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Valid as of version
01.00.zz (Device firmware)

Products   Solutions   Services

Special documentation
Proline Promag 400

Heartbeat Technology Application Package

Endress+Hauser [EH]

People for Process Automation

Table of contents

1   Document information

1.1   Document function

The document is part of the Operating Instructions and serves as a reference for application-specific parameters, providing a detailed explanation of each individual parameter of the operating menu.

1.2   Using this document

1.2.1   Information on the document structure

For the alignment of parameters with short descriptions according to the **Display/ Operation**, **Setup**, **Diagnostics** menu structure, Operating Instructions manual for the device.

For information about the operating philosophy, see the "Operating philosophy" chapter in the device's Operating Instructions

1.3   Symbols used

1.3.1   Symbols for certain types of information

Symbol	Meaning
ⓘ A0011193	**Tip** Indicates additional information.
📖 A0011194	**Reference to documentation** Refers to the corresponding device documentation.
📄 A0011195	**Reference to page** Refers to the corresponding page number.
🖼 A0011196	**Reference to graphic** Refers to the corresponding graphic number and page number.
▤ A0013140	**Operation via local display** Indicates navigation to the parameter via the local display.
▤ A0013143	**Operation via operating tool** Indicates navigation to the parameter via the operating tool.
🔒 A0013144	**Write-protected parameter** Indicates a parameter that can be locked against changes by entering a user-specific code.

1.3.2   Symbols in graphics

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

1.4   Documentation

This manual is a Special Documentation; it does not replace the Operating Instructions included in the scope of supply.

For detailed information, refer to the Operating Instructions and other documentation on the CD-ROM provided or visit "www.endress.com/deviceviewer".

The Special Documentation is an integral part of the following Operating Instructions:

Sensor	HART	EtherNet/IP	Modbus RS485	PROFIBUS DP
D	BA01061D	BA01212D	BA01229D	BA01232D
L	BA01062D	BA01213D	BA01230D	BA01233D
W	BA01063D	BA01214D	BA01231D	BA01234D

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 page:
  www.endress.com → Download

1.4.1   Content and scope

This Special Documentation contains descriptions f the additional parameters and technical data that are available with the Heartbeat Technology application package. All other parameters that are not relevant for Heartbeat Technology are described in the Operating Instructions.

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**).

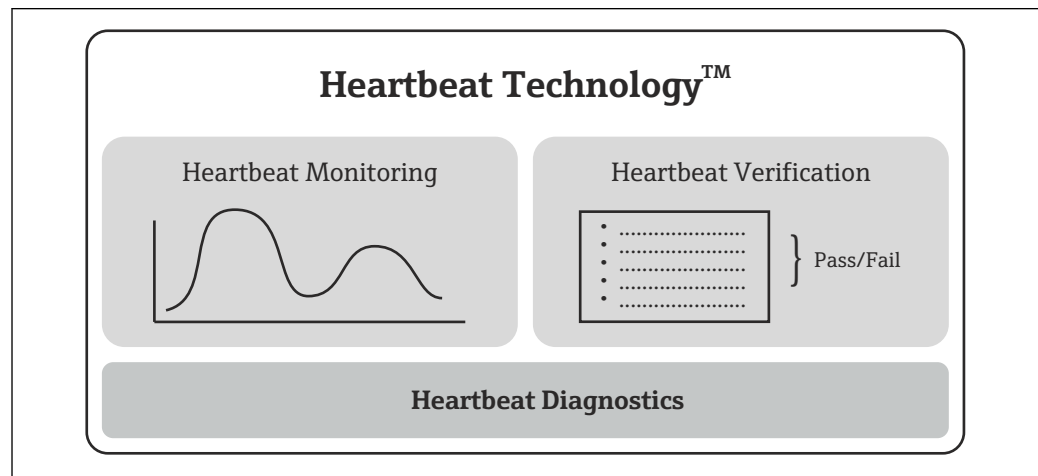*⊞ 1   Heartbeat Technology: Overview of modules and correlated functions*

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

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

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 (→ 🖹 14).

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.

List of currently available Proline Promag products:
• Proline Promag 400 HART
• Proline Promag 400 EtherNet/IP
• Proline Promag 400 Modbus RS485
• Proline Promag 400 PROFIBUS DP

Please contact your Endress+Hauser sales organization for further information.

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

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.

For information on how to enable the function (→ 🔖 14).

3   Product description

3.1   Overview

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**).

This Special Documentation complements the Operating Instructions and describes the additional functions that are available when the "Heartbeat Verification + Monitoring" option is ordered. The Special Documentation is an integral part of the Operating Instructions.

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.

The information gathered during self-monitoring is made available by the **Heartbeat Diagnostics**, **Heartbeat Monitoring** and **Heartbeat Verification** functions in a variety of ways (→ 🖹 6):

- 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 is a statement on the condition of the device: **Pass** or **Fail**.

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 remedial measures.

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

Advantages
- Continuous monitoring and integration with the higher-order system ensure that information on the condition of the measuring device is available in real time and 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 measures in the area of maintenance (such as cleaning) or process optimization. Ideally these measures can be implemented before the process safety or product quality of the application is affected.

