Special Documentation
Proline Promass 100

Heartbeat Verification + Monitoring application package

Endress+Hauser
People for Process Automation

Table of contents

1 About this document

1.1 Document function

This manual is Special Documentation; it does not replace the Operating Instructions pertaining to the device. It serves as a reference for using the Heartbeat Technology function integrated in the measuring device.

1.2 Content and scope

This documentation contains a description of the additional parameters and technical data that are provided with the **Heartbeat Verification + Monitoring** application package.

It provides detailed information on:
- Application-specific parameters
- Advanced technical specifications

1.3 Symbols used

1.3.1 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.

1.3.2 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

1.3.3 Symbols in graphics

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

1.4 Documentation

For an overview of the scope of the associated Technical Documentation, refer to the following:
- The *W@M Device Viewer* : Enter the serial number from the nameplate (www.endress.com/deviceviewer)
- The *Endress+Hauser Operations App*: Enter the serial number from the nameplate or scan the 2-D matrix code (QR code) on the nameplate.

This documentation is not a substitute for the Operating Instructions supplied with the device.

The Operating Instructions and additional documentation contain all detailed information on the device:
- Internet: www.endress.com/deviceviewer
- Smart phone/tablet: *Endress+Hauser Operations App*

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

Measuring device	Documentation code PROFINET
Promass A 100	BA01424D
Cubemass C 100	BA01425D
Promass E 100 (8E1B**-...)	BA01426D
Promass E 100 (8E1C**-...)	BA01715D
Promass F 100	BA01427D
Promass H 100	BA01428D
Promass I 100	BA01429D
Promass O 100	BA01430D
Promass P 100	BA01431D
Promass S 100	BA01432D
Promass X 100	BA01437D

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 → Download

1.4.1 Content and scope

This documentation contains a description of the additional parameters and technical data that are provided with the **Heartbeat Verification + Monitoring** application package.

It provides detailed information on:
- Application-specific parameters
- Advanced technical specifications

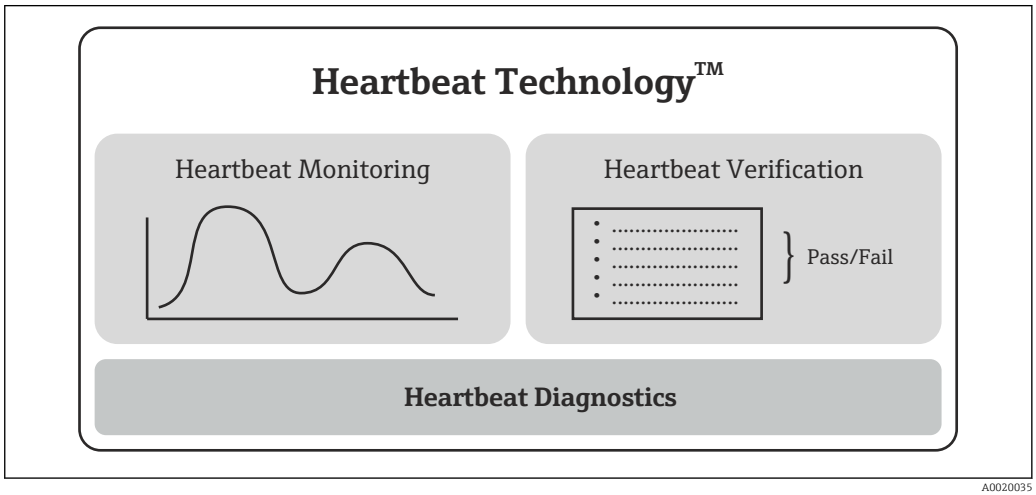
1.5 Registered trademarks

PROFINET®
Registered trademark of the PROFIBUS User Organization, Karlsruhe, Germany

2 Product features and availability

2.1 Product features

Proline flowmeters with Heartbeat Technology offer diagnostic functions through continuous self-monitoring (**Heartbeat Diagnostics**), the transmission of additional measured variables to an external Condition Monitoring system (**Heartbeat Monitoring**) and the in-situ verification of flowmeters in the application (**Heartbeat Verification**).



1 *Heartbeat Technology: Overview of modules and correlated functions*

The **Heartbeat Monitoring** and **Heartbeat Verification** modules are optional → 7.

2.1.1 Heartbeat Diagnostics

The **Heartbeat Diagnostics** function provides information on the device status and is represented in the form of status signals (device diagnostics).

For more information on diagnostics, see the "Diagnostics and troubleshooting" section of the Operating Instructions.

2.1.2 Heartbeat Monitoring

Continuous output of monitoring measured values for monitoring in an external Condition Monitoring system. The measured values are transmitted to a Condition Monitoring system via the outputs provided on the measuring device.

2.1.3 Heartbeat Verification

The functionality of the device is checked on demand. The results of the check are saved as a data set in the measuring device and documented in the form of a verification report.

It is recommended to use the **Heartbeat Verification** function for the first time directly as part of the commissioning routine → 15.

2.2 Availability (product list and order option)

Heartbeat Technology is available for all Proline measuring principles. This enables the use of the function for the entire installed base of Proline flowmeters.

For information on how to enable the function → 15.

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

Please contact your Endress+Hauser service or sales organization for further information regarding product availability and upgrades to existing measuring devices.

2.2.1 Order options

Heartbeat Diagnostics is a basic function of all the Proline measuring devices.

Heartbeat Monitoring and Heartbeat Verification

The **Heartbeat Monitoring** and **Heartbeat Verification** modules are optional and are indicated as order options in the product price list:

Order feature "Application Package", **EB** "Heartbeat Verification + Monitoring" option

If this order option is selected, the functionalities for **Heartbeat Monitoring** and **Heartbeat Verification** are already available in the device on leaving the factory. It is also possible to upgrade to this function during the life cycle of the measuring device.

3 Product description

3.1 Overview

Proline measuring devices with Heartbeat Technology have an integrated self-monitoring system that monitors the entire measuring chain from the sensor to the outputs. This integrated self-monitoring system supplies additional information (measured variables) for the direct assessment of the state of the measuring device, and information on process influences that affect the measuring function and performance.

3.1.1 Heartbeat Monitoring and Verification

The "Heartbeat Verification + Monitoring" application package can be used to verify the functionality of the device in the application (**Heartbeat Verification**); the measuring device can also be used to output additional measured variables to an external Condition Monitoring system (**Heartbeat Monitoring**).

The information gathered during self-monitoring is made available by the **Heartbeat Diagnostics**, **Heartbeat Monitoring** and **Heartbeat Verification** features in a variety of ways → 🖹 7:

The **Heartbeat Diagnostics** function supplies continuous information about the state of the measuring device. It is represented in the form of status signals (device diagnostics).

With **Heartbeat Monitoring** it is possible to output additional monitoring-specific measured values for monitoring in an external Condition Monitoring system during continuous operation. The measured values are transmitted to a Condition Monitoring system via the outputs provided on the measuring device.

The flowmeter is verified on demand using the **Heartbeat Verification** function. The results of the check are documented as a data set in the measuring device and in the form of a verification report. The result of the verification provides information about the condition of the device.

3.2 Detailed product description

3.2.1 Heartbeat Diagnostics

Purpose
With the **Heartbeat Diagnostics** function, information on the status of the measuring device is generated on the basis of continuous self-monitoring and represented in the form of status signals (device diagnostics). The diagnostic data are classified and contain information on the cause of the error and measures to rectify the error.

Aim
Continuously output status signals via the operating interfaces and to the higher-level system (system integration).

Advantages
- Continuous monitoring and integration into the higher-order system ensure that information on the condition of the measuring device is available in real time and can be processed in time.
- Remedial measures are provided for each diagnostic event to ensure that problems can be rectified quickly.

Customer and industry requirements
The status signals are classified in accordance with VDI/VDE 2650 and NAMUR Recommendation NE 107.

For more information on diagnostics, see the "Diagnostics and troubleshooting" section of the Operating Instructions.

3.2.2 Heartbeat Monitoring

Purpose
Condition Monitoring is defined as the continuous monitoring of flowmeter measured variables in an external system. This is different from the continuous self-monitoring performed by the device, which forms the basis for device diagnostics. On the basis of continuous self-monitoring, **Heartbeat Monitoring** makes additional monitoring-specific measured values available. A range of measured variables is provided that relates to the measuring performance of the flowmeter.
The analysis of these continuous measured variables in a Condition Monitoring system makes it possible to assess these measured variables from the perspective of the application. Device diagnostics assesses measured variables with regard to the condition of the measuring device (system integrity, operation outside of manufacturer's specifications) and with regard to any restrictions or interruptions in the measuring function due to unsuitable process conditions. The purpose of **Heartbeat Monitoring**, on the other hand, is to use additional measured variables in the context of the application. Therefore the measured variables are interpreted in the Condition Monitoring system as opposed to interpretation by the flowmeter. The flowmeter only serves to supply the information.

Aim
To monitor the application, relevant monitoring-specific measured values are transmitted to a Condition Monitoring system via the outputs provided at the measuring device. The monitoring-specific measured values are assessed in the Condition Monitoring system and used to control maintenance-related measures (e.g. cleaning) or process optimization. Ideally these measures can be implemented before the process safety or product quality of the application is affected.
Possible applications of Condition Monitoring:
– 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

Advantages
- Measured variables preprocessed in the measuring device are made available for easy integration into the Condition Monitoring system.
- Early detection of changes (trends) to ensure plant availability and product quality.
- Use of information for the proactive planning of measures (cleaning).
- Identification of undesirable process conditions as the basis to optimizing the facility and the processes.

Customer and industry requirements
- For a product to have a high level of quality, the process quality must be monitored continuously and the quality of flow measurement must remain constant.
- High system availability requires the prevention of unscheduled downtime and short turnaround times for repair work – proactive, forward planning is a prerequisite for this.

3.2.3 Heartbeat Verification

Purpose
Heartbeat Verification uses the self-monitoring function of the Proline flowmeters to check the measuring device functionality. Verification is performed on demand. During the verification process, the system checks whether the measuring device components comply with the factory specifications. Both the sensor and the electronic modules are included in the tests. The results of the check are saved as a data set in the measuring device and documented in the form of a verification report, if required. The request for verification can come from a higher-order system via the system integration interface. The overall result of the device function test can also be relayed to this higher-order system. The result of the verification provides information about the condition of the measuring device. Data interpretation by the user is not required.

Aim
To confirm the consistent quality of the measurement in the life cycle of the measuring device by periodically checking the measuring device functionality. To create traceable documentation of the condition of the measuring device in the life cycle of the measuring device.

Advantages
- The functionality is integrated in the measuring device and therefore available via all the operating and system integration interfaces. No onsite presence is required to use the function, thereby saving time and making the function easily available at any time.
- As the measuring device interprets and documents the results of the verification itself (**Pass**/**Fail**), no special knowledge is required on the part of the user.
- The documentation of the verification (verification report) can be used to prove quality measures to a third party.
- The use of the **Heartbeat Verification** function as a method to test Proline measuring devices in the application means it can replace other maintenance tasks (periodic check, repeat calibration) or be used to extend the testing intervals.

Customer and industry requirements
- Compliance with ISO 9001 (measuring points relevant to quality)
- Testing of measuring points with regard to energy monitoring, utilities and greenhouse gas emissions
- Testing of measuring points as regards billing

3.3 Performance characteristics

Heartbeat Technology™ carries out checks on the measuring device which increase the reliability of the measured value output.

3.3.1 Heartbeat Diagnostics

Heartbeat Diagnostics carries out diagnostic tests in the electronics modules based on continuous self-monitoring. The test scope achieved using these diagnostic tests is referred to as Total Test Coverage – TTC.

The TTC is expressed by 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 dangerous undetected failures are not identified by the instrument diagnosis and, if they occur, can distort the measured value that is output or interrupt the output of measured values.

Heartbeat Diagnostics checks the device function within the specified measuring tolerance using a defined TTC.

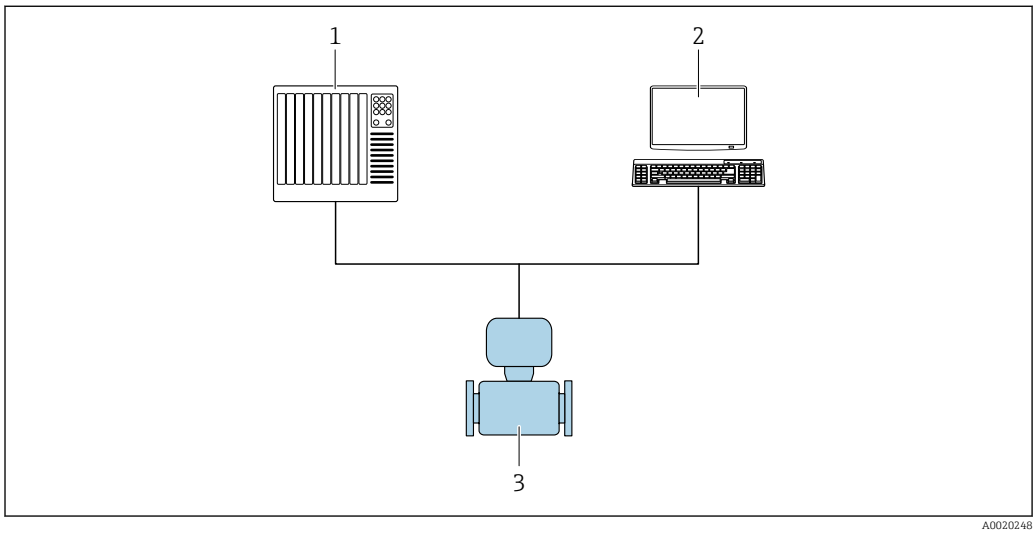
3.3.2 Heartbeat Verification

Heartbeat Verification is carried out on demand and, by means of additional checks, complements the diagnostics performed during diagnosis: internal verification also checks the 4 to 20 mA current output, and external verification supports the testing of all output modules.

