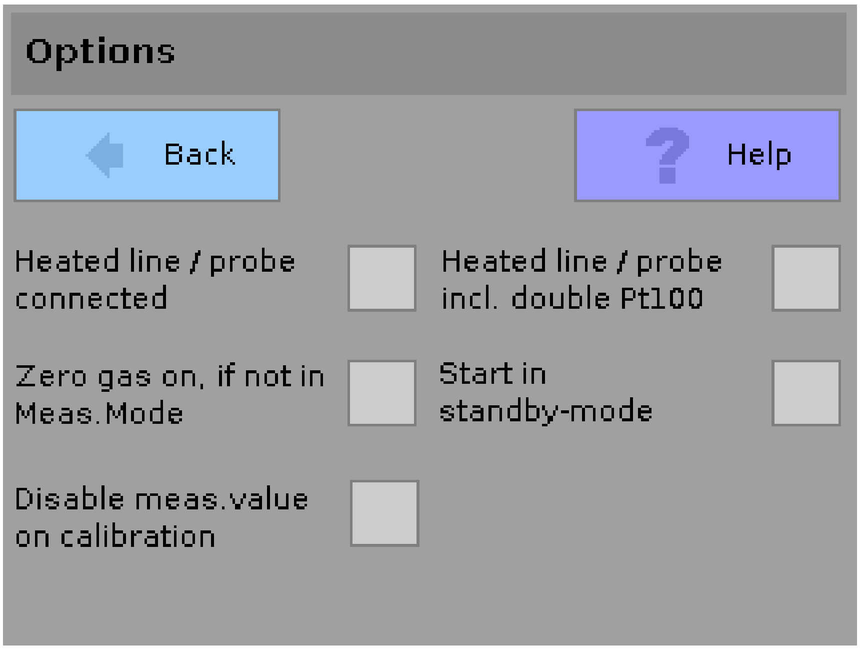


Figure 55: Configuration of device options

6.5.1.4 Inputs and Outputs

By invoking the menu inputs and Outputs the interface configuration is shown. It includes configuration options for the analog Outputs, digital Outputs, the Ethernet interface and external inputs and outputs via modbus.

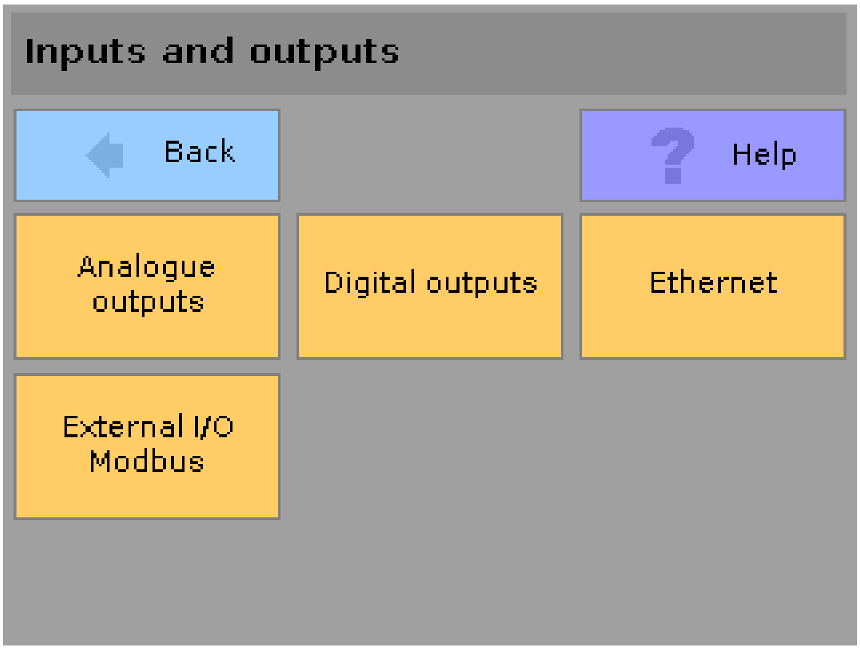


Figure 56: Menu to configure the inputs and outputs

Analog Outputs

By calling this menu the user can configure the settings concerning the two analog outputs.

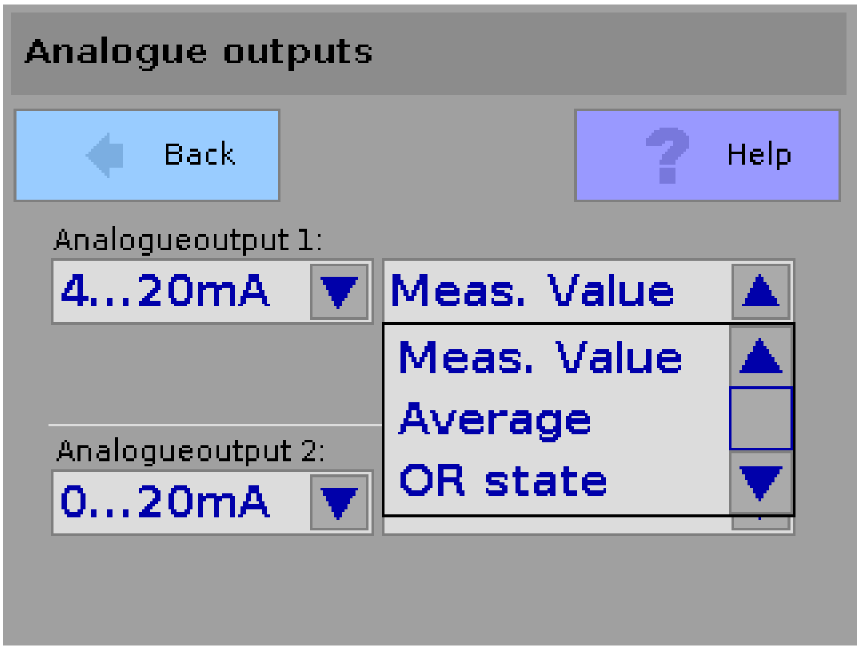


Figure 57: Configuration of analog outputs

Using the lists on the right side determines whether the analog Outputs No.1 and No.2 are designed to represent an Output range of 0 to 20 mA or 4 to 20 mA, respectively. Figure 57 shows 4 to 20 mA for the first analog Output and 0 to 20 mA for the second one.

The selection lists to the right set for each output, whether the measured value, the average (with respect to a defined interval) or the range Status is displayed.

If the Option "average" is selected, the averaging interval in seconds has to be configured. In this case a field appears below the selection lists in which an appropriate value must be entered (see Figure 58).

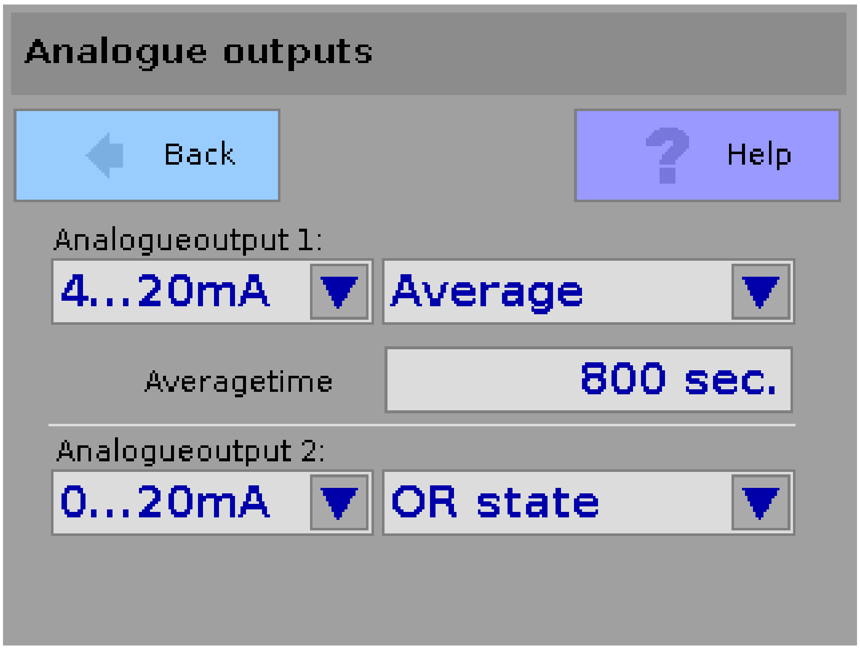


Figure 58: Configuration of the averaging period

If the Option "OR-state" is selected, then a current is sent out that equals the Output range multiplied by a factor of two. So a 500 Ohm resistor connected in parallel to the analog Output represents the current output-range in volts.

Digital Outputs

The SmartFID has three freely configurable digital Outputs (alarm contacts). The adjustments can be made in this menu. On delivery of the unit these Signal contacts are disabled. The menu shows for each Signal contact two selection lists. On the left the function or the terms of the contact is selected and on the right the operation logic can be set. The right selection list contains the entries “negative” and “positive”. Positive logic implies that the signal contact closes, if the above criterion is met. Negative logic means that the Signal contact opens when the above criterion occurs. For the exemplary configuration in Figure 59 the following possibilities result:

Criterion	Logic	Behavior
main-alert	negative	Contact is basically closed and opens if a main-alert occurs
main-alert	positive	Contact is basically open and closes if a main-alert occurs

Table 12: Behavior of the device with respect to positive and negative logic

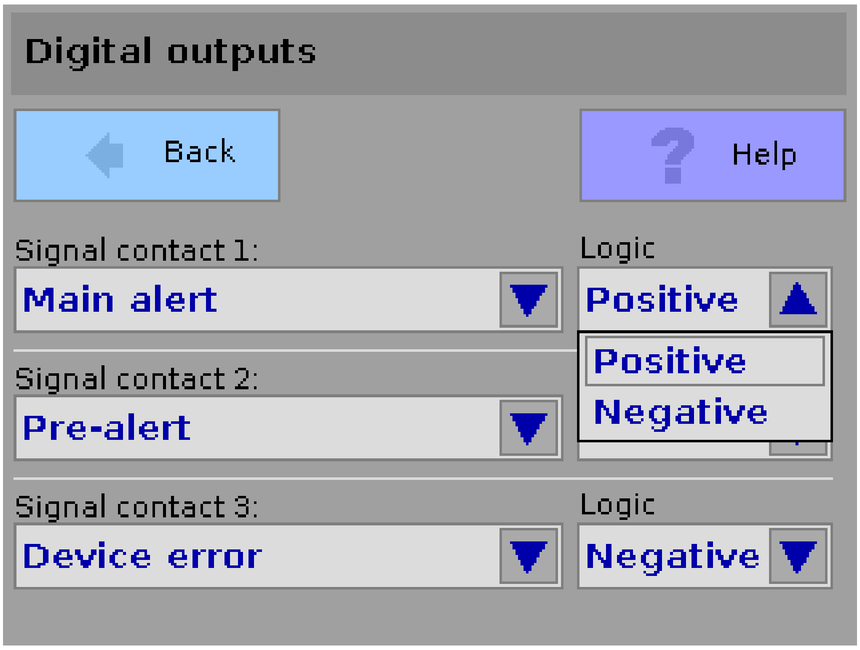


Figure 59: Configuration of the logic for digital outputs

On the left a criterion for each Signal contact can be chosen of the following selection:

- No function
  (The output remains off permanently)
- Calibration in progress
  (The output is activated if a calibration is done)
- Measuring-mode
  (The output is activated if the device is in measuring-mode)
- Maintenance requirements
  (The output is activated if the device detects a need for maintenance)
- Shortage of calibration gas
  (The output is activated if the pressure of calibration gas is too low)
- Main-alert
  (The output is activated if a main-alert occurs)
- Pre-alert
  (The output is activated if a pre-alert occurs)
- Failure
  (The output is activated if a failure on the device is detected)

Ethernet-Interface

At this point it is possible to perform the configuration of the network card in SmartFID. With its help you can operate the SmartFID remote-controlled in a network via VNC.

