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01.06.zz (Device firmware)

Special Documentation
Proline Promass 500

Heartbeat Verification + Monitoring application package
Modbus RS485

Endress+Hauser
People for Process Automation

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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 (TTC) 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 a Special Documentation and does not replace the Operating Instructions included in the scope of supply. It is a part of the Operating Instructions and serves as a reference for using the 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.
	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
↳	Result of a step

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 and other 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
Promass A 500 (8A5B**-...)	BA01537D
Promass A 500 (8A5C**-...)	BA01884D
Promass E 500	BA01539D
Promass F 500	BA01540D
Promass H 500	BA01541D
Promass I 500	BA01542D
Promass O 500	BA01543D
Promass P 500	BA01544D
Promass Q 500	BA01545D
Promass S 500	BA01546D
Promass X 500	BA01547D

The following certification is available for this documentation:

Certification	Documentation code
Manufacturer declaration Promass 300/500	HE_01640

2.5 Registered trademarks

Modbus®
Registered trademark of SCHNEIDER AUTOMATION, INC.

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

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

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
- Call up the Device Viewer via the website www.endress.com/deviceviewer: enter the serial number from the nameplate and check whether the feature is displayed
- In the operating menu Expert → System → Administration : The **Software option overview** parameter indicates whether the application package is enabled

3.2.2 Activation

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

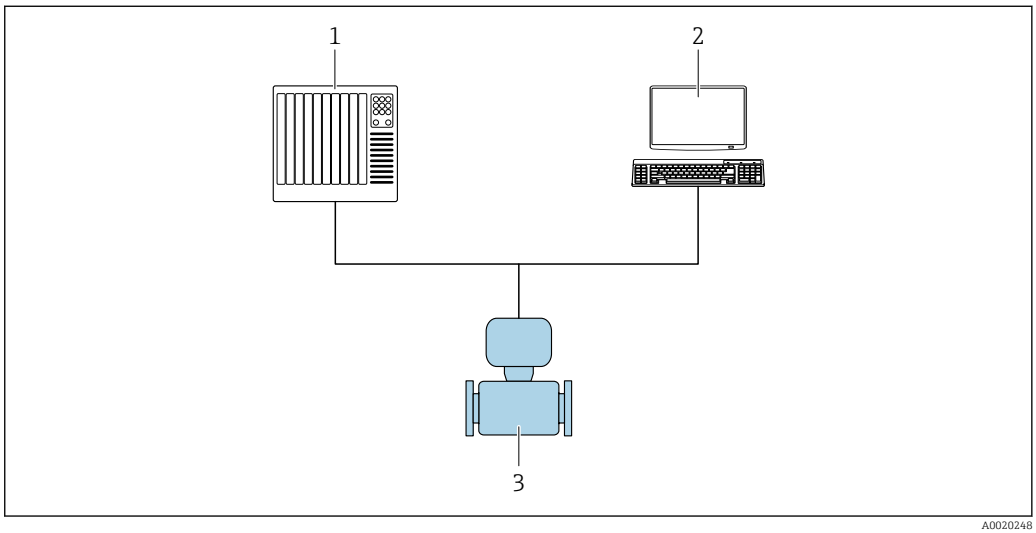
For detailed information on "Activating application packages via the software license code", see Installation Instructions EA01164D

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

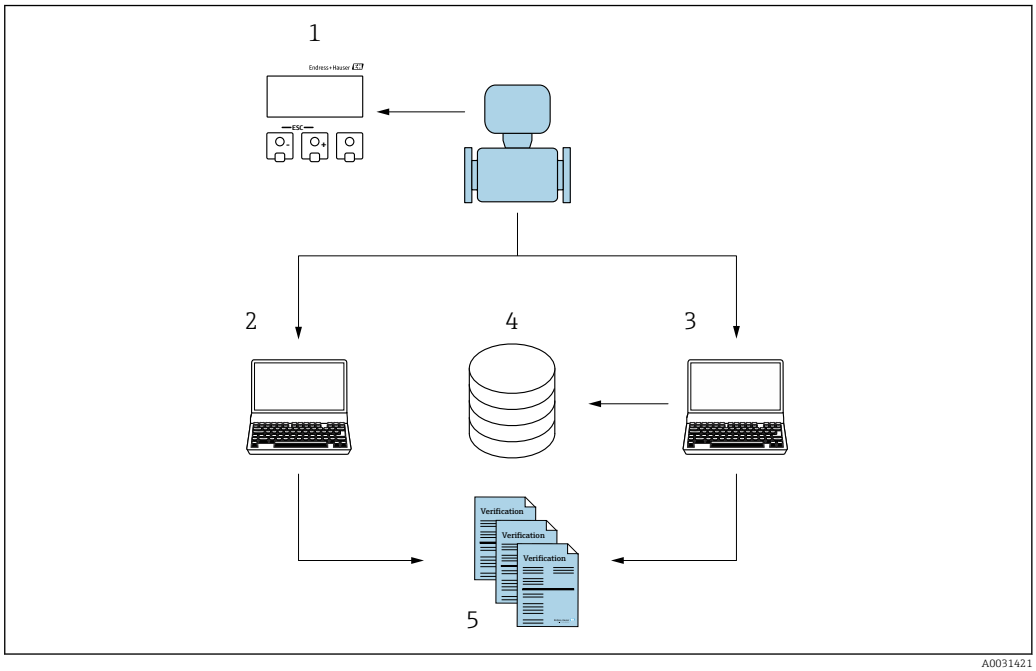
The **Heartbeat Technology** features are available via the local display module and the digital interfaces. The features can be used both via an asset management system and via the automation infrastructure (e.g. PLC).



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
- WLAN interface
- 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 (8 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 and the Web server integrated in the measuring device 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.

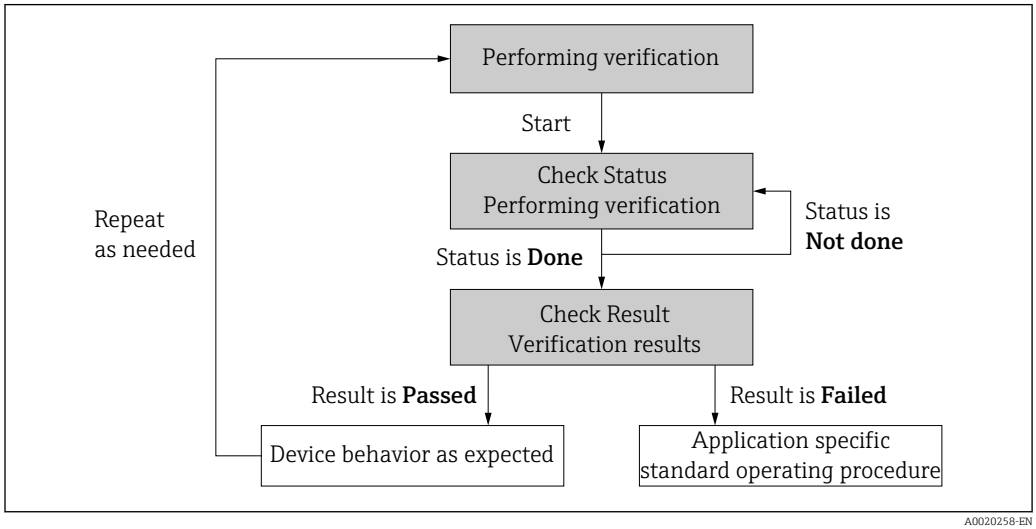
Data exchange can take place automatically or be triggered by a user.

4.2 Integration into the PLC system

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

For further information on "System integration", see the Operating Instructions → 6 (documentation code)

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

Heartbeat Verification
The Heartbeat Verification result is displayed in the operating menu.

4.3.2 Asset management system

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

Heartbeat Verification
- Start the verification
- Upload, archive and document the verification results including detailed results

4.3.3 PLC system

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

Heartbeat Verification
The Heartbeat Verification result is displayed in the operating menu.

4.4 Data management

The results of a **Heartbeat Verification** are saved as a non-volatile parameter set in the measuring device memory:
- 8 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 Web server integrated in the measuring device the Endress+Hauser asset management software, FieldCare.