The target applications for Promag Condition Monitoring are as follows:
- Magnetite-containing media
- Multi-phase fluids (gas content in liquid fluids)
- Applications in which the sensor is exposed to a programmed amount of wear
- Applications with cathodic protection systems
- Applications with pipes that are not grounded

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 (**Pass/Fail**) can also be relayed to this higher-order

system. The result of the verification is a statement on the condition of the measuring device: **Pass** or **Fail**. Data interpretation by the user is not required.

Aim

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

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
- Proof testing as part of functional safety (SIL)

4　System integration

For basic information on system integration, see the "System integration" section of the Operating Instructions.

The Heartbeat Technology functions are available via the digital interfaces. The functionalities can be used via an asset management system and the automation infrastructure (e.g. PLC).
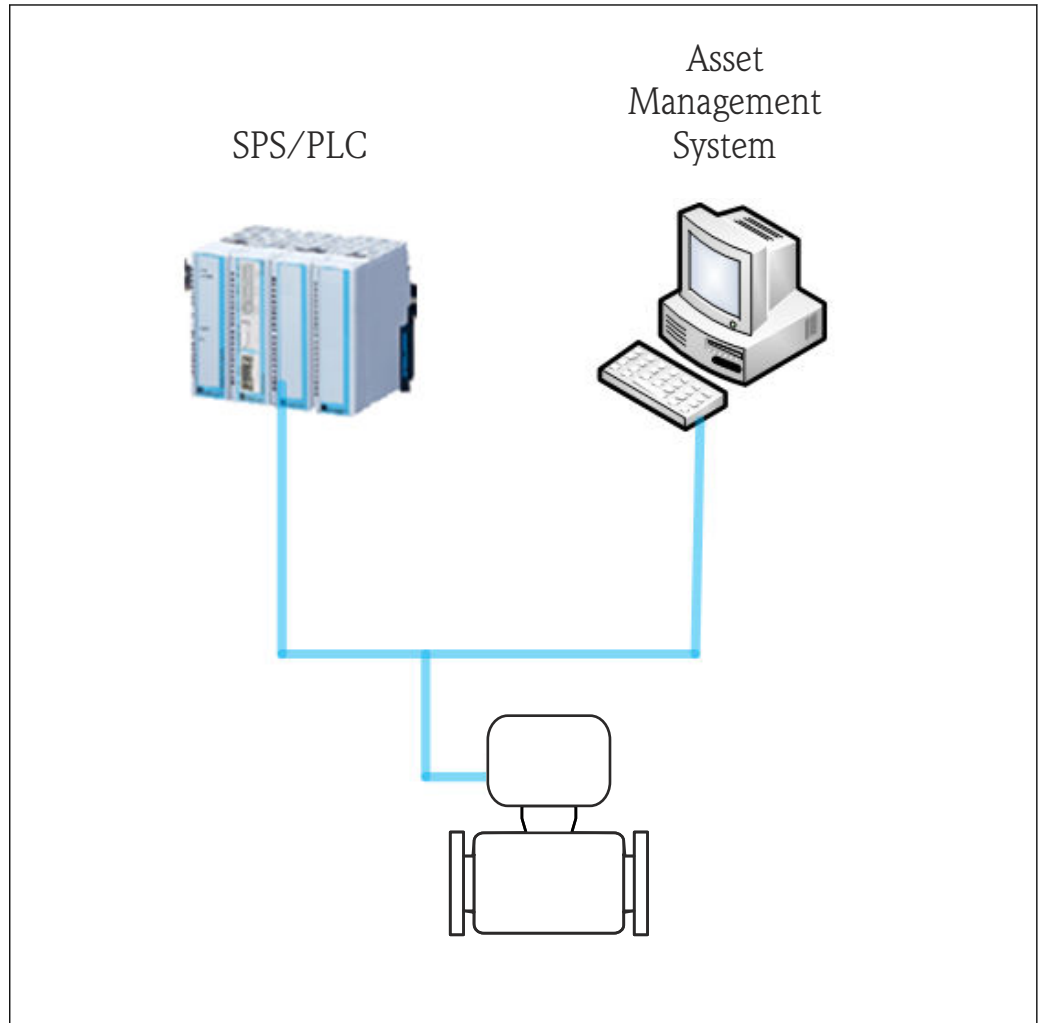
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Here, data exchange can be either automated or performed by a user.

