LoopSeries LB 430
Detectors

Software operating manual

69691BA24 Rev.00 01/2025
Embedded Software from version 01.00.00

BERTHOLD

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1 General Information

1.1 Validity of the Operating Manual

The operating manual is valid from the delivery of the Berthold product to the user until its disposal. The version and release date of this operating manual can be found at the bottom of each page. No modification service is performed by the manufacturer Berthold.

The manufacturer reserves the right to make changes to this operating manual at any time without prior notice or justification.

HINWEIS

The current revision of the software manual replaces all previous versions.

Target Group

This operating manual is directed at qualified specialist personnel who are familiar with handling electrical and electronic assemblies as well as with communication and measuring techniques.

Specialist personnel refer to those who can assess the work assigned to them and recognize possible dangers through their specialist training, knowledge and experience as well as knowledge of the relevant regulations.

Storage Location

This operation manual, along with all product-specific documentation relevant to the respective application, must always be accessible near the device.

Copyrights

This operation manual contains copyright-protected information. No chapter may be copied or reproduced in any form without prior approval from the manufacturer.

1.2 Structure of the Operating Manual

This operating manual is divided into chapters. The order of the chapters is designed to help you quickly and safely familiarize yourself with the operation of the device.

Formatting Style

Identifier	Description	Example
Quotation marks	Field in the software interface	„Linear“
Vertical line	Path specification	Setup | Device
Gear icon	Clickable button	**Reset to Default**
Round brackets	Image reference	Attach the plug (Fig. 1, Pos. 1)

In the software description, the term "clicking" is used if a process is to be activated. This also refers to the pressing of a button (key) or an area on the touch display if a mouse is not used for controlling.

Symbols Used

NOTICE

If this information is not observed, deterioration in the operation and/or property damage may occur.

IMPORTANT

Sections marked with this symbol point out important information on the product or on handling the product.

Tip

Provides tips on application and other useful information.

2 Operation

2.1 Operating Software

To configure and parameterize the detector via a PC, the connection must be established. The connection through the interface to the detector is described in the detector's operating manual. An FDT (Field Device Tool) frame application must be installed on the PC, with which the DTM (Device Type Manager) can be opened.

The following describes the operation via the FDT frame application PACTware. To use PACTware, the following software prerequisites must be met:

- Windows® operating system (32-bit XP, 32-bit Vista, 32-bit and 64-bit Windows® 7, and Windows® 10/11) with administrator rights for installing the operating software
- Installed Microsoft .NET Framework
- PACTware installation files
- Berthold DTM Library

2.2 Software installation

PACTware (Process Automation Configuration Tool) is a manufacturer- and fieldbus-independent software for the easy operation of field devices. The latest version can be downloaded for free from the website www.pactware.com. Berthold provides a DTM Library, which allows the installation of applications for density and level measurement.

PACTware

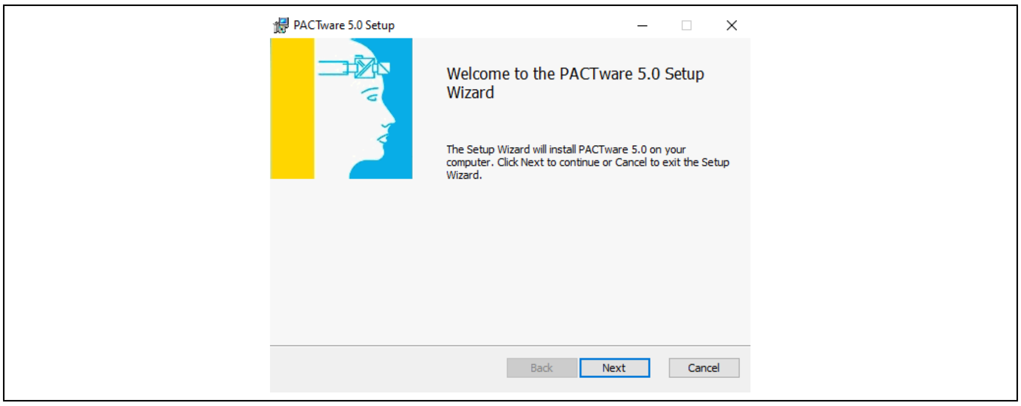


Fig. 1 PACTware installation.

Berthold DTM Library

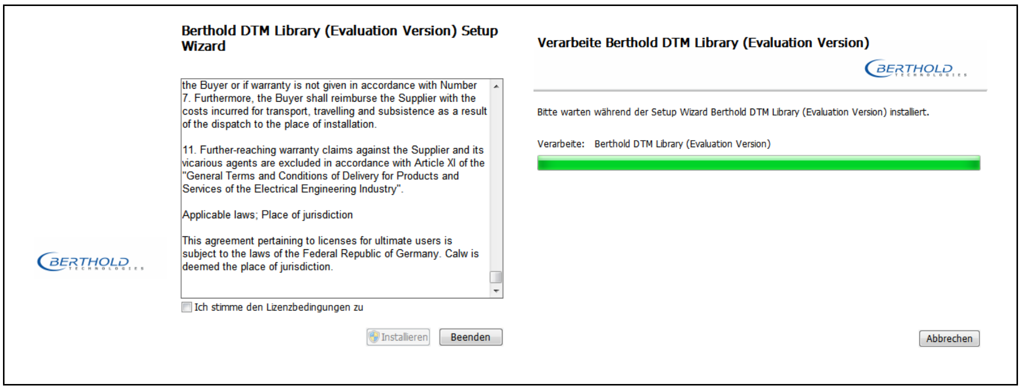


Fig. 2 DTM Library installation.

2.3 Start DTM with PACTware

After successful installation, the DTM can be started via PACTware.

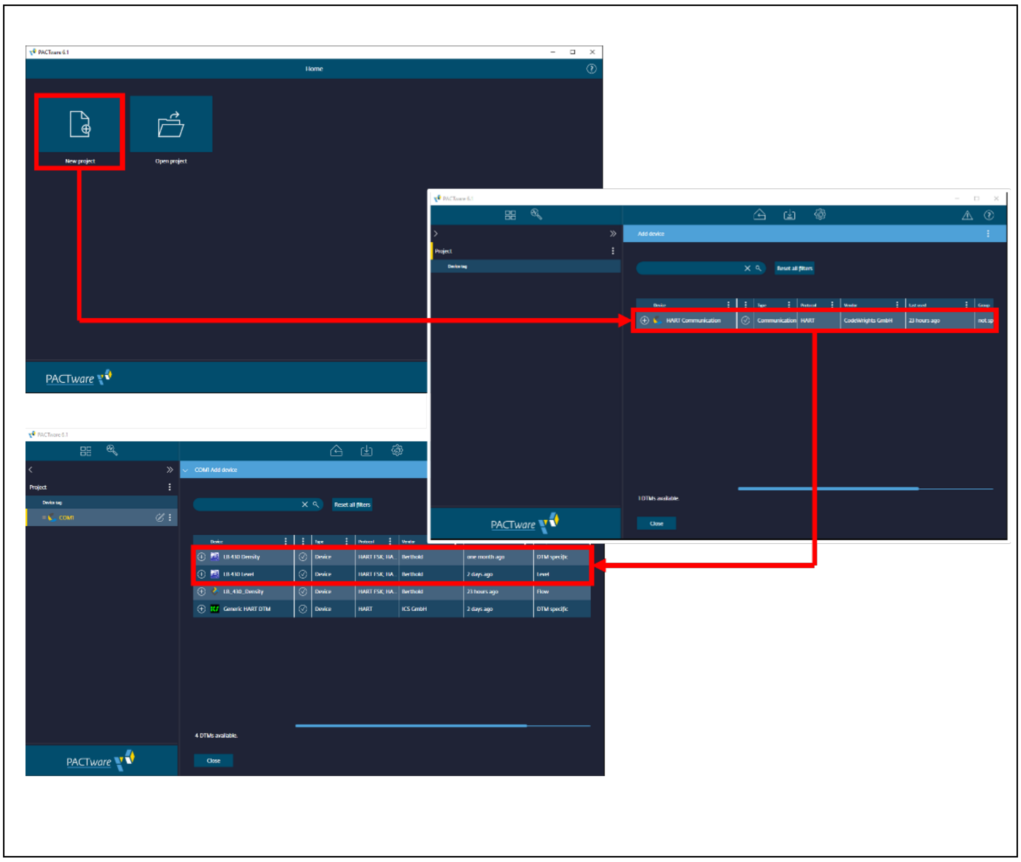


Fig. 3 Starting PACTware.

1. Click on „New Project“.
   - ▶ The installed DTMs will be displayed in the right window.
2. Click on the symbol ⊕ to display the installed DTM applications.
3. Click on the DTM application of the connected detector.
   - ▶ The DTM application will be added to the project.

4. Ensure that the correct COM port of the USB-HART interface is set under "Parameter".

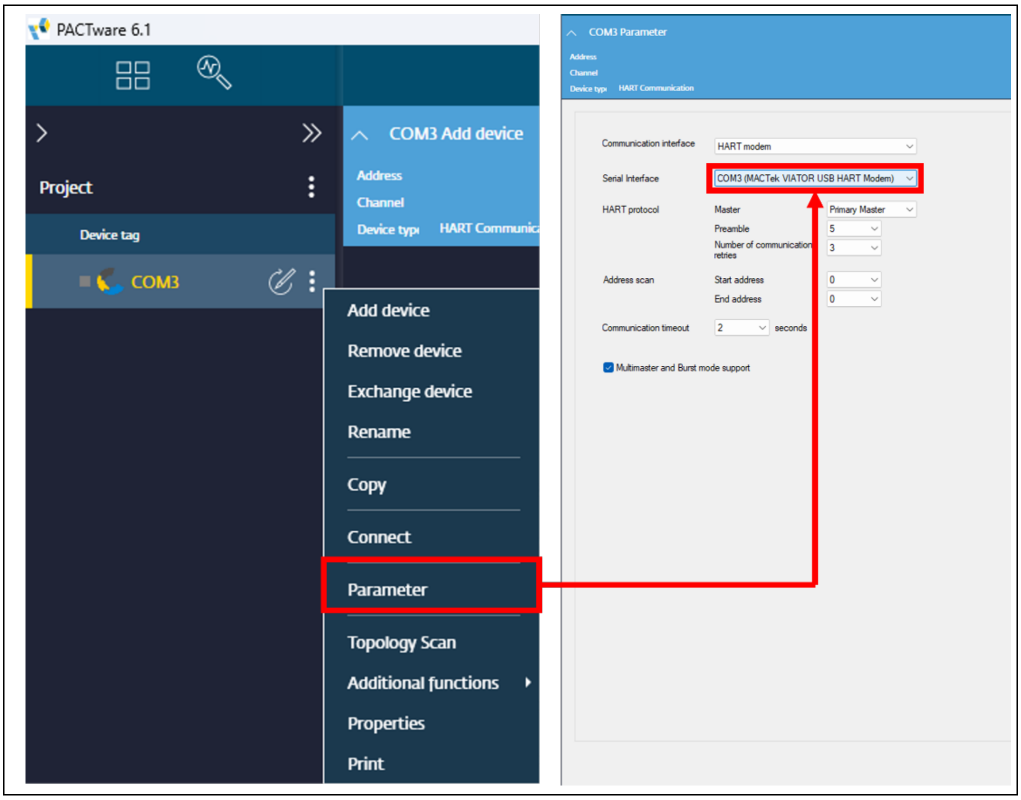


Fig. 4 Checking the COM-Port in PACTware 6.1.

5. Select the added DTM and establish the connection by right-clicking and selecting „Connect".

▶ Upon successful connection, green dots ● ○ will be displayed.

6. Start the DTM with a double-click.

▶ The DTM will be displayed in online mode.

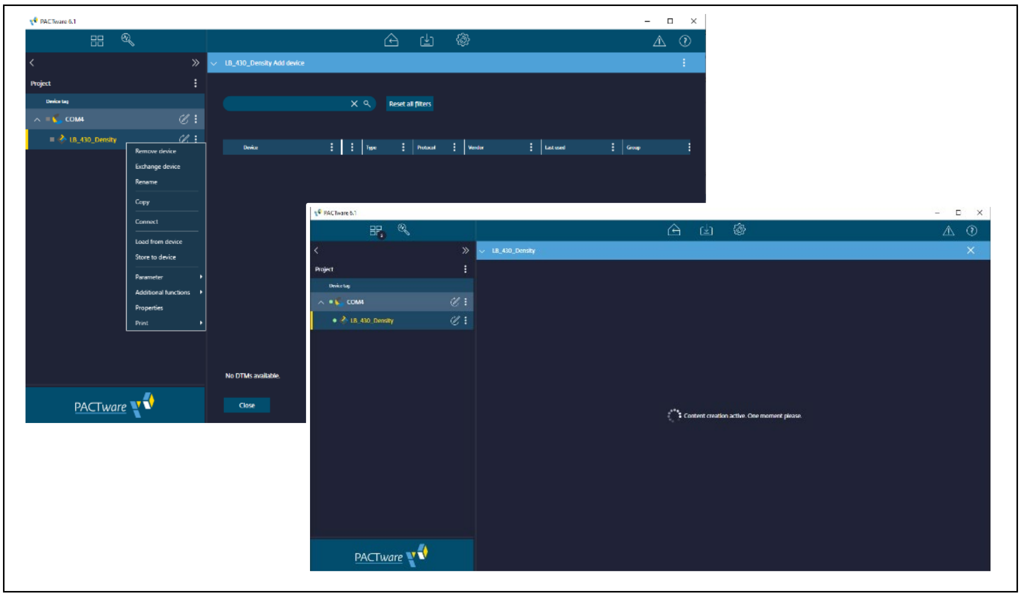


Fig. 5 Start the DTM.

IMPORTANT

It is possible to transfer the parameters of a connected detector to the offline menu. The configuration saved in this way can then be transferred to another detector in online mode. For more details, refer to Chapter 4 of this operating manual – Main Menu Offline Parameters.

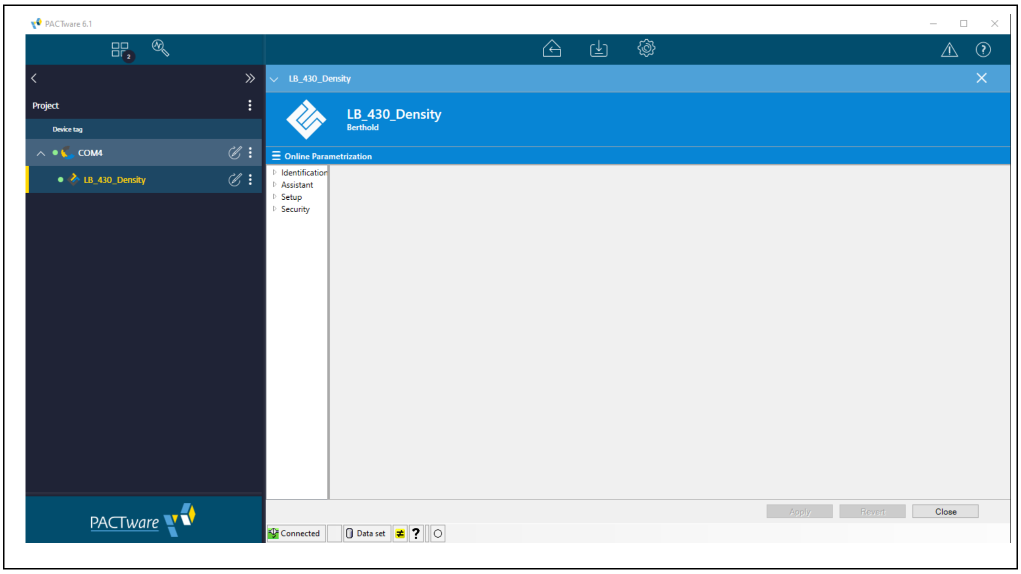


Fig. 6 Running DTM in online-mode.

3 Main Menu: Online Parameterization

3.1 Accessing the Main Menu: Online Parameterization

Accessing the online parameterization of the device is done through the main menu tree of the respective connected application. In PACTware 6.1, right-click on “Parameter” and then select “Online Parameterization”. Please note that the representation of the main menus for accessing the application may vary across different host systems.

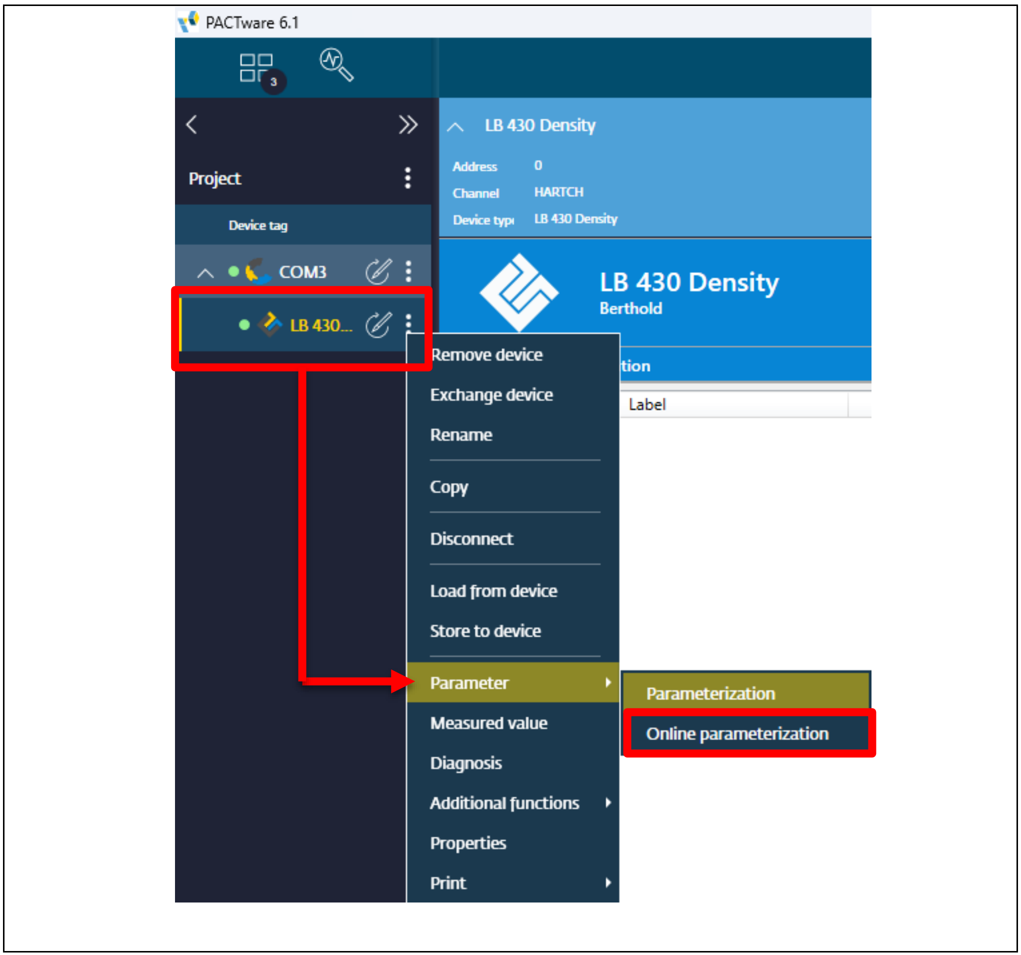


Fig. 7 Accessing Online Parameterization in PACTware 6.1.

3.2 General Information

NOTICE

Changes to the configuration and parameters may affect the behavior of any connected controllers and can lead to unintended operating states.

Therefore, changes to the configuration and parameters must not be made without a thorough understanding of this operating manual, as well as a clear understanding of the behavior of a connected controller and the potential impacts on the controlled operating process.

IMPORTANT

The communication between the detector and the USB-HART interface is limited to 1200 baud. Accordingly, there is a loading time for data retrieved from the detector.

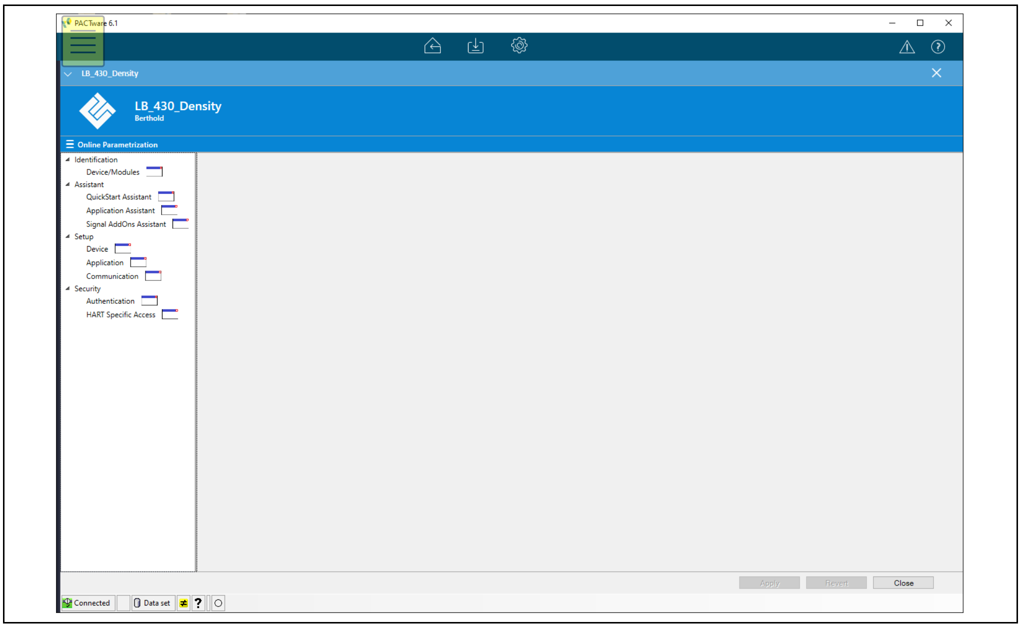
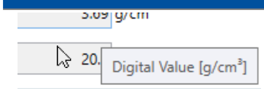
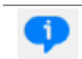


Fig. 8 Menu Structure of the DTM in Online-Mode.

Symbols / Display- and Input fields

Menüfenster	
	Display Field / Input Field. When hovering over display and input fields, a help text will be displayed.
	The value cannot be displayed or is invalid.
	The value / parameter has not been updated and is being loaded from the detector.
	A query from the assistant will be displayed.
	Buttons with this symbol trigger the displayed command when clicked.
	The value has been entered / changed and has not yet been sent to the detector via the **Apply** button.
	The detector is in operation without any malfunction.
	This symbol appears in the case of a serious malfunction. The measurement has been stopped.

	This symbol appears when either maintenance work (e.g., calibration, curve adjustment, or backup/restore) has been initiated or the detector has been switched to simulation mode.
	This symbol appears when one or more parameters are outside their manufacturer-specified limits.
	This symbol indicates that the device or the measurement point requires maintenance, such as the replacement of the radiation source.
	Indicates the establishment of a connection with the device.

Buttons

Close	Closes the DTM window of the detector.
Abort	During an installation wizard, the routine can be aborted. After aborting, the parameters that have already been entered are saved and restored upon resumption.
Next	During the execution of a wizard, this button can be used to open the next window of the routine.
Apply	All modified inputs will be applied and sent to the detector.
Revert	All changes made since the last save will be undone. This applies only to the displayed submenu.

IMPORTANT

A device data backup can be performed via the DTM after calibration. Additionally, a backup of the detector parameters can be transferred to a new detector. The backup/restore process is described in detail in Chapter 4 of this operating manual.

3.3 Menu: Identification

3.3.1 Submenu: Identification | Device/Modules

3.3.1.1 Tab: Identification | Device/Modules | Device

The tab **"Device"** provides an overview of the configured characteristics of the measuring point (Fig. 9, Pos.1), the factory settings of the detector (Fig. 9, Pos.2), as well as information about the installed software version and the build number (Fig. 9, Pos.3).

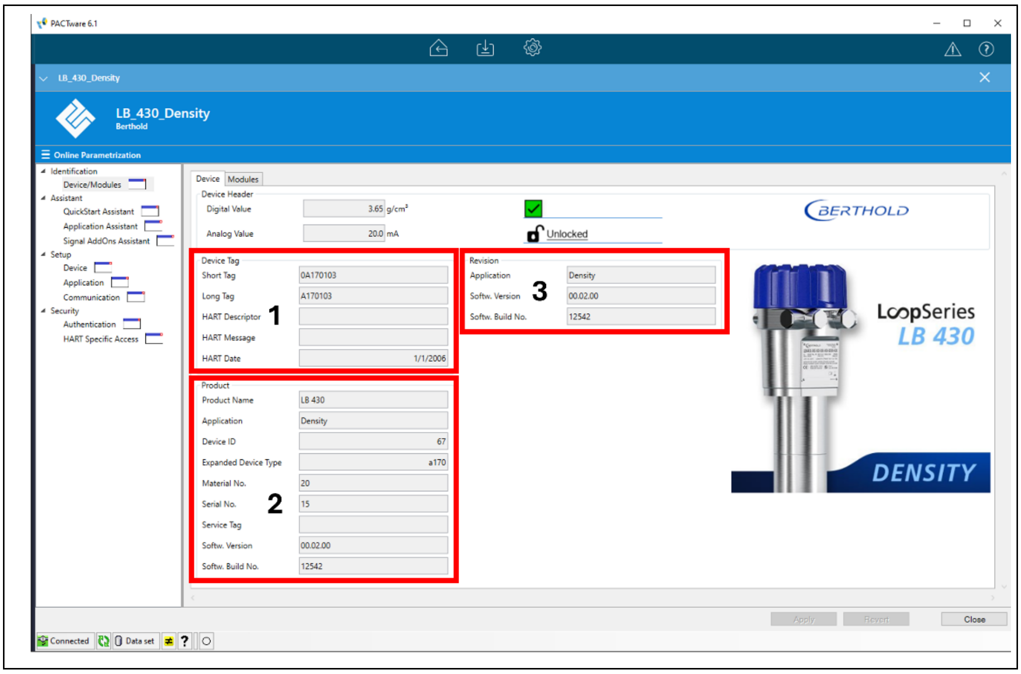


Fig. 9 Tab: Identification | Device/Modules | Device.

3.3.1.2 Tab: Identification | Device/Modules | Modules

The tab **"Modules"** provides information about the installed software version and the build number (Fig. 10, Pos. 1) and an overview of the electronics revision as well as the installed software version of all connected modules such as the frontend module, the main module as well as the optional display, if connected (Fig. 10, Pos. 2 and Pos. 3).

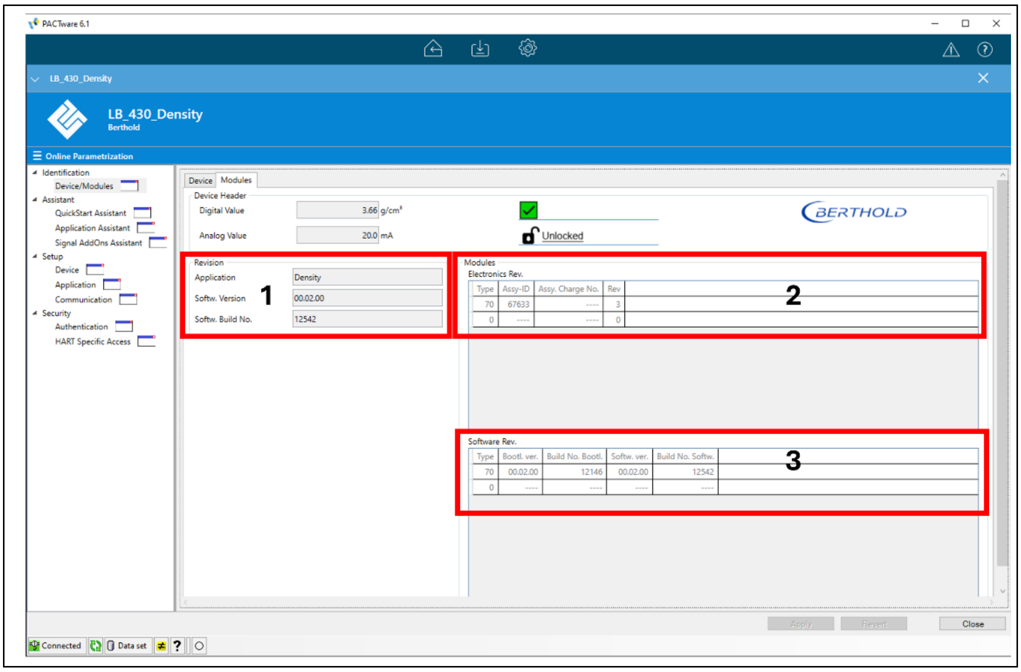


Fig.10 Tab: *Identification | Device/Modules | Modules.*

3.4 Menu: Assistants

The assistants allow you to start up the detector in a guided manner without extensive prior knowledge. If additional functions from the submenus are required, these can also be activated and edited after calibration via the Quick Start Assistant.

NOTICE

Errors in calibration or parameter settings can lead to incorrect measurement results. This may potentially cause production downtime or damage to the system.

For verification, we recommend performing a simulation to check the calibration points.
In general, it is recommended to have the commissioning carried out by Berthold.

Tip

In the assistant windows, the storage paths (e.g., **Quick Start Assistant > Sensor > Sensor Parameters**) of the settings and entered values in the Setup menu are displayed.

3.4.1 Submenu: Assistant | Quick Start Assistant

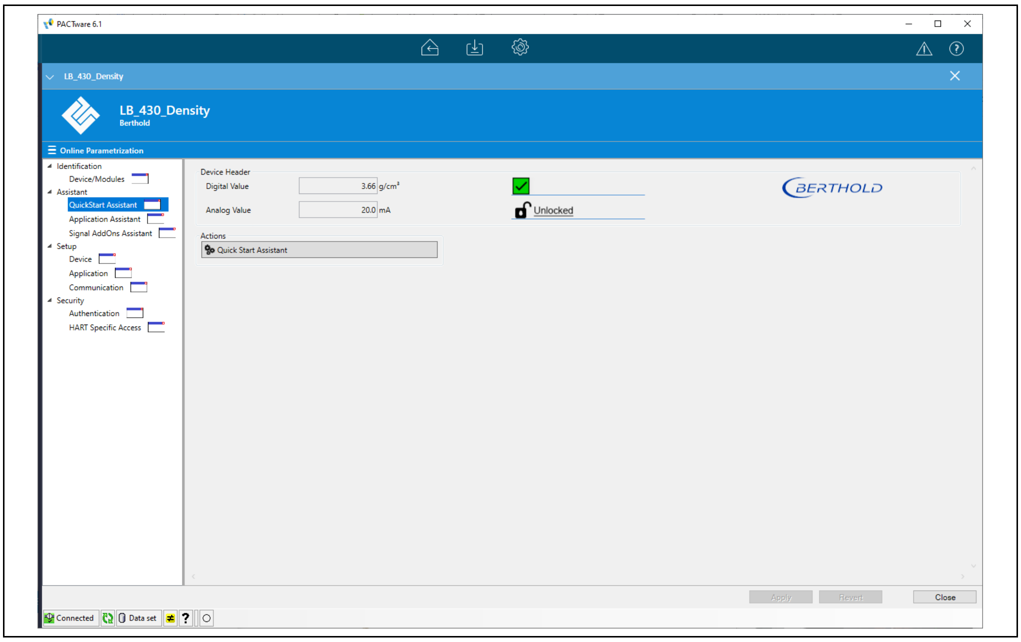


Fig. 11 Submenu: *Assistant | Quick Start Assistant.*

After clicking the **Quick Start Assistant** button, a window with the query routine will open. In the first step, there is the option to retrieve existing data from the measurement parameter set to adjust only individual parameters. If the data is not retrieved, the query routine will start with a pre-configured standard parameter set. For a new calibration, the desired measurement mode must first be selected. These modes, of course, differ between the "Density" and "Level" applications.

3.4.1.1 Copy of the measurement data into the calibration data

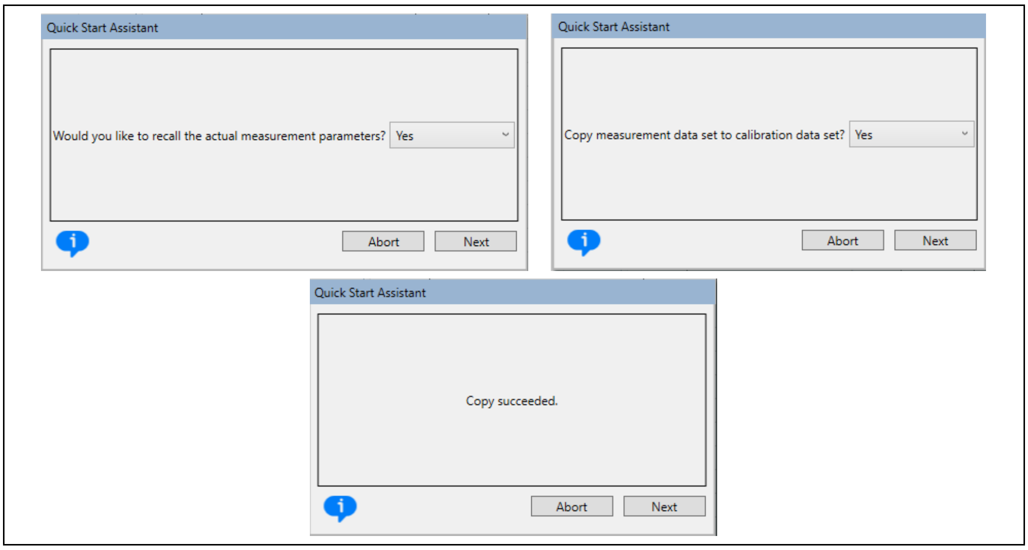


*Fig. 12 Submenu: **Assistant | Quick Start Assistant**. Step 1: Copy of the measurement data into the calibration data.*

In the first step of the guided commissioning, you will be asked whether you want to transfer an existing measurement parameter set into a valid calibration parameter set by copying it. This is particularly useful if the device is already calibrated, and only specific points need to be modified.

