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Valid as of version
01.00.zz (Device firmware)

Special Documentation
Proline Promag 10

Heartbeat Verification + Monitoring application package
Modbus RS485

Endress+Hauser
People for Process Automation

Table of contents

1 Certification

Certification is issued by an independent certification body.

The following requirements are certified:
- Inspection method
- Test principles
- Test results with total test coverage specified
- Traceable verification according to DIN EN ISO 9001:2015, Section 7.1.5/7.1.5.2 a)

Requirements according to DIN EN ISO 9001
Heartbeat Technology™ also meets the requirements for traceable verification according to DIN EN ISO 9001: 2015 - Section 7.1.5/7.1.5.2 a) "Control of monitoring and measuring equipment". According to the standard, the user is responsible for specifying the verification interval in a manner that complies with requirements.

Further information on the documentation → 6.

2 About this document

2.1 Document function

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

2.2 Content and scope

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

- Application-specific parameters
- Advanced technical specifications

2.3 Symbols

2.3.1 Safety symbols

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

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

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

NOTICE
This symbol contains information on procedures and other facts which do not result in personal injury.

2.3.2 Symbols for certain types of Information

Symbol	Meaning
	**Permitted** Procedures, processes or actions that are permitted.
	**Preferred** Procedures, processes or actions that are preferred.
	**Forbidden** Procedures, processes or actions that are forbidden.
	**Tip** Indicates additional information.
	Reference to documentation
	Reference to page
	Reference to graphic
▶	Notice or individual step to be observed
1., 2., 3...	Series of steps

Symbol	Meaning
	Result of a step
 A0028662	Operation via local display
 A0028663	Operation via operating tool
 A0028665	Write-protected parameter

2.3.3 Symbols in graphics

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

2.4 Documentation

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

This Special Documentation is available:
In the Download Area of the Endress+Hauser website: www.endress.com → Downloads

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

Measuring device	Documentation code
Promag D 10	BA02077D
Promag H 10	BA02071D
Promag P 10	BA02072D
Promag W 10	BA02073D

Certification	Documentation code
Manufacturer declaration Promag 10	HE_01407

2.5 Registered trademarks

Modbus®
Registered trademark of SCHNEIDER AUTOMATION, INC.

3 Product features and availability

3.1 Product features

Heartbeat Technology offers diagnostic functionality through continuous self-monitoring, the transmission of additional measured variables to an external Condition Monitoring system and the in-situ verification of flowmeters in the application.

The test scope achieved using these diagnostic and verification tests is expressed as the **total test coverage** (TTC). The TTC is calculated using the following formula for random errors (calculation based on FMEDA as per IEC 61508):

$TTC = (\lambda_{TOT} - \lambda_{du}) / \lambda_{TOT}$

λ_{TOT}: Rate of all theoretically possible failures

λ_{du}: Rate of undetected dangerous failures

Only the dangerous undetected failures that are not captured by the device diagnostics can falsify the measured value that is output or interrupt the output of measured values.

Heartbeat Technology checks the device function within the specified measuring tolerance with a defined TTC. The defined TTC is indicated in the product-specific TÜV certificate (TÜV = Technical Inspection Association).

The current value for the TTC depends on the configuration and integration of the measuring device. The values indicated above were determined under the following conditions:
- Integration of measuring device for measured value output via 4 to 20 mA HART output
- Simulation operation not active
- Error behavior, current output set to **Minimum alarm** or **Maximum alarm** and evaluation unit recognizes both alarms
- Settings for diagnostic behavior correspond to factory settings

3.2 Availability of the application package

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

3.2.1 Order code

If ordering directly with the device or subsequently as a retrofit kit:
Order code for "Application package", option EB "Heartbeat Verification + Monitoring"

The availability of the application package can be checked as follows:
- Order code with breakdown of the device features on the delivery note
- Open the Device Viewer via the website www.endress.com/deviceviewer: Enter the serial number on the nameplate and check whether the order code is displayed
- In the operating menu System → Software configuration : The **Software option overview** parameter indicates whether the application package is enabled

3.2.2 Activation

The **Heartbeat Verification + Monitoring** application package must be enabled in the device if the package is ordered subsequently as a retrofit kit. The retrofit kit contains an activation code that must be entered via the operating menu:

System → Device management

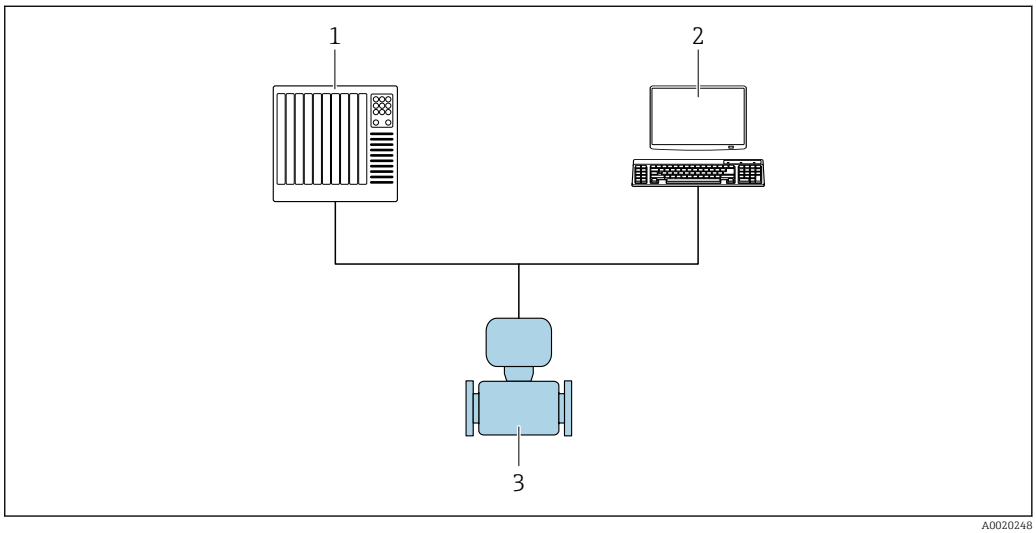
- ▶ Enter the activation code.
  - ↳ The application package is available.
    The **Software option overview** parameter displays the packages that are currently activated.

3.2.3 Access

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

4 System integration

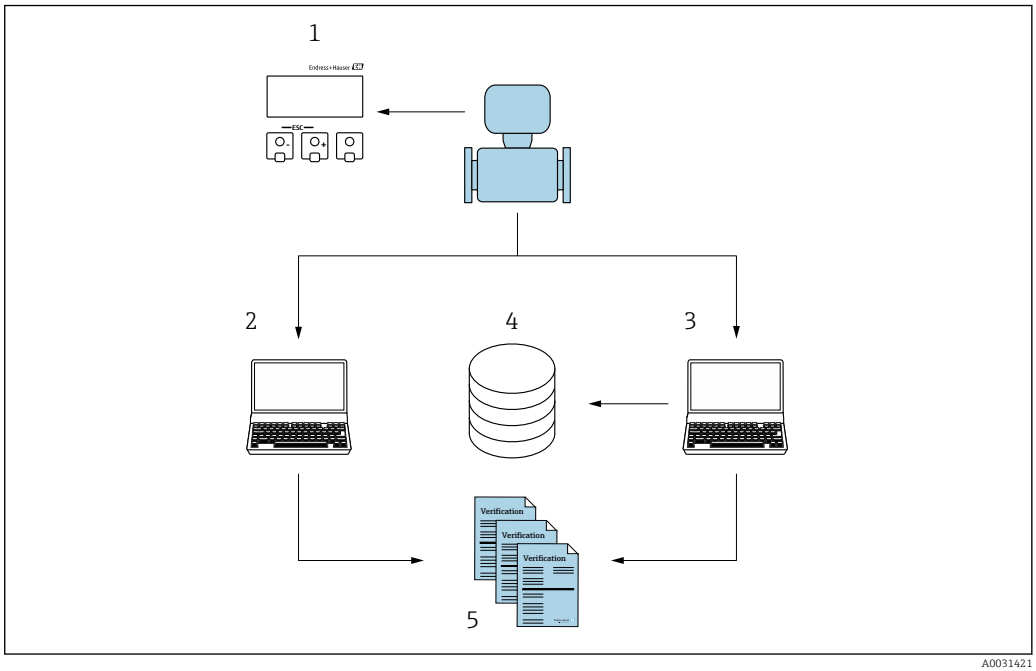
The **Heartbeat Technology** features are available via the local display module and the digital interfaces. The features can be used via an asset management system and also via the automation infrastructure (e.g. PLC).



1 *General screen layout*

1 PLC
2 Asset management system
3 Measuring device

4.1 Performing verification and creating a verification report



1 Local display
2 Web browser
3 FieldCare
4 Data memory in the measuring device
5 Verification report

Run the **Heartbeat Verification** via one of the following interfaces:
- System integration interface of a higher-level system
- Local display
- Bluetooth
- Service interface CDI-RJ45 (CDI: Common Data Interface)

The device must be accessed externally from a higher-level system via the system integration interface in order to start a verification and signal the verification result (Passed or Failed). It is not possible to start the verification via an external status signal and relay the results to a higher-level system via the status output.

The detailed results of the verification (3 data records) are saved in the device and provided in the form of a verification report.

Verification reports can be created using the device DTM, or FieldCare, the Endress+Hauser plant asset management software.

With the Flow Verification DTM, FieldCare also offers the possibility of data management and of archiving the verification results to create traceable documentation.

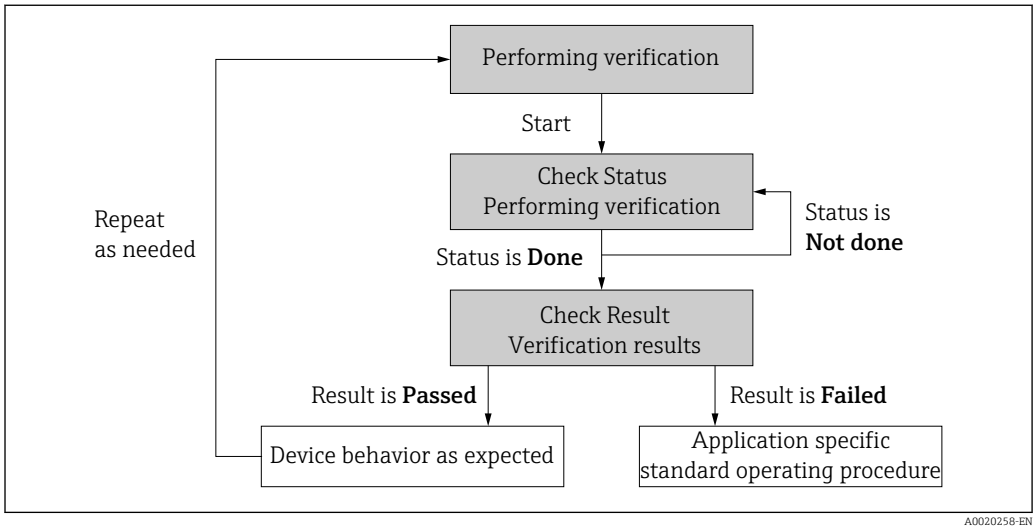
The Flow Verification DTM also enables trend analysis – i.e. the ability to monitor, compare and track the verification results of all the verifications performed on the device. This can be used for assessment purposes, e.g. to be able to extend recalibration intervals.

Data exchange can take place automatically or be triggered by a user.

4.2 Integration into the PLC system

The measuring device's built-in verification can be activated via a control system the SmartBlue app and the results can be checked.

The following procedure must be implemented for this purpose:



Verification result: The overall result of the verification is indicated in the **Overall result** parameter. Different, application-specific measures must be performed by system routines depending on the result, e.g. a "Maintenance Required" alert is triggered if the result is **Failed**.

4.3 Data availability for the user

The data from the **Heartbeat Monitoring** and **Heartbeat Verification** function can be made available in a variety of ways.

4.3.1 Device

Heartbeat Monitoring
The user can read the monitoring measured variables in the operating menu.

Heartbeat Verification
- Start verification
- Read out the last verification result

4.3.2 Asset management system

Heartbeat Monitoring
Configuration of the monitoring function: specify which diagnostic parameters are output continuously via the system integration interface.

Heartbeat Verification
- Start verification in the operating menu
- Upload, archive and document the verification results including detailed results with Flow Verification DTM

4.3.3 PLC system

Heartbeat Monitoring
Configuration of the monitoring function: specify which diagnostic parameters are output continuously via the system integration interface.

Heartbeat Verification
- Start verification
- The user can read the verification result in the system

4.4 Data management

The results of a **Heartbeat Verification** are saved as a non-volatile parameter set in the measuring device memory:
- 3 storage locations available for parameter data records
- New verification results overwrite old data following the FIFO [1] principle

The results can be documented in the form of a verification report using the , the Endress+Hauser asset management software, FieldCare, and Netilion Health.