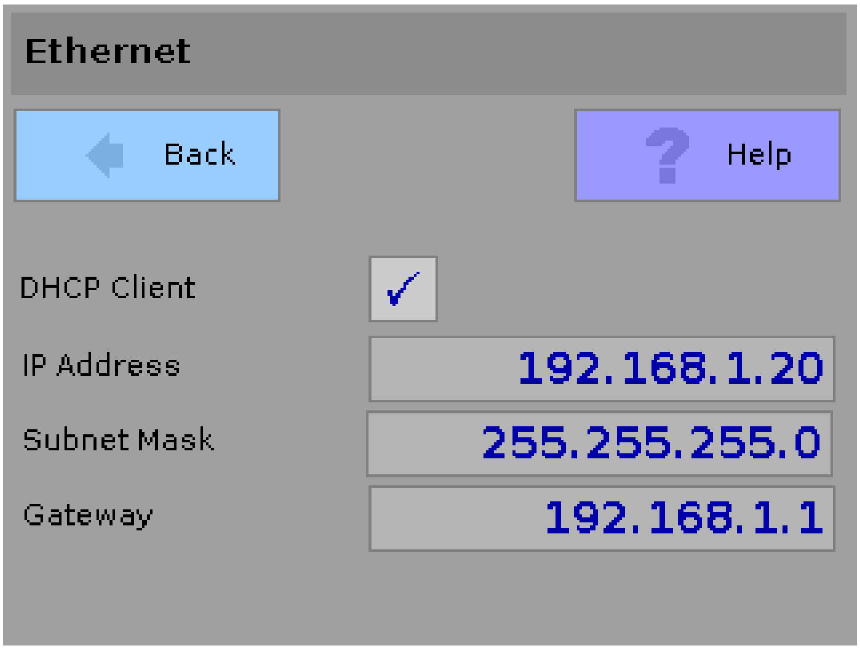


Figure 60: Configuring the Ethernet interface

By activating the field "DHCP client" the device obtains an IP-address of a DHCP Server on the network just at the moment when the user leaves this page. Information about the running process of IP assignment will be displayed. If after some time the Operation failed there will be a notice on the screen. During the allocation process by the DHCP Server no Operation of SmartFID is possible.

If the SmartFID should not assume the role of a DHCP client, the IP-configuration can be done manually. For this, valid values need to be input in the fields “IP-Address” and “Subnet Mask”. It's important in this case that the individual numbers (octets) are entered without leading zeroes (see the value “20” in Figure 60). These inputs are active after leaving the configuration page "Ethernet".

In case that a gateway is used to connect two different networks, its IP address can be set in the referring field.

<u>External inputs and outputs / modbus</u>

The modbus-module is an optional extension of SmartFID which offers various additional analog and digital inputs and outputs.

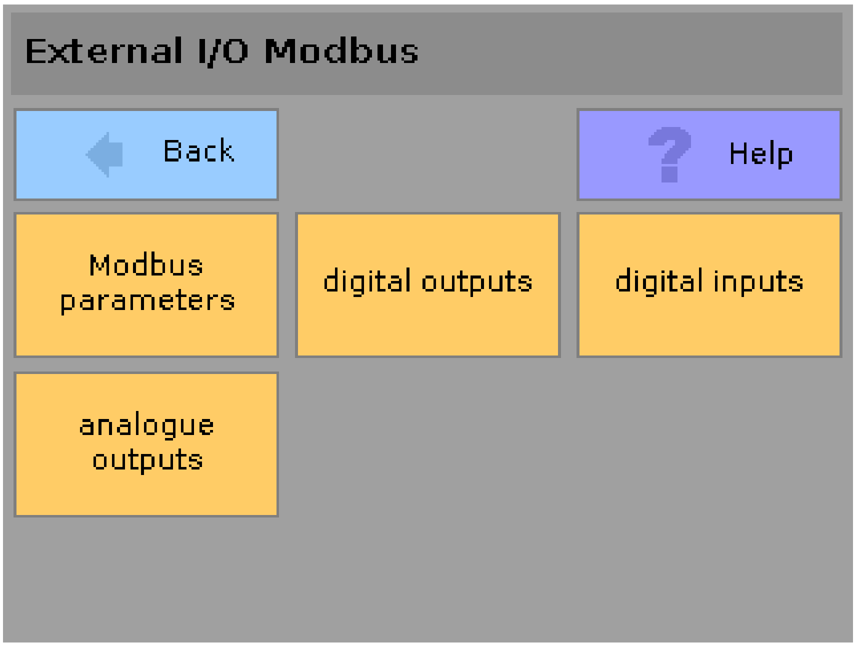


Figure 61: External modbus inputs and outputs

<u>Modbus parameters</u>

This button allows configuring the modbus parameters.

<u>Digital outputs</u>

By touching this button the settings for the digital outputs can be done. For this the user selects a digital output an associates a function and the logic (analogously to the configuration of the internal standard digital outputs - Section 6.5.1.4 “Inputs and Outputs” on page 71).

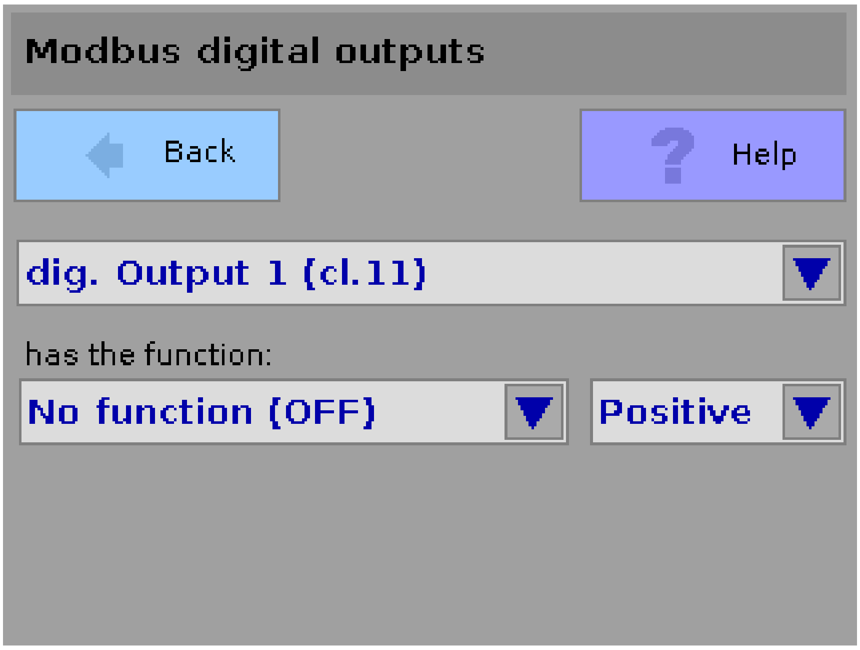


Figure 62: Configuration of digital outputs (modbus)

Digital inputs

Following the same principle the digital inputs of the modbus can be configured. The user selects a digital input a function and the logic analogously to the configuration of the internal standard digital inputs - Section 6.5.1.4 “Inputs and Outputs” on page 71). The following functions are provided to a digital input: None (“Disabled”), Reset of provoked Pre and Main-alerts (“Alert-reset”), start of a calibration or avoiding a calibration or span-test (“Start calibration” and “Calibration lock”).

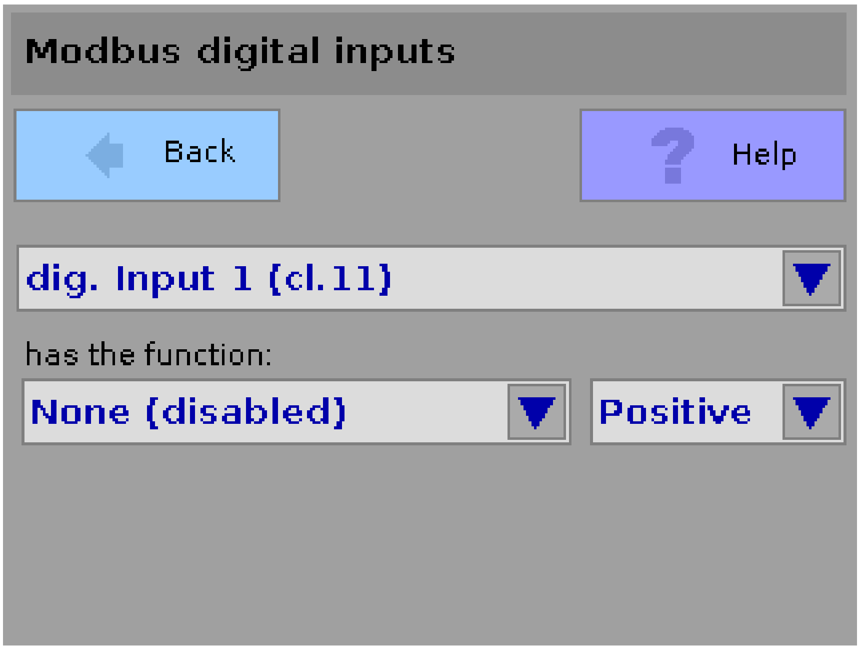


Figure 63: Configuration of digital inputs (modbus)

Analogue outputs

The configuration of the analogue outputs of modbus is the same procedure as described in section 6.5.1.4 "Inputs and Outputs" on page 71. The first list defines whether the scale starts at 0 or 4 mA. The second one defines what is given to the output. More details can be found in the referenced section.