This reduces the percentage of the failures undetected by diagnosis (λ_{du}).

4 System integration

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



1 PLC
2 Asset Management System
3 Measuring device

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

Detailed information concerning system integration:

Operating Instructions, "System integration" section .

4.1 Automated data exchange

Heartbeat Diagnostics
- Analyze field device diagnostics.
- Diagnostic events for integration with the PLC.

Heartbeat Monitoring
- Continuous trend analysis.
- Additional monitoring measured variables for processing in a Condition Monitoring system.

Heartbeat Monitoring
- Continuous trend analysis.
- Additional monitoring measured variables for processing in a Condition Monitoring system.

Heartbeat Monitoring
There is no automatic exchange of data. The monitoring measured variables are read only.

Heartbeat Verification
- Instrument check via self-monitoring.
- Start verification and upload verification results.

4.1.1 Automated data exchange: Heartbeat Monitoring

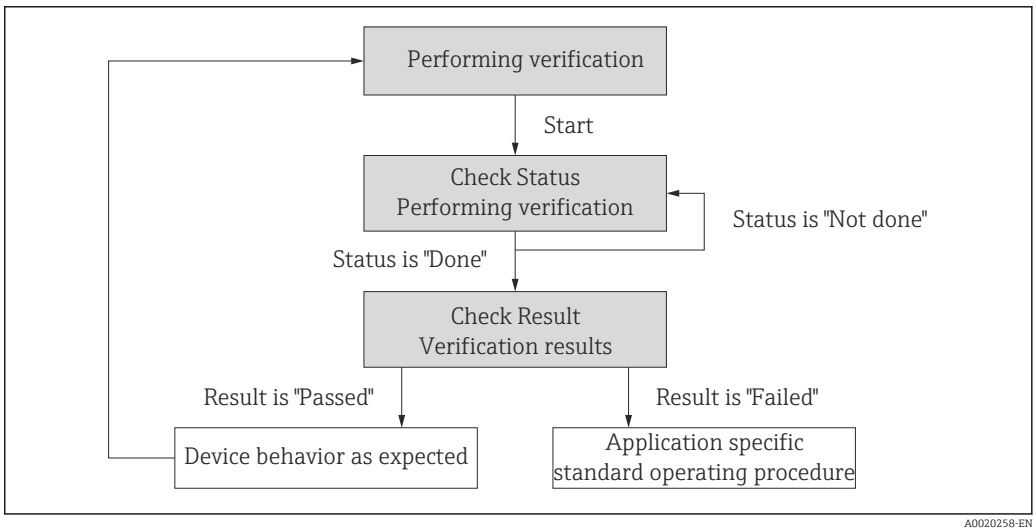
The following procedure describes the work flow that is principally involved in the automated handling of the **Heartbeat Monitoring** function, and the use of data for Condition Monitoring:

- The host application configures the cyclic services of the field device for **Heartbeat Monitoring**
- The field device communicates PVs (process variables) from **Heartbeat Monitoring**
- The host application analyzes the **Heartbeat Monitoring** PVs (e.g. trends, limit value monitoring)
- The host application initiates application-specific standard operating procedures (e.g. a "Maintenance Required" alarm is signaled or maintenance instructions are triggered)

The fieldbus-specific implementation is described in the "Technical data" section of the Operating Instructions under "Output".

4.1.2 Automated data exchange: Heartbeat Verification

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



- Verification performance:
  Verification is started 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 Diagnostics

- Identify remedial measures.
- Information on the cause of the error and remedial measures are provided in the asset management system.

Heartbeat Monitoring
Configuration of the monitoring system.

Heartbeat Monitoring
Configuration of the monitoring system.

Heartbeat Monitoring
The user can only read the monitoring measured variables.

Heartbeat Verification
- Instrument verification via self-monitoring.
- Start verification.
- Upload, archive and document verification results including detailed results.

5 Commissioning

5.1 Availability

5.1.1 Heartbeat Monitoring and Verification

If the optional package for **Heartbeat Monitoring** and **Heartbeat Verification** was ordered for the flowmeter from the factory, the function is already available when the measuring device is delivered to the customer. The function is accessed via the operating interfaces of the measuring device, via the Web server or Endress+Hauser's FieldCare asset management software. No particular measures are required to put the function into operation.

Ways to check function availability in the measuring device:
- Using the serial number:
  W@M Device Viewer [1] → Order code for option **EB** "Heartbeat Verification + Monitoring"
- In the operating menu:
  Check whether the function appears in the operating menu: Diagnostics → Heartbeat.
  If the "Heartbeat" option is available the function is activated.

If the function is not available in the measuring device, the optional package was not selected. It is then possible to upgrade to this function during the life cycle of the measuring device. On most flowmeters it is possible to activate the function without having to change the firmware.

5.1.2 Activation without firmware upgrade

You require a conversion kit from Endress+Hauser to enable the function without upgrading the firmware. Among other things, this kit contains an activation code which must be entered via the operating menu to activate the "Heartbeat Verification + Monitoring" function.

The function can be activated under Setup → Advanced setup → Enter access code.

Once activated, the **Heartbeat Monitoring** and **Heartbeat Verification** modules are permanently available in the measuring device.

Activation without firmware upgrade is possible as of the following firmware versions:
PROFINET: 01.00.zz

5.1.3 Firmware upgrade before activation

If you have a measuring device that requires a firmware upgrade before it can be activated, please contact your Endress+Hauser service organization.

This function requires service-level access to the device.

A firmware upgrade is required for measuring devices with earlier firmware versions (see "5.1.1 Activation without firmware upgrade").

In addition the reference condition of the sensor must be recorded and selected during commissioning.

Please contact your Endress+Hauser service or sales organization for further information regarding product availability and upgrades to existing measuring devices.

1) www.endress.com/deviceviewer

5.2 Heartbeat Diagnostics

The diagnostics functions are part of the basic features of Proline flowmeters: See the "Diagnostics and troubleshooting" section of the Operating Instructions.

5.3 Heartbeat Monitoring

Heartbeat Monitoring is put into operation by activating the monitoring function and assigning the measured variables, which are relevant for monitoring from the point of view of the application, to the outputs on the measuring device. Once commissioning is completed, the selected monitoring-specific measured variables are continuously available at the outputs.

Activating/deactivating the monitoring function
The transmission of monitoring-specific measured variables is switched on or off in the operating menu:
→ 18

5.3.1 Parameter selection: Outputs

The monitoring-specific parameters listed below can be assigned to the outputs for continuous transmission to a Condition Monitoring system.

Some parameters are only available if the "Heartbeat Monitoring" function is enabled in the measuring device.

Parameter	Description	Value range
Oscillation damping	Mechanical damping of the measuring tubes/tube in A/m	0 to 100 000
Oscillation damping 1 (Promass I only) [1]	Mechanical damping of the measuring tube torsion mode in A/m	0 to $3.0 \cdot 10^{+38}$
Sensor integrity (Promass I only) [1]	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.	±4 %
Carrier pipe temperature [1]	Temperature of the sensor carrier tube in the set system unit	−60 to +200 °C
Electronic temperature	Temperature of the electronics in the set system unit	−50 to +90 °C
Oscillation frequency	Oscillation frequency of the measuring tube/tubes in Hz	Depends on the sensor type, version and nominal diameter (see Service Checklist SH01003D)
Oscillation frequency 1 (Promass I only) [1]	Oscillation frequency of the measuring tube torsion mode in Hz	Depends on the sensor type, version and nominal diameter (see Service Checklist SH01003D)
Frequency fluctuation 0	Fluctuation of the oscillation frequency of the measuring tube(s)	0 to $3.0 \cdot 10^{+38}$
Frequency fluctuation 1 (Promass I only) [1]	Fluctuation of the oscillation frequency of the measuring tube torsion mode	0 to $3.0 \cdot 10^{+38}$
Oscillation amplitude [1]	Relative mechanical oscillation amplitude of the measuring tube/tubes in % of the target value	0…150 %

Parameter	Description	Value range
Oscillation amplitude 1 (Promass I only) [1]	Relative mechanical oscillation amplitude of the measuring tube torsion mode in % of the target value	0...100 %
Tube damping fluctuation 0	Fluctuation of the mechanical damping of the measuring tube(s)	0 to $3.0 \cdot 10^{+38}$
Fluctuation of the oscillation damping 1 (Promass I only) [1]	Fluctuation of the mechanical damping of the measuring tube torsion mode	0 to $3.0 \cdot 10^{+38}$
Signal asymmetry	Relative deviation of the signal amplitude between the inlet and outlet sensor in %	±10 % (in the event of a defect: ±200 %)
Exciter current	Exciter current of the measuring tube/ tubes in mA	±25 mA
Exciter current 1 (Promass I only) [1]	Exciter current of the measuring tube torsion mode in mA	±25 mA

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

For information on using the parameters and interpreting the measurement results → 37.

5.3.2 Sensor integrity Proline Promass I

In Proline Promass I devices, the "Sensor integrity" measured variable is continuously available as a monitoring parameter, while in the other Promass sensors it is only available on demand as part of the **Heartbeat Verification** function.

Any deviation in the "Sensor integrity" parameter 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, increased wear (e.g. corrosion, abrasion) or the formation of buildup in the measuring tube.

5.4 Heartbeat Verification

It is not necessary to commission the **Heartbeat Verification** function.

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.

5.4.1 Recording of customer and location

It is possible to manually record reference data relating to the customer and the location. If this function is used, these reference data appear in the verification report.

Reference data are recorded in the operating menu:
- Setup → Advanced setup → Heartbeat setup → Heartbeat base settings → Plant operator
- Setup → Advanced setup → Heartbeat setup → Heartbeat base settings → Location
- Expert → Diagnostics → Heartbeat → Heartbeat base settings → Plant operator
- Expert → Diagnostics → Heartbeat → Heartbeat base settings → Location

6 Operation

6.1 Heartbeat Diagnostics

The diagnostics functions are part of the basic features of Proline flowmeters.

For more information on diagnostics, see the "Diagnostics and troubleshooting" section of the Operating Instructions.

6.2 Heartbeat Monitoring

Activating/deactivating the monitoring function
Once the device has been commissioned successfully, the continuous transmission of monitoring-specific measured variables to the outputs is switched on or off in the operating menu:
- "Setup → Advanced setup → Heartbeat setup → Heartbeat monitoring"
- "Expert → Diagnostics → Heartbeat → Heartbeat monitoring"

6.3 Heartbeat Verification

6.3.1 Initial verification

It is advisable to perform an initial verification when commissioning the measuring device and to save the results as the initial situation in the life cycle of the measuring device.

If verification is started during the first 60 minutes following commissioning, measured value output is interrupted for a period of up to two minutes.

6.3.2 Product features

For basic information on the product features of **Heartbeat Verification** → 9. Refer to this section of the manual before continuing device operation.

6.3.3 Operation – performing a verification

Verification is performed on demand and started in the operating menu or via the Verification-DTM.

Access via the operating menu and Web server:
- Diagnostics → Heartbeat → Performing verification
- Expert → Diagnostics → Heartbeat → Performing verification

Access via FieldCare DTM:
Heartbeat → Performing verification

Diagnostic behavior
The information event "302 – Device verification active" signals that verification is being performed.

Unlike a diagnostic event, an information event is displayed in the event logbook only and not in the diagnostic list.

For additional information on the diagnostic behavior, see the "Diagnostics and troubleshooting" section in the Operating Instructions.

Only use intrinsically safe measuring equipment in hazardous zones!

Parameters for "Performing verification/Start"

Navigation
"Diagnostics" submenu → Heartbeat → Performing verification

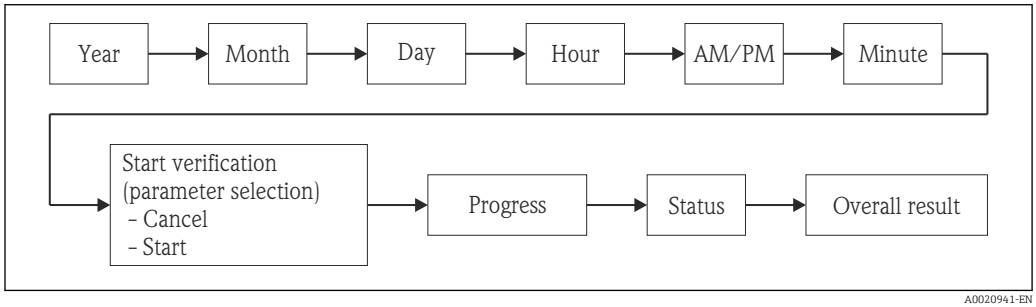
Navigation
"Expert" menu → Diagnostics → Heartbeat → Performing verification

Parameter overview with brief description

Parameter	Prerequisite	Description	User entry / Selection / User interface	Factory setting
Year	Can be edited if verification status 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 verification status 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 verification status is not active.	Entry for date and time (field 3): enter the day verification is performed.	1 to 31	1
Hour	Can be edited if verification status is not active.	Entry for date and time (field 4): enter the hour verification is performed.	0 to 23	12
AM/PM	Can be edited if verification status is not active. The **dd.mm.yy hh:mm am/pm** option or the **mm/dd/yy hh:mm am/pm** option are 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 verification status is not active.	Entry for date and time (field 6): enter the minute verification is performed.	0 to 59	0
Start verification	–	Start verification. To carry out a complete verification, the selection parameters must be selected individually. Once the external measured values have been recorded, verification is started using "Start verification".	▪ Cancel ▪ Output 1 low value ▪ Output 1 high value ▪ Output 2 low value ▪ Output 2 high value ▪ Frequency output ▪ Pulse output ▪ Start verification	Cancel
Progress	–	Shows the progress of the process.	0 to 100 %	0 %

Parameter	Prerequisite	Description	User entry / Selection / User interface	Factory setting
Status	–		▪ Done ▪ Busy ▪ Failed ▪ Not done	Not done
Overall result	For the following order code: "Application package", option EB "Heartbeat Verification" The software options currently enabled are displayed in the **Software option overview** parameter.	Overall result of the verification. Failed: At least one test group was outside the specifications. Passed: All verified test groups complied with the specifications (even if "Check not done" is the result for a test group). Check not done: No verification was performed for any of the test groups.	▪ Failed ▪ Not used ▪ Passed ▪ Check not done	Check not done

Performing the verification: sequence of steps



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.

