SD01703D/06/EN/03.18
71418927
2018-11-01

Valid as of version
01.00.zz (Device firmware)

Special Documentation
Proline Promass 500 FOUNDATION Fieldbus

Heartbeat Verification + Monitoring application package

Endress+Hauser
People for Process Automation

Table of contents

1 Certification

BESCHEINIGUNG ◆ ATTESTATION ◆ 证明书 ◆ СВИДЕТЕЛЬСТВО ◆ CONSTANCIA ◆ ATTESTAZIONE

ATTESTATION

Industrie Service

The Certification Body of
TÜV SÜD Industrie Service GmbH
Business Area Energy and Systems

confirms that the product

Proline Promass 300,
Proline Promass 500
with Heartbeat Technology™

manufactured by

Endress + Hauser Flowtec AG
Kägenstraße 7
4153 Reinach BL
Switzerland

complies with the following requirements:

Heartbeat Technology™ is a test method integrated in the measuring device for the diagnostics and verification of flowmeters when used in a particular application throughout the useful lifetime of the measuring device. Testing is based on internal factory-traceable references which are redundantly reproduced in the device.
Heartbeat Technology™ includes Heartbeat Diagnostics and Heartbeat Verification.

Test specifications:

DIN EN IEC 61508-2:2011-02, Appendix C
DIN EN IEC 61508-3:2011-02, Section 6
DIN EN ISO 9001:2008, (Section 7.6 a), Control of monitoring and measuring equipment

Test results:

Heartbeat Verification verifies the function of Proline Promass 300 / Proline Promass 500 on demand within the specified measuring tolerance with a total test coverage ("TTC") of TTC > 95%.

Heartbeat Technology™ complies with the requirements for traceable verification according to DIN EN ISO 9001:2008 – Section 7.6 a) "Control of monitoring and measuring equipment". In accordance with this standard, the user is responsible for providing a definition of the verification interval that satisfies the particular requirements.

This Attestation is based on report no.: TR.2065342.014.17, Rev. 1, dated October 26, 2017.

Munich, October 26, 2017

TÜV SÜD Industrie Service GmbH · Certification Body Energy and Systems

Katrin Hausmann
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TÜV®

TÜV SÜD Industrie Service GmbH · Certification Body Energy and Systems · Westendstraße 199 · 80686 Munich · Germany

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 used

2.3.1 Safety symbols

Symbol	Meaning
DANGER	**DANGER!** This symbol alerts you to a dangerous situation. Failure to avoid this situation will result in serious or fatal injury.
WARNING	**WARNING!** This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in serious or fatal injury.
CAUTION	**CAUTION!** This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in minor or medium injury.
NOTICE	**NOTE!** 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
	**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
	Operation via local display

Symbol	Meaning
	Operation via operating tool
	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:
- *W@M Device Viewer* (www.endress.com/deviceviewer): Enter the serial number from nameplate
- *Endress+Hauser Operations App*: Enter the serial number from the nameplate or scan the 2D matrix code (QR code) on the nameplate

This Special Documentation is available:
- On the CD-ROM supplied with the device (depending on the device version ordered)
- In the Download Area of the Endress+Hauser Internet site: www.endress.com → Downloads

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

Measuring device	Documentation code
Promass A 500 (8A5B**-...)	BA01559D
Promass A 500 (8A5C**-...)	BA01883D
Promass E 500	BA01561D
Promass F 500	BA01562D
Promass H 500	BA01563D
Promass I 500	BA01564D
Promass O 500	BA01565D
Promass P 500	BA01566D
Promass Q 500	BA01567D
Promass S 500	BA01568D
Promass X 500	BA01569D

2.5 Registered trademarks

FOUNDATION™ Fieldbus
Registration-pending trademark of the FieldComm Group, Austin, Texas, 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 referred to 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 are not diagnosed by the device diagnostics. If these failures occur, they can distort the measured value that is displayed or interrupt the output of measured values.

Heartbeat Technology checks the device function within the specified measuring tolerance with a defined TTC.

The TTC is at least 95%.

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 the measuring device for measured value output via 4 to 20mA 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
- On the Web using the Device Viewer (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.

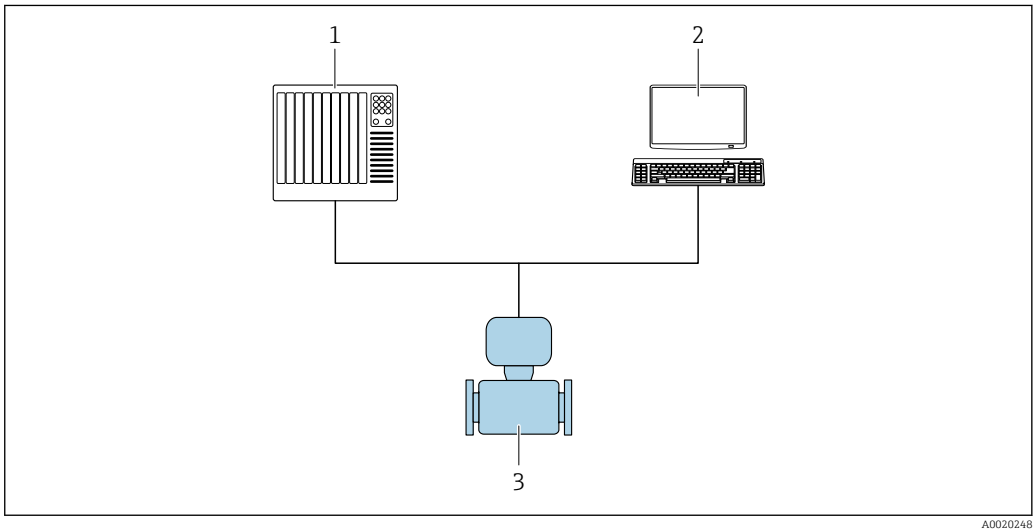
4 System integration

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

Heartbeat Verification is performed via the following interfaces:
- System integration interface of a higher-level system
- Local operation
- Service interface (CDI-RJ45)
- WLAN interface

To start a verification and signal the result (Passed or Failed) the device must be accessed externally from a higher-level system via the system integration interface. 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.

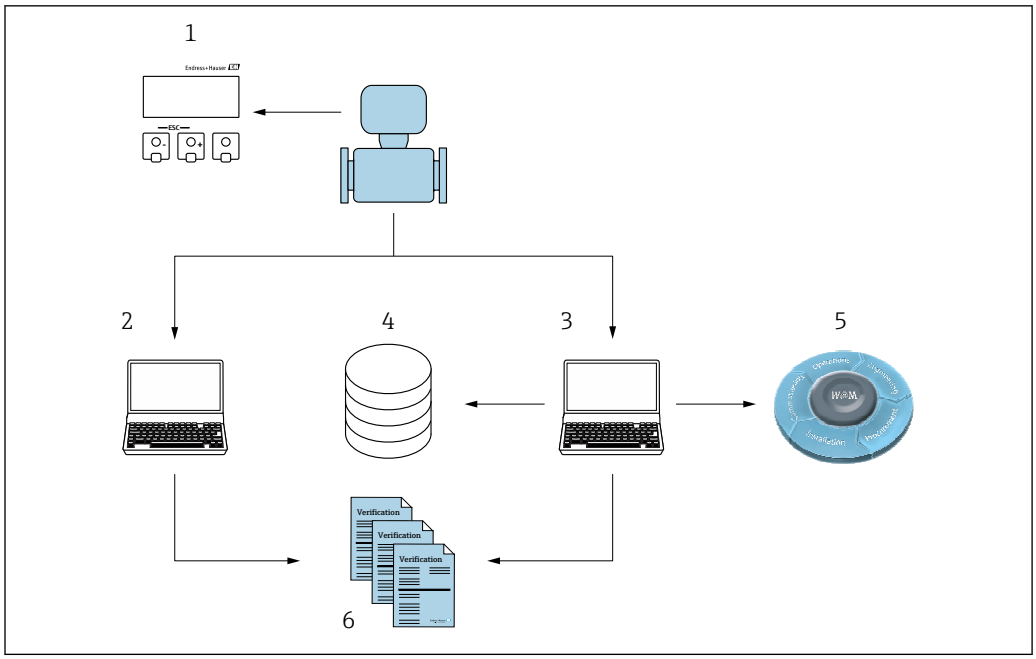
The detailed results of the verification (8 data records) are saved in the device. These results can be downloaded in the form of a verification report using the Web server integrated in the device.