Calibration data set	The calibration data set describes all the data that has been entered for the calibration of the measurement but has not yet directly impacted the measurement itself. To apply this data, it is essential to use the **Calibrate** function
Measurement data set	The measurement parameter set describes all the data that currently affects the ongoing measurement. Changing the measurement parameters leads to a changed measurement result even without recalibration. (e.g., offset and scaling of the calibration curve).
Recall	A recall transfers the current measurement parameter set into a calibration parameter set. This ensures that any parameters modified in the meantime are included in the new calibration.

3.4.1.2 Application density: selection of measurement mode

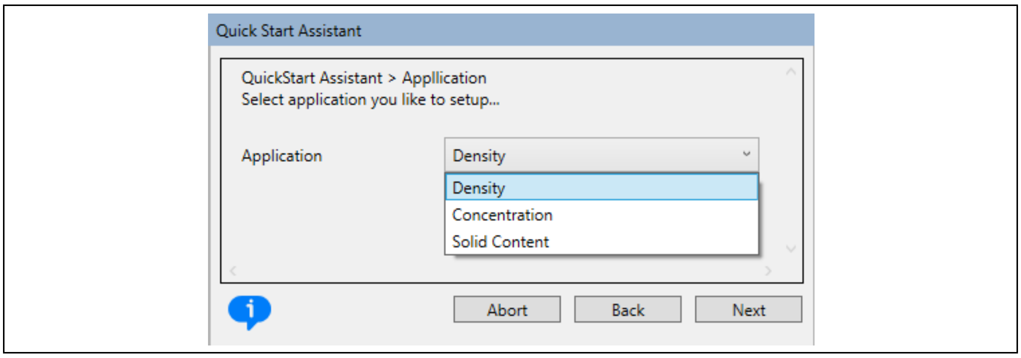


*Fig. 13 Submenu: **Assistant | Quick Start Assistant**. Step 2: Selection of Measurement Mode.*

NOTICE

If you selected the option "Yes" in the previous step and generated calibration data from the measurement parameter set, this step is no longer necessary.

Also, if application level is selected, this step is not necessary

Density	Select "Density" if the detector is used for density measurement. For more information about this measurement mode, refer to Chapter 5 Calibration Methods and Curve Types, Subchapter 5.2.1 Measurement Mode Density.
Concentration	Select "Concentration" if the detector is used for concentration measurement. Solid concentration refers to the mass of solids within the total volume of the suspension. The unit (e.g., g/l) should not be confused with density. For more information about this measurement mode, refer to Chapter 5 Calibration Methods and Curve Types, Subchapter 5.2.3 Measurement Mode Concentration.
Solid Content	Select "Solid Content" if the detector is used for measuring the solid content. Solid content refers to the mass of solids relative to the total mass of the suspension. This results in the unit %, understood as weight percent [wt%/wt]. For more information about this measurement mode, refer to Chapter 5 Calibration Methods and Curve Types, Subchapter 5.2.5 Measurement Mode Solid Content.

3.4.1.3 Input of identification parameters

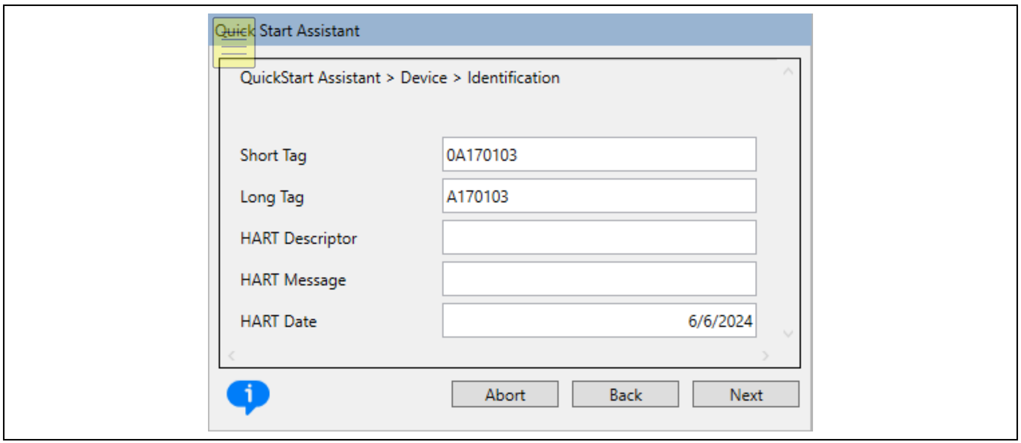


*Fig. 14 Submenu: **Assistant | Quick Start Assistant**. Step 3: Input of identification parameters of the measurement point.*

In the window Quick Start Assistant | Device | Identification, information about the measuring point is entered.

Short Tag	Optional entry of a short description for the measuring point. Any text is allowed, with a maximum of 8 characters.
Long Tag	Optional entry of a long description for the measuring point. Any text is allowed, with a maximum of 32 characters.
HART Descriptor	Optional entry of a detailed description of the measuring point, which will be transmitted via the HART protocol. Any text is allowed.
HART Message	Optional entry of a device message, which will be transmitted via the HART protocol. Any text is allowed.
HART Date	Entry of the date to be transmitted via the HART protocol. It is recommended to use the commissioning date.

3.4.1.4 Input of local system time

In the "Date/Time" window, the current date and time must be entered. The correct date is required for the automatic decay compensation of the isotope. Since the activity of the radiation source decreases over time, the calibration count rates are automatically compensated based on the date.

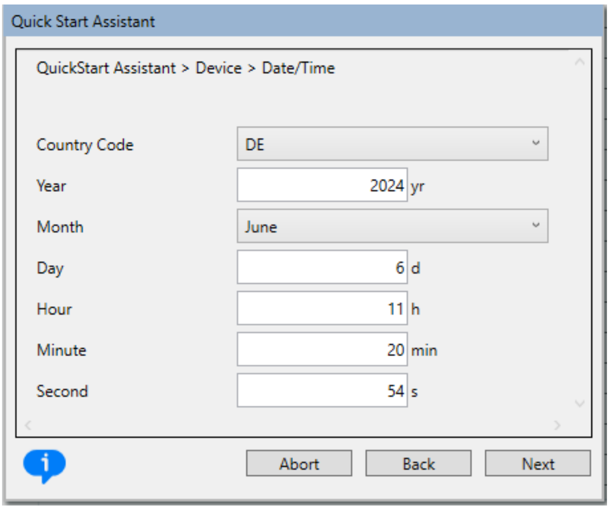


Fig. 15 Submenu: ***Assistant | Quick Start Assistant***. Step 4: Input of local system time

3.4.1.5 Input of measuring units

By clicking on the respective dropdown list, the available units for the measurements are displayed. The selected unit will be used in the display and in the calibration settings.

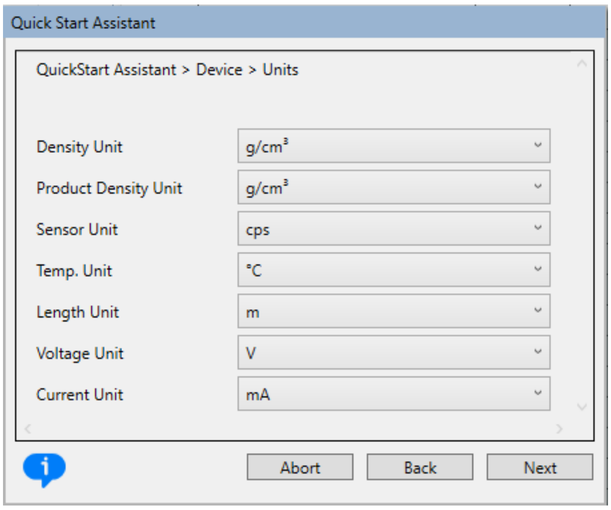


Fig. 16 Submenu: ***Assistant | Quick Start Assistant***. Step 5: Input of measuring units.

3.4.1.6 Input of sensor parameters

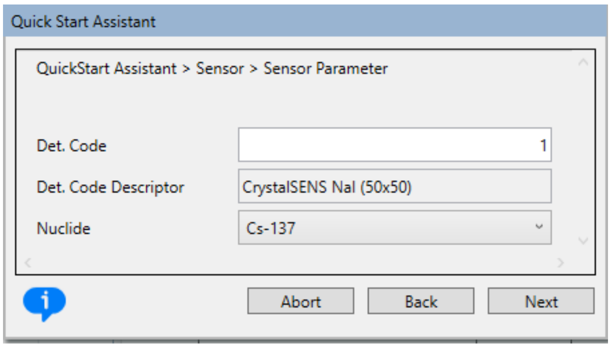


*Fig 17 Submenu: **Assistant | Quick Start Assistant**. Step 6: Input of detector code and nuclide.*

By setting the detector code, internal device parameters are adjusted to the used scintillator size, the applied control, and the selected isotope. The correct detector code for the current configuration can be selected from the dropdown list or found in the table below. The correct detector code is pre-set at the factory, and usually, no change is required. If the displayed detector code does not match the correct measurement setup, it can also be changed at this point.

IMPORTANT

A change of the detector code between point and rod configurations (e.g., Det. Code 0 → Det. Code 22) is difficult to reverse. In this case, please contact Berthold Service. Make sure that the correct detector code is set, and if necessary, only change it within the used detector type.

Detector Code	Measurement Control and Nuclide
CrystalSens Point Detector NaI 50x50 mm	
0	Ratio Control, Cs-137
1	Cosmic Control, Cs-137 oder Co-60
2	Ratio Control, Co-60

NOTICE

Incorrect settings can negatively affect the long-term stability of the device and lead to other malfunctions.

3.4.1.7 Entry/Input of the background radiation

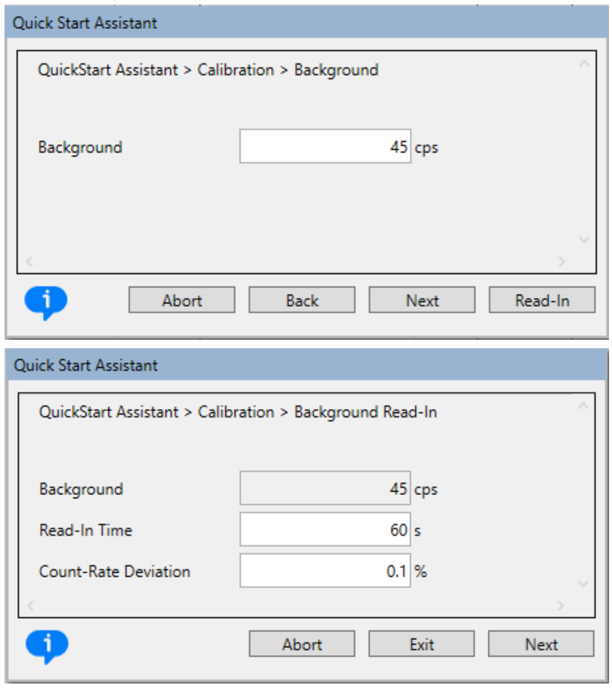


*Fig. 18 Submenu: **Assistant | Quick Start Assistant**. Step 7: Entry or input of the background radiation.*

Background	The background count rate refers to the count rate measured by the detector without the influence of the used radiation source. This count rate originates from the location-dependent natural background radiation. Accurate recording of the background count rate allows for proper decay compensation, thus influencing the long-term stability. Before reading the background count rate, any influences from artificial sources, including the radiation sources used for measurement, must be excluded to avoid deviations. The measurement duration in seconds is entered via the **Read-In Time** button. The longer the read-in time is set, the more accurate the result will be. A maximum deviation between two consecutive read-in operations can also be specified. The reading of the background count rate will automatically end once the system has reached either the desired read-in time or a smaller deviation. The background count rate value can also be entered manually if it is known.

NOTICE

Even with a closed shield (Fig. 19, Pos. 1), the detector can still detect measurable radiation, which can distort the measurement of background radiation. Therefore, it is recommended to position the detector (Fig. 19, Pos. 4) at an appropriate distance (approximately 10 m, Fig. 19, Pos. 3) during the determination of the background count rate, or to shield it appropriately, for example, with a concrete wall (Fig. 19, Pos. 2).

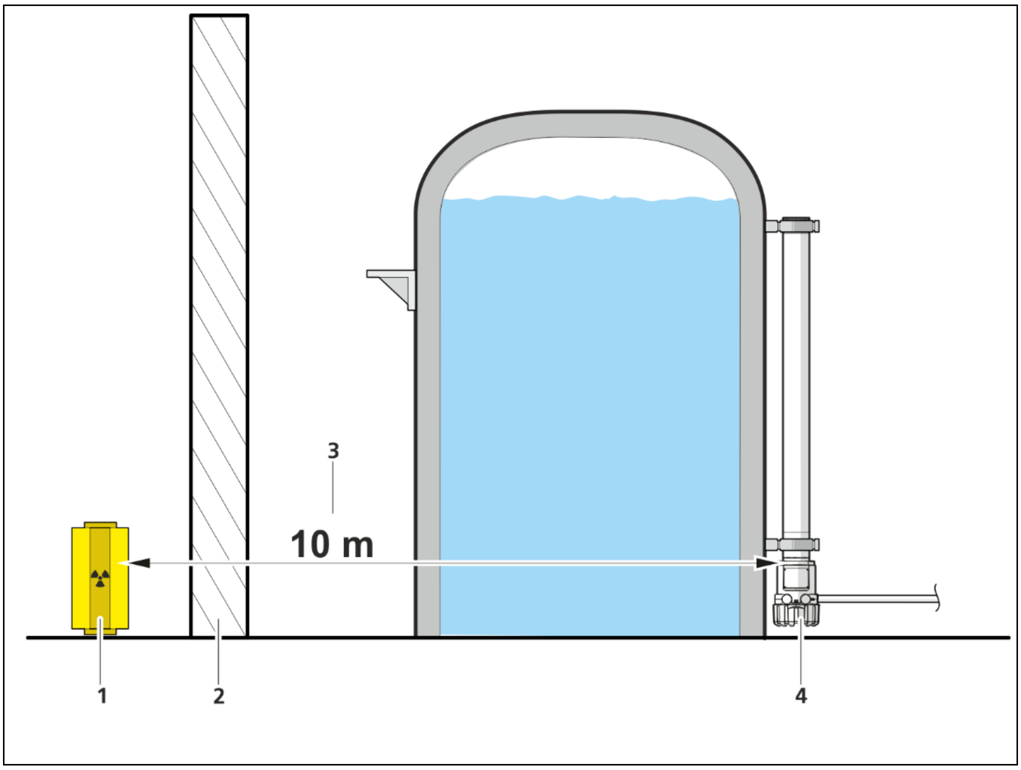


Fig. 19 Recommended setup to determine the background radiation.

3.4.1.8 Application density: Input of calibration settings

The following provides a brief explanation of the calibration settings that can be made for measuring product density. The exact calibration settings for the density applications depend heavily on the desired measurement parameter and its calculation. A detailed explanation of the calibration methods used, and their derivations can be found in Chapter XX of this user manual.

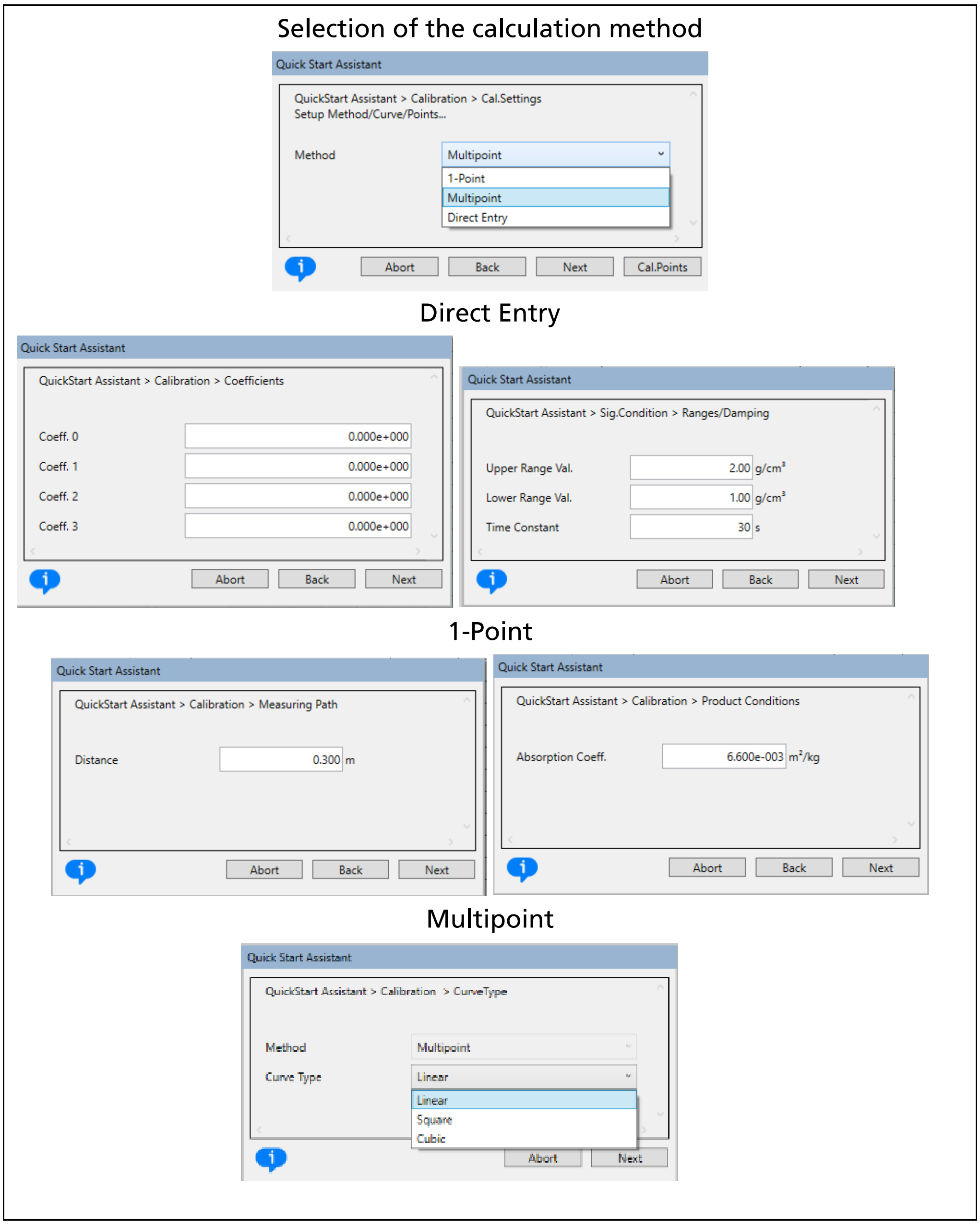


*Fig. 20 Submenu: **Assistant | Quick Start Assistant**. Step 8: Input of calibration settings for density measurements.*

Method

Direct Entry	If the coefficients of the calibration equation are known, they can also be entered directly. This is the case, for example, if the measurement has already been calibrated once, and the coefficients from the previous calibration can be used. When selecting direct entry, valid coefficients must be provided. The type of calibration curve for direct entry corresponds to the number of coefficients entered (2 coefficients - Linear, 3 coefficients - Quadratic, 4 coefficients - Cubic).
1-Point	For this calibration method, only one calibration point is required. To obtain a calibration equation, the measurement path as well as the linear absorption coefficient of the medium to be measured must also be specified. This calibration method is particularly useful when, for example, no samples can be taken for density measurement on a pipeline (e.g., due to high flow rates), so no reference is available. In this case, a one-point calibration can be performed with water, and the absorption coefficient can be adjusted between the values of [-10, 10], so that the resulting measurement effect meets the desired conditions.
Multipoint	Recommended calibration method when enough calibration points, i.e., count rate-process value pairs, can be measured. A multi-point calibration can be performed with at least 2 and a maximum of 11 calibration points.

Curve Type

For the density application, the type of calibration curve defines the function to which the measured calibration data should be fitted and is only selectable in the case of multi-point calibration.

Reasons for changing the curve type can include more complex container geometries or density fluctuations in the product to be measured. In such cases, it is possible to adjust the calibration curve accordingly to achieve more accurate measurements.

Linear	This option is used when at least two value pairs are available. This curve type should also be used when multiple calibration points are measured very close to each other, as in this case, the entire measurement range is not covered.
Quadratic	The quadratic calculation method can be selected when at least 3 calibration points are available. It is only necessary in exceptional cases and is used when the "linear" calculation method results in measurement deviations.
Cubic	The cubic calculation method should be used when the same conditions as for the quadratic calculation method apply, but at least 4 value pairs are available, and it is observed during operation that the quadratic calculation method results in measurement deviations in certain areas.

3.4.1.9 Application level: Input of calibration settings

The following provides a brief explanation of the calibration settings that can be made for measuring the level inside a vessel. The exact calibration settings for the level application depend heavily on the measurement arrangement used. A detailed explanation of the calibration methods and their derivations can be found in Chapter 3.6 of this user manual.

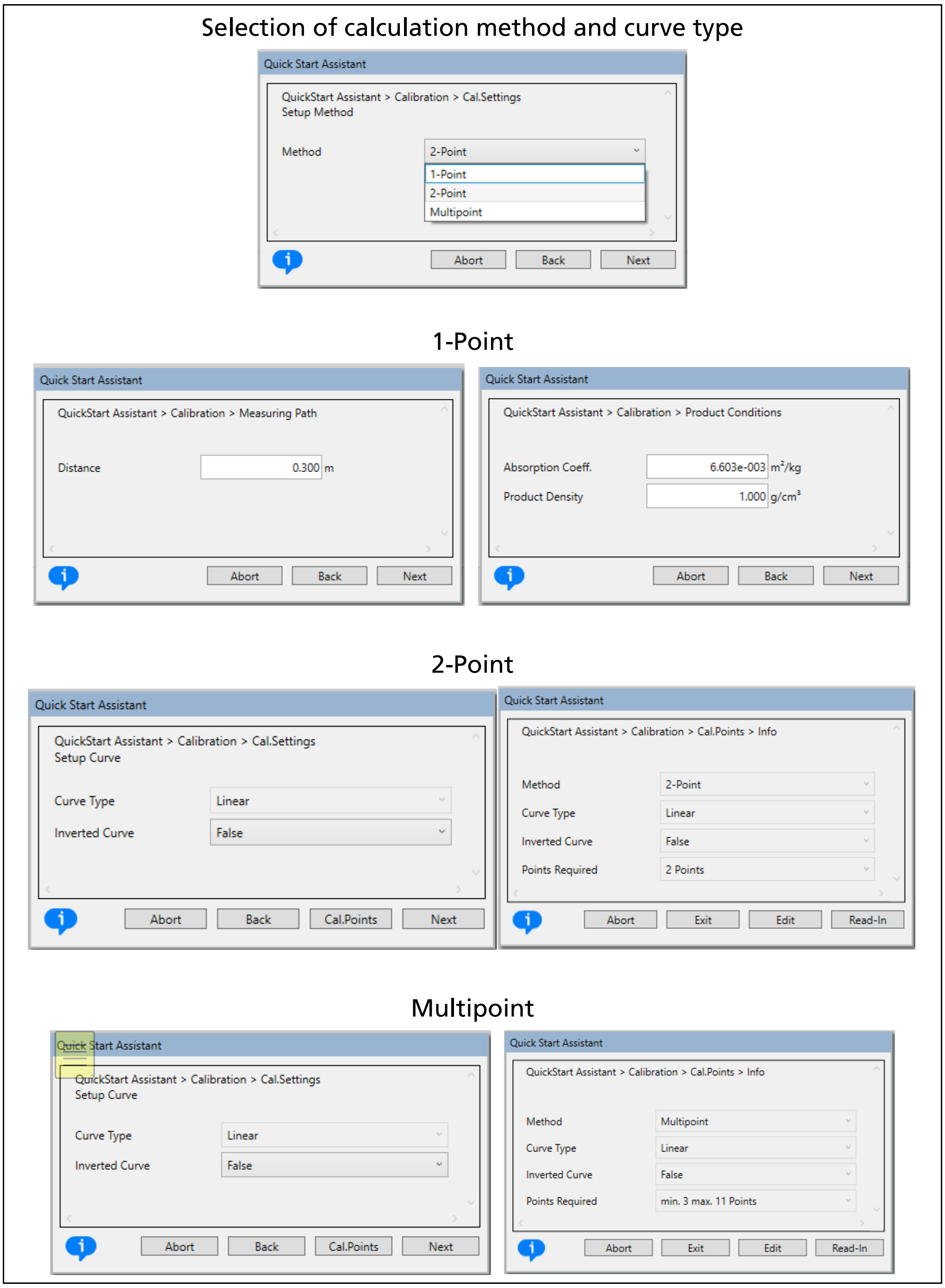


Fig. 21 Submenu: ***Assistant | Quick Start Assistant***. step 8: Input of calibration settings for level measurements.

Method

1-Point	For this calibration method, only one calibration point is required. In order to obtain a calibration curve, the measurement path as well as the linear absorption coefficient of the medium to be measured must also be specified.
2-Point	Exactly two calibration points must be entered. The calibration curve is linearly interpolated between these two points. For this type of calibration, it is sensible to choose two calibration points that span the entire fill level range (0% and 100%).
Multipoint	Multiple calibration points (minimum 3, maximum 11) can be entered. Linear interpolation is performed between the individual calibration points. This calibration method provides the best precision in any case.

NOTICE

For the 2-point calibration method, the precision of the calibration curve is greatest at the two chosen calibration points. For intermediate values, deviations from the actual fill level values may occur.

Curve Type

For the level application, linear and exponential curve types can be chosen. In addition, for the level measurement, the display of an inverted calibration curve can be selected. This becomes relevant for backscatter measurement arrangements, where the radiation source and the detector are mounted on the same side of the container.

IMPORTANT

The selection of the exponential curve is only possible up to the 2-point calibration and is intended for special applications, such as absorption level measurement. In a multi-point calibration, the calibration curve is determined more accurately anyway, so an exponential curve is not needed.

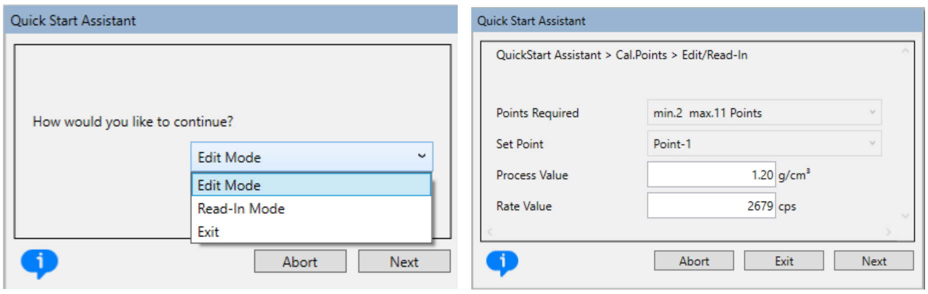
Linear	When selecting a linear curve in the level application, two calibration points are required, which are connected by a straight line.
Exponential	When selecting an exponential curve type, an exponential function of the following form is used: $\text{Prozesswert} = a * e^{-\mu * d * CPS} + c$ NOTE: This curve type should only be used for absorption level measurements, not for standard coverage measurements.

NOTICE

In a 1-point calibration, the second point of the exponential curve is calculated by the system using the provided attenuation coefficient (μ) and the measurement path (d).

3.4.1.10 Entry/Read-In of calibration points

Application density



Application level

*Fig. 22 Submenu: **Assistant | Quick Start Assistant**. Step 9: Entry or Read-In of calibration points.*

If you have selected the calibration methods 1-Point, 2-Point, or Multipoint, three options are available to you when editing the calibration table:

1. **Edit Mode:** The calibration points are already known, for example, in the case of detector replacement and previously conducted calibration. In this case, the known calibration values can be manually entered into the table. To do this, press the **Edit** button (Level application) or select **„Edit Mode"** from the drop-down menu (Density application).

2. **Read-In Mode:** If the device is undergoing its initial commissioning, meaning the calibration values are entirely unknown, individual calibration values can be read in. To do this, press the **Read-In** button (Level application) or select "**Read-In Mode"** from the drop-down menu (Density application).

NOTICE

In this case, ensure that the minimum number of required calibration points is met for the chosen combination of calibration method and curve type.

3. **Exit:** If the **Exit** option is selected, a factory-set calibration table will be used. This will not correspond to the desired process calibration. This option should be chosen if the goal is, for example, dummy calibration for functionality testing.

3.4.1.11 Input of Signal Processing Parameters

Ranges/Damping

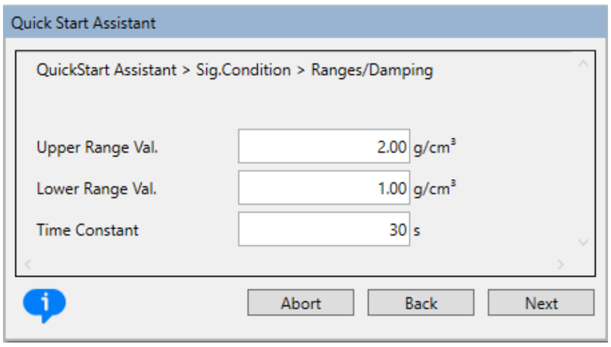


*Fig. 23 Submenu **Assistant | Quick Start Assistant**. Step 10: Setting the Measurement Range and Time Constant.*

Upper Range Value / Lower Range Value	Upper and lower process value limit: Under this setting, it can be specified which process value the maximum current of 20 mA and which process value the minimum current of 4 mA should correspond to.
Time Constant	The time constant determines the time window over which a moving mean value filter is applied to the measured count rate, and is thus responsible for smoothing the output signal. With small time constants (minimum 1 second), faster process changes (approximately 3 seconds) can be better responded to, but the signal will contain more statistical noise. The default setting for the time constant is 20 seconds.

IMPORTANT

The system needs approximately 3 times the time constants to represent 99% of the process change. This means that with a default setting of 20 seconds, a process change can be fully represented after about 60 seconds. Therefore, the choice of the time constant is always a compromise between response time and signal smoothing.

Scaling

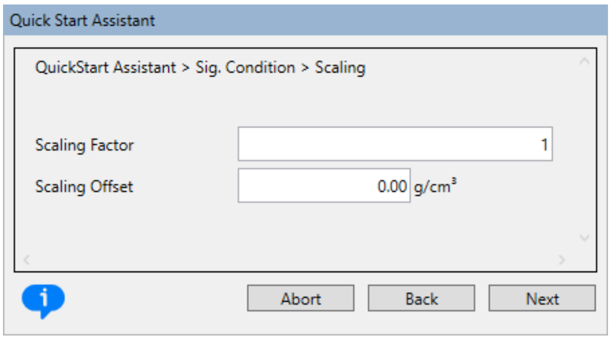


*Fig. 24 Submenu: **Assistant | Quick Start Assistant**. Step 11: Scaling and Offset.*

Scaling Factor	A factor by which the measured value is multiplied. This allows for correcting deviations in the calibration. It enables adjustment to changed operating conditions, such as deposits or wear on the pipe wall, without the need for recalibration. The default value is 1. The corrected display, considering the offset and factor, is calculated as follows: **Display = Measured Value × Factor + Offset**
Scaling Offset	If the measurement was calibrated in a different range, the calibration curve can be shifted parallel by specifying an offset, without the need to re-enter the calibration values.

3.4.1.12 Calibration

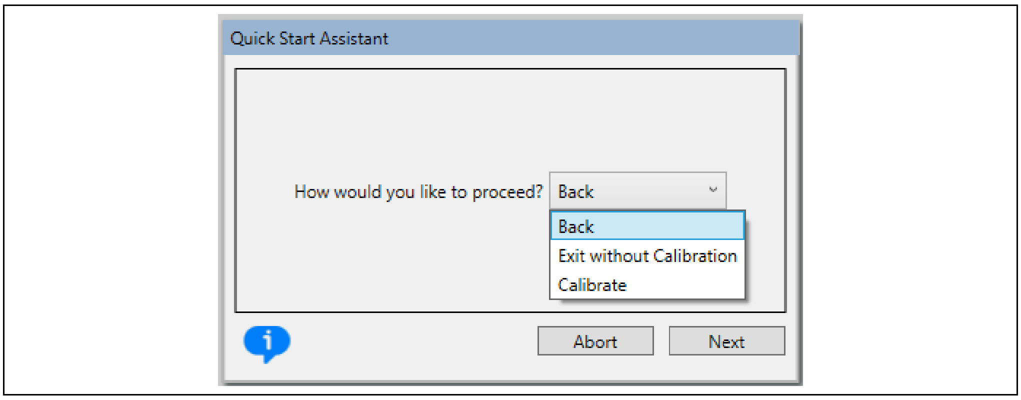


*Fig. 25 Submenu: **Assistant | Quick Start Assistant**. step 12: Calibrate the device.*

Calibrate	When the “Calibrate” option is executed by confirming with **Next**, all entered data will be used to calibrate the device accordingly. This process may take a few seconds. During calibration, the device is set to the NAMUR status "Function Check". A successful calibration is indicated both by the pop-up "Calibration Successful" and by the device switching to the NAMUR status "OK".
Exit without Calibration	If the **Exit without Calibration** option is selected, the Quick Start Assistant will be exited without calibrating the device. The calibration settings are saved, and calibration can also be performed later through the setup menu.

3.4.2 Submenu: Assistant | Application Assistant

The LoopSeries LB 430 detector offers the ability to switch between the two main applications, level and density, as well as between the different measurement modes of the density measurement.

With the help of the application assistant, the desired standard application (level or density) can either be loaded from the external memory and the active application in the internal memory overwritten, or the selected measurement mode of the active application can be adjusted.