FieldCare also offers additional capabilities with the Flow Verification DTM:
- Archiving of verification results
- Export of data from these archives
- Trend analysis of verification results (line recorder function)

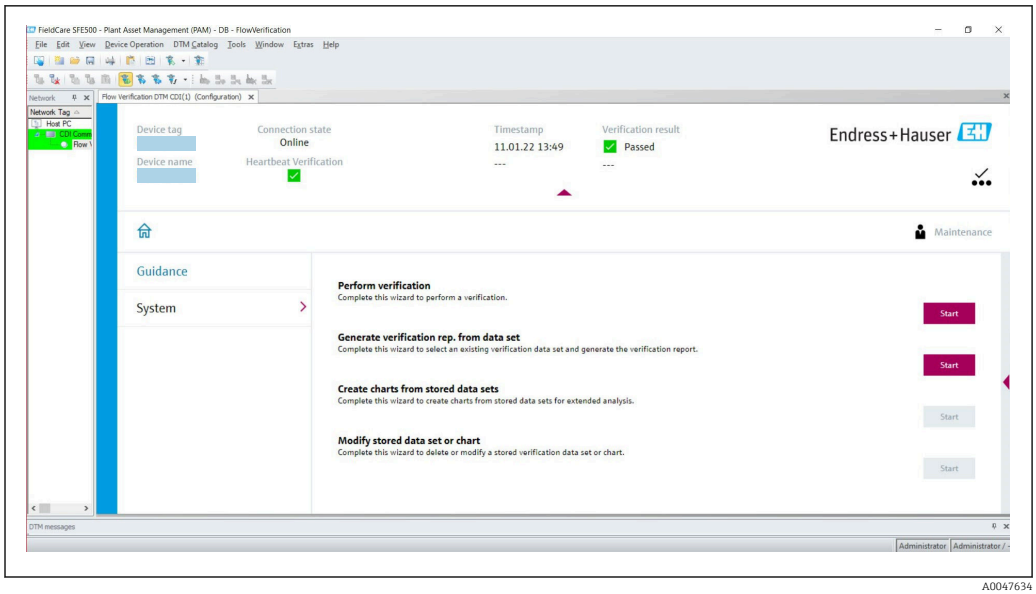
4.4.1 Data management via device DTM

With the device DTM, it is possible to operate the device and perform**Heartbeat Verification**. The results that are generated are displayed as a verification report and saved in PDF format.

4.4.2 Data management via Flow Verification DTM

A special DTM (Flow Verification DTM) is available for **Heartbeat Verification**. The Flow Verification DTM offers advanced capabilities for managing and visualizing the results.

1) First In – First Out

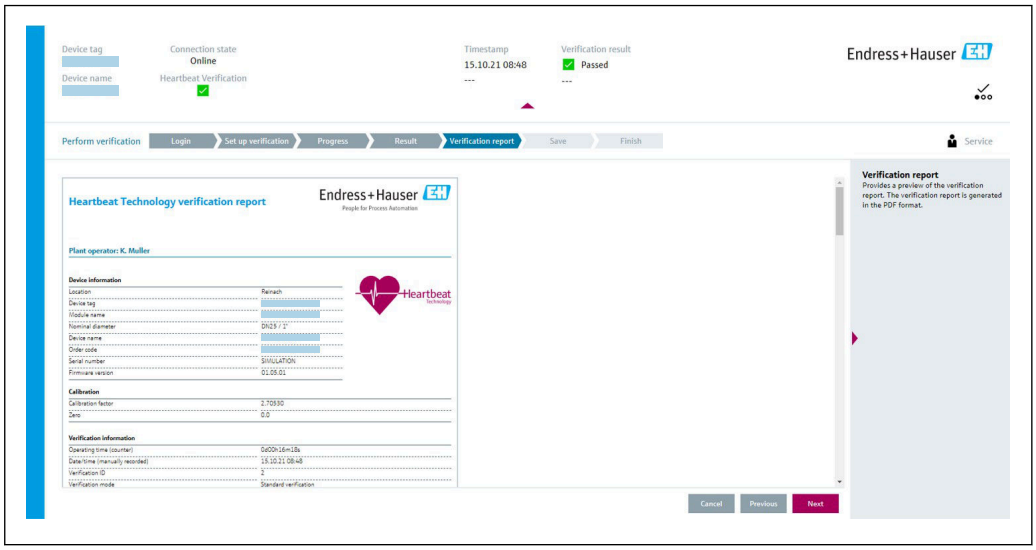


2 *Home page of "Flow Verification DTM" in FieldCare SFE500*

A wizard with help text guides you step-by-step through four different procedures.

Starting point	Description of procedure
Perform verification *Online connection to device required.*	Perform verification and create a verification report.
Create the verification report using a verification data record ▪ from the device (online) ▪ from the archive (offline)	Select an existing verification data record and create the verification report.
Create charts on selected diagnostic parameters from saved verification data records	Create charts on selected diagnostic parameters from archived verification data records for advanced analyses and trending.
Manage saved verification data records or chart templates	Delete or change archived verification data records or chart templates.

Perform verification



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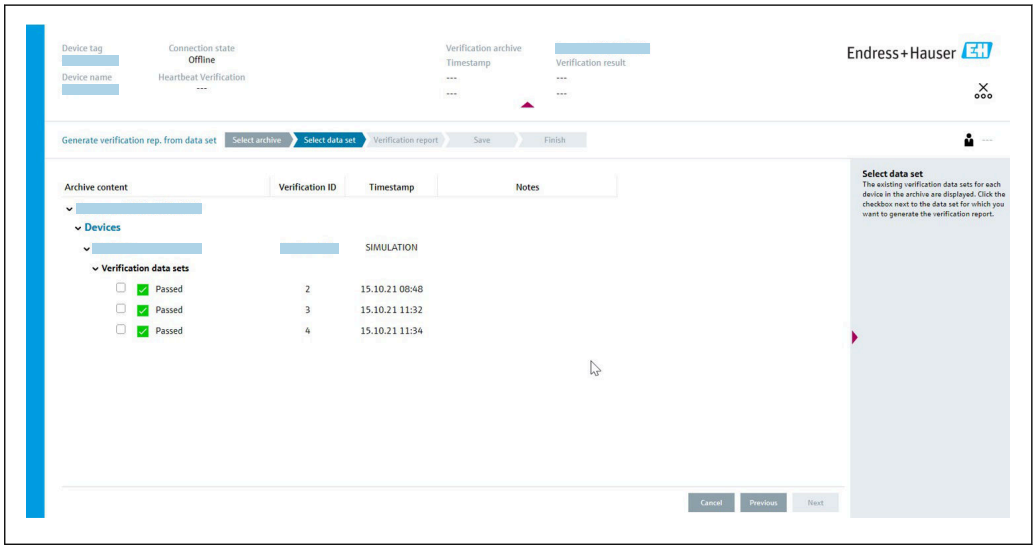
3 Example: Displaying the verification report after performing verification

Online connection to device required.

Creating the verification report using a verification data record



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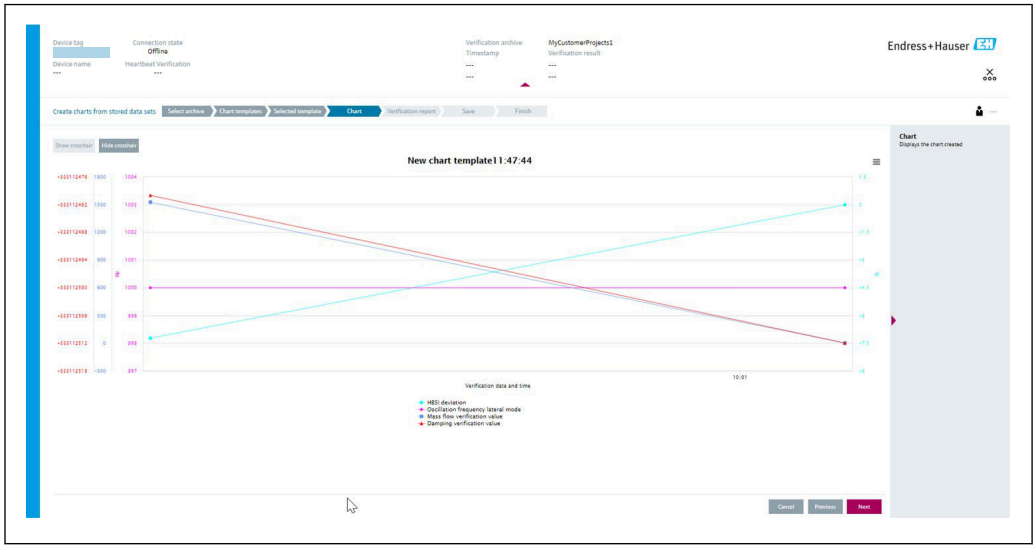
4 Example: Creating the verification report using a verification data record

Reading in the verification data record from the
- Device: Online connection to device required.
- Archive: Offline use sufficient.

Creating charts on selected diagnostic parameters from saved verification data records



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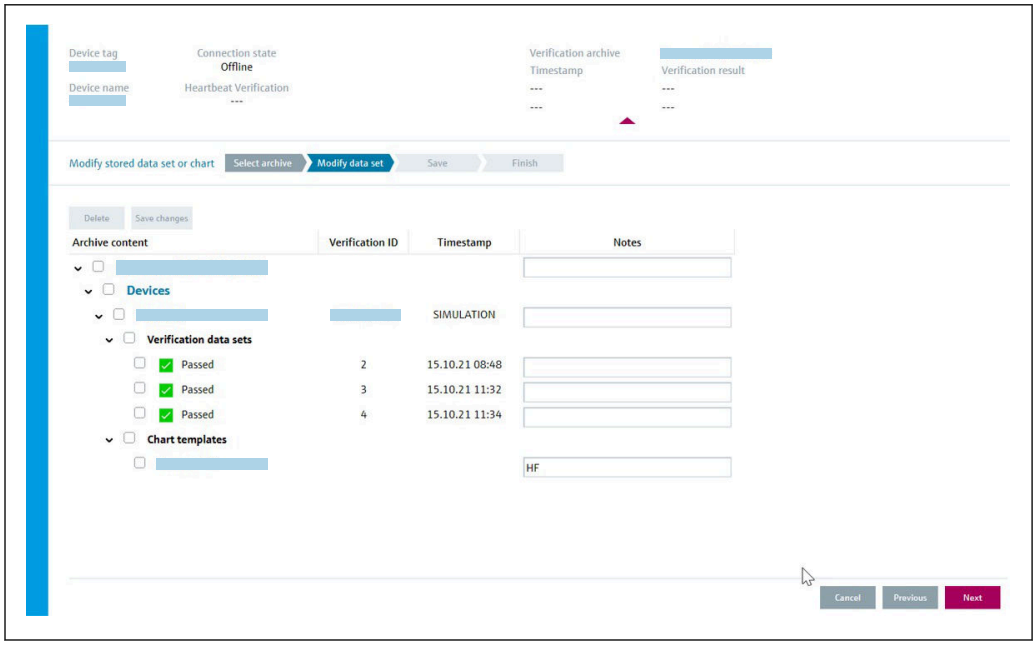
5 *Example: Creating self-edited charts on selected diagnostic parameters from saved verification data records*

It is possible to create templates.

Managing saved verification data records or chart templates



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6 *Example: Deleting or changing saved verification data records or chart templates*

5 Heartbeat Verification

Heartbeat Verification checks the device function within the specified measuring tolerance on demand. The result of the verification is "Passed" or "Failed".

The verification data are saved in the device and, optionally, are archived on a PC with the FieldCare asset management software . A verification report is generated automatically on the basis of these data to ensure the traceable documentation of the verification results.

Heartbeat Technology offers two ways to perform Heartbeat Verification:
Standard verification → 17
Verification is performed by the device without manual checking of external measured variables.

5.1 Performance characteristics

Heartbeat Verification is performed on demand and supplements permanent self-monitoring with additional checks (electronic current loss, coil circuit measurement, shot control circuit, electrode signal integrity).

Standard verification additionally checks the following analog inputs and outputs:
- 4 to 20 mA current output, active and passive
- Pulse/frequency output, active and passive
- 4 to 20 mA current input, active and passive
- Double pulse output, active and passive
- Relay output

The extended verification supports the verification of the following output modules:
- 4 to 20 mA current output, active and passive
- Pulse/frequency output, active and passive

Heartbeat Verification does not check the digital inputs and outputs and does not output any result for them.

The verification is based on references that are incorporated in the measuring device, traceable from the factory and redundant in the device. **Heartbeat Verification** confirms on demand the device function with the total test coverage (TTC).

Assessed by an independent body: **Heartbeat Technology** meets the requirement for traceable verification according to DIN EN ISO 9001: 2015 Chapter 7.1.5.2 a) Control of monitoring and measuring equipment.

5.2 Commissioning

The configuration (factory reference) required as part of **Heartbeat Verification** is recorded during calibration at the factory and is permanently stored in the measuring device. When verifying in the application, the current situation of the measuring device is compared against this factory reference.

Recommendation: During the process of commissioning the measuring device, an initial verification (and all additional verifications during the life cycle) is performed under process or reference conditions → 11.

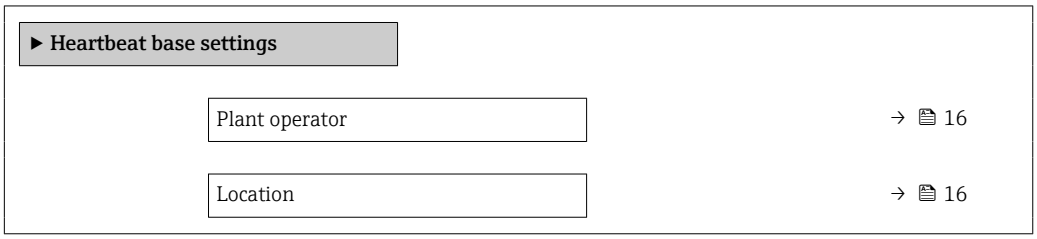
The results are saved as the initial situation in the life cycle of the measuring device up to the 8th verification. From the 9th verification, it is recommended to upload the results using the verification DTM so that the data of the previous verifications is not lost.