4.1　Automated data exchange

Heartbeat Diagnostics	Heartbeat Monitoring	Heartbeat Verification
▪ Analyze field device diagnostics ▪ Diagnostic events for integration with the PLC	▪ Continuous trend analysis ▪ Additional monitoring of measured variables for processing in a Condition Monitoring system	▪ 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)

ℹ️ The fieldbus-specific implementation (Modbus RS485, EtherNet/IP, HART, PROFIBUS DP) 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:
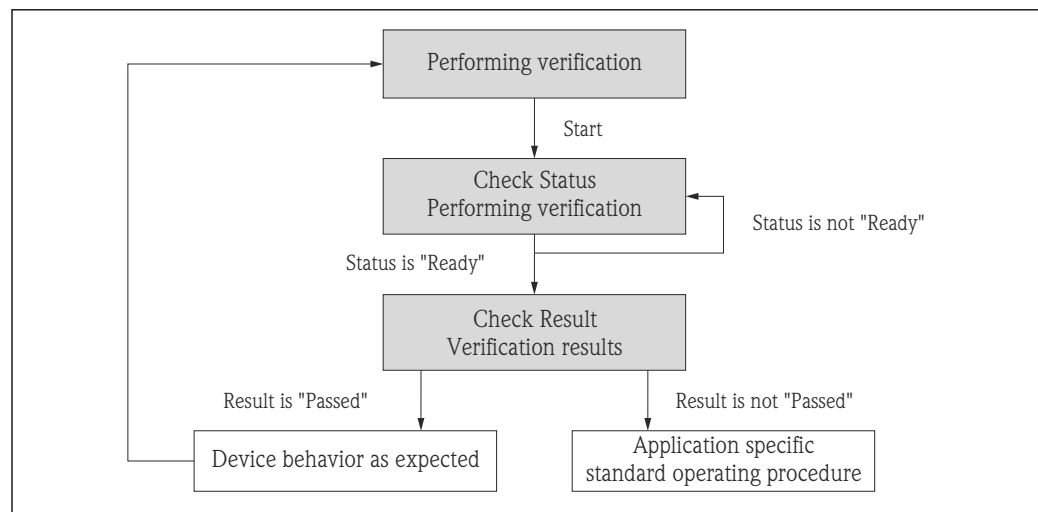
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- Verification performance:
  The verification is started using the "Start verification" parameter.
- Verification status:
  When verification is complete, the value of the "Status" parameter changes to **Ready**.
- Verification result:
  The overall result of the verification is indicated in the "Result" parameter. Different application-specific measures must be performed by the system depending on the result, e.g. a "Maintenance Required" alarm is triggered if "**Passed**" is not displayed as the result.

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

Heartbeat Diagnostics	Heartbeat Monitoring	Heartbeat Verification
• Identify remedial measures • Information on the cause of the error and remedial measures are provided in the asset management system	Configuration of the monitoring system	• Instrument verification via self-monitoring • Start verification Upload, archive and document verification results including detailed results

Data exchange performed by the user is described in the "Commissioning" (→ 🖹 14), "Operation" (→ 🖹 16) and "Heartbeat Technology – integration" (→ 🖹 30) sections.

5   Commissioning

5.1   Availability

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 option **EB** "Heartbeat Verification + Monitoring"
- In the operating menu:
  Check whether the function is indicated in the operating menu: Diagnostics → Heartbeat
  If the "Heartbeat" option is available the function is activated.

If the function cannot be accessed 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 upgrade the firmware.

5.1.1   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 activation function is available 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:
- HART: 01.04.zz
- EtherNet/IP: 01.00.zz
- Modbus: 01.00.zz
- PROFIBUS DP: 01.00.zz

5.1.2   Upgrade before activation

It is possible to upgrade Promag 400 generation "B" devices with Heartbeat Technology. To do so, the existing transmitter must be replaced.

To carry out this replacement, you will need a conversion kit from Endress+Hauser.

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

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.

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1)   www.endress.com/deviceviewer

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:
(→ 🖹 16)

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:

Parameter	Description	Value range
Noise	This parameter indicates the degree to which the differential signal from both measuring electrodes is dispersed	0 to $+3.0 \cdot 10^{+38}$
Coil current shot time	Shot time of coil current for buildup of magnetic field	2 to 500 ms
Reference electrode potential against PE	Voltage of reference electrode based on potential of measuring tube	−30 to +30 V

For information on using the parameters and interpreting the measurement results (→ 🖹 39).

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.

It is advisable to perform an initial verification when commissioning the measuring device or directly after activating the **Heartbeat Verification** function and to save the results as the initial situation in the life cycle of the measuring device (→ 🖹 16).

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 → Customer"
- "Setup → Advanced setup → Heartbeat setup → Heartbeat base settings → Location"
- "Expert → Diagnostics → Heartbeat → Heartbeat base settings → Customer"
- "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.

6.3.2 Product features

For basic information on the product features of **Heartbeat Verification**(→ 🖺 8). 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"

ℹ️ In the case of a device that is suitable for custody transfer measurement, custody transfer mode must be deactivated in order to use the **Heartbeat Verification** function.

For more information on deactivating custody transfer mode, see the "Custody transfer measurement" section in the Operating Instructions.

Measurement is interrupted briefly while the verification is being carried out. The output of measured values resumes; in the meantime, a "last valid value" is output. The interruption lasts for a maximum of 2 to 7 minutes, depending on the sensor type. The interruption to operation is indicated by a diagnostic message as well as a "Function check" status signal, see also "Diagnostic behavior" section(→ 🖺 17).