6.3.4 Verification results

The results of the verification can be called up via the operating menu or via the FieldCare Verification-DTM.

Access via the operating menu and Web server:
- Diagnostics → Heartbeat → Verification results
- Expert → Diagnostics → Heartbeat → Verification results

Access via FieldCare DTM:
Heartbeat → Verification results

Parameter/Test group 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.	Entry for date and time in real time.		0
Verification ID	The verification has been performed.	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.	Days (d), hours (h), minutes (m), seconds (s)	
Overall result	For the following order code: "Application package", option EB "Heartbeat Verification" The software options currently enabled are displayed in the **Software option overview** parameter.	Overall result of the verification. Failed: At least one test group was outside the specifications. Passed: All verified test groups complied with the specifications (even if "Check not done" is the result for a test group). Check not done: No verification was performed for any of the test groups.	▪ Failed ▪ Not used ▪ Passed ▪ Check not done	Check not done
Sensor	In the **Overall result** parameter, the **Failed** option is displayed.	Result for sensor test group.	▪ Failed ▪ Not used ▪ Passed ▪ Check not done	Check not done
Sensor integrity	–		▪ Failed ▪ Not used ▪ Passed ▪ Check not done	Check not done
Pre-amplifier module	In the **Overall result** parameter, the **Failed** option is displayed.		▪ Failed ▪ Not used ▪ Passed ▪ Check not done	Check not done

Parameter	Prerequisite	Description	User interface	Factory setting
I/O module	In the **Overall result** parameter, the **Failed** option is displayed.	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 external verification only) ▪ For frequency output: Accuracy of frequency (for external verification only)	▪ Failed ▪ Passed ▪ Check not done Limit value for current output (for internal verification only): ▪ ±1 % ▪ ±300 µA Limit value for current output (for external verification only, for 4 mA and for 20 mA): ▪ ±1 % ▪ ±300 µA Limit value for pulse output (for external verification only): Simulation: 1 pulse/s, pulse width 100 ms, with 1000 pulses ±10 pulses Limit value for frequency output (for external verification only): ±0.1 %	Check not done
System status	In the **Overall result** parameter, the **Failed** option is displayed.	Tests the measuring device for active errors.	▪ Failed ▪ Not used ▪ Passed ▪ Not done	Not done

Classify results

Classification of results

- 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".
- Check not done: No test has been performed for this test group.

Classification of overall results

- 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".
- Check not done: No verification was performed for any of the test groups (result for all test groups is "Check not done").

Test groups

- Sensor: Electrical components of the sensor (signals, circuits and cables)
- Sensor integrity: Electrical, electromechanical and mechanical components of the sensor, including the measuring tube
- Sensor electronic module: Electronic module for exciting the sensor and converting
- I/O electronics module: Results of input and output modules installed at the measuring device
- System condition: test for active measuring device errors of "alarm"-type diagnostic behavior.

For more information on the test groups and individual tests → 📄 23.

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 for 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 in the detailed verification results which can be accessed via the Verification-DTM.

6.3.5 Detailed verification results

The detailed verification results and process conditions at the time of the verification can be accessed via the FieldCare Verification-DTM.

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

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

Parameters for "Detailed verification results"

Parameter/individual test	Description	Result/limit value
"Sensor" test group		
Inlet sensor coil	Condition of the inlet sensor coil: Intact/not intact (short-circuit/ interruption)	No value range Passed / Failed
Outlet sensor coil	Condition of the outlet sensor coil: Intact/not intact (short-circuit/ interruption)	No value range Passed / Failed
Measuring tube temperature sensor	Condition of the measuring tube temperature sensor: Intact/not intact (short-circuit/interruption)	No value range Passed / Failed
Carrier tube temperature sensor	Condition of the carrier tube temperature sensor: Intact/not intact (short-circuit/interruption)	No value range Passed / Failed
Sensor coil symmetry	Monitoring of the signal amplitude between the inlet and outlet sensor	No value range Passed / Failed
Lateral mode frequency	Monitoring of the oscillation frequency of the measuring tube/ tubes	Depends on the sensor type, version and nominal diameter
Frequency torsion mode (Promass I only)	Monitoring of the oscillation frequency of the measuring tube torsion mode	Depends on the sensor type, version and nominal diameter
"Sensor integrity" test group		
Sensor integrity	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 pick-ups, excitation system, cables etc.), in % of the reference value.	±4 %

Parameter/individual test	Description	Result/limit value
▸ Sensor integrity deviation	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.	±4 %
"Sensor electronic module" test group		
Zero point monitoring	Monitoring of the zero point for flow measurement	±500
Reference clock	Monitoring of the reference clock for flow measurement	±100 ppm
Reference temperature	Temperature measurement monitoring	±10 Ω (defined as a resistance value, not as a temperature value)

Furthermore, the current process conditions at the time of verification are recorded, thereby improving the comparability of the results.

Process conditions

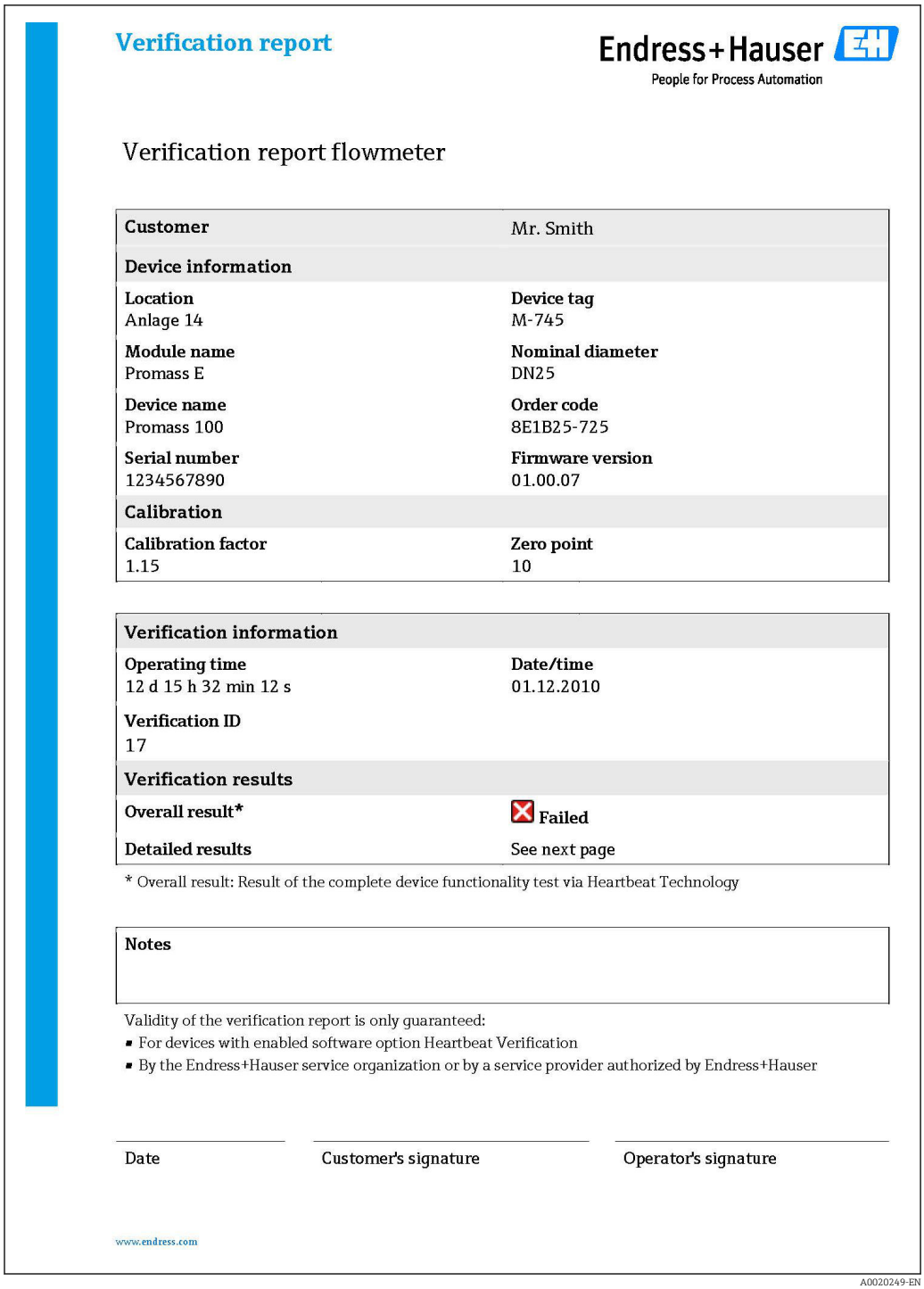
Process conditions	Description, value range
Mass flow verification value	Actual measured value for mass flow
Density verification value	Current measured value for density
Damping verification value	Actual measured value for measuring tube damping
Process temperature verification value	Current measured value for process temperature (temperature in the sensor)
Electronic temperature	Current measured value for the electronic temperature in the transmitter

6.3.6 Verification report

The results of the verification can be documented in the form of a verification report using a Web server or the FieldCare asset management software . The verification report is created on the basis of the data set saved in the measuring device after verification. As the verification results are automatically and uniquely identified with the verification ID and the operating time, they are suitable for the traceable documentation of the verification of flowmeters.

Content of the verification report
The verification report is a two-page report. The first page contains information to identify the measuring point and the verification result and confirms that verification has been performed.
- Customer: Customer reference
- Device information: Information on the place of operation (tag) and the current configuration of the measuring point. This information is managed in the measuring device and indicated in the verification report.
- Calibration: Information on the calibration factor and zero point setting for the sensor. To ensure that the measuring device complies with the factory specification, these values must correspond to those of the last calibration or repeat calibration.

- Verification information: The operating time and verification ID are used to uniquely assign the verification results for the traceable documentation of the verification. The manual entry for the date and time is saved in addition to the current operating time in the measuring device and also appears in the verification report.
- Verification results: Overall result of the verification. The verification is only passed if all the test groups pass. The results for the test groups are indicated on the second page of the report.
- Validity – Disclaimer: As a prerequisite for the validity of the verification report, the **Heartbeat Verification** function 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

Verification report flowmeter

Customer	Mr. Smith
Device information	
Location Anlage 14	**Device tag** M-745
Module name Promass E	**Nominal diameter** DN25
Device name Promass 100	**Order code** 8E1B25-725
Serial number 1234567890	**Firmware version** 01.00.07
Calibration	
Calibration factor 1.15	**Zero point** 10

Verification information	
Operating time 12 d 15 h 32 min 12 s	**Date/time** 01.12.2010
Verification ID 17	
Verification results	
Overall result*	**Failed**
Detailed results	See next page

* Overall result: Result of the complete device functionality test via Heartbeat Technology

Notes

Validity of the verification report is only guaranteed:
- For devices with enabled software option Heartbeat Verification
- By the Endress+Hauser service organization or by a service provider authorized by Endress+Hauser