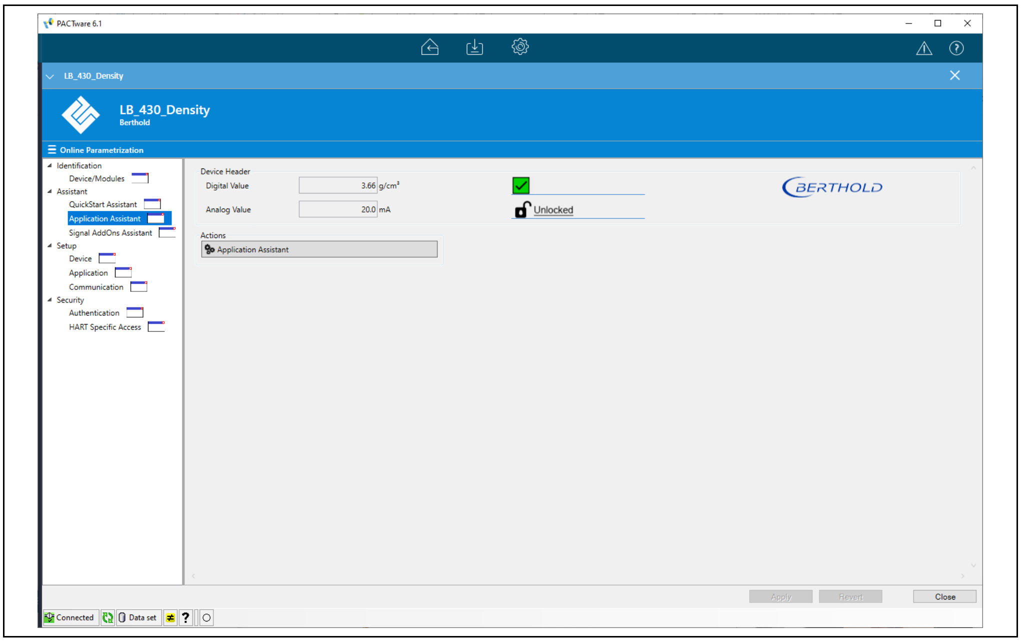


Fig. 26 Submenu: ***Assistant | Application Assistant***.

If the density application is active on the detector, the first step of the application assistant offers the choice between changing the measurement mode or uploading a different base application.

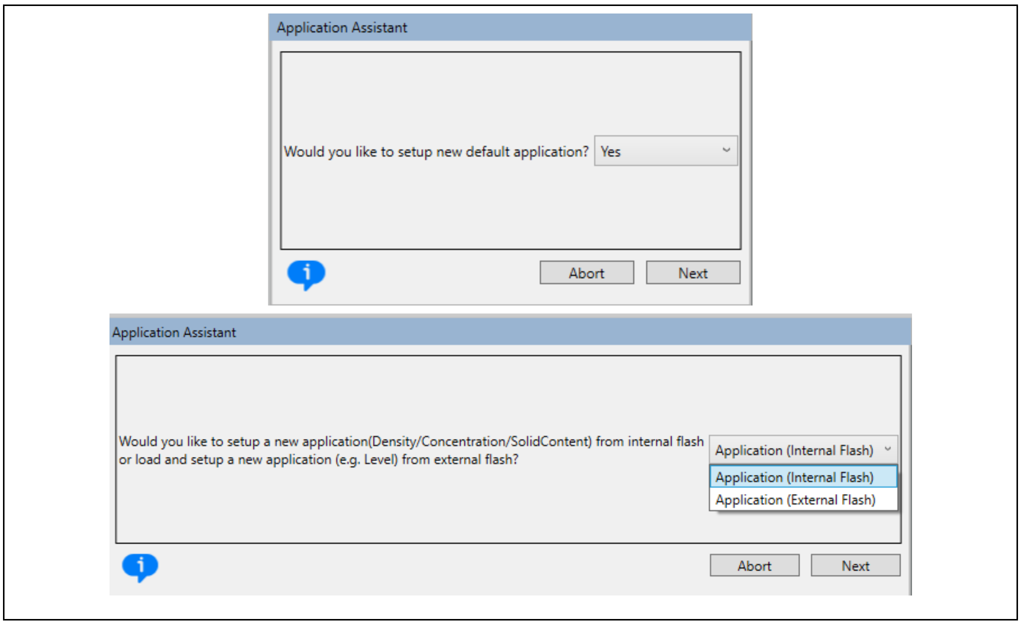


Fig. 27 Submenu: ***Assistant | Application Assistant***. *Selection between change of measurement mode or change of application (Only applicable for application density).*

Application (Internal Flash)	Select the "Application (Internal Flash)" option to choose a different density measurement mode from the internal flash memory.
Application (External Flash)	Select the "Application (External Flash)" option to activate a new base application from the external flash memory.

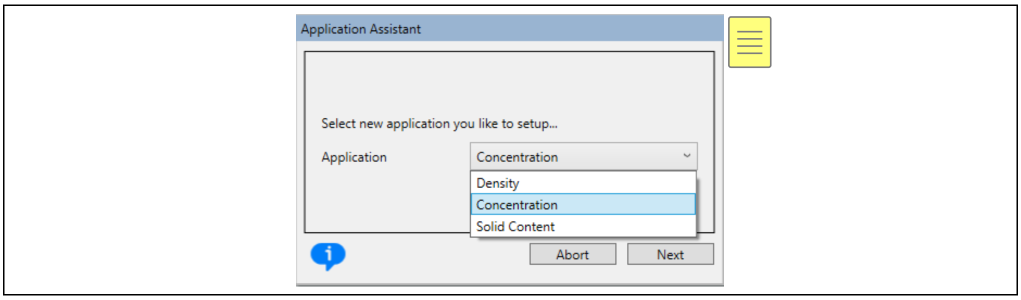


*Fig. 28 Submenu: **Assistant | Application Assistant**. Switching the measurement mode from internal flash. Only within density application.*

To upload a new base application, a Target Device Type must also be entered along with the application. This number ensures the correct addressing of the application on the external memory.

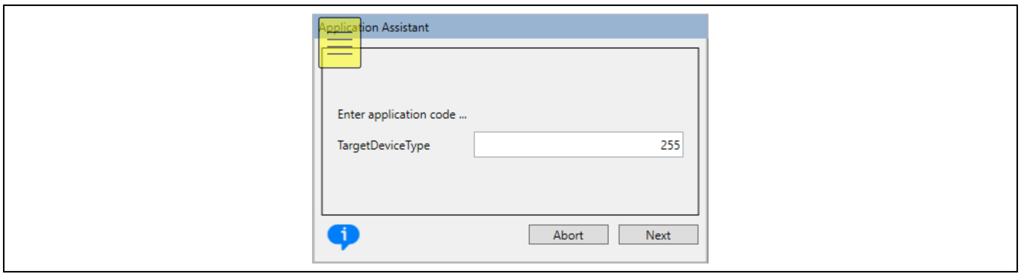


*Fig. 29 Submenu: **Assistant | Application Assistant**. Switching the base application from external flash drive.*

TargetDeviceType	Desciption
114	Level application
112	Density application

NOTICE

The external flash process takes approximately 5 to 10 minutes. After this time, briefly disconnect the device from the power supply and perform a restart with the corresponding new DTM.

Tip

After the flashing process, an event may be reported (F005: Memory corrupted [FRAM]). In this case, please perform a repair reset, which will clean up faulty memory units. Afterward, the device should be ready for use again. If the error persists, please contact Berthold Service.

3.4.3 Submenu: Assistant | Signal-Addon-Assistant

The Signal Add-on Assistant is used to activate various features to support the active measurement, such as the Rapid Switch – or the X-Ray Interference Protection (XIP) function.

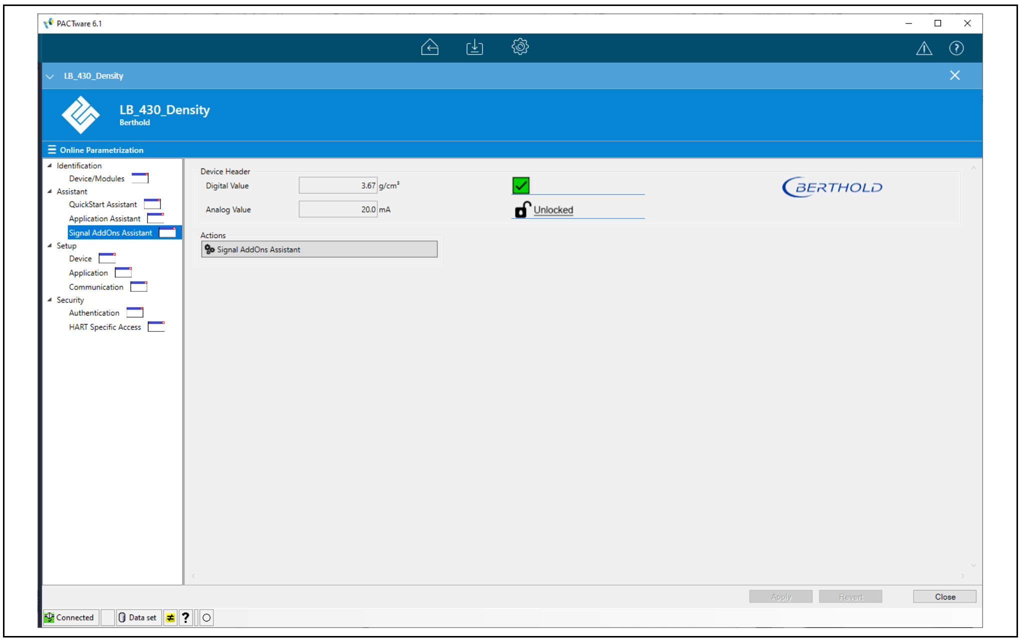


Fig. 30 Submenu: ***Assistant | SignalAddon Assistant***.

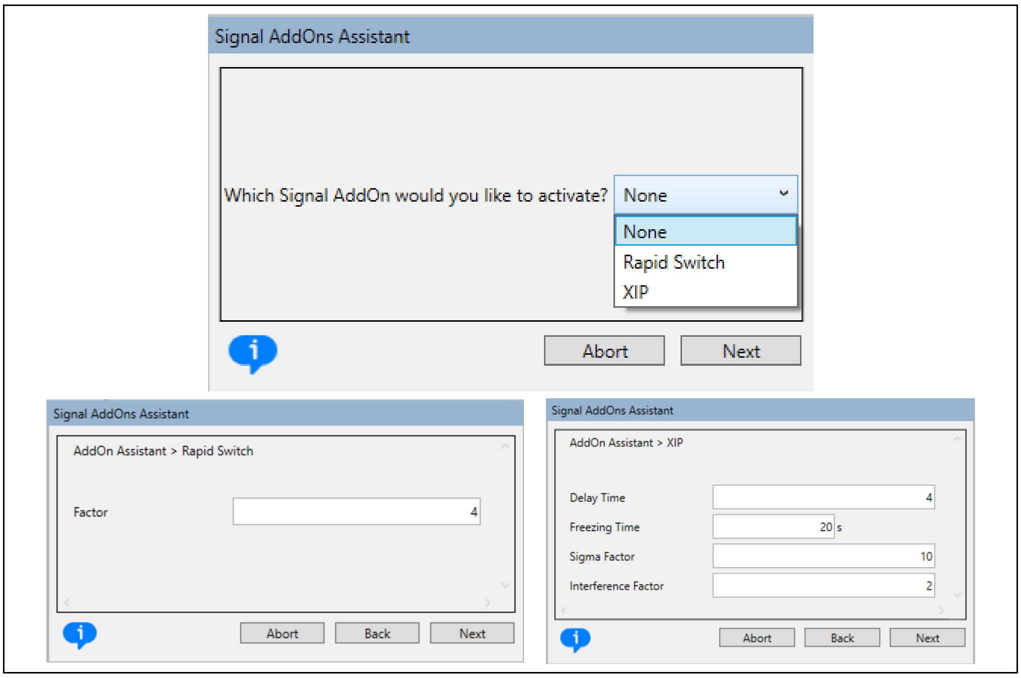


Fig. 31 Submenu: ***Assistant | SignalAddon Assistant***. Activation of Rapid Switch or XIP.

Rapid Switch	The activation of the rapid switch function is recommended when process values can change very quickly and sporadically (e.g., slurry detection in boreholes). When such a rapid process change is detected, the fast switching is automatically activated and sets the time constant to 1/10 of the set value, allowing the control unit to react

	more effectively to this process change. When activating fast switching, only the sigma value needs to be defined. This specifies the factor by which the count rate must change within two output cycles to activate the rapid switch function. Example calculation: The default value for sigma is 4.0, meaning the count rate must increase or decrease by a factor of 4 within two measurement cycles to activate fast switching.
XIP	XIP - short for "X-Ray Interference Protection," describes an internal function of the detector that detects stray radiation and protects both the measurement and the device from such interference. This function is particularly important when, for example, welding inspections are frequently carried out at the installation site. When stray radiation is detected with the XIP function activated, the detector will stop measuring for a certain period, and the measurement value will be frozen. This ensures that both the internal decay compensation and the measurement itself are not affected. Additionally, the detector is effectively protected from premature aging. To activate the XIP function, the following settings must be made: 1) **Delay Time**: Specifies the time after which XIP should be triggered when stray radiation is detected. The default value is set to 4 seconds. 2) **Freezing Time**: Specifies the time the measurement value should remain frozen after the delay time. A default of 20 seconds is recommended. 3) **Sigma Factor**: Defines a process signal-dependent count rate at which XIP should be activated. 4) **Interference Factor:** Defines a process signal-dependent threshold count rate at which XIP should be deactivated after the freezing time.

3.4.4 Submenu: Assistant | Adjust Assistant

With the help of the Adjust Assistant, calibration curves can be modified without the need to re-enter or re-read calibration data. This makes it easier, for example, to correct wall effects or avoid re-calibration after the replacement of the radiation source.

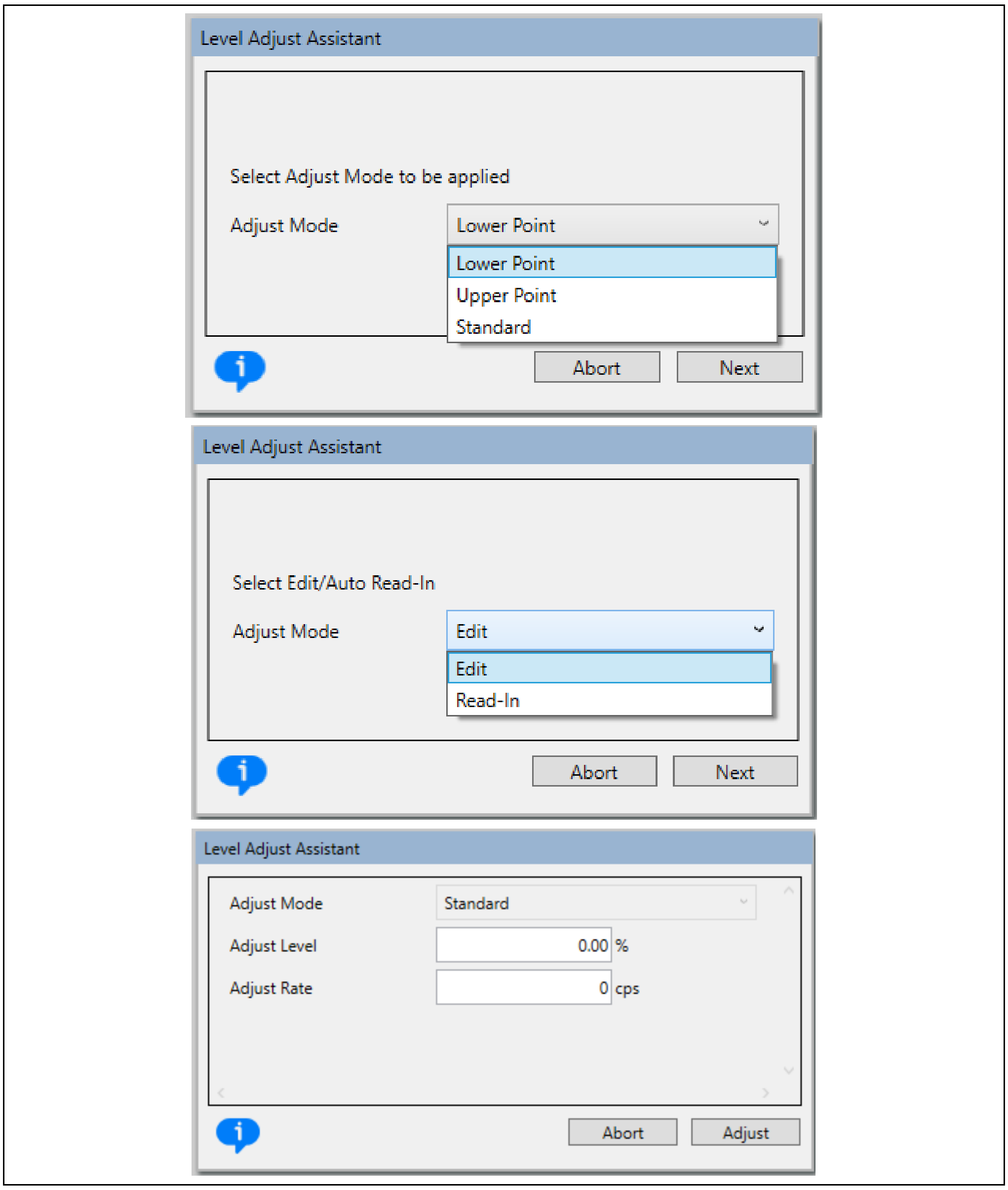


*Fig. 32 Submenu: **Assistant | Adjust Assistant**.*

Lower Point	Use this function if you: • Replace the radiation source and a curve with multiple calibration points has been entered. • Want to calibrate the measurement with a calculated curve and only a blank adjustment, possibly with a full adjustment. Changes made through the Lower Adjust also affect the entire calibration curve and will require the execution of **Calibrate** at the end.

Upper Point	Use this function if you want to adjust the entire calibration curve with an alignment of the upper calibration point. Changes made through the Upper Adjust also affect the entire calibration curve and will require the execution of **Calibrate** at the end.
Standard	Calculates a new calibration curve based on a pair of values (Adjust Level & Adjust Rate) and the stored calibration table. The new calibration table will then overwrite the existing one. Changes made through the Standard Adjust also affect the entire calibration curve and will require the execution of **Calibrate** at the end.

NOTICE

The Adjust Assistant is only relevant for the level application and cannot be selected in the density application.

3.5 Menu: Setup

3.5.1 Submenu: Setup | Device

3.5.1.1 Tab: Setup | Device | Identification

In the **"Identification"** tab, the factory-set product properties can be displayed, and device tags can be edited.

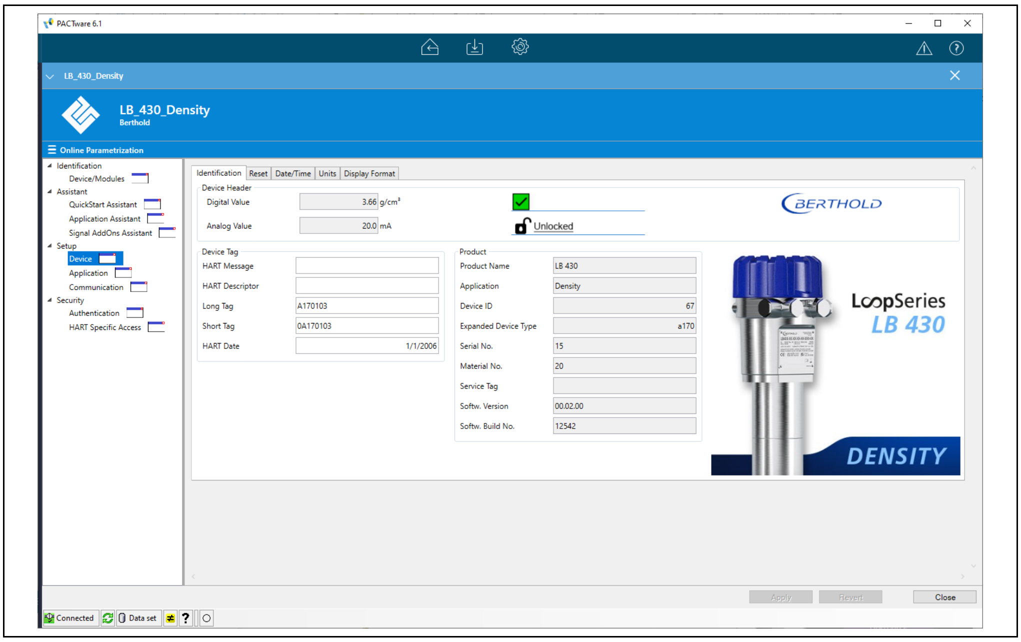


Fig. 33 Tab: *Setup | Device | Identification.*

3.5.1.2 Tab: Setup | Device | Reset

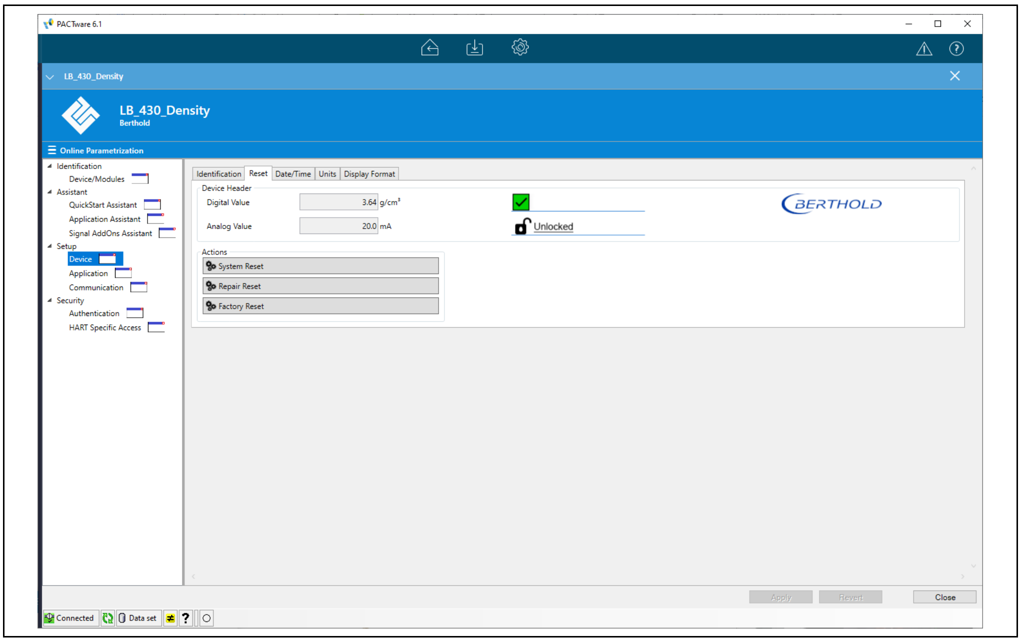


Fig. 34 Tab: *Setup | Device | Reset.*

In this tab, the detector can be restarted or reset to the factory settings. Three different types of resets are available:

Reset	Description
System Reset	Systemneustart des Komplettgerätes. Alle Einstellungen und Kalibrierdaten bleiben erhalten.
Repair Reset	Systemneustart der Prozessoreinheit. Korrumpierte Dateien in Flash-Speicher werden repariert. Nach Applikationswechsel auszuführen.
Factory Reset	Zurücksetzen des Gerätes auf Werkseinstellungen. Sämtliche Kalibrierdaten und Einstellungen gehen verloren.

NOTICE

If a communication interruption occurs during a detector software update, reinstallation may no longer be possible. By using the **Repair Reset**, button, the connection to the detector can be restored, and the update can be restarted.

3.5.1.3 Tab: Setup | Device | Date/Time

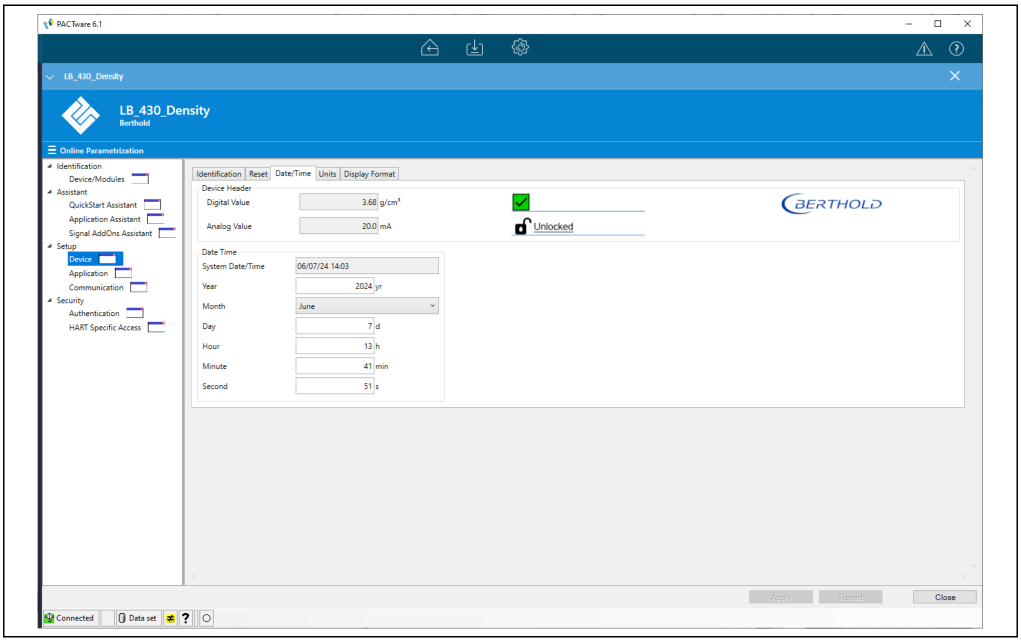


*Fig. 35 Tab: **Setup | Device | Date/Time**.*

In the **"Date/Time"** tab, the date and time can be entered or changed. The correct date is required for the automatic decay compensation of the isotope. Since the activity of the radiation source decreases over time, the calibration count rates are automatically compensated based on the date.

3.5.1.4 Tab: Setup | Device | Units

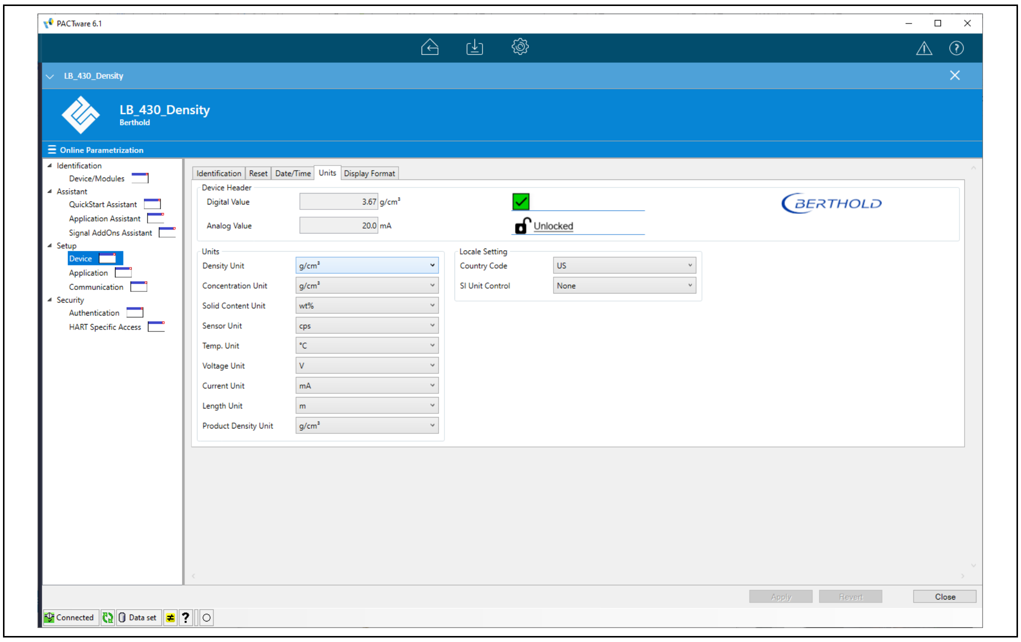


*Fig. 36 Tab: **Setup / Device / Units**.*

In the **"Units"** tab, the available units for the measurement values are listed by clicking the respective selection arrow. The selected unit will be used in the display and in the calibration settings.

3.5.1.5 Tab: Setup | Device | Display Format

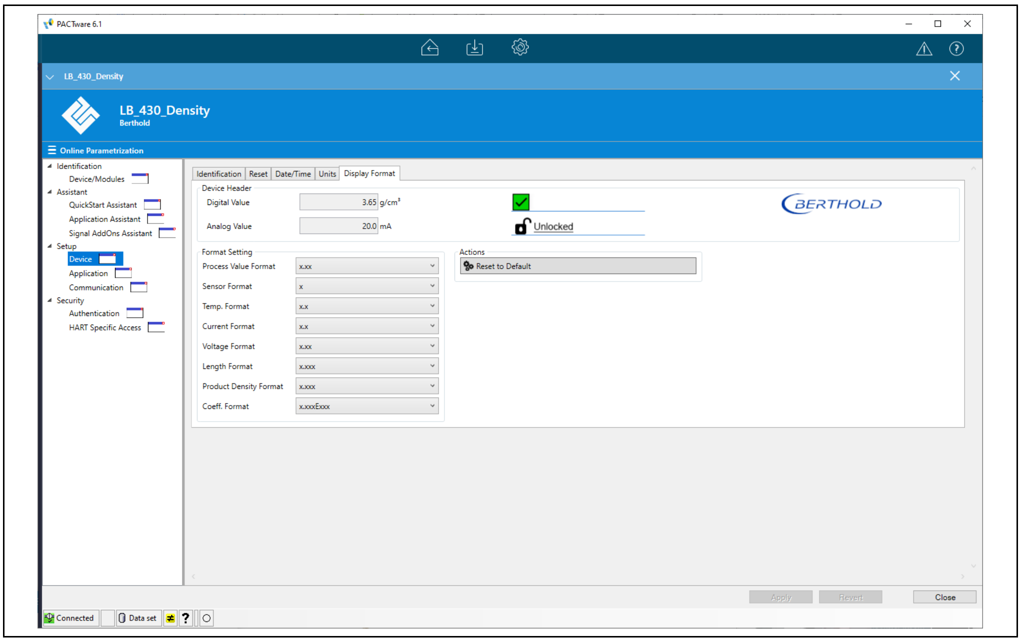


*Fig. 37 Tab: **Setup / Device / Display Format**.*

In the **"Display Format"** tab, the number of decimal places for the respective values can be defined. By pressing the **Reset to Default** button, the factory-set decimal places will be restored.

3.5.2 Submenu: Setup | Application

3.5.2.1 Tab: Setup | Application | Sensors

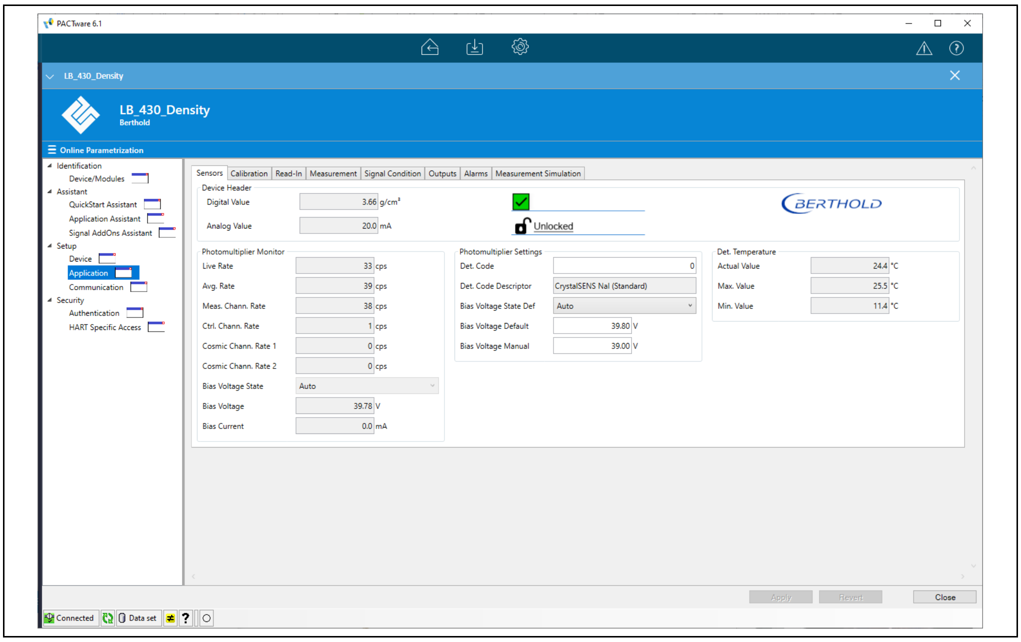


*Fig. 38 Tab: **Setup | Application | Sensors**.*

In the **"Sensors"** tab, the raw count rates of the photomultiplier and the detector temperature are displayed. In the "Photomultiplier Settings" field, the detector code and the voltage can be modified.

By setting the detector code, the internal device parameters are adjusted to the used scintillator size. The correct detector code is set at the factory, and changes are generally not required.

NOTICE

The default voltage is preconfigured by Berthold, and typically, no changes are necessary. The use of the "Manual" mode as a normal operating mode for high-voltage control is not recommended by Berthold. The "Manual" selection should only be used for service purposes.

3.5.2.2 Tab: Setup | Application | Calibration

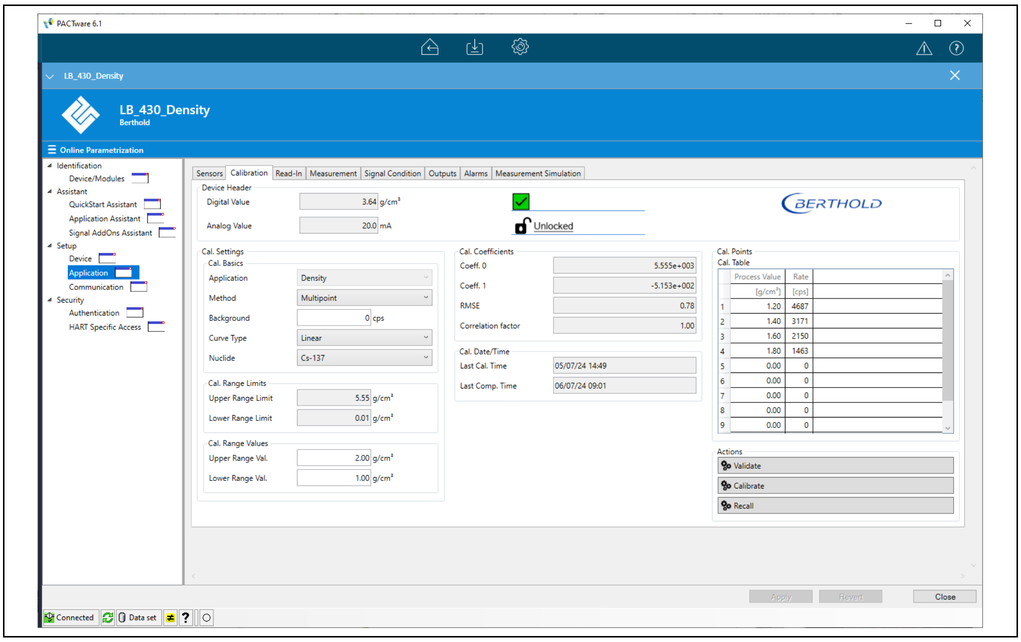


*Fig. 39 Tab: **Setup | Application | Calibration**.*

In the **"Calibration"** tab, all settings for calibrating the measurement system can be configured. It is important to note that the configured calibration parameters will only affect the measurement after executing the **Calibrate** function.