5.2.1 Recording reference data

It is possible to manually record reference data relating to the operator and the location. These reference data appear on the verification report.

Navigation
"Setup" menu → Advanced setup → Heartbeat setup → Heartbeat base settings

Navigation
"Expert" menu → Diagnostics → Heartbeat → Heartbeat base settings



Parameter overview with brief description

Parameter	Description	User entry / Selection
Plant operator	Enter the plant operator.	Max. 32 characters such as letters, numbers or special characters (e.g. @, %, /)
Location	Enter the location.	Max. 32 characters such as letters, numbers or special characters (e.g. @, %, /)
Partially filled pipe	Indicate, if the measuring tube is partially filled during the verification process in order to avoid evaluating the EPD electrode cable.	▪ No ▪ Yes

5.3 Operation

5.3.1 General information

The **Heartbeat Verification** function can be used without restriction on a custody-transfer (CT) measuring device in the custody transfer mode.

5.3.2 Initial verification

▶ When commissioning the measuring device:
An initial verification is performed to archive the results as the initial situation in the life cycle of the measuring device. From the 9th verification onwards, an upload using the verification DTM is recommended.

Initial verification can be performed in 2 ways:
- Standard verification → 17
- Extended verification → 21

5.3.3 Device behavior and interpretation

Result is "Passed"

All test results are within the specifications.

If the calibration factor and the zero point match the factory settings, there is a high degree of certainty that the measuring device complies with the specification for flow.

Verification generally delivers the result "Passed" in most applications.

Result is "Failed"

One or more test results are outside the specifications.

If the result of the verification is "Failed", take the following measures:

1. Establish defined and stable process conditions.
   ↳ Ensure a constant process temperature.
   Avoid wet gases, two-phase mixtures, pulsating flow, pressure shock and very high flow rates.
2. Repeat verification.
   ↳ Repeat verification "Passed"
   If the result of the second verification is "Passed", the result of the first verification can be ignored. In order to identify possible deviations, compare the current process conditions with the process conditions of a previous verification.

If the result of the verification is "Failed" again, take the following measures:

1. Take remedial action on the basis of the verification results and the diagnostic information of the measuring device.
   ↳ The cause of the error can be narrowed down if the test group that "Failed" the verification is identified.
2. Provide Endress+Hauser Service with the verification result with the current process conditions.
3. Check the calibration or calibrate the measuring device.
   ↳ The calibration has the advantage that the "as found" measuring device state is recorded and the actual measured error is determined.

5.3.4 Standard verification

Standard verification is performed automatically by the device and without manual checking of external measured variables.

Diagnostic behavior

The device signals that standard verification is being performed: ⚠**C302 Device verification in progress** diagnostic message
- Factory setting for diagnostic behavior: warning
- The device continues to measure.
- The last good value is output intermittently for 10 seconds.
- The signal outputs and totalizers are not affected.
- All measured values during the verification are added to the totalizers.
- Test duration: approx. 60 seconds.

- The diagnostic behavior can be changed by the user if necessary:
  Expert → System → Diagnostic handling → Diagnostic behavior
  If **Alarm** is selected as the diagnostic behavior, the output of measured values is interrupted in the event of an error and the signal outputs and totalizers adopt the defined alarm condition.
- In the **Diagnostic configuration** submenu, a category is assigned to the diagnostic message of the outputs.
  Expert → Communication → Diagnostic configuration
  If the device does not have outputs, they are output as an error. To prevent an error from being output, assign the **No effect (N)** option to any outputs that are not present on the device.

Detailed information on diagnostics and troubleshooting and on diagnostic information and associated troubleshooting measures can be found in the Operating Instructions → 📄 6.

Performing standard verification

Before verification starts

The date and time are saved with the current operating time and the verification results and also appear in the verification report.

The **Year** parameter, **Month, Day, Hour, AM/PM and Minute** are used to manually record the data at the time of verification.

1. Enter date and time.

Select the verification mode

2. In the **Verification mode** parameter, select the **Standard verification** option.

Starting the verification test

3. In the **Start verification** parameter, select the **Start** option.
   ↳ While the verification is being performed, the progress of the verification is indicated as a % (bar graph indicator) in the **Progress** parameter.

Displaying the verification status and result

The current status of standard verification is displayed in the **Status** parameter (→ 21):
- Done
  The verification test is finished.
- Busy
  The verification test is running.
- Not done
  A verification has not yet been performed on this measuring device.
- Failed
  A precondition for performing the verification has not been met, the verification cannot start (e.g. due to unstable process parameters) → 16.

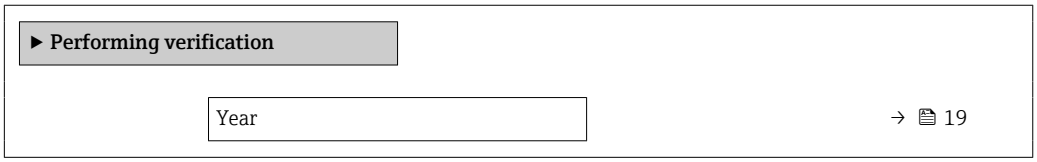
The result of the verification is displayed in the **Overall result** parameter (→ 21):
- Passed
  All the verification tests were successful.
- Not done
  A verification has not yet been performed on this measuring device.
- Failed
  One or more verification tests were not successful → 16.

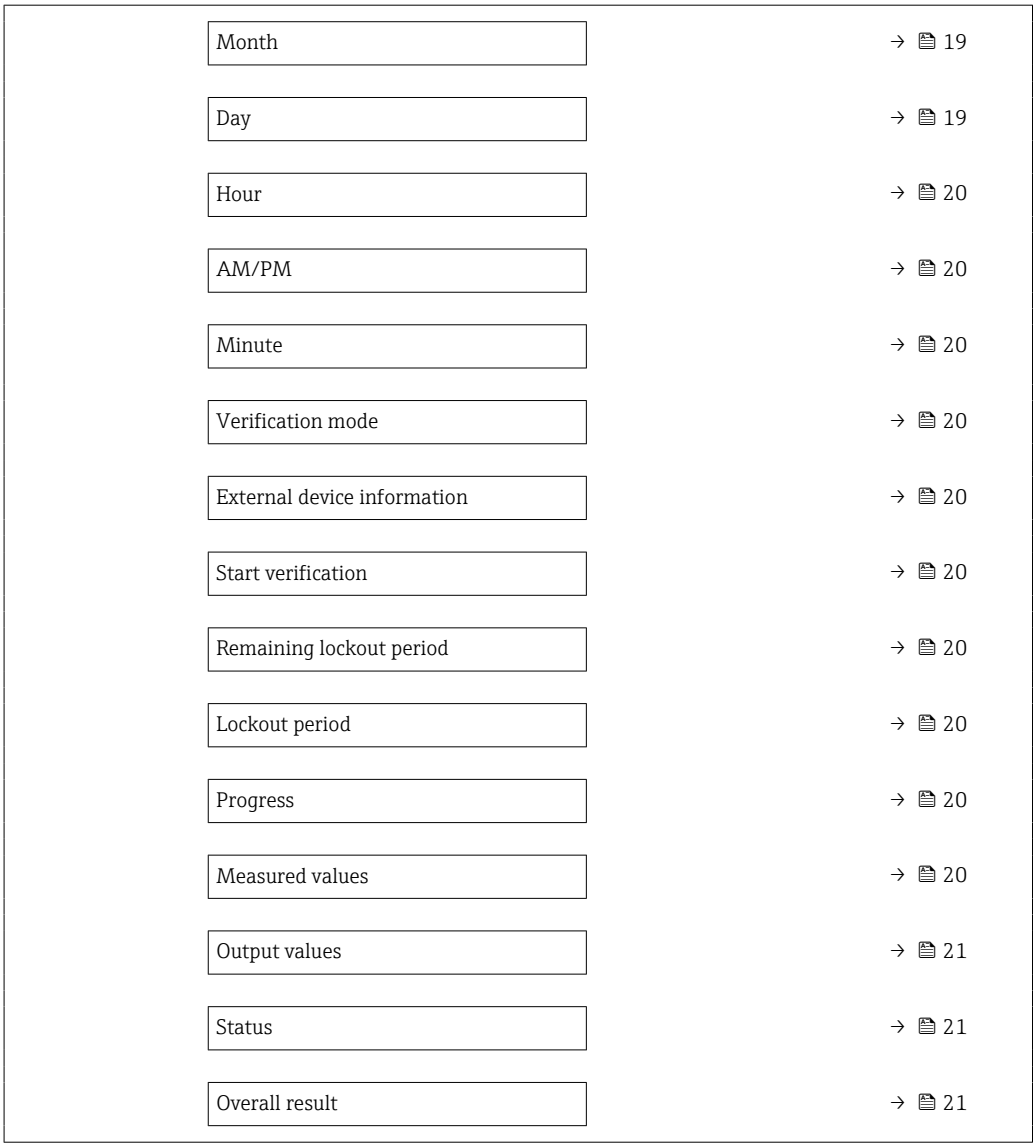
- The overall result of the last verification can always be accessed in the menu.
- Navigation:
  Diagnostics → Heartbeat Technology → Verification results
- Detailed information on the verification result (test groups and test status) are shown in the verification report in addition to the overall result → 31.
- If the device does not pass the verification, the results are saved nonetheless and indicated in the verification report.
- This facilitates a targeted search for the cause of the fault → 16.

"Performing verification" submenu

Navigation

"Diagnostics" menu → Heartbeat Technology → Performing verification





Parameter overview with brief description

Parameter	Prerequisite	Description	User entry / Selection / User interface	Factory setting
Year	Can be edited if Heartbeat Verification is not active.	Entry for date and time (field 1): enter the year verification is performed.	9 to 99	–
Month	Can be edited if Heartbeat Verification is not active.	Entry for date and time (field 2): enter the month verification is performed.	▪ January ▪ February ▪ March ▪ April ▪ May ▪ June ▪ July ▪ August ▪ September ▪ October ▪ November ▪ December	–
Day	Can be edited if Heartbeat Verification is not active.	Entry for date and time (field 3): enter the day verification is performed.	1 to 31 d	–

Parameter	Prerequisite	Description	User entry / Selection / User interface	Factory setting
Hour	Can be edited if Heartbeat Verification is not active.	Entry for date and time (field 4): enter the hour verification is performed.	0 to 23 h	–
AM/PM	Can be edited if Heartbeat Verification is not active. The **dd.mm.yy hh:mm am/pm** option or the **mm/dd/yy hh:mm am/pm** option is selected in the **Date/ time format** parameter (2812).	Entry for date and time (field 5): enter the morning or afternoon.	▪ AM ▪ PM	–
Minute	Can be edited if Heartbeat Verification is not active.	Entry for date and time (field 6): enter the minute verification is performed.	0 to 59 min	–
Verification mode	Can be edited if Heartbeat Verification is not active.	Select the verification mode. Standard verification Verification is performed automatically by the device and without manual checking of external measured variables.	Standard verification	–
External device information	With the following conditions: ▪ The **Extended verification** option is selected in the **Verification mode** parameter. ▪ Can be edited if the verification status is not active.	Record measuring equipment for extended verification.	Free text entry	–
Start verification	–	Start the verification. Start the verification with the **Start** option.	▪ Cancel ▪ Start	–
Remaining lockout period	–	Shows the remaining number of hours until the lockout period has elapsed.	0 to 99 h	–
Lockout period	–	Enter the lockout period in hours. When the device is in custody transfer mode, it is not possible to perform a verification during this time.	0 to 99 h	–
Progress	–	Shows the progress of the process.	0 to 100 %	–
Measured values	One of the following options is selected in the **Start verification** parameter (→ 🖹 20): ▪ Output 1 low value ▪ Output 1 high value ▪ Output 2 low value ▪ Output 2 high value ▪ Output 3 low value ▪ Output 3 high value ▪ Frequency output 1 ▪ Pulse output 1 ▪ Frequency output 2 ▪ Pulse output 2 ▪ Double pulse output	Use this function to enter the measured values (actual values) for the external measured variables:. ▪ Current output: Output current in [mA] ▪ Pulse/frequency output: Output frequency in [Hz] ▪ Double pulse output: Output frequency in [Hz]	Signed floating-point number	–

Parameter	Prerequisite	Description	User entry / Selection / User interface	Factory setting
Output values	–	Displays the simulated output values (target values) for the external measured variables:. ▪ Current output: Output current in [mA]. ▪ Pulse/frequency output: Output frequency in [Hz].	Signed floating-point number	-
Status	–	Displays the current status of the verification.	▪ Done ▪ Busy ▪ Failed ▪ Not done	–
Verification result	–	Displays the overall result of the verification. Detailed description of results classification: → 31	▪ Not supported ▪ Passed ▪ Not done ▪ Failed	Not done

5.3.5 Extended verification

The extended verification supplements the standard verification with the output of various measured variables. During the verification process, these measured variables are recorded manually with the help of external measuring equipment, for example, and entered in the measuring device → 26. The value entered is checked and verified by the measuring device to ensure that it complies with the factory specifications. A status (Passed or Failed) is issued accordingly and is documented as an individual result of the verification and taken into account in the overall result.