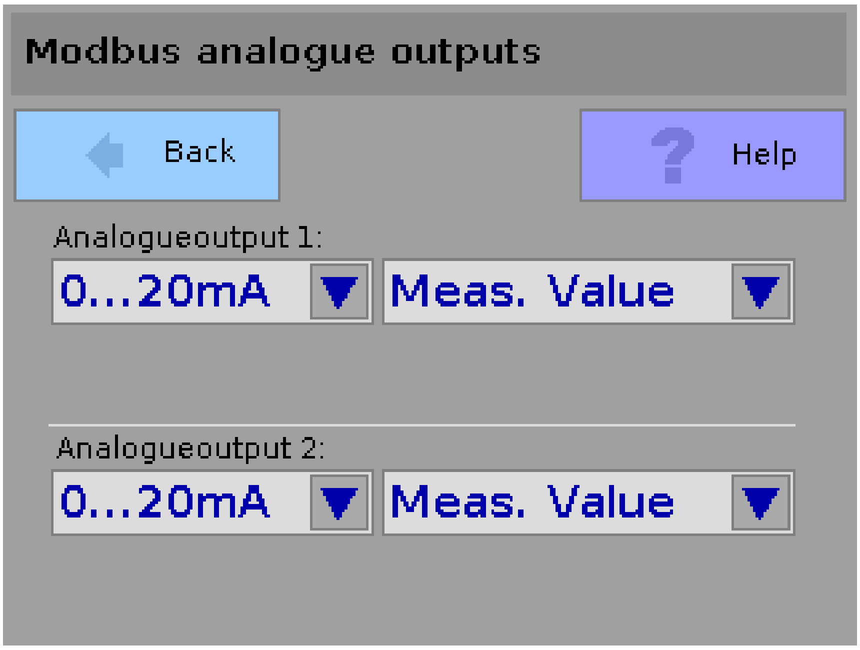


Figure 64: Configuration of analogue outputs (modbus)

6.5.1.5 Automatic calibration

With the help of automatic calibration the device performs an adjustment to be carried out automatically at defined time intervals by the user. The Option "active" has to be set to activate this function.

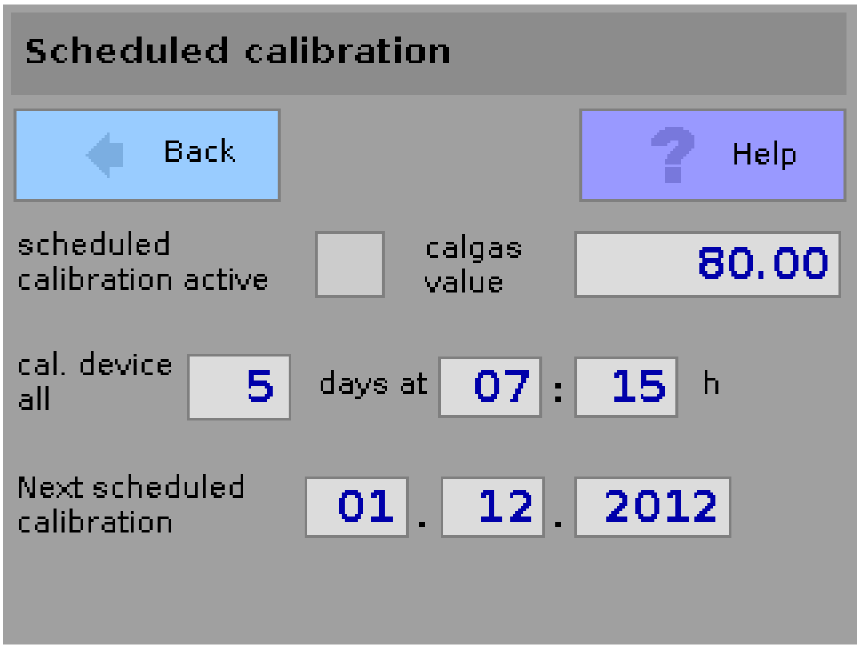


Figure 65: Configuration of the automatic calibration

To the right of the enabling-option the value of the calibration can be entered in ppm. As this value is unique in the SmartFID-system it's the same value as in section 5.3.2 "Calibrating the device" on page 38. The option is locate here for a convenient configuration. This means changing the value in this menu affects also the configuration for manual calibration.

Beyond the interval and the timestamp needs to be set after which the SmartFID needs to be re-calibrated- At (re) activation of the automatic adjustment the user has the option to specify a final date from which the defined auto-calibration parameters should be applied.

If automatic calibration is already active the field "next date for calibration" contains the system-determined date in accordance with preset rules. If the device is powered off at the end of the interval, the automatic calibration will be performed on the next start-up process namely 30 minutes after the measuring-mode has been started.

6.5.1.6 Alarm thresholds

On this page the settings for the release of the pre-and main alarm are configured.

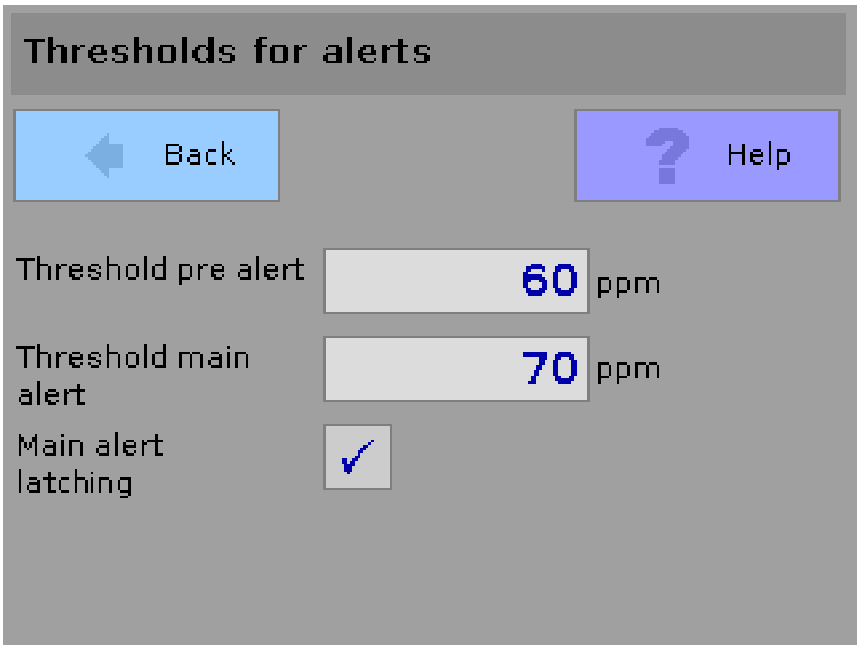


Figure 66: Configuration of alarm thresholds

In the preceding example, the alarm is triggered if the measured value exceeds 60 ppm. The main alarm is triggered if the measured value exceeds 70 ppm. The unit, in which the alarm thresholds can be defined, refers to the unit that was set for the calibration relation (See section 6.5.4.1 “Calibration ratio” on page 82).
If the Option “Main-Alert latching” is enabled a triggered alarm has to be confirmed by the user on the screen “measuring-mode” before it is turned off. In contrast, the alarm will stop if the measured value falls below the threshold, if the Option is not selected. Pre-and main alarm can be deactivated by entering alarm thresholds containing the value “0”.

6.5.2 Waiting times

In this menu the waiting times for the calibration gases and the maximum calibration time in seconds can be modified. The first value defines the time period after an automatic adjustment continues when zero gas or calibration gas is given in the analysis chamber. In the example stated below (Figure 67) the system waits 30 seconds for zero or calibration gas when performing an auto calibration. The waiting time for the check determines the length of time a check is performed from the sample menu. After the time is elapsed the System terminates the check automatically and switches back to measuring mode (see also section 5.4.2 "User actions during the measuring Operation" on page 43). In the example stated below a check ends automatically after 10 seconds.

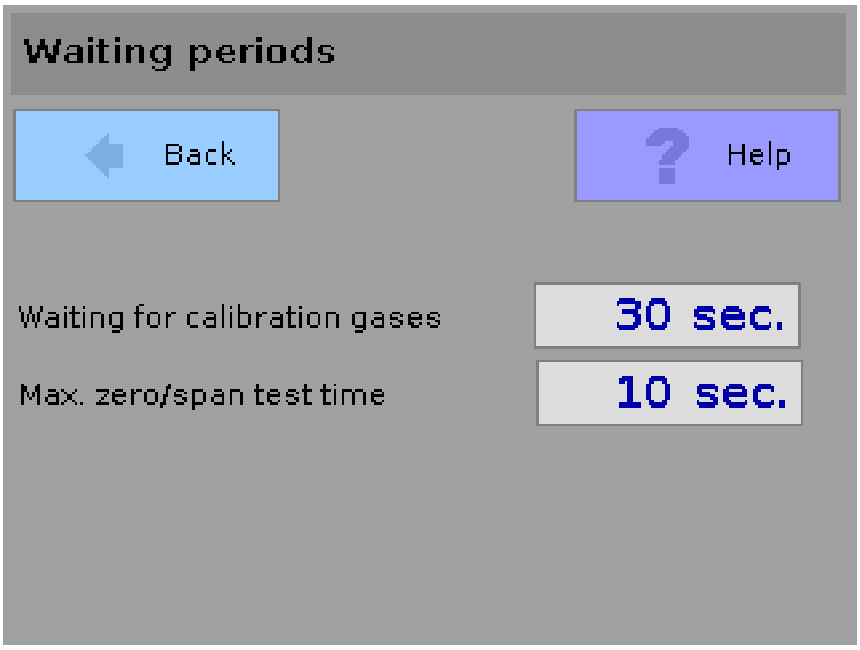


Figure 67: Configuration of waiting times

6.5.3 Display settings

Using the display settings the user may adapt the brightness of the touch panel. The value has to be in between 5 and 100.