NOTICE

Damage to the device or system!
Errors in calibration or parameter settings can lead to incorrect measurement results. This may potentially result in production downtime or damage to the system.

- We recommend having the calibration and commissioning performed by Berthold Service.

Calibration Settings

In the "Cal. Settings" field, basic calibration settings are defined in the selection fields "Method" and "Curve Type." More information can be found in Chapter *3.6 Calibration methods and curve types*.

In the "Background" field, the background count rate is displayed, which can be determined in the "Read-In" submenu.

In the "Nuclide" selection field, the isotope used can be selected. The isotope of the radiation source must be chosen. The source isotope is specified on the type plate of the shield.

In the "Cal. Range Value" field, the lower and upper limits of the process range for the active measurement parameter set can be configured. These values define the signal range of the analog current output (4 ... 20 mA or 0 ... 20 mA).

NOTICE

The Cal. Range Values must be within the Cal. Range Limits, which are displayed in the box above and are dependent on the calibration points in the calibration table.

Calibration Points

In the "Cal. Points" field, you can add, edit, and delete calibration points.

NOTICE

The number of calibration points is determined by the selection in the "Method" field.

- Please refer to the details in Chapter *3.6 Calibration methods and curve types*. for further guidance.

The inputs and adjustments to the calibration points can be checked using the **Validate** button. When the **Calibrate** button is clicked, the validation process is automatically performed, followed by calibration.

The **Recall** button allows you to overwrite the measurement parameter set into the calibration parameter set.

3.5.2.3 Tab: Setup | Application | Read-In

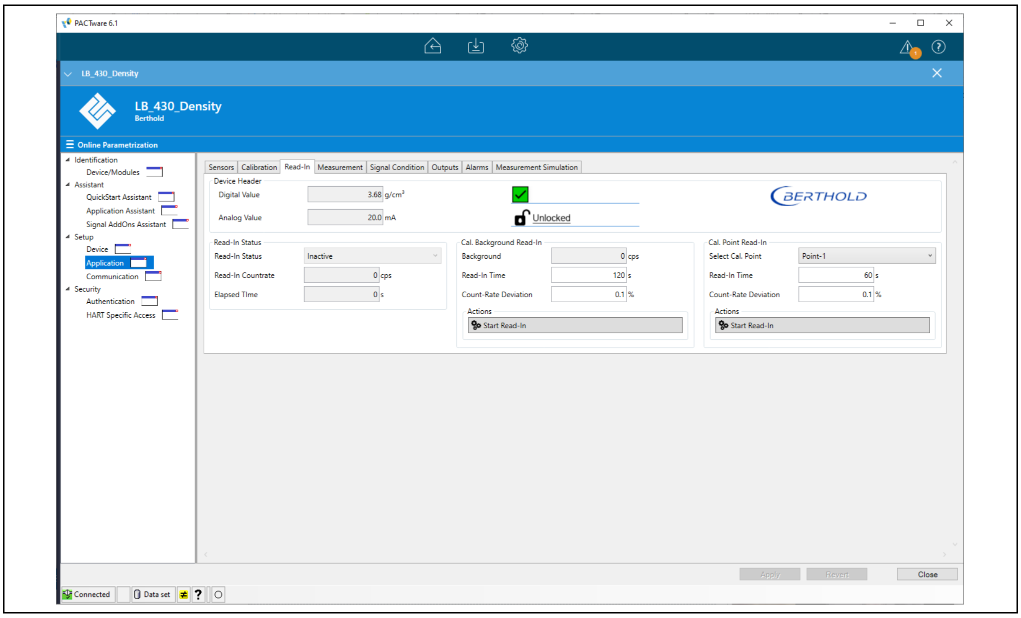


Fig. 40 Tab: ***Setup | Application | Read-In.***

In the tab **"Read-In"**, you can configure the read-in time for background determination and calibration points. The read-in process can then be started using the **Read-In** buttons. Two options are available for determining the read-in time and accuracy, providing flexibility to suit your specific requirements.

Read-In Time	The maximum read-in time can be configured. By default, the system sets a read-in time of **120 seconds** for background count rates and **60 seconds** for calibration points, which typically have significantly higher count rates. The minimum Read-In Time that can be configured is **60 seconds.**
Count-Rate Deviation	This setting allows you to specify a desired average deviation of the count rate in percentage. If the desired deviation is achieved during the read-in process, the routine will be completed before the configured time elapses. The higher the set deviation, the less time is required for the read-in process. By default, the deviation is set to **0.1%**.

3.5.2.4 Tab: Setup | Application | Measurement

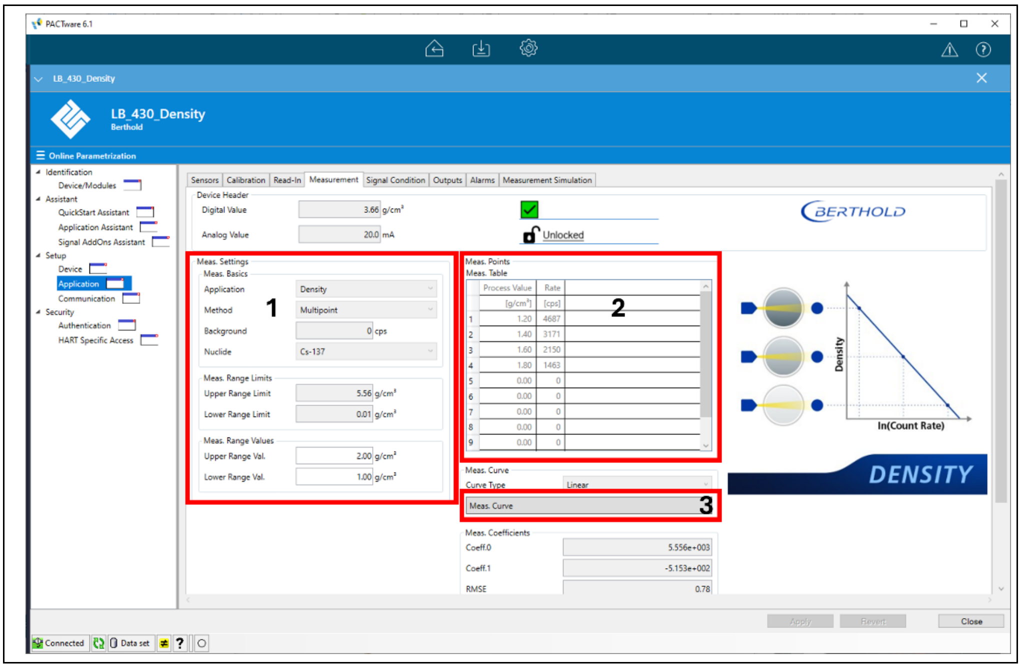


*Fig. 41 Tab: **Setup | Application | Measurement**.*

The tab **"Measurement"** provides an overview of the current measurement settings. The following elements can be viewed and verified:

- **Meas. Settings**: Displays the relevant settings for the measurement (Fig. 41, Pos. 1).
- **Meas. Points**: Shows the current calibration table (Fig. 41, Pos. 2), providing an overview of the calibration values currently in use.
- **Meas. Curve**: Enables visualization and verification of the measurement curve (via the **Meas. Curve** button, Fig. 41, Pos. 3).

3.5.2.5 Tab: Setup | Application | Signal Conditions

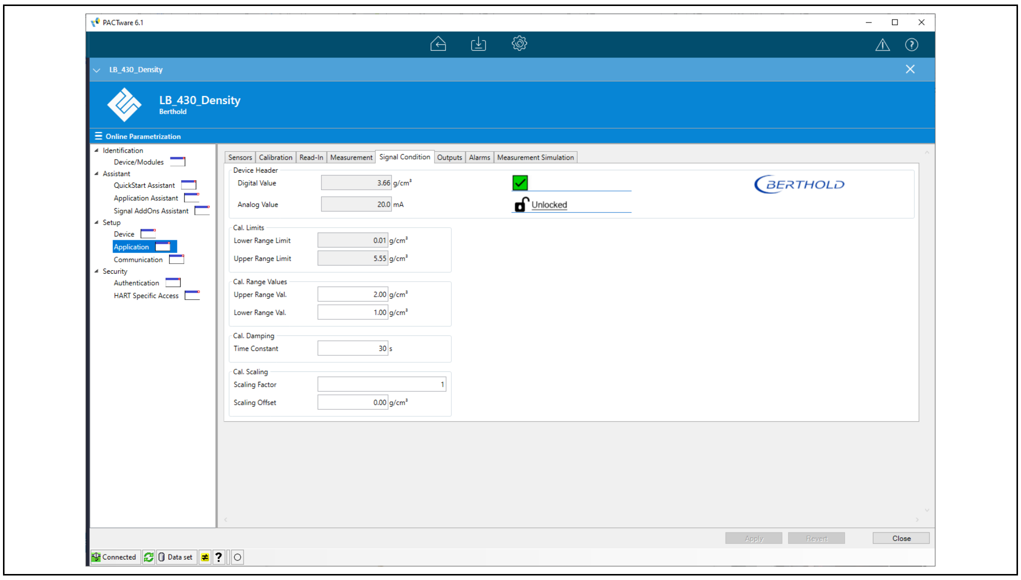


*Fig. 42 Tab: **Setup / Application / Signal Condition**.*

In the **"Signal Conditions"** tab, you can see the range limits and configure the range values, damping (time constant), and scaling.

Upper/Lower Range Limit	Displays the lower limit of the measurement range, which is calculated by the system based on the calibration. The values of the defined measurement range (Upper/Lower Range Value) must lie within these limits.
Upper/Lower Range Value	Upper and lower process value limit: Under this setting, it can be specified which process value the maximum current of 20 mA and which process value the minimum current of 4 mA should correspond to.
Time Constant	The time constant determines the time window over which a moving mean value filter is applied to the measured count rate and is thus responsible for smoothing the output signal. With small time constants (minimum 1 second), faster process changes (approximately 3 seconds) can be better responded to, but the signal will contain more statistical noise. The default setting for the time constant is 20 seconds.
Scaling Factor	A factor by which the measured value is multiplied. This allows for correcting deviations in the calibration. It enables adjustment to changed operating conditions, such as deposits or wear on the pipe wall, without the need for recalibration. The default value is 1. The corrected display, considering the offset and factor, is calculated as follows: **Display = Measured Value × Factor + Offset**
Scaling Offset	If the measurement was calibrated in a different range, the calibration curve can be shifted parallel by specifying an offset, without the need to re-enter the calibration values.

NOTICE

Changes to the Scaling Offset and Scaling Factor directly affect the measured value.

3.5.2.6 Tab: Setup | Application | Output

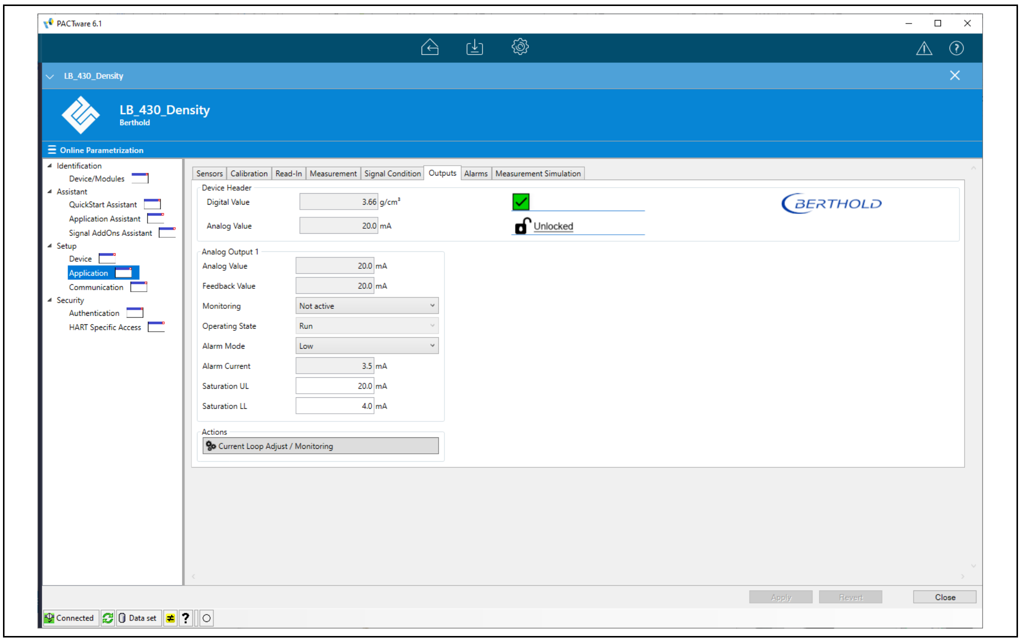


*Fig 43 Tab: **Setup | Application | Output**.*

Here, you can activate or deactivate the monitoring of the 4 … 20 mA current signal. The monitoring checks whether the set current is flowing in the current loop and reports an error if there is a deviation. Additionally, the alarm mode can be configured, meaning you can determine which error current will be output in the event of a failure.

Alarm Mode High	In the event of a failure, the current output will be set to **>21 mA**.
Alarm Mode Low	In the event of a failure, the current output will be set to **<3.6 mA**.

If there are deviations between the setpoint and the actual value of the current signal, the current output can be recalibrated. The **Current Loop Adjust / Monitoring** button allows for the verification or calibration of the current output.

3.5.2.7 Tab: Setup | Application | Alarms

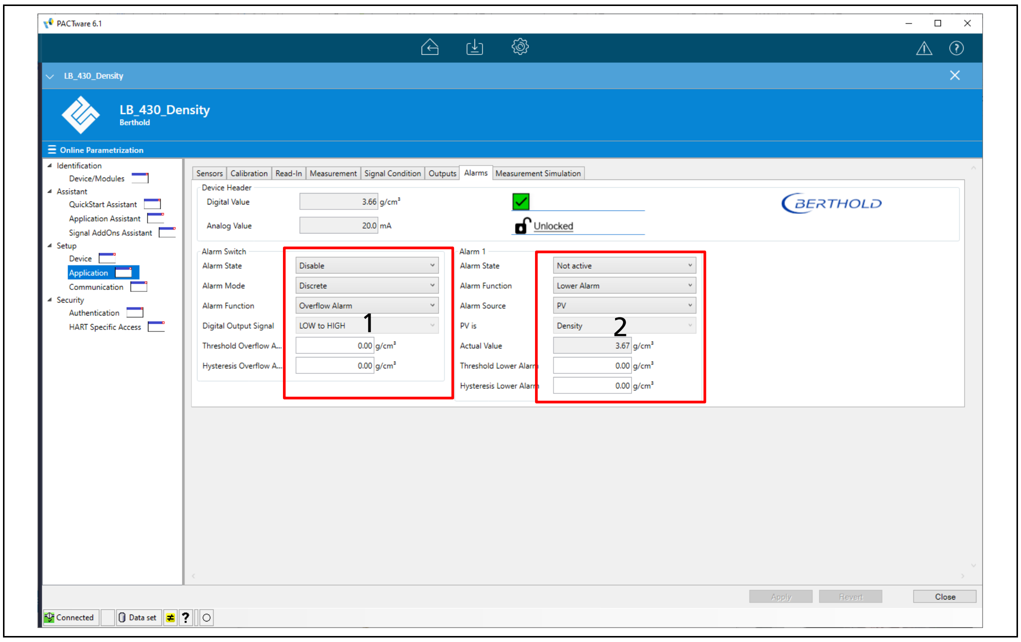


*Fig 44 Tab: **Setup | Application | Alarms**.*

In the **"Alarms"** tab, both the **Switch Alarm** ("Alarm Switch" in Fig. 40, Pos. 1) and the **Standard Alarm** ("Alarm 1" in Fig. 40, Pos. 2) can be configured. Different settings can be made for both alarm systems.

Alarm State	Indicates whether the alarm is **active** ("Active") or **in-active** ("Not Active").
Alarm Mode	**Alarm Switch:** Here, you can choose between **„Continuous“** and **„Discrete“** modes. • In **„Continuous“** mode, the measurement signal is represented over or under the switch value via the current output. • In **„Discrete“** mode, only the two switch current values are differentiated. **Alarm 1:** Differentiates between **„Upper Alarm“**, **„Lower Alarm“**, and **„Upper AND Lower Alarm“**. This allows setting upper or lower alarm limits for the selected process variable. The threshold and hysteresis settings are automatically adjusted to match the cho-sen mode.
Alarm Function	Selection between **„Overflow Alarm“** and **„Under-flow Alarm“**. This option is only available for the Switch Alarm. • **Overflow Alarm:** The alarm is activated when the value exceeds the set threshold. • **Underflow Alarm:** The alarm is activated when the value falls below the set threshold. The choice of alarm function directly impacts the **„Dig-ital Output Signal“**. **Example:**

	• If **„Overflow Alarm"** is selected with a threshold at 80% and a hysteresis of 5%, the alarm will deactivate at 75%. • If **„Underflow Alarm"** is selected with a threshold of 20% and the same hysteresis, the alarm will deactivate at 25%.
Digital Output Signal	Only for the **Switch Alarm**. Depending on the chosen alarm function, either a **„LOW to HIGH"** signal (for Overflow Alarm) or a **„HIGH to LOW"** signal (for Underflow Alarm) will be output.
Analog Output Signal	Here, the analog output signal can be adjusted. The following configurations are available: • 8 mA to 16 mA • 16 mA to 8 mA • 4mA to 20 mA • 20 mA to 4 mA
Alarm Source / **PV/SV/TV/QV is/** **Actual Value**	Only available for **Standard Alarms**. The **Switch Alarm** is limited to the **Primary Value (PV)**. Here, the source HART variable for the alarm (PV/SV/TV/QV) can be set. The physical variable mapped to the selected HART variable will be displayed in the **„PV/SV/TV/QV is"** field. The current value of this variable will be visible in the **„Actual Value"** field.
Threshold	The **Threshold** defines the limit above which the alarm will be triggered.
Hysteresis	The **Hysteresis** defines the value below (or above) which the alarm will no longer be triggered once it has been activated. **Example:** • If **„Upper Alarm"** is selected with a threshold at 80% and a hysteresis of 5%, the alarm will deactivate at 75%. • If **„Lower Alarm"** is selected with a threshold of 20% and the same hysteresis, the alarm will deactivate at 25%.

3.5.2.8 Tab: Setup | Application | Measurement Simulation

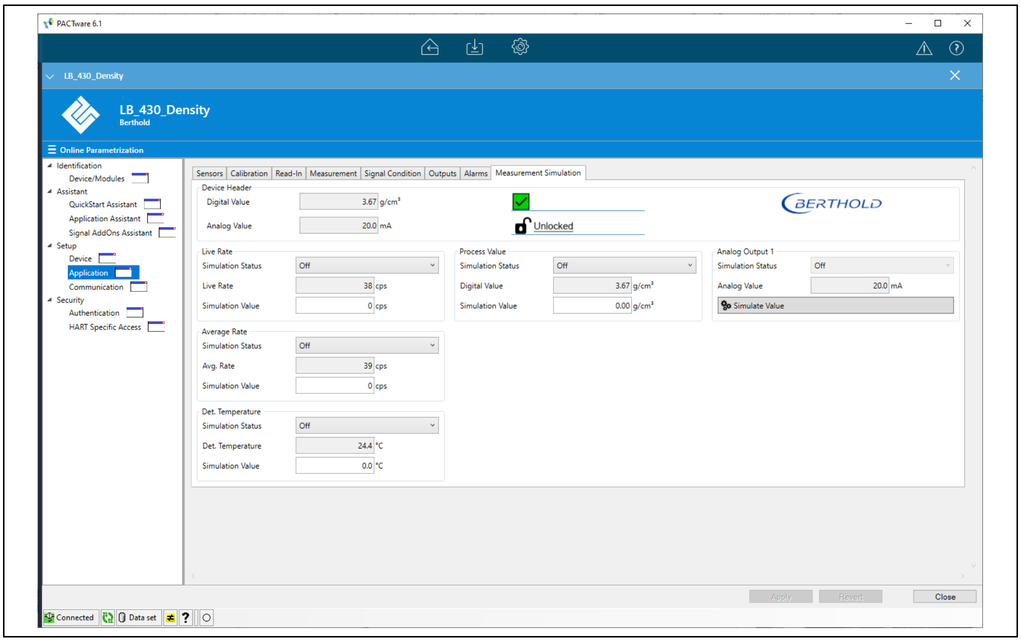


Fig 45 Tab: Setup | Application | Measurement Simulation.

In the tab **"Simulation"**, it is possible to simulate the live count rate, the averaged count rate, the detector temperature, as well as the process value or the analog current output, to test the functionality of the configuration.

To simulate a specific process value, the "Simulation Status" option must first be set to "On." The simulated value can then be entered in the "Simulated Value" field, while the measured values are displayed in the respective fields: "Live Rate," "Avg. Rate," "Det. Temperature," and "Digital Value."

The analog current output can be simulated using the "Analog Output 1" box. To do so, a value to be simulated must be entered, and the **Simulate Value** button must be pressed.

The simulation is started by clicking the **Apply** button.

NOTICE

Don't forget to switch from ON to OFF after testing or to restart the device; otherwise, the test values will remain frozen.

3.5.3 Submenu: Setup | Communication

3.5.3.1 Tab: Setup | Communication | Communication

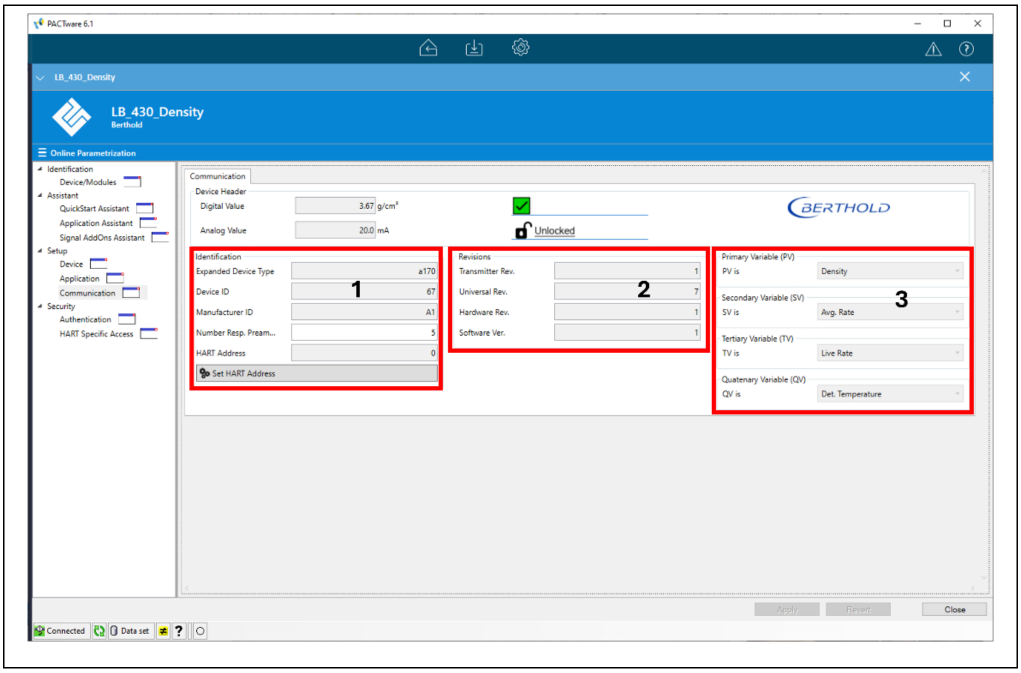


Fig 46 Tab: ***Setup | Communication | Communication***.

In the **"Communication"** tab, you can view the factory-set product properties (Fig 46, Pos. 1), the revision status of the HART protocol (Fig 46, Pos. 2), and the assigned HART variables. By pressing the **Set HART Address** button, a new HART address can be assigned to the device for communication with the control system.

3.6 Calibration methods and curve types

The basic principle of radiometric measurement systems lies in the interaction of gamma radiation with a product to be measured and the detection of the radiation after this interaction. As shown in Fig 47, the setup of a radiometric measurement requires a radioactive source, a container with the product to be measured, and a detector for gamma radiation. For simplicity, the explanation here employs a basic density measurement using a point source-point detector arrangement on opposite sides of the container. However, it should be noted that more complex arrangements are possible for radiometric measurements, especially for level detection. These are explained in more detail in the corresponding Chapter 3.6.1.2 Typical measurment arrangements.

If the gamma radiation has an initial intensity I_0 at the source, it is attenuated to an intensity I after passing through the container and interacting with the measurement product. This process is physically described by the law of absorption:

$$I = I_0 \cdot e^{-\mu \rho d}$$

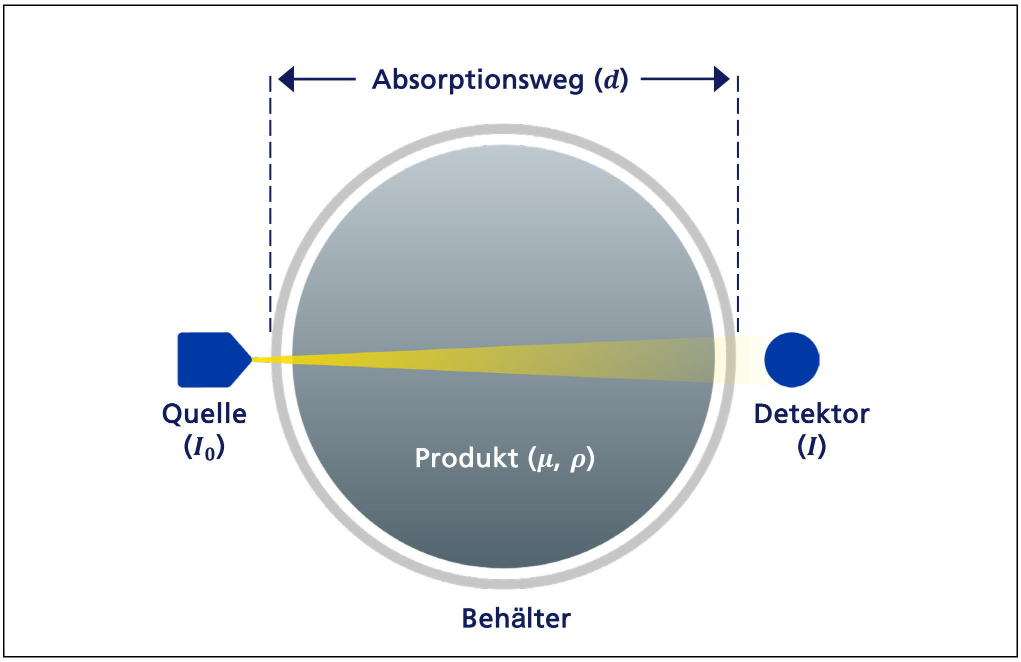


Fig 47 Setup of a radiometric measurement.

Here, ρ represents the density of the material being penetrated, and d denotes the absorption path, i.e., the distance the radiation travels from the source to the detector. The parameter μ refers to the mass attenuation coefficient, which is both a property of the material being penetrated and dependent on the radiation's energy.

It is worth noting that for many common radiation energies (e.g., from Cs-137 or Co-60), the dependence of μ on the material being penetrated is negligibly small.

The intensity I is typically measured as a count rate at the detector, which reflects the number of gamma quanta detected by the scintillation counter in the form of light flashes. For more information on scintillation and the technology underlying our radiation detectors, please visit our Knowledge Base at www.berthold.com.

3.6.1 Application: Level

The radiometric determination of the level in containers is based on the coverage of the radiation field emitted by the radioactive source by the material inside the container. The higher the level of the material, the more the radiation field generated by the source is covered, resulting in a lower measurement signal.

3.6.1.1 Calibration of a level measurement

When calibrating a level measurement system, a calibration curve must be determined that links the level within the container to a specific count rate I measured by the detector. The system then calculates the continuous level along this curve, even between the empirically determined calibration points.

Since the shape of the calibration curve for arbitrary arrangements of the source and detector depends on numerous factors – such as the detector's sensitivity, the angle of incidence of the radiation, the geometry of the container, and the energy of the radiation source – radiometric systems must support multiple calibration methods. This flexibility ensures that these systems can effectively accommodate a wide range of measurement configurations.

2-Point calibration – linear curve

For calibration, exactly two count rates I are required. These should represent the minimum (hereafter referred to as 0) and maximum (hereafter referred to as 1) levels within the sensitive measurement range to achieve the highest measurement accuracy. Between these two points, the measured value is linearly interpolated.

This calibration method assumes that the system's calibration curve is strictly linear. The linearity is described by the following equation:

$$I(\text{Level}) = m \cdot \text{Level} + c$$

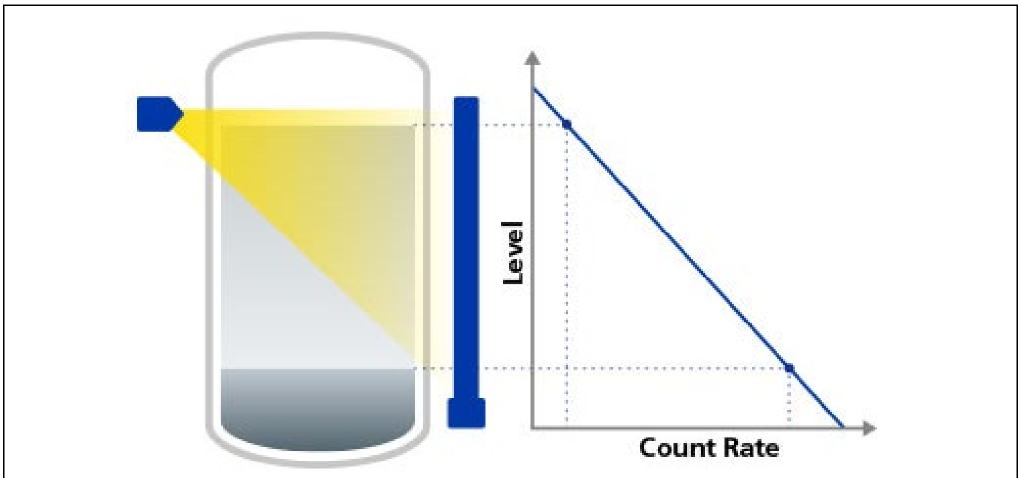


Fig 48 2-Point calibration – Linear Curve.

The slope of the line m and the intercept with the y-axis c are determined based on the two calibration points $I(0)$ and $I(1)$ as follows:

$$c = I(0)$$
$$m = I(1) - I(0)$$

IMPORTANT

A linear calibration curve for level measurements is not feasible for all measurement configurations but is essential for this type of calibration. For configurations using rod sources from Berthold, this calibration method can be applied without concern. However, configurations with point sources may exhibit significant deviations between the two calibration points, making the linear assumption less accurate in those cases.

2-Point calibration – exponential curve

Similar to the linear 2-Point calibration, *exactly two* count rates I are required here as well. These should also represent the minimum (hereafter referred to as 0) and maximum (hereafter referred to as 1) levels within the sensitive measurement range to achieve the highest measurement accuracy.

The two count rates are logarithmized, and linear interpolation is performed between the logarithmized values. The relationship is expressed as:

$$\text{Level} = m \cdot \ln I(\text{Level}) + c$$

By applying the reverse transformation, the following calibration curve equation is obtained:

$$I(\text{Level}) = e^{\frac{\text{Level}-c}{m}}$$

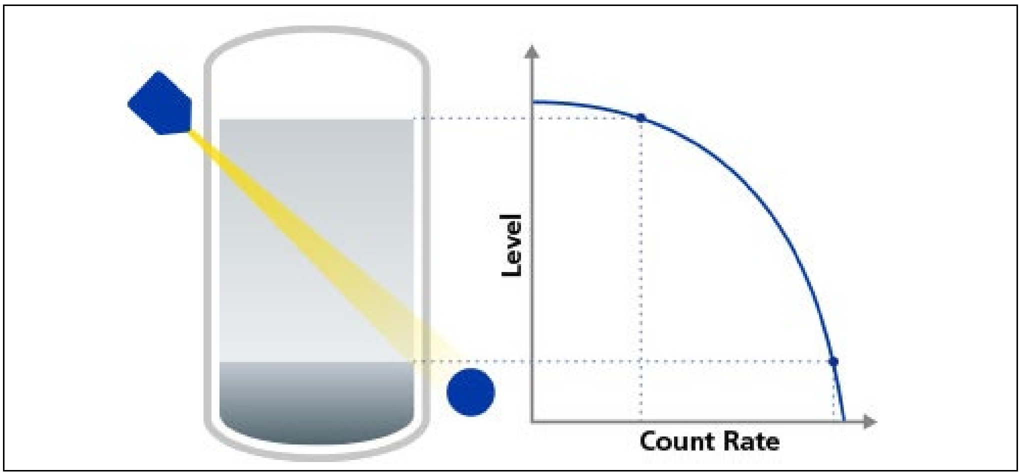


Fig 49 2-Point calibration – Exponential curve.

IMPORTANT

Exponential 2-Point calibration is intended only for specialized applications where the calibration curve resembles an exponential function and multi-point calibration is not possible. An example of this is absorption level measurements with a point-source point-detector arrangement (Fig. 49). This arrangement is explained in more detail in the following Chapter *3.6.1.2 - Typical measurement arrangements*.