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 Web browser

Thanks to the integrated Web server the device can be operated and configured via a Web browser. In addition, it is possible to query the results of the verification and create a verification report.

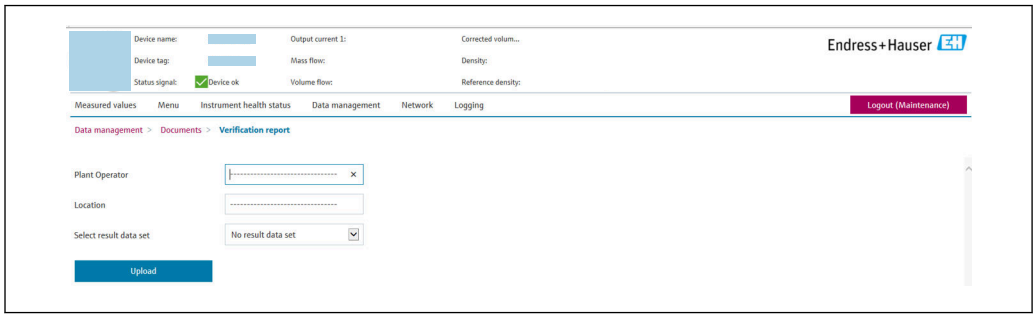
Printing a verification report

A verification report is created in PDF format.

Prerequisite: A verification has already been performed.

1) First In – First Out

User interface in the Web browser following login:



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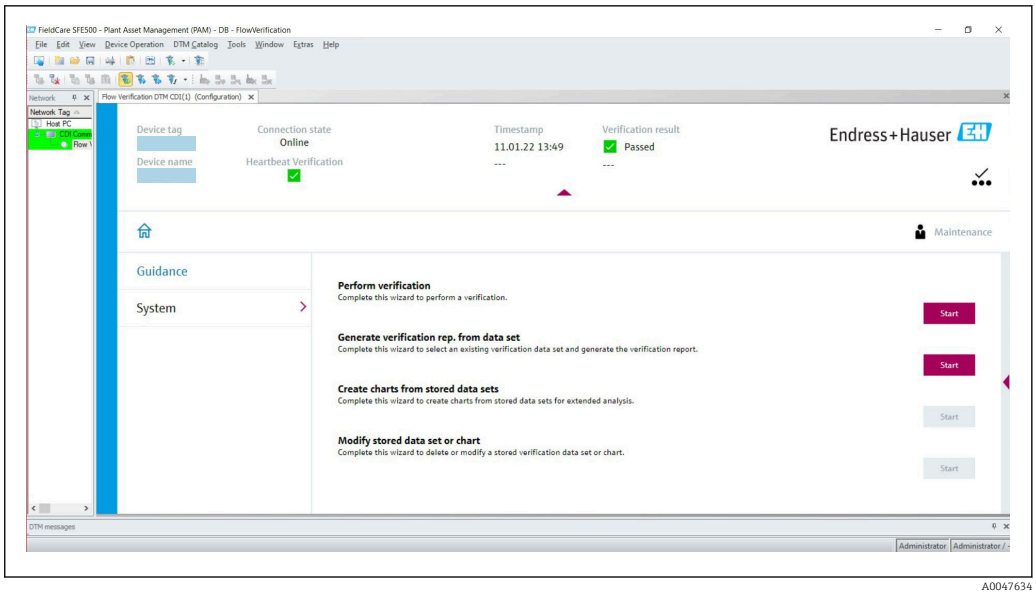
1. Click the navigation buttons **Data management** → **Documents** → **Verification report**.
   ↳ The input area for downloading verification reports is displayed.
2. Enter the necessary information in the **Plant operator** and **Location** fields.
   ↳ The information entered here appears in the verification report.
3. Select the result data set.
   ↳ A result data set is indicated as a time stamp in the drop-down list.
   If no verification has been performed, the message "No result data set" is displayed here.
4. Click **Upload**.
   ↳ The Web server generates a verification report in PDF format.

4.4.2 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.

4.4.3 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.



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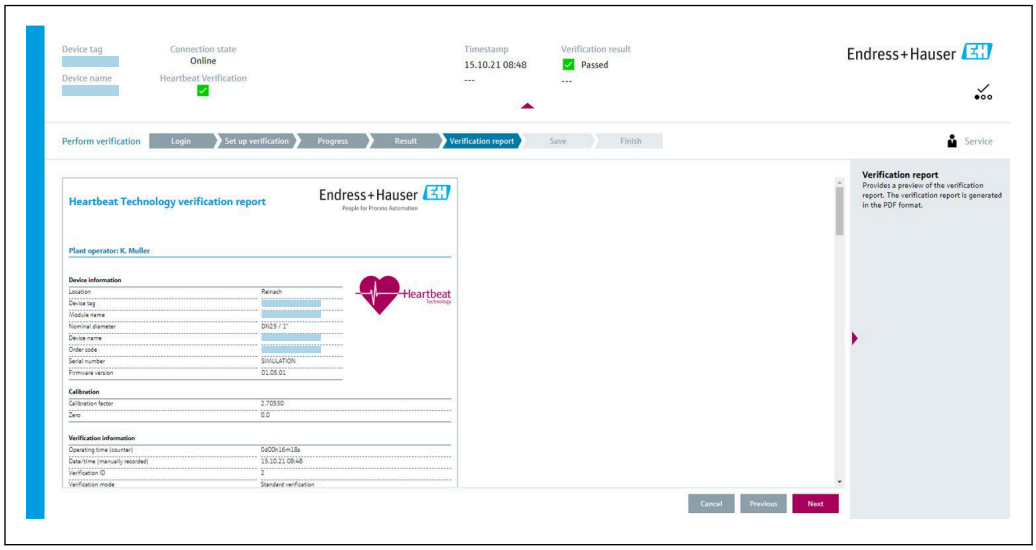
2 *Home page of "Flow Verification DTM" in FieldCare SFE500*

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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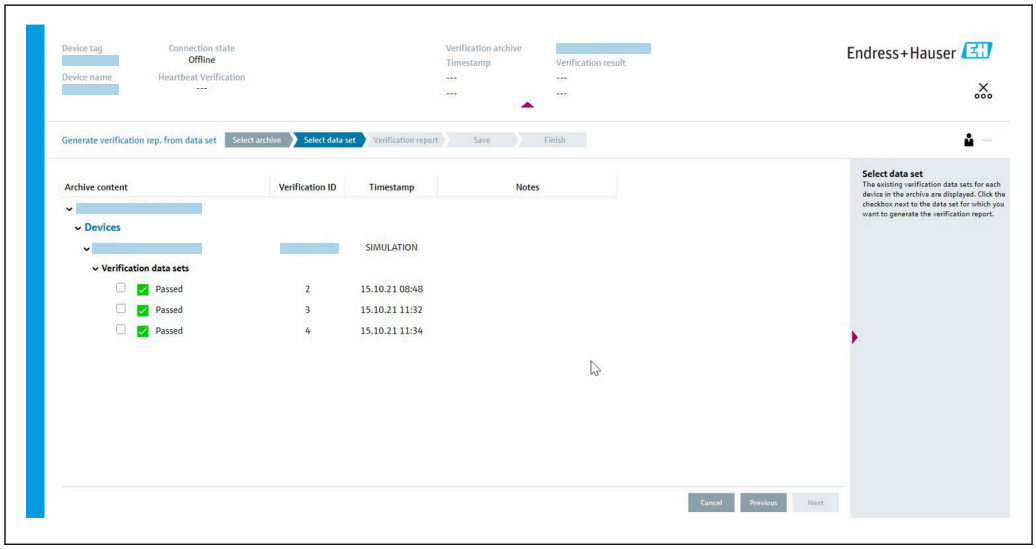
3 *Example: Displaying the verification report after performing verification*

Online connection to device required.