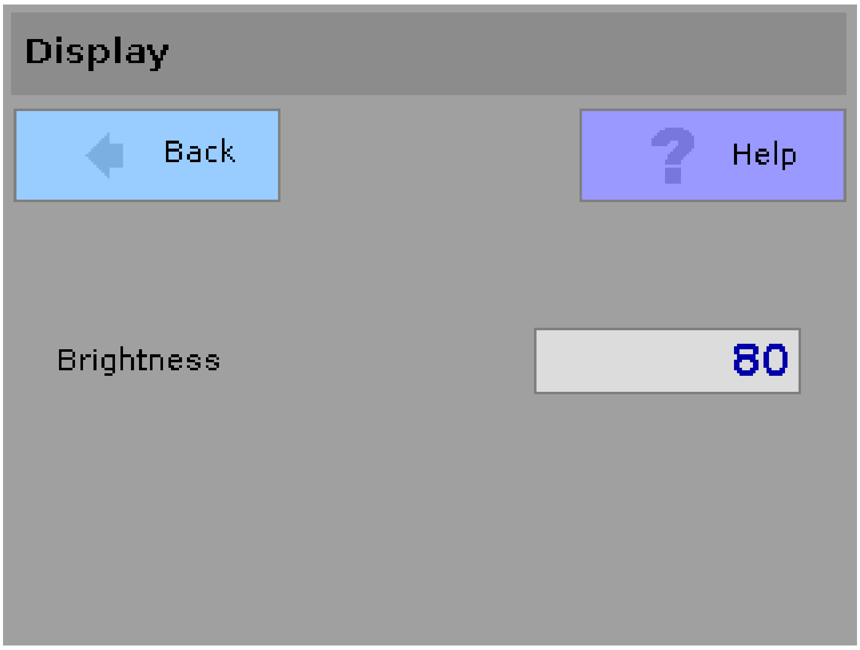


Figure 68: Display settings

6.5.4 Measuring value operations

This menu provides options to change parameters referring to operate the measured value. It contains calibration relation, measuring-range, output-ranges und the data logger.

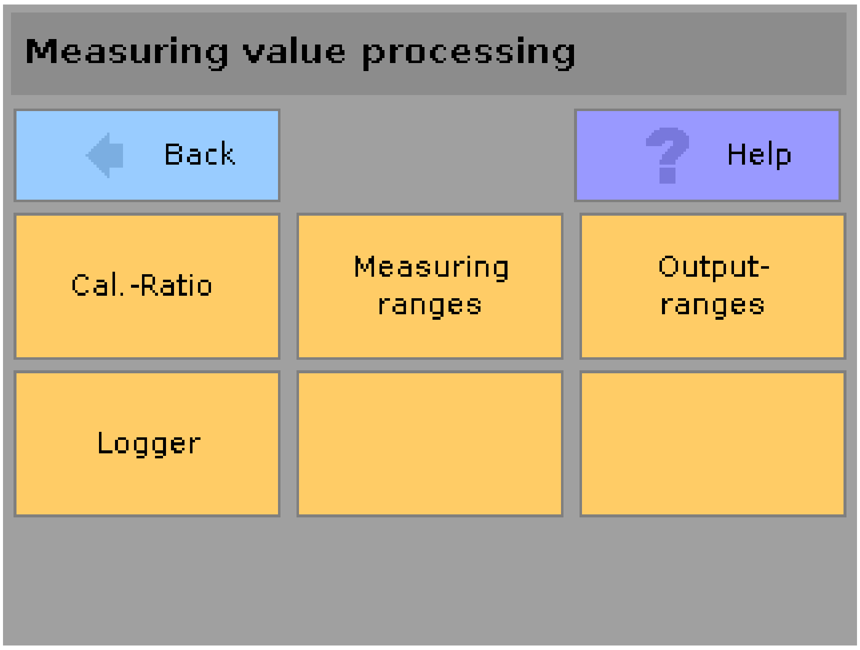


Figure 69: Measurement value processing

6.5.4.1 Calibration ratio

The calibration-ratio (R) describes the ratio of the benchmark (calibration gas) to the measured value.

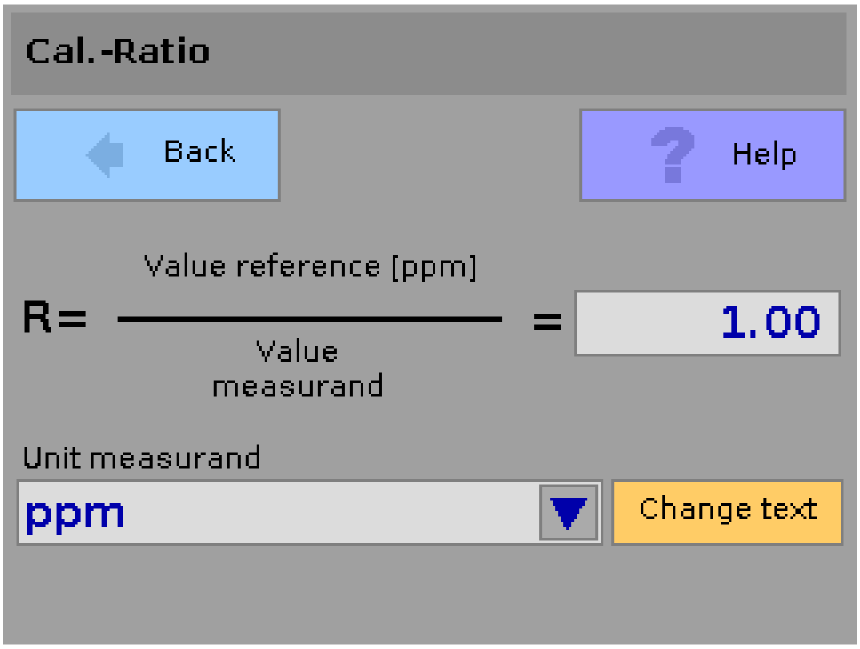


Figure 70: Indication of the calibration ratio

It provides the conversion factor for the correct unit and concentration of the measured value and is configured depending on the particular application in order to obtain reliable results; you should use the calibration relation, as otherwise only a propane equivalent concentration is measured. Relevant background information is provided in Appendix "Measuring Correct Values of Hydrocarbon Concentrations".

The list-field “Unit measurand” provides 10 entries to select a unit. Ppm und mg C/m³ are preset ex works; the other items can be configured by the user. For every unit the corresponding value R is saved separately. By touching the button “Change text” it is possible to set an individual label for the unit (e.g. “mg methane / m³”).

6.5.4.2 Measuring Range

At this point the current measuring range is set, which contains the expected measured value. The drift values of the adjustment are based on the at this point configured range. In the example below, the device is calibrated by 80 ppm. The hydrocarbon concentration of the calibration gas is defined as 80% of full scale value, so at this point 100 ppm is the end of the full scale. The expected measured value is in between 0 and 100 ppm.

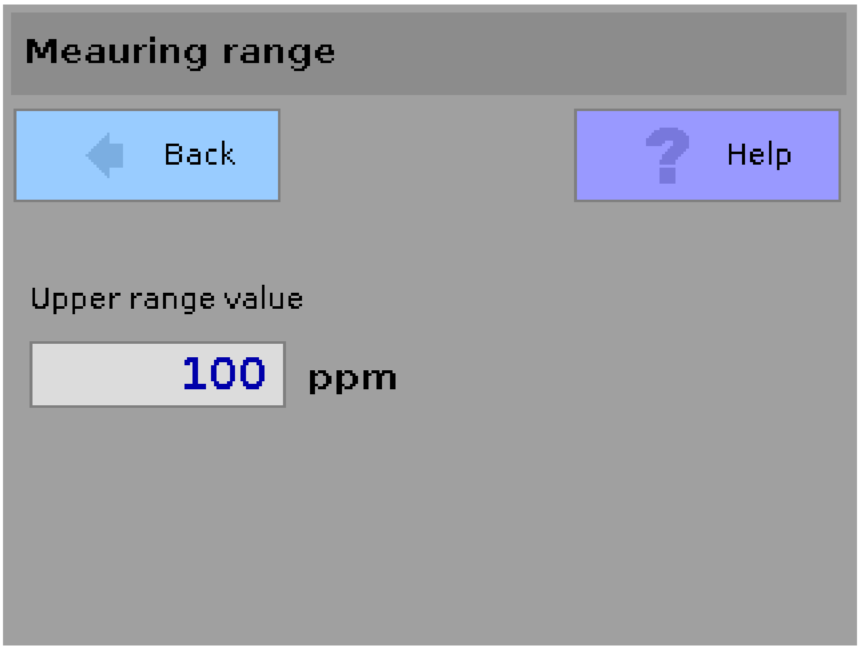


Figure 71: Upper range value

Relevant background information is provided in Appendix "Measuring Correct Values of Hydrocarbon Concentrations" (last page).

6.5.4.3 Output ranges

By setting Output ranges it's possible to determine which measurement values in the form of a current Signal of 0/4..20mA corresponds to the analog Output. When calling this menu the following settings for each of the five ranges have to be set.

- Output range (O...x ppm)
- Lower threshold
- Upper threshold

For each output range the final value has to be defined. For the following example (see Figure 72) this means 20mA analog output is equal to a measured value of 100 ppm (for the configuration of the inputs and Outputs (see section 6.5.1.4 “Inputs and Outputs” on page 71).

The set percentage for the lower threshold marks its limit. If the measured value falls below for a certain time the System switches over to the next lower output-range. This value cannot be configured for the first output area as there is no smaller output range.

Similarly the set percentage for the upper threshold marks its limit. If the measured value exceeds the threshold the system switches to the next higher output range. This value cannot be configured referring to the fifth output-area as there’s no higher one.

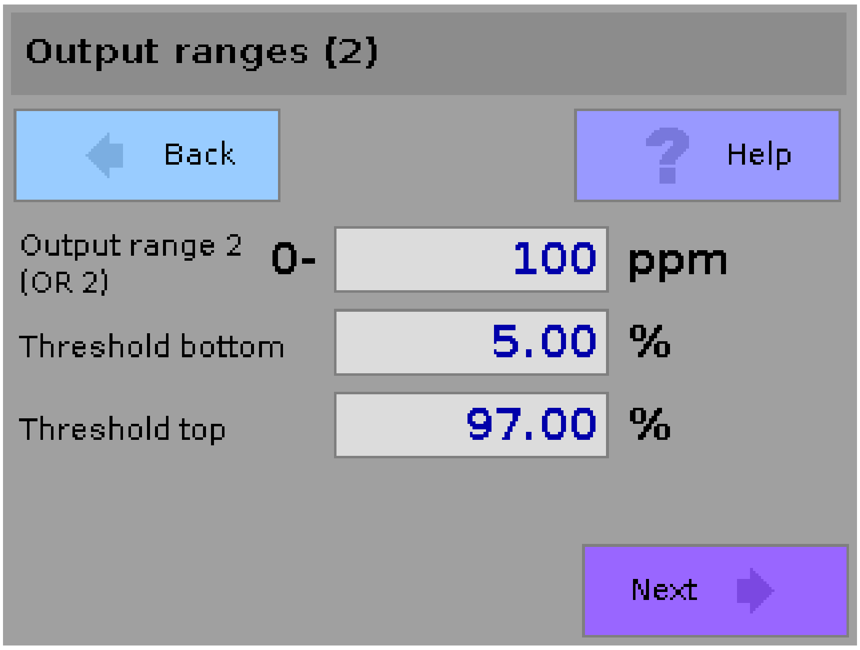


Figure 72: Configuration of an output area

After the configuration page for the fifth Output range a page titled "OR switch" follows. At this point, the behavior of the automatic Output range switching can be determined.