Date | Customer's signature | Operator's signature

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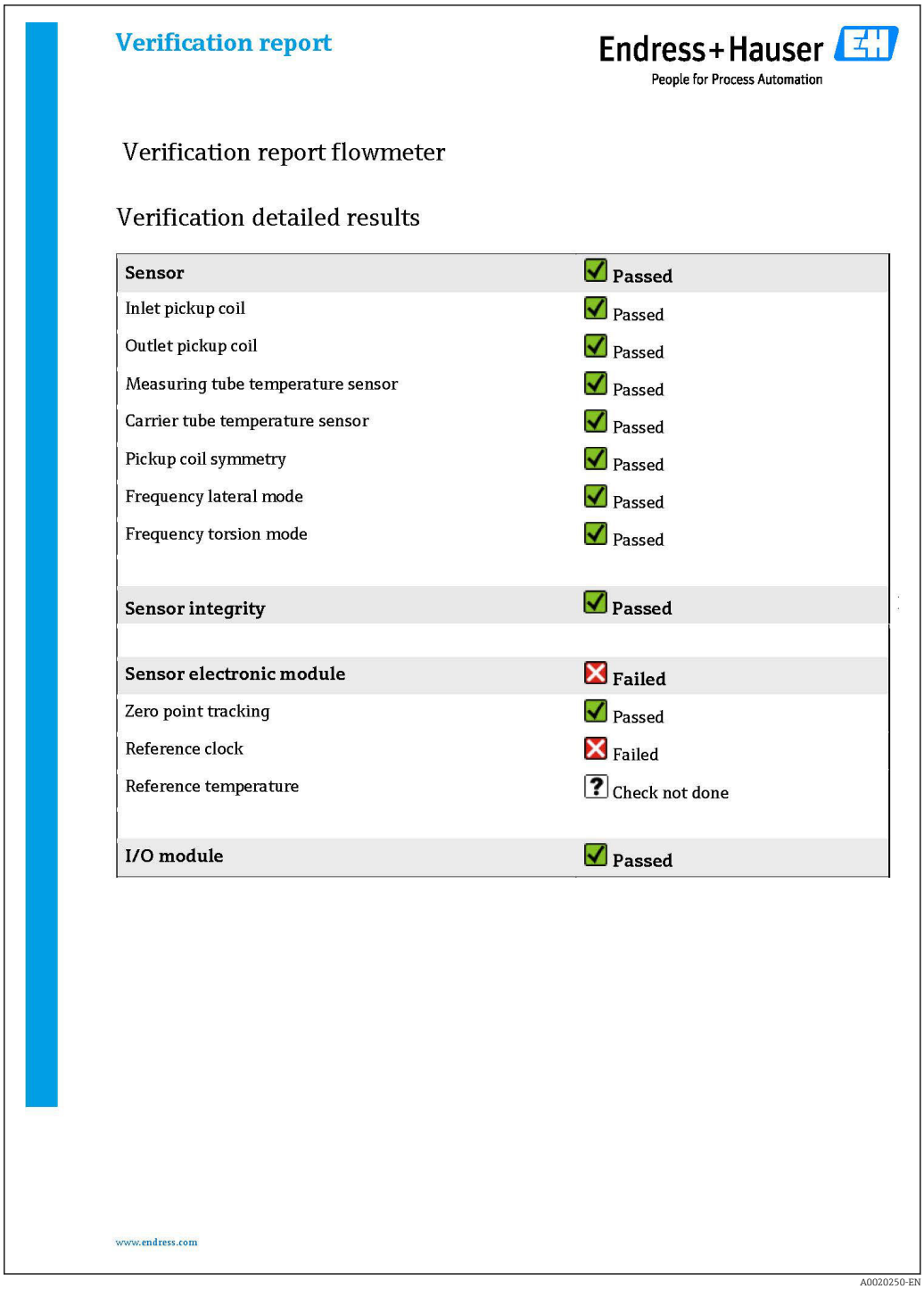
2 *Verification report (Page 1)*

The second page of the verification report lists the individual test groups and the individual test group results. For information on the meaning of the individual test groups and a description of the individual tests → 23



Verification report

Endress+Hauser
People for Process Automation

Verification report flowmeter

Verification detailed results

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
Frequency torsion mode	Passed
Sensor integrity	**Passed**
Sensor electronic module	**Failed**
Zero point tracking	Passed
Reference clock	Failed
Reference temperature	Check not done
I/O module	**Passed**

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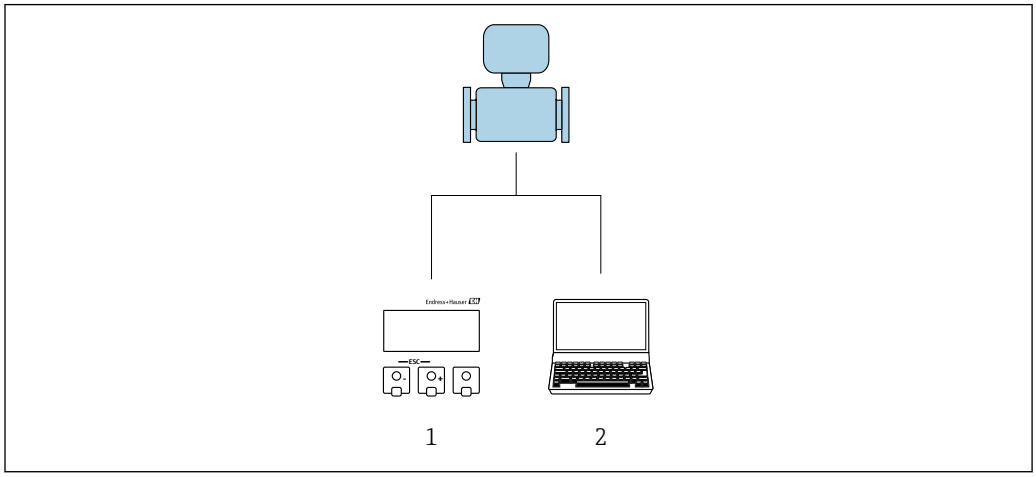
3 *Verification report (Page 2)*

Data administration using Web server and FieldCare verification DTM
(Verweisziel existiert nicht, aber @y.link.required='true')

7 Mode of operation

7.1 Totalization

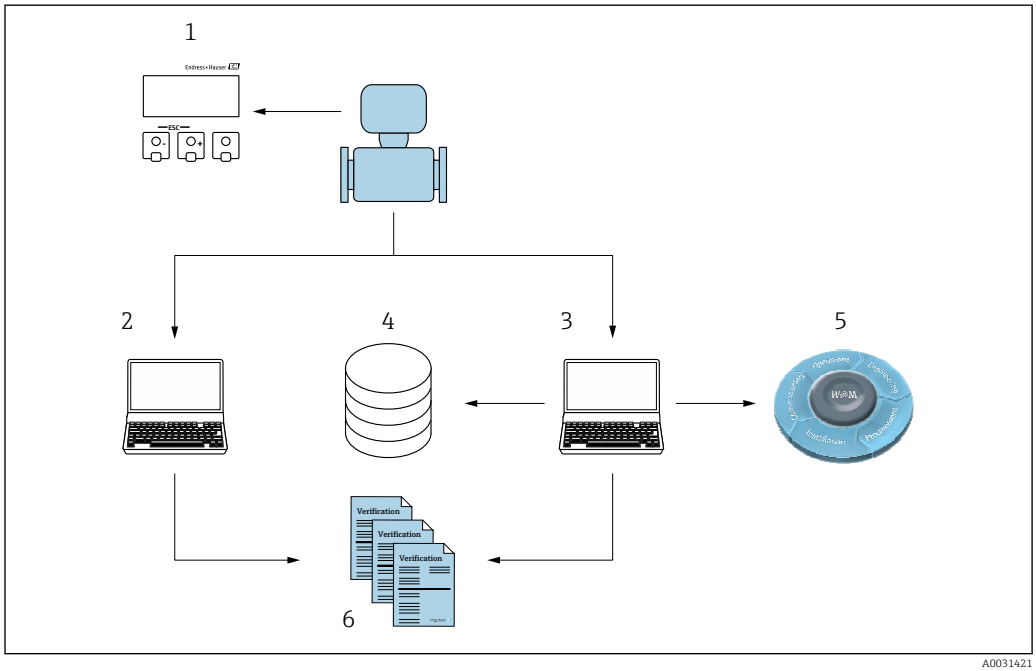
Heartbeat Technology is accessible via all the operating interfaces.



A0031420

1 Local display
2 Web server or FieldCare

In addition, access is also possible via the system integration interface, allowing the device to be used without onsite presence in the field. Via the process control system or asset management system, it is possible to periodically check the measuring point with a minimum amount of effort.



A0031421

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 and reports to create traceable documentation.

W@M (Web Asset Management) by Endress+Hauser is an open information system for lifecycle management – device documentation and administration:
- Project configuration
- System integration
- Operation
- Maintenance
- Repair

7.2 Data management

The results of a **Heartbeat Verification** are saved as a non-volatile parameter set in the measuring device memory:
- 8 storage spaces available for parameter sets
- FIFO [2] 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)

7.2.1 Data management via Web browser

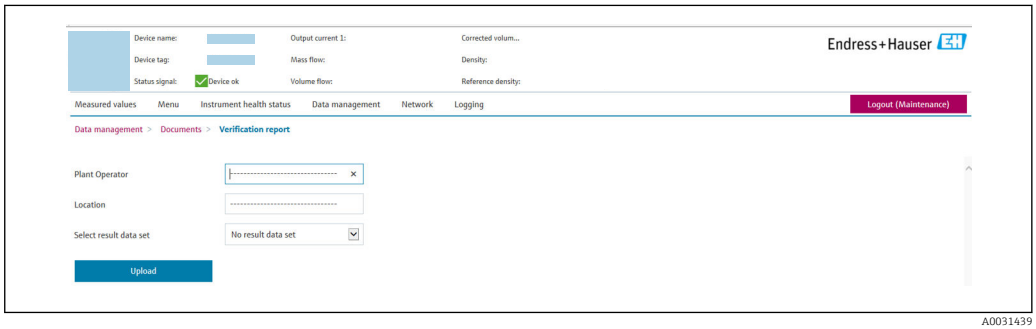
Thanks to the integrated Web server the device can be operated and configured via a Web browser. In addition, it is possible to query the results of the verification and create a verification report.

Print verification report

A verification report is created in PDF format.

Prerequisite: A verification has already been performed.

Web browser interface after login:



A0031439

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) First In – First Out

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.

7.2.2 Data management via Flow Verification DTM

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

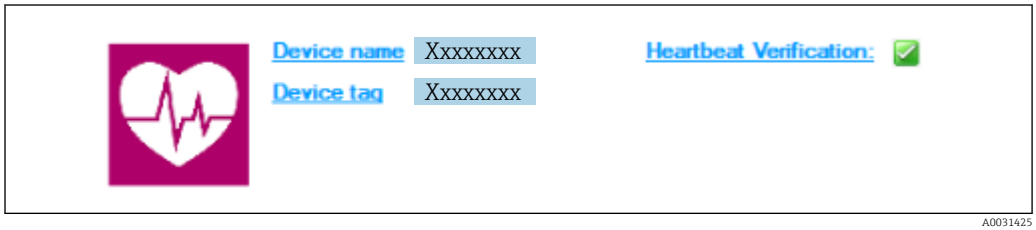
A special DTM for **Heartbeat Verification** (Flow Verification DTM) is also available in addition to the DeviceDTM. The Flow Verification DTM offers advanced capabilities for managing and visualizing the results.

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

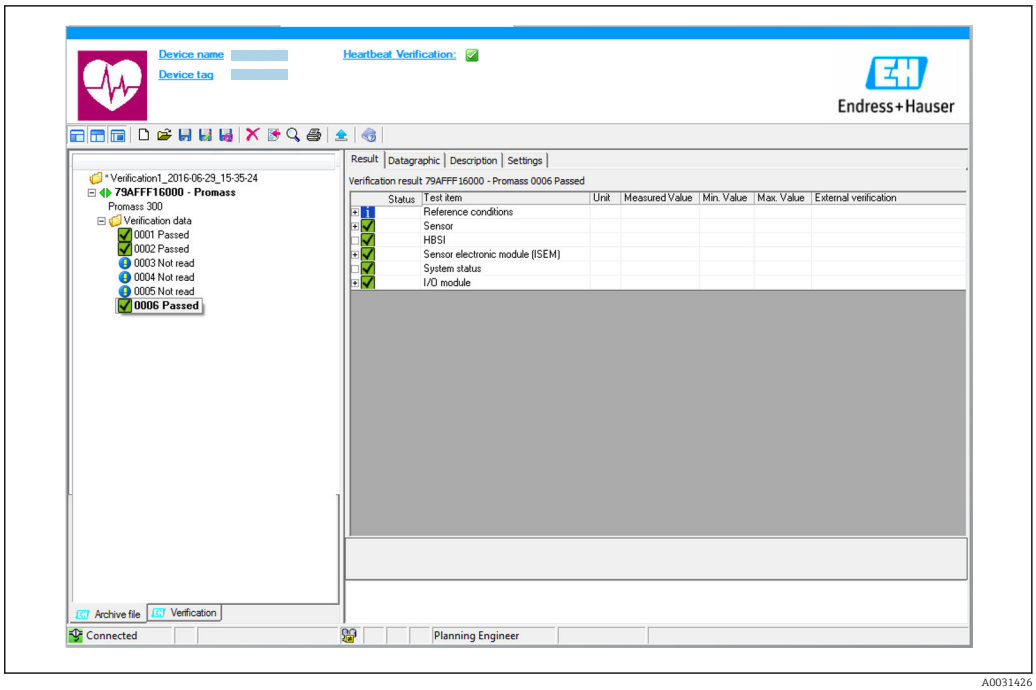


A0031425

- 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.



A0031426

4 *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.

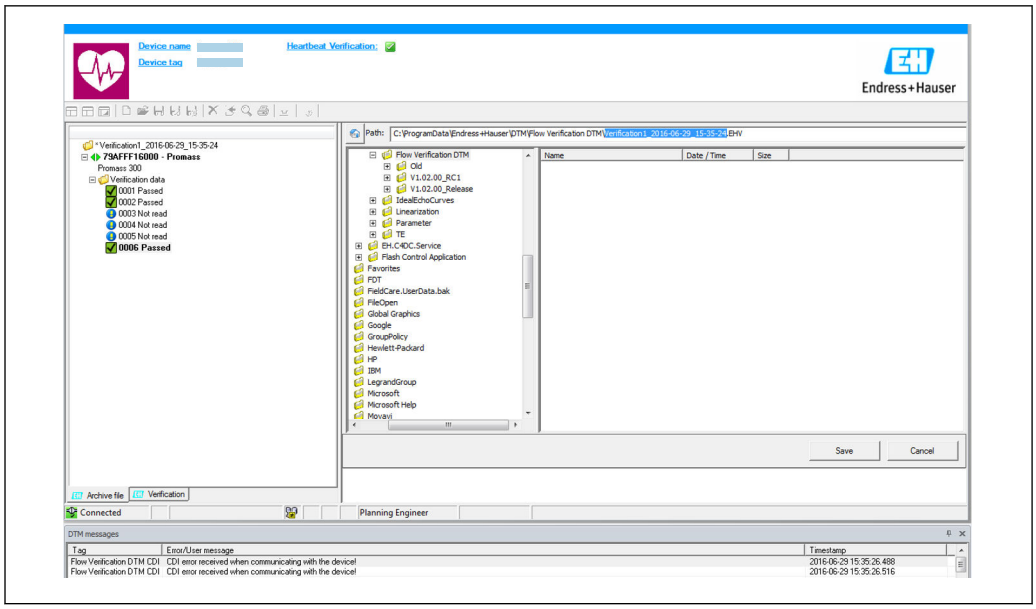
Verification results

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.