1 PLC
2 Asset Management System
3 Measuring device

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

For more information on system integration, see the Operating Instructions
→ 6(Verweisziel existiert nicht, aber @y.link.required='true')



1 *Local display*
2 *Web server*
3 *FieldCare*
4 *Data archive*
5 *W@M*
6 *Verification report*

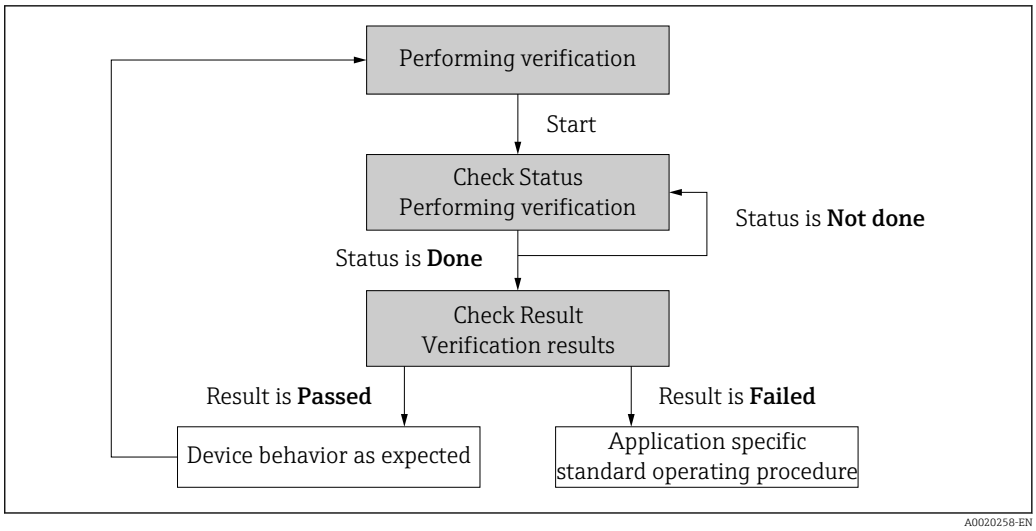
The creation of verification reports is supported by both the Web server integrated in the measuring device and by Endress+Hauser's FieldCare asset management software. With the Flow Verification DTM, FieldCare also offers the possibility of archiving the verification results to create traceable documentation.

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.

4.1 Automated data exchange

- Instrument check via self-monitoring
- Start the verification and read out the verification results

The verification function integrated in the measuring device can be activated by a control system and the results can be checked. The following procedure must be implemented for this purpose:



Performing a verification

- Start the verification via the **Start verification** parameter.
  - Verification status: On completion of the verification, the value of the **Status** parameter changes to **Done**.

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 **Failed** is displayed as the result.

4.2 Data exchange performed by the user (asset management system)

Heartbeat Monitoring
Monitoring configuration: Specify which monitoring parameters should be output continuously via the system integration interface.

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

4.3 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 sets
- FIFO [1)] method applies - new verification results overwrite old data

The results can be documented in the form of a verification report via the Web server or Endress+Hauser's FieldCare asset management software.

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)

1) First In – First Out

4.3.1 Data management via Web browser

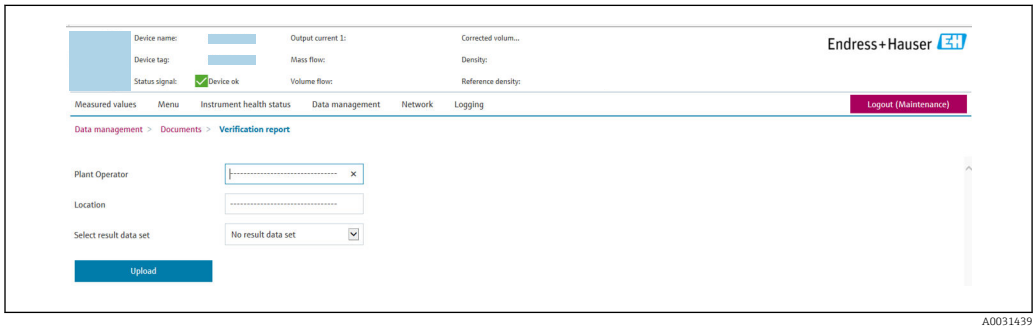
Thanks to the integrated Web server the device can be operated and configured via a Web browser. In addition, it is possible to query the results of the verification and create a verification report.

Print verification report

A verification report is created in PDF format.

Prerequisite: A verification has already been performed.

Web browser interface after login:



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1. In the menu, select the **Data Management**, **Documents** and **Verification Report** tabs one after the other.
   ↳ The Web browser opens the entry field for printing verification reports.
2. Enter the necessary information in the **Customer** and **Location** fields.
   ↳ The information entered here appears in the verification report.
3. In the **Sel. result set.** field (select result data set), select the desired data set with the verification results.
   ↳ The verification data sets are identified by the time stamp in the drop-down menu.
   If a verification has not been performed, the message "No result data set" is displayed here.
4. Click the **Upload** field.
   ↳ The Web server generates a verification report in PDF format.

4.3.2 Data management via Flow Verification DTM

A verification can be performed and a verification report printed via the DeviceDTM.

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

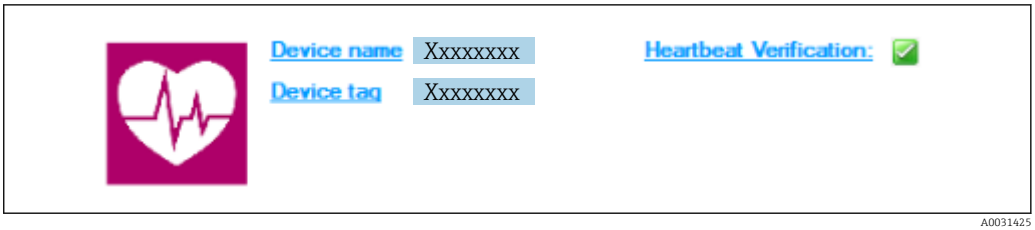
Basic functions

The following basic functions are available:

	Read data records from the device
	Create a new archive

	Open saved archive files
	Save data sets to an existing archive file or initial saving of data sets to a new archive file
	Save the data sets under a new file name; a new archive file is created in this case
	Create a verification report in PDF format

Header



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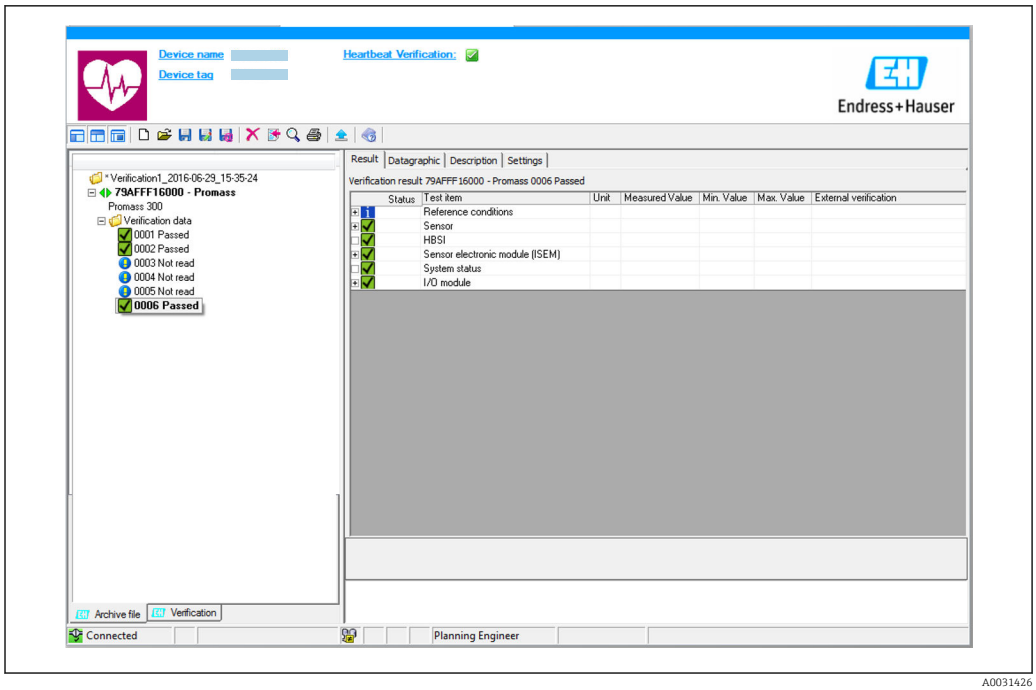
- Top display area of the DTM
- Contains the following information:
  - Measuring device
  - Device tag
- Indicates whether verification is active: ☑

Reading out data

Start uploading the data from the measuring device to the asset management software.



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1 *Sample graphic*

- ▶ Click an individual data set.
  - ↳ Selected data sets, which are saved in the measuring device, are transmitted to the asset management software and visualized.

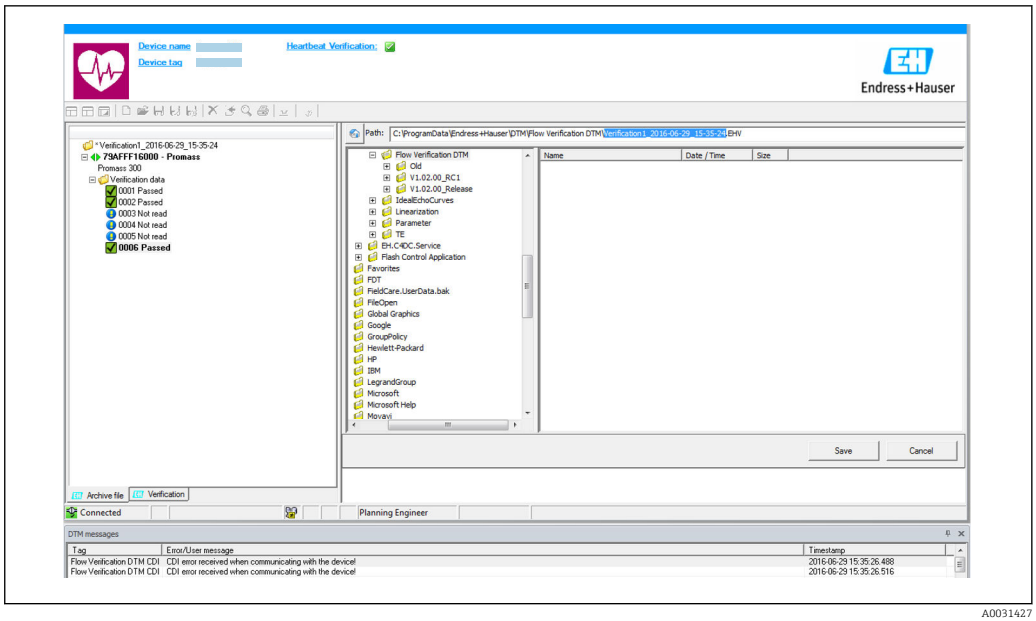
Verification results

Details for the verification results are displayed in the data area.