Permanently predefined output signals, which do not represent the current measured value, are simulated during extended verification of the outputs. To measure the simulated signals, it may be necessary to set the higher-level process control system to a safe state beforehand. In order to perform a verification, the pulse/frequency/switch output must be enabled and assigned to a measured variable.

Extended verification measured variables

Output current (current output)
- Simulation of the measured values for every output physically present on the device
- Simulation "Low value" and "High value"
- Measurement of the two values
- Entry of the two measured values in the verification screen

Output frequency (pulse/frequency output)
- Simulation of the measured values for every output physically present on the device
- Simulation value pulse output: Simulated frequency depending on the pulse width configured
- Simulation value frequency output: Maximum frequency

For more information on simulation, see the Operating Instructions → 6.

Measuring equipment requirements

Recommendations for the measuring equipment

DC current measuring uncertainty	±0.2 %
DC current resolution	10 µA
DC voltage measuring uncertainty	±0.1 %
DC voltage resolution	1 mV

Frequency measuring uncertainty	±0.1 %
Frequency resolution	1 Hz
Temperature coefficient	0.0075 %/°C

Connecting the measuring equipment in the measuring circuit

⚠ WARNING

Danger to persons from non-approved equipment in the hazardous area!

- ▶ Only use intrinsically safe measuring equipment in hazardous zones.
- ▶ Measure intrinsically safe circuits with approved equipment only.
- ▶ Outputs (passive) for the hazardous area may only be connected to suitable intrinsically safe circuits.

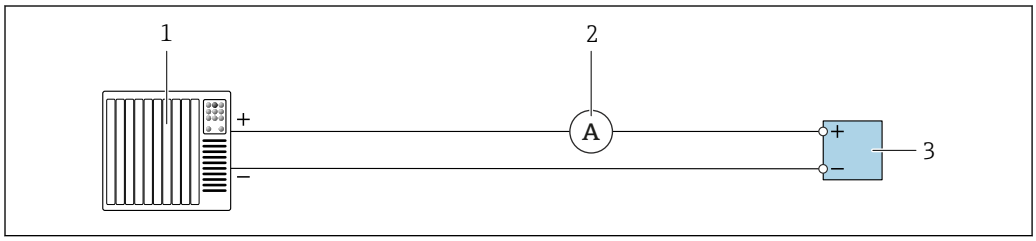
Determining the terminal assignment for the outputs

The terminal assignment depends on the specific device version.

To determine the device-specific terminal assignment:
- See the adhesive label in the terminal cover
- Check the operating menu via the local display, web browser or operating tool
  - Setup → I/O configuration → I/O module 1 to n terminal numbers
  - Expert → I/O configuration → I/O module 1 to n terminal numbers

For detailed information on terminal assignment, see the Operating Instructions for the device → 6

Active current output



7 *Extended verification of the active current output*

1 Automation system with current input (e.g. PLC)
2 Ammeter
3 Transmitter

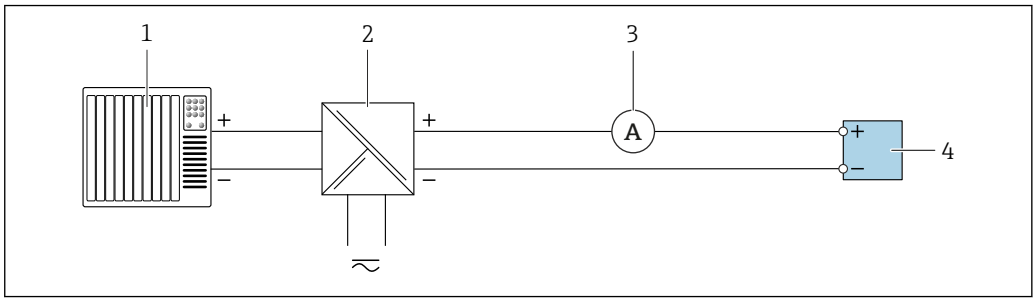
Extended verification of the active current output

- ▶ Connect the ammeter to the transmitter by looping it in series into the circuit.

If the automation system is switched off, the measuring circuit may be interrupted as a result. It is then not possible to perform a measurement. If this is the case, proceed as follows:

1. Disconnect the output cables of the current output (+/–) from the automation system.
2. Short the output cables of the current output (+ / -).
3. Connect the ammeter to the transmitter by looping it in series into the circuit.

Passive current output



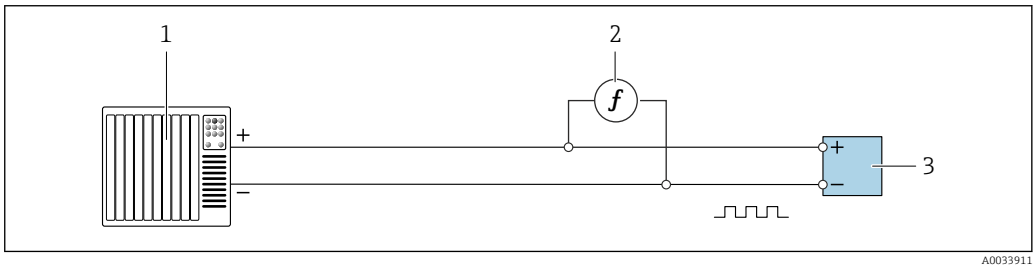
8 Extended verification of the passive current output

1 Automation system with current input (e.g. PLC)
2 Power supply unit
3 Ammeter
4 Transmitter

Extended verification of the passive current output

1. Connect the ammeter to the transmitter by looping it in series into the circuit.
2. Connect the power supply unit.

Active pulse/frequency/switch output



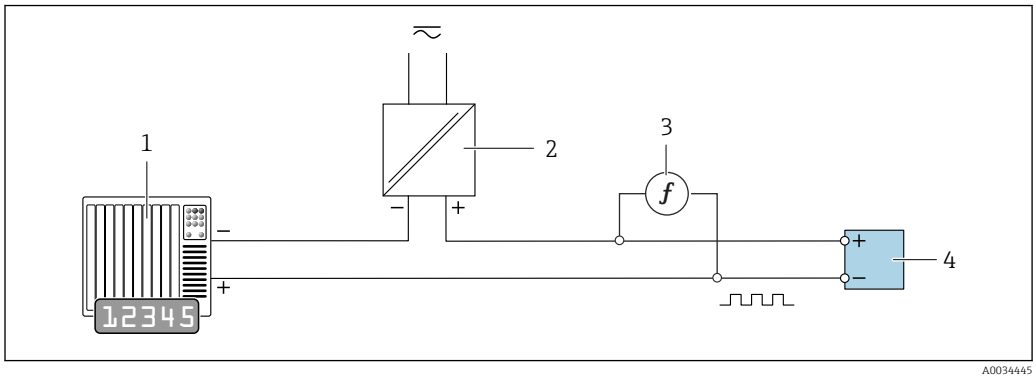
9 Extended verification of the active pulse/frequency output

1 Automation system with pulse/frequency input (e.g. PLC)
2 Frequency meter
3 Transmitter

Extended verification of the active pulse/frequency output

- Connect the frequency meter in parallel to the pulse/frequency output of the transmitter

Passive pulse/frequency/switch output



10 *Extended verification of the passive pulse/frequency output*

1 *Automation system with pulse/frequency input (e.g. PLC)*
2 *Power supply unit*
3 *Frequency meter*
4 *Transmitter*

Extended verification of the passive pulse/frequency output

1. Connect the power supply unit
2. Connect the frequency meter in parallel to the pulse/frequency output of the transmitter

Diagnostic behavior

A diagnostic event signals that extended verification is being performed:
- The screen alternates between the status signal "C" (Function Check) and the operational display:
  Verification is currently active in the device.
- Different diagnostic behaviors, along with the relevant diagnostic codes, can be displayed depending on the device version.
  The output selected under the **Start verification** parameter is always displayed, however:
  Output 1…n low value option, **Output 1…n high value** option

Diagnostic code	Diagnostic behavior	Options in Start verification
C491	**Current output 1 to n simulation** active	Output 1…n low value Output 1…n high value
C492	**Simulation frequency output 1 to n** active	Frequency output 1…n
C493	**Simulation pulse output 1 to n** active	Pulse output 1…n
C302	⚠**C302 Device verification in progress**	

An extended verification (simulation mode) may be started only if the process plant is not in the automatic mode.

If the **Start** option is selected in the **Start verification** parameter, the following diagnostic event is output on the display (second part of the external verification): ⚠**C302 Device verification in progress** diagnostic message
- Factory setting for diagnostic behavior: warning
- The device continues to measure.
- The last good value is output intermittently for 10 seconds.
- All measured values during the verification are added to the totalizers.
- Test duration (all outputs switched on): approx. 60 seconds.

- The diagnostic behavior can be changed by the user if necessary:
  Expert → System → Diagnostic handling → Diagnostic behavior
  If **Alarm** is selected as the diagnostic behavior, the output of measured values is interrupted in the event of an error and the signal outputs and totalizers adopt the defined alarm condition.
- In the **Diagnostic configuration** submenu, a category is assigned to the diagnostic message of the outputs.
  Expert → Communication → Diagnostic configuration
  If the device does not have outputs, they are output as an error. To prevent an error from being output, assign the **No effect (N)** option to any outputs that are not present on the device.

Detailed information on diagnostics and troubleshooting and on diagnostic information and associated troubleshooting measures can be found in the Operating Instructions → 🖹 6.

Performing extended verification

A full standard verification is performed in the course of the verification. The validity of the entered and measured values of the outputs is checked. Additional standard verification of the outputs does not take place.

NOTICE

If the electrical connections have not been established and the ammeter is not looped in during verification, extended verification is not possible.
- ▶ Establish the electrical connection before starting the extended verification.
- ▶ Loop in ammeter before extended verification starts.

Before verification starts

The date and time are saved with the current operating time and the verification results and also appear in the verification report.

The **Year** parameter, **Month, Day, Hour, AM/PM and Minute** are used to manually record the data at the time of verification.

1. Enter date and time.

Select the verification mode

2. In the **Verification mode** parameter, select the **Extended verification** option.

Further parameter settings

3. In the **External device information** parameter, enter a unique ID (e.g. serial number) of the measuring equipment used (max. 32 characters).
4. In the **Start verification** parameter, select one of the options available (e.g. the **Output 1 low value** option).
5. In the **Measured values** parameter, enter the value shown on the external measuring equipment.
6. Repeat steps 4 and 5 until all the output options are checked.
7. Adhere to the sequence indicated and enter the measured values.

The duration of the process and number of outputs depend on the device configuration.

The value displayed in the **Output values** parameter (→ 21) shows the value simulated by the device at the selected output → 22

Starting the verification test

8. In the **Start verification** parameter, select the **Start** option.
   ↳ While the verification is being performed, the progress of the verification is indicated as a % (bar graph indicator) in the **Progress** parameter.

Displaying the verification status and result

The current status of standard verification is displayed in the **Status** parameter (→ 21):
- Done
  The verification test is finished.
- Busy
  The verification test is running.
- Not done
  A verification has not yet been performed on this measuring device.
- Failed
  A precondition for performing the verification has not been met, the verification cannot start (e.g. due to unstable process parameters) → 16.

The result of the verification is displayed in the **Overall result** parameter (→ 21):
- Passed
  All the verification tests were successful.
- Not done
  A verification has not yet been performed on this measuring device.
- Failed
  One or more verification tests were not successful → 16.

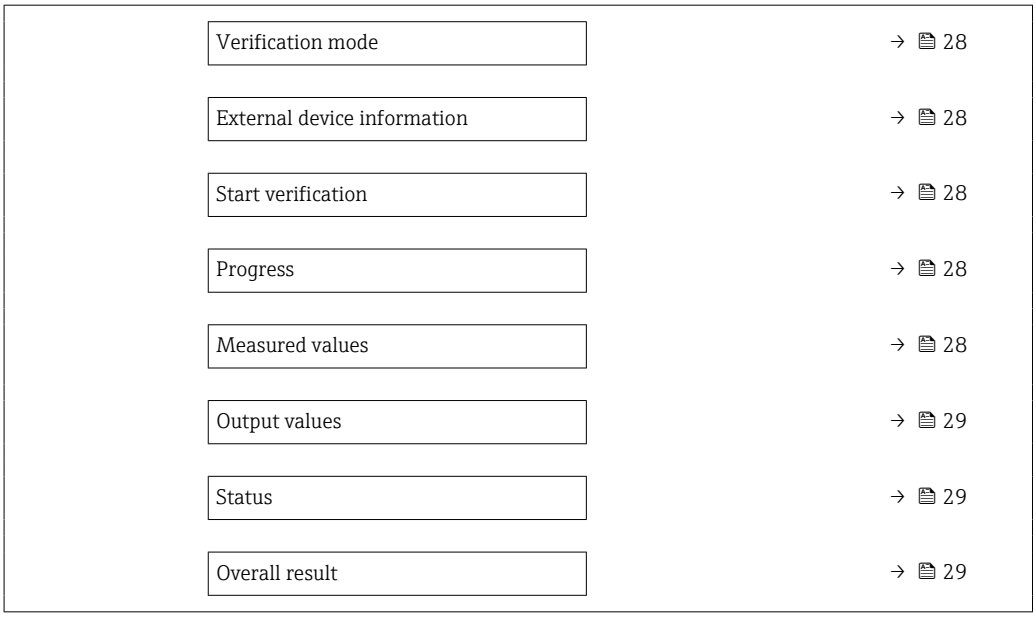
- The overall result of the last verification can always be accessed in the menu.
- Navigation:
  Diagnostics → Heartbeat Technology → Verification results
- Detailed information on the verification result (test groups and test status) are shown in the verification report in addition to the overall result → 31.
- If the device does not pass the verification, the results are saved nonetheless and indicated in the verification report.
- This facilitates a targeted search for the cause of the fault → 16.