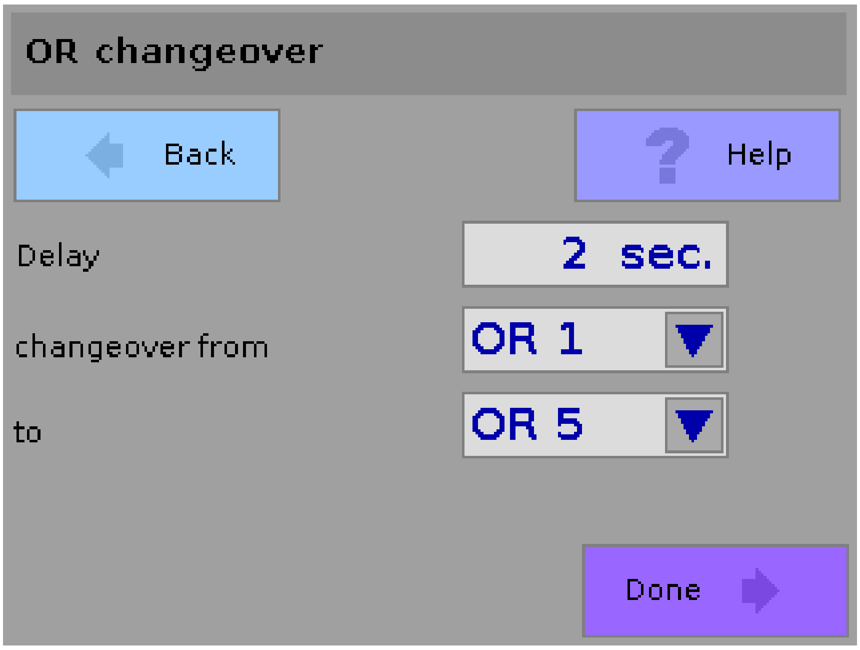


Figure 73: Behavior of auto output range switching

The delay time determines how many seconds the previously set thresholds have to be exceeded before the System Switches into the next higher or lower Output range. By selecting the appropriate Output ranges in the selection lists “switch from OR” and “to OR” it is possible to apply the function of automatic output range switching to only a subset of all available Output ranges (for example, output range three to Output range five). It should be noted here that the interval is set by a small to a larger Output range. Otherwise the user receives an error message. The following figure illustrates the possibility of navigation by the user to configure the output areas.

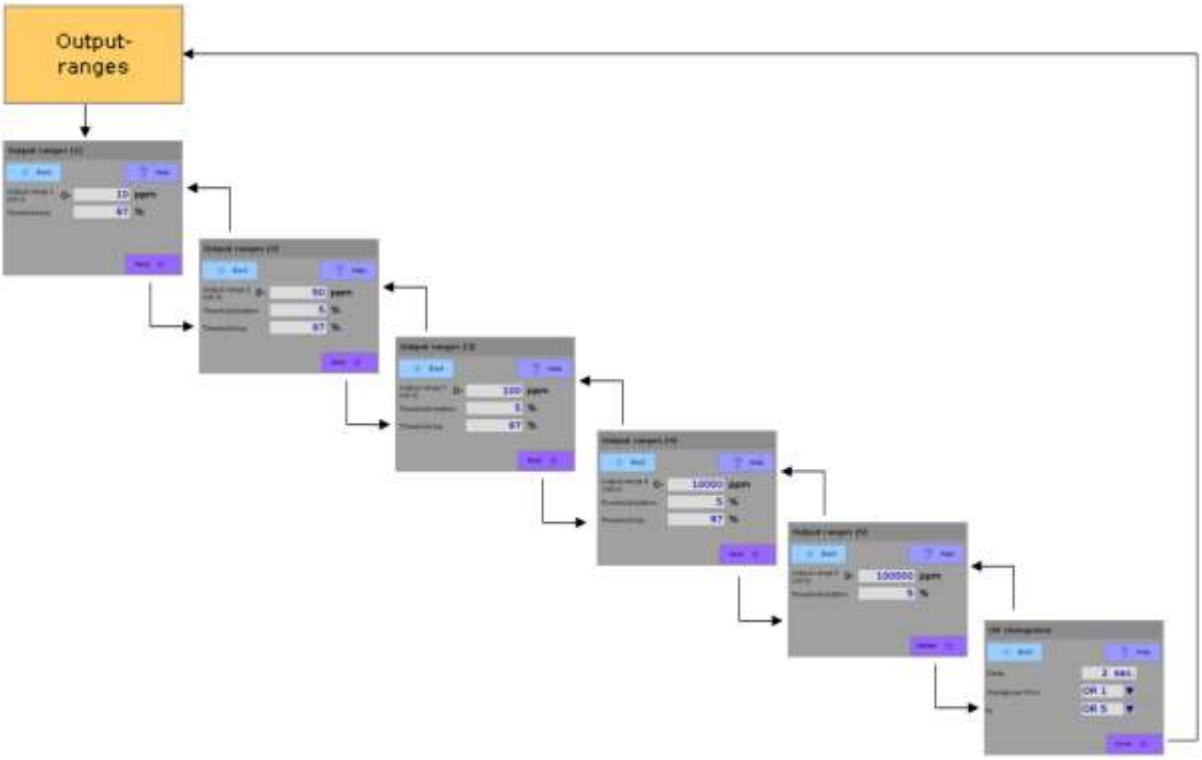


Figure 74: Navigation scheme of the output range configuration

By touching the button “output ranges” the configuration is initiated. Use the buttons “back” and “next” for navigating to each of the previous or next configuration page. In the end the general configuration of output range switching is done. On that page the button “Done” leads the user to the menu “measuring value processing”.

6.5.4.4 Data-logger

Logging is the process of recording measuring values. The SmartFID has a built-in ring memory, in which the measured values of the Instrument may be recorded. If this memory is full, the System Starts to overwrite the old values). This menu is used to configure recording and perform a transfer of measurement data. In the following section the single buttons of this menu are explained:

<u>Logger Start</u>

If the logger is ready this button is green. If the user touches it in that state the logger is started. If it's started successfully the button is disabled (it is colored grey then and the stop-button is colored red). At any time a red dot in the upper right area of the System gives the user information that the measurement recording is active (see Figure 76). This symbol is no longer shown if the recording was terminated. Figure 75 shows the Logger menu in the condition described. Alternatively the logger can be started from the measuring-screen (see section 5.4.2 "User actions during the measuring Operation" on page 43).

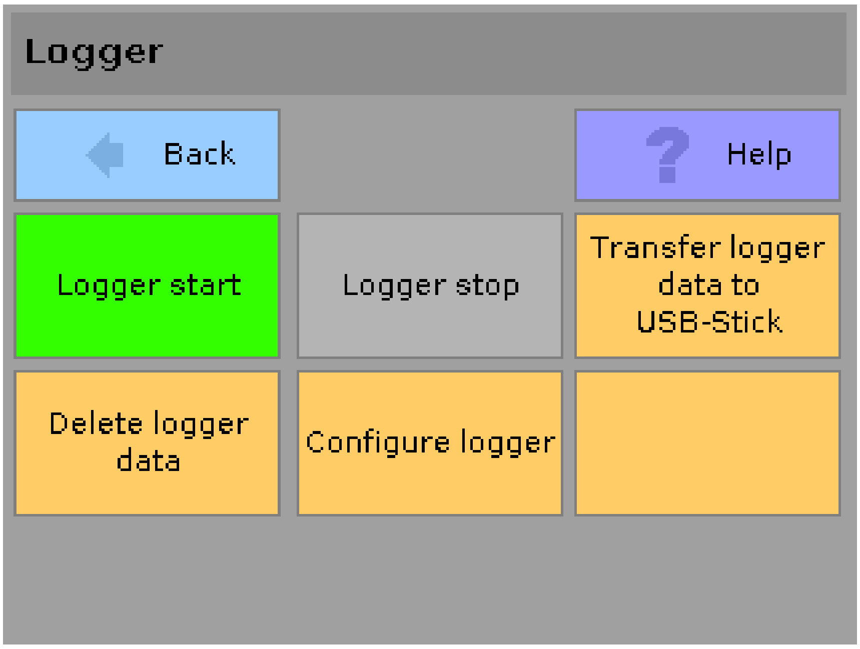


Figure 75: Data logger ready to record

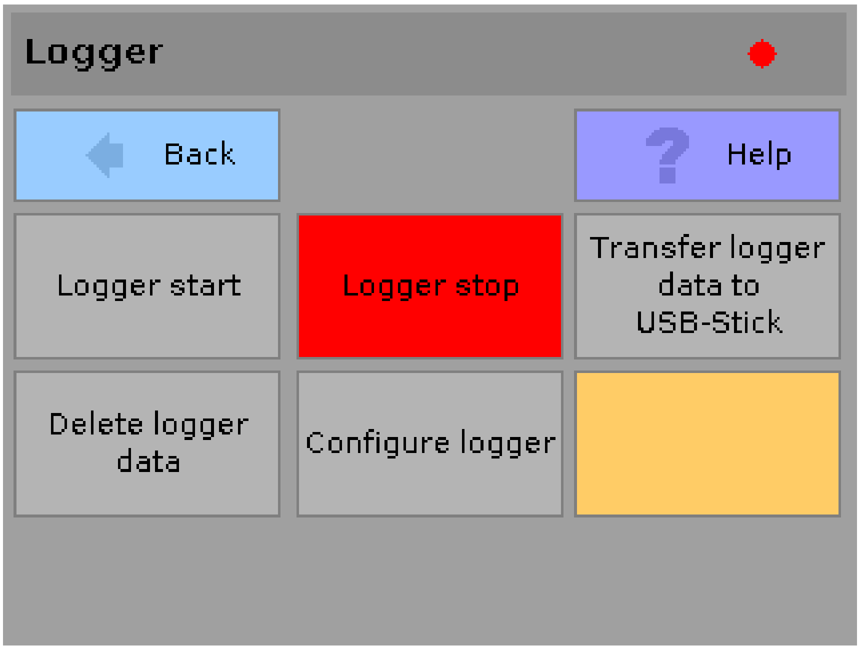


Figure 76: Logger menu during recording process

Logger Stop

If the measurement recording is not active, this button is disabled (it is grayed out). If the data logger is active it is highlighted in red and will terminate the process of recording the values when it's touched by the user (See Figure 75 versus Figure 76). The data logging can also be terminated from the measuring-screen (see section 5.4.2 “User actions during the measuring Operation” on page 43).