The data area is split into 3 tabs:
- Result – status, test group and detailed results including limit values
- Data graphic – visualization of results as a trend curve
- Description – additional descriptions and information entered by the user

Saving to an archive file

Save the data to an archive after upload.



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2 *Sample graphic*

- Click the icons or .
  - A file with the extension ".EHV" is generated.
    This file is used to archive the data. It can be read and interpreted by every asset management system with an installed Flow Verification DTM and is therefore also suitable for analysis by a third party (e.g. Endress+Hauser service organization).

Opening the archive file

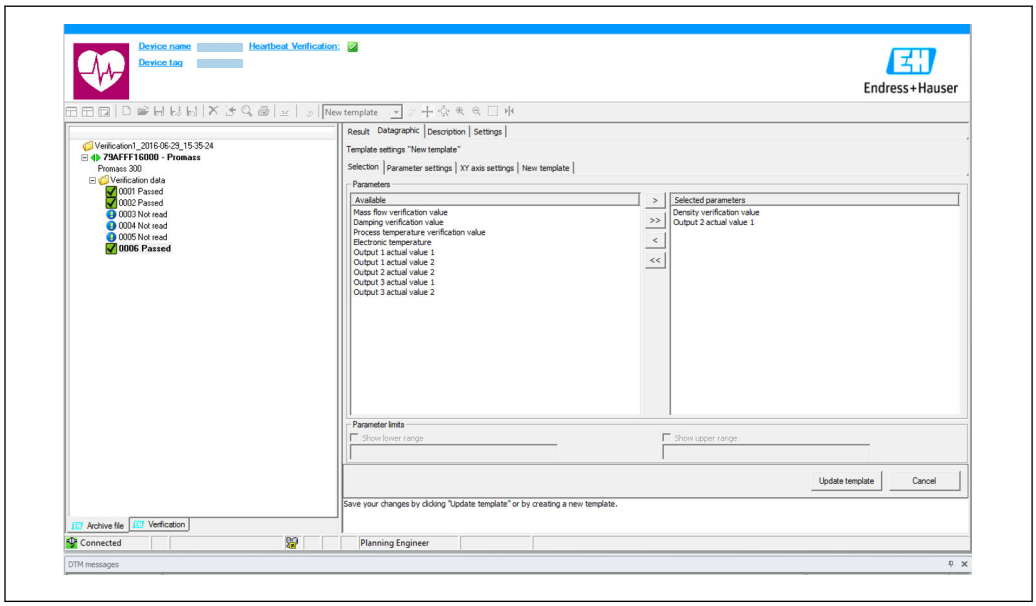
Open archive files already available.

- Click the icon.
  - The archive data are uploaded to the Flow Verification DTM.

Configuring visualization and trending

The verification data can be visualized in the Graphic tab in the data area. The data saved in the archive are visualized as a graph over time. For this purpose, any of the data available can be selected.

Selecting the measured variables



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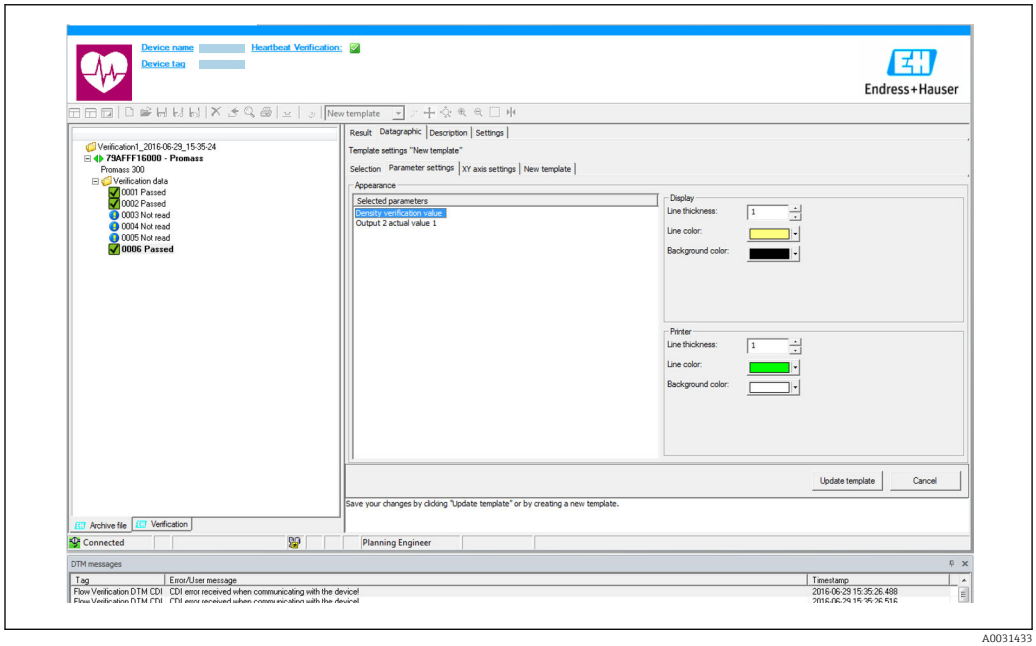
3 *Sample graphic*

► Select the measured variables using the list displayed.

Visualizing a graph



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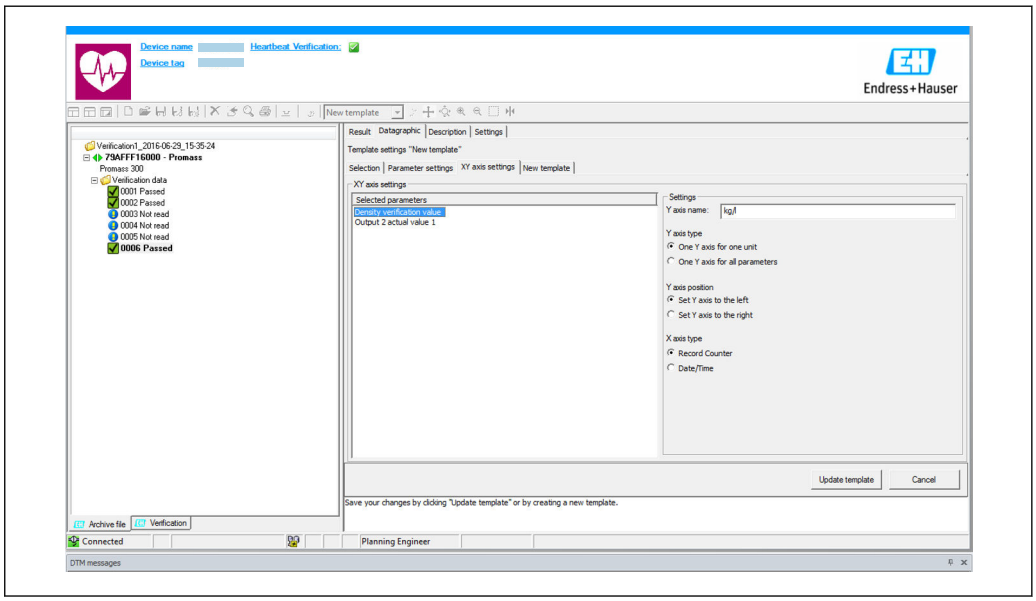
4 *Sample graphic*

► Assign properties for visualization of the graph.

Configuring the Y-axis



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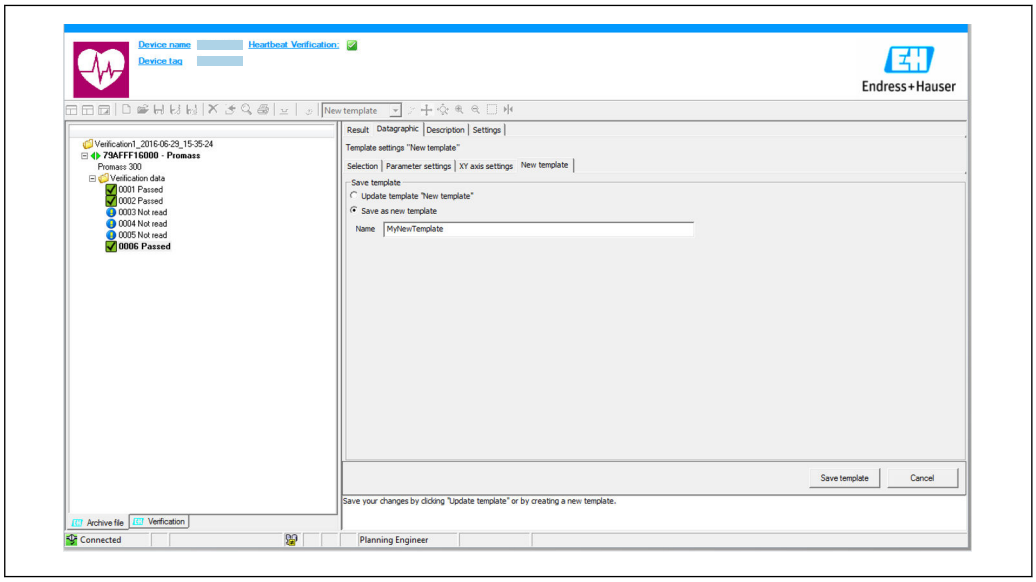
5 *Sample graphic*

- Assign the measured variables of the Y-axis.