Verification types

The measuring device can be verified internally or externally.
– Internal: Verification is performed automatically by the device and without manual checking of external measured variables.
– External: Similar to internal verification but with the entry of external measured variables. During the verification process, measured variables are recorded manually with the help of external measuring equipment and entered into the measuring device (e.g. actual current at output). The value entered is checked and verified by the measuring device to ensure that it complies with the factory specifications. A (**Pass/Fail**) status is indicated, and this is documented as a partial result of the verification process and taken into account in the overall result.

Measured variables for external verification

• Reference voltage of measuring device:
The measuring device uses two internal reference voltages. The actual value of the reference voltages can be picked up at the sensor electronic module. The measured values of both test points are entered at the flowmeter (→ 🕮 19).
• Output current (current output):
Measured values are simulated by the flowmeter for each output that is physically present at the measuring device. A "Low Value" and a "High Value" are simulated in each case. Both measured values are entered at the flowmeter.
• Output frequency (pulse/frequency output):
Measured values are simulated by the flowmeter for each output that is physically present at the measuring device.
– Simulation value frequency output: Maximum frequency
– Simulation value pulse output: Simulated frequency depending on the pulse width configured
For additional information, see the "Configuring pulse/frequency/switch output" section in the Operating Instructions.

Diagnostic behavior

A diagnostic event signals that verification is being performed: Event "302 – Device verification active". The status signal switches to "C – Function check".
Factory setting: Warning. The output of measured values resumes; in the meantime, a "last valid value" is output. The signal outputs and totalizers are not affected.
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.

This diagnostic behavior is valid for internal and external verification.

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

Requirements 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

Performing external verification

ℹ Permanently predefined output signals are simulated during external verification of the outputs. These output signals do not represent the current measured value. This may have an effect on the higher-level system. In order to perform a verification, the current output and the pulse/frequency/switch output must be assigned to a measured variable.

Terminal assignment

A0021021
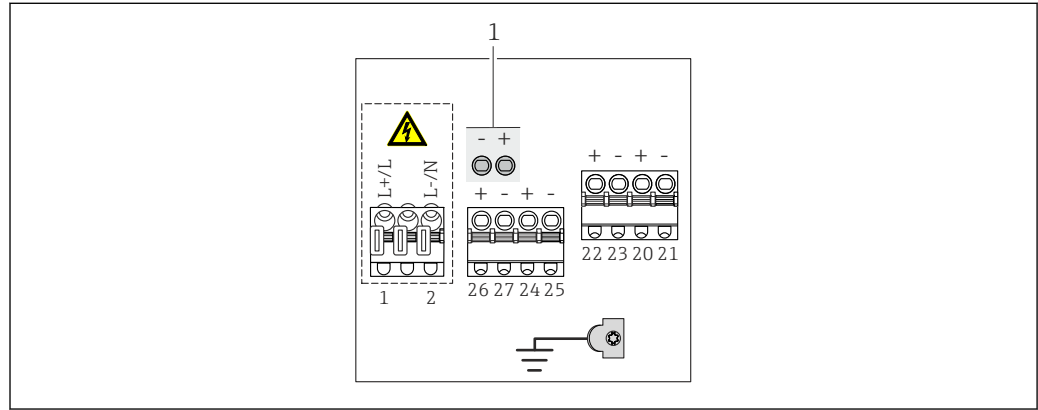
1   *Test points for current output (on the circuit board)*

Signal transmission 0-20 mA/4-20 mA HART with additional outputs and inputs

Order code for "Output" and "Input"	Terminal numbers							
	Output 1		Output 2		Output 3		Input	
	26 (+)	27 (-)	24 (+)	25 (-)	22 (+)	23 (-)	20 (+)	21 (-)
Option **H**	▪ 4-20 mA HART (active) ▪ 0-20 mA (active)		Pulse/frequency output (passive)		Switch output (passive)		–	
Option **I**	▪ 4-20 mA HART (active) ▪ 0-20 mA (active)		Pulse/frequency/ switch output (passive)		Pulse/frequency/ switch output (passive)		Status input	
Option **I** (Promag W only)	▪ 4-20 mA HART (active) ▪ 0-20 mA (active)		Permanently assigned Pulse output adjusted (passive)		Pulse/frequency/ switch output (passive)		Status input	