A0031427

5 Sample graphic

- Click the icons and .
  - 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

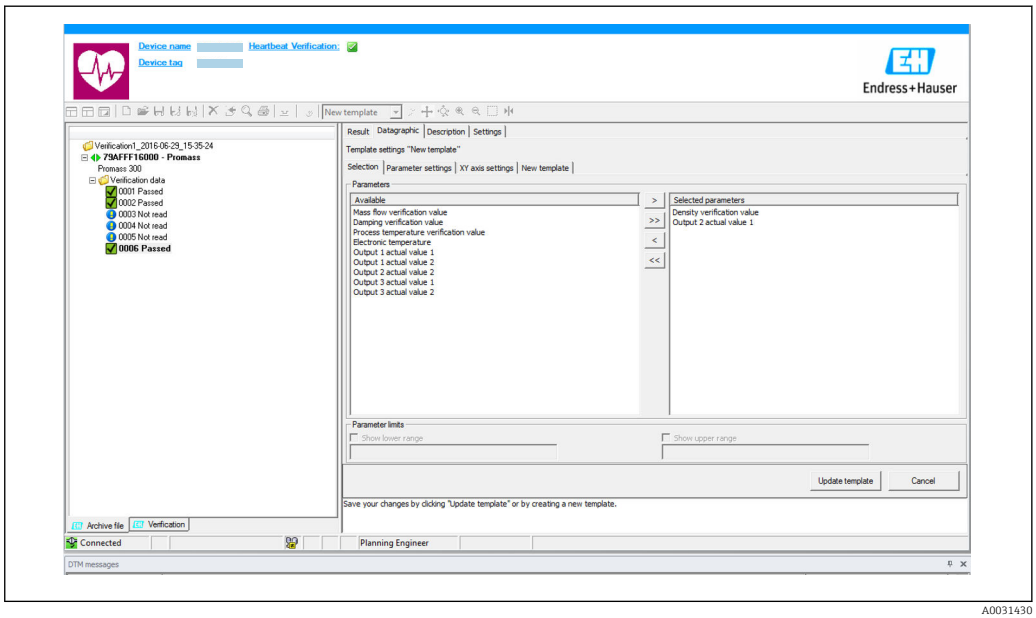
Open archive files already available.

- 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

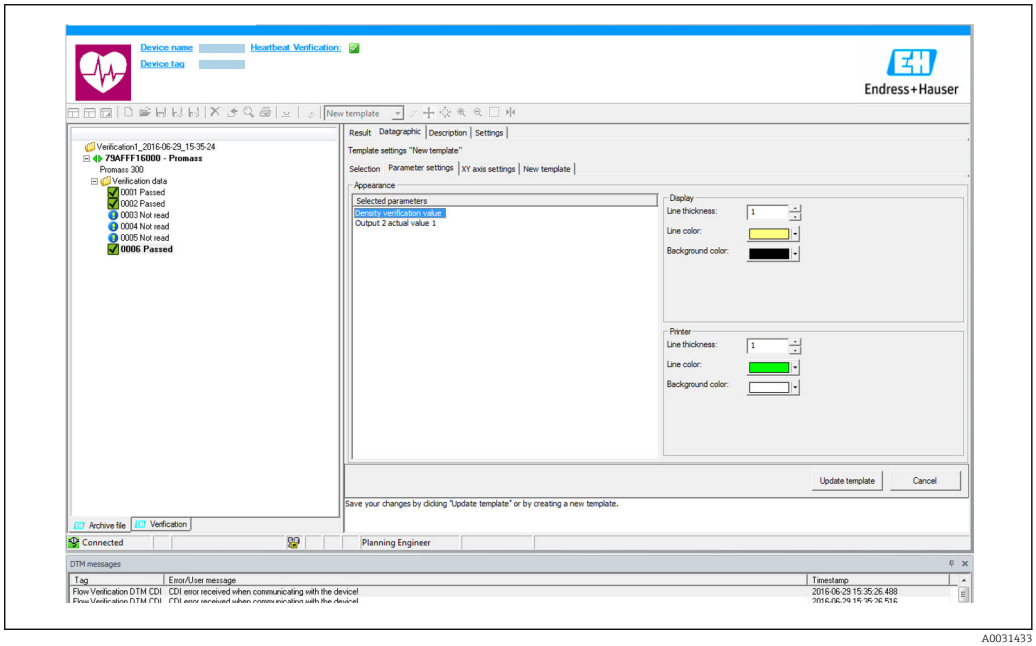


A0031430

6 *Sample graphic*

▶ Select the measured variables using the list displayed.

Visualizing a graph

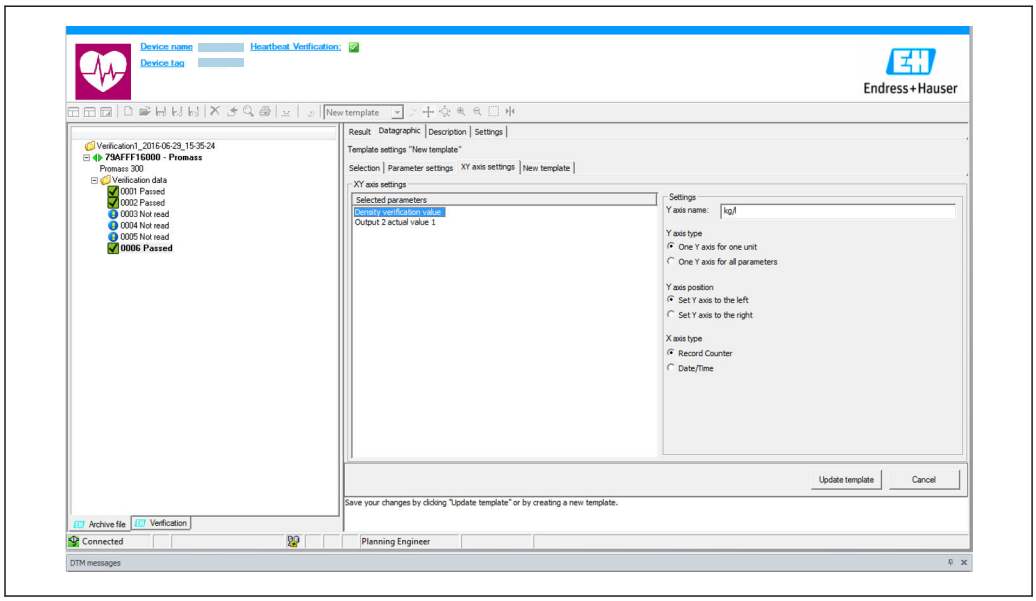


A0031433

7 *Sample graphic*

▶ Assign properties for visualization of the graph.

Configuring the Y-axis

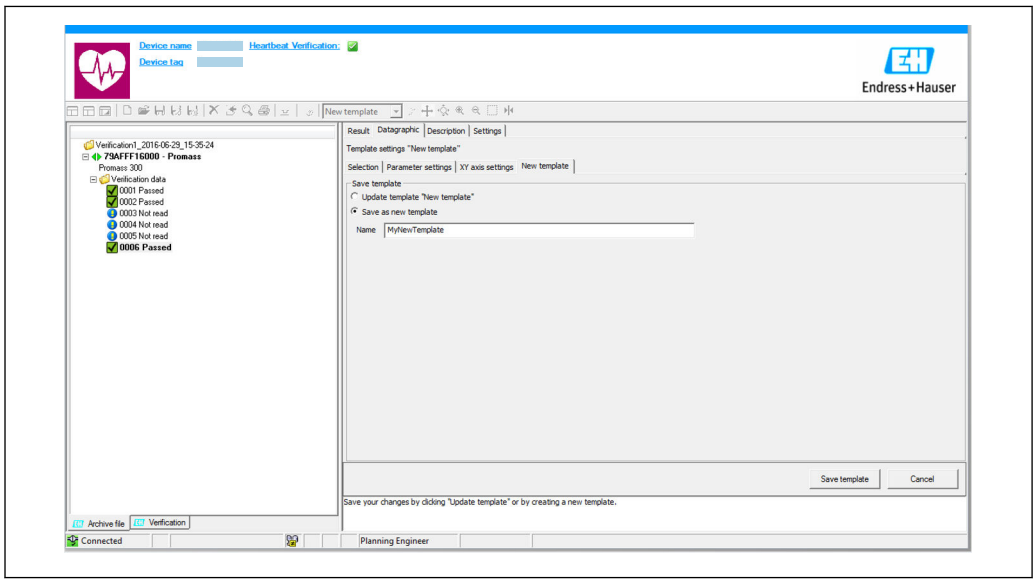


A0031434

8 *Sample graphic*

- Assign the measured variables of the Y-axis.

Update template or create new template

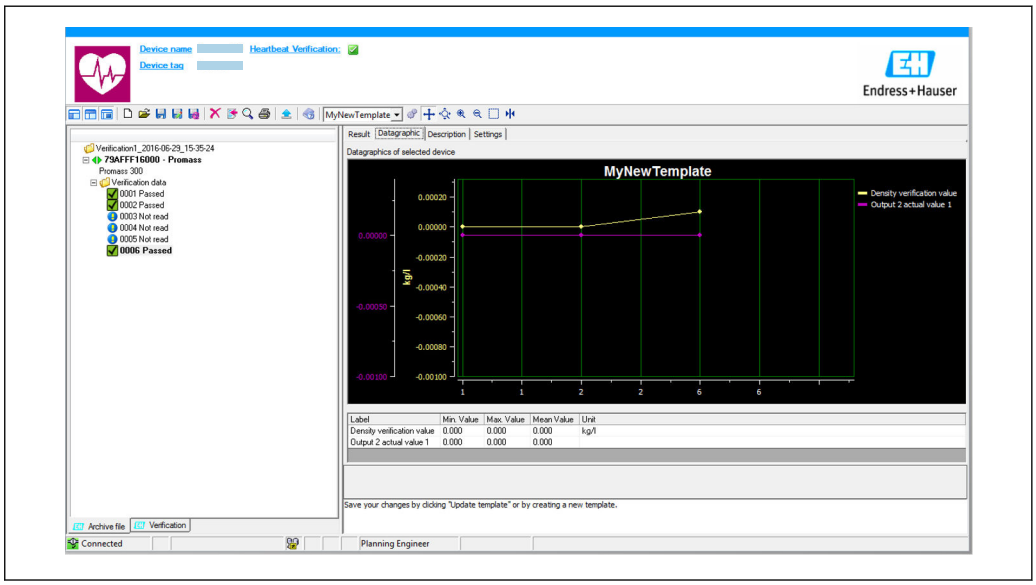


A0031437

9 *Sample graphic*

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

Showing the visualization trend



A0031438

10 Sample graphic

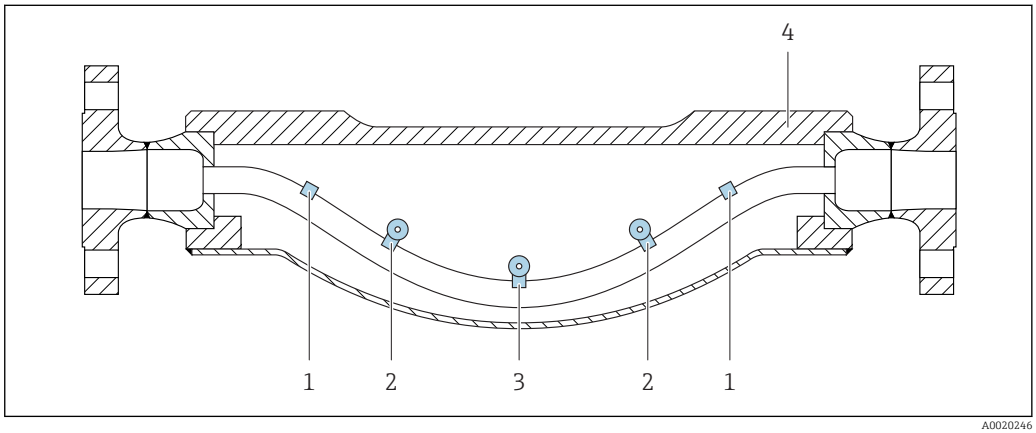
- ▶ Display the template.
  - ↳ The template shows the data in chronological order. The data points are referenced by the verification ID (X-axis), the Y-axis displays the parameters defined in the configuration.

Creating a verification report

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

7.3 Modules

Self-monitoring of the measuring device using Heartbeat Technology comprises the measuring chain from the sensor to the outputs. The table below lists the individual modules (test groups) and possible and recognized causes of errors.



A0020246

11 Model of a Coriolis sensor

1 Temperature sensor
2 Electrodynamic pick-ups
3 Electrodynamic excitation system
4 Sensor ground

Sensor module

Sensor module/test group	Test and recognized causes of errors
Sensor	Electrical testing of electrodynamic excitation system, electrodynamic pick-ups and temperature sensors. Testing of resistance and insulation: Detection of signal interruption, damping problems, short circuits, contact corrosion, wiring problems, mechanical damage, moisture inside the sensor and poor grounding.
HBSI	Check 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.), using a test value. HBSI: Monitoring of HBSI and detection of possible damage to the sensor resulting from excessive mechanical or thermal strain, wear and tear of the sensor (corrosion, abrasion, deformation, aging) or of individual sensor components, or the formation of coating in the measuring tube. These factors can result in increased measuring uncertainty.