Update template or create new template



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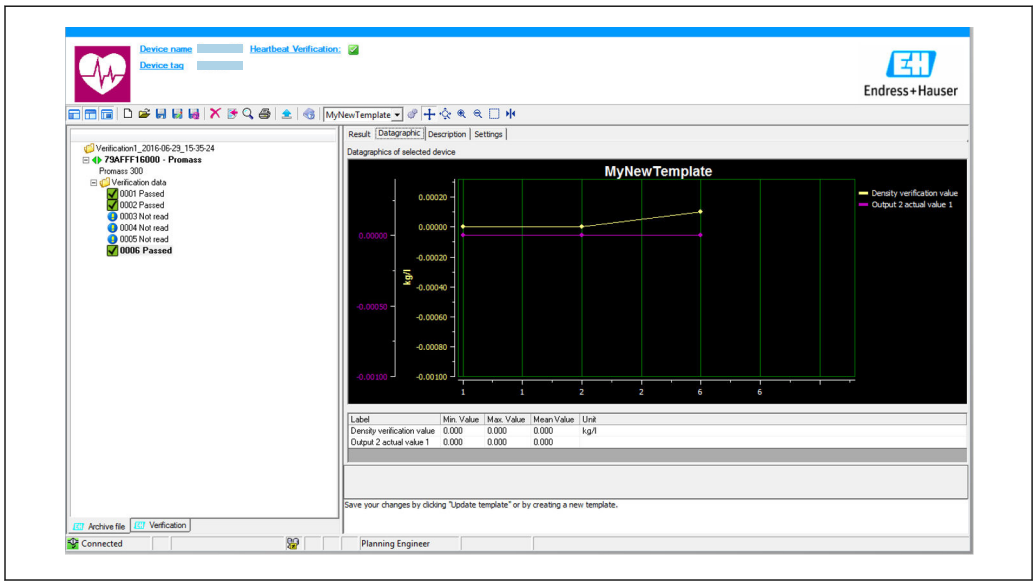
6 *Sample graphic*

- Add a selected parameter configuration to the template or save under a new template name.

Showing the visualization trend



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7 Sample graphic

- ▶ Display the template.
  - ↳ The template shows the data in chronological order. The data points are referenced by the verification ID (X-axis), the Y-axis displays the parameters defined in the configuration.

Creating a verification report

1. Click the icon.
2. Select the data set.
   - ↳ A verification report is generated.

5 Heartbeat Verification

Heartbeat Verification checks the device function within the specified measuring tolerance on demand with a total test coverage (TTC) of > 95%. 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.

Therefore Heartbeat Verification also supports the documentation of proof tests as per IEC 61511-1. For details, see the Functional Safety Manual.

Heartbeat Technology offers two ways to perform Heartbeat Verification:
- Internal verification → 🖹 21
  Verification is performed by the device without manual checking of external measured variables.
- External verification → 🖹 24
  Verification includes the entry of external measured variables.

5.1 Performance characteristics

Heartbeat Verification is performed on demand and complements the self-monitoring function, which is performed constantly, with other tests.

The internal verification additionally checks the following 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
- Relay output

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

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).

Confirmed by TÜV Industry Service: **Heartbeat Technology** meets the requirement for traceable verification according to DIN EN ISO 9001: 2008 Chapter 7.6 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: Perform initial verification when commissioning the device. The results are then saved as the initial situation in the measuring device life cycle.

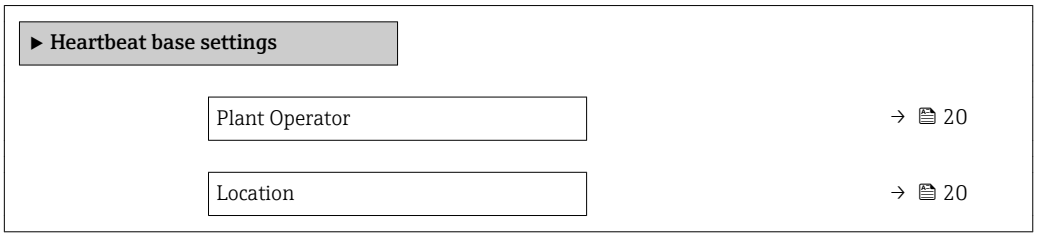
5.2.1 Recording reference data

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 → 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 notes

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

Initial verification

▶ When commissioning the measuring device:
Perform an initial verification to save the results as the initial situation in the measuring device life cycle.

Initial verification can be performed in 2 ways:
- Internal verification → 21
- External verification → 24

Device behavior and interpretation

Result Passed
- All test results are within the specifications.
- If the calibration factor and zero point match the factory settings, there is a high degree of certainty that the measuring device complies with the specification for flowand density.
- Verification generally delivers the result Passed in most applications.

Result Failed

One or more test results are outside the specifications.

1. Repeat verification.
   ↳ If the result of the second verification is Passed, the result of the first can be ignored.
2. In order to identify possible variations, compare the current process conditions with those of a previous verification.
3. Ensure defined and stable process conditions to rule out process-specific influences as much as possible.

4. Repeat verification.
5. If the verification repeatedly delivers a Failed result, take the following measures:
6. 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.
7. 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.

5.3.2 Internal verification

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

Diagnostic behavior

A diagnostic event signals that internal verification is being performed:
- Event diagnostic message ⚠**C302 Device verification active**
- Factory setting: warning.
  - The device continues to measure.
  - The signal outputs and totalizers are not affected
- Test duration: approx. 60 seconds

The diagnostic behavior can be reconfigured by the user if necessary: If set to alarm, measured value output is interrupted, and the signal outputs and totalizers adopt the defined alarm condition.

Performing internal verification

Before verification starts

The entry for the date and time is saved in addition to the current operating time and the results of the verification and also appears 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 **Internal verification** option.

Start 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 the internal verification is indicated in the **Status** parameter (→ 24):
- 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) → 20.

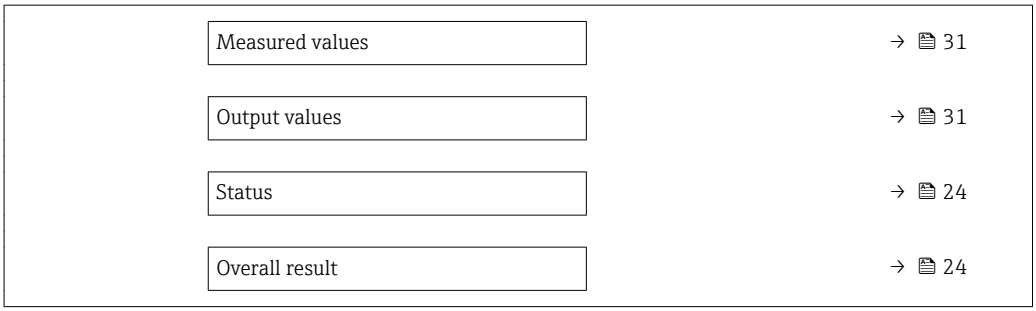
The result of the verification is displayed in the **Overall result** parameter (→ 24):
- Passed
  All the verification tests were successful.
- Not done
  A verification has not yet been performed on this measuring device.
- Failed
  One or more verification tests were not successful → 20.

- The overall result of the last verification can always be accessed in the menu.
- Navigation:
  Diagnostics → Heartbeat → Verification results
- Detailed information on the result of the verification (test groups and test status) is also provided 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 helps users to perform a targeted search for the cause of the error → 20.

"Performing verification" wizard

Navigation
"Diagnostics" submenu → Heartbeat → Performing verification

▶ Performing verification	
Year	→ 23
Month	→ 23
Day	→ 23
Hour	→ 23
AM/PM	→ 23
Minute	→ 23
Verification mode	→ 23
Start verification	→ 23
Progress	→ 23



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. In the **Date/time format** parameter (2812), the **dd.mm.yy hh:mm am/pm** option or the **mm/dd/yy hh:mm am/pm** option is selected.	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 verification mode. Internal verification Verification is performed automatically by the device and without manual checking of external measured variables.	Internal verification	Internal verification
Start verification	–	Start verification. Start the verification with the **Start** option.	▪ Cancel ▪ Start	Cancel
Progress	–	Shows the progress of the process.	0 to 100 %	0 %

Parameter	Prerequisite	Description	User entry / Selection / User interface	Factory setting
Status	–	Displays the current status of the verification.	▪ Done ▪ Busy ▪ Failed ▪ Not done	–
Overall result	–	Displays the overall result of the verification. Detailed description of the classification of the results: → 33	▪ Passed ▪ Not done ▪ Failed	–

5.3.3 External verification

External verification is similar to the internal verification function but additionally outputs a number of different measured variables. During the verification process, these measured variables are recorded manually with the help of external measuring equipment and entered into the measuring device (e.g. actual value at current output). The value entered is checked and verified by the measuring device to ensure that it complies with the factory specifications. A status of (Passed or Failed) follows, accordingly, and is documented as an individual result of the verification and evaluated in the overall result.

Permanently predefined output signals are simulated during external verification of the outputs. These output signals do not represent the current measured value. To measure the simulated signals, it can 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.