Creating the verification report using a verification data record



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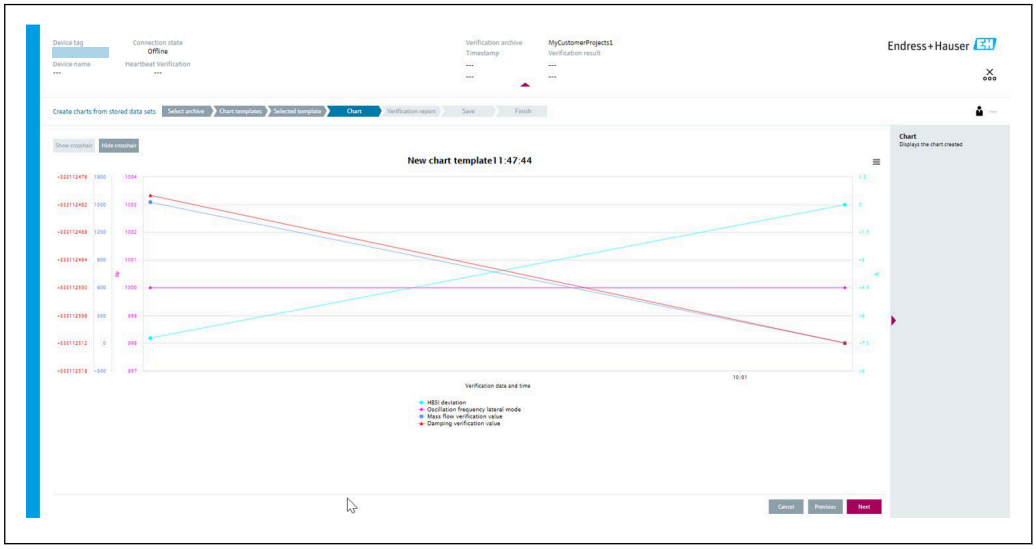
4 *Example: Creating the verification report using a verification data record*

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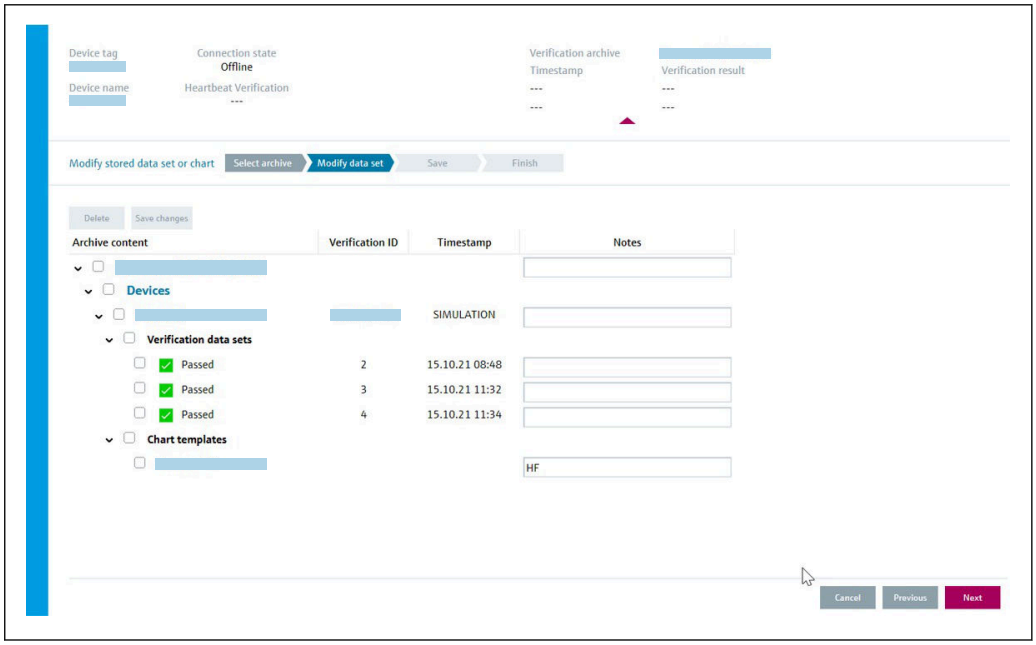
5 *Example: Creating self-edited charts on selected diagnostic parameters from saved verification data records*

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 → 18
  Verification is performed by the device without manual checking of external measured variables.
- Extended verification → 22
  Verification includes the entry of external measured variables.

5.1 Performance characteristics

Heartbeat Verification is performed on demand and supplements permanent self-monitoring with additional checks .

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

Extended verification supports verification 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.

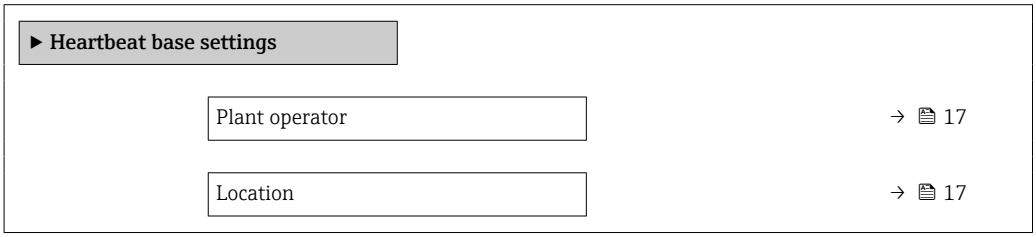
5.2.1 Recording reference data

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

Operation continues while the reference data are being recorded.

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

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



Parameter overview with brief description

Parameter	Description	User entry
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. @, %, /)

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 → 18
- Extended verification → 22

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 and density.

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 signal outputs and totalizers are not affected.
- 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.
- A category is assigned to the diagnostic message of the outputs in the **Diagnostic configuration** submenu.
  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 (→ 📄 22):
- 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) → 📄 17.

The result of the verification is displayed in the **Overall result** parameter (→ 22):
- 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 → 17.

- 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 → 34.
- 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 → 17.

"Performing verification" submenu

Navigation
"Diagnostics" menu → Heartbeat Technology → Performing verification

▶ Performing verification	
Year	→ 21
Month	→ 21
Day	→ 21
Hour	→ 21
AM/PM	→ 21
Minute	→ 21
Verification mode	→ 21
External device information	→ 21
Start verification	→ 21
Progress	→ 21
Measured values	→ 22
Output values	→ 22
Status	→ 22
Overall result	→ 22

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	10
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	January
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	1 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	12 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	AM
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	0 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	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	Cancel
Progress	–	Shows the progress of the process.	0 to 100 %	–

Parameter	Prerequisite	Description	User entry / Selection / User interface	Factory setting
Measured values	One of the following options is selected in the **Start verification** parameter (→ 🖹 21): ▪ Output 1 low value ▪ Output 1 high value ▪ Output 2 low value ▪ Output 2 high value ▪ Output 3 low value ▪ Output 3 high value ▪ Output 4 low value ▪ Output 4 high value ▪ Frequency output 1 ▪ Pulse output 1 ▪ Frequency output 2 ▪ Pulse output 2 ▪ Frequency output 3 ▪ 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	0
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: → 🖹 32	▪ 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 → 🖹 27. 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.