"Performing verification" submenu

Navigation

"Diagnostics" menu → Heartbeat Technology → Performing verification

▶ Performing verification		
	Year	→ 27
	Month	→ 27
	Day	→ 27
	Hour	→ 27
	AM/PM	→ 27
	Minute	→ 27



Parameter overview with brief description

Parameter	Prerequisite	Description	User entry / Selection / User interface	Factory setting
Year	Can be edited if Heartbeat Verification is not active.	Entry for date and time (field 1): enter the year verification is performed.	9 to 99	–
Month	Can be edited if Heartbeat Verification is not active.	Entry for date and time (field 2): enter the month verification is performed.	▪ January ▪ February ▪ March ▪ April ▪ May ▪ June ▪ July ▪ August ▪ September ▪ October ▪ November ▪ December	–
Day	Can be edited if Heartbeat Verification is not active.	Entry for date and time (field 3): enter the day verification is performed.	1 to 31 d	–
Hour	Can be edited if Heartbeat Verification is not active.	Entry for date and time (field 4): enter the hour verification is performed.	0 to 23 h	–
AM/PM	Can be edited if Heartbeat Verification is not active. The **dd.mm.yy hh:mm am/pm** option or the **mm/dd/yy hh:mm am/pm** option is selected in the **Date/ time format** parameter (2812).	Entry for date and time (field 5): enter the morning or afternoon.	▪ AM ▪ PM	–
Minute	Can be edited if Heartbeat Verification is not active.	Entry for date and time (field 6): enter the minute verification is performed.	0 to 59 min	–

Parameter	Prerequisite	Description	User entry / Selection / User interface	Factory setting
Verification mode	Can be edited if Heartbeat Verification is not active.	Select the verification mode. Extended verification Standard verification is extended by the additional entry of external measured variables: **Measured values** parameter.	Extended verification	–
External device information	With the following conditions: ▪ The **Extended verification** option is selected in the **Verification mode** parameter. ▪ Can be edited if the verification status is not active.	Record measuring equipment for extended verification.	Free text entry	–
External reference voltage 1	–	Use this function to enter the reference voltage. The external reference voltage can be measured at the GND and REF terminals.	Signed floating-point number	–
Start verification	–	Start the verification. To carry out a complete verification, select the selection parameters individually. Once the external measured values have been recorded, verification is started using the **Start** option.	▪ Cancel ▪ Output 1 low value * ▪ Output 1 high value * ▪ Start	–
Remaining lockout period	–	Shows the remaining number of hours until the lockout period has elapsed.	0 to 99 h	–
Lockout period	–	Enter the lockout period in hours. When the device is in custody transfer mode, it is not possible to perform a verification during this time.	0 to 99 h	–
Progress	–	Shows the progress of the process.	0 to 100 %	–
Measured values	One of the following options is selected in the **Start verification** parameter (→ 🖹 20): ▪ Output 1 low value ▪ Output 1 high value ▪ Output 2 low value ▪ Output 2 high value ▪ Output 3 low value ▪ Output 3 high value ▪ Frequency output 1 ▪ Pulse output 1 ▪ Frequency output 2 ▪ Pulse output 2 ▪ Double pulse output	Use this function to enter the measured values (actual values) for the external measured variables:. ▪ Current output: Output current in [mA] ▪ Pulse/frequency output: Output frequency in [Hz] ▪ Double pulse output: Output frequency in [Hz]	Signed floating-point number	–

Parameter	Prerequisite	Description	User entry / Selection / User interface	Factory setting
Output values	–	Displays the simulated output values (target values) for the external measured variables:. ▪ Current output: Output current in [mA]. ▪ Pulse/frequency output: Output frequency in [Hz].	Signed floating-point number	-
Status	–	Displays the current status of the verification.	▪ Done ▪ Busy ▪ Failed ▪ Not done	–
Verification result	–	Displays the overall result of the verification. Detailed description of results classification: → 31	▪ Not supported ▪ Passed ▪ Not done ▪ Failed	Not done

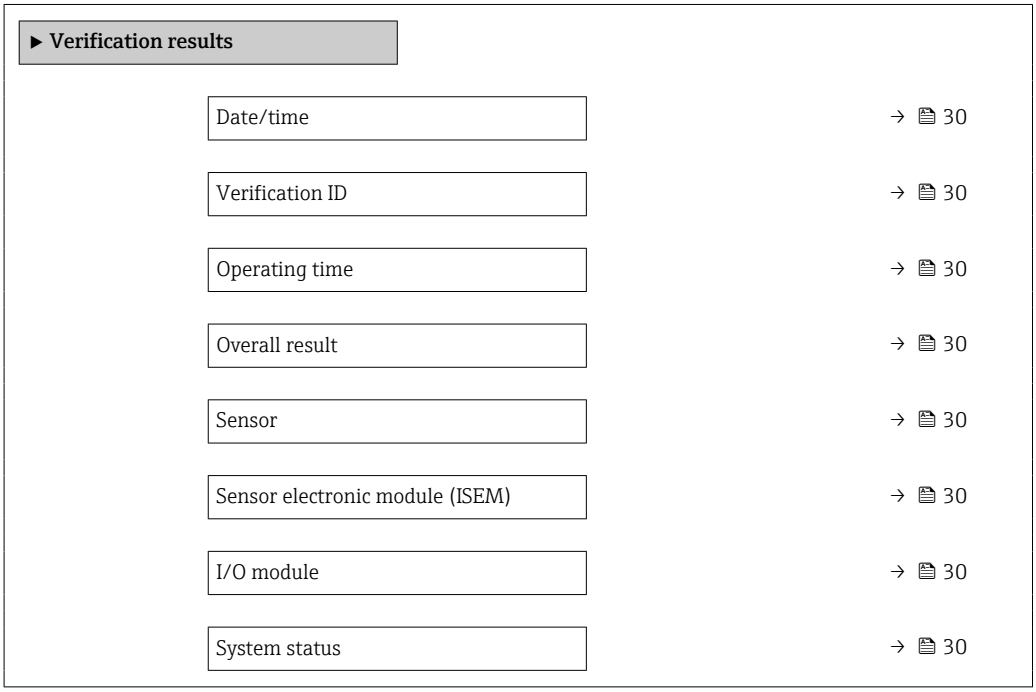
* Visibility depends on order options or device settings

5.3.6 Verification results

Access to the verification results:
In the operating menu via the local display, operating tool
Diagnostics → Heartbeat Technology → Verification results

Navigation
"Diagnostics" submenu → Heartbeat → Verification results

Navigation
"Expert" menu → Diagnostics → Heartbeat → Verification results



Parameter overview with brief description

Parameter	Prerequisite	Description	User interface	Factory setting
Date/time	The verification has been performed.	Date and time.	dd.mmmm.yyyy; hh:mm	1 January 2010; 12:00
Verification ID	The verification has been performed.	Displays consecutive numbering of the verification results in the measuring device.	0 to 65 535	–
Operating time	The verification has been performed.	Indicates how long the device has been in operation up to the verification.	Days (d), hours (h), minutes (m), seconds (s)	–
Verification result	–	Displays the overall result of the verification. Detailed description of results classification: → 31	▪ Not supported ▪ Passed ▪ Not done ▪ Failed	Not done
Sensor	The **Failed** option is shown in the **Overall result** parameter.	Displays the result for the sensor. Detailed description of results classification: → 31	▪ Not supported ▪ Passed ▪ Not done ▪ Failed	–
Sensor electronic module (ISEM)	The **Failed** option is shown in the **Overall result** parameter.	Displays the result for the sensor electronics module (ISEM). Detailed description of results classification: → 31	▪ Not supported ▪ Passed ▪ Not done ▪ Failed	–
I/O module	The **Failed** option is shown in the **Overall result** parameter.	Displays the result for I/O module monitoring of the I/O module. ▪ For current output: Accuracy of the current ▪ For pulse output: Accuracy of the pulses ▪ For frequency output: Accuracy of the frequency ▪ Current input: Accuracy of the current ▪ Double pulse output: Accuracy of the pulses ▪ Relay output: Number of switching cycles **Heartbeat Verification** does not check the digital inputs and outputs and does not output any result for them. Detailed description of results classification: → 31	▪ Not supported ▪ Passed ▪ Not done ▪ Failed	–
System status	The **Failed** option is shown in the **Overall result** parameter.	Displays the system condition. Tests the measuring device for active errors. Detailed description of results classification: → 31	▪ Not supported ▪ Passed ▪ Not done ▪ Failed	–

Classification of results

Individual results

Result	Description
Failed	At least one individual test in the test group was outside the specifications.
Passed	All individual tests in the test group complied with the specifications. The result is also "Passed" if the result of an individual test is "Check not done" and the result of all other tests is "Passed".
Not done	No test has been performed for this test group.

Overall results

Result	Description
Failed	At least one test group was outside the specifications.
Passed	All verified test groups complied with the specifications (result "Passed"). The overall result is also "Passed" if the result for an individual test group is "Check not done" and the result for all other test groups is "Passed".
Not done	No verification was performed for any of the test groups (result for all test groups is "Check not done").

Heartbeat Verification confirms the device function within the specified measuring tolerance on demand. Based on redundant references in the device which are traceable from the factory, **Heartbeat Technology** meets all the requirements concerning traceable device verification according to DIN ISO 9001: 2015 Chapter 7.1.5.2 a).

For more information on the test groups and individual tests → 31.

The results for a test group (e.g. sensor) contain the result of several individual tests. All the individual tests must be passed for the test group to pass.

The same applies to the overall result: All the test groups must pass for the overall result to be "passed". Information on the individual tests is provided in the verification report and the individual test group results which can be accessed with the Flow Verification DTM.

Limit values

I/O module

Output; input	Extended verification
Current output 4 to 20 mA, active and passive	▪ Lower value 4 mA: ±1 % ▪ Upper value 20 mA: ±0.5 %
Pulse/frequency/switch output, active and passive	▪ Pulse: ±0.3 % ▪ Frequency: ±0.3 %

5.3.7 Detailed verification results

Individual results according to test groups and detailed verification results can be called up via the Flow Verification DTM.

This also applies for the process conditions that are determined at the time of verification.

Process conditions

To increase the comparability of the results, the process conditions that apply at the time of verification are recorded and documented as process conditions on the last page of the verification report.

Process conditions	Description
Current potential difference	Current measured value for potential difference
Current potential of electrode 1	Current measured value for potential of electrode 1
Current potential of electrode 2	Current measured value for potential of electrode 2
Current potential of pipe GND electrode	Current measured value for potential of pipe GND electrode
Electronic temperature	Current measured value for the electronic temperature in the transmitter
HSBI	Current measured value of HBSI (relative change of magnetic system)
Buildup index	Current measured value of build-up detection

Individual test group results

The individual test group results listed below provide information on the results of the individual tests within a test group.

Sensor

Parameter/individual test	Description	Result/limit value	Interpretation/cause/remedial measures
Shot time symmetry	Monitoring of symmetry in the exciter circuit for coil current shot times while both field polarities are changed.	No value range ▪ Passed ▪ Failed ▪ Not done	▪ EMC interference ▪ Defective H-bridge in the amplifier
Holding voltage symmetry	Monitoring of symmetry in holding voltages of exciter circuit for setting the coil current for both field polarities.	No value range ▪ Passed ▪ Failed ▪ Not done	▪ EMC interference ▪ Defective H-bridge in the amplifier
Coil current loss	Monitoring of the coil current path for leak current. Comparison of incoming and outgoing currents.	No value range ▪ Passed ▪ Failed ▪ Not done	Sensor short-circuit. Check entire sensor system: ▶ Check for moisture (e.g. condensation) ▶ Check for faulty sensor and cable connections or interfaces ▶ Check coils ▶ Check insulation resistance
Coil current stability	Monitoring the correct adjustment of the coil current.	No value range ▪ Passed ▪ Failed ▪ Not done	EMC interference
Coil resistance	Monitoring of the coil resistance.	No value range ▪ Passed ▪ Failed ▪ Not done	▪ Faulty connections: check the outer connection parts, clamp connections and connecting cables ▪ Process temperature too high ▪ Coil in the sensor is defective
Electrode circuit 1	Monitoring of the impedance in electrode circuit 1.	No value range ▪ Passed ▪ Failed ▪ Not done	Electrode cable is defective The test is not performed if the measuring tube is empty Status indicated: "Not done"
Electrode circuit 2	Monitoring of the impedance in electrode circuit 2.	No value range ▪ Passed ▪ Failed ▪ Not done	Electrode cable is defective The test is not performed if the measuring tube is empty Status indicated: "Not done"
EPD electrode circuit	Monitoring of the impedance in the EPD circuit.	No value range ▪ Passed ▪ Failed ▪ Not done	EPD cable is defective The test is not performed if the measuring tube is empty Status indicated: "Not done"

Sensor electronics module (ISEM)