Measured variables for external verification

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

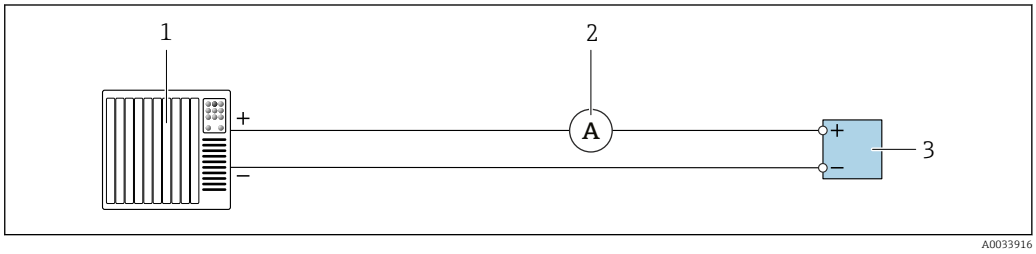
The terminal assignment depends on the specific device version.

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 the terminal assignment, see the Operating Instructions for the device → 6

Active current output



8 *External verification of active current output*

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

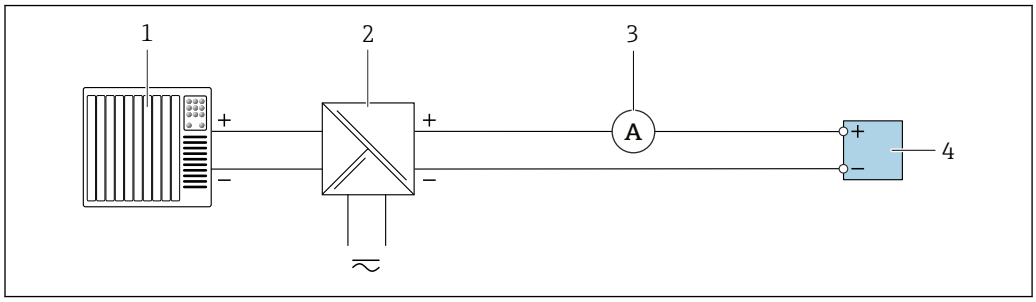
External verification of active current output

- ▶ 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



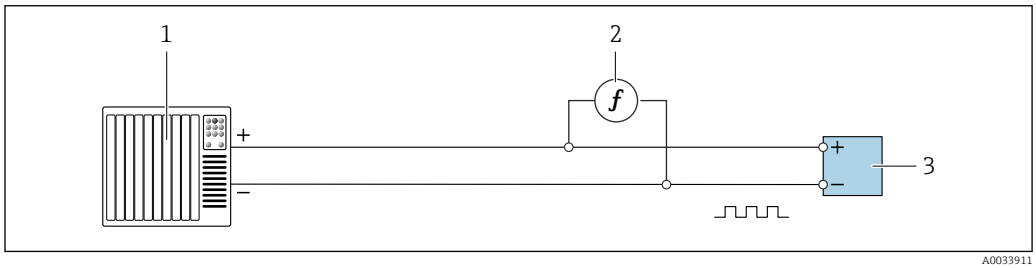
9 External verification of passive current output

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

External verification of 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



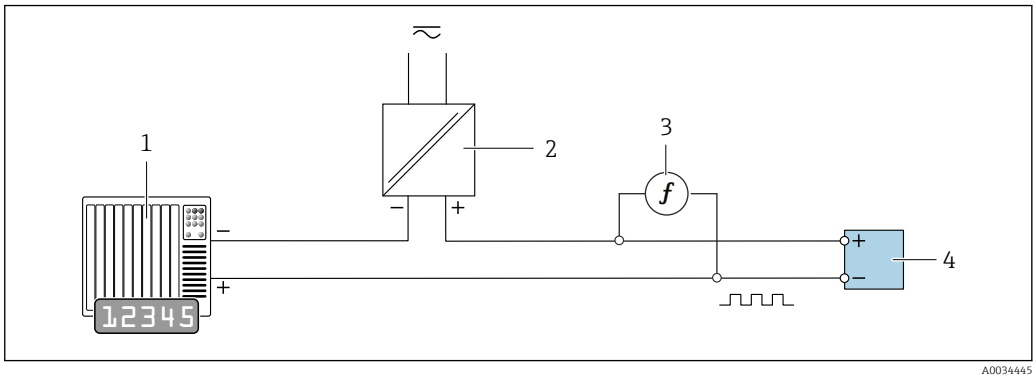
10 External verification of active pulse/frequency output

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

External verification of active pulse/frequency output

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

Passive pulse/frequency/switch output



11 *External verification of passive pulse/frequency output*

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

External verification of 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 external 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 displayed in all cases: **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	**Device verification active**	

The following diagnostic event appears on the display (part 2 of the external verification) as soon as the **Start** option is selected in the **Start verification** parameter:
- Event diagnostic message ⚠**C302 Device verification active**
- Factory setting: warning.
  - The device continues to measure.
  - The signal outputs and totalizers are not affected
- Test duration: approx. 60 seconds

The diagnostic behavior can be reconfigured by the user if necessary: If set to alarm, measured value output is interrupted, and the signal outputs and totalizers adopt the defined alarm condition.

For detailed information on the diagnostics, see the Operating Instructions → 6.

Performing external verification

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

NOTICE

External verification is not possible if no connection has been established and the ammeter is looped in during verification.

- Establish a connection before external verification starts.
- Loop in ammeter before external verification starts.

Before verification starts

The entry for the date and time is saved in addition to the current operating time and the results of the verification and also appears 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.

The entry for the date and time is saved in addition to the current operating time and the results of the verification and also appears in the verification report.

Select the verification mode

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

Further parameter settings

3. In the **External device information** parameter, enter a unique ID (e. g. serial number) for the measuring equipment used (max. 32 characters).
4. In the **Start verification** parameter, select one of the available options (e. g. the **Output 1 low value** option).
5. In the **Measured values** parameter, enter the value displayed 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 (→ 31) indicates the value simulated by the device at the selected output.→ 25 .

Start 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 the internal verification is indicated in the **Status** parameter (→ 24):
- 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) → 20.

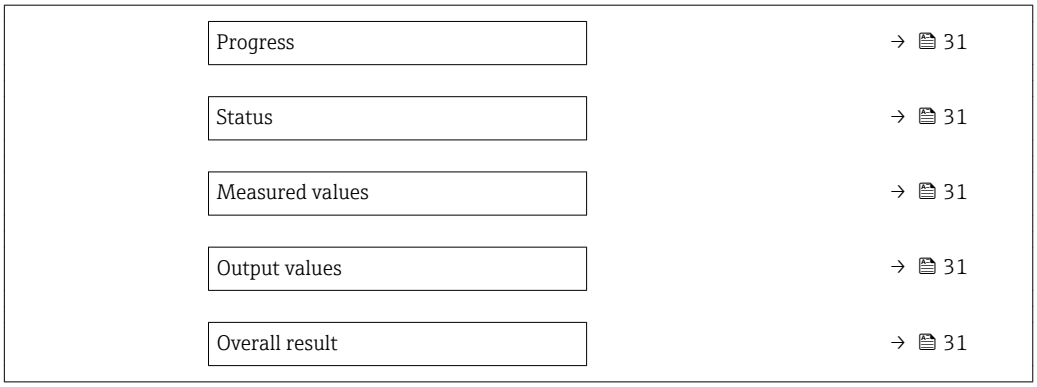
The result of the verification is displayed in the **Overall result** parameter (→ 24):
- Passed
  All the verification tests were successful.
- Not done
  A verification has not yet been performed on this measuring device.
- Failed
  One or more verification tests were not successful → 20.

- The overall result of the last verification can always be accessed in the menu.
- Navigation:
  Diagnostics → Heartbeat → Verification results
- Detailed information on the result of the verification (test groups and test status) is also provided 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 helps users to perform a targeted search for the cause of the error → 20.

"Performing verification" wizard

Navigation
"Diagnostics" submenu → Heartbeat → Performing verification

▶ Performing verification	
Year	→ 30
Month	→ 30
Day	→ 30
Hour	→ 30
AM/PM	→ 30
Minute	→ 30
Verification mode	→ 30
External device information	→ 31
Start verification	→ 31



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. In the **Date/time format** parameter (2812), the **dd.mm.yy hh:mm am/pm** option or the **mm/dd/yy hh:mm am/pm** option is selected.	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 verification mode. External verification Similar to internal verification but with the entry of external measured variables: **Measured values** parameter.	External verification	Internal verification

Parameter	Prerequisite	Description	User entry / Selection / User interface	Factory setting
External device information	With the following conditions: ▪ In the **Verification mode** parameter (→ 🖹 23), the **External verification** option is selected. ▪ Can be edited if verification status is not active.	Record measuring equipment for external verification.	Free text entry	–
Start verification		Start 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 ▪ Frequency output 1 ▪ Pulse output 1 ▪ Start	Cancel
Measured values	One of the following options is selected in the **Start verification** parameter (→ 🖹 23): ▪ Output 1 low value ▪ Output 1 high value ▪ Output 2 low value ▪ Output 2 high value ▪ Frequency output 1 ▪ Pulse output 1	Displays the references 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 references for the external measured variables. ▪ Current output: Output current in [mA]. ▪ Pulse/frequency output: Output frequency in [Hz].	Signed floating-point number	0
Progress	–	Shows the progress of the process.	0 to 100 %	0 %
Status	–	Displays the current status of the verification.	▪ Done ▪ Busy ▪ Failed ▪ Not done	–
Overall result	–	Displays the overall result of the verification. Detailed description of the classification of the results: → 🖹 33	▪ Passed ▪ Not done ▪ Failed	–