Electronics module

Electronics module/test group	Test and recognized causes of errors
Sensor electronics module Main electronics module	Supply voltage, zero point monitoring, signal feedback, redundant reference clock monitoring and reference temperature monitoring in the electronics module: Detection of drift and aging among electronic components due to environmental or process influences (temperature, vibration etc.).
I/O module I/O electronics module	**Internal verification** ▪ Signal feedback in 4 to 20mA HART current output: Detection of drift and aging due to environmental or process influences (temperature, radiation, vibration etc.). ▪ Signal feedback of pulse/frequency output ▪ Signal feedback of current input ▪ Signal feedback of relay output **Internal verification** Detection of drift and aging due to environmental or process influences (temperature, radiation, vibration etc.). **External verification** ▪ External testing of all active outputs at the measuring device. ▪ Verification of the following outputs: – Signal feedback of current output 4 to 20mA – Signal feedback of pulse/frequency output

8 Application examples

8.1 Heartbeat Monitoring

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-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 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. These target applications are:
- 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. The parameters available with **Heartbeat Monitoring**, however, display a specific behavioral pattern for the applications listed above. This is explained in greater detail in the following chapters.

8.1.1 Overview of the monitoring parameters

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

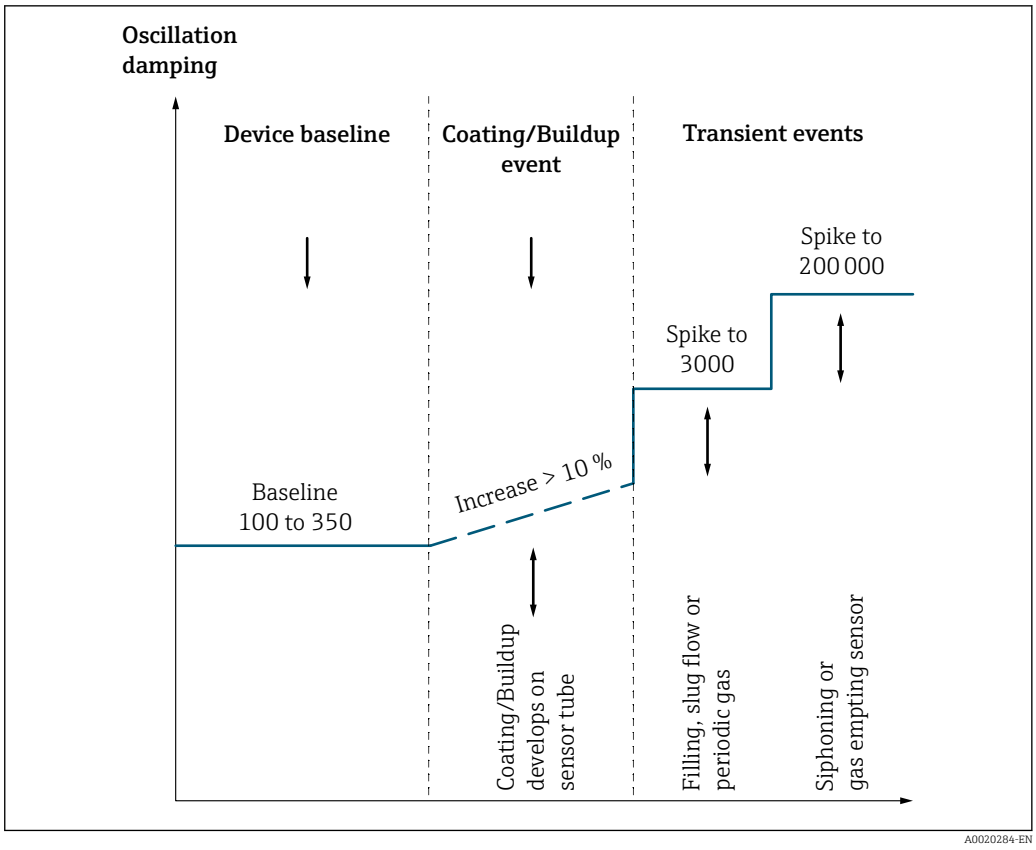
Monitoring parameter	Possible reasons for deviation
Mass flow	If the mass flow can be kept constant and can be repeated, a deviation from the reference indicates a zero point shift.
Density	A deviation from the reference may be caused by a change in the resonance frequency of the measuring tube, e.g. 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.

Monitoring parameter	Possible reasons for deviation
Temperature	Use this diagnostics parameter to check the functionality of the temperature sensor.
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, corrosion, abrasion).
Signal asymmetry	Use this parameter to determine whether the sensor signals are symmetrical.
Frequency fluctuation	A deviation in the frequency fluctuation is an indicator of rapidly changing process conditions, e.g. gas content in a liquid fluid.
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.
HBSI (Promass I only)	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 case of coating/buildup, fouling, abrasion or corrosion in the sensor: Inspect the sensor and 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 (pipework not insulated).

8.1.2 Oscillation damping

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 coating/buildup, fouling or corrosion. It can also indicate multiphase conditions. Oscillation damping is a variable that reacts in a linear manner to sensor excitation. Typical values range from between 70 to sometimes more than 500 000, e.g. for processes with multiphase fluids.

Tube damping fluctuation can be split 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.



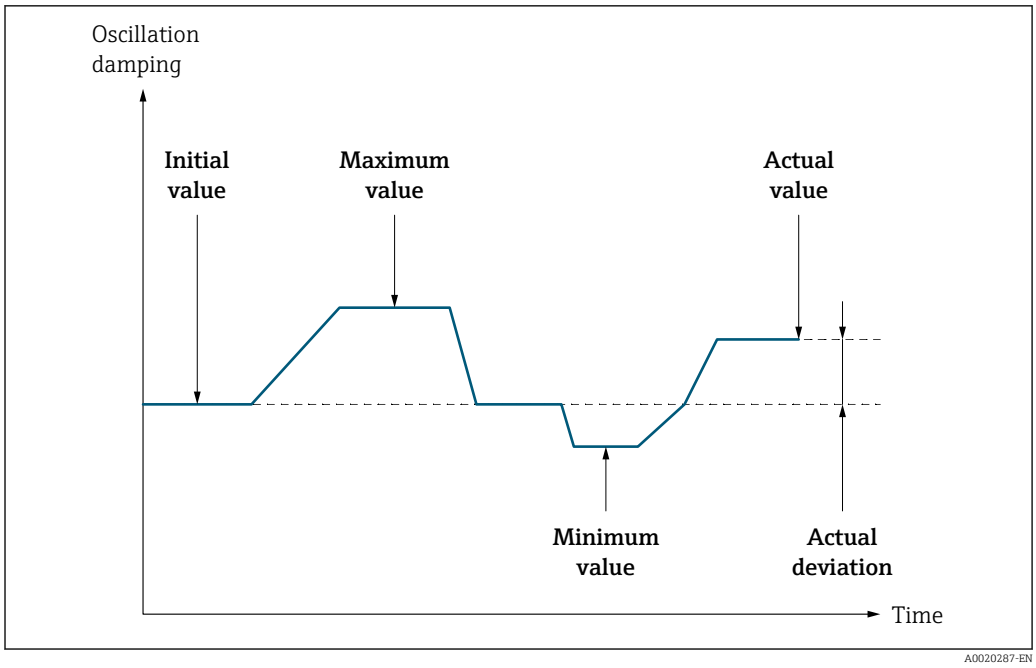
12 *Typical behavior in the event of coating/buildup*

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 probably due to the temporary process effects caused by entrained gas, or pipes running full or empty, and should be ignored.

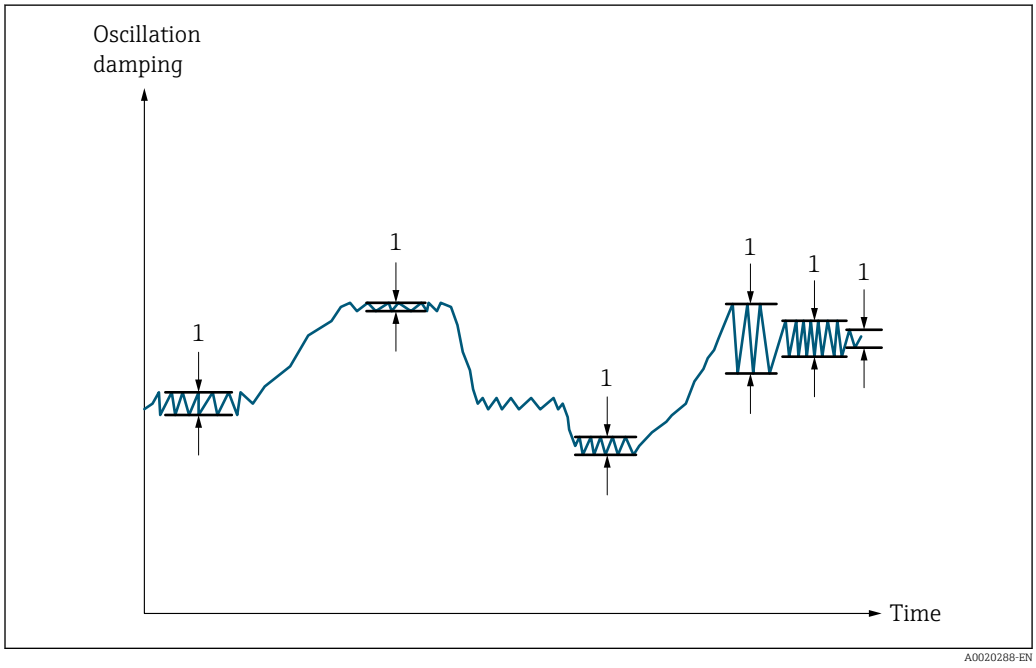
8.1.3 Oscillation damping and tube damping fluctuation

The current oscillation damping is output as an absolute value and is specific to the application. The initial value (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.



13 *Oscillation damping*

The tube damping fluctuation measured variable 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.



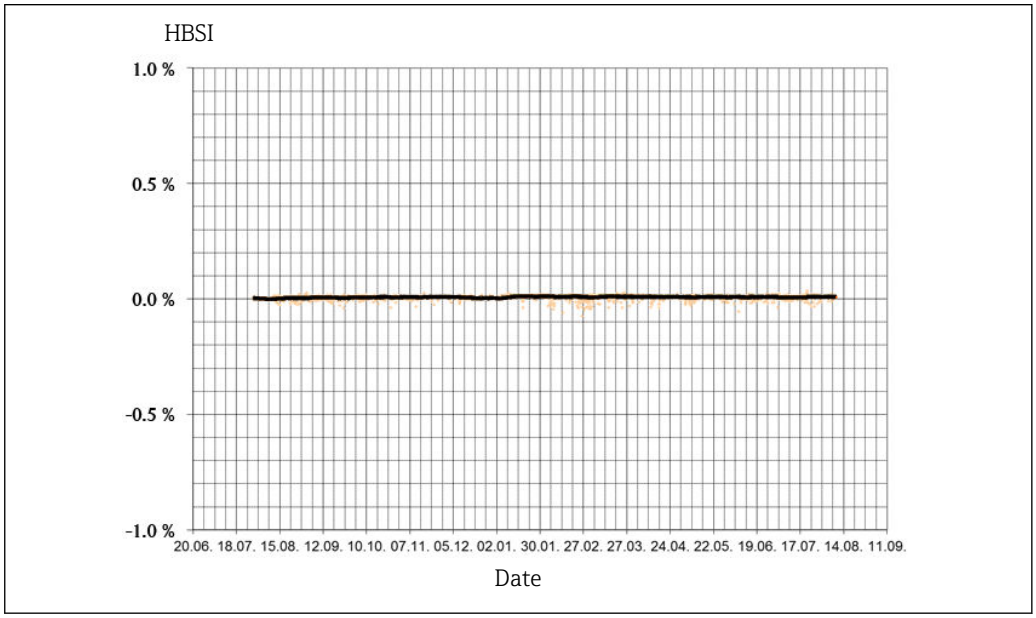
1 *Tube damping fluctuation*

8.1.4 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**. The factory reference condition applies for all process conditions – field reference values are not required.

Any deviation in the **HBSI** parameter 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, increased wear (e.g. corrosion, abrasion) or the formation of buildup in the measuring tube.

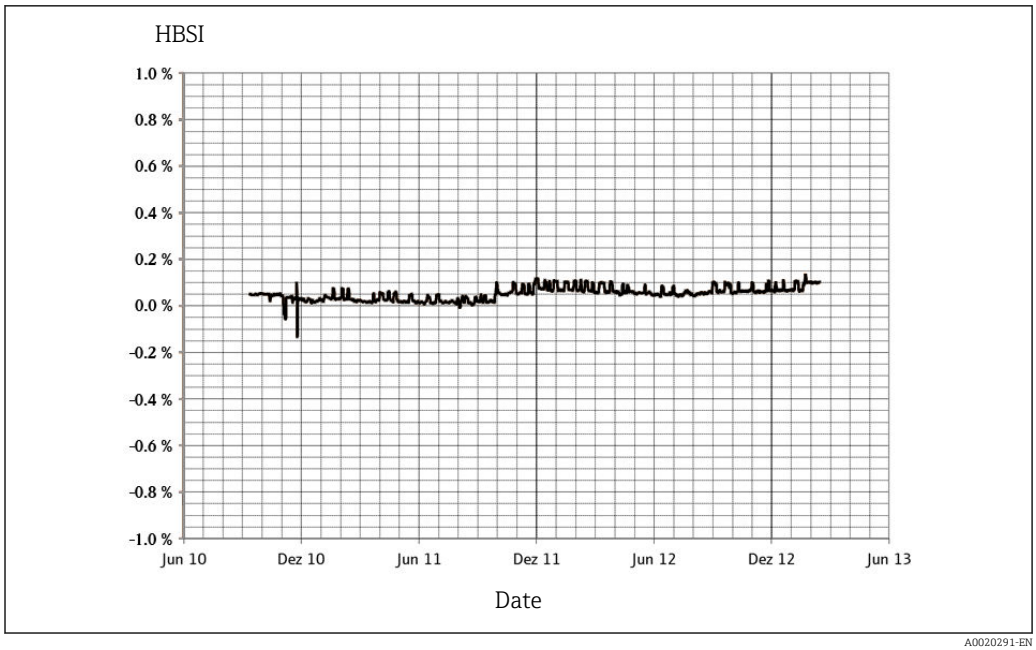
Application example 1
A Promass I (DN 50) flowmeter with a straight single-tube design in an application with mica sludge, which is a very abrasive fluid. The **HBSI** parameter is used to be able to detect measuring tube abrasion at an early stage.