Multipoint calibration

In some configurations, it is not possible to achieve a linear calibration curve due to various factors such as the radiation field geometry, container geometry, or the specific arrangement used. In such cases, multipoint calibration can be utilized. A minimum of two and a maximum of eleven calibration points are recorded. Linear interpolation is performed in the segments j between the respective calibration points I_{j-1} und I_{j+1}.

$$I(\text{Level}_{\text{egment j}}) = m_{\text{Segment j}} \cdot \text{Level}_{\text{Segment j}} + c_{\text{Segment j}}$$

A nonlinear calibration curve can thus be approximated by a maximum of 10 linear segments.

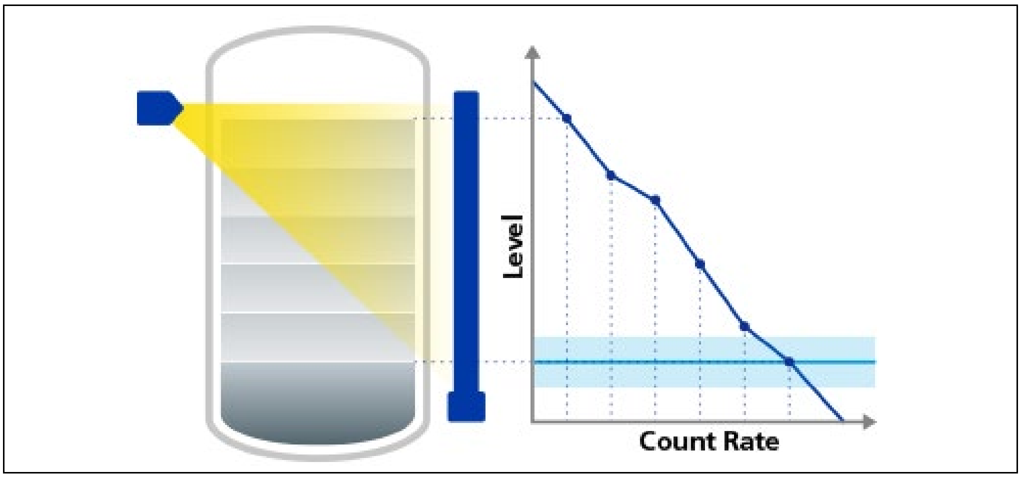


Fig 50 Multipoint calibration.

The slopes $m_{\text{Segment j}}$ and y-axis intercepts $c_{\text{Segment j}}$ of the respective segments are determined by the system based on the adjacent calibration points I_{j-1} und I_{j+1}, just as in the linear two-point calibration.

$$c_{\text{Segment j}} = I_{j-1}$$
$$m_{\text{Segment j}} = I_{j+1} - I_{j-1}$$

IMPORTANT

Multipoint calibration provides the highest accuracy in almost all level measurements with the fewest required prerequisites. It is therefore recommended to use this calibration method whenever possible. All other calibration methods are associated with assumptions. Not meeting these assumptions can lead to significant deviations in the measured value.

1-Point calibration – linear curve

The linear one-point calibration can be used when it is not possible to determine more than one calibration point. This calibration method requires a count rate I_n at any level n, the product and gas density (ρ_L, ρ_G), the background count rate I_BG, as well as the absorption path d and the mass attenuation coefficient of the product μ. The system then calculates the count rates at 0% and 100% fill levels approximately and performs a linear interpolation like a two-point calibration.

$$I_{0\%} = \frac{I_\mathrm{n} - I_\mathrm{BG}}{1 - \frac{\mathrm{n}}{100\%} \cdot \left(1 - \mathrm{e}^{-\mu \cdot (\rho_\mathrm{L} - \rho_\mathrm{G}) \cdot d}\right)} + I_\mathrm{BG}$$

$$I_{100\%} = (I_{0\%} - I_\mathrm{BG}) \cdot \mathrm{e}^{-\mu \cdot (\rho_\mathrm{L} - \rho_\mathrm{G}) \cdot d} + I_\mathrm{BG}$$

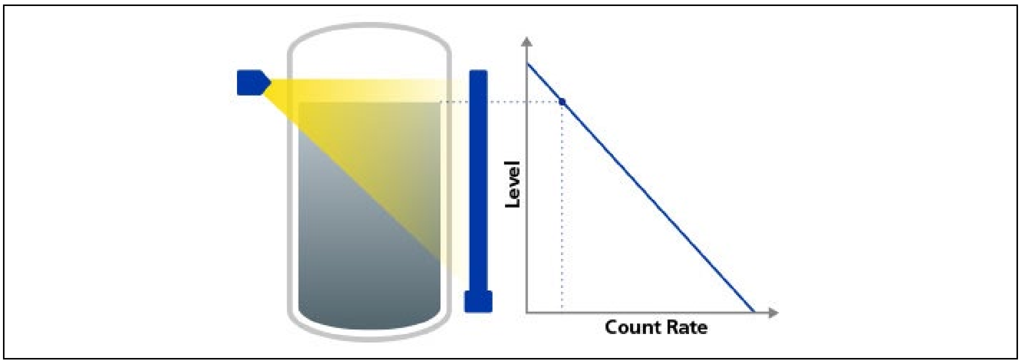


Fig 51 1-Point calibration – linear curve.

IMPORTANT

It is important to note that the following assumptions must be made when using the linear one-point calibration method:

1. **Linearity of the Calibration Curve**

   This is only accurately achieved when using a rod source with a precisely planned activity distribution. When point sources are used, the calibration curve is generally nonlinear. The use of multiple point sources can partially linearize the curve.
2. **Knowledge of the Correct Product and Gas Density**

   In practice, determining the product and gas density is challenging, and estimated or calculated values are often used, which can significantly deviate from actual values. If incorrect values for product and gas density are used in the calculation, the computed count rates will also be inaccurate.
3. **Internal diameter of the container matches the absorption path**

   In continuous radiometric level measurements (excluding absorption-based level measurements), the average absorption path is always larger than the container's internal diameter due to geometry. The difference increases with the beam angle of the radiation field.

If these assumptions are not fully or only partially met, the calculated calibration curve will deviate correspondingly from the actual calibration curve.

1-Point calibration – exponential curve

The exponential one-point calibration can be used when it is not possible to determine more than one calibration point, and it is known that the calibration curve follows an exponential trend. This calibration method requires a count rate I_n at any level n, the product and gas density (ρ_L, ρ_G), the background count rate I_{BG}, the absorption path d at 100% level, and the mass attenuation coefficient of the product μ benötigt.

The system approximates the count rate $I_{100\%}$ at 100% level and performs a linear interpolation using the logarithmic values $\ln I_n$ and $\ln I_{100\%}$, like an exponential two-point calibration.

$$I_{100\%} = (I_n - I_{BG}) \cdot e^{-\mu \cdot (\rho_L - \rho_G) \cdot d_{100\%} \cdot \left(1 - \frac{n}{100\%}\right)} + I_{BG}$$

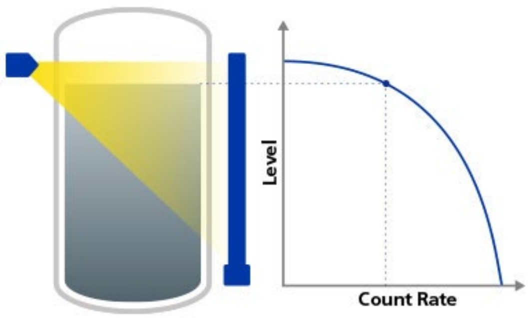


Fig 52 1-Point calibration – exponential curve.

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It is important to note that the following assumptions must be made when using the linear one-point calibration method:

1. **Knowledge of the correct product and gas density**

   In practice, determining the product and gas density is challenging, and estimated or calculated values are often used, which can significantly deviate from actual values. If incorrect values for product and gas density are used in the calculation, the computed count rates will also be inaccurate.

2. **Internal diameter of the container matches the absorption path**

   In continuous radiometric level measurements (excluding absorption-based level measurements), the average absorption path is always larger than the container's internal diameter due to geometry. The difference increases with the beam angle of the radiation field.

If these assumptions are not fully or only partially met, the calculated calibration curve will deviate correspondingly from the actual calibration curve.

An exponential one-point calibration, like the exponential two-point calibration, is only suitable for specific measurement arrangements, such as absorption-based level measurement, and should not be used for any other setup.

3.6.1.2 Typical measurment arrangements

Point source – Rod detector

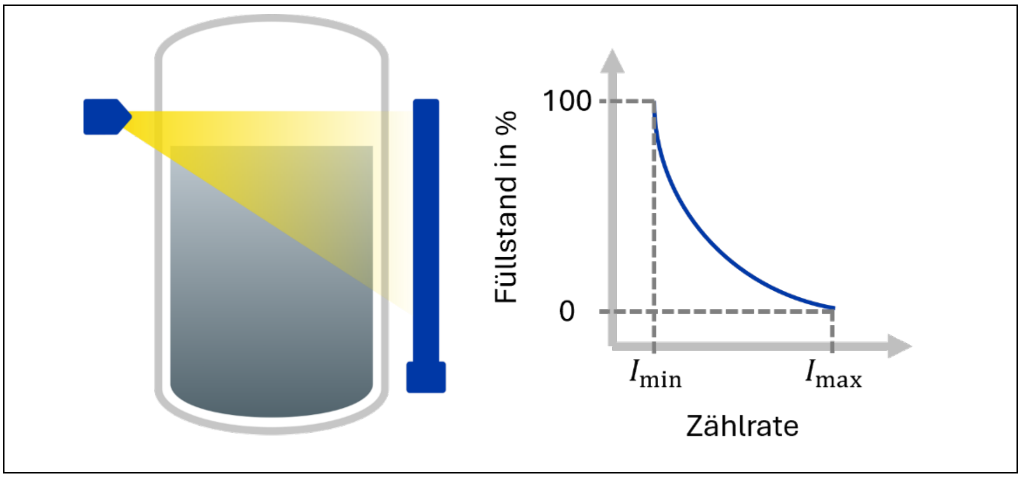

Fig 53 Measurement arrangement: Point source – Rod detector

The point source-rod detector arrangement is the simplest and most cost-effective way to realize a level measurement and is considered a standard setup. The point source is typically mounted so that it forms a line with the upper limit of the sensitive detector area. The beam angle of the source is chosen to illuminate the entire sensitive area of the detector. Due to the geometry of the setup, the calibration curve tends to have a parabolic shape, as both the amount of material being irradiated and the angle of incidence of the radiation vary along the sensitive detector area. While a two-point calibration is possible, a multipoint calibration is clearly recommended to achieve the required measurement accuracy across the entire range.

Rod source – Point detector

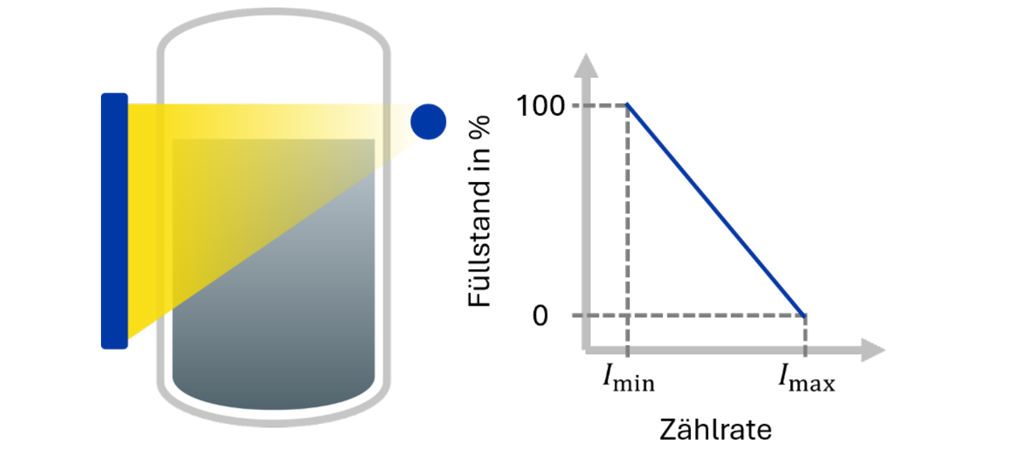

Fig 54 Measurement arrangement: Rod source – Point detector

The rod source-point detector arrangement is the simplest setup that allows for control of the radiation field in such a way that a true linear calibration curve results. In this arrangement, the density of the winding of the radioactive cobalt wire in the rod source is controlled during production to compensate for the nonlinear radiation field geometry.

A clear advantage of this setup is that it provides a technically elegant solution for level measurement. On one hand, the linearity of the calibration curve is ensured, which allows the system to be easily commissioned with a simple two-point calibration and provides the best accuracy between the two calibration points. On the other hand, the use of rod sources typically involves the isotope Co-60, which emits approximately twice the gamma energy compared to the isotope Cs-137, which is preferably used in point sources. This results in reduced influence from variables such as fluctuating gas pressure, process deposits, or weld inspection on the measurement. Another advantage of this arrangement is the simplified replacement of detectors should a malfunction occur.

Rod source – Rod detector

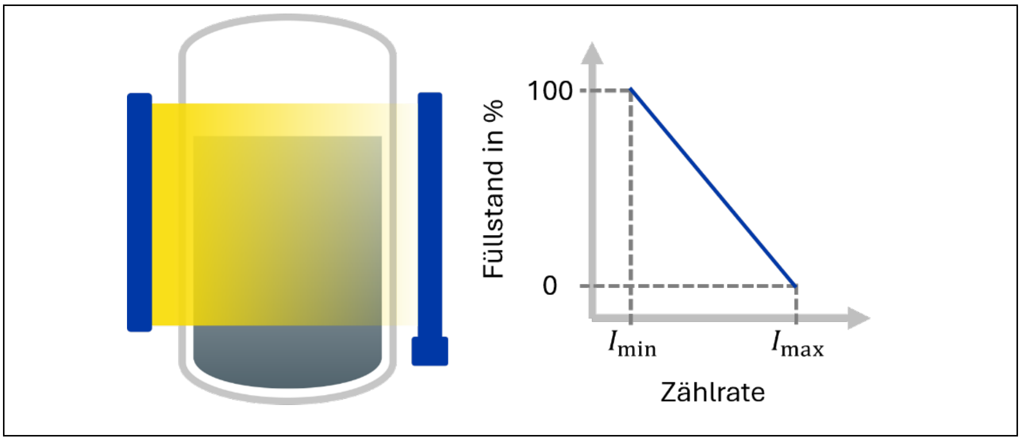

Fig 55 Measurement arrangement: Rod source – Rod detector.

With a rod source-rod detector arrangement, a linear calibration curve can be specifically tailored to the measurement setup through the special winding of the cobalt wire. Compared to the rod source-point detector arrangement, this setup requires less complex winding of the cobalt wire, as the geometry of the radiation field itself ensures the linearity of the calibration curve. Only the container geometry or product properties need to be considered during custom manufacturing.

Advantages of this arrangement include, on one hand, the linearity of the calibration curve, allowing the system to be easily commissioned with a simple two-point calibration without deviations. On the other hand, the use of rod sources involves the isotope Co-60, which emits approximately twice the gamma energy of the isotope Cs-137, which is primarily used in point sources. As a result, variables such as fluctuating gas pressure or process deposits have less influence on the measurement.

However, weld inspections may have a slightly greater impact on the measurement due to the use of rod detectors. Therefore, the use of the X-Ray Interference Protection (XIP)- or the Radiation Interference Discrimination (RID) function (www.berthold.com) is recommended.

Point source – Point detector (Absorption level measurement)

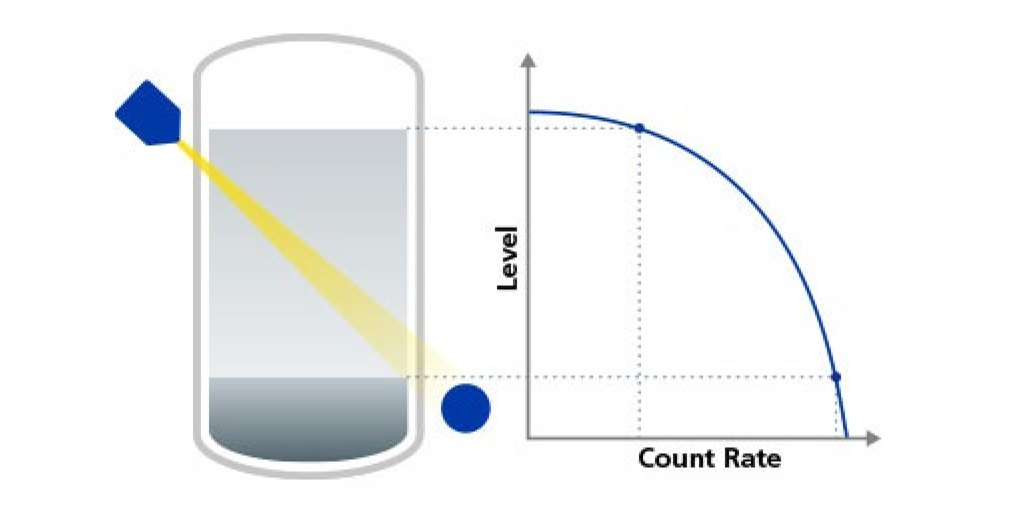

Fig 56 Measurement arrangement: Point source – Point detector for absorption level measurement.

The point source-point detector arrangement is typically used for density or switch measurements and is only applied in a few exceptions for level measurement. This is a more specialized application, generally referred to as "absorption level measurement," which, as the name suggests, involves an absorption measurement rather than a measurement of radiation field coverage. In this arrangement, multipoint calibration is also recommended, as factors such as container geometry, gas pressure, or product properties cannot be ignored. If only two calibration points can be recorded, an exponential two-point calibration is recommended, as it better describes the absorption of gamma radiation by the medium than a linear calibration curve.

3.6.2 Application: Density

The radiometric determination of density works differently from level measurement. Here, the focus is not on how much radiation is shielded by the measured product, but rather on how much gamma radiation is absorbed as it passes through the material. If the absorption path d and the mass attenuation coefficient μ remain constant, the material's density can be calculated using the attenuation law along with the measured and reference radiation intensities.

This means that the measurement signal decreases as the density of the measured product increases. By measuring the density, other process values that depend on it can also be determined. These process values are part of the density application and are referred to as the "measurement mode" in Berthold devices.

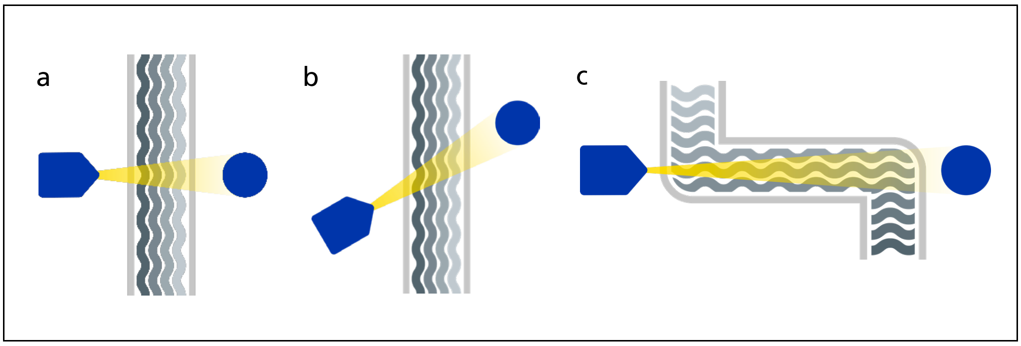

Fig. 57 Different measurement arrangements for density applications. A standard application with a 90° beam angle (a), which can be used for large pipelines, a 45° beam angle arrangement (b) to increase the absorption path, and an arrangement on an S-bend (c), where the pipeline’s curve is utilized to create a large absorption path.

The measurement setup plays a less important role in the calibration possibilities for density measurement, unlike in level measurement. In most cases, density is measured on pipelines. A critical factor in this setup is the length of the absorption path. If the absorption path is too short, only a small amount of gamma radiation is absorbed by the product, resulting in a small measurement effect. Therefore, in addition to the standard arrangement (Fig. 57, a), for small pipelines, measurement setups at a 45° angle (Fig. 57, b) as well as setups on an S-bend (Fig. 57, c) are used to increase the absorption path.

For the calibration of density measurements, the chosen measurement mode plays a significant role, as the required calibration curves can vary significantly due to the different definitions of the density of a material, depending on the desired process values.

3.6.2.1 Measurement Mode: Density

This measurement mode is used to determine the density value of a single measurement product. For material mixtures, it is recommended to use the measurement mode for concentration or solid content. Based on the attenuation law,

$$I = I_0 \cdot e^{-\mu\rho d}$$

the density of the measured product can be expressed as a linear function of the logarithmic count rates $\ln I$:

$$\rho = \underbrace{-\frac{1}{\mu d}}_{=a_1} \cdot \ln I + \underbrace{\frac{1}{\mu d} \ln I_0}_{a_0}$$

or equivalently:

$$\rho = a_1 \cdot \ln I + a_0$$

The use of logarithmic count rates allows for a simple linear calibration for density measurement on containers, either through multipoint or 1-point calibration or by directly entering the equation coefficients.

3.6.2.2 Calibration of a density measurement

Multipoint calibration

The user must record both the background count rate I_{BG} nd at least 2 (up to a maximum of 11) calibration points, i.e., pairs of calibration density M and the corresponding calibration count rate I_M.The free parameters of the calibration curve can then be determined through regression of the logarithmic count rates.

Linear regression

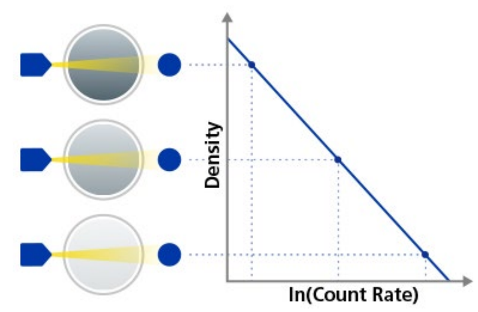

Fig 58 Linear regression (Density).

In linear regression (curve type "Linear"), the calibration points are fitted to a straight line of the form:

$$M = a_0 + a_1(\ln(I_M - I_{BG}))$$

The choice of this calibration curve form requires at least 2 calibration points.

IMPORTANT

In addition to a simple linear regression, options for quadratic or cubic regression curves are also available. The reason for this is that the logarithmic count rates may appear nonlinear due to factors such as complex geometries of the process containers or disturbances like agitators or sieves. In such cases, nonlinear curve types can be used for regression to best compensate for these influences. It is therefore always recommended to check the deviation of the calibration points for linearity after recording, so that the calibration can be adjusted if necessary. Furthermore, it is important to note that at least 3 calibration points are required for a quadratic regression, and at least 4 calibration points for a cubic regression.

Quadratic regression

In quadratic regression (curve type "Quadratic"), the calibration points are fitted to a function of the form:

$$M = a_0 + a_1(\ln(I_M - I_{BG})) + a_2(\ln(I_M - I_{BG}))^2$$

The choice of this calibration curve form requires at least 3 calibration points.

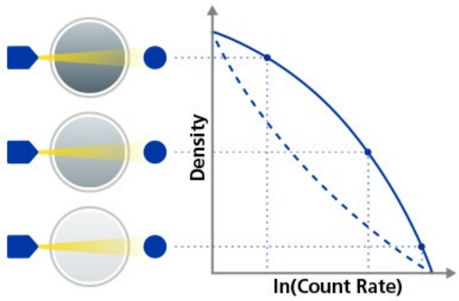

Fig 59 Quadratic regression (Density).

Cubic regression

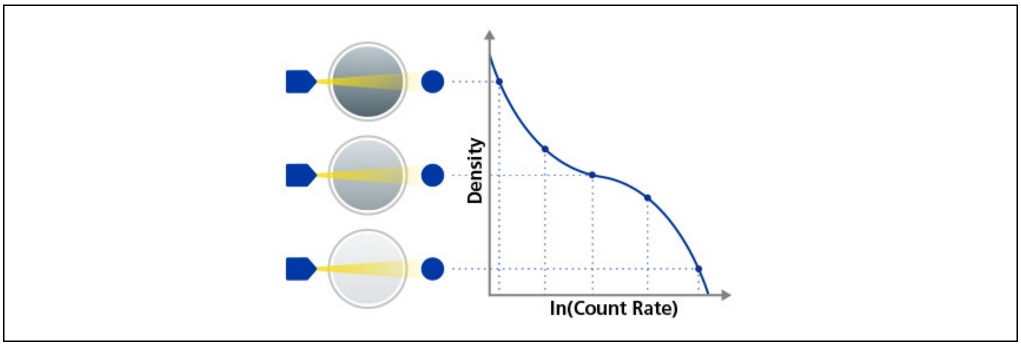

Fig 60 Cubic regression (Density).

In cubic regression (curve type "Cubic"), the calibration points are fitted to a function of the form:

$$M = a_0 + a_1(\ln(I_M - I_{BG})) + a_2(\ln(I_M - I_{BG}))^2 + a_3(\ln(I_M - I_{BG}))^3$$

The choice of this calibration curve form requires at least 4 calibration points.

1-Point calibration

The user must capture both the background count rate I_{BG} and a calibration point, i.e., a pair of values consisting of a calibration density M and a corresponding calibration count rate I_M. Additionally, the absorption coefficient μ and the measurement path length d in the product must be entered.

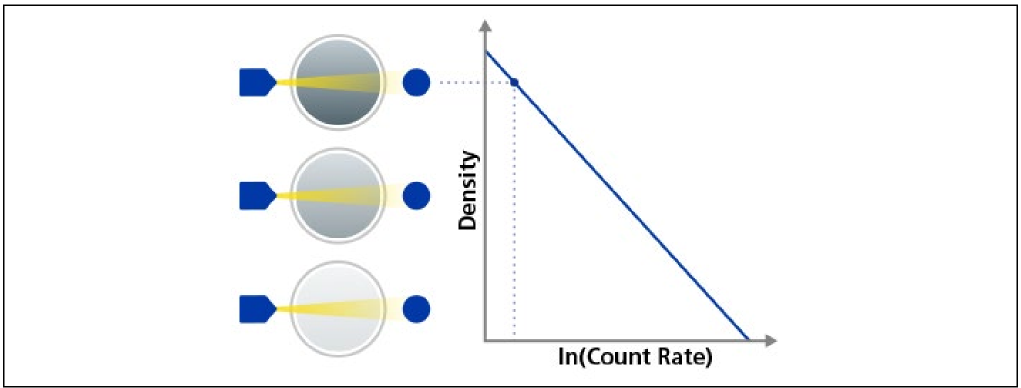

Fig 61 1-Point calibration (Density).

The calibration can only be performed via linear regression of the following form:

$$M = a_0 + a_1(\ln(I_M - I_{BG}))$$

The parameters a_0 and a_1 are calculated analytically as:

$$a_1 = -\frac{1}{\mu d}$$

$$a_0 = M_{cal} - a_1 \cdot \ln\left(I_{M_{cal}}\right)$$

In other words, this method does not account for more complex geometries of the container or the measurement setup, nor for nonlinear effects. In such cases, it is recommended to use a multi-point calibration approach.

Direct entry

If the coefficients of the calibration equation are known, they can also be entered directly. This is the case, for example, when the measurement has already been calibrated once, and the coefficients from the previous calibration can be reused. When selecting the option for direct input, valid coefficients must be provided. The chosen curve type determines the number of coefficients that need to be entered in the direct input mode.

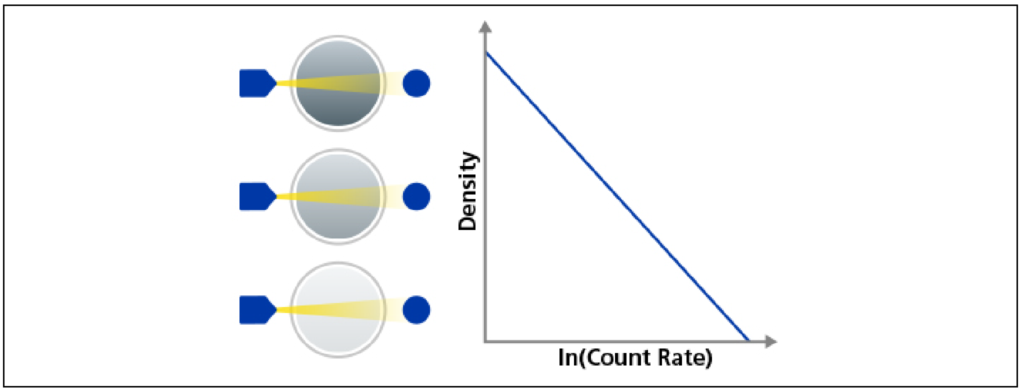

Fig 62 Direct entry – Linear regression (Density).

Direct entry of I_{BG}, a_0, a_1 – linear regression:

$$M = a_0 + a_1(\ln(I_M - I_{BG}))$$

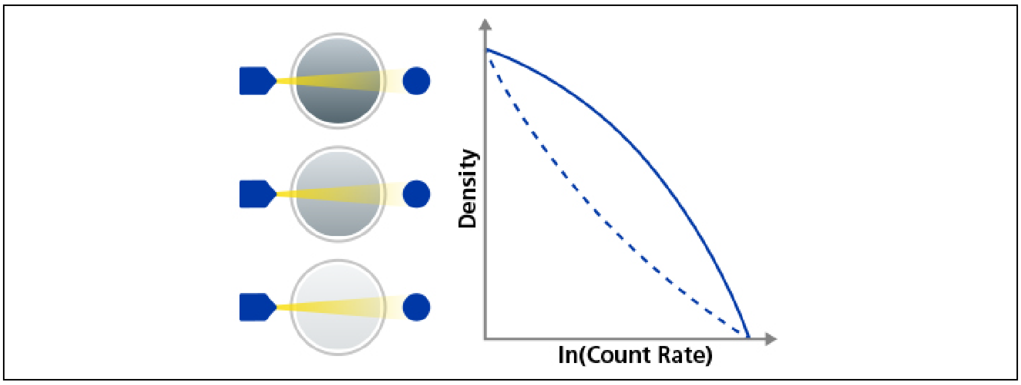

Fig 63 Direct entry – Quadratic regression (Density).

Direct entry of I_{BG}, a_0, a_1, a_2 – Quadratic regression:

$$M = a_0 + a_1(\ln(I_M - I_{BG})) + a_2(\ln(I_M - I_{BG}))^2$$

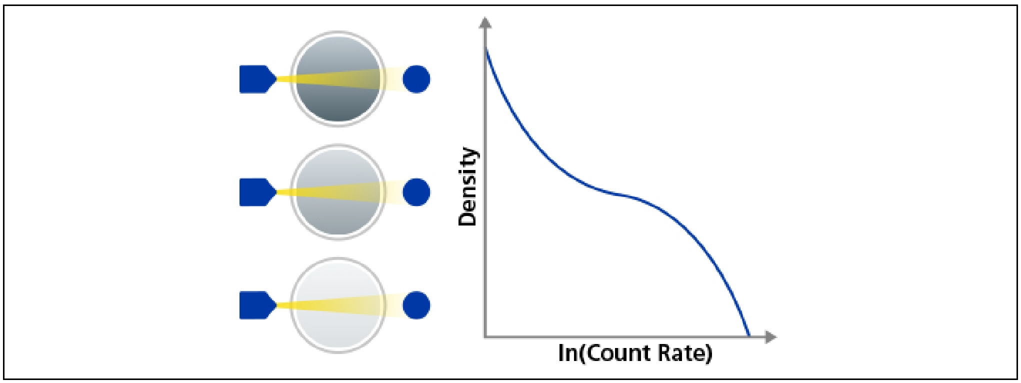

Fig 64 Direct entry – Cubic regression (Density).

Direct entry of I_{BG}, a_0, a_1, a_2, a_3 – Cubic regression:

$$M = a_0 + a_1(\ln(I_M - I_{BG})) + a_2(\ln(I_M - I_{BG}))^2 + a_3(\ln(I_M - I_{BG}))^3$$

3.6.2.3 Measurement Mode: Concentration

This measurement mode is used to determine the solid concentration [solid mass/total volume] of a suspension. The average density of a suspension $\bar{\rho}$ can be described using the solid concentration s as follows:

$$\bar{\rho} = \left(1 - \frac{\rho_L}{\rho_S}\right) s + \rho_L$$

where ρ_L represents the density of the liquid phase and ρ_S the density of the solid phase of the suspension. The solid concentration can also be described as the mass of the solid phase m_S relative to the total volume V:

$$s = \frac{m_S}{V}$$

Using this definition of the average density $\bar{\rho}$ in conjunction with the attenuation law:

$$I = I_0 \cdot e^{-\mu\bar{\rho}d}$$

the solid concentration s of the suspension can be expressed, similarly to the calculation of the density of a single material, as a linear function of the logarithmic count rates $\ln I$ with modified coefficients b_0 and b_1:

$$s = \underbrace{-\frac{1}{\mu d(1 - \frac{\rho_L}{\rho_S})}}_{=b_1} \cdot \ln I + \underbrace{\frac{1}{\mu d(1 - \frac{\rho_L}{\rho_S})} \ln I_0 + \frac{\rho_L}{1 - \frac{\rho_L}{\rho_S}}}_{b_0}$$

Thus:

$$s = b_1 \cdot \ln I + b_0$$

The use of logarithmic count rates enables simple linear calibration for measuring the solid concentration in containers. This calibration can be carried out using either multi-point or single-point calibration, as well as by directly entering the equation coefficients.

3.6.2.4 Calibration of a concentration measurement

Multipoint calibration

The user must record both the background count rate I_{BG} and at least 2 (up to a maximum of 11) calibration points, i.e., pairs of calibration density M and the corresponding calibration count rate I_M.The free parameters of the calibration curve can then be determined through regression of the logarithmic count rates.