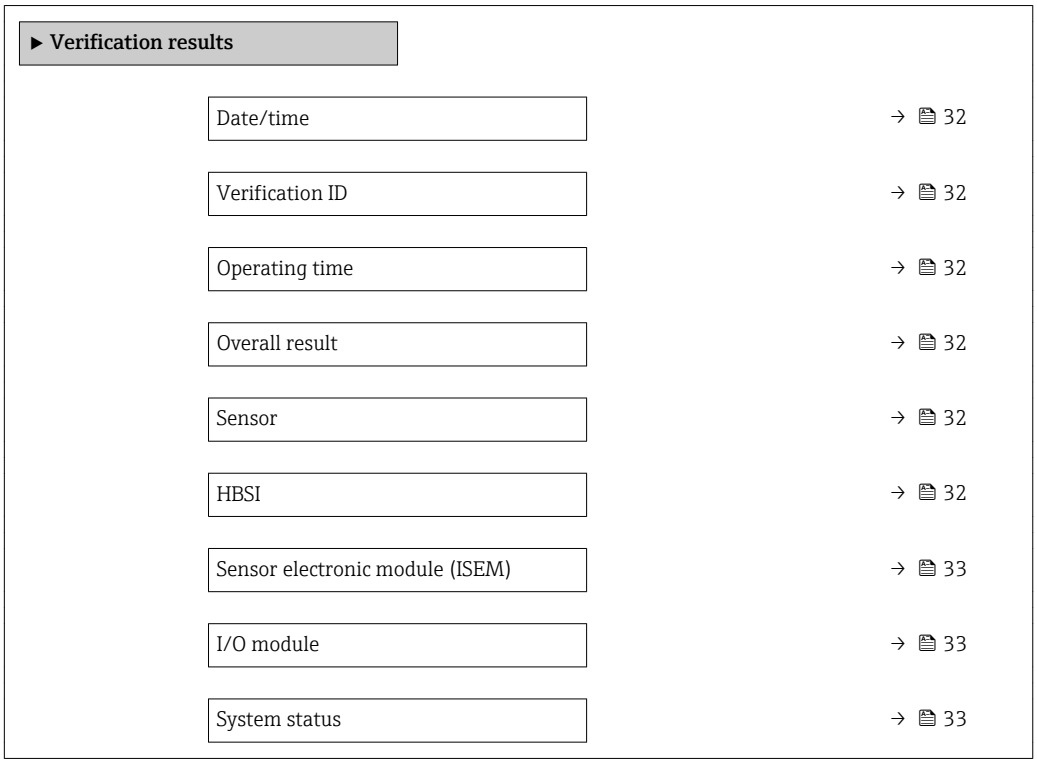
5.3.4 Verification results

Access to the verification results:
In the operating menu via the local display, operating tool or Web browser
– Diagnostics → Heartbeat → Verification results
– Expert → Diagnostics → Heartbeat → 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	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)	–
Overall result	–	Displays the overall result of the verification. Detailed description of the classification of the results: → 33	▪ Passed ▪ Not done ▪ Failed	–
Sensor	In the **Overall result** parameter, the **Failed** option is displayed.	Displays the result for the sensor. Detailed description of the classification of the results: → 33	▪ Passed ▪ Not done ▪ Failed	Not done
HBSI	–	Displays the relative change in the sensor with all the sensor components. Detailed description of the classification of the results: → 33	▪ Passed ▪ Not done ▪ Failed	Not done

Parameter	Prerequisite	Description	User interface	Factory setting
Sensor electronic module (ISEM)	In the **Overall result** parameter, the **Failed** option is displayed.	Displays the result for the sensor electronics module (ISEM). Detailed description of the classification of the results: → 33	▪ Passed ▪ Not done ▪ Failed	Not done
I/O module	In the **Overall result** parameter, the **Failed** option is 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 pulses ▪ For frequency output: Accuracy of frequency ▪ Current input: Accuracy of the current ▪ Double pulse output: Accuracy of the pulses ▪ Relay output: Number of switching cycles Detailed description of the classification of the results: → 33	▪ Passed ▪ Not done ▪ Not plugged ▪ Failed	Not done
System status	In the **Overall result** parameter, the **Failed** option is displayed.	Displays the system condition. Tests the measuring device for active errors. Detailed description of the classification of the results: → 33	▪ 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 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").

Result	Description
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 (U300) is plugged into the slot and has not been configured. This is equivalent to the slot in question being "deactivated".

Heartbeat Verification confirms the device function within the specified measuring tolerance on demand with a TTC [2)] > 95 %. 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 EN ISO 9001:2008.

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)	Electronic 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 .

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	Internal verification	External 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 internal verification is possible.
Double pulse output, active and passive	±0.05 %, with a 120 s cycle	Only internal verification is possible.
Relay output	The number of switching cycles depends on the hardware	Only internal verification is possible.

5.3.5 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.

2) Total Test Coverage

- 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.

Process conditions	Description, value range
Process temperature verification value	Actual 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
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: The 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	Checking of all the input and output modules installed at the measuring device→ 🖹 19	No value range ▪ Passed ▪ Failed ▪ Not done Limit values → 🖹 34	**Causes** ▪ Output values out of specification. ▪ I/O modules defective. **Corrective action** ▶ Check cabling. ▶ Check connections. ▶ Check load (current output). ▶ Replace the I/O module.

5.3.6 Verification report

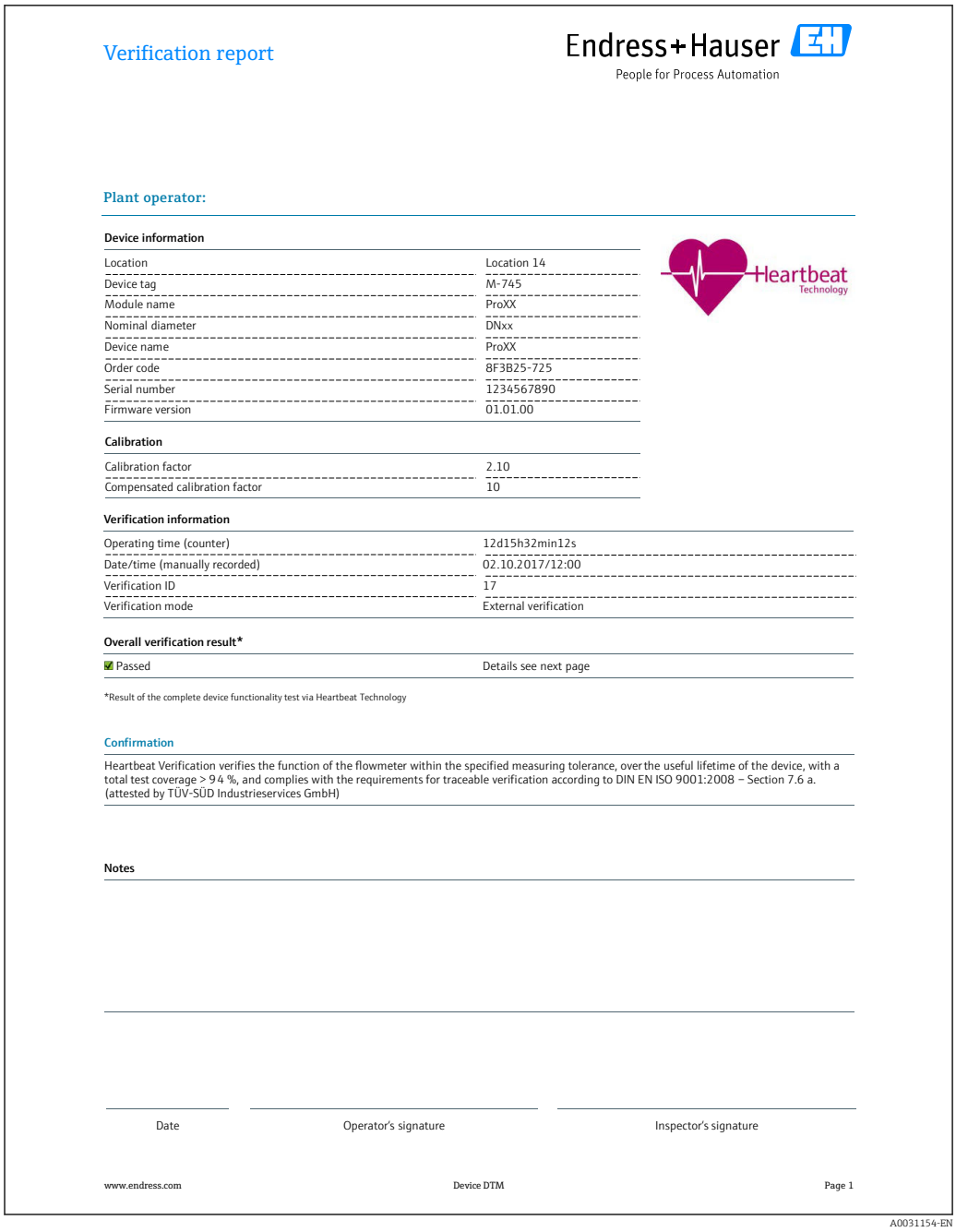
The results of the verification can be documented in the form of a verification report via the Web server or FieldCare operating tool . The verification report is created on the basis

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
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: internal or external verification
- Overall verification result
  Overall result of the verification passed if all of the individual results are passed

Second page
Details on the individual results for all test groups:
- System operator
- Test groups
  - Sensor
  - Main electronics module
  - System condition
  - I/O module

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.