Parameter/individual test	Description	Result/limit value	Interpretation/cause/remedial measures
Supply voltage	All the relevant supply voltages are checked. Monitoring of the supply voltage for the sensor electronics module guarantees that the system is functioning correctly.	No value range ▪ Passed ▪ Failed ▪ Not done	Sensor electronics module (ISEM) defective ▶ Replace sensor electronics module (ISEM)
Linearity and reference voltage	▪ Monitoring of flowmeter circuit with regard to gain and linearity. ▪ Monitoring of reference voltages in flowmeter circuit and exciter circuit	No value range ▪ Passed ▪ Failed ▪ Not done	Sensor electronics module (ISEM) defective ▶ Replace sensor electronics module (ISEM)
Offset electrode signal amplifier	Monitoring of flow measurement amplifier with regard to zero point.	No value range ▪ Passed ▪ Failed ▪ Not done	Sensor electronics module (ISEM) defective ▶ Replace sensor electronics module (ISEM)
Hold voltage feedback	The configured hold voltage is fed back to ensure the secure and constant functioning of the hold voltage.	No value range ▪ Passed ▪ Failed ▪ Not done	Sensor electronics module (ISEM) defective ▶ Replace sensor electronics module (ISEM)
Overvoltage feedback	The overvoltage is fed back to ensure the secure and constant functioning of the overvoltage.	No value range ▪ Passed ▪ Failed ▪ Not done	Sensor electronics module (ISEM) defective
Electronic current loss	Monitoring of the coil current path for leak current.	No value range ▪ Passed ▪ Failed ▪ Not done	Sensor electronics module (ISEM) defective
Coil current measurement	Monitoring of low-side current measurement.	No value range ▪ Passed ▪ Failed ▪ Not done	Sensor electronics module (ISEM) defective
Overvoltage circuit	Monitoring of overvoltage.	No value range ▪ Passed ▪ Failed ▪ Not done	Sensor electronics module (ISEM) defective
Electrode signal integrity	Monitoring of input stage, sensor and electrode cable.	No value range ▪ Passed ▪ Failed ▪ Not done	One of the electrode signals is missing. This can be due to the following: ▪ Sensor electronics module (ISEM) defective ▪ Faulty connection to the sensor ▪ Electrode short-circuit or open circuit ▪ Sensor defective

System condition

Parameter/individual test	Description	Result/limit value	Interpretation/cause/remedial measures
System condition	System condition monitoring	No value range ▪ Passed ▪ Failed ▪ Not done	**Causes** System error during verification **Corrective action** ▶ Check diagnostic event in the **Event logbook** submenu.

I/O modules

Parameter/individual test	Description	Result/limit value	Interpretation/cause/remedial measures
Output 1 to n	Check of all the input and output modules installed at the measuring device	No value range ▪ Passed ▪ Failed ▪ Not done Limit values	**Causes** ▪ Output values out of specification ▪ I/O modules defective **Measures** ▶ Check cabling. ▶ Check connections. ▶ Check load (current output). ▶ Replace the I/O module.

5.3.8 Verification report

The results of the verification can be documented in the form of a verification report via the FieldCare operating tool → 🖹 11. The verification report is created on the basis of the data records saved in the measuring device after verification. As the verification results are automatically and uniquely identified with a verification ID and the operating time, they are suitable for the traceable documentation of the verification of flowmeters.

First page: identification
Measuring point identification, identification of the verification results and confirmation of completion:
- System operator
  Customer reference
- Device information
  - Information on the place of operation (tag) and the current configuration of the measuring point
  - Management of the information in the device
  - Display on the verification report
- Calibration
  - Information on the calibration factor and zero point setting for the sensor
  - These values must correspond to those from the last calibration or repeat calibration in order to comply with factory specifications
- Verification information
  - The operating time and verification ID are used to uniquely assign the verification results for the traceable documentation of the verification
  - Storage and display of the manual date and time entry as well as the current operating time in the device
  - Verification mode: standard verification or extended verification
- Overall verification result
  Overall result of the verification passed if all of the individual results are passed

Second page: test results
Details on the individual results for all test groups:
- System operator
- Test groups → 🖹 31
  - Sensor
  - Sensor electronics module (ISEM)
  - System condition
  - I/O module

Third page (and subsequent pages, if applicable): measured values and visualization
Numerical values and graphic presentation of all the values recorded:
- System operator
- Test object
- Unit
- Current: measured value
- Min.: lower limit
- Max.: upper limit
- Visualization: graphic presentation of the measured value, within the lower and upper limits.

Last page: process conditions
Information on the process conditions that applied during the verification:
- Volume flow
- Conductivity
- Electronics temperature
- Current potential difference
- Current potential of electrode 1
- Current potential of electrode 2
- Current potential of pipe GND electrode
- Build-up index value (only with the Heartbeat Verification + Monitoring application package)

As a prerequisite for the validity of the verification report, the **Heartbeat Verification** feature must be activated on the measuring device concerned and must have been performed by an operator tasked to carry out this job by the customer. Alternatively, an Endress+Hauser service technician or a service provider authorized by Endress+Hauser can be tasked with performing the verification.

Individual test groups and description of individual tests: → 31

Data management with FieldCare (Flow Verification DTM): → 11

5.3.9 Interpreting and using the verification results

Heartbeat Verification uses the self-monitoring function of the Proline flowmeters to check the measuring device functionality. During the verification process, the system checks whether the measuring device components comply with the factory specifications. Both the sensor and the electronics modules are included in the tests.

Compared to flow calibration, which assesses the flow measuring performance directly (primary measured variable), **Heartbeat Verification** checks the function of the measuring chain from the sensor to the outputs.

Here, the function checks device-internal parameters that are correlated with flow measurement (secondary measured variables, comparative values). The check is based on reference values that were recorded during the factory calibration.

If a verification is passed, this confirms that the comparative values checked are within the factory specification and that the measuring device is working correctly. At the same time, zero point and calibration factor of the sensor can be traced via the verification report. To ensure that the measuring device complies with the factory specification, these values must correspond to those of the last calibration or repeat calibration.

- Confirmation of compliance with the flow specification with 100 % test coverage can only be obtained by verifying the primary measured variable (flow) by means of recalibration or proving.
- **Heartbeat Verification** confirms on demand that the device is functioning within the specified measuring tolerance.

Recommended course of action if the result of a verification is "Failed"

If the result of a verification is **Failed**, it is advisable to begin by repeating the verification.

Ideally, ensure defined and stable process conditions in order to rule out process-specific influences as much as possible. When repeating the verification, it is advisable to compare the current process conditions to those of the previous verification in order to identify any deviations.

The process conditions for the previous verification are documented on the last page of the verification report or can be called up using the Flow Verification DTM → 31.

Additional remedial measures if the result of a verification is "Failed"

- Calibrate the measuring device
  The calibration has the advantage that the "as found" measuring device state is recorded and the actual measured error is determined.
- Direct remedial measures
  Take remedial action on the basis of the verification results and the diagnostic information of the measuring device. Narrow down the possible cause of the error by identifying the test group that **failed** the verification.

Detailed information on diagnostics and troubleshooting and on diagnostic information and associated troubleshooting measures can be found in the Operating Instructions → 6.

6 Heartbeat Monitoring

With Heartbeat Monitoring, additional measured values are output continuously and monitored in an external Condition Monitoring system so that changes to the measuring device and in the process can be detected at an early stage. The measured variables can be interpreted in a Condition Monitoring system. The information obtained in this way helps users to control measures concerning maintenance or process optimization. Possible applications of Condition Monitoring include the detection of the formation of build-up or wear as a result of corrosion.

6.1 Commissioning

Assign the diagnostic parameters to the outputs for commissioning. After commissioning, the parameters are available at the outputs and in case of digital communication they are generally continuously available.

Enabling or disabling Heartbeat Monitoring
The output of the HBSI and build-up index diagnostic parameters is switched on or off in the operating menu:
→ 📄 38

6.1.1 Description of the monitoring parameters

The following diagnostic parameters can be assigned to the various outputs of the measuring device for continuous transmission to a Condition Monitoring system.

Some measured variables are only available if the **Heartbeat Verification + Monitoring** application package is enabled in the measuring device.

Parameter	Description	Value range
Noise [1]	Degree to which the differential signal from both measuring electrodes is dispersed	0 to $+3.0 \cdot 10^{+38}$
Coil current shot time [1]	Rise time of coil current for buildup of magnetic field	

1) Only available if the "Heartbeat Monitoring" function is enabled in the measuring device.

For information on using the parameters and interpreting the measurement results → 📄 41.

6.1.2 HBSI monitoring

The **HBSI** parameter (Heartbeat Sensor Integrity) offers another method of process and device monitoring. The HBSI value can be used as a support to assess the reliability of the device used and the displayed measured values.

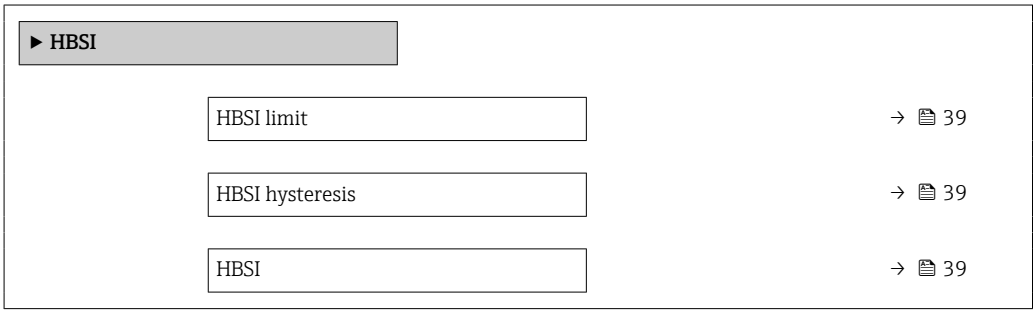
The following points can help users to draw conclusions concerning the process and the state of the device in service:
- Prevention of production downtime
- Promotion of a high level of reliability
- Forward-looking scheduling of service intervals

Examples of situations that can influence the HBSI value include the following:
- Magnetic field interference from outside (external electromagnetic field, drift expected in negative range)
- Magnetic field interference from inside (external electromagnetic field, drift expected in positive range)
- Systematic errors caused by mechanical influences (handling, maintenance, repairs)

When calibrating the devices during production, the output value is initially determined, adjusted to 0% and saved in the device. The value is output in percentage from -100 to 100. The measurement is based on the general principles of magnetic flow within an electromagnetic measuring device that is continuously monitored. A minor deviation after commissioning a new device is possible due to the process conditions. A warning for the **HBSI** parameter is preset at the factory at a limit value of +/- 4 %. This can be modified by the user.

Configuration of HBSI monitoring

Navigation
"Expert" menu → Sensor → Process parameters → HBSI



Parameter overview with brief description

Parameter	Description	User entry / User interface
HBSI limit	Enter HBSI limit value.	0 to 100 %
HBSI hysteresis	Enter hysteresis for HBSI limit value.	0 to 100 %
HBSI	Displays the relative change of the entire sensor, with all its electrical, mechanical and electromechanical components incorporated in the sensor housing (including the measuring tube, electrodynamic pick-ups, excitation system, cables etc.), in % of the reference value.	−100.0 to 100.0 %

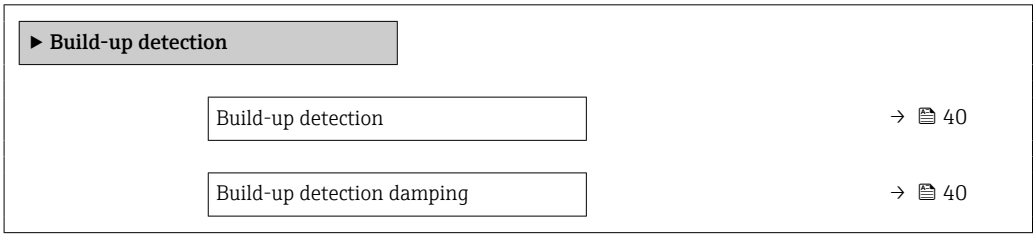
6.1.3 Build-up index monitoring

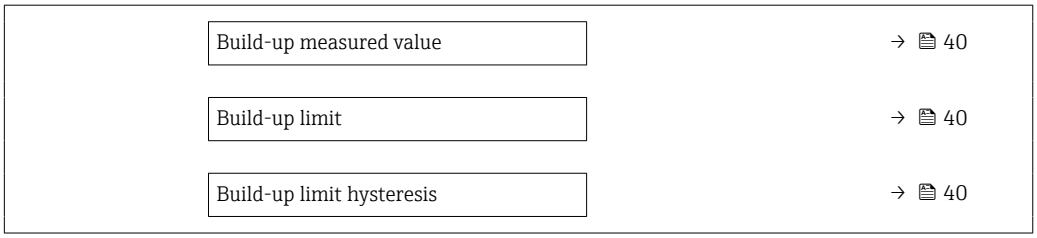
Build-up detection using the Build-up index is part of Heartbeat Monitoring. It is used to detect and monitor an even coating forming on the inside of the measuring tube.