Linear regression

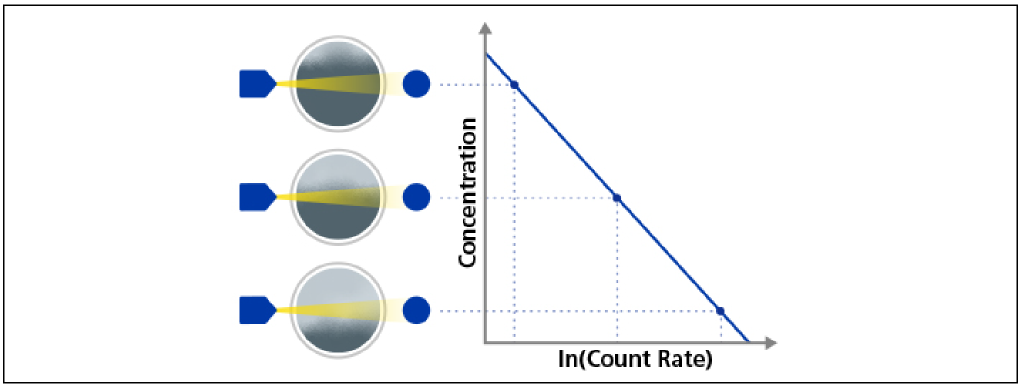

Fig 65 Linear regression (Concentration).

In linear regression (curve type "Linear"), the calibration points are fitted to a straight line of the form:

$$M = b_0 + b_1(\ln(I_M - I_{BG}))$$

The choice of this calibration curve form requires at least 2 calibration points.

IMPORTANT

In addition to simple linear regression, options for quadratic or cubic regression curves are also available. This flexibility addresses cases where logarithmic count rates appear nonlinear due to factors such as complex geometries of process containers or disturbances like agitators or sieves. In such instances, nonlinear curve types can be used for regression to better compensate for these influences.
It is therefore always recommended to check the deviation of the calibration points for linearity after data acquisition to adjust the calibration if necessary. Furthermore, note that quadratic regression requires at least 3 calibration points, while cubic regression requires at least 4 calibration points.

Quadratic regression

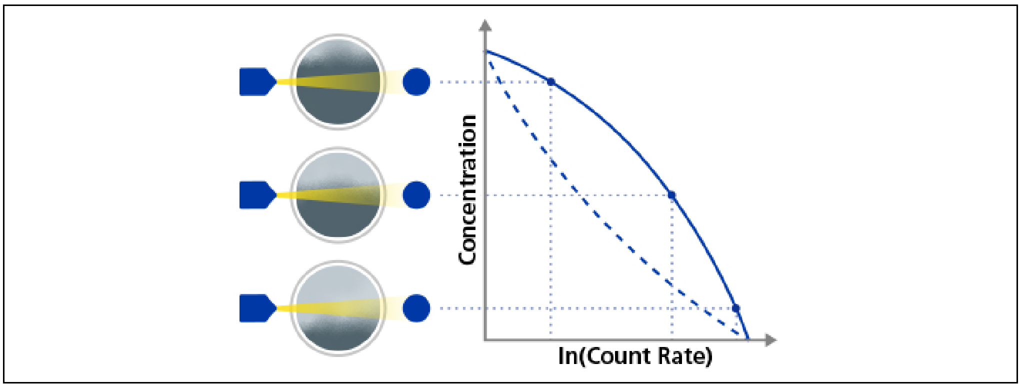

Fig 66 Quadratic regression (Concentration).

In quadratic regression (curve type "Quadratic"), the calibration points are fitted to a function of the form:

$$M = b_0 + b_1(\ln(I_M - I_{BG})) + b_2(\ln(I_M - I_{BG}))^2$$

The choice of this calibration curve form requires at least 3 calibration points.

Cubic regression

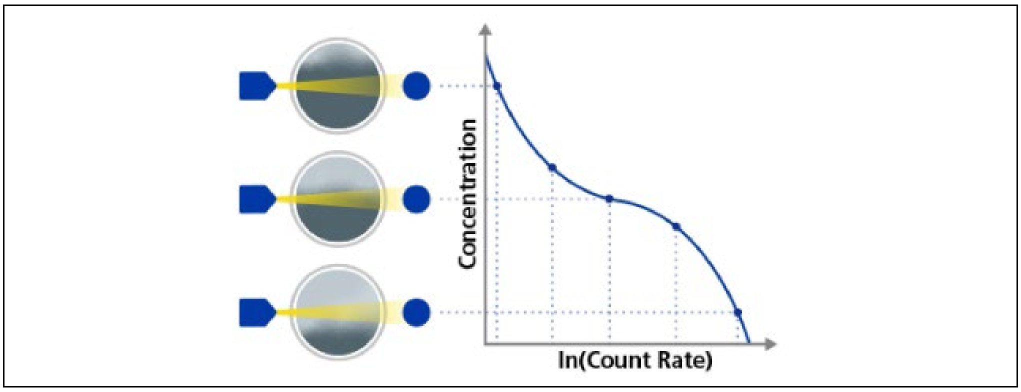

Fig 67 Cubic regression (Concentration).

In cubic regression (curve type "Cubic"), the calibration points are fitted to a function of the form:

$$M = b_0 + b_1(\ln(I_M - I_{BG})) + b_2(\ln(I_M - I_{BG}))^2 + b_3(\ln(I_M - I_{BG}))^3$$

The choice of this calibration curve form requires at least 4 calibration points.

1-Point calibration

The user must capture both the background count rate I_{BG} and a calibration point, i.e., a pair of values consisting of a calibration density M and a corresponding calibration count rate I_M. Additionally, the absorption coefficient μ and the measurement path length d in the product must be entered.

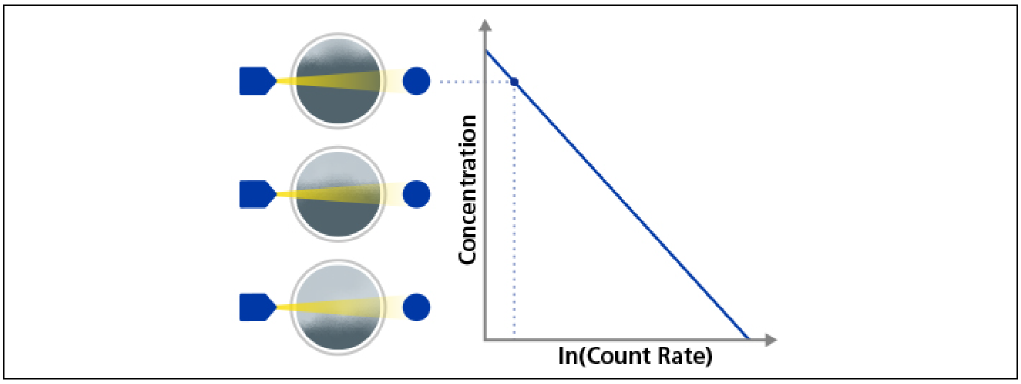

Fig 68 1-Point calibration (Concentration).

The calibration can only be performed via linear regression of the following form:

$$M = b_0 + b_1(\ln(I_M - I_{BG}))$$

The parameters b_0 and b_1 are calculated analytically as:

$$b_1 = -\frac{1}{\mu d(1 - \frac{\rho_L}{\rho_S})}$$

$$b_0 = M_{cal} - b_1 \cdot \ln\left(I_{M_{cal}}\right)$$

In other words, this method does not account for more complex geometries of the container or the measurement setup, nor for nonlinear effects. In such cases, it is recommended to use a multi-point calibration approach.

Direct entry

If the coefficients of the calibration equation are known, they can also be entered directly. This is the case, for example, when the measurement has already been calibrated once, and the coefficients from the previous calibration can be reused. When selecting the option for direct input, valid coefficients must be provided. The chosen curve type determines the number of coefficients that need to be entered in the direct input mode.

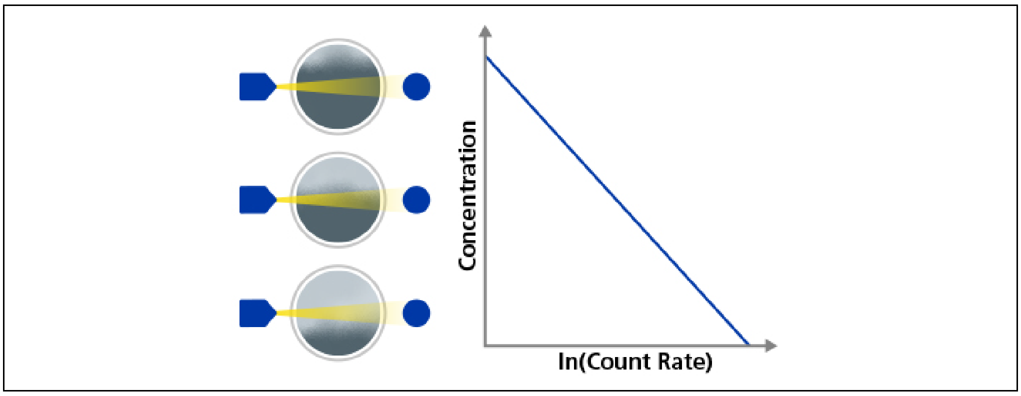

Fig 69 Direct entry – linear regression (Concentration).

Direct entry of I_{BG}, b_0, b_1 – linear regression:

$$M = b_0 + b_1(\ln(I_M - I_{BG}))$$

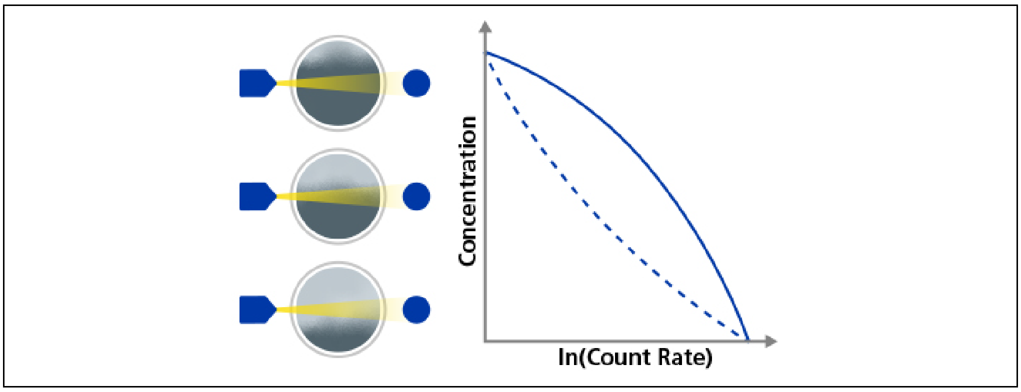

Fig 70 Direct entry – Quadratic regression (Concentration).

Direct entry of I_{BG}, b_0, b_1, b_2 – Quadratic regression:

$$M = b_0 + b_1(\ln(I_M - I_{BG})) + b_2(\ln(I_M - I_{BG}))^2$$

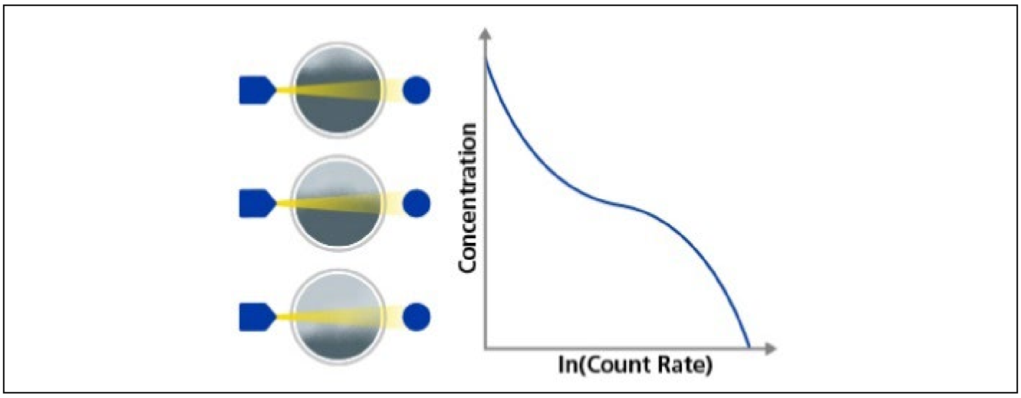

Fig 71 Direct entry– Cubic regression (Concentration).

Direct entry of I_{BG}, b_0, b_1, b_2, b_3 – Cubic regression:

$$M = b_0 + b_1(\ln(I_M - I_{BG})) + b_2(\ln(I_M - I_{BG}))^2 + b_3(\ln(I_M - I_{BG}))^3$$

3.6.2.5 Measurement Mode: Solid Content

This measurement mode is used to determine the solid content [solid mass/total mass] of a suspension. The average density of a suspension $\bar{\rho}$ can be described using the solid content w_S as follows:

$$\bar{\rho} = \frac{\rho_L}{w_S \cdot \left(\frac{\rho_L}{\rho_S} - 1\right) + 1}$$

with:

$$w_S = \frac{w_S}{w_S + w_L}$$

where ρ_L represents the density of the liquid phase and ρ_S the density of the solid phase of the suspension. Using this definition of the average density $\bar{\rho}$ n conjunction with the attenuation law:

$$I = I_0 \cdot e^{-\mu\bar{\rho}d}$$

the solid content w_S of the suspension can be expressed as a hyperbolic function of the logarithmic count rates $\ln I$ and coefficients c_0 , c_1 and c_2:

$$w_S = \underbrace{\frac{\rho_S \cdot \rho_L}{\rho_S - \rho_L} \cdot \mu \cdot d}_{c_1} \cdot \frac{1}{\ln(I) \underbrace{-\ln(I_0)}_{c_2}} + \underbrace{\frac{\rho_S}{\rho_S - \rho_L}}_{c_0}$$

$$\hookrightarrow w_S = c_1 \cdot \frac{1}{\ln(I) + c_2} + c_0$$

The solids content can be calibrated either by direct entry of the parameters, a 1-point calibration, a 2-point calibration or a multipoint calibration.

IMPORTANT

The "Solid Content" measurement mode can also be applied to liquid-liquid solutions. However, the underlying model assumes additive volumes. For two liquids, this assumption may not hold due to system-specific mixing effects (e.g., volume contraction). In such cases, the "Density" measurement mode should be selected, and a careful nonlinear calibration should be performed.

3.6.2.6 Calibration of a solid content measurement

Multipoint calibration

To simplify the regression, the hyperbolic relationship between the solid content M and the logarithmic count rate $\ln(I_M - I_{BG})$ can be adequately approximated by a quadratic function:

$$M = \tilde{c}_0 + \tilde{c}_1(\ln(I_M - I_{BG})) + \tilde{c}_2(\ln(I_M - I_{BG}))^2$$

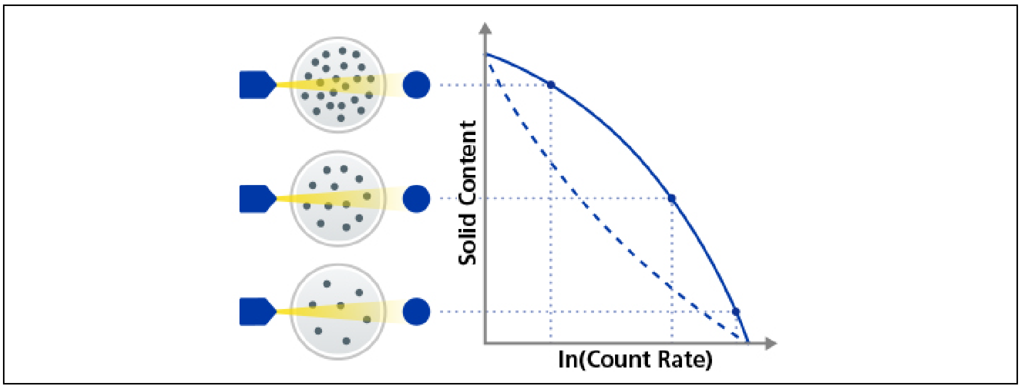

Fig 72 Multipoint calibration (Solid Content).

Accordingly, the user must record at least 3 calibration points $(I_M|M)$ as well as the background count rate I_{BG}. A polynomial regression is performed to determine the coefficients $\tilde{c}_0$, $\tilde{c}_1$, and $\tilde{c}_2$.

It should be noted that this formula is purely empirical. Unlike for other calibrations, the coefficients do not have any physical significance.

1-Point calibration

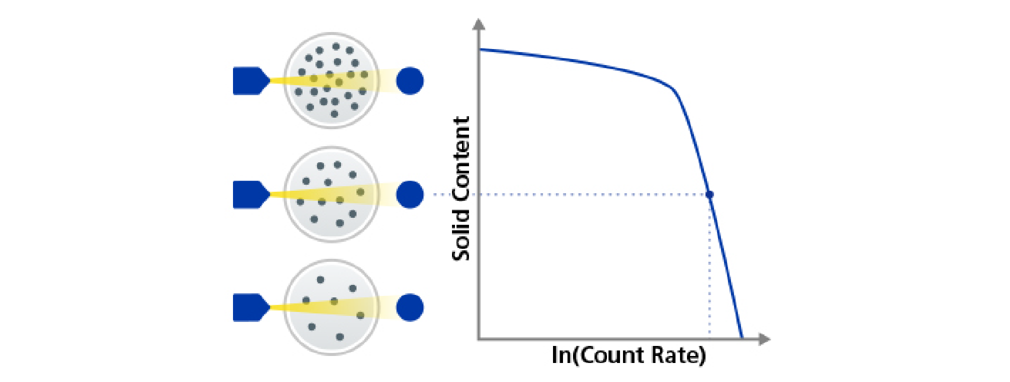

Fig 73 1-Point calibration (Solid Content).

The user must record one calibration point$(I_M|M)$. If the parameters c_0 and c_1 are known, they can be entered directly. The free parameter c_2 can then be determined analytically. If c_0 and c_1 are not known, they can also be calculated. To do so, the mass attenuation coefficient μ, the measurement path d, the density of the liquid phase ρ_L as well as the solid phase ρ_S must be known:

$$c_0 = \frac{\rho_S}{\rho_S - \rho_L}$$

$$c_1 = \frac{\rho_S \cdot \rho_L}{\rho_S - \rho_L} \cdot \mu d$$

$$c_2 = \frac{c_1}{M - c_0} - \ln(I_M - I_{BG})$$

2-Point calibration

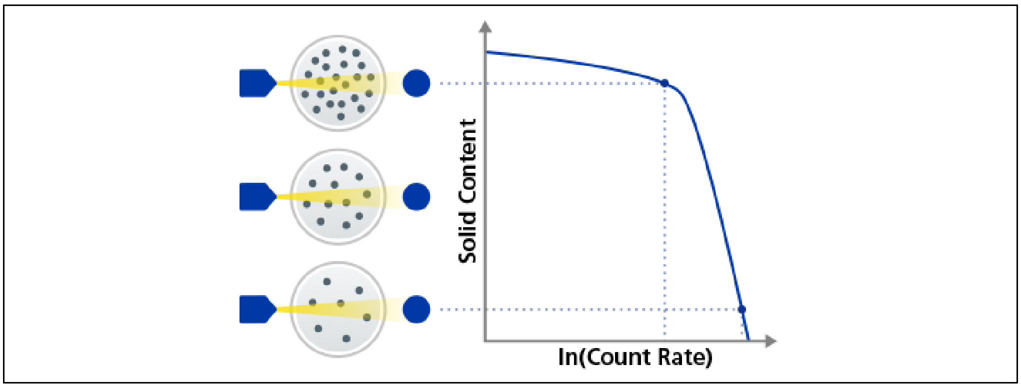

Fig 74 2-Point calibration (Solid Content).

The user must record two calibration points $(I_M|M)$ and enter an additional coefficientc_0. If the parameter c_0 is not known, it can be determined from the density of the liquid phase ρ_L and the density of the solid phase ρ_S as follows:

$$c_0 = \frac{\rho_S}{\rho_S - \rho_L}$$

Die freien Parameter der hyperbolischen Kennlinie c_1 und c_2 werden analytisch bestimmt

$$c_1 = (M_1 - c_0) \cdot (M_2 - c_0) \cdot \frac{\ln(I_1 - I_{BG}) - \ln(I_2 - I_{BG})}{M_2 - M_1}$$

$$c_2 = (M_1 - c_0) \cdot \frac{\ln(I_1 - I_{BG}) - \ln(I_2 - I_{BG})}{M_2 - M_1} - \ln(I_2 - I_{BG})$$

Direct entry

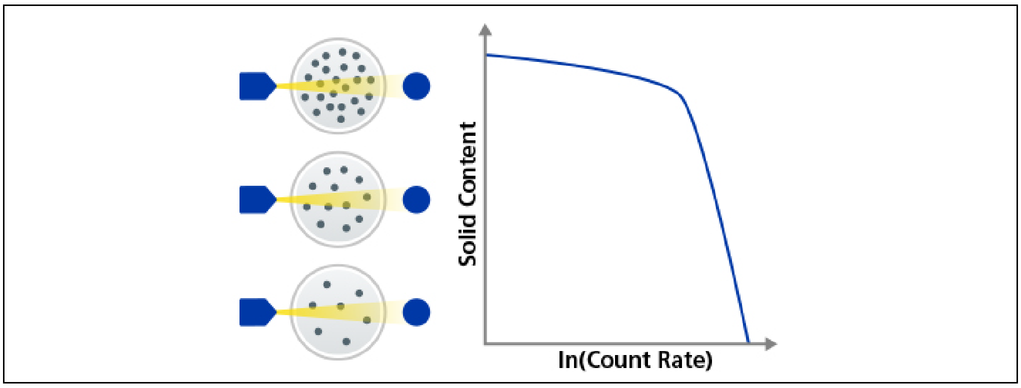

Fig 75 Direct entry (Solid Content).

If the coefficients of the calibration equation are known, they can also be entered directly. This is the case, for example, when the measurement has already been calibrated once, and the coefficients from the previous calibration can be reused. When selecting direct input, valid coefficients such as $c_0 > 1$, $c_1 > 0$, $c_2 > 0$ must be provided. When determining the solid content, a fixed number of parameters must be entered due to the established hyperbolic dependence.

3.7 Menu: Security

3.7.1 Submenu: Security | Authentification

3.7.1.1 Tab: Security | Authentification | Authentification

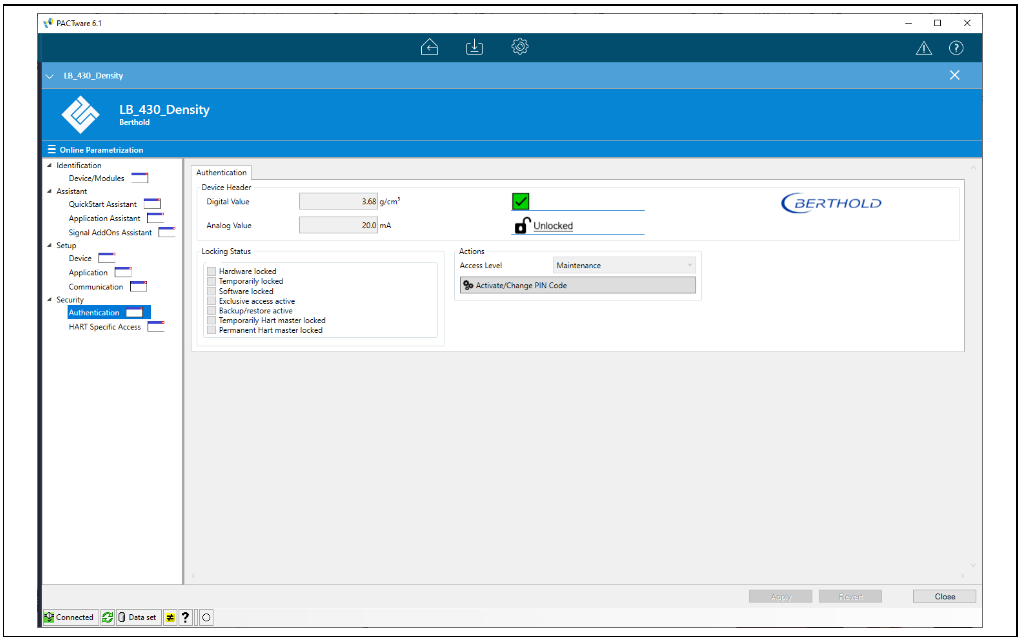

Fig 76 Tab: *Security | Authentification | Authentification*.

The **"Authentication"** tab is used for password entry and locking the device to prevent configuration changes. A password must be entered to lock the detector against unauthorized access. Locking restricts access to adjustable parameters.

To unlock the device, the password must be re-entered. Multiple locks can be active simultaneously, depending on the desired security level of the device:

Write Protection	Description
Hardware locked	Dip switches in the connection compartment must be set to the "locked" position. Write protection can only be deactivated within the connection compartment.
Temporarily locked	The device is temporarily write-protected. Write protection can be unlocked with a "System Reset" or by restarting the device.
Software locked	Same effect as hardware lock. It can only be unlocked via "Security | HART Specific Access" using the "Lock/Unlock Device" option.
Exclusive Access Active	Password protection has been activated in the "Security | Authentication" menu. The respective user levels require a password to disable write protection for the parameters they have access to.
Backup/Restore active	During a backup and restore process, the device is write-protected to prevent corruption of the output or input files.
Temporarily HART Master locked	Important for measurement cascades. The write protection can only be removed by restarting the HART Master unit.

The device lock against unauthorized access must first be activated. The shipping package includes the Device-ID-dependent passwords for the access levels "Operator" (read access) and "Maintenance" (write access) for the specific device.

After activation, each access to the device must be confirmed with the assigned password. If there is no interaction for 20 minutes, the device will automatically switch to write-protected mode.

NOTICE

The device can also be operated without activating the security levels. However, unauthorized write access to the device is possible at any time in this mode.

IMPORTANT

A loss of the supplied passwords may result in the inability to access the device. In this case, please contact Berthold Service. They can provide you with a new password.

3.7.2 Submenu: Security | HART Specific Access

3.7.2.1 Tab: Security | HART Specific Access | HART Specific Access

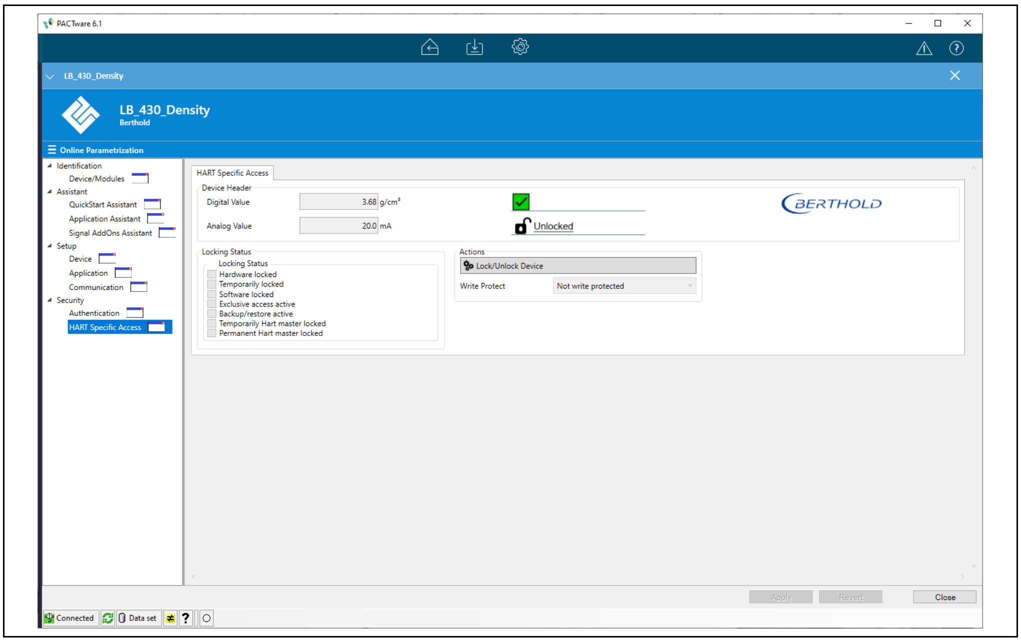

Fig 77 Tab: ***Security | HART Specific Access | HART Specific Access***.

This tab is used to activate/deactivate the software lock (see Chapter 3.7.2.1 – "Software locked"). If authentication is enabled, entering the respective password for the user level is required to unlock the device.

4 Main Menu: Offline Parameter

4.1 Accessing the Main Menu: Offline Parameter

Access to the device's online parameterization is done through the main menu tree of the respective connected application. In PACTware 6.1, right-click on the "Parameter" option and then select "Parametrization." Please note that the layout of the main menus for accessing the application may differ across all HOST systems.

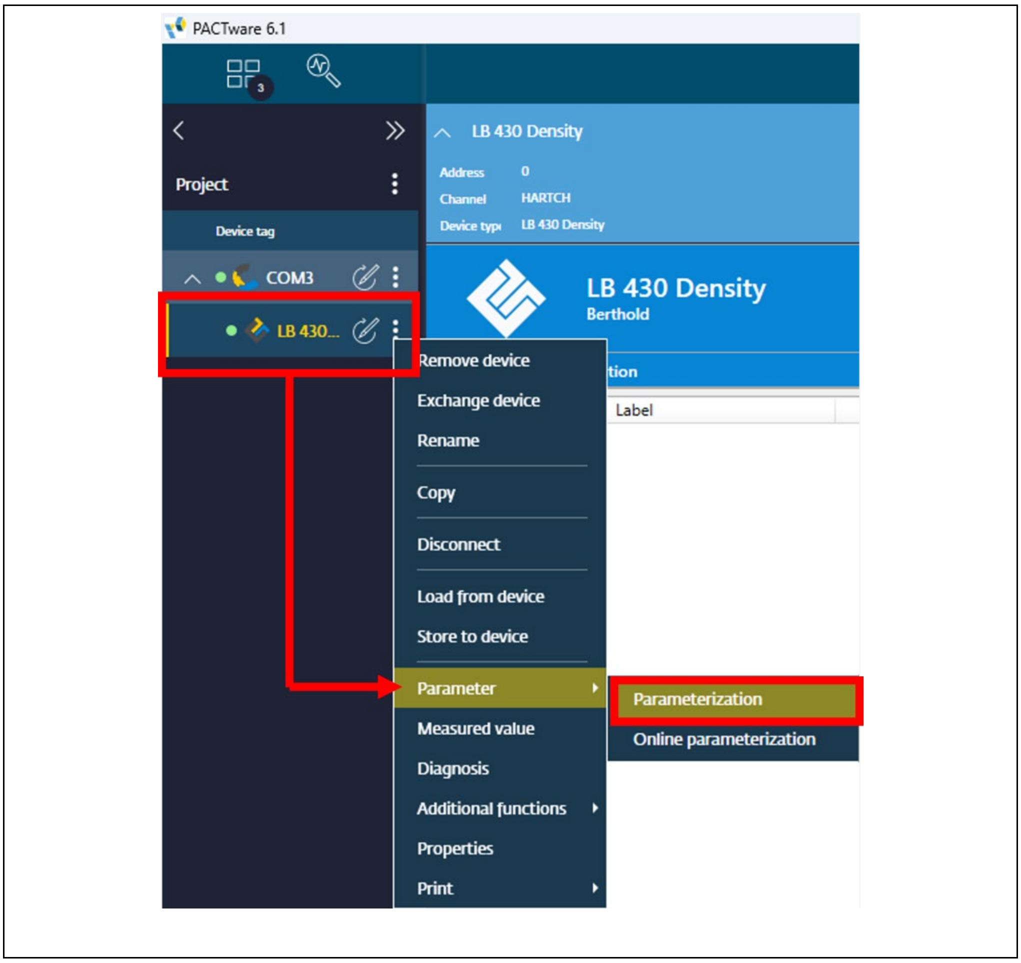

Fig 78 Accessing the Offline Parameter List in PACTware 6.1.

4.2 Backup - Transferring Device Settings to the Offline Parameter List

The transfer of device settings to the offline parameter list of the HOST system is done through the main menu tree of the respective connected application. In PACTware 6.1, right-click on the "Load from device" option. The device settings will then be transferred to the offline parameter list. You can track the progress via a progress bar under the connected application (Fig. 79, Pos. 1). Please note that the layout of the main menus for accessing the application may differ across all HOST systems.

NOTICE

Only one parameter set from a device can be transferred to the offline parameter list at a time. If a factory reset is performed, the data in the offline parameter list will also be lost.

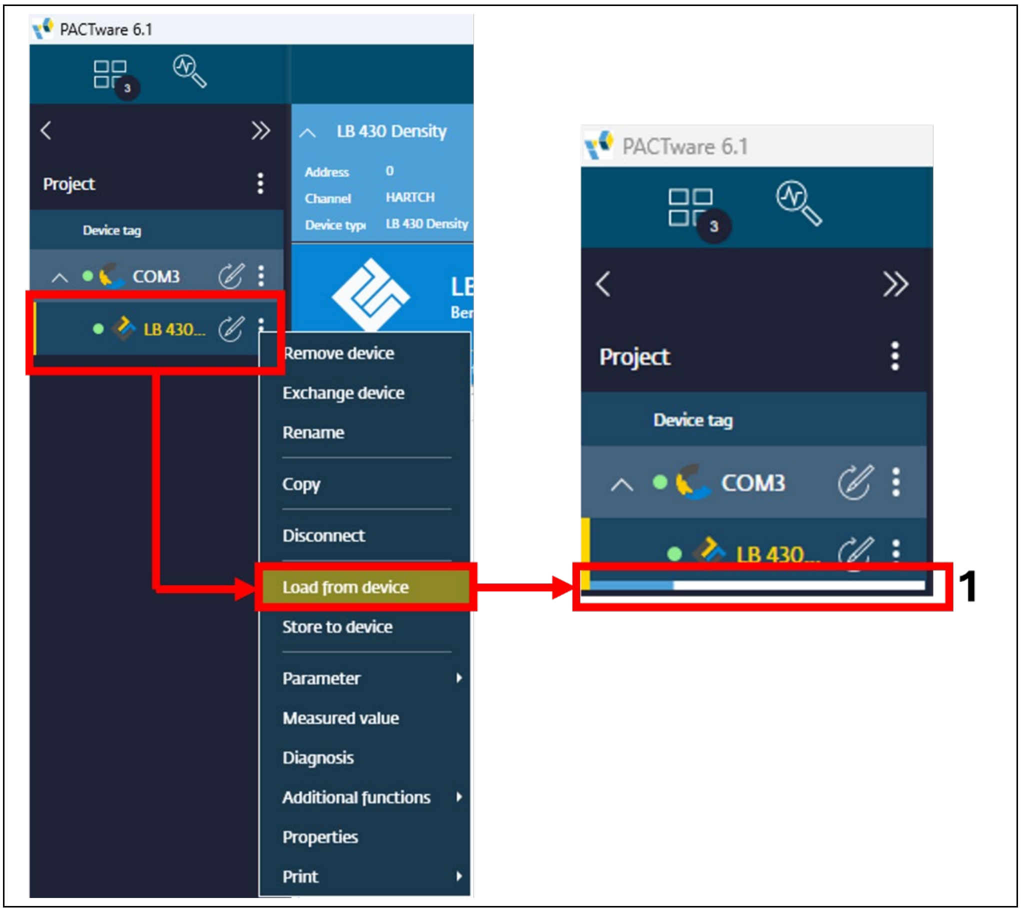

Fig 79 Transferring Device Settings to the Offline Parameter List in PACTware 6.1.