Verification report

Endress+Hauser
People for Process Automation

Plant operator:

Device information

Location	Location 14
Device tag	M-745
Module name	ProXX
Nominal diameter	DNxx
Device name	ProXX
Order code	8F3B25-725
Serial number	1234567890
Firmware version	01.01.00

Heartbeat Technology

Calibration

Calibration factor	2.10
Compensated calibration factor	10

Verification information

Operating time (counter)	12d15h32min12s
Date/time (manually recorded)	02.10.2017/12:00
Verification ID	17
Verification mode	External verification

Overall verification result*

☑ Passed	Details see next page

*Result of the complete device functionality test via Heartbeat Technology

Confirmation

Heartbeat Verification verifies the function of the flowmeter within the specified measuring tolerance, over the useful lifetime of the device, with a total test coverage > 94 %, and complies with the requirements for traceable verification according to DIN EN ISO 9001:2008 – Section 7.6 a. (attested by TÜV-SÜD Industrieservices GmbH)

Notes

Date | Operator's signature | Inspector's signature

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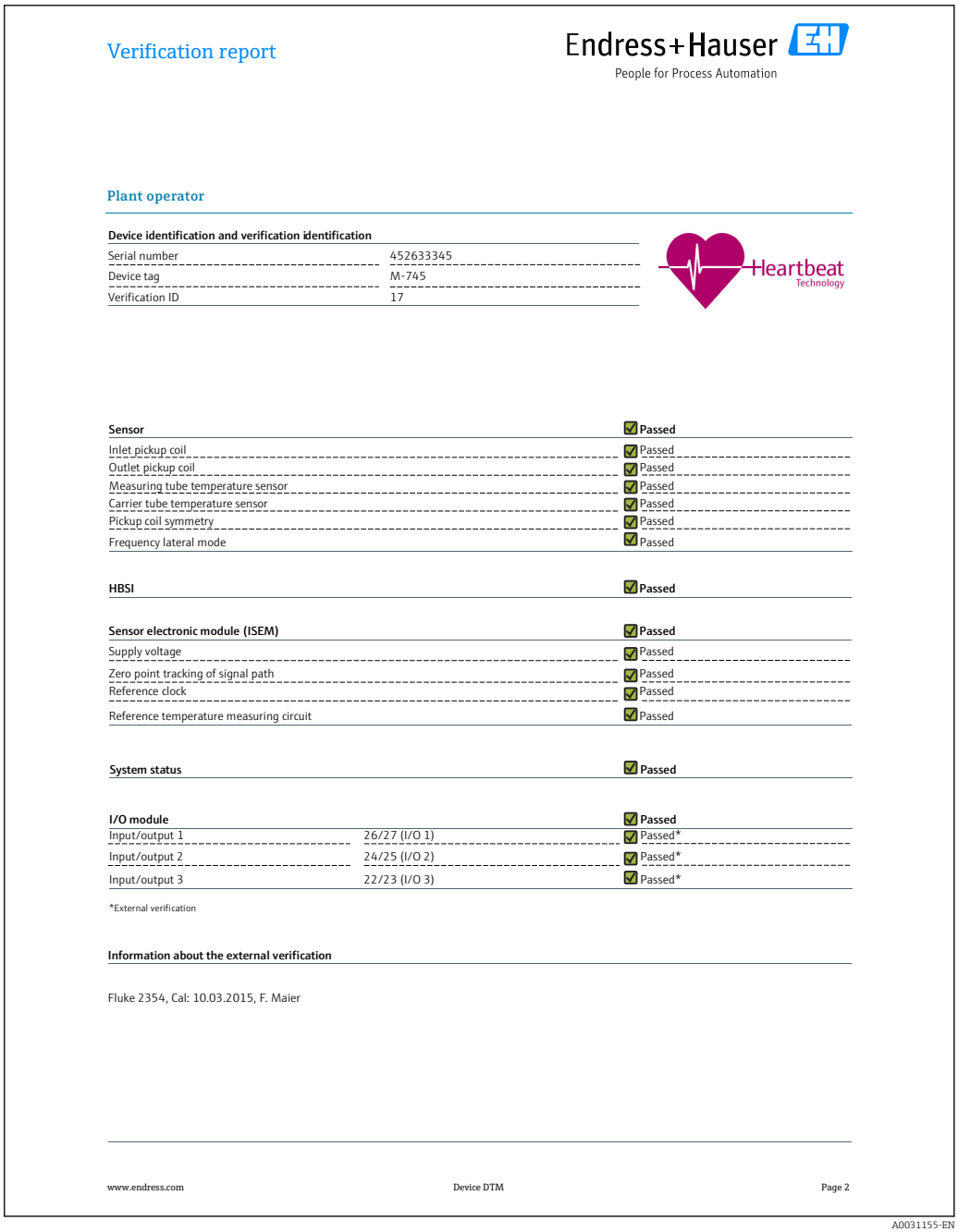
12 *Example of a verification report (Page 1)*

The remaining pages of the verification report list the individual test groups and the individual test group results.

Individual test groups and description of individual tests:



Verification report

Endress+Hauser
People for Process Automation

Plant operator

Device identification and verification identification

Serial number	452633345
Device tag	M-745
Verification ID	17

Heartbeat Technology

Sensor	**Passed**
Inlet pickup coil	Passed
Outlet pickup coil	Passed
Measuring tube temperature sensor	Passed
Carrier tube temperature sensor	Passed
Pickup coil symmetry	Passed
Frequency lateral mode	Passed
HBSI	**Passed**
Sensor electronic module (ISEM)	**Passed**
Supply voltage	Passed
Zero point tracking of signal path	Passed
Reference clock	Passed
Reference temperature measuring circuit	Passed
System status	**Passed**

I/O module		**Passed**
Input/output 1	26/27 (I/O 1)	Passed*
Input/output 2	24/25 (I/O 2)	Passed*
Input/output 3	22/23 (I/O 3)	Passed*

*External verification

Information about the external verification

Fluke 2354, Cal: 10.03.2015, F. Maier

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13 *Example of a verification report (Page 2)*

Comments from the person carrying out the verification appear in the "Information about the External Verification" field. It is also recommended for information on the type and serial number of the external testing device used to carry out the external verification.

Data administration with Web server and FieldCare (Flow Verification DTM): → 11

5.3.7 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 comparison values that are checked are within the factory specification and that the measuring device is working correctly. At the same time, the zero point and calibration factor of the sensor are documented and traceable in 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 specifications with a total test coverage of 100 % is only possible by verifying the primary measured variable (flow) by recalibrating or by proving the value.
- **Heartbeat Verification** confirms the device function within the specified measuring tolerance on demand with a TTC [3] > 95 %.

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. In this case, it is advisable to compare the current process conditions to those of a previous verification to identify any deviations. To inhibit process-related influences as much as possible, the ideal solution is to establish defined and stable process conditions and then to repeat the verification.

Recommended remedial action if the result of the 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.

For detailed information on the diagnostics, see the Operating Instructions → 6.

3) Total Test Coverage

6 Heartbeat Monitoring

With Heartbeat Monitoring, additional measured values are output continuously and monitored in an external Condition Monitoring system so that changes 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 deposit buildup or wear as a result of corrosion.

6.1 Commissioning

Assign the diagnostic parameters to the outputs for commissioning. After commissioning, these parameters are permanently available at the outputs.

Enabling or disabling Heartbeat Monitoring
The output of the diagnostic parameters is switched on or off in the operating menu:
→ 📄 43

6.1.1 Description of the diagnostic 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
Electronic 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, 2nd torsion 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, 2nd torsion 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, 2nd torsion 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, 2nd torsion 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, 2nd torsion mode in Hz	[1]
Oscillation damping 0	Mechanical damping of the measuring tubes/tube in A/m	0 to 100 000 [1]
Oscillation damping 1 [2]	Mechanical damping of measuring tube, 2nd torsion mode in A/m	0 to 100 000

Measured variable	Description	Value range
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

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.

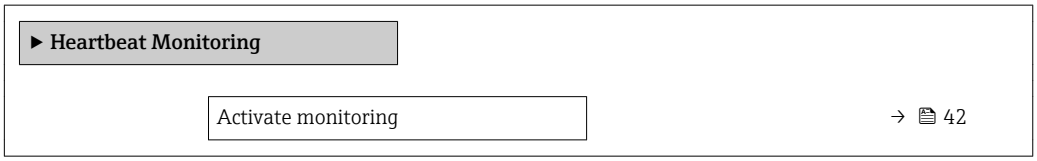
HBSI Monitoring is continuously available for Promass I.

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

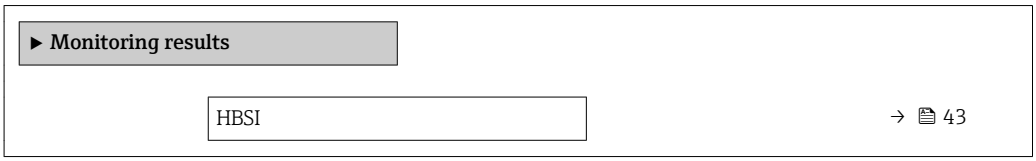
Parameter	Prerequisite	Description	Selection / User entry	Factory setting
Activate monitoring	–	Activate monitoring to enable cyclic transmission of the HBSI measured value.	▪ Off ▪ On	Off
HBSI cycle time	The **Time-controlled HBSI** option is selected in the **Activate monitoring** parameter. Not available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

HBSI display

The current **HBSI** parameter (→ 43) value 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.	Signed floating-point number	0...4 %

6.1.3 Configuration of the outputs and local display

Additional monitoring measured variables → 41 are available to the user with the "Heartbeat Verification + Monitoring" application package. 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 which indicate a change in the performance of the measuring device brought about by process-related 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 which only impact the integrity of the sensor over the medium term but which also bring about a gradual change in the measuring performance (e.g. abrasion, corrosion or the formation of 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:
- Formation of 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 Overview of the monitoring parameters

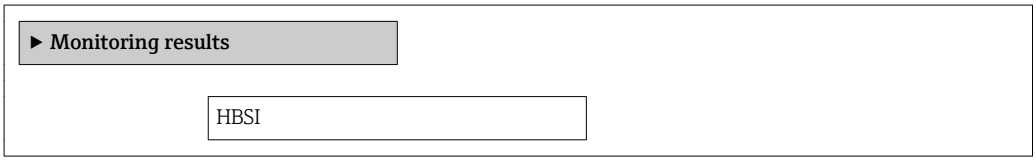
This section describes the interpretation of certain monitoring-specific parameters in the context of the application.