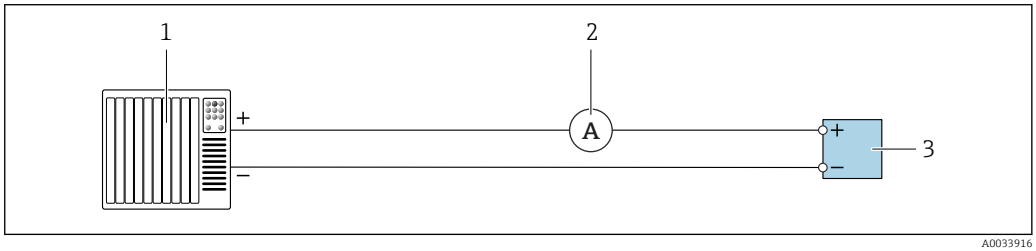
Determining the terminal assignment for the outputs

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

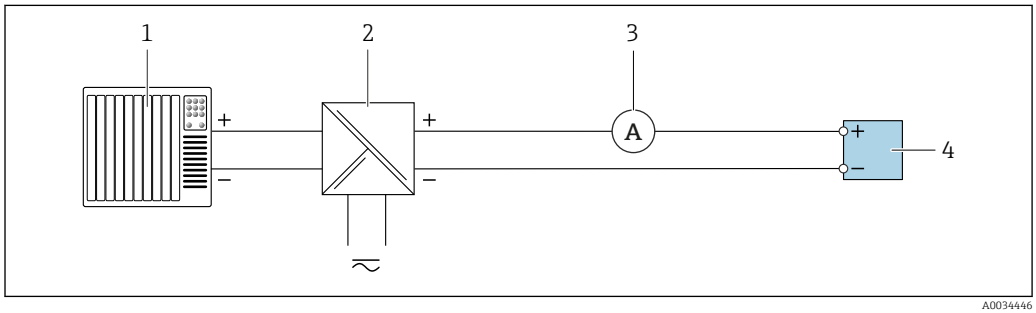
Extended verification of the active current output

▶ 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



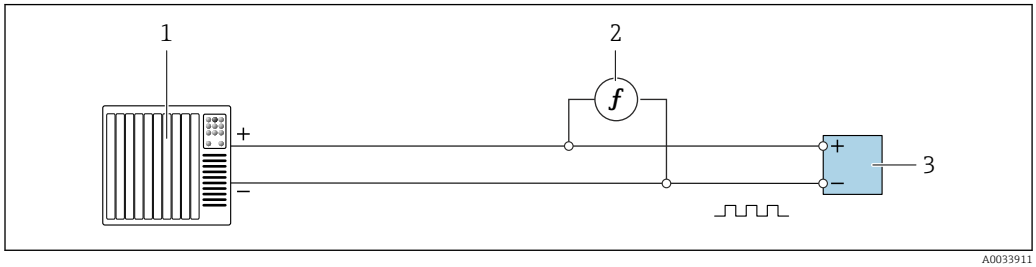
8 *Extended verification of the passive current output*

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



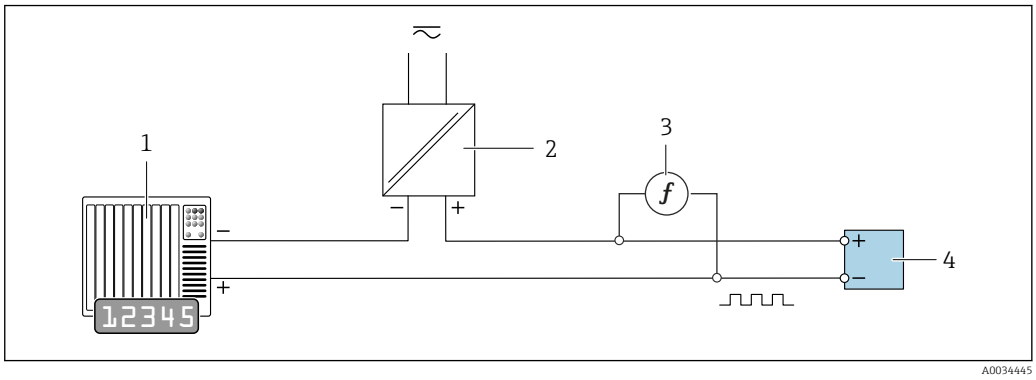
9 *Extended verification of the active pulse/frequency output*

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 shown on the display (2nd part of external verification): ⚠**C302 Device verification in progress** diagnostic message
- Factory setting for diagnostic behavior: warning
- The device continues to measure.
- The totalizers are not affected.
- 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.
- A category is assigned to the diagnostic message of the outputs in the **Diagnostic configuration** submenu.
  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, on whether the output is switched on and on whether the output is active or passive.

The value displayed in the **Output values** parameter (→ 22) shows the value simulated by the device at the selected output → 23

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 (→ 22):
- 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) → 17.

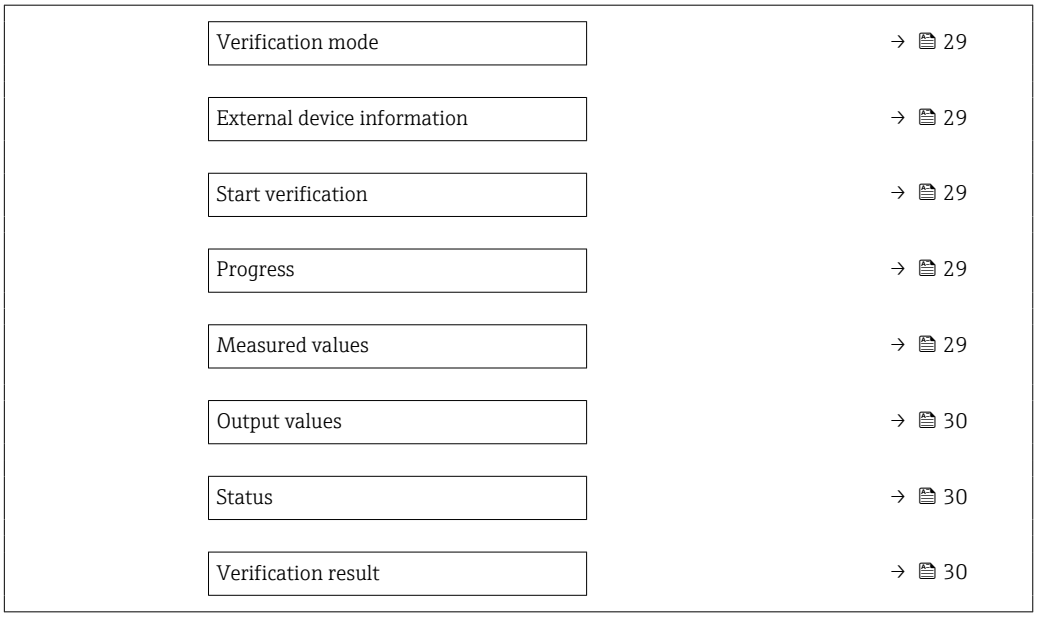
The result of the verification is displayed in the **Overall result** parameter (→ 22):
- Passed
  All the verification tests were successful.
- Not done
  A verification has not yet been performed on this measuring device.
- Failed
  One or more verification tests were not successful → 17.

- 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 → 34.
- 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 → 17.

"Performing verification" submenu

Navigation
"Diagnostics" menu → Heartbeat Technology → Performing verification

▶ Performing verification		
	Year	→ 28
	Month	→ 28
	Day	→ 28
	Hour	→ 28
	AM/PM	→ 28
	Minute	→ 28



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	10
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	January
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	1 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	12 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	AM
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	0 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	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. 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 * ▪ Output 2 low value * ▪ Output 2 high value * ▪ Output 3 low value * ▪ Output 3 high value * ▪ Output 4 low value * ▪ Output 4 high value * ▪ Frequency output 1 * ▪ Pulse output 1 * ▪ Frequency output 2 * ▪ Pulse output 2 * ▪ Frequency output 3 * ▪ Double pulse output * ▪ Start	Cancel
Progress	–	Shows the progress of the process.	0 to 100 %	–
Measured values	One of the following options is selected in the **Start verification** parameter (→ 🖹 21): ▪ Output 1 low value ▪ Output 1 high value ▪ Output 2 low value ▪ Output 2 high value ▪ Output 3 low value ▪ Output 3 high value ▪ Output 4 low value ▪ Output 4 high value ▪ Frequency output 1 ▪ Pulse output 1 ▪ Frequency output 2 ▪ Pulse output 2 ▪ Frequency output 3 ▪ 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	0

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: → 32	▪ Not supported ▪ Passed ▪ Not done ▪ Failed	Not done