4.3 Restore - Transferring Device Settings from the Offline Parameter List

The transfer of device settings from the offline parameter list of the HOST system to the device is done through the main menu tree of the respective connected application. In PACTware 6.1, right-click on the "Store to device" option. The device settings will then be transferred from the offline parameter list to the device. You can track the progress via a progress bar under the connected application (Fig. 80, Pos. 1). Please note that the layout of the main menus for accessing the application may differ across all HOST systems.

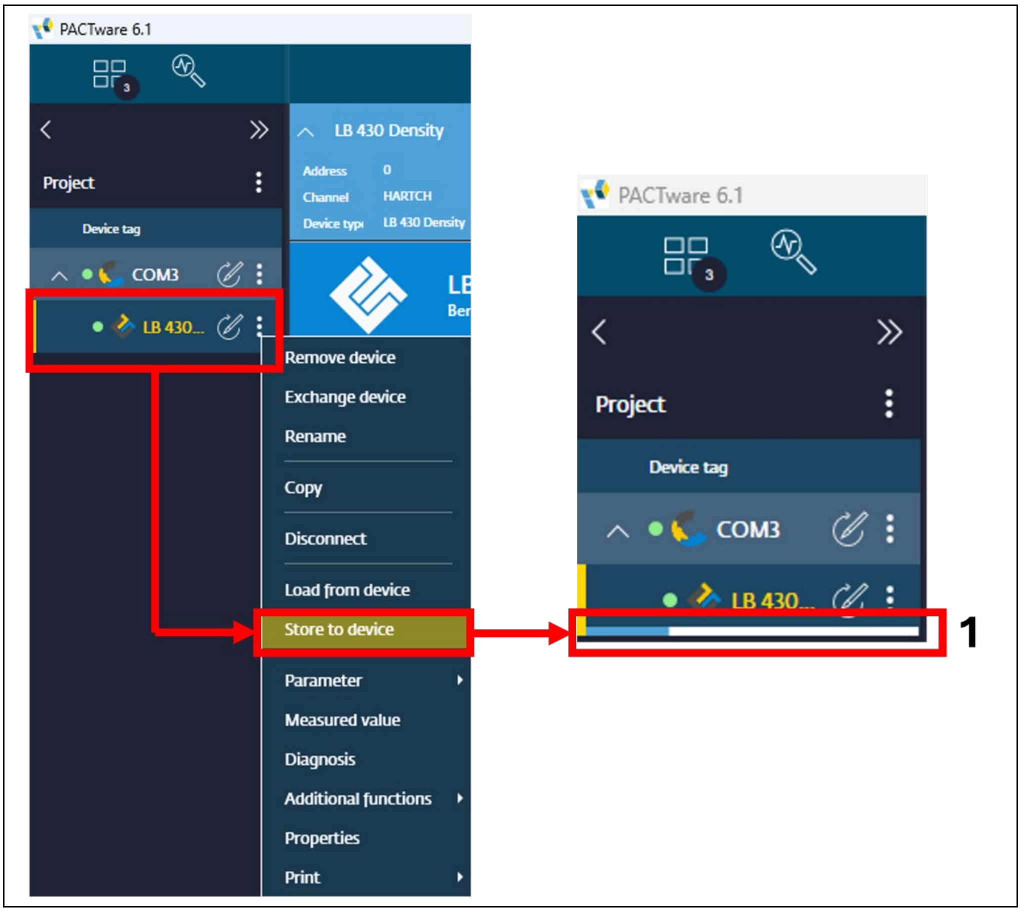

Fig 80 *Transferring Device Settings from the Offline Parameter List to the Device in PACTware 6.1.*

4.4 Parameter-Report

To create a parameter report, first navigate to the main menu of Offline Parameters, as described in Chapter 4.1 of this manual. The offline menu will open, where you can view the complete device settings (Fig 81, Pos. 1). To create a report, click the "Offline Report" button (Fig 81, Pos. 2). This will open the routine for generating a parameter report (Fig 81, Pos. 3).

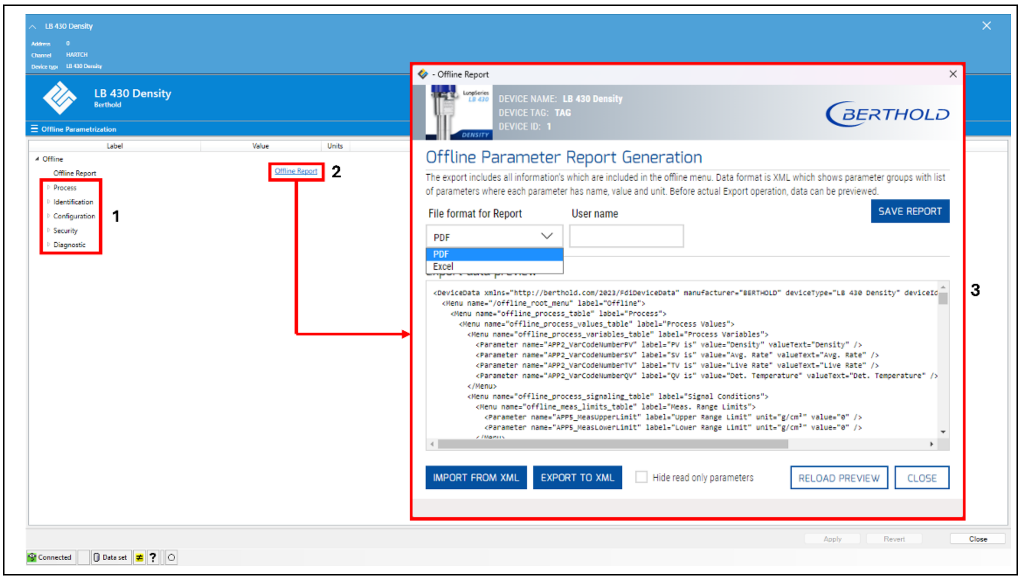

Fig 81 Creation of a Parameter Report.

Using this routine, the offline parameter set can now be saved as a PDF, Excel, or XML file on the PC.

Tip

The parameter reports can be ideally used as commissioning protocols for the measurements. To do this, after each commissioning, save the data in the offline parameter set as described in *Chapter 4.2 – Backup – Transferring Device Settings to the Offline Parameter List*. Create an additional PDF or Excel file for better readability, as well as an XML file in case device parameters need to be easily restored later.

4.5 Procedure for Duplicating Measurement Points

To duplicate measurement points, proceed as follows:

1. Parameter and calibrate the first device.
2. Transfer the device settings to the offline parameter list as described in Chapter 4.2 of this manual. These settings will then be saved on the HOST system.
3. Connect the next device to the HOST system.
4. Load the device settings from the offline parameter list onto the newly connected device, as described in *Chapter 4.3 – Restore – Transferring Device Settings from the Offline Parameter List to the Device*.
5. Calibrate the newly connected device.

Tip

If measurement points with different parameter configurations need to be duplicated, save an XML file for each different device configuration, as described in *Chapter 4.4 – Parameter Report*. This allows you to easily switch between different offline parameter sets.

5 Main Menu: Measurement

5.1 Accessing the Main Menu: Measurement

The entry into the device's measurement menu is done through the main menu tree of the respective connected application. In PACTware 6.1, right-click on the "Measured value" option. Please note that the layout of the main menus for accessing the application may differ across all HOST systems.

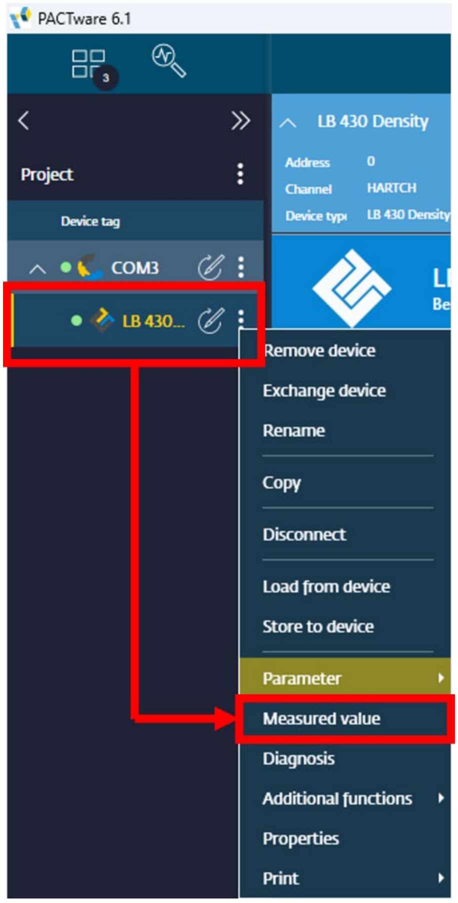

Fig 82 Accessing the Measurement Main Menu in PACTware 6.1.

5.2 Menu: Process Values

5.2.1 Submenu: Process Values | Process Values

5.2.1.1 Tab: Process Values | Process Values | Process Values

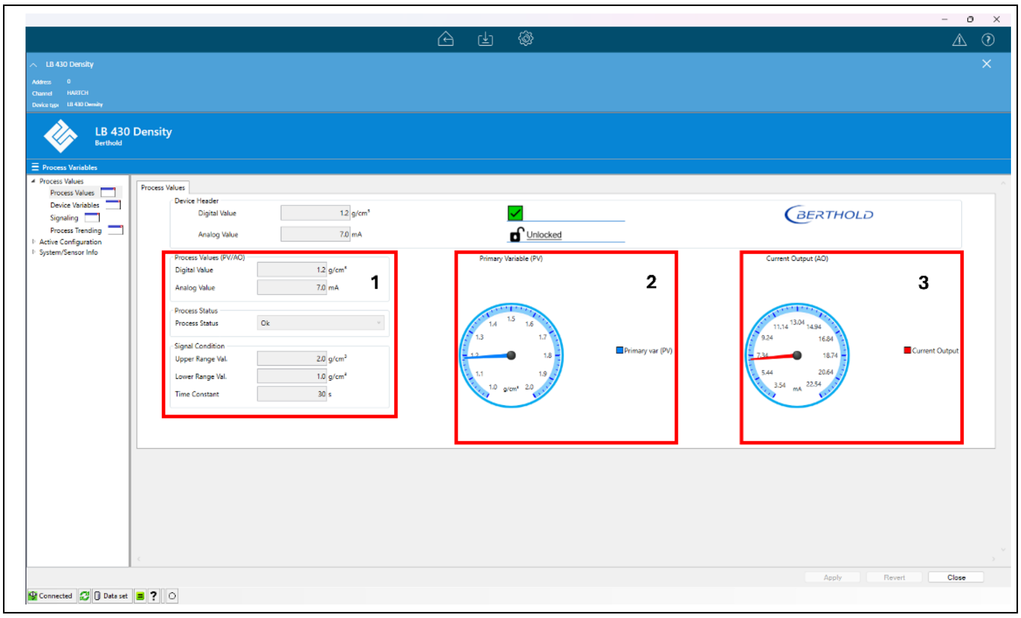

Fig 83 Tab: ***Process Values | Process Values | Process Values*** *for the density application.*

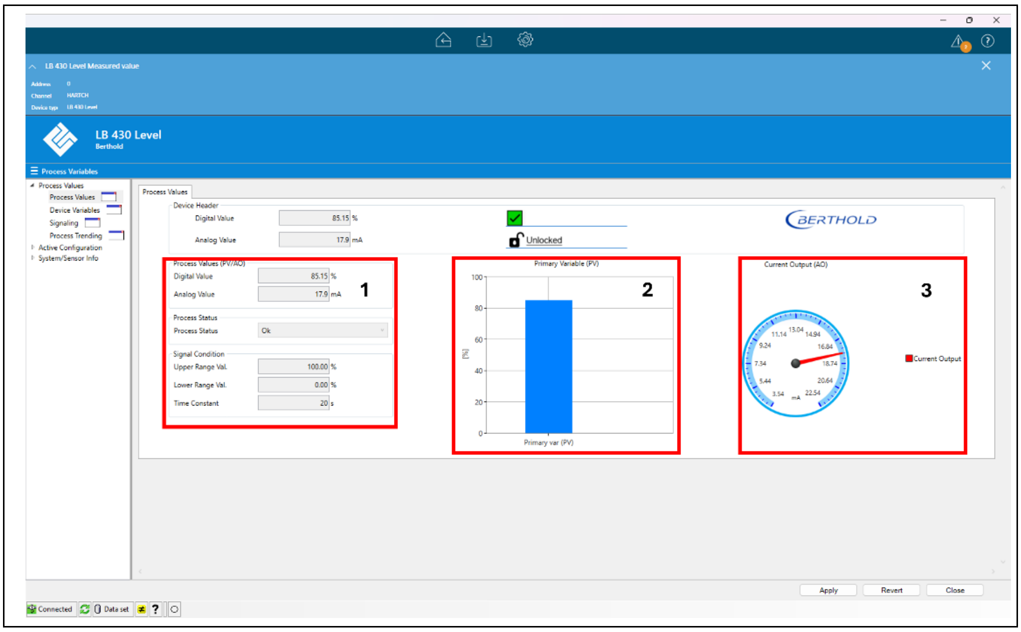

Fig 84 Tab: ***Process Values | Process Values | Process Values*** *for the level application.*

In the tab **"Process Values"**, you will find an overview of all critical parameters in your process. The display varies depending on the selected application. If the density application is active, the tab will appear as shown in Fig 83, whereas for an active level application, the tab will appear as shown in Fig 84.

This tab includes current process values, current output values, and measurement range settings displayed both as numerical values (Fig 83 and Fig 84, Pos. 1) and graphically, showing the digital process value (PV, Fig 83 and Fig 84, Pos. 2) and the analog output value (AO, Fig 83 and Fig 84, Pos. 3).

5.2.2 Submenu: Process Values | Device Variables

5.2.2.1 Tab: Process Values | Device Variables | Device Variables

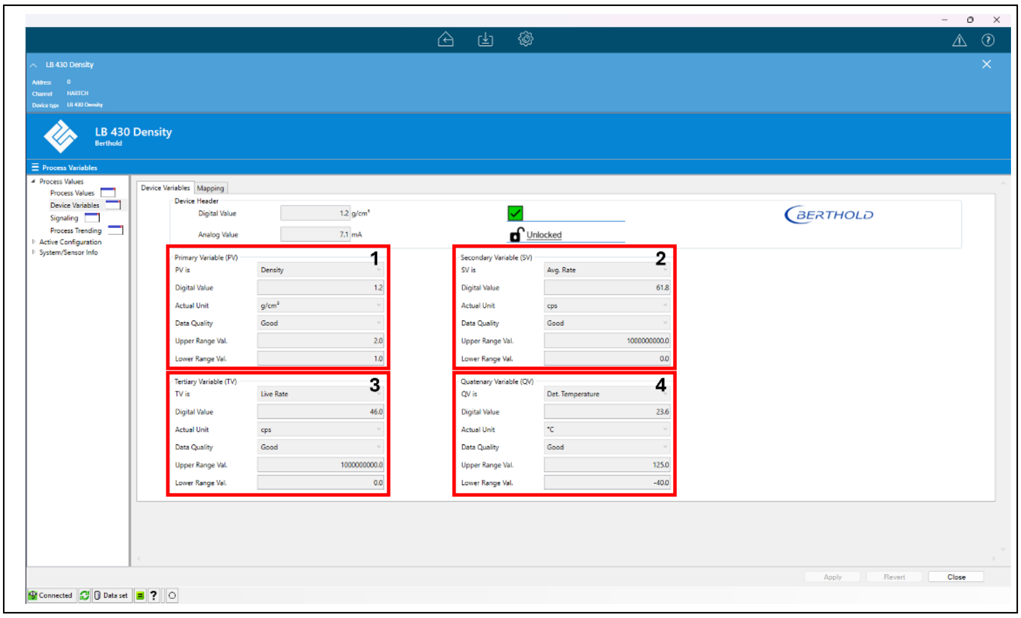

Fig 85 Tab: ***Process Values | Device Variables | Device Variables***.

In the **"Device Variables"** tab, you can access information about each of the HART variables:

- PV (Primary Variable, Fig 85, Pos. 1)
- SV (Secondary Variable, Fig 85, Pos. 2)
- TV (Tertiary Variable, Fig 85, Pos. 3)
- QV (Quaternary Variable, Fig 85, Pos. 4)

Here, you will find details about the current assignment, digital value, configured unit, and the spanned measurement range. Additionally, the data quality of the ongoing measurement for each variable can also be retrieved.

5.2.2.2 Tab: Process Values | Device Variables | Mapping

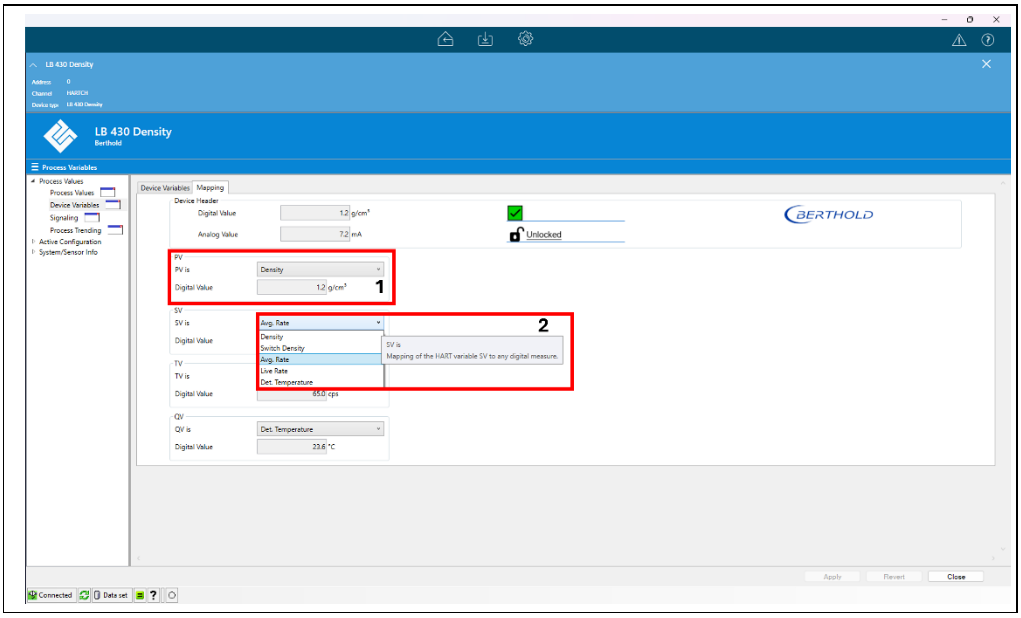

Fig 86 Tab: ***Process Values / Device Variables / Device Variables.***

Through the **"Mapping"** tab, you can view the variable assignments as well as the digital variable values (Fig 86, Pos. 1). If needed, the assignment of each HART variable can be adjusted via a drop-down menu (Fig 86, Pos. 2).

5.2.3 Submenu: Process Values | Signaling

5.2.3.1 Tab: Process Values | Device Variables | Signal Condition

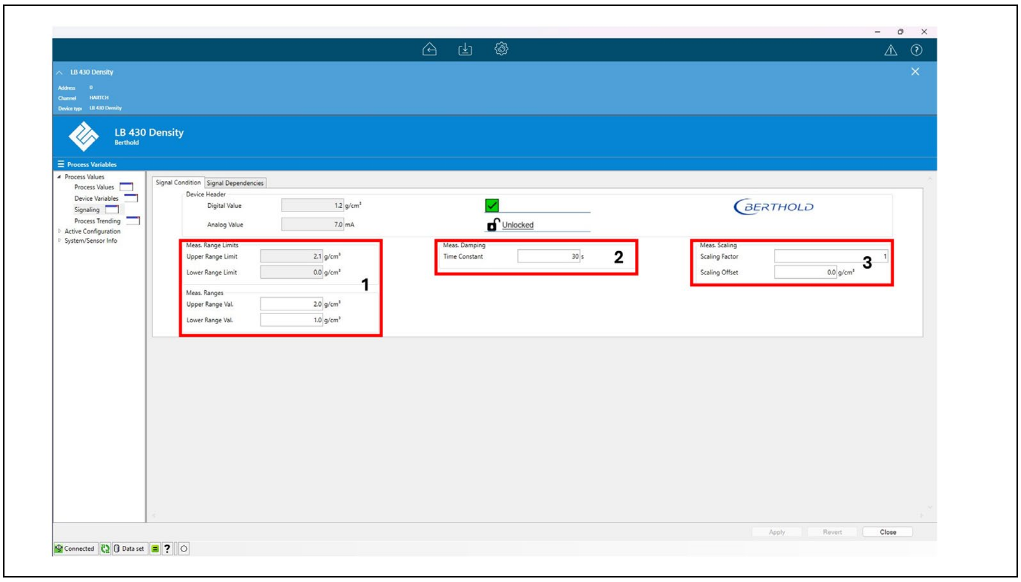

Fig 87 *Tab Process Values | Signaling | Signal Conditions.*

In the tab **"Signal Condition"**, the calculated measurement range limits can be viewed, and settings for the defined measurement range can be adjusted (Fig 87, Pos. 1). Additionally, the settings for process value smoothing (Fig 87, Pos. 2) and measurement range scaling (Fig 87, Pos. 3) can also be configured here.

IMPORTANT

The system needs approximately 3 times the time constants to represent 99% of the process change. This means that with a default setting of 20 seconds, a process change can be fully represented after about 60 seconds. Therefore, the choice of the time constant is always a compromise between response time and signal smoothing.

5.2.3.2 Tab: Process Values | Device Variables | Signal Dependencies

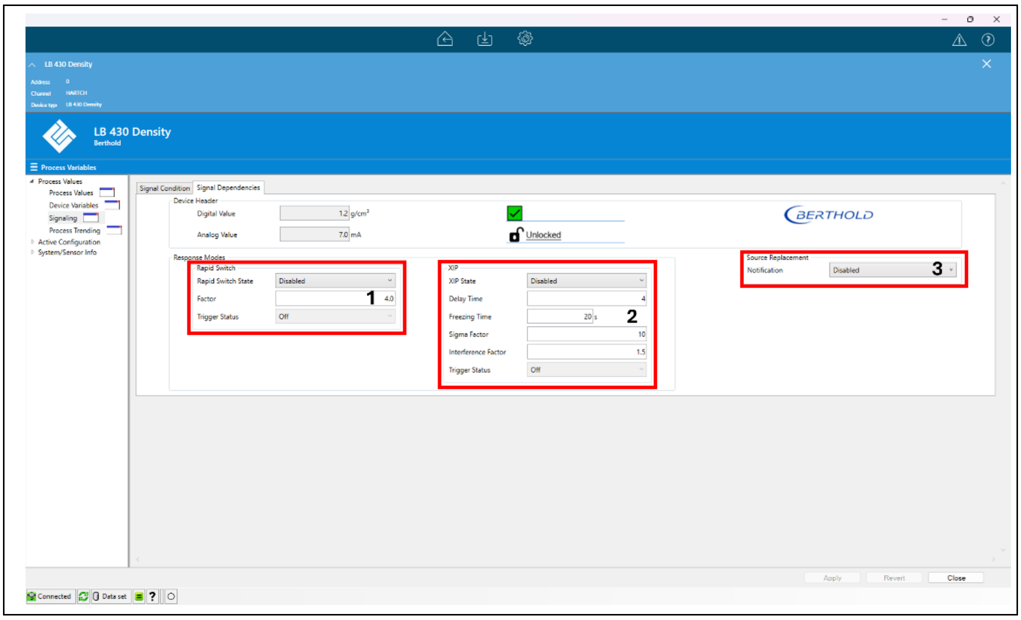

Fig 88 Tab: ***Process Values | Signaling | Signal Dependencies***.

In the **"Signal Dependencies"** tab, you can configure settings for signal extensions, such as Rapid Switch (Fig 88, Pos. 1) or X-Ray Interference Protection (XIP, Fig 88, Pos. 2).

Additionally, the "Source Replacement Notification" (Fig 88, Pos. 3) can be activated here to indicate when an aging radiation source needs to be replaced in a timely manner. Changes made in this menu directly affect the active measurement.

Rapid Switch	The activation of the rapid switch function is recommended when process values can change very quickly and sporadically (e.g., slurry detection in boreholes). When such a rapid process change is detected, the fast switching is automatically activated and sets the time constant to 1/10 of the set value, allowing the control unit to react more effectively to this process change. When activating fast switching, only the sigma value needs to be defined. This specifies the factor by which the count rate must change within two output cycles to activate the rapid switch function. Example calculation: The default value for sigma is 4.0, meaning the count rate must increase or decrease by a factor of 4 within two measurement cycles to activate fast switching.

XIP

XIP - short for "X-Ray Interference Protection," describes an internal function of the detector that detects stray radiation and protects both the measurement and the device from such interference. This function is particularly important when, for example, welding inspections are frequently carried out at the installation site. When stray radiation is detected with the XIP function activated, the detector will stop measuring for a certain period, and the measurement value will be frozen. This ensures that both the internal decay compensation and the measurement itself are not affected. Additionally, the detector is effectively protected from premature aging.

To activate the XIP function, the following settings must be made:

5) **Delay Time**: Specifies the time after which XIP should be triggered when stray radiation is detected. The default value is set to 4 seconds.
6) **Freezing Time**: Specifies the time the measurement value should remain frozen after the delay time. A default of 20 seconds is recommended.
7) **Sigma Factor**: Defines a process signal-dependent count rate at which XIP should be activated.
8) **Interference Factor:** Defines a process signal-dependent threshold count rate at which XIP should be deactivated after the freezing time.

5.2.4 Submenu: Process Values | Process Trending

5.2.4.1 Tab: Process Values | Process Trending | PV/SV

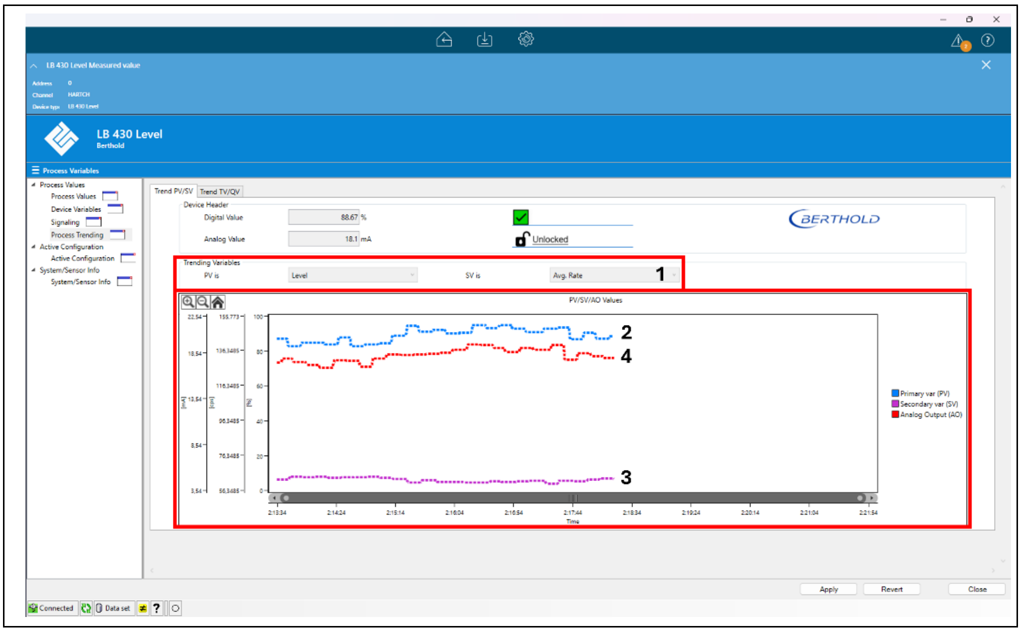

Fig 89 Tab: *Process Values | Process Trending | PV/SV.*

In the **"PV/SV"** tab, you can view the assignment settings of the respective variables (Fig 89, Pos. 1). Additionally, the temporal progression of the device variables PV (Primary Variable, Fig 89, Pos. 2) and SV (Secondary Variable, Fig 89, Pos. 3), along with the progression of the current signal (Analog Output, Fig 89, Pos. 4), is displayed graphically.

5.2.4.2 Process Values | Process Trending | TV/QV

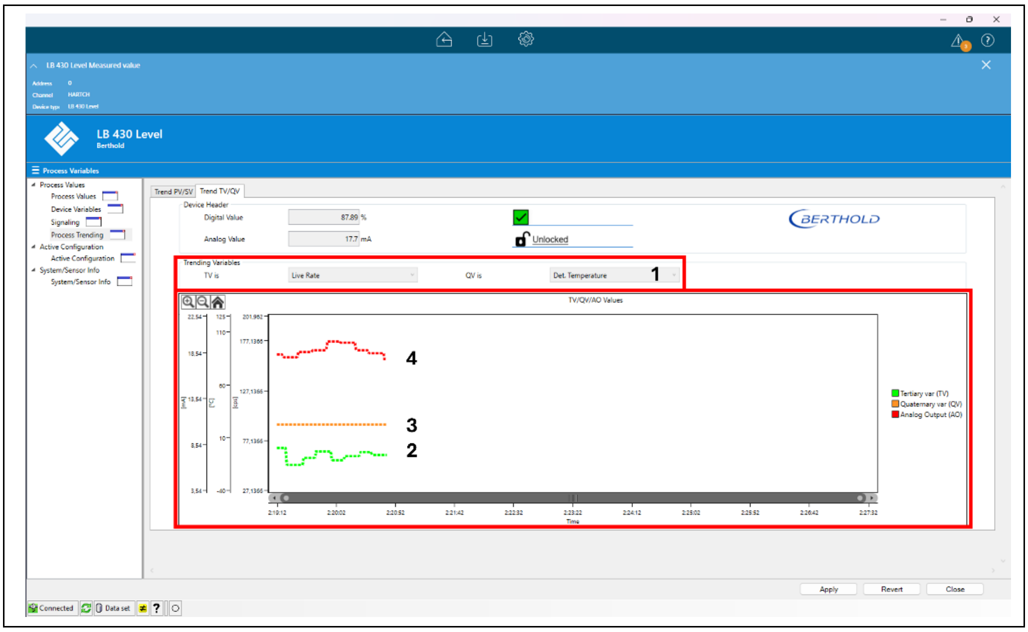

*Fig 90 Tab: **Process Values | Process Trending | TV/QV**.*

In the **"TV/QV"** tab, you can view the assignment settings of the respective variables (Fig 90, Pos. 1). Additionally, the temporal progression of the device variables TV (Tertiary Variable, Fig 90, Pos. 2) and QV (Quaternary Variable, Fig 90, Pos. 3), along with the progression of the current signal (Analog Output, Fig 90, Pos. 4), is displayed graphically.

5.3 Menu: Active Configuration

5.3.1 Submenu: Active Configuration | Active Configuration

5.3.1.1 Tab: Active Configuration | Active Configuration | Measurement

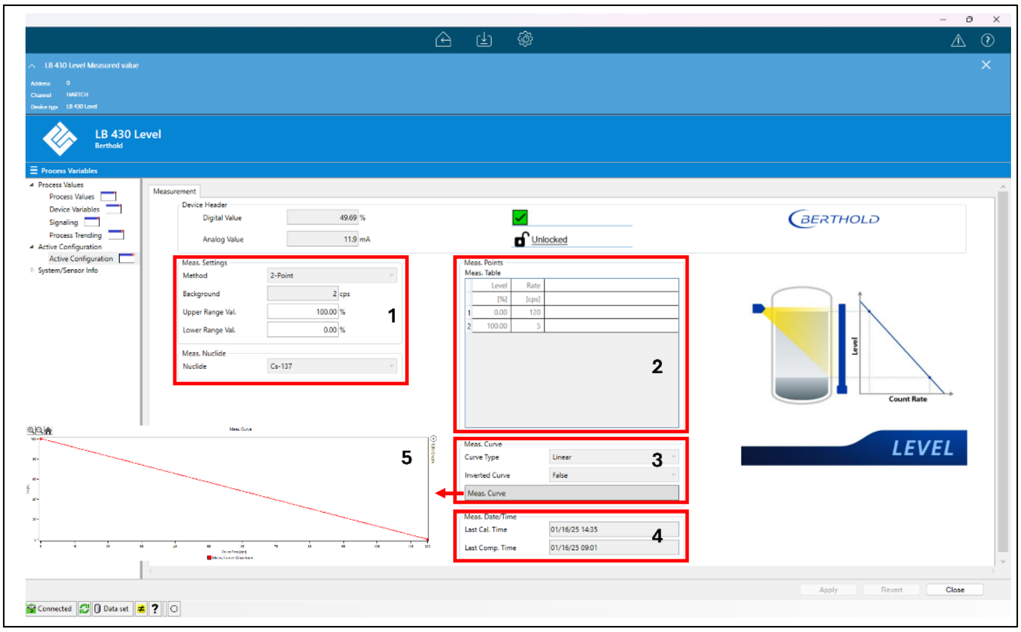

Fig 91 Tab: Active Configuration | Active Configuration | Measurement.

In the **"Measurement"** tab, you can view the current measurement configuration (Fig 91, Pos. 1), the calibration table (Fig 91, Pos. 2), and the calibration curve settings (Fig 91, Pos. 3) based on the device's current calibration.

Additionally, you can check when the device was last calibrated and when the last decay compensation was performed (Fig 91, Pos. 4). Clicking the **Meas. Curve** button calculates and displays the currently used calibration curve (Fig 91, Pos. 5).