- The build-up detection function is only available in conjunction with the Promag W sensor.
- For additional prerequisites for the optimum and reliable use of the build-up detection function, see → 49

Enabling and disabling Build-up index monitoring

Navigation
"Expert" menu → Sensor → Process parameters → Build-up index





Parameter overview with brief description

Parameter	Description	Selection / User entry / User interface
Build-up index operating mode	Select the operating mode for the build-up index. The operating mode indicates the interval at which the value of the build-up index is determined.	▪ Off ▪ Slow ▪ Standard ▪ Fast
Coating detection damping	Enter damping value for coating detection. Damping value: ▪ 0 = minimum damping ▪ 15 = maximum damping The damping value should only be increased if the measured value is unstable.	0 to 15
Coating measured value	Shows current coating measured value.	0.0 to 100.0 %
Build-up limit	Enter limit value for the build-up measured value.	0 to 100 %
Build-up limit hysteresis	Enter hysteresis for build-up detection. If the value for build-up detection hysteresis is higher than the Build-up limit, the "Build-up detected" diagnostic information is not reset until the measuring tube has been cleaned and a restart has been performed.	0 to 100 %

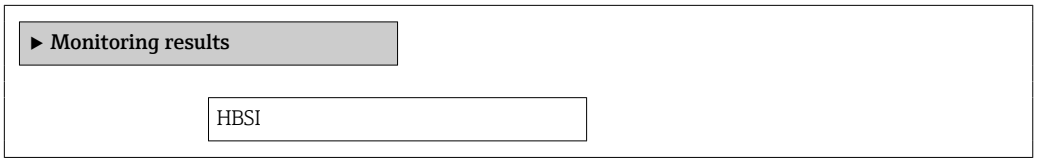
6.1.4 Displaying the monitoring results

The current value of the **HBSI** parameter and **Build-up index** parameter is continuously displayed in the Expert menu.

In the case of measuring devices with a local display, the value can also be configured as a display value.

Navigation

"Diagnostics" submenu → Heartbeat → Monitoring results



Parameter overview with brief description

Parameter	Description	User interface
Noise	Indicates the degree to which the differential signal from both measuring electrodes is dispersed.	0 to 3.0 · 10^{+38} µV
Coil current shot time	Indicates the rise time of the coil current for the buildup of the magnetic field.	2 to 500 ms
Reference electrode potential against PE	Displays the voltage of the reference electrode in relation to the potential of the measuring tube.	−30 to +30 V

Parameter	Description	User interface
Coating measured value	Shows current coating measured value.	0.0 to 100.0 %
HBSI	Displays the relative change of the entire sensor, with all its electrical, mechanical and electromechanical components incorporated in the sensor housing (including the measuring tube, electrodynamic pick-ups, excitation system, cables etc.), in % of the reference value.	−100.0 to 100.0 %

6.1.5 Configuration of the outputs and local display

With the application package "Heartbeat Verification + Monitoring", the user has additional monitoring parameters available → 38 . The following examples illustrate how a monitoring measured variable is assigned to a current output or is shown on the local display.

Example: Configuring the current output

Select the monitoring measured variable for current output

1. Prerequisite:
   Setup → I/O configuration
   ↳ Configurable I/O module displays the **I/O module type** parameter with **Current output** option
2. Setup → Current output
3. Select the monitoring measured variable for the current output in the **Assign current output** parameter

Navigation
"Setup" menu → Current output → Assign current output

Example: Configuring the local display

Select the measured value that is shown on the local display

1. Setup → Display → Value 1 display
2. Select the measured value.

6.2 Operation

The benefits of **Heartbeat Monitoring** are in direct correlation with the recorded data selection and their interpretation. Good data interpretation is critical for deciding whether a problem has occurred and when and how maintenance should be scheduled or performed (good knowledge of the application is required). The elimination of process effects that cause misleading warnings or interpretation must also be ensured. For this reason it is important to compare the recorded data against a process reference.

Heartbeat Monitoring enables additional monitoring values to be displayed in continuous operation mode.

focuses on measured variables that indicate a change in the performance of the device brought about by process-specific influences. There are two difference categories of process-specific influences:

- Temporary process-specific influences that impact the measuring function directly and therefore result in a higher level of measuring uncertainty than would normally be expected (e.g. measurement of multiphase fluids). These process-specific influences generally do not affect the integrity of the device but do impact measuring performance temporarily.
- Process-specific influences that only impact the integrity of the sensor over the medium term but that also bring about a gradual change in the measuring performance (e.g. abrasion, corrosion or buildup in the sensor). These influences also affect the integrity of the device on the long term.

Devices with **Heartbeat Monitoring** offer a range of parameters that are particularly suitable for monitoring specific, application-related influences. These target applications are:

- Fluids containing magnetite
- Multi-phase fluids (gas content in liquid fluids)
- Applications in which the sensor is exposed to a programmed amount of wear
- Applications with cathodic protection systems
- Applications with pipes that are not grounded
- Applications in which build-up can form.

The results of must always be interpreted in the context of the application.

6.2.1 Possible interpretation of the monitoring parameters

This section describes the interpretation of certain monitoring parameters in connection with the process and the application.

Monitoring parameter	Possible reasons for deviation
Noise	A change can be an indicator of multi-phase fluids (gas content in liquid fluids or a change in the solids content of the fluid) or changing electrical conductivity. This value allows conclusions to be drawn about the process.
Coil current shot time	At constant process temperatures, a change can indicate a possible build-up of magnetite or an increase in the magnetite content of the medium. Strong external magnetic fields influence this value too.
Reference electrode potential against PE	This diagnostic value describes the voltage between the fluid and the protective ground. This value is of significance if the measuring device with the reference electrode contacting the fluid is disconnected from the protective ground.
Build-up index value	Detection and monitoring of an even coating forming on the inside of the measuring tube.

7 Modbus RS485 Register Information

7.1 Notes

7.1.1 Structure of the register information

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

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

NOTICE

If non-volatile device parameters are modified via the MODBUS RS485 function codes 06, 16 or 23, the change is saved in the EEPROM of the measuring device.

The number of writes to the EEPROM is technically restricted to a maximum of 1 million.

- ▶ Make sure to comply with this limit since, if it is exceeded, data loss and measuring device failure will result.
- ▶ Avoid constantly writing non-volatile device parameters via the MODBUS RS485.

7.1.2 Address model

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

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

Depending on the function code used, a number is added at the start of the register address with this specification:

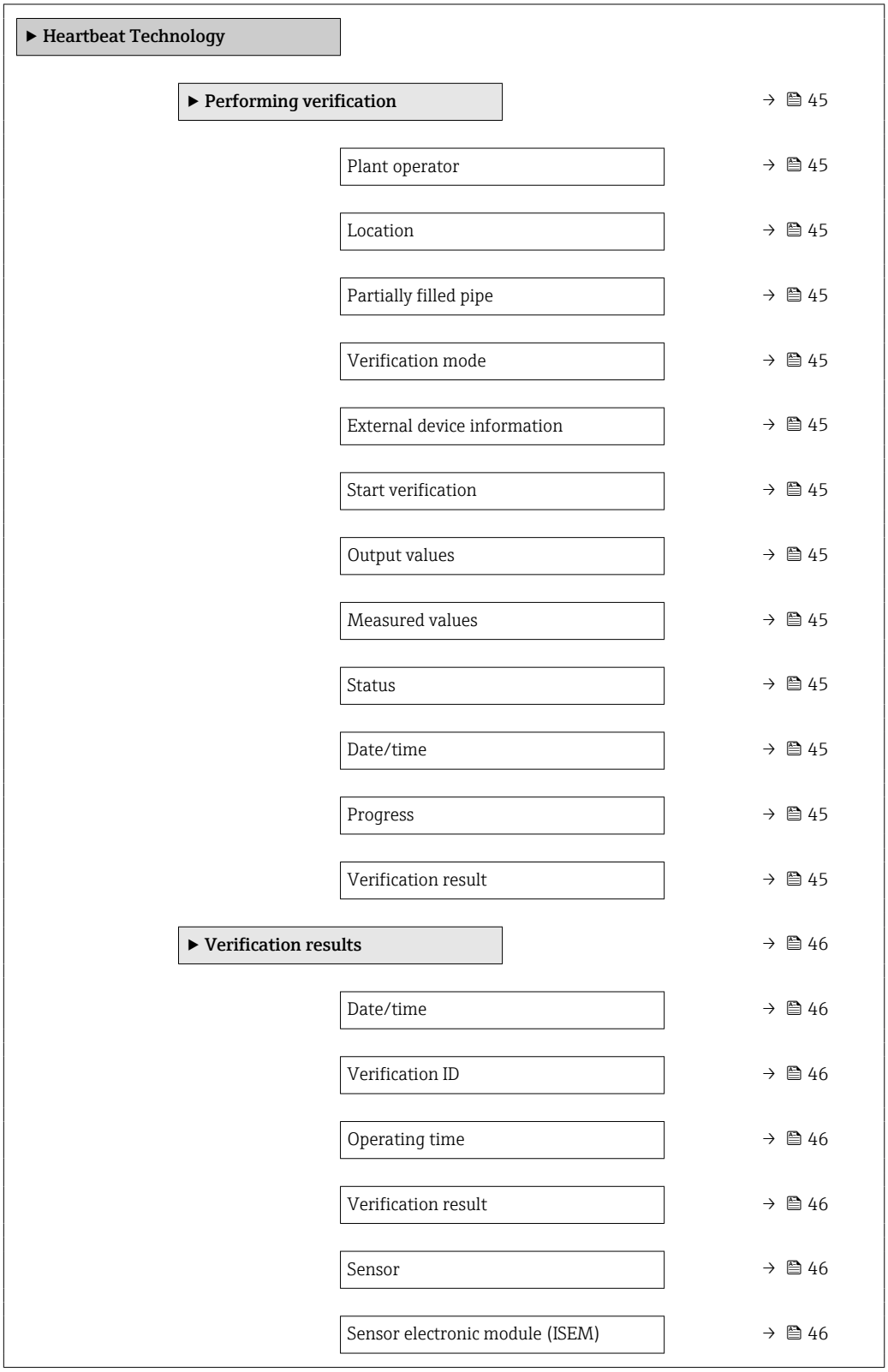
- "3" → "Read" access
- "4" → "Write" access

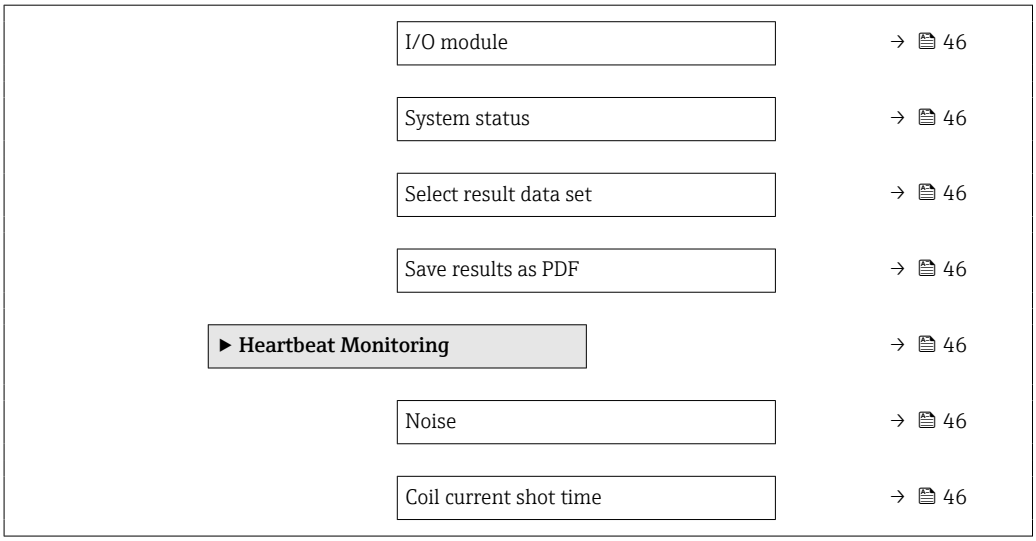
Function code	Access type	Register in accordance with "Modbus Applications Protocol Specification"	Register in accordance with "Modicon Modbus Protocol Reference Guide"
03 04 23	Read	XXXX Example: mass flow = 2007	3XXXX Example: mass flow = 32007
06 16 23	Write	XXXX Example: reset totalizer = 6401	4XXXX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

7.2 Overview of the operating menu

The following tables provide an overview of the structure of the Heartbeat Technology operating menu along with the parameters. The page reference indicates where the associated description of the submenu or parameter can be found.