Verification of current output
For verification purposes, an ammeter is connected to the output.
Two methods are available:
– Without interrupting the electric circuit:
  The ammeter is connected to the test points of the current output.
  Advantage: The electric circuit to the higher-level system is not interrupted and is included in the verification.
– Direct measurement at the output terminals:
  The ammeter is looped into the circuit. To do so, it is necessary to break the existing connection to the higher-level system for a brief period of time.
  This method is particularly suitable for outputs which are not integrated with a system.
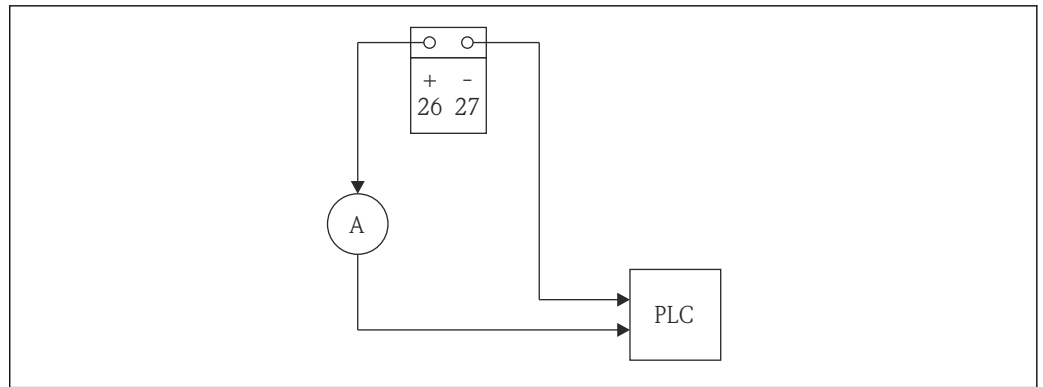
⊡ 2   *External verification of current output: Looping in of an ammeter (A)*

Current values are simulated during external verification. These are recorded by the measuring equipment and entered at the flowmeter.

Verification of the pulse/frequency/switch output
- For verification purposes, a frequency meter is connected to the output and the actual frequency recorded. For measurement purposes, it is necessary to connect the output to a power supply unit.
- During verification, a frequency value is simulated for pulse and frequency output.

Frequency values are simulated during external verification These are recorded by the measuring equipment and entered at the flowmeter.

Verification of reference voltage
To verify the reference voltage, a voltmeter is connected to the test points of the flowmeter. The test points are located on the sensor electronic module that is installed below the on-site display.
Assignment of test points:
– Middle: Mass potential (GND)
– Left and right: Reference voltage 1 and 2

During external verification, voltages are recorded using the measuring equipment and entered at the flowmeter.

To record the measured variables for external verification, the user receives instructions from the measuring device (see the following screenshot).

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Parameters for "Performing verification/Start"

Parameter	Description	Selection/ User entry	Factory setting
Year	Entry for date and time (field 1): Year verification is performed	9...99	10
Month	Entry for date and time (field 2): Month verification is performed	• January • February • March • April • May • June • July • August • September • October • November • December	January
Day	Entry for date and time (field 3): Day verification is performed	• 1...28 • 29 • 30 • 31	1
Hour	Entry for date and time (field 4): Hour verification is performed	• 1...12 • 0...23	12
AM/PM	Entry for date and time (field 5): Morning or afternoon	• AM • PM	AM
Minute	Entry for date and time (field 6): Minute verification is performed	0...59	0

Parameter	Description	Selection/ User entry	Factory setting
Verification mode	Selecting verification mode: • Internal: Verification is performed automatically by the device and without manual checking of external measured variables. • External: Similar to internal verification but with the entry of external measured variables (see also "Measured values" parameter).	• Internal • External	Internal
Information external device	Measuring equipment recording for external verification. i The option appears only if the **External** option has been selected in the "Verification mode" parameter.	Free text entry	–
External reference voltage 1 to 2	Input of external reference voltages. Reference voltage in [V]	–	–
Start verification	Start the verification i The option appears only if the **Internal** option has been selected in the "Verification mode" parameter.	• Cancel • Start	Cancel
Start verification	Start the 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". i The option appears only if the **External** option has been selected in the "Verification mode" parameter.	• Cancel • Current output 1 lower value • Current output 1 upper value • Frequency output 1 • Pulse output 1 • Frequency output 2 • Pulse output 2 • Start	Cancel
Measured values	Entry of external measured variables. Entries are made with the help of a wizard. • Current in [mA] • Frequency in [Hz]	–	–
Output values	References for external measured variables. • Current output: Output current in [mA] • Pulse/frequency output: Output frequency in [Hz]	–	–
Progress	The progress is displayed	0...100 %	0