Transfer logger data to USB-device

This Option allows the user to save the recorded data to a USB disk. It is important to make sure that a USB-disk is inserted into the USB port of the device (See Figure 4 side wall of the device on page 16) *before* the button is touched. Otherwise the System displays an error message.

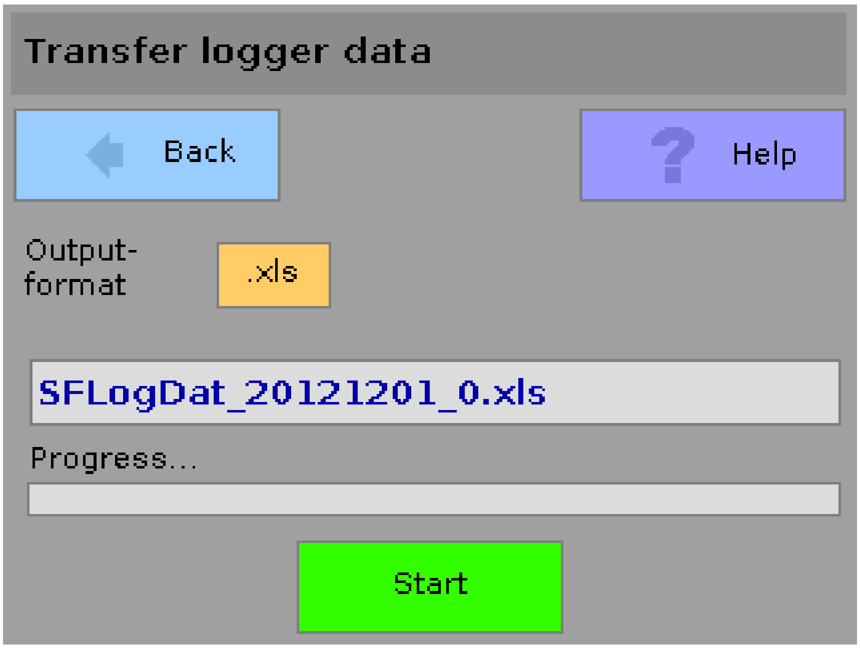


Figure 77: Preparing export of the recorded measured values

The following screen shows a file name which is proposed by the System. It consists of the current date and a suffix for the number of the exports carried out that day. The output format is selectable between MS-Excel (.xls) and text-data (.csv). If .csv is chosen it’s possible to define the value-separator (comma, semicolon, tabulator or blank). The device stores these decisions and uses them as default when a new export is triggered. So it’s not necessary to do this settings again.

The following figure shows the settings for an export of logger data in .csv-format with the tabulator for value separation.

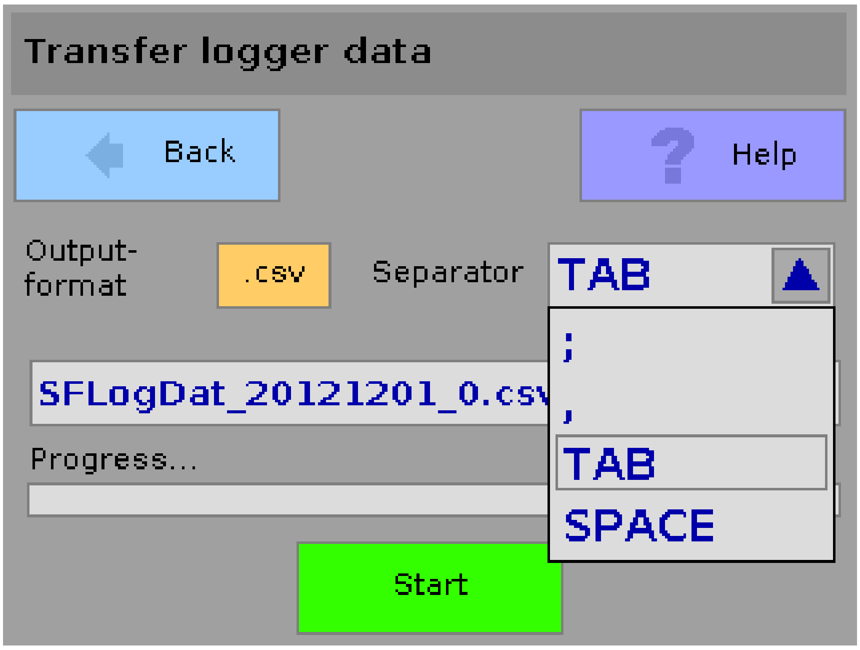


Figure 78: Export of logger-data in .csv-format

The user can assign a different file name by touching the field that contains the suggested file name. The file extension of the right destination format (".xls" or ".csv") is added automatically if it was not given by the user (according to the selected format).
Finally the export is triggered by touching the button „"start". A progress bar informs the user about the current export-state. When the file is written a message appears which has to be acknowledged by the user.

WARNING

Do not remove the USB-device during export process To avoid damages on your USB-device it should not be removed during the writing-process. → Only remove the device if the systems menu "Transfer logger data to usb stick" is *not* opened or if the device is switched off!

Delete logger data

The call of this menu item deletes the stored measuring values in SmartFID. The System displays a security question that needs to be confirmed by the user before deleting the values (see Figure 79). After a positive acknowledgement the recorded data will be erased from memory. Once deleted a hint about the successful removal of the data is shown which has to be confirmed by the user as well.

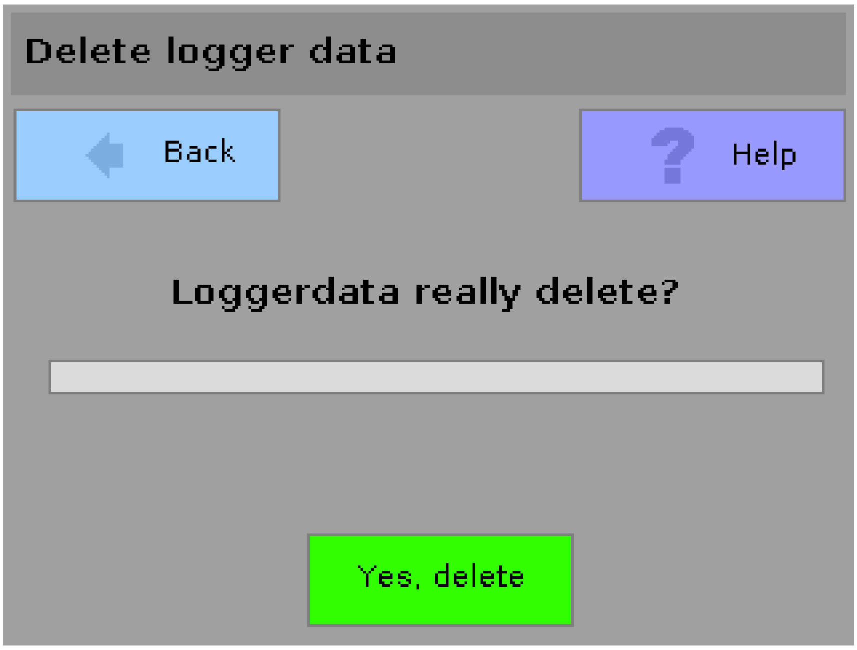


Figure 79: Delete the recorded values

Logger configuration

In this menu, the parameters of the data logger can be determined.

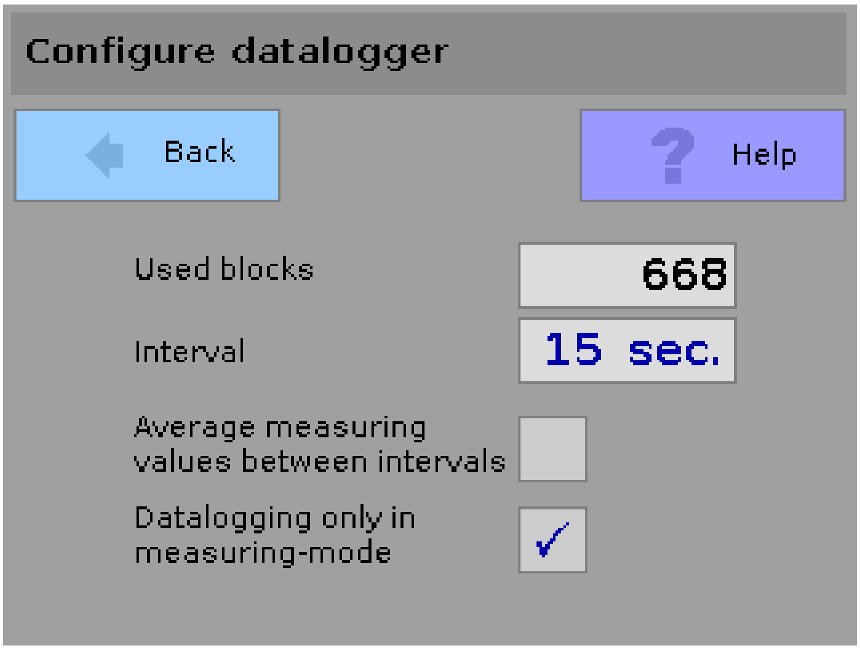


Figure 80: Configuration of the measurement recording

The value in the field "used blocks" is used as indicator to the user how many values are currently recorded. This value is reset to zero when the logger data is erased. Below the recording interval is defined. In the example in Figure 80 it is set to 15 seconds. This means that the System picks up the measured value every 15 seconds and saves it. By touching this button the user can define the interval in steps of one seconds between 1 and 60.

If the underlying Option "Average measuring values between intervals" is activated the value is taken every second during the interval and arithmetical averaged when the interval is over and then saved. That leads to the situation that this option is not available if the interval is set to 1 second.
The last Option on the page "log only in measurement mode" ensures that no values are stored if the device is in another mode than "measuring" (such as "standby" or "failure").

7 Taking device out of service

The following describes how the device is turned off correctly, what has to be considered for the transport, how the SmartFID is stored correctly and if necessary disposed properly.