Navigation
"Diagnostics" menu → Heartbeat Technology





7.3 Register information

7.3.1 "Performing verification" submenu

Navigation: Heartbeat Technology → Performing verification					
Parameter	**Register**	**Data type**	**Access**	**Selection / User entry / User interface**	**→**
Plant operator	3414 to 3429	String	Read / Write	Max. 32 characters such as letters, numbers or special characters (e.g. @, %, /)	16
Location	3430 to 3445	String	Read / Write	Max. 32 characters such as letters, numbers or special characters (e.g. @, %, /)	16
Partially filled pipe	37517	Integer	Read / Write	0 = Yes 1 = No	16
Verification mode	2366	Integer	Read / Write	0 = Standard verification	20
External device information	20493 to 20508	String	Read / Write	Free text entry	20
Start verification	2270	Integer	Read / Write	0 = Cancel 1 = Start	20
Output values	5516 to 5517	Float	Read	Signed floating-point number	21
Measured values	5512 to 5513	Float	Read / Write	Signed floating-point number	20
Status	2079	Integer	Read	0 = Failed 1 = Done 3 = Not done 8 = Busy	21
Date/time	--	String	Read		
Progress	6797	Integer	Read	0 to 100 %	20
Verification result	2355	Integer	Read	0 = Failed 2 = Passed 3 = Not done 250 = Not supported	21

7.3.2 "Verification results" submenu

Navigation: Heartbeat Technology → Verification results					
Parameter	**Register**	**Data type**	**Access**	**Selection / User entry / User interface**	**→**
Date/time	--	String	Read		
Verification ID	2315	Integer	Read	0 to 65 535	30
Operating time	3346	String	Read	Days (d), hours (h), minutes (m), seconds (s)	30
Verification result	2355	Integer	Read	0 = Failed 2 = Passed 3 = Not done 250 = Not supported	21
Sensor	2384	Integer	Read	0 = Failed 2 = Passed 3 = Not done 250 = Not supported	30
Sensor electronic module (ISEM)	2385	Integer	Read	0 = Failed 2 = Passed 3 = Not done 250 = Not supported	30
I/O module	2386	Integer	Read	0 = Failed 2 = Passed 3 = Not done 250 = Not supported	30
System status	5790	Integer	Read	0 = Failed 2 = Passed 3 = Not done 250 = Not supported	30
Select result data set	--	Integer	Read / Write		
Save results as PDF	--	Integer	Read		

7.3.3 "Heartbeat Monitoring" submenu

Navigation: Heartbeat Technology → Heartbeat Monitoring					
Parameter	**Register**	**Data type**	**Access**	**Selection / User entry / User interface**	**→**
Noise	2463 to 2464	Float	Read	0 to 3.0 · 10^{+38} µV	40
Coil current shot time	2465 to 2466	Float	Read	2 to 500 ms	40

8 Build-up detection using the Build-up index

Build-up detection makes it possible to:
- Draw conclusions regarding accuracy
- Avoid process disruptions
- Identify and control necessary cleaning intervals early on

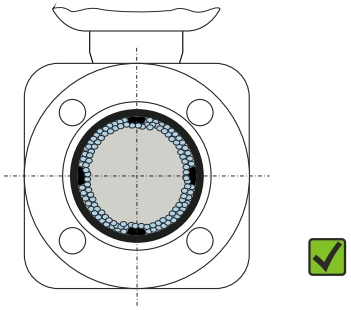
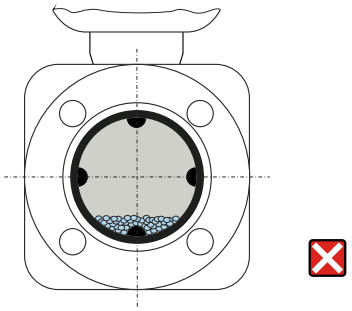
Build-up is understood to be an even coating that forms over the entire inner wall of the measuring tube and increases in the course of the process. The time required for build-up to form varies. Depending on the process and medium, build-up can form within just a few hours or only after a few months.

Build-up detection is particularly suitable for processes in which an even coating forms, e.g:
- Heating circuits with magnetite deposits
- Sugar refining processes with oxalates
- Dairy and food processing with protein or sugar deposits
- Iron clogging in drinking water and water processes

8.1 General principles

8.1.1 Build-up and deposits

The build-up detection function is designed to detect and monitor the formation of an even coating and **cannot** be used for the detection of deposits at the bottom of a measuring tube.

Coating (build-up)	Deposits
	
11 *Build-up formed on the inside of the inner wall of the measuring tube*	12 *Deposits on the bottom of the measuring tube*

8.1.2 Operating principle

The electrical conductivity values of the flowing medium and the build-up differ from one another. By analyzing the distribution of electrical conductivity within the measuring tube, it is possible to detect the formation of build-up.

The distribution of electrical conductivity in the cleaned measuring tube serves as the reference situation. In this state, a reference value is calibrated and the value of 0% is assigned to the Build-up index value before the device is delivered.

Build-up detection using the Build-up index assesses the difference between the conductivity of the flowing medium and the conductivity of the build-up. If the thickness of the build-up increases, the Build-up index value also increases. This effect is used to track the formation of build-up or cleaning progress.

Evaluation of build-up formation

For a comparative assessment, it is important to note that if build-up has already formed in the pipe, a change in the conductivity of the flowing medium can also cause a change in the Build-up index value. Build-up formation should therefore always be assessed at a constant medium conductivity.

Build-up index value

The formation of build-up is indicated as a percentage in the Build-up index value parameter. The higher the percentage value, the thicker the layer of build-up.

Build-up index value = 0%
- No build-up present
- Measuring tube as-delivered state (initial value)
- Measuring tube was cleaned thoroughly after formation of build-up

Build-up index value = 100%
- Value for the maximum measurable build-up thickness
- The thickness of the build-up at 100% varies depending on the process
- 100% does **not** indicate a clogged measuring tube

The percentage indicated in the Build-up index value parameter does not provide direct information about the absolute thickness or the composition of the build-up. Therefore, to make optimum use of the build-up detection function with the Build-up index, it is necessary to first compare the formation of build-up in the process, as known from experience, with the associated Build-up index value. The aim is to determine the Build-up index value at the time the cleaning is usually performed.

On the basis of the Build-up index value during cleaning, it is possible to make a valid assessment of the condition inside the measuring tube and to plan the cleaning using the Build-up limit and Build-up limit hysteresis parameters.

In addition, conclusions about possible effects on neighboring processes can be drawn from the Build-up index value.

Interval for build-up detection

The interval for recording the Build-up index value can be specified in the Build-up index parameter.
- If it is known, from experience, that build-up is formed quickly, a short interval should be selected (**Fast** option). This option is also suitable for cleaning processes with a short monitoring duration of approx. 5 to 20 minutes.
- A longer interval, e.g. one measurement per minute or less, suffices for build-up that forms slowly over several months (**Slow** option).

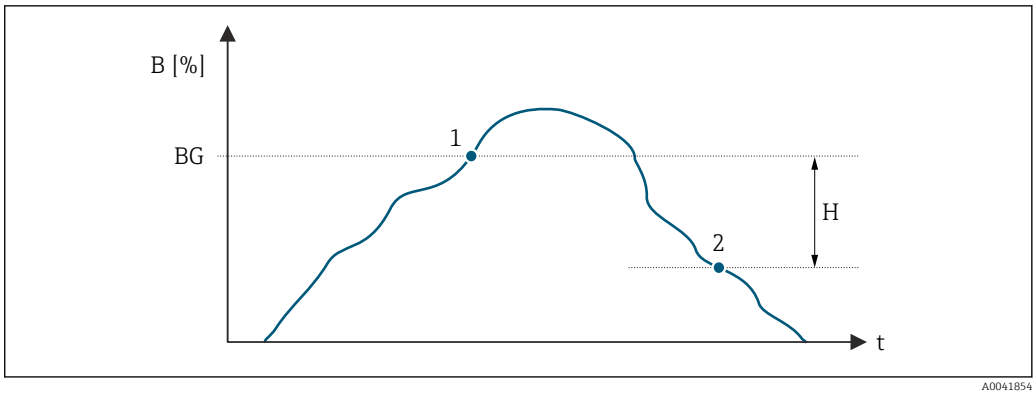
The Fast, Standard and Slow options each differ from one another by a time factor of 10.

Example for the measuring interval with DN 25 nominal diameter:
- **Fast** option: Every 6 seconds
- **Standard** option: Every 60 seconds
- **Slow** option: Every 600 seconds

Displaying the "Build-up detected" diagnostic information

Use the Build-up limit and Build-up limit hysteresis parameters to define a range for the thickness of the build-up in which the "Build-up detected" diagnostic information is output.

- If the value for the build-up detection hysteresis is higher than the Build-up limit, the "Build-up detected" diagnostic information is only reset once the measuring tube has been cleaned and the device is restarted.
- If the "Build-up detected" diagnostic information is displayed for an empty measuring tube, this can be avoided by activating empty pipe detection: Setup → Empty pipe detection



B Build-up index value [%]
t Time
BG Build-up limit [%]
1 Diagnostics information switch-on point
H Build-up limit hysteresis [%]
2 Diagnostics information switch-off point

8.1.3 Prerequisites

The following conditions must be met to ensure the optimum and reliable use of the build-up detection function.

Device version

The build-up detection function is only available in conjunction with the Promag W sensor.

Potential equalization

Potential equalization must be ensured in line with the operational environment of the measuring device in the plant.

For more information on ensuring potential equalization, see the Operating Instructions → 🖹 6.

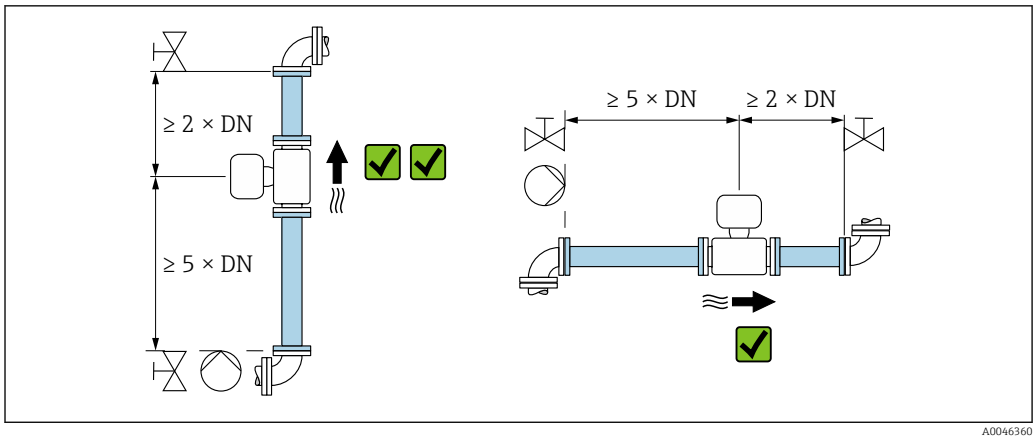
Conductivity measurement

Build-up detection is only available if conductivity measurement is activated: Expert → Sensor → Process parameters → Conductivity measurement

Mounting

- Vertical orientation (preferable)
- Mount the device downstream of assemblies such as valves, T-sections or pumps
- Observe inlet and outlet runs

For devices with the order code for "Design", option C , H, I , no inlet or outlet runs need to be considered.



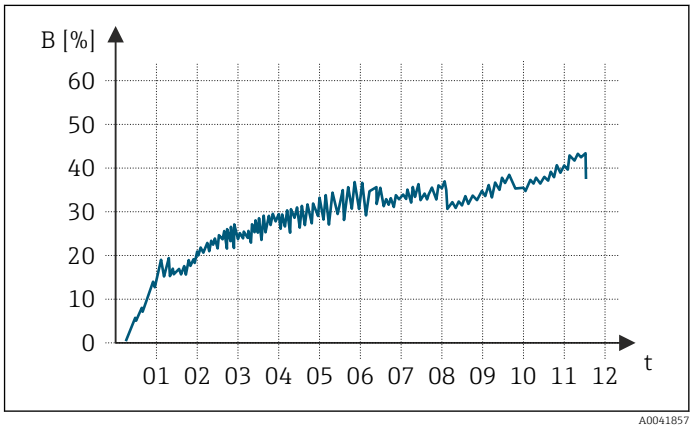
For more information on installation, see the Operating Instructions → 6.

8.2 Application examples

The following application examples show how differently build-up forms in various processes. While the values indicated cannot be applied directly on a one-to-one basis, they do provide an indication of behavior in similar processes.

8.2.1 Water application

Application	Water supply
Type of build-up	Iron clogging
Monitoring duration	12 months
Build-up detection	Standard (one measurement per minute)
Nominal diameter of measuring tube	DN 100
Build-up formed	9 mm
Analysis	

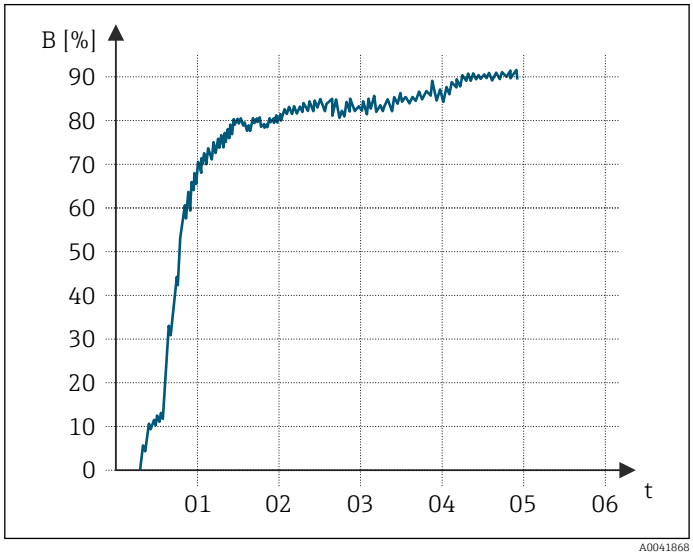


B *Build-up index value [%]*
t *Time [months]*

Build-up index value:
- 0 to 5% : no build-up present
- > 5% : build-up is detected

8.2.2 Application in the food industry: sugar

Application	Sugar refinery
Type of build-up	Oxalates in sugar beet juice
Monitoring duration	4 months
Build-up detection	Standard (one measurement per minute)
Nominal diameter of measuring tube	DN 100
Build-up formed	4 to 8 mm
Analysis	



B *Build-up index value [%]*
t *Time [months]*

Build-up index value:
- 0 to 5% : no build-up present
- > 5% : build-up is detected

8.2.3 Application in the food industry: whey protein

Application	Food processing facility
Type of build-up	Whey protein
Monitoring duration	1 day
Build-up detection	Standard (one measurement per minute)
Measuring tube nominal diameter	DN 25
Build-up formed	3-4 mm

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