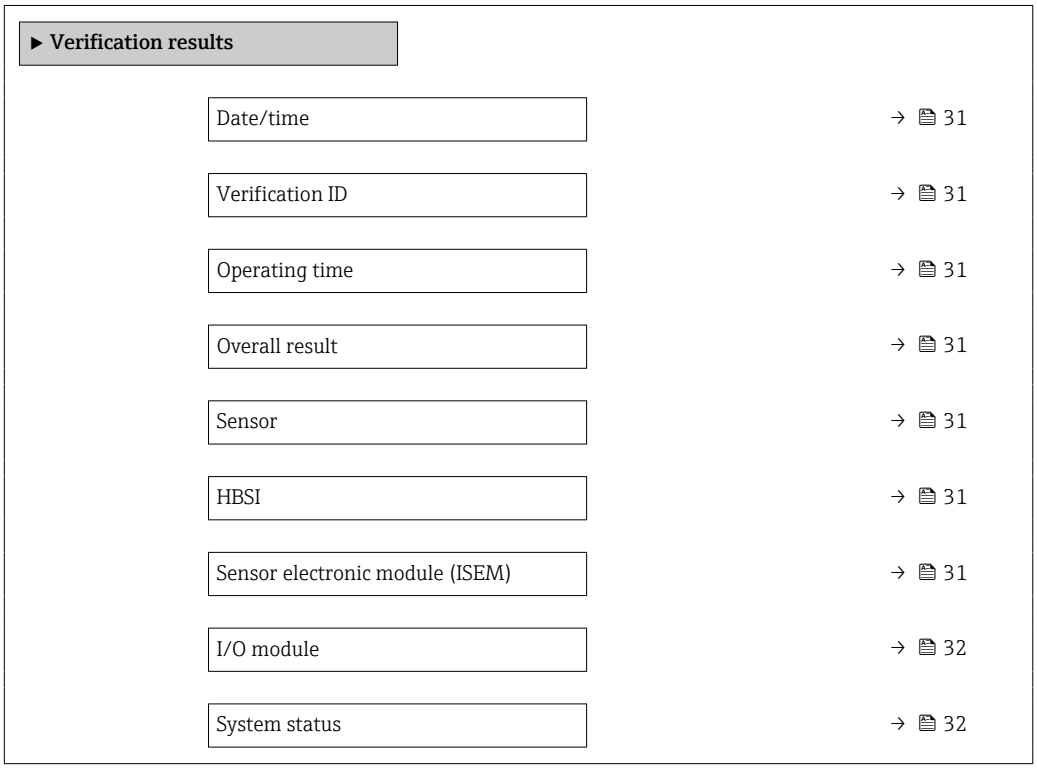
* Visibility depends on order options or device settings

5.3.6 Verification results

Access to the verification results:
In the operating menu via the local display, operating tool or Web browser
▪ Diagnostics → Heartbeat Technology → Verification results
▪ Expert → 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 (manually entered)	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	0
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: → 32	▪ Not supported ▪ Passed ▪ Not done ▪ Failed	Not done
Sensor	The **Failed** option result is shown in the **Overall result** parameter.	Displays the result for the sensor. Detailed description of results classification: → 32	▪ Not supported ▪ Passed ▪ Not done ▪ Failed	Not done
HBSI	In the **Overall result** parameter, the **Failed** option was displayed.	Displays the relative change in the sensor with all the sensor components. Detailed description of results classification: → 32	▪ Not supported ▪ Passed ▪ Not done ▪ Failed	Not done
Sensor electronic module (ISEM)	The **Failed** option result is shown in the **Overall result** parameter.	Displays the result for the sensor electronics module (ISEM). Detailed description of results classification: → 32	▪ Not supported ▪ Passed ▪ Not done ▪ Failed	Not done

Parameter	Prerequisite	Description	User interface	Factory setting
I/O module	In the **Overall result** parameter, the **Failed** option was displayed.	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: → 32	▪ Not supported ▪ Passed ▪ Not done ▪ Not plugged ▪ Failed	Not done
System status	The **Failed** option result is shown in the **Overall result** parameter.	Displays the system condition. Tests the measuring device for active errors. Detailed description of results classification: → 32	▪ Not supported ▪ Passed ▪ Not done ▪ Failed	Not done

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. For example, because this parameter is not available in the current device configuration.
Not supported	The result is used for internal purposes.
Not plugged	The result is displayed if no I/O module is plugged into the slot.
Off	The result is displayed if a universal module is plugged into the slot and has not been configured. This is equivalent to the slot in question being "deactivated".

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).

Test groups

Test group	Description
Sensor	Electrical components of the sensor (signals, circuits and cables)
HBSI	Electrical, electromechanical and mechanical components of the sensor, including the measuring tube
Sensor electronics module (ISEM)	Electronics module for activating and converting the sensor signals
I/O module	Results of the input and output modules installed on the measuring device
System condition	Test for active measuring device errors of "alarm"-type diagnostic behavior

Test groups and individual tests → 34.

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 resultswhich can be accessed with the Flow Verification DTM.

Limit values

I/O module

Input; Output	Standard verification	Extended verification
Current output 4 to 20 mA, active and passive	▪ ±1 % ▪ ±100 µA (offset)	▪ Lower value 4mA: ±1 % ▪ Upper value 20mA: ±0.5 %
Pulse/frequency/switch output, active and passive	±0.05 %, with a 120 s cycle	▪ Pulse: ±0.3 % ▪ Frequency: ±0.3 %
Current input 4 to 20 mA, active and passive	▪ −20 %: 24 V −20 % = 19.2 V ▪ In addition: −5 %: 19.2 V− 5 %	Only standard verification possible.
Double pulse output, active and passive	±0.05 %, with a 120 s cycle	Only standard verification possible.
Relay output	The number of switching cycles depends on the hardware	Only standard verification possible.

5.3.7 Detailed verification results

The process conditions at the time of verification and the individual test group results can be accessed with the Flow Verification DTM.

- Process conditions: "VerificationDetailedResults → VerificationActualProcessConditions"
- Verification results: "VerificationDetailedResults → VerificationSensorResults"

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
Mass flow verification value	Current measured value for mass flow
Density verification value	Current measured value for density
Damping verification value	Current measured value for measuring tube damping
Process temperature verification value	Current measured value for medium temperature
Electronic temperature	Current measured value for the electronic temperature in the transmitter

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
Inlet sensor coil	Condition of the inlet sensor coil: Intact/not intact (short-circuit/open circuit)	No value range ▪ Passed ▪ Failed	▶ Check connecting cable between sensor and transmitter ▶ Replace sensor
Outlet sensor coil	Condition of the outlet sensor coil: Intact/not intact (short-circuit/open circuit)	No value range ▪ Passed ▪ Failed	▶ Check connecting cable between sensor and transmitter ▶ Replace sensor
Measuring tube temperature sensor	Condition of the measuring tube temperature sensor: Intact/not intact (short-circuit/open circuit)	No value range ▪ Passed ▪ Failed	▶ Check connecting cable between sensor and transmitter ▶ Replace sensor
Carrier tube temperature sensor (Not Promass E)	Condition of the carrier tube temperature sensor: Intact/not intact (short-circuit/open circuit)	No value range ▪ Passed ▪ Failed	▶ Check connecting cable between sensor and transmitter ▶ Replace sensor
Sensor coil symmetry	Monitoring of the signal amplitude between the inlet and outlet sensor	No value range ▪ Passed ▪ Failed	Indication of mechanical damage or electronic interference ▶ Check connecting cable between sensor and transmitter ▶ Replace sensor

Parameter/individual test	Description	Result/limit value	Interpretation/cause/remedial measures
Lateral mode frequency	Monitoring of the oscillation frequency of the measuring tube/tubes	No value range ▪ Passed ▪ Failed	▶ Check whether the sensor is outside the operational range ▶ Check for damage on the measuring tube, e.g. as a result of corrosion ▶ Check connecting cable between sensor and transmitter ▶ Replace sensor
Promass I: frequency torsion mode Promass Q: frequency second mode	Monitoring of the oscillation frequency of measuring tube, oscillating frequency torsion mode/second mode	No value range ▪ Passed ▪ Failed	▶ Check whether the sensor is outside the operational range ▶ Check for damage on the measuring tube, e.g. as a result of corrosion ▶ Check connecting cable between sensor and transmitter ▶ Replace sensor

HBSI

Parameter/individual test	Description	Result/limit value	Interpretation/cause/remedial measures
HBSI	Monitoring of 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 sensors, excitation system, cables etc.), in % of the reference value.	No value range ▪ Passed ▪ Failed	▶ Deviations of the HBSI value indicate corrosion, abrasion or other damage, such as shock/impact. In the case of Promass I, it also is an indication of the formation of deposits and buildup in the measuring tube. If the result is "Failed", the sensor is seriously impaired and must be checked.