5.4 Menu: System/Sensor Info

5.4.1 Submenu: System/Sensor Info | System/Sensor Info

5.4.1.1 Tab: System/Sensor Info | System/Sensor Info | System/Sensor Info

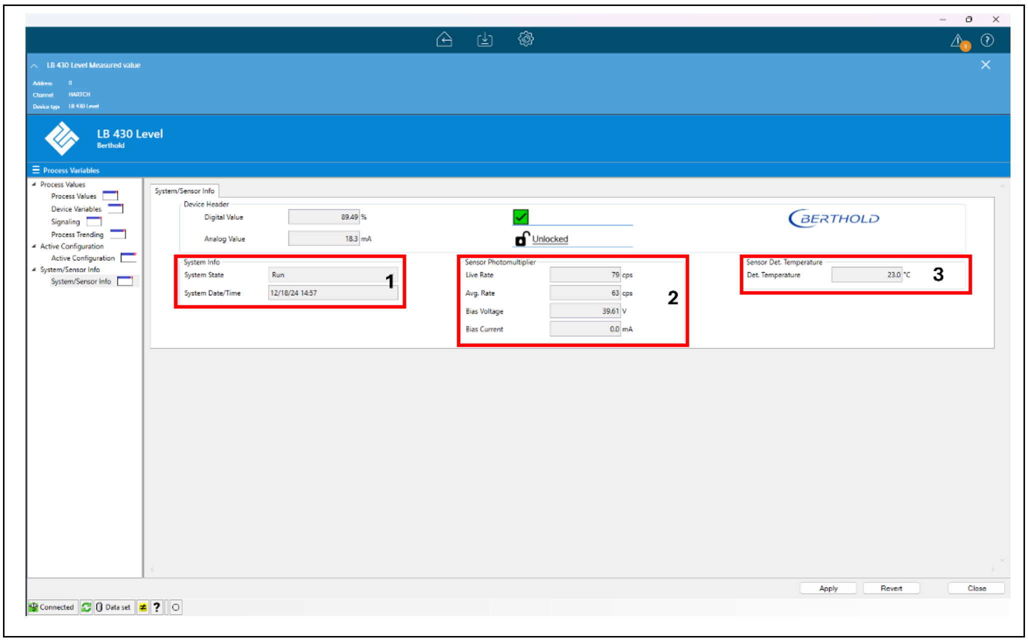

*Fig 92 Tab: **System/Sensor Info | System/Sensor Info | System/Sensor Info**.*

In the **"System/Sensor Info"** tab, you can access current information about the entire system. This includes the device status and the current system time (System Info, Fig 92, Pos. 1), the count rates, voltages, and currents (Sensor Photomultiplier, Fig 92, Pos. 2), as well as the detector temperature (Sensor Det. Temperature, Fig 92, Pos. 3).

6 Main Menu: Diagnosis

6.1 Accessing the Main Menu: Diagnosis

Access to the diagnostics main menu is done via the main menu tree of the connected application. In PACTware 6.1, right-click on the "Diagnosis" option to open it. Please note that the layout of the main menus for accessing the application may vary across different HOST systems.

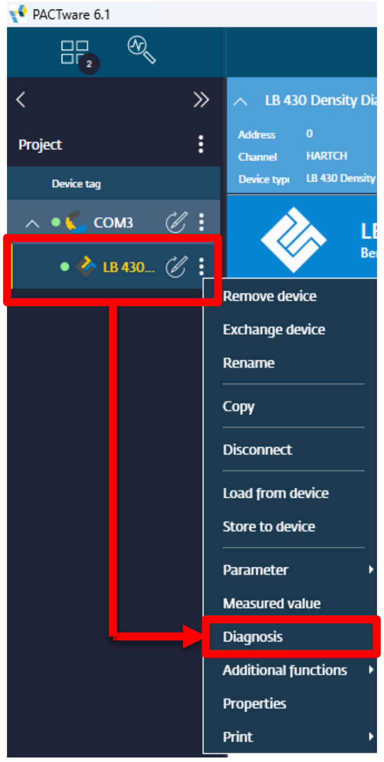

Fig 93 Accessing the Main Menu Diagnosis.

6.2 Menu: Device Status Events

6.2.1 Tab: Device Status Events | Active Event

In the **"Active Event"** tab, you can view information about the currently highest-priority active event. Each event is represented by a code (Fig 94, Pos. 1) in the following format:

F 000

The letter represents the "Condensed Status" according to NAMUR 107 (Fig 94, Pos. 2), and the three-digit code indicates the specific event code.

For each error message, the software provides a brief description (Fig 94, Pos. 3) as well as instructions (Fig 94, Pos. 4), which must be followed to ensure the smooth operation of the device.

NOTICE

In addition to the displayed event codes, a "Service ID" is also shown. This ID describes the underlying issue for Berthold Service and will not be further discussed in this operating manual.

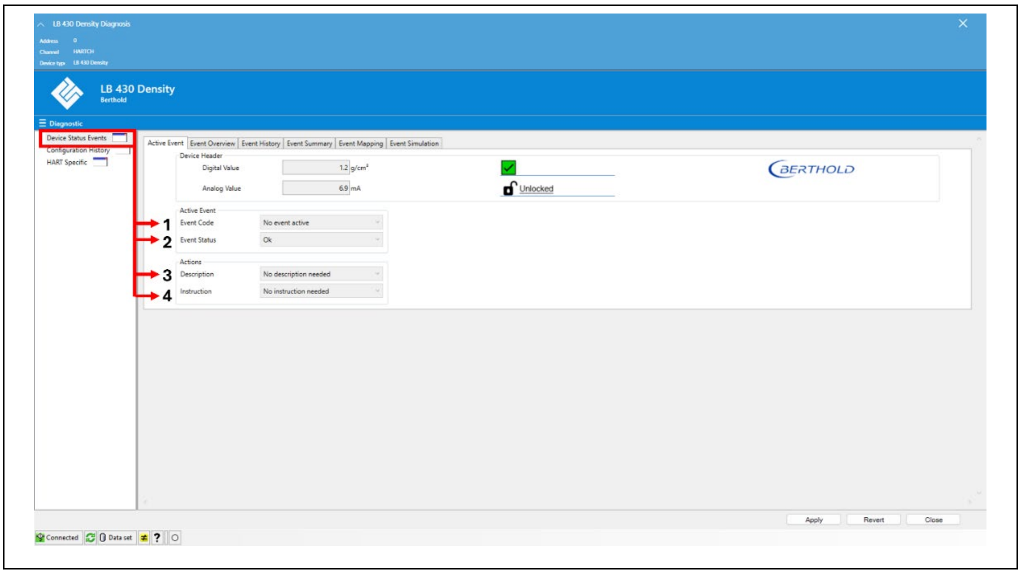

*Fig 94 Tab: **Device Status Events | Active Event.***

6.2.2 Tab: Device Status Events | Event Overview

In the **"Event Overview"** tab, the currently active events of the device are displayed visually. This is particularly helpful when multiple events occur simultaneously. The "Device Specific Status 0 – 5" windows list the device-specific events, while the "Device Specific Status 6" window shows application-specific events, such as active alarms.

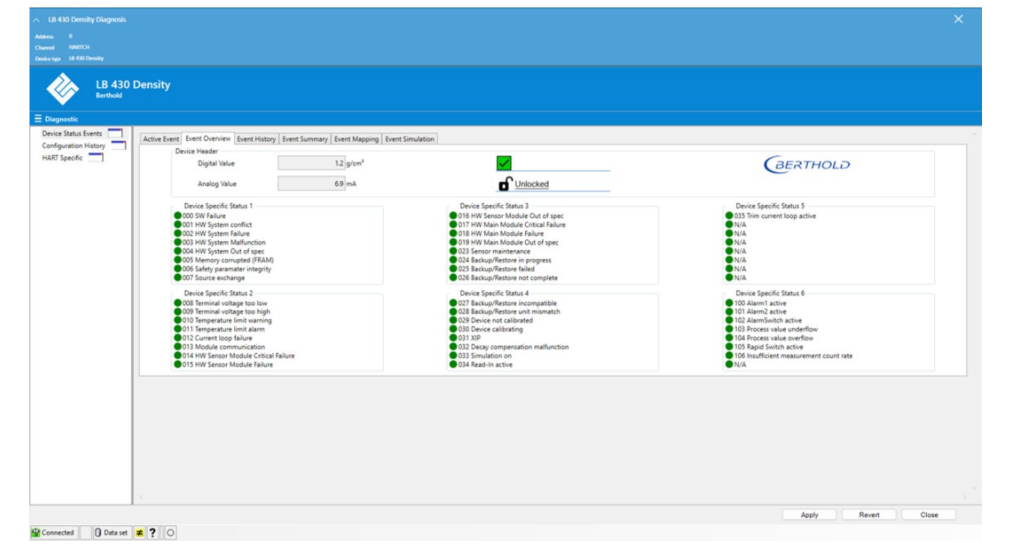

*Fig 95 Tab: **Device Status Events | Event Overview.***

6.2.3 Tab: Device Status Events | Event History

In the **"Event History"** tab, you can view the device's event log, which lists individual events in chronological order when they are no longer marked as active events. The event log must first be loaded by clicking the **Refresh** button (Fig 96, Pos. 1) before it becomes accessible.

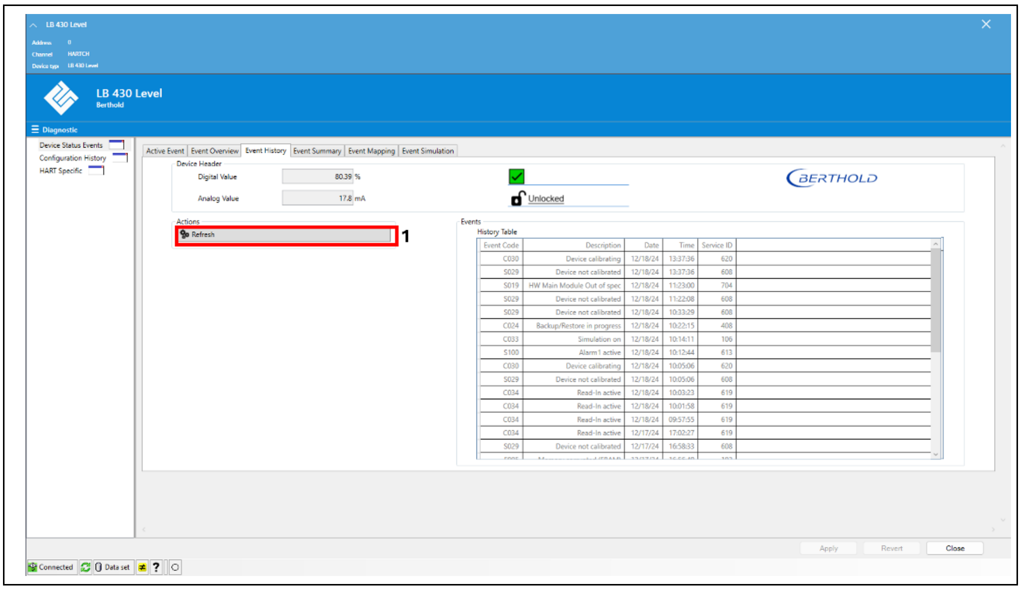

*Fig 96 Tab: **Device Status Events | Event History**.*

NOTICE

If the **Refresh** button is not visible, the event log is up to date.

6.2.4 Tab: Device Status Events | Event Summary

In the **"Event Summary"** tab, a summary of all events reported by the device can be displayed. The "Event-ID" column shows all possible events for the device. The "Counter" column indicates how often each event has occurred. The "Date/Time In" and "Date/Time Out" columns provide information on when and for how long each event occurred. The **Refresh** button (Fig. 97, Pos. 1) must first be clicked to update the summary.

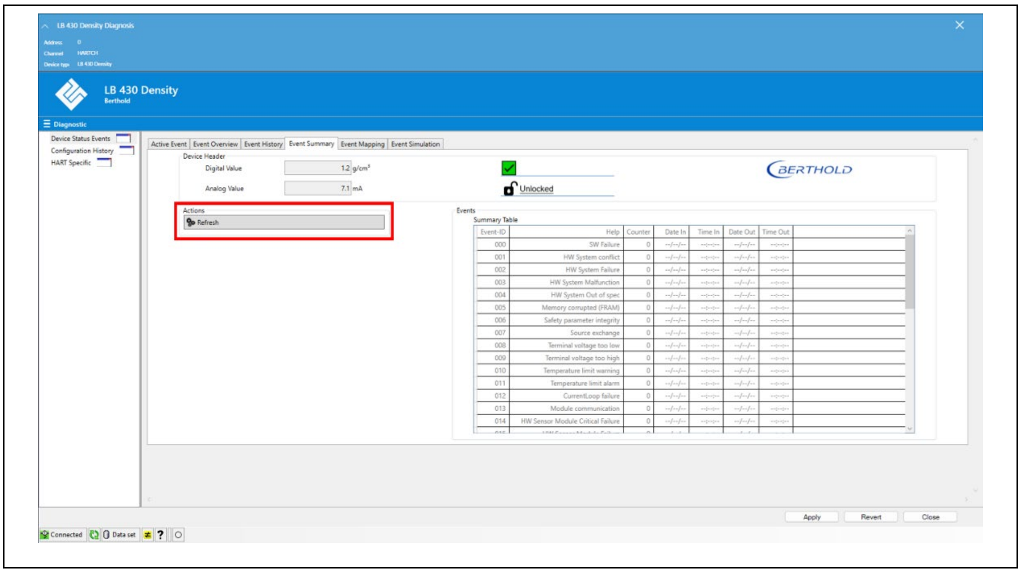

*Fig 97 Tab: **Device Status Events | Event Summary**.*

NOTICE

If the **Refresh** button is not visible, the event summary is up to date.

6.2.5 Tab: Device Status Events | Event Mapping

Certain event IDs for the device can be customized in terms of their impact on the process. The configurable event IDs are marked with "Yes" in the "Configurable" column in *Chapter 6.3 – Device Specific Event Codes* and *Chapter 6.4 – Application Specific Event Codes*. This customization, known as "Event Mapping," is performed via the **"Event Mapping"** tab.

To start event mapping, click the **Change Profile** button (Fig 98, Pos. 1). In the drop-down menu, you can choose between the profiles "Standard," "SIL," and "Custom." Select **Custom** (Fig 98, Pos. 2) to apply individual settings.

For configurable events, an option will now appear where you can define the **Condensed Status** according to NAMUR 107 (Fig 98, Pos. 3) and specify how the event is handled in the process control system (Fig 98, Pos. 4).

- With **Active**, the status is reported to the process control system.
- With **No Effect**, the event is only displayed on the device and is not reported further.

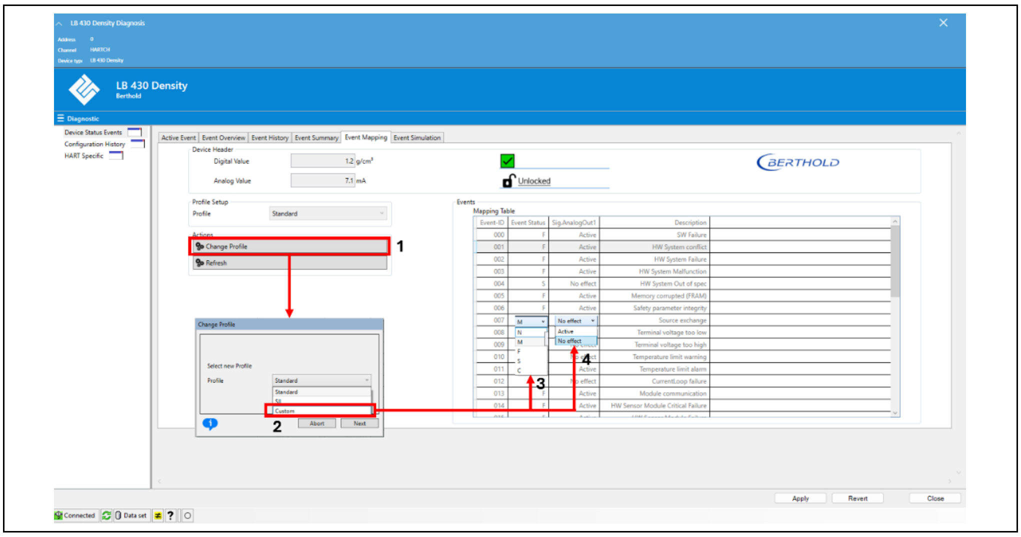

*Fig 98 Tab: **Device Status Events|Event Mapping**.*

6.2.6 Tab: Device Status Events | Event Simulation

In the **"Event Simulation"** tab, all possible events can be simulated. This includes both the device signaling and the effect on the current output. While the simulation mode is active, the device sends the NAMUR status „Check Function" to the process control system until the mode is manually deactivated or the device is restarted.

To start or stop the simulation mode, click the **Enable/Disable Simulation** button. In the event list, you can select "Active" or "Not active" for each event in the drop-down menu. The simulation of an event starts when you choose the "Active" option.

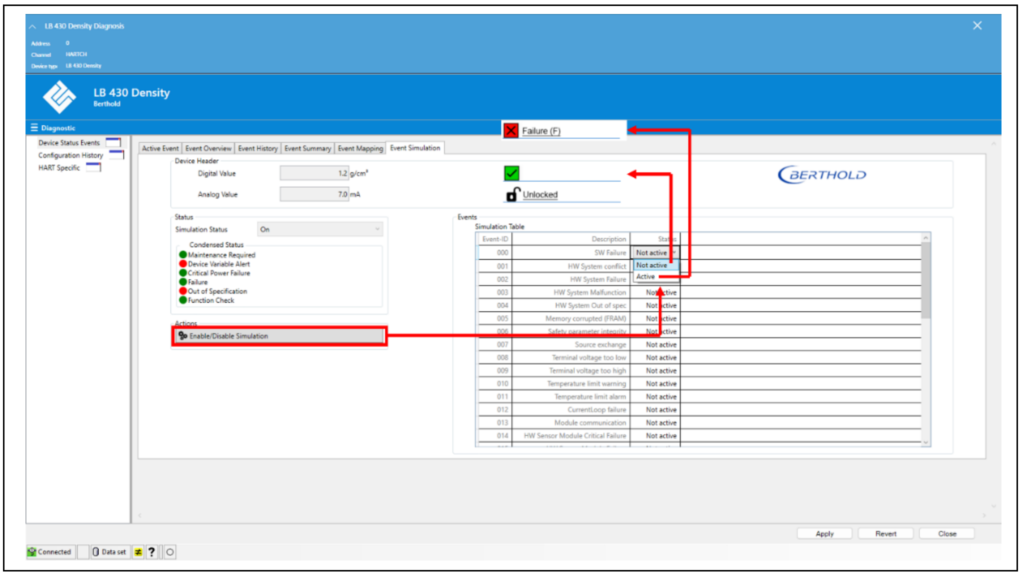

Fig 99 Tab: ***Device Status Events | Event Simulation***.

6.3 Device Specific Event Codes

Event messages can influence the device status. The transmitted NAMUR status may depend on the event mapping profile (see Chapter 6.1.6 of this manual – Device Status Events | Event Mapping). For example, an event might send the status **"Out of Specification" (S)** in standard mode, while transmitting **"Failure" (F)** in safety mode.

Symbol	Name	Description
N	No effect	The event is not considered for the device status.
S	Out of specification	One or more parameters are outside the specified limits.
M	Maintenance required	Maintenance required, e.g., replacement of the radiation source.
C	Function check	Routine in progress, e.g., calibration.
F	Failure	Hardware or software error detected. The measurement is affected.

Code		Message	Configurable	Description/Istruction
Mode Standard	Mode Safety			
F000	F000	SW Failure	No	Software issues with timing, data exchange, faulty RAM, or the device module cannot be contacted. The device enters the safety mode, and the measurement is stopped. • Perform a restart. If the problem persists, contact Berthold Service.
F001	F001	HW System Conflict	No	Hardware compatibility issues, e.g., after installing incompatible modules. The device enters the safety mode, and the measurement is stopped. • Contact Berthold Service.
F002	F002	HW System Failure	No	Faulty hardware component. The device enters the safety mode, and the measurement is stopped. • Contact Berthold Service.
F003	F003	HW System Malfunction	No	Faulty hardware component, but the measurement is not interrupted. This directly affects the decay compensation of the count rates and calibration data. • Reset the system time and restart the device via a system reset. If the issue persists, contact Berthold Service.

S004	S004	HW System Out of spec	Yes	Watchdog jumper set to "Off." • Contact Berthold Service.
F005	F005	Memory corrupted (FRAM)	No	The data record is invalid/corrupted, possibly due to a software update or failed write operation. The device enters the safety mode, and the measurement is stopped. • Perform a repair reset and then restart the device with a system reset. If the issue persists, perform a factory reset and restart the device with a system reset. If the error continues, contact Berthold Service.
M007	M007	Source exchange	Yes	Message indicating when the radiation source needs to be replaced. This is dependent on the selected nuclide and its associated half-life. • To replace the radiation source, contact Berthold Service.
F008	F008	Terminal voltage too low	No	Terminal voltage too low. The device enters a safety mode, and the measurement is stopped. • Check the applied terminal voltage. It must be above 14 V. If necessary, increase the terminal voltage.
S009	S009	Terminal voltage too high	No	Terminal voltage too high. There is a risk of overvoltage to the device. • Check the applied terminal voltage. It should be below 30 V. If necessary, decrease the terminal voltage.
S010	S010	Temperature limit warning	Yes	The device is approaching the temperature limit. • Check the ambient temperature and reduce it if possible. If necessary, use water cooling to reduce the temperature increase.
F011	F011	Temperature limit alarm	No	Outside of the valid temperature range. The device enters the safety mode, and the measurement is stopped. • Check if the device is operating within the specified limits. Restart the device with a system reset. If necessary, use water cooling to reduce the temperature increase.

F012	F012	CurrentLoop failure	No	Error in the process-relevant current output. The current output is not reliable at this moment. Fault currents may not be transmitted to the process control system. • Contact Berthold Service.
F013	F013	Module communication	No	Communication issues at the module level, faulty data exchange between two modules (e.g., LB 430 sensor and display). • Perform a restart via a system reset. If the issue persists, contact Berthold Service.
F014	F014	HW Sensor Module Critical Failure	No	Critical error in the sensor module. The device enters the safety mode, and the measurement is stopped. • Contact Berthold Service.
F015	F015	HW Sensor Module Failure	No	Error in the sensor module. The device transmits a fault current. • Contact Berthold Service.
S016	S016	HW Sensor Module Out of spec	Yes	Sensor module outside the specification limits, e.g., triggered by the watchdog. The device transmits a fault current. • Perform a system restart via the system reset and contact Berthold Service.
F017	F017	HW Main Module Critical Failure	No	Critical error in the main module. The device enters the safety mode, and the measurement is stopped • Contact Berthold Service.
F018	F018	HW Main Module Failure	No	Error in the main module. Triggers the watchdog in any case. A fault current is transmitted. • Perform a system restart via the system reset and contact Berthold Service.
S019	S019	HW Main Module Out of spec	Yes	Main module (processing unit) outside the specification limits. • Contact Berthold Service.
M023	M023	Sensor maintenance	Yes	Measurement outside of specifications. • Contact Berthold Service.
C024	F024	Backup/Restore in progress	Yes	Backup/Restore process active. • No action required.
F025	F025	Backup/Restore failed	Yes	Backup/Restore process was interrupted. • Check the device connection and restart your backup/restore process. If the issue persists, contact Berthold Service.

S026	F026	Backup/Restore not complete	Yes	Backup/Restore compatible, but incomplete. This may occur when restoring device settings after a software update, especially if additional parameters are made available with the software update. • Compare the software versions at the time of the backup and the time of the restore. It is advisable to create a backup after every software update.
F027	F027	Backup/Restore incompatible	Yes	Conflict of software versions between the device and the backup file. This occurs only if the detector software is more recent than at the time of the backup. Newly added parameters cannot be restored because they are not present in the backup file. • Manually configure the device and create a new backup.
F028	F028	Backup/Restore unit mismatch	Yes	The unit in the backup does not match the device's configured units (e.g., g/cm^3 <-> kg/m^3). • Adjust the units on the device according to the information in the backup file and restart the restore process.
S029	S029	Device not calibrated	No	Device not calibrated. • Calibrate the device.
C030	C030	Device calibrating	No	The device is being calibrated. • No action required.
S031	S031	XIP	Yes	Interference radiation detected. The measurement value is frozen. • No action required. If the XIP mode persists for too long or is continuously reported, contact Berthold Service.
M032	M032	Decay compensation malfunction	No	Error in compensation of the detector parameters for the decay of the radiation source. • Check if the system time is correctly set. Verify the compensation timestamp, which should be updated daily. If necessary, reset the system time and recalibrate the device. If the issue persists, contact Berthold Service.
C033	C033	Simulation on	No	Simulation is active. The measurement is affected by this. • If necessary, exit the simulation mode or restart the device.

C034	C034	Read-In active	Yes	Background count rates / calibration points are being read. • No action required.
C035	C035	Trim current active	No	The current output is being calibrated. • No action required.

6.4 Application Specific Event Codes

In addition to device-specific event codes, the system also supports application-specific events. These are used for signaling alarms or executing routine-specific tasks.

6.4.1 Application Level

Code		Message	Configurable	Description/Instruction
Mode Standard	Mode Safety			
S100	S100	Alarm1 active	Yes	Alarm 1 is active. • Depending on the individual settings, check the affected process variable.
S101	S101	Alarm2 active	Yes	Alarm 2 is active. • Depending on the individual settings, check the affected process variable.
S102	S102	AlarmSwitch active	Yes	The switch alarm is active. • Depending on the individual settings, check the affected process variable.
N103	N103	Level underflow	Yes	Level < 0%. • The calibration may be incorrect. Please check the calibration. • Check for possible interference radiation.
N104	N104	Level overflow	Yes	Level > 100%. • The calibration may be incorrect. Please check the calibration. • Check if the radiation source is closed. If necessary, open the shutter of the shield.
S105	S105	Rapid Switch active	Yes	Fast switching is active. The time constant will automatically be set to 1/10 of the configured value for rapid process changes. This is only applicable if compatible with the time constant of the host system.
C106	C106	Adjust active	Yes	The calibration curve is being adjusted. This is applicable after replacing the radiation source or when de-calibrating wall deposits.

6.4.2 Application Density

Code		Message	Configurable	Description/Instruction
Mode Standard	Mode Safety			
S100	S100	Alarm1 active	Yes	Alarm 1 is active. • Depending on the individual settings, check the affected process variable.
S101	S101	Alarm2 active	Yes	Alarm 2 is active. • Depending on the individual settings, check the affected process variable.
S102	S102	ApplicationAlarm active	Yes	The switch alarm is active. • Depending on the individual settings, check the affected process variable.
N103	N103	PV underflow	Yes	The process variable (PV) is below the set measurement range. • The calibration may be incorrect. Please check the calibration. • Check if the cause lies within the process and, if necessary, adjust the measurement range.
N104	N104	PV overflow	Yes	The process variable (PV) is above the set measurement range. • The calibration may be incorrect. Please check the calibration. • Check if the cause lies within the process and, if necessary, adjust the measurement range.
S105	S105	Rapid Switch active	Yes	Fast switching is active. The time constant will automatically be set to 1/10 of the configured value for rapid process changes. This is only applicable if compatible with the time constant of the host system.
F106	F106	Insufficient Meas. Countrate	Yes	The measured count rate after background compensation is < 2 cps. • Check if the background count rate is correctly set and whether the shutter of the radiation source is opened. If the issue persists, contact Berthold Service.

6.5 Menu: Configuration History

6.5.1 Tab: Configuration History | Configuration History

In the configuration log under the **"Configuration History"** tab, all changes to the device parameters are recorded. The log contains 35 entries, and when new changes occur, the oldest entries are removed. The complete deletion of the entries can only be done by Berthold Service, but this is generally not necessary. The counters can be reset using the **Reset Counters** (Fig 100, Pos. 1) button.

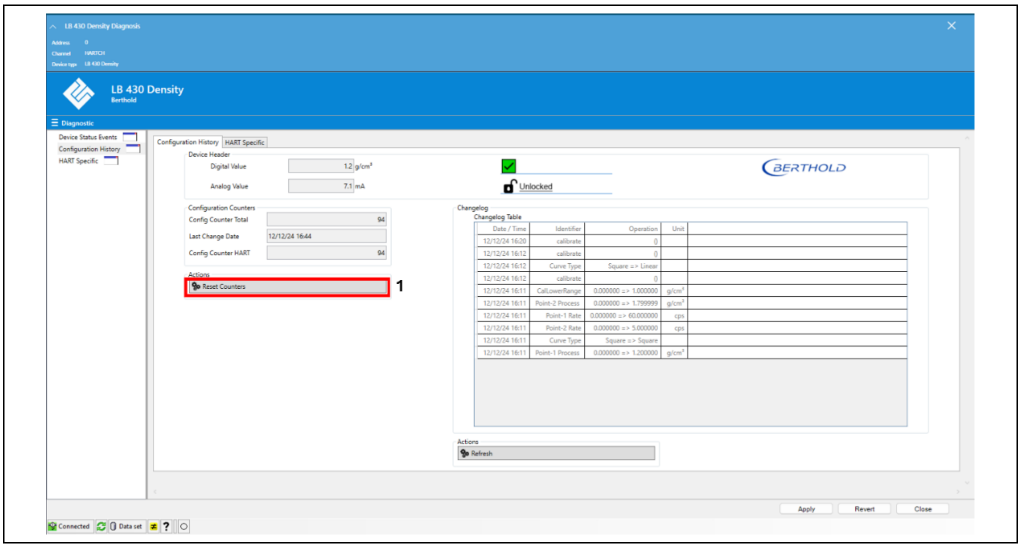

Fig 100 Tab: Configuration History | Configuration History.

6.5.2 Tab: Configuration History | HART Specific

The counters for HART-specific configurations, such as address changes, can be reset in the **"HART Specific"** tab by clicking the **Reset Change Flag HART** (Fig 101, Pos. 1) button.

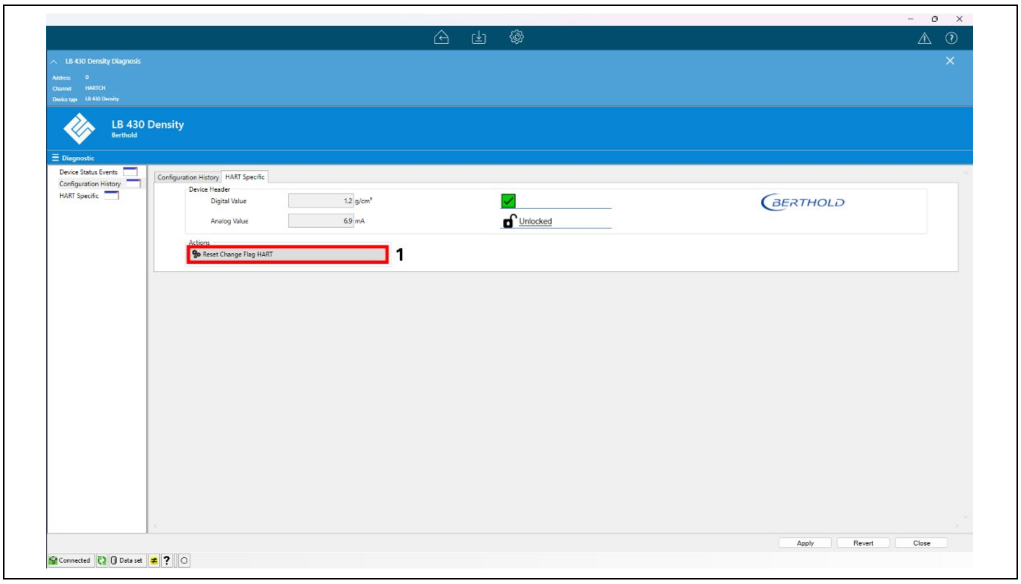

Fig 101 Tab: Configuration History | HART Specific.

6.6 Menu: HART Specific

6.6.1 Tab: HART Specific | HART Diagnostics

In the tab **"HART Diagnosis"**, you can view the HART-specific diagnostics. Here, events such as "Simulation Active" are displayed to indicate that the simulation mode (for measurements or events) is active. This diagnostic information is generally not required for daily operation but serves as support for Berthold Service.

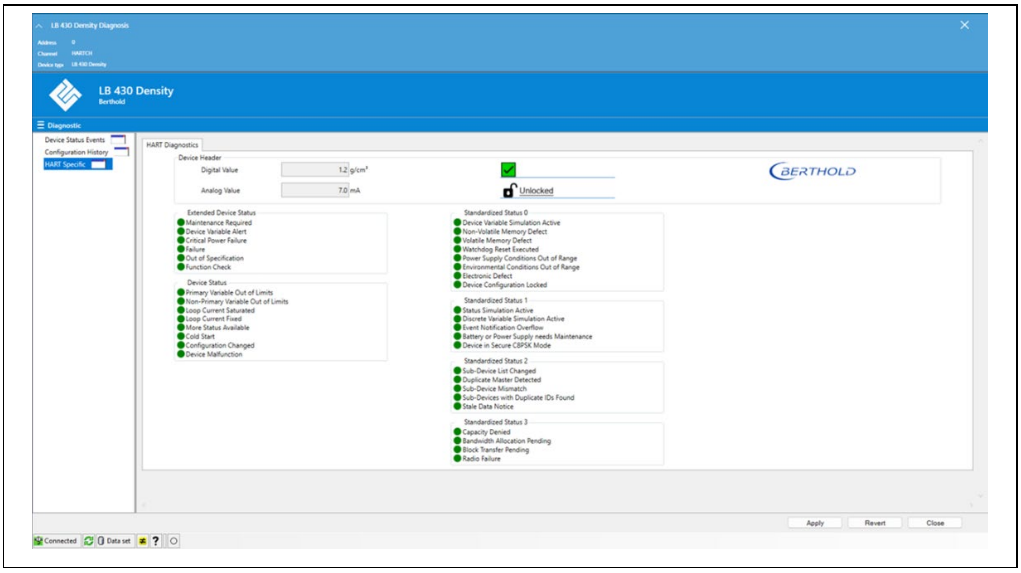

*Fig 102 Tab: **HART Specific | HART Diagnostics**.*

Subject to changes due to technical advancements.

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