Parameter	Description	Selection/ User entry	Factory setting
Status	Verification status • Ready: The last verification is finished and the device is ready for the next verification • Busy: The verification is running • Failed: A precondition for performing the verification is not met. The verification cannot be started (e.g. due to unstable process parameters) • Check not done: A verification has never been performed on this measuring device	• Ready • Busy • Failed • Check not done	Ready
Overall result	Overall result of the verification • 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: Verification was not carried out for any of the test groups (result for all test groups is "Check not done").	• Failed • Passed • Check not done	Check not done
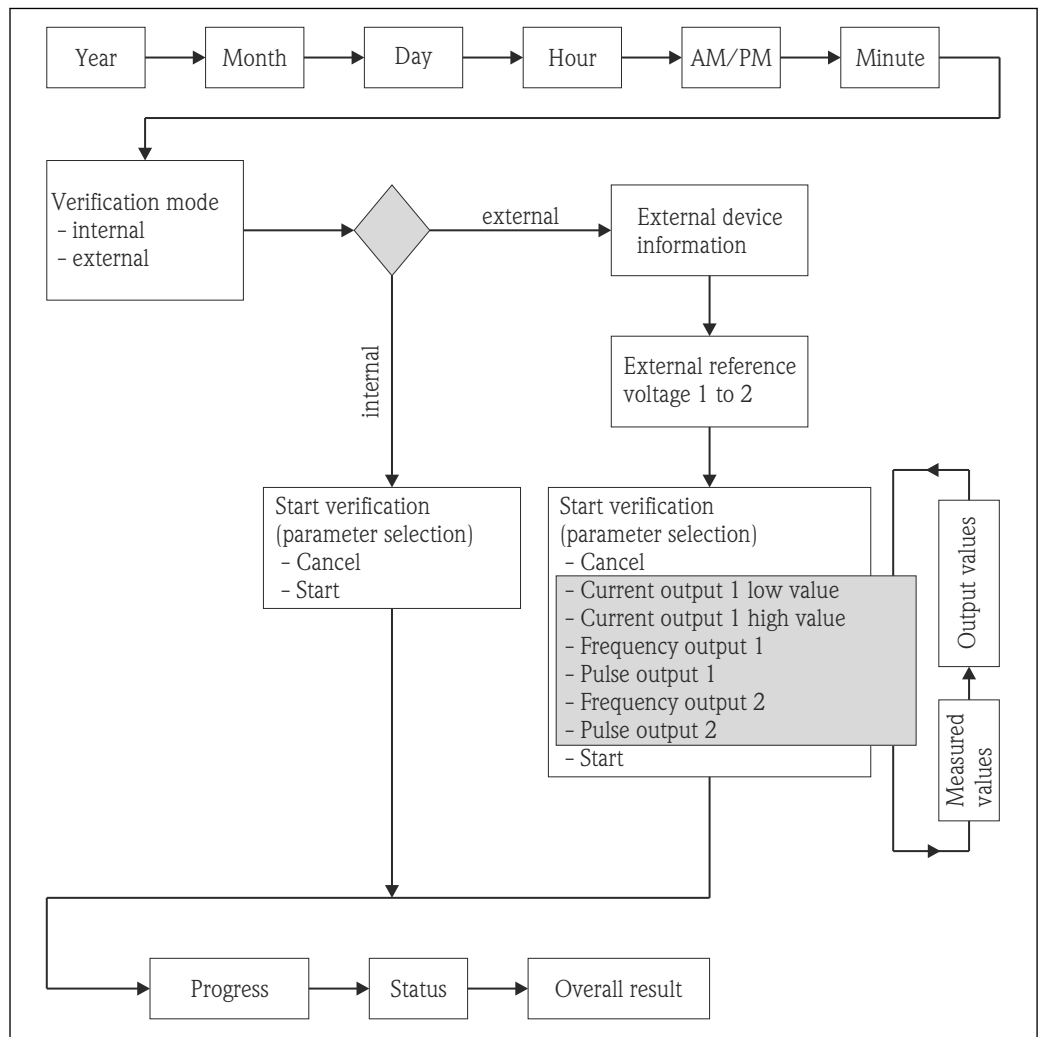
A0020942-EN

Comments for external verification of the reference voltage
In menu "External reference voltage 1 to 2" the actual value from the external measuring equipment is entered and confirmed by "Enter" key.

Comments for external verification of the outputs
Selection of Parameters:
- In menu "Start verification" the module to be verified is selected (parameter selection) and the selection confirmed by "Enter" key.
- In menu "Measured values" the actual value from the external measuring equipment is entered.

The above two steps are repeated for all modules. The external verification is completed by selecting the parameter "Start". This performs a verification of the complete measuring pint and verifies if the external input values are valid.

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"

Parameters for "Verification results"

Parameter	Description	Selection/ User entry	Factory setting
Date/time	Entry for date and time in real time	User entry	0
Verification ID	Consecutive numbering of the verification results in the measuring device	0...65535	0
Operating time	Operating time of the measuring device at the time of verification	–	–
Result	Overall result of the verification	• Failed • Passed • Check not done	Check not done
Sensor	Result for sensor test group	• Failed • Passed • Check not done	Check not done
Sensor electronic module	Result for sensor electronic module test group	• Failed • Passed • Check not done	Check not done
I/O module	Result for I/O module test group	• Failed • Passed • Check not done	Check not done

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 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
  Only the 4-20 mA HART output is verified during internal verification.
  During external verification, all 4-20 mA current and pulse/frequency outputs are verified.

For more information on the test groups and individual tests (→ 🔖 24).