7.1 Turning off the device

→ To turn off the device perform the following Steps:

1. Disconnect the sample gas line.
2. If you activated the Option "zero gas on when the device is not in measurement mode" (see section 6.5.1.3 "Options" on page 70), turn the device into standby mode. Otherwise, you should turn manually zero gas on in measurement mode to flush the gas-ways.
3. Wait 5 minutes.
   The gas channels are flushed. This prevents condensation.
4. Turn the power switch to position "0"
5. Turn the supply of fuel gas and calibration gas off. Close the bottles carefully. The couplings are no shutoff devices.
6. Remove all electrical connections.

Ready to continue...

✓ **The device is turned off now.**

7.2 Transport

Follow these Steps if you don't use the device or if you want to move it to another measuring point.

<u>Prerequisites:</u>

☑ The device is turned off.

☑ The supply of all gases is disabled.

<u>Requirements:</u>

☑ Suitable stoppers to seal the pneumatic connections

☑ Suitable stoppers to seal the gas ways

→ Perform the following Steps:

1. Remove all electrical connections
2. Seal all pneumatic connectors at the sidewall with stoppers.
3. Close the protection dampers of the electrical connectors at the sidewall
4. Close the Cover of the device and lock it if necessary.

Ready to continue...

Danger of burning due to hot gas ways!
During operation, sample gas line and exhaust will be very hot.
→ Before disconnecting the gas lines let them cool down sufficiently.
→ Wear gloves.

✓ **The device is ready for transport. You can store the unit or transport it to another site.**

7.3 Storage

If you do not use the device for long periods of time, you can store it under the following conditions:

- Put the device on a suitable base and align it carefully horizontally and plane.
- Take care of a well-ventilated storage area with low humidity.
- Avoid temperatures below +4 °C and above 30 °C. Also avoid fluctuations of temperature.

7.4 Disposal

At the end of its life cycle you should dispose the device in an environmentally safe manner and in accordance with local regulations.

For the environmentally correct disposal, the following principles must be applied:

- Metal parts have to be disposed of as sorted scrap metal.
- Plastic materials have to be disposed of as sorted types.
- Cables and electronic components have to be disposed of as electronic waste.

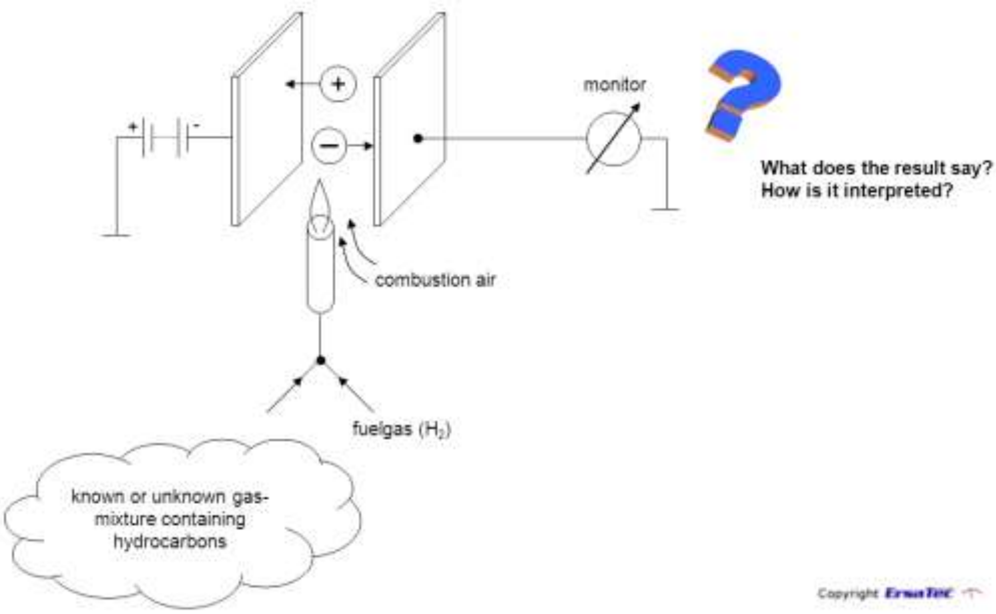
HINT

ErsaTec disposes your device on your request. You can send it to us. Our Address can be found on page 2.

Measuring Hydrocarbon Concentrations Correctly

When measuring gases using hydrocarbon-Analyzers, here flame-ionization-detectors (FID), often measured variables are required (e.g., mg C or mg substance), which do not correlate with the calibration-gas.[4]

This problem affects the majority of use cases, because of the large number of possible chemical compounds containing carbon and being measured with a FID, only a few gases are suitable to be used for the calibration of the device. The reason for this can be found in their physical or chemical properties.
This document is intended to provide background knowledge in order to achieve reliable results.



Sketch of the Interpretation problem

Generally, the FID detects the carbon contents in chemical compounds. During the combustion of these compounds in a hydrogen flame, carbon contributes significantly to the ionization of parts of the combustion intermediates.
These ionized products are electrically charged particles and produce a measurable current in an electrical field.

This low current is displayed on the monitor after having been amplified and it is proportional to the detector supplied mass flow of carbon. Hence, the current is a measure of the carbon concentration in the measured gas.

[4] The calibration means an intervention in the configuration of the FID to define a zero point and an endpoint.

Imagine you feed to the FID a single molecule of methane (CH_4). Then the resulting measurement value can be defined as 1. The signal of the detector corresponds to one carbon atom of the molecule.

If you feed to the FID one single propane molecule (C_3H_8) the FID provides almost exactly three times the previous reading due to the basis of the 3 carbon atoms. So the signal can be read as meaning that 3 carbon atoms were fed to the detector.

Methane and propane consist exclusively of carbon and hydrogen and so they belong to the group of hydrocarbons. Regardless of their chemical structure hydrocarbons have the property that, when measuring the carbon concentration they demonstrate the same sensitivity within narrow limits on the FID. This means (to express it vividly) that it is quite irrelevant, in which way the carbon is "wrapped".

The *relative sensitivity* is described as response and the value of a certain compound in relation to the value of a selected Standard compound (gas for calibration) is the response factor.

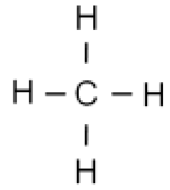
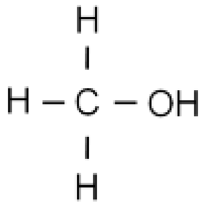
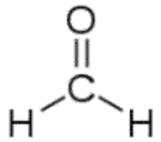
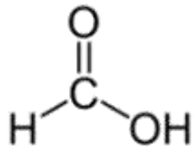
Often propane is selected as the default compound which results in the response factor of propane being 1.00. The response factor for methane then results in a value of 1.05.[5]

Remark:
Many compounds that can be measured with a FID are modified hydrocarbons by added oxygen. This set contains for example alcohols, aldehydes, ketones, fatty acids and esters.

The response factors of these compounds are always lower than those of hydrocarbons and need to be determined experimentally in general in order to achieve sufficient accuracy in measurements.

This fact is understandable when one considers the addition of oxygen to a hydrocarbon as a partial combustion, which has already taken place outside the detector. Because of this fact the production of ionized particles in the flame is reduced.
The combustion is then different (disadvantageous for the measurement). The following table shows an example of how the response factor decreases with increasing oxidation of methane to carbon dioxide.[6]

[5] There are other than the carbon mass-based definitions of the response factor. This is not considered here because of the clarity.
[6] So far, there are inconsistent determinations of the response factor of formaldehyde, which is due to the specific chemical properties of this compound.

Molecule	Substance	Signal / Response factor	Oxidation Level
	Methane	1	low
	Methanol	ca. 0,6	↓
	Formaldehyde	(0 to 0,3)	↓
	Formic acid	ca. 0,08	↓
	Carbon dioxide (CO_2)	0	high

Example of increasing stages of oxidation

As already indicated for calibrating a FID a mixture of propane and synthetic air or nitrogen is used as a calibration gas. The indication of the concentration is generally done in "ppm", e.g. 80 ppm propane in synthetic air.
Behind this claim lies a volume concentration, indicating that there are on average 80 molecules of propane among 1.000.000 (=10^6) molecules of the gas (parts per million). So, the concentration value is the ratio (quotient) of the number of molecules considered in relation to the total amount:

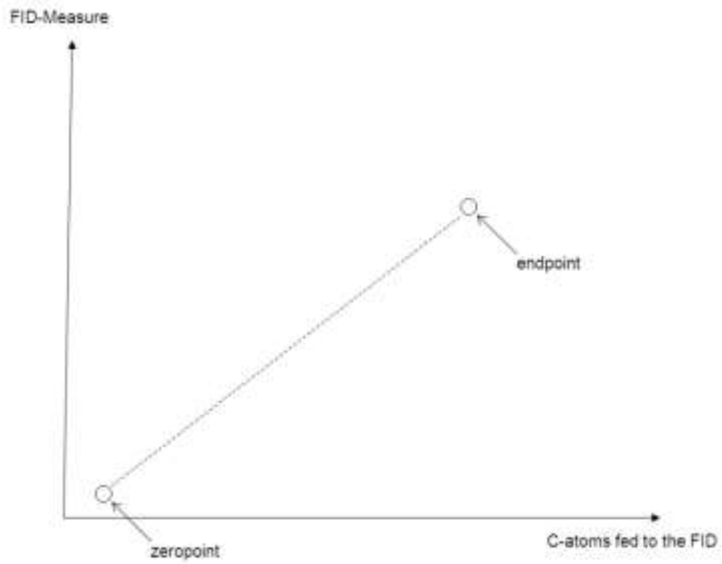
$$\frac{80}{1.000.000} = \frac{80}{10^6} = 80 \cdot 10^{-6} = 80 \text{ ppm}$$[7]

[7] Ppm is only another name for the number 1 /1.000.000, as well as % describes the number 1/100.

For setting a scale to the FID two points are needed. The first sets the zero point of the scale. Hence, a gas is required which does not contain carbon in some form. This gas is called the zero gas. It is the gas with the concentration of zero.

The lower the concentration to be measured, the more crucial for the accuracy of the measurement is that the zero gas meets that condition. I.e. ambient air is in general not suitable as zero gas.

In conventional FID, the user has to wait after feeding zero gas in the calibration process for the idle state of the meter and adjust it then by turning a corresponding adjustment knob. After that the endpoint is determined by the same pattern. Calibration gas is fed and the meter is adjusted to the value of the calibration gas. The EnviFID 900 is the only device of ErsaTec which has to be calibrated manually. In case of SmartFID and SmartFID ST this process is (partially) automated.



Setting of zero point and end point

If the concentration of the calibration gas is given in ppm the FID has a scale in ppm after calibration. More precisely: in ppm propane equivalent (ppm Peq). If for example a sample is supplied to the FID and the scale shows the value “40 ppm”, then one can say that the sample gas in the FID behaves like 40 ppm propane. That's why it is called propaneequivalent. However the measuring of concentrations of propane is the task of very few applications.