Sensor electronics module (ISEM)

Parameter/individual test	Description	Result/limit value	Interpretation/cause/remedial measures
Supply voltage	Monitoring of the main supply voltage of the sensor electronics module Execution: Monitoring of the supply voltage for the sensor electronics module guarantees that the system is functioning correctly.	No value range ▪ Passed ▪ Failed	Sensor electronics module (ISEM) defective ▶ Replace sensor electronics module (ISEM)
Zero point monitoring	Test of the entire signal path, amplitude and zero point.	No value range ▪ Passed ▪ Failed	Sensor electronics module (ISEM) defective ▶ Replace sensor electronics module (ISEM)
Reference clock	Monitoring of the reference clock for flow and density measurement	No value range ▪ Passed ▪ Failed	Sensor electronics module (ISEM) defective ▶ Replace sensor electronics module (ISEM)
Reference temperature	Temperature measurement monitoring	No value range ▪ Passed ▪ Failed	Sensor electronics module (ISEM) defective ▶ Replace sensor electronics module (ISEM)

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 → 16	No value range ▪ Passed ▪ Failed ▪ Not done Limit values → 33	**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 Web server or 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 → 🖹 34
  - Sensor
  - HBSI
  - Sensor electronics module (ISEM)
  - System condition
  - I/O module

Third page (and subsequent pages): 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:
- Flow
- Process temperature
- Electronic temperature
- Density
- Damping

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: → 34

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 incorporates the entire measuring device and 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 and the specified total test coverage TTC.

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 of the previous verification are documented on the last page of the verification report and can be accessed using the Flow Verification DTM → 34.

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 diagnostic parameter is switched on or off in the operating menu:
→ 41

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.

Measured variable	Description	Value range
Electronics temperature	Temperature of the electronics in the set system unit	−50 to +90 °C [1]
Exciter current 0	Exciter current of the measuring tube/ tubes in mA	±100 mA
Exciter current 1 [2]	Exciter current of measuring tube 2, oscillation mode in mA	±100 mA
Frequency fluctuation 0	Fluctuation of the oscillation frequency of the measuring tube(s)	[1]
Frequency fluctuation 1 [2]	Fluctuation of the oscillation frequency of measuring tube 2, oscillation mode	[1]
HBSI	HBSI % deviation from reference value.	±4 %
Oscillation damping fluctuation 0	Fluctuation of the mechanical damping of the measuring tube(s)	[1]
Oscillation damping fluctuation 1 [2]	Fluctuation of the mechanical damping of measuring tube 2, oscillation mode	[1]
Oscillation amplitude 0	Relative mechanical oscillation amplitude of the measuring tube/tubes in % of the target value	0 to 100 % Can be > 100% temporarily.
Oscillation amplitude 1 [2]	Relative mechanical oscillation amplitude of measuring tube 2, oscillation mode in % of the target value	0 to 100 % Can be > 100% temporarily.
Oscillation frequency 0	Oscillation frequency of the measuring tube/tubes in Hz	[1]
Oscillation frequency 1 [2]	Oscillation frequency of measuring tube 2, oscillation mode in Hz	[1]
Oscillation damping 0	Mechanical damping of the measuring tubes/tube in A/m	0 to 100 000 [1]

Measured variable	Description	Value range
Oscillation damping 1 [2]	Mechanical damping of measuring tube 2, oscillation mode in A/m	0 to 100 000
Signal asymmetry	Relative deviation of the signal amplitude between the inlet and outlet sensor in %	0 to 25 %
Carrier pipe temperature [3]	Temperature of the sensor carrier tube in the set system unit	Depends on the medium temperature. −200 to +350 °C

1) Depends on the sensor type, version and nominal diameter
2) Only available with Promass I and Q
3) Not available for Promass E

For information on using the parameters and interpreting the measurement results → 43.

6.1.2 HBSI monitoring

Enables monitoring of the **HBSI** parameter (Heartbeat Sensor Integrity). This parameter monitors the sensor (measuring tube, electrodynamic sensors, exciter system, cables etc.) for changes that can cause deviations in flow and density measurement.

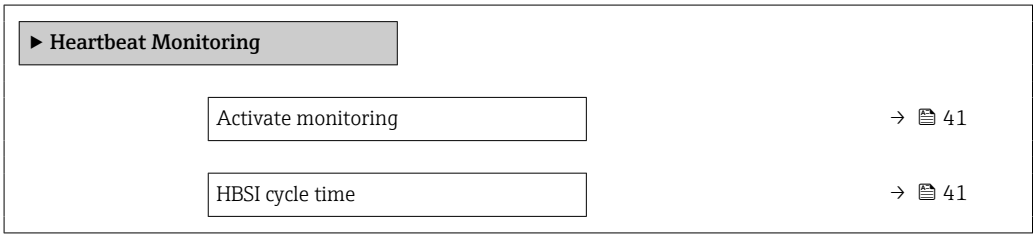
HBSI Monitoring is continuously available for Promass I.

HBSI Monitoring is periodically available for all other sensors. The function must be enabled during commissioning in order to use the additional measured variable.

Enabling and disabling HBSI Monitoring

Navigation

"Setup" menu → Advanced setup → Heartbeat setup → Heartbeat Monitoring



Parameter overview with brief description

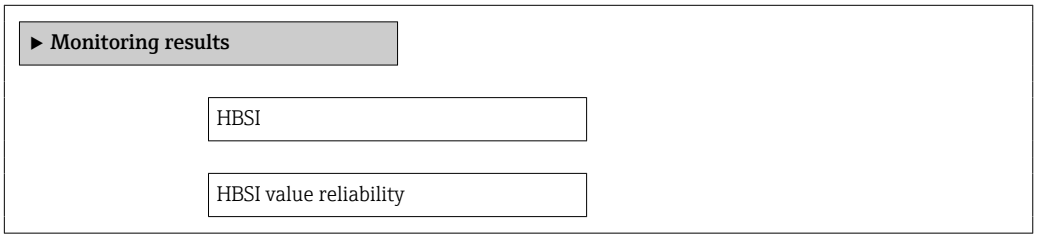
Parameter	Prerequisite	Description	Selection / User entry	Factory setting
Activate monitoring	–	Activate monitoring to enable cyclic transmission of the HBSI measured value.	Time-controlled HBSI	On
HBSI cycle time	In the **Activate monitoring** parameter, the **Time-controlled HBSI** option is selected. Not available for Promass I.	This parameter can be used to set the cycle time for determining the HBSI measured value.	0.5 to 4 320 h	12 h

6.1.3 Displaying the monitoring results

The current value of the **HBSI** 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	Factory setting
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 %	–
HBSI value reliability	Shows the status of the HBSI value. Uncertain or Bad: Due to difficult process conditions over a long time no HBSI value could be determined.	▪ Good ▪ Uncertain ▪ Bad	Uncertain

6.1.4 Configuration of the outputs and local display

With the application package "Heartbeat Verification + Monitoring", the user has additional monitoring parameters available → 📄 40 . 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.

With Heartbeat Monitoring it is possible to output additional monitoring-specific measured values for monitoring in an external Condition Monitoring system during continuous operation.

Condition Monitoring 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:
- Buildup in the sensor
- Corrosive or abrasive fluids
- Multi-phase fluids (gas content in liquid fluids)
- Wet gases
- Applications in which the sensor is exposed to a programmed amount of wear.

The results of condition monitoring 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
Mass flow	If the mass flow can be kept constant and can be repeated, a deviation from the reference indicates a zero point shift.
Density	A deviation from the reference may be caused by a change in the resonance frequency of the measuring tube, e.g. due to coating/buildup in the measuring tube, corrosion or abrasion.
Reference density	The reference density values can be interpreted in the same way as the density values. If it is not possible to keep the liquid temperature entirely constant, you can analyze the reference density (density at a constant temperature, e.g. at 20 °C) instead of the density. Make sure that the parameters required for calculating the reference density have been configured correctly.