Interpretation
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		
Coil current shot time	Monitoring of symmetry in the exciter circuit for coil current shot times while both field polarities are changed	No value range Passed / Failed
Coil hold voltage	Monitoring of symmetry in holding voltages of exciter circuit for driving the coil current for both field polarities	No value range Passed / Failed
Coil current	Monitoring of coil current at input/output	No value range Passed / Failed
"Sensor electronic module" test group		
Reference voltage	Monitoring of reference voltages in flowmeter circuit and exciter circuit	No value range Passed / Failed
Reference voltage with external verification	External verification of reference voltages in flowmeter circuit and exciter circuit	No value range Passed / Failed
Linearity of electrode signal amplifier	Monitoring of flowmeter circuit with regard to gain and linearity	No value range Passed / Failed
Offset electrode signal amplifier	Monitoring of flow measurement amplifier with regard to zero point	No value range Passed / Failed

Parameter/individual test	Description	Result/limit value
"I/O module" test group		
I/O module	I/O module monitoring For current output: Accuracy of the current For frequency output: Accuracy of frequency (for external verification only)	For current output: • ±1 % • ±100 µA For current output (for external verification only): • ±1 % • ±10 µA For frequency output: ±0.3 %

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
Verification value conductivity	Actual measured value for medium conductivity (if switched on)
Process temperature verification value	Actual measured value for medium temperature (if available)
Verification value volume flow	Actual measured value for volume flow
Electronics 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.

Creating the verification report
(→ 🖺 31)

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 included 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

Verification report flowmeter

Customer	Mr. Smith

Device information

Location	Device tag
Location 14	M-745
Module name	**Nominal diameter**
Promag W	DN25
Device name	**Order code**
Promag 400	5W4C25-725
Serial number	**Firmware version**
1234567890	01.00.00

Calibration

Calibration factor	Zero point
1.15	10

Verification information

Operating time	Date/time
12 d 15 h 32 min 12 s	01.12.2010/12:00
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 given:
- For devices with the Heartbeat Verification enabled software option
- For verifications, carried out by the Endress+Hauser Service, or an authorized Endress+Hauser service provider

Date	Customer's signature	Operator's signature

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🖻 3   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 (→ 🗎 24)

Verification report   Endress+Hauser [E+H]
                                                 People for Process Automation

Verification report flowmeter

For serial number: 1234567890
Detailed results of verification ID: 17

Sensor	✓ Passed
Coil current shot time	✓ Passed
Coil hold voltage	✓ Passed
Coil current	✓ Passed
Sensor electronic module	✗ **Failed**
Reference voltage	✓ Passed
Linearity of electrode measuring circuit	✗ Failed
Offset of electrode measuring circuit	✓ Passed
I/O module	✓ **Passed**

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⊠ 4   *Verification report, internal verification (Page 2)*

Verification report

Endress+Hauser
People for Process Automation

Verification report flowmeter

For serial number: 1234567890
Detailed results of verification ID: 17

Sensor	✅ Passed
Coil current shot time	✅ Passed
Coil hold voltage	✅ Passed
Coil current	✅ Passed
Sensor electronic module	❌ **Failed**
Reference voltage	✅ Passed
External reference voltage	✅ Passed*
Linearity of electrode measuring circuit	❌ Failed
Offset of electrode measuring circuit	❓ Check not done
I/O module	✅ **Passed**
Output 1	✅ Passed*
Output 2	❓ Check not done*
Output 3	✅ Passed*

*External verification

Information about the external verification

Fluke 2354, Cal: 10.0.2012, F. Maier

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🖻 5   *Verification report, external verification (Page 2)*

Data administration using web server and FieldCare verification DTM
(→ 🖹 31)

7 Function

7.1 Calibration and self-monitoring using Heartbeat Technology

The Heartbeat Technology function is based on reference values that are recorded during the factory calibration or series-specific limit values. Device-internal parameters (measuring points) that are correlated with flow measurement (secondary measured variables, comparative values) are recorded during the calibration. The reference values for these parameters are stored permanently in the measuring device and act as the basis for Heartbeat Technology and particularly for the **Heartbeat Verification** function integrated in the measuring device. Throughout the life cycle of the flowmeter, the **Heartbeat Verification** function checks whether the measuring points deviate from the reference condition defined at the time of the calibration and indicates if the deviation is outside the factory specification. The validity of the testing method is additionally ensured by redundant components and signal feedback (feedback loop). This ensures that any component drift is detected.