To obtain the concentration value of the measured gas (or gas mixture) a conversion is necessary. To perform this it is necessary to know on the one hand the composition of the measuring gas and on the other hand (according to the desired measure) facts about various parameters. These are, for example, the number of carbon atoms (n_c) the response factor (r_c), the molecular weight (m) or the lower explosive limit. With the simultaneous presence of several components the corresponding averages are used.

There might be tasks in which a conversion is not possible and the user must be content with the declaration of equivalent concentration.

Next you'll find some conversion equations which are explained by examples:

Example 1:
The zero point of a measuring instrument is calibrated with ambient air and the end point with 80 ppm propane. The received values define zero and end point. The area in between these points (range) is linear.
Supplying an unknown gas mixture to the FID, which provides a measure of half of the range one can make the following Statement: 40 ppm *propane equivalent* (symbol: c_{VPe}) are measured. Without more information regarding the sample one can make no more precise conclusions on the reading!

A first possibility to make a more precise Statement is a conversion from “ppm propane equivalent” to the concentration “ppm substance”. This requires the user to know the number of carbon atoms in the molecule and the carbon-related response factor of the substance to be measured with respect to detector and the known calibration substance (in this case propane). To convert the measuring value the following equation (Equation 1)
is applicable.

Equation 1:

$$c_V = c_{VPe} \cdot \frac{3}{n_C \cdot r_C}$$

n_C Number of C-Atoms in the molecule

r_C response factor related to carbon

(3 is the number of C-Atoms in Propane)

The small letter “c” symbolizes the relative concentrations where **cv** is the volume concentration of the measured substance and **c_{VPe}** describes the volume concentration (propane equivalent) displayed by the FID.

<u>Example 2:</u>
Acetone is measured with a FID which was calibrated with 80 ppm of propane. The meter displays a value of 70 ppm. This means that measuring gas behaves as if 70 ppm of propane are measured which does not correspond to the acetone concentration. To find this out equation 1 is applicable with the following values:

n_C = 3 → 3 C-Atoms in an acetone-molecule
r_C = 0,7 → response factor of acetone

$$c_v = 70\ \text{ppm} \cdot \frac{3}{3 \cdot 0{,}7} = \frac{70\ \text{ppm}}{0{,}7} = \underline{\underline{100\ \text{ppm}}}$$

That means the measured value of 70 ppm propane equivalent corresponds to 100 ppm acetone.

If the sample gas is composed of various hydrocarbons and the mixing ratio does not change they may be included pro rata in the equation (e.g., A [20%], B [10%] and C [70%], relative volume):

$$c_v = c_{VPe} \cdot \frac{3}{0{,}2 \cdot (n_{cA} \cdot r_{cA}) + 0{,}1 \cdot (n_{cB} \cdot r_{cB}) + 0{,}7 \cdot (n_{cC} \cdot r_{cC})}$$

In a further step it's possible to convert the volume concentration of the substance to the concentration of the substance within a Standard cubic meter. Such a Standard cubic meters describes a gas volume of one cubic meter under specified conditions.

These conditions are:

- The pressure (p_0) is 101,325 kPa (=atmospheric - 1013,25 mbar)
- The absolute temperature (T_0) is 273,15 K -> 0° Celsius

To calculate the concentration relative to a Standard cubic meter (c_m) the value of the molar mass of the substance in grams per mole [g/mol] and the molar volume in liters per mole [l/mol] are required. Last mentioned value is constant under the described Standard conditions and is 22.41 l/mol.

The corresponding equation is:

Equation 2:

$$c_m = c_V \cdot \frac{M}{V_{mol}}$$

Results for the example 2:

M = 58,08 g/mol
V_{mol} = 22,41 l/mol (under standard-conditions) = constant.

$$c_m = 100 \cdot \frac{58{,}08}{22{,}41} = 259{,}17 \text{ mg/ } m^3_N \text{ acetone}$$

The equation number 1 and 2 can be summarized in an equation 3 to convert the propane equivalent directly to the concentration substance per Standard cubic meter. Performing this step leads to the following equation:

Equation 3

$$c_m = c_{VPE} \cdot \frac{3\ M}{n_c \cdot r_c\ V_{mol}}$$

For completeness, the measured value of 70 ppm propane equivalent acetone is applied in Equation 3:

$$c_m = 70 \cdot \frac{3 \cdot 58{,}08}{3 \cdot 0{,}7 \cdot 22{,}41} = 259{,}17 \text{ mg/ } m^3_N \text{ acetone}$$

The result shows that the combined equation delivers the same result as applying equation 1 and 2 successively.

It is often less interesting how many milligrams of a substance the sample gas contains, than the question how many milligrams of carbon in a Standard cubic meter of gas is present.

To convert one can start again with equation 3:

$$c_m = c_{VPE} \cdot \frac{3 \cdot M}{n_c \cdot r_c\, V_{mol}}$$

For the conversion the following values are used:

M = 12,011 (This value is the molar mass of carbon)

n_C = 1 (because the conversion relates to 1 C-atom)

This results in:

$$c_m = c_{VPE} \cdot \frac{3 \cdot 12{,}011}{1 \cdot r_c \cdot 22{,}41} = c_{VPE} \cdot \frac{1{,}608}{r_c}$$

Calculating the specified values the equation for the direct conversion is:

Equation 4:

$$C_C = c_{VPE} \cdot \frac{1{,}608}{r_c}$$

It is important to know that the value of 1,608 is not a universal constant. It results from the calibration of the instrument with propane.

For the previously calculated example 2 one finds at this point:

$$C_C = 70 \cdot \frac{1{,}608}{0{,}7} = 160{,}8 \text{ mgC} / m^3_N$$

If the value in mgC is already known it can be converted to mg/m^3_N with the following equation:

Equation 5:

$$C_m = c_C \cdot \frac{1}{\mu_C}$$

In this case uC is the relative proportion of the mass of carbon in the total mass.
It is formed as follows:

$$\mu_C = \frac{n_C \cdot M_C}{M}$$

Used in the original equation gives:

$$c_m = c_C \cdot \frac{M}{n_C \cdot M_C}$$

To verify example 2 reveals the following μ_C:

$$\mu_C = \frac{3 \cdot 12{,}011}{58{,}08} = 0{,}620$$

M_C = 12,011 g/mol → molecular mass of carbon
M = 58,08 g/mol → molecular weight of acetone

The calculation of the amount of acetone mg/m^3_N results using the first equation with the calculated value of μ_C:

$$C_m = 160{,}8 \cdot \frac{1}{0{,}620} = 259\ mg/m^3_N \text{ acetone}$$

Zur Kontrolle noch einmal die Berechnung mit der Zusammengesetzten Gleichung:

$$c_m = 160{,}8 \cdot \frac{58{,}08}{3 \cdot 12{,}011} = 259\ mg/m^3_N \text{ acetone}$$

Both ways of calculation of substance in mg/m^3_N compound lead to the same result.

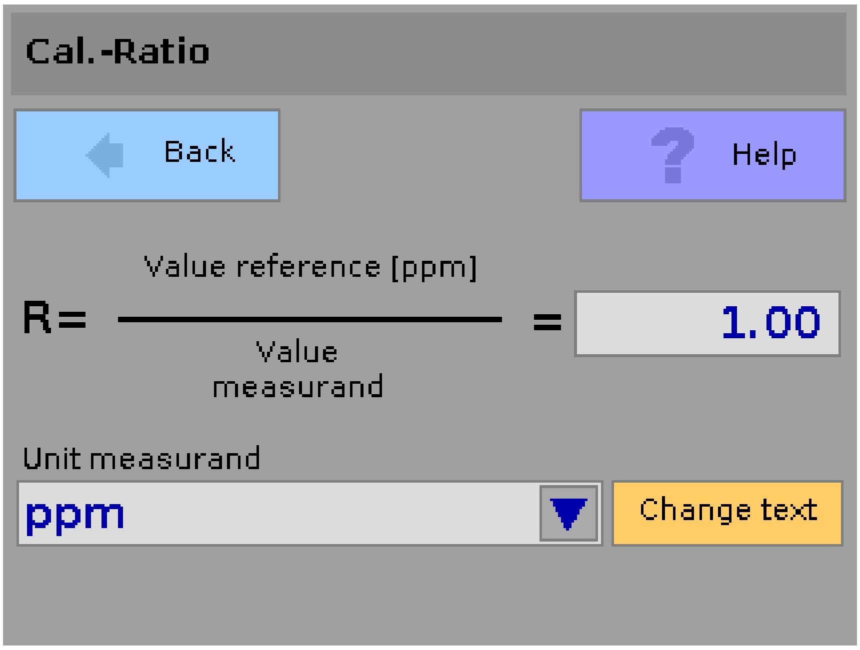
<u>Example 3:</u>
A sample gas is given with an unknown concentration of the substance toluene. The molecular weight of toluene is 92,14 g/mol.
The number of carbon atoms is 7.
The response factor is 0,97.
On the FID 147 ppm propane equivalent are shown.

According to equation 3 the mass of toluene per Standard cubic meter has to be calculated as follows:

$$c_m = c_{VPe} \cdot \frac{3 \cdot M}{n_c \cdot r_c \; V_{mol}}$$

$$c_m = 147 \cdot \frac{3 \cdot 92{,}14}{7 \cdot 0{,}97 \cdot 22{,}41} = 147 \cdot 1{,}8166 = 267 \text{ mg/ } m^3_N \text{ toluene}$$

Using these equations, the value of the SmartFID caübration ratio can be determined. Using the calibration ratio the System is given the information how the measuring gas in its unit correlates to the propane equivalent measured by the FID.



Setting the calibration relation in SmartFID

For the above example the calibration ratio R has to be set to the value of 1.8166 and the unit “mg/m^3” (or e.g. self-defined “mg T/m^3” to give the concentration of toluene per Standard cubic meter.

For a good measurement result, it is important to choose the correct range. First, it is necessary to distinguish the following terms from each other:

- The measurement range is an indication that describes a range for the calibration in which the expected measured value is in. For good results, this area has to be defined in a way that the expected measured value is in the upper third of the scale.

- The output range is an indication which describes a range in which the mA output of the FID is configured (for example the configuration of an output range from 0 to 150 ppm causes that 0..4-20mA correspondent to 0-150 ppm).

The measurement range should be selected in a way that the endpoint of the calibration gas is in the upper quartile of the range. For example using a calibration gas of 80 ppm a final value of the measurement range of 100 ppm is optimal.