Monitoring parameter	Possible reasons for deviation
Temperature	Use this diagnostics parameter to monitor the process temperature.
Oscillation damping	A deviation from the reference state can be caused by a change in the measuring tube damping, e.g. by mechanical changes (formation of coating or buildup, fouling).
Signal asymmetry	A deviation is an indicator of abrasion or corrosion.
Frequency fluctuation	A deviation in the frequency fluctuation is an indicator of rapidly changing process conditions, e.g. gas content in a liquid medium or moisture in gaseous media.
Tube damping fluctuation	A deviation in the tube damping fluctuation is an indicator of rapidly changing process conditions, e.g. gas content in a liquid medium.
HBSI	A deviation in the HBSI indicates a 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 the event of deposits/buildup, fouling in the sensor: or In the event of abrasion or corrosion in the sensor: Inspect the sensor, clean the measuring tube if necessary ▪ In case of mechanical damage or aging of sensor and excitation coils: Replace the sensor
Electronic temperature	Indication of high ambient temperatures or heat transfer from the process, e.g. due to installation conditions (incorrect insulation of the pipework).

6.2.2 Description of typical applications

Coating or deposit buildup in the measuring tube

If it emerges that the process causes coating/build-up in the measuring tubes of the measuring device, **Heartbeat Monitoring** can be used for this application.

Relevant monitoring parameters:

- Oscillation damping
  Oscillation damping is a number that defines the ratio of the exciter current to the oscillation amplitude of the tubes. Coating or deposit buildup in the measuring tube have a significant influence on this value. Note: Medium viscosity and entrained gas in liquid media can also influence the Oscillation damping .
- HBSI
  In the case of Promass I, the **HBSI** parameter is also suitable for detecting deposits and the formation of buildup in the measuring tube. The shift from the baseline value depends on whether the buildup forming on the measuring tube is soft or hard.
- Density
  Mechanical changes to the tubes cause a shift in the resonance frequency. The formation of buildup and deposits reduces the resonance frequency. This causes the measured density value to increase compared to the reference value. Note: A reliable comparison with the reference value requires a reference condition, i.e. a medium of known density or an empty measuring tube.

Corrosion or abrasion in the measuring tube

If there is evidence or the suspicion that the process is causing corrosion or abrasion in the measuring tubes of the measuring device, **Heartbeat Monitoring** can be used for this application.

Relevant monitoring parameters:

- HBSI
  An increase in the **HBSI** parameter is a clear indication of increased wear of the sensor due to corrosion or abrasion.
- Sensor asymmetry
  Corrosion or abrasion is rarely constant over the entire length of the measuring tube. Abrasion often occurs at the inlet, i.e. in areas of higher fluid velocity. Corrosion attacks the weak points of a measuring system and occurs at welds (flow splitters etc.). Changes to the sensor asymmetry can be caused by corrosion and abrasion in the Coriolis sensor.
- Density
  Mechanical changes to the tubes cause a shift in the resonance frequency. If the density has changed in relation to the reference value, this can indicate eroded or corroded measuring tubes. Note: A reliable comparison with the reference value requires a reference condition, i.e. a medium of known density or an empty measuring tube.

Application with multiphase fluids

If there is evidence or the suspicion that multiphase conditions are present in the process, **Heartbeat Monitoring** can be used for the following applications:

- Air entrained in liquids
- Wet gas

Relevant monitoring parameters:

- Frequency fluctuation
  If the process is stopped or if constant process conditions are present, a value close to 0 can be expected. An increase in the current value in applications involving liquids is an indicator of gas content in the fluid. In applications with gaseous fluids, the Frequency fluctuation is a good indicator of wet gas, as the fluctuation in the frequency indicates that a fluid is not homogeneous.
- Oscillation damping and Oscillation damping fluctuation
  An increase in oscillation damping coupled with a rapid change in Oscillation damping is an indicator of multiphase conditions in the process (particularly gas content in liquid fluids), as these conditions cause increased damping in the measuring tube. The changes in the Oscillation damping are caused by the changing gas concentration and distribution of the gas in the liquid.

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

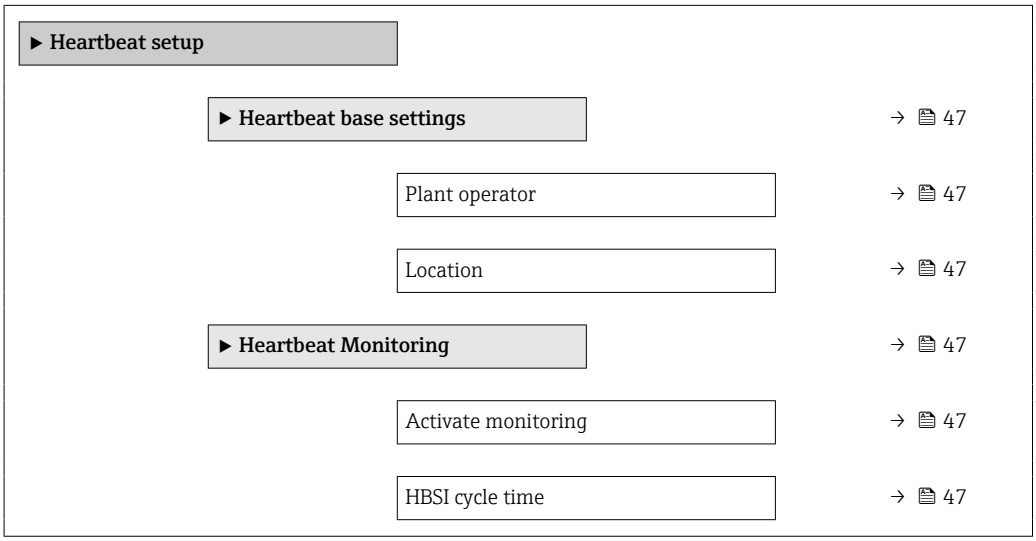
Function code	Access type	Register in accordance with "Modbus Applications Protocol Specification"	Register in accordance with "Modicon Modbus Protocol Reference Guide"
03 04 23	Read	XXXX Example: mass flow = 2007	3XXXX Example: mass flow = 32007
06 16 23	Write	XXXX Example: reset totalizer = 6401	4XXXX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