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.
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 fluid.

Monitoring parameter	Possible reasons for deviation
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).

Navigation
"Diagnostics" menu → Heartbeat → Monitoring results

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



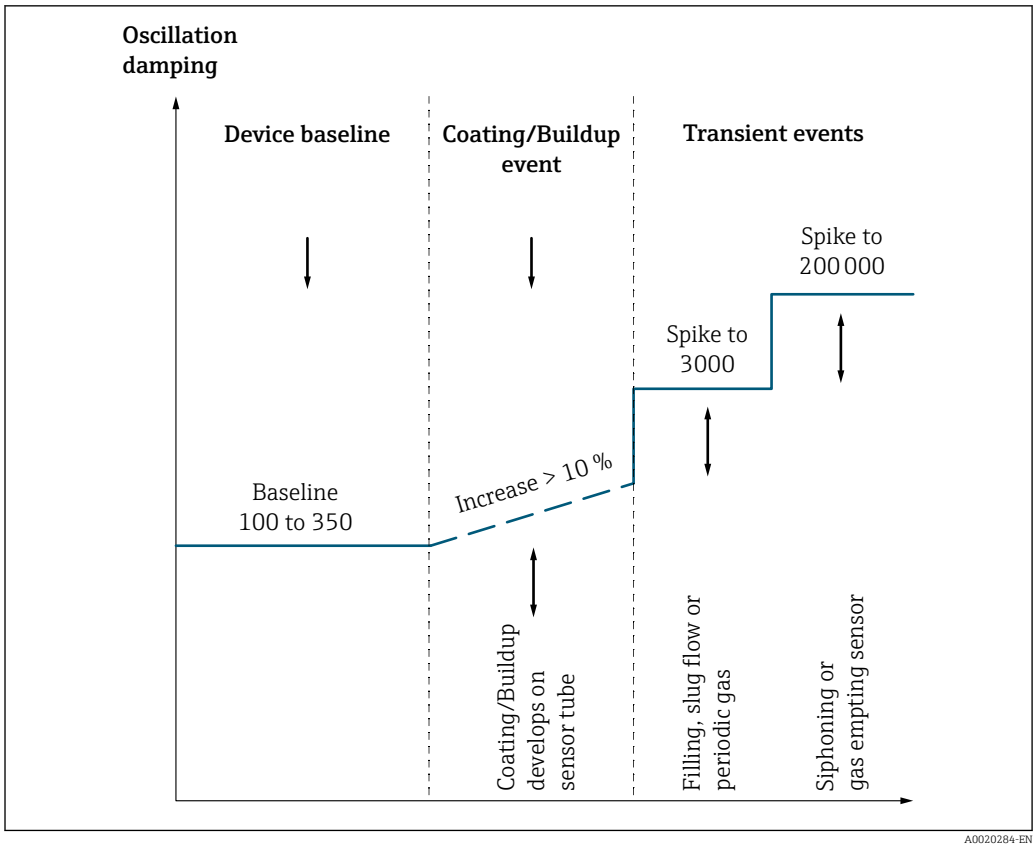
6.2.2 Description of the monitoring measured variables

Oscillation damping

The Oscillation damping is an indicator of the state of the oscillation system. A change in the Oscillation damping under reference conditions is an indicator of mechanical changes to the measuring tube that can be caused by buildup/deposits and fouling. It can also indicate multiphase conditions. Typical values range from between 70 to sometimes more than 500 000, e.g. for processes with multiphase fluids.

Changes to the Oscillation damping can be divided into two groups:
- Gradual changes appear over a longer period and are typical of coating/buildup, fouling, abrasion or corrosion.
- Temporary changes are spikes in Oscillation damping which can be caused by multiphase fluids.

The current Oscillation damping is output as an absolute value and is specific to the application. The initial value for oscillation damping (value at the time of commissioning) should be recorded and used as the reference value for monitoring in the Condition Monitoring system. The current measured value is always assessed in relation to this reference value.



14 *Typical behavior in the event of coating/buildup*

Interpretation

- During commissioning and process start-up, a device baseline for oscillation damping is established. This device baseline is determined by the sensor type and application. Depending on the properties of the fluid, a different baseline may establish itself. This baseline value is the reference value used for monitoring oscillation damping in the life cycle of the flowmeter. The Oscillation damping parameter is always analyzed with reference to this baseline.
- The formation of coating/buildup in a sensor causes a gradual and sustained change in the oscillation damping.
- Random spikes in the oscillation damping values are due to temporary process effects caused by entrained gas, or by filling or emptying the pipes.

Frequency fluctuation

The measured variable Frequency fluctuation is output as an absolute value. 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.

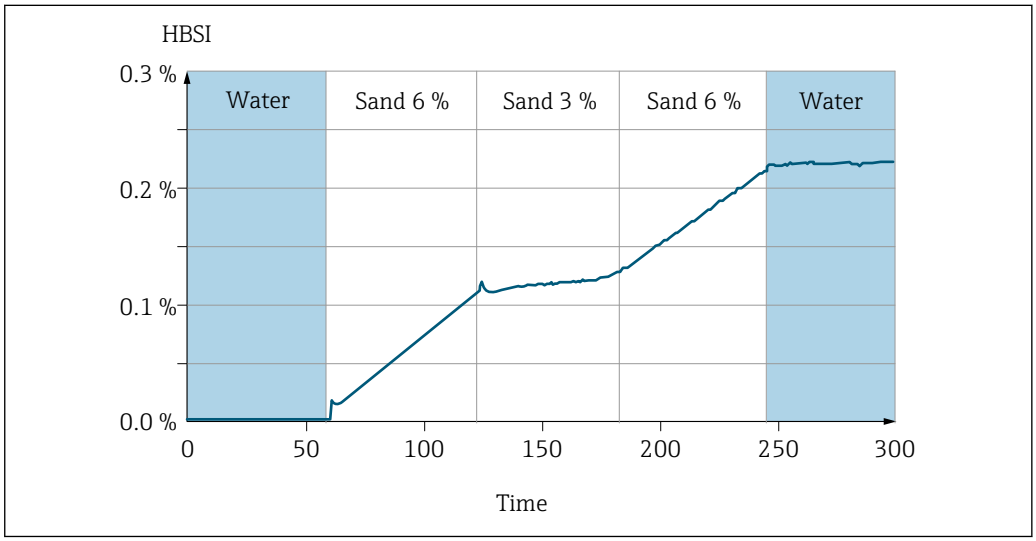
sensor integrity (HBSI)

HBSI (**H**eart**b**eat **S**ensor **I**ntegrity) is based on reference values that were recorded when the flowmeter was calibrated in the factory. This factory reference condition is stored permanently in the flowmeter and is used as a point of reference for **Heartbeat Monitoring** and **Heartbeat Verification**.

Any deviation in the **HBSI** parameter (→ 43) indicates a change in the sensor or individual components of the sensor (measuring tube, electrodynamic pick-ups, excitation system, cables etc.), which results in increased measured errors/measuring uncertainties in flow and density measurement. This can be caused by excessive mechanical or thermal strain on the sensor and increased sensor wear (e.g. corrosion, abrasion). In the case of

Promass I, a deviation can also be caused by the formation of buildup on the measuring tube.

Application example
The following example shows the sensitivity of the **HBSI** parameter (→ 43) in the event of sensor abrasion caused by the process. The Promass flowmeter measures a water/sand mixture. The initial situation with water is visible in the first segment of the measurement. Water/sand mixtures with 3 or 6% mass sand content cause abrasion of the measuring tube. A continuous change in the **HBSI** parameter (→ 43) can be observed under the process condition with 6% sand content. This is an indication that this process condition is continuously wearing down the sensor.



15 *Promass I abrasion*

The **HBSI** parameter (→ 43) is suitable for diagnosing corrosion or abrasion in the sensor. Sensor failure can only be expected if the value deviates from the reference by 8%. The device is configured at the factory to issue a warning as soon as the deviation from the reference value reaches 4%. This allows the user to reliably detect the process-specific influence, and avoid an unexpected sensor failure.

Signal asymmetry

Signal asymmetry is determined from the difference between the oscillation amplitudes at the inlet and outlet of the measuring tube. 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 Signal asymmetry can be caused by corrosion and particularly abrasion in the Coriolis sensor.

6.2.3 Description of typical applications

Coating or deposit buildup in the measuring tube

If it emerges that the process causes coating or build-up in the measuring tubes of the 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 excitation current to the oscillation amplitude of the tubes. Coating or deposit buildup in the measuring tube have a significant influence on this value. Note: Fluid density and gas pockets in liquid media can also affect the Oscillation damping .
- HBSI (→ 🖹 43)
  In the case of Promass I devices, the **HBSI** parameter (→ 🖹 43) can also be used to detect buildup and deposits 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 (→ 🖹 43)
  An increase in the **HBSI** parameter (→ 🖹 43) 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.

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