Reason: A Promass F (DN 80) sensor with a curved dual-tube design was previously used in this application. After a few months, this sensor was so badly affected by the abrasive fluid that it broke down.

Since the changeover to Promass I no more abrasion has occurred in a period of over a year, as proven by the monitoring system.

Application example 2
Hastelloy version of Promass F (DN 15) for the measurement of highly corrosive acid chlorides.

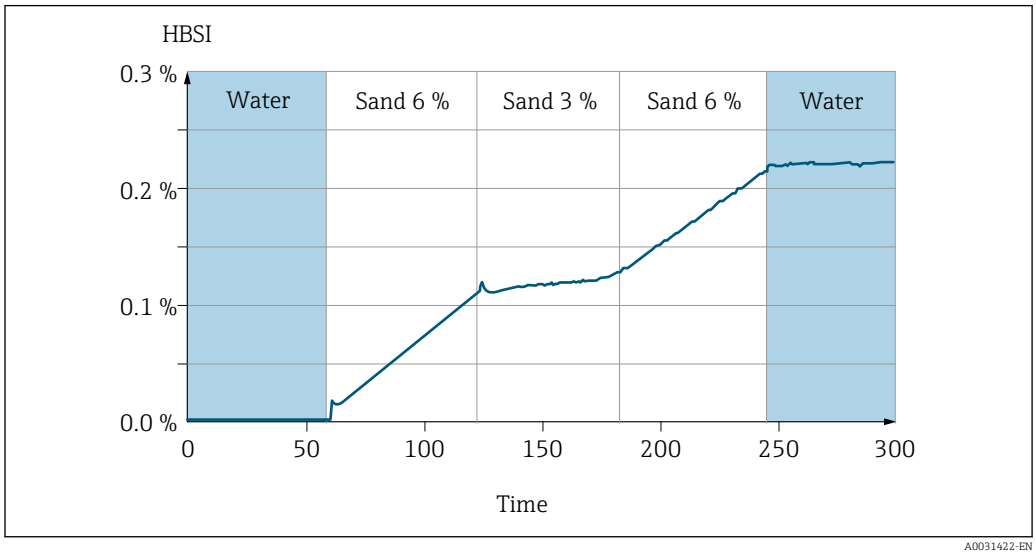


The **HBSI** parameter remains very stable (practically zero change) in the observation period of over two years. This is an indicator of the integrity of the measuring device.

Note: The small spikes in the measuring signal are caused by quick temperature changes in the process; this does not have a negative impact on the monitoring function, however.

Two qualification tests are explained below. These were performed specifically to qualify the **HBSI** parameter.

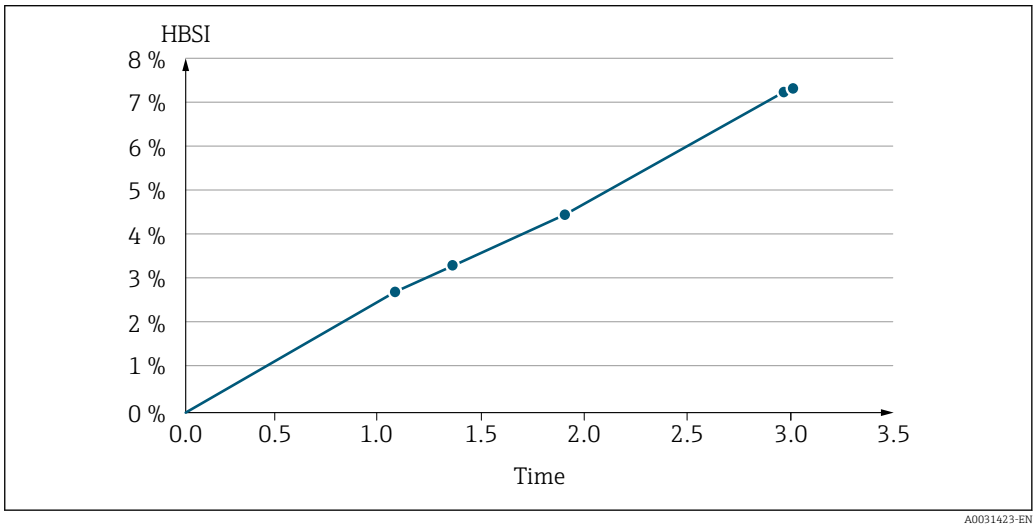
Qualification test 1
The aim of this qualification test was to prove the sensitivity of the **HBSI** parameter in the event of sensor abrasion caused by the process. During the test, a Promass I (DN 25) flowmeter is exposed to a water/sand mixture. Very abrasive sand is used especially for the test. The initial situation with water was documented in the first segment of the measurement. Then a water/sand mixture was used that contained 6 % sand, then approx. 2 to 3 % sand, and then 6 % sand again. Values with water were then recorded again as a reference on completion of the test.



14 *AbrasionPromass I*

Interpretation: A continuous change in the **HBSI** parameter can be observed under the process condition with 6 % sand content. This is a indication that this process condition is continuously wearing down the sensor. In the period under observation, the change is less than +0.3 %. The **HBSI** parameter (water – 3 % sand content – 6 % sand content) responds independently of the process conditions currently present, a fact which allows the reliable monitoring of the operating state.

Qualification test 2
The aim of this qualification test was to prove the sensitivity of the **HBSI** parameter in the event of sensor corrosion caused by the process. During the test, a Promass F (DN 25) flowmeter is exposed to a mixture of hydrochloric and nitric acid. **Heartbeat Verification** was performed periodically. The test was repeated until the sensor failed as a result of initial corrosion cracks.



15 CorrosionPromass F

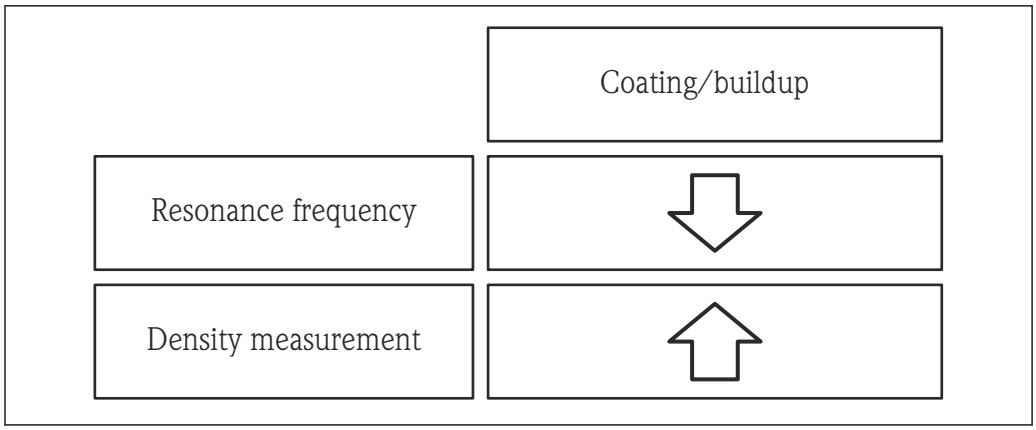
Interpretation: The **HBSI** parameter is suitable for diagnosing corrosion in the sensor. The parameter indicates a clear change – the sensor only fails when a deviation of +8 % occurs. This allows the user to reliably detect the process-specific influence, and avoid an unexpected sensor failure.

8.1.5 Application in the event of coating or build-up

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

Density
Mechanical changes to the tubes cause a shift in the (natural) resonance frequency. If the frequency drops, coating or build-up has formed in the tubes.



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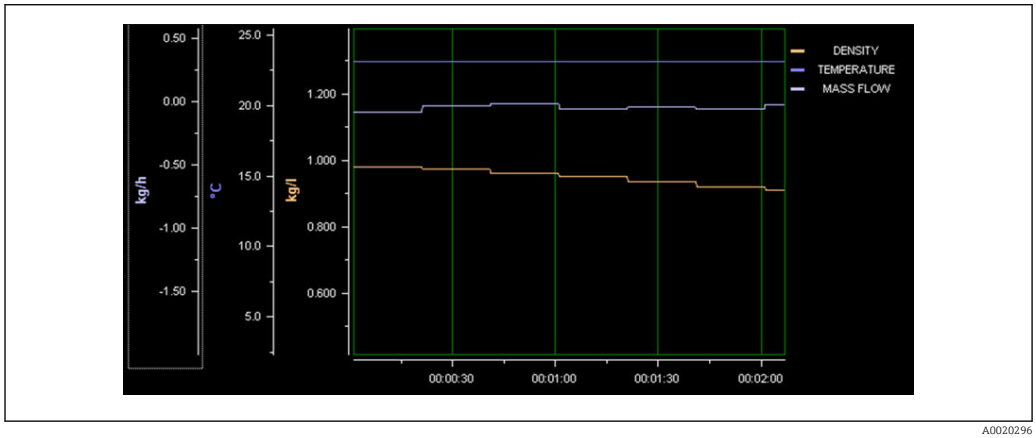
Each Coriolis device line size has a characteristic resonance frequency in air and water which correlates with the density. In the process, it is necessary to define what density values exist during commissioning. These values can then be monitored during the process. Either to see if there is a drift or to adjust the tolerance in order to provide an indication of process conditions (such as coating or buildup formation) and thereby trigger a cleaning, for example. This is explained in the graphic below:



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Oscillation damping
Oscillation damping is a number that defines the ratio of the excitation current to the oscillation amplitude of the tubes. Therefore, oscillation damping is a numerical expression of the distance the tube oscillates and the drive power required in milliamps to set the tube in motion. Oscillation damping provides an exponentially higher number compared to density measurement, which enables better detection of process-related changes. Many process applications need to isolate transient events which could compromise the detection of buildup or deposit formation. If a Coriolis sensor is commissioned in a process application, a sustained increase in oscillation damping will take place.

HBSI (Promass I only)
In typical cases of buildup or deposit formation in the measuring tube, in which soft deposits from the fluid build up in the measuring tube, there are no appreciable changes to the sensor that are identified as wear or excessive sensor strain as defined by HBSI. The actual value for HBSI is not changed in this case.
If thick or solid buildup such as limescale occurs, the sensor can change to the extent that a drop in the value for HBSI can be observed.

Interpretation

As coating or buildup forms, the measuring tube gets heavier. The measuring device recognizes this effect. The power supplied to the exciter current increases and the

amplitude distance that must be maintained in the Coriolis measurement and that is expressed as oscillation damping, needs to increase. A 10 % increase in oscillation damping results in an estimated 1 % offset in mass flow rate, while a decrease in resonance frequency of only 1 Hz is reported. The effects of buildup or deposit formation can cause a change in mass flow accuracy and a corresponding density change, resulting in a higher error overall for the volume flow.

8.1.6 Application in the event of corrosion and abrasion

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.

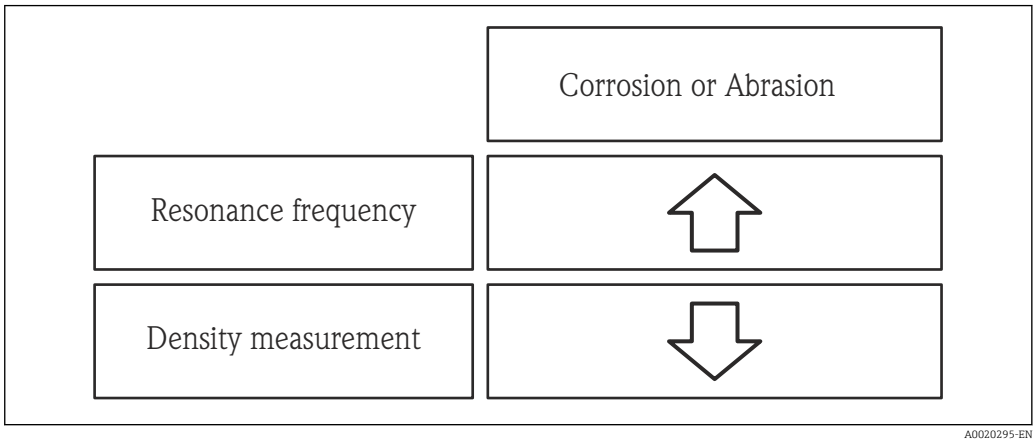
Suspicion that the process is causing corrosion in the measuring tubes of the measuring device. A user-defined variation level is used to trigger an alarm so that the tube can be replaced before a failure occurs.

The customer has a system which relies on a Coriolis measuring device for product transfer. This device undergoes a cleaning cycle seven times a day. The customer expects the measuring device's tube system to fail over time, creating a potential operator and disposal hazard. The customer would therefore prefer to replace the measuring system when an obvious drift in the tube reference condition occurs. The condition of the measuring device after cleaning provides a baseline reference value. Any excessive deviation from this value can indicate a change in the sensor.