7.2 Overview of the Heartbeat 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.

7.2.1 "Heartbeat setup" submenu

Navigation
"Setup" menu → Advanced setup → Heartbeat setup



7.2.2 Register information

"Heartbeat base settings" submenu

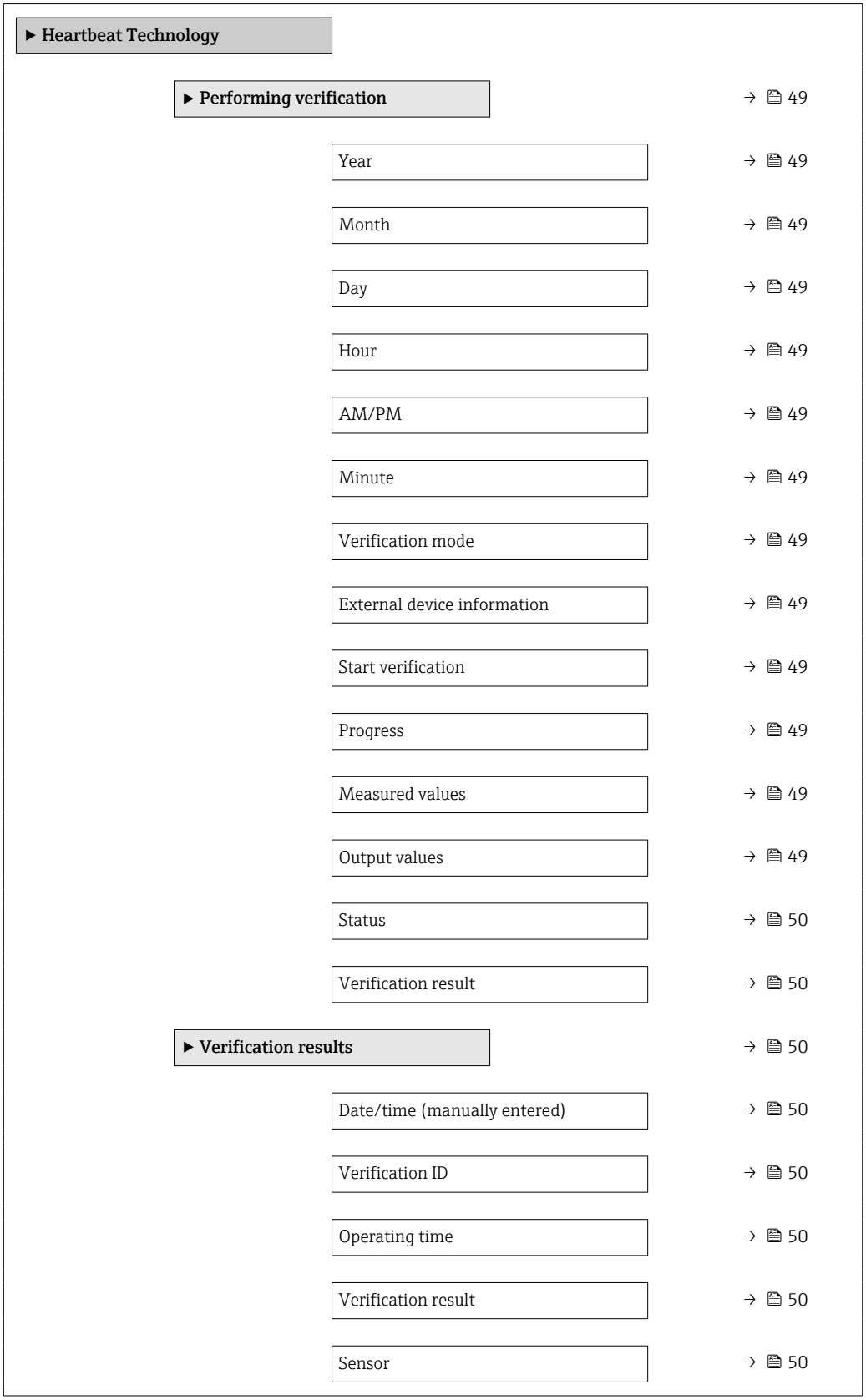
Navigation: Heartbeat setup → Heartbeat base settings					
Parameter	**Register**	**Data type**	**Access**	**Selection / User entry / User interface**	**→**
Plant operator	3414 to 3429	String	Read / Write	Max. 32 characters such as letters, numbers or special characters (e.g. @, %, /)	17
Location	3430 to 3445	String	Read / Write	Max. 32 characters such as letters, numbers or special characters (e.g. @, %, /)	17

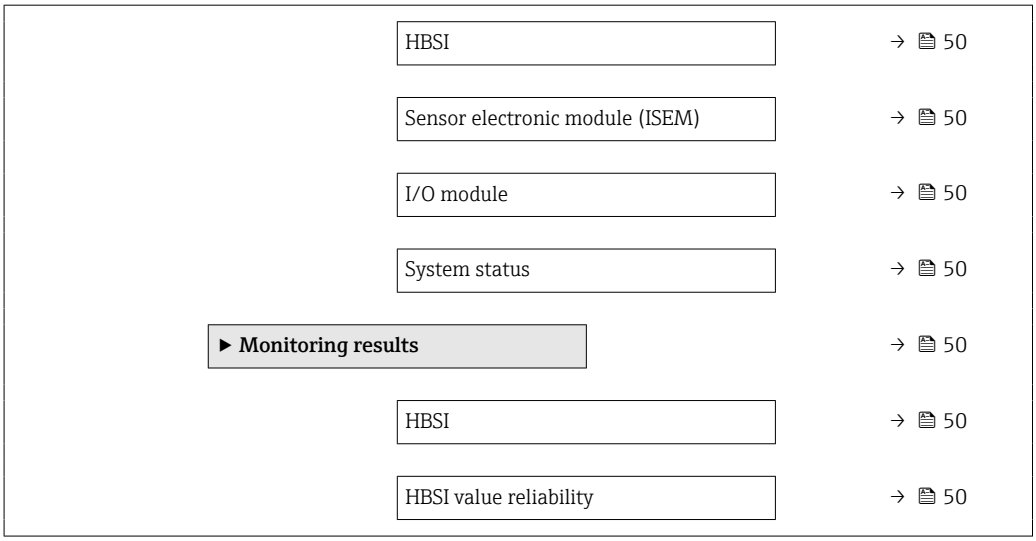
"Heartbeat Monitoring" submenu

Navigation: Heartbeat setup → Heartbeat Monitoring					
Parameter	**Register**	**Data type**	**Access**	**Selection / User entry / User interface**	**→**
Activate monitoring	2088	Integer	Read / Write	2 = Time-controlled HBSI	41
HBSI cycle time	28625 to 28626	Float	Read / Write	0.5 to 4 320 h	41

7.2.3 "Heartbeat" submenu

Navigation
"Heartbeat" submenu





7.2.4 Register information

"Performing verification" wizard

Navigation: Heartbeat Technology → Performing verification					
Parameter	**Register**	**Data type**	**Access**	**Selection / User entry / User interface**	**→**
Year	2495	Integer	Read / Write	9 to 99	21
Month	2494	Integer	Read / Write	**0 = January** 1 = February 2 = March 3 = April 4 = May 5 = June 6 = July 7 = August 8 = September 9 = October 10 = November 11 = December	21
Day	2493	Integer	Read / Write	1 to 31 d	21
Hour	2492	Integer	Read / Write	0 to 23 h	21
AM/PM	2496	Integer	Read / Write	**0 = AM** 1 = PM	21
Minute	2467	Integer	Read / Write	0 to 59 min	21
Verification mode	2366	Integer	Read / Write	**0 = Standard verification**	21
External device information	20493 to 20508	String	Read / Write	Free text entry	21
Start verification	2270	Integer	Read / Write	**0 = Cancel** 1 = Start	21
Progress	6797	Integer	Read	0 to 100 %	21
Measured values	5512 to 5513	Float	Read / Write	Signed floating-point number	22
Output values	5516 to 5517	Float	Read	Signed floating-point number	22

Navigation: Heartbeat Technology → Performing verification					
Parameter	**Register**	**Data type**	**Access**	**Selection / User entry / User interface**	**→**
Status	2079	Integer	Read	0 = Failed 1 = Done 3 = Not done 8 = Busy	22
Verification result	2355	Integer	Read	0 = Failed 2 = Passed 3 = Not done 250 = Not supported	22

"Verification results" submenu

Navigation: Heartbeat Technology → Verification results					
Parameter	**Register**	**Data type**	**Access**	**Selection / User entry / User interface**	**→**
Date/time (manually entered)	2372 to 2381	String	Read	dd.mmmm.yyyy; hh:mm	31
Verification ID	2315	Integer	Read	0 to 65 535	31
Operating time	3346	String	Read	Days (d), hours (h), minutes (m), seconds (s)	31
Verification result	2355	Integer	Read	0 = Failed 2 = Passed 3 = Not done 250 = Not supported	22
Sensor	2384	Integer	Read	0 = Failed 2 = Passed **3 = Not done** 250 = Not supported	31
HBSI	2129	Integer	Read	0 = Failed 2 = Passed **3 = Not done** 250 = Not supported	31
Sensor electronic module (ISEM)	2385	Integer	Read	0 = Failed 2 = Passed **3 = Not done** 250 = Not supported	31
I/O module	2386	Integer	Read	0 = Failed 2 = Passed **3 = Not done** 250 = Not supported 254 = Not plugged	32
System status	5790	Integer	Read	0 = Failed 2 = Passed **3 = Not done** 250 = Not supported	32

"Monitoring results" submenu

Navigation: Heartbeat Technology → Monitoring results					
Parameter	**Register**	**Data type**	**Access**	**Selection / User entry / User interface**	**→**
HBSI	--	Float	Read		
HBSI value reliability	34882	Integer	Read	0 = Bad **64 = Uncertain** 128 = Good	42

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