Relevant monitoring parameters

The following parameters can give an indication of corrosion or abrasion:

Density
Mechanical changes to the tubes cause a shift in the (natural) resonance frequency. If the frequency increases, the tubes are eroded or corroded.



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Each sensor nominal diameter has a characteristic resonance frequency in air and water which correlates with the density. In the process, we have to define what density values exist during commissioning. We can then monitor them over the process to see if there is a drift or adjust the tolerance to provide an indication of process conditions, such as corrosion or abrasion.

Oscillation damping
Oscillation damping is a number that defines the ratio of the excitation current to the oscillation amplitude of the tubes. Therefore, oscillation damping is a numerical expression of the distance the tube oscillates and the drive power required in milliamps to set the tube in motion. Oscillation damping allows an exponentially higher number compared to density measurement, which enables better detection of process-related changes. Many process applications need to isolate transient events which could compromise the detection of buildup or deposit formation. If a Coriolis sensor is

commissioned in a process application, a sustained increase in oscillation damping will take place.

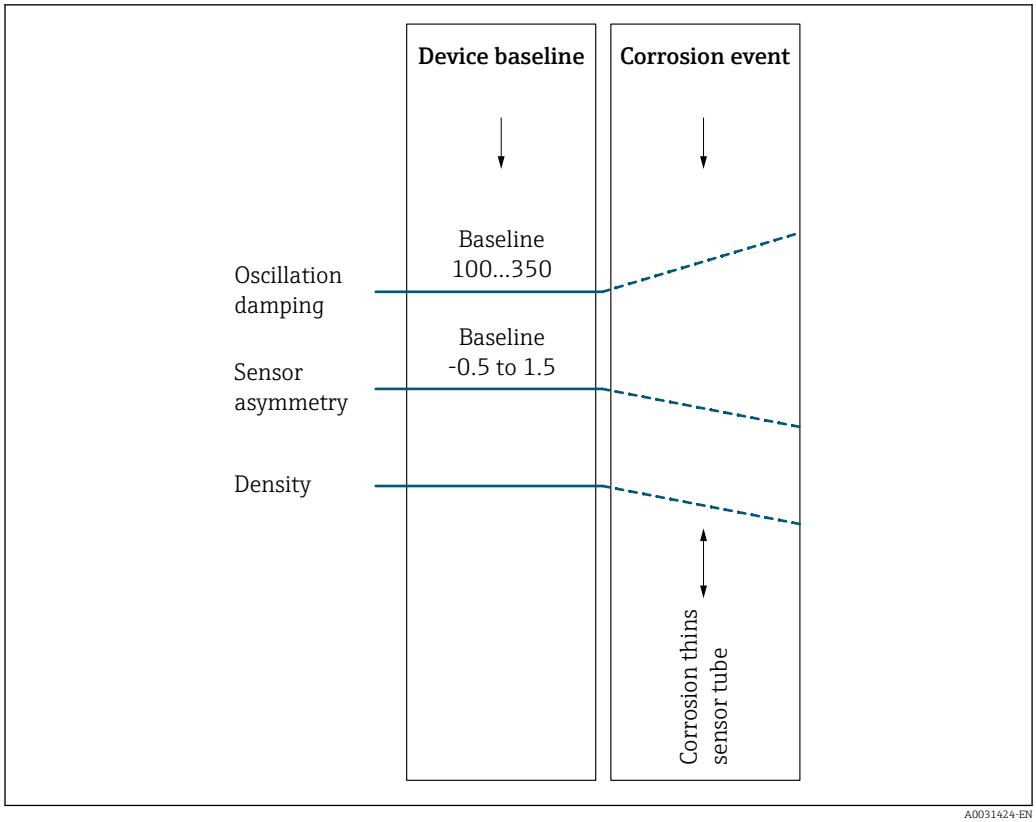
Sensor asymmetry
Corrosion or abrasion is never uniform from one end of the measuring tube to the other. Even the tubes in a dual-tube system do not display the same corrosion or abrasion patterns. Abrasion often occurs at the inlet, i.e. in areas of higher fluid velocity. Corrosion attacks the weak points of a measuring system and occurs at welds (flow splitters etc.). The sensor asymmetry value can be used to determine if the sensor balance and symmetrical movement between the inlet and outlet pickup points have changed. Since this system is manufactured as a mass balanced system, corrosion or abrasion will affect the balance. The impact of sensor symmetry, or the "sensor asymmetry value", is the electrochemical deviation (change) from the original sensor balancing baseline. This makes it possible to compare the baseline against process-related effects that indicate corrosion or abrasion in a Coriolis sensor.

HBSI (Promass I only)
An increase in the "HBSI" parameter may indicate increased wear or tear of the sensor due to corrosion or abrasion.

Interpretation

A review of the meter, e.g. on a quarterly basis, will indicate a slow deviation from the reference condition (situation at the time of commissioning).

Application example: Increase in oscillation damping of > 2 %, increase in sensor asymmetry of more than 150 %.



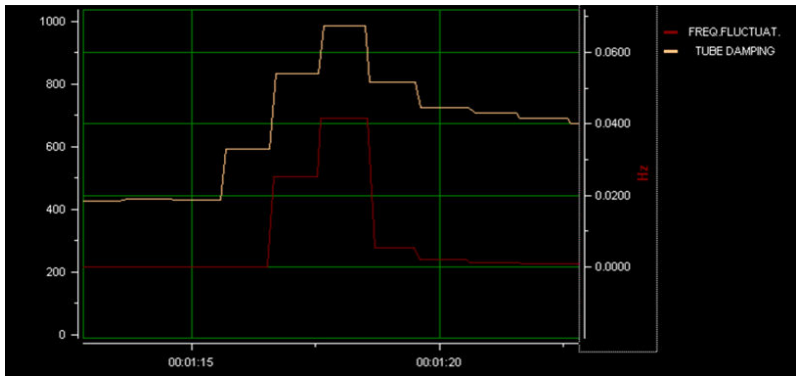
Recommendation: A change in the values for "Oscillation damping" or "Sensor asymmetry" "Oscillation damping", "Sensor asymmetry" or "HBSI" (Promass I only) "Oscillation damping" or "Sensor asymmetry" would also be a reason for a **Heartbeat Verification** to be performed on the measuring device to ensure a failure is not imminent.

8.1.7 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:
- Entrained air in liquids (gas content in liquid fluids)
- Wet gas

The example shown below relates to applications with air entrained in liquids:
Relevant monitoring parameters:
Oscillation damping
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 variable gas concentration and distribution of the gas in the liquid.

The example shown below relates to wet gas applications:
Relevant monitoring parameters:
- **Damping fluctuation**
  Due to the typically low viscosity values for gas, a threshold could start within the range of 1 000 to 5 000. Since the absolute value of tube damping depends on the gas velocity, meter type and meter size, there is no general good value for all measuring devices. In high-velocity applications, additional tube damping can be caused by harmonics inside the measuring tube, which means that a higher threshold will need to be set. As a guideline, we can use an increase-factor to determine the damping threshold. For example, if tube damping increases (from the damping value for static single-phase air or water) by a factor 3, we assume that the gas is wet.
- **Frequency fluctuation**
  This is a good indicator of wet gas, as the fluctuation in the frequency indicates that a fluid is not homogeneous. In addition, frequency fluctuation is more sensitive in a gas application due to the low viscosity of gases. A threshold could be as small as 0.0004 Hz or 0.0400 Hz, for example – this is a factor of 100 or even much higher. Values depend greatly on the application.
  Oscillation damping and frequency fluctuation increase if wet gas is present inside the measuring device. For this application with low gas density, relatively low values will need to be set.



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Example from the application:
Oscillation damping shows a maximum value of 1216 compared to the user reference value of 395. This corresponds to an adjustment factor of 12 as the gas became wet.
The maximum value for frequency fluctuation is 0.0498 Hz compared to the user reference value of 0.0000 Hz. This corresponds to a factor of 498 and shows how sensitive the deviation can be if the gas becomes wet.

8.2 Heartbeat Verification

8.2.1 Scope of the test

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 electronic 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.

8.2.2 Interpreting and using the verification results

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 with 100% total test coverage for compliance with the flow specification can only be achieved through validation of the primary measured variable (flow) by means of recalibration or proving.
- Heartbeat Verification confirms the device function within the specified measuring tolerance on demand with a TTC [3] > 95 %94 %.

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 verification. This applies in particular if the individual tests of the "Sensor" or "Sensor integrity" test groups are affected as a process-specific influence could then be possible.
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 create defined and stable process conditions and then to repeat verification:
Stabilize or stop flow, ensure that process temperature is stable, drain the sensor if possible.

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.

3) Total Test Coverage

Test group	Possible cause of error and recommendation
Sensor	Electrical components of the sensor (signals, circuits and cables): ▪ Wiring for remote installation ▪ Grounding of sensor ▪ Defect in the sensor → replace
HBSI	Excessive strain on sensor or sensor wear or formation of buildup in the measuring tube. ▪ Inspect the sensor, clean the measuring tube if necessary ▪ Faulty sensor → replace
Sensor electronics module	Electronic module for exciting the sensor and converting Electronics module drift or defect → replace
Main electronics module	Drift or aging of electronic components due to environmental or process influences (temperature, vibration etc.) Electronics module drift or defect → replace
I/O electronics module	**Internal verification** Detection of drift and aging due to environmental or process influences (temperature, radiation, vibration etc.). **External verification** External testing of all active outputs at the measuring device.
I/O module	Results of all the input and output modules installed on the measuring device ▪ Check wiring and connections, check the load (current output) ▪ I/O module drift or defect → replace
System condition	Test for active measuring device errors of "alarm"-type diagnostic behavior. The "Passed/Failed" result depends on the diagnostic behavior that is defined for the diagnostic event. If the "Alarm" diagnostic behavior is defined and the corresponding diagnostic event occurs, the result is "Failed". This also applies for customer-specific diagnostic events. If the "Warning" diagnostic behavior is defined, the diagnostic event is ignored.

For detailed information on diagnostics, see the "Diagnostics and troubleshooting" section of the Operating Instructions .

9 Glossary and terminology

Measuring device	Flowmeter in its entirety
Sensor	Entire sensor system. This comprises the measuring tube, the electrodynamic pick-ups, the excitation system, the wiring, the temperature sensors etc. inside the sensor housing.
Process interface	Mechanical interface between the flow sensor and the medium under measurement. The process interface is technology-specific: e.g. it is the measuring tube in the case of the Coriolis flowmeter, and the measuring tube liner in the case of electromagnetic flowmeters etc. Note: A deterioration in the process interface due, for example, to excess pressure, thermal shock, corrosion, abrasion or coating/buildup may mean that the measurement is outside of the specification, or may result in a dangerous operating state.
FieldCare	Software-based asset management system from Endress+Hauser. FieldCare is used for the documentation and analysis of the verification results.
On-board	Built-in device functionality. An on-board functionality enables on-line and in-line checks.
On-line	During an on-line check, the measuring device continues to perform its designated function. In any event, the process does not need to be interrupted for an on-line check. On-line checks can be continuous, periodical or event-controlled (e.g. following power-up).
In-situ	An in-situ check implies that the measuring device does not need to be removed from the application in order to perform the specific check. A reference condition can be established during the in-situ check (e.g. measuring tube filled with water or empty pipe condition). The test is usually performed on demand (e.g. **Heartbeat Verification**).
Internal references	Heartbeat Technology based on references that are incorporated into the measuring device (flowmeter electronics). References are technology-specific.
Flow calibration	This is the process which establishes a relation between the values of a flow standard (also known as a calibration rig) with its known measuring uncertainties, and the corresponding values of the flowmeter with its associated measuring uncertainties. Calibration may be performed with or without adjustment of the calibration factor.
Verification	This involves proving that a flowmeter complies with manufacturer specifications regarding functionality. It also serves as confirmation that the technical characteristics of the measuring device have been implemented, thereby increasing confidence in the measured variable (flow). Verification must not be confused with calibration.
Validation	A verification, whereby the manufacturer specifications are deemed adequate for the intended application.
Heartbeat Verification	A dedicated embedded instrumentation, the objective of which is to monitor the functionality of different components of the flowmeter in accordance with manufacturer specifications. It uses internal diagnostic tools to check flowmeter functionality based on factory references and corresponding specifications. **Heartbeat Verification** is not a calibration system.
Verification report	Document in which the results of the **Heartbeat Verification** are recorded.
Quantitative check	Check with a result that can be measured as "absolute or relative (additional) measuring uncertainty", e.g. a reference drift is proportional to the change of the actual flow.
Qualitative check	This is a check with a result that generally does not correlate to an additional measuring uncertainty, e.g. the effect of coating/buildup at the process interface to the flow can depend on the type and uniformity of the coating/buildup.
Off-line time	Off-line time is defined as a limited period of time in which a measuring device is unable to work normally (output actual process data) as it is busy with other tasks (e.g. performing a verification).

Data set	A data set permanently saves a collection of information that comprises the verification results, including the ID, time stamp, device parameters etc. A range of **Heartbeat Verification** data sets are stored internally in Proline flowmeters.
Metrological traceability	Characteristic of a measurement result based a reference using a documented and unbroken chain of calibrations. Each of these calibrations must be linked either to an international measurement standard or a national measurement standard for the intended quantity, in order to have a measuring uncertainty, a clear measurement procedure, accredited technical competence, metrological traceability to the SI (international system of units) and defined calibration intervals.
Condition Monitoring	The concept of Condition Monitoring is based on regular or continuous recording of the system status by measuring and analyzing meaningful measured variables. For the purpose of Condition Monitoring, **Heartbeat Monitoring** continuously provides measured variables in an external condition monitoring system.

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