7.2 Heartbeat Technology - integration

The Heartbeat Technology function is accessible via all the operating interfaces.
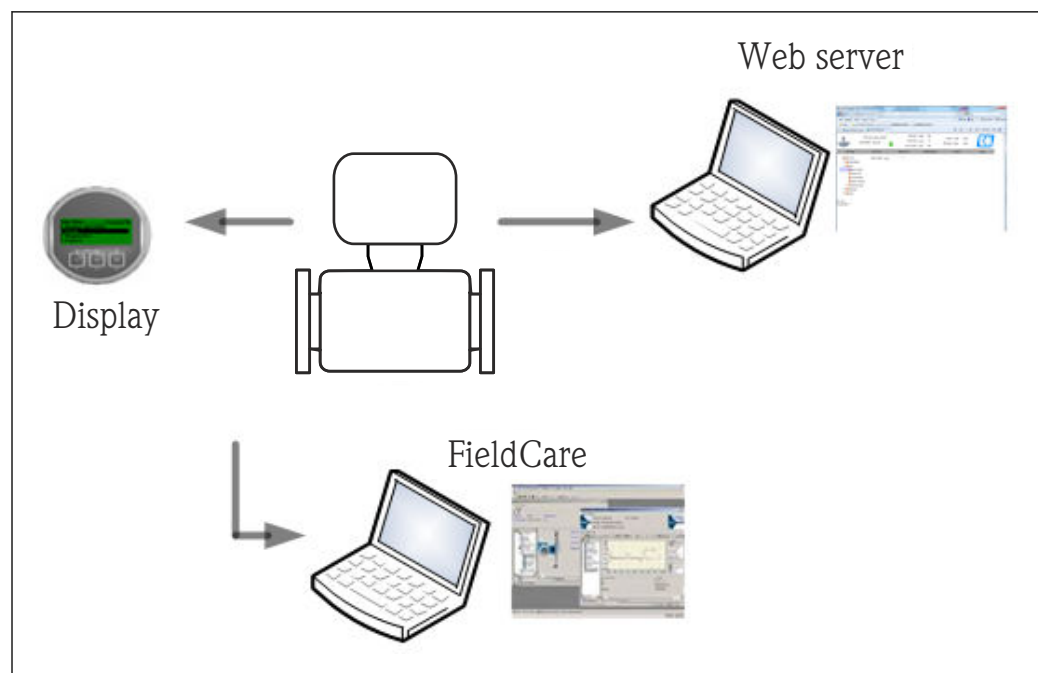
A0020243-EN

In addition, it is possible to access the function 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.

A0020244-EN
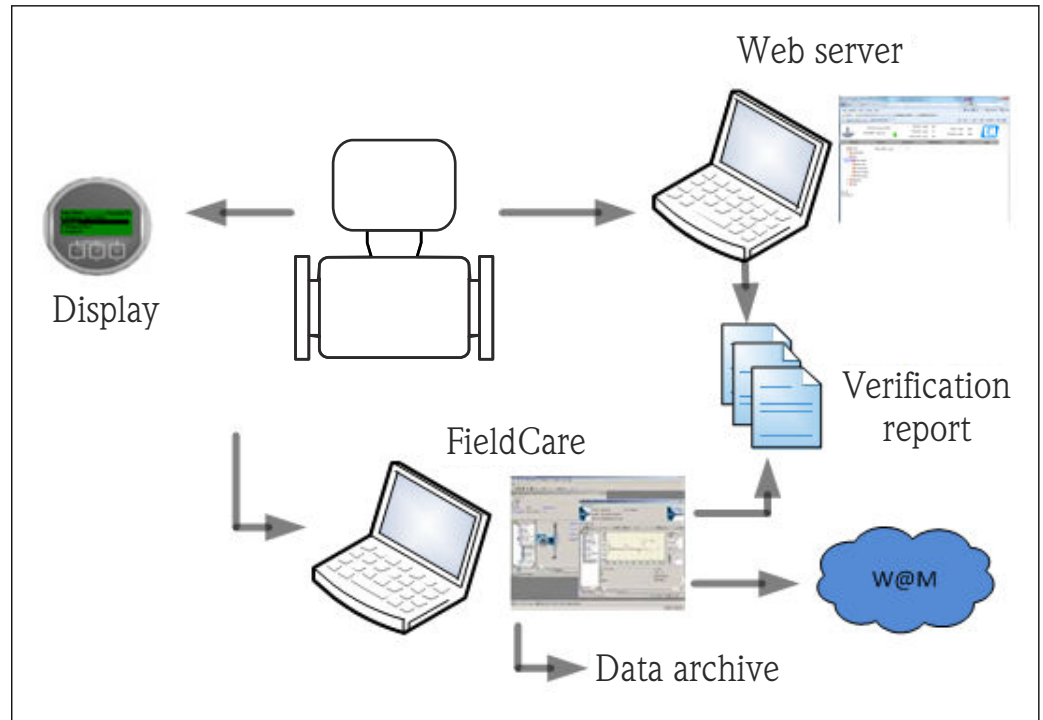
The creation of verification reports is supported by both the Web server integrated in the measuring device and Endress+Hauser's FieldCare asset management software. The FieldCare DTM module for verification also offers the possibility of archiving the verification results and reports to create traceable documentation.

7.3   Heartbeat Verification – data management

The results of a **Heartbeat Verification** are saved as a non-volatile parameter set in the measuring device memory.

Eight storage areas are available for parameter sets.

New verification results overwrite older data on a "first in – first out" basis.

The results can be documented in the form of a verification report via the Web server and Endress+Hauser's FieldCare asset management software. In addition to the option of printing out the results in a verification report, FieldCare also offers a DTM for archiving the results of the verification. Furthermore, with FieldCare it is also possible to export data from these archives and to analyze trends in the verification results (line recorder function). For details see the "Description of the Verification-DTM" section.

7.3.1   Data management using web server

Print verification report

Using the web server, the menu for printing the verification reports can be accessed via the "Data management" tab. The information on "Customer" and "Location" can be entered in the relevant areas. The information entered here appears in the verification report.

In the "Select result dataset" area, the desired data set with verification results can be selected; verification data sets are referenced by time stamp in the drop-down menu.

If you select "VerificationReport.pdf", a verification report is generated in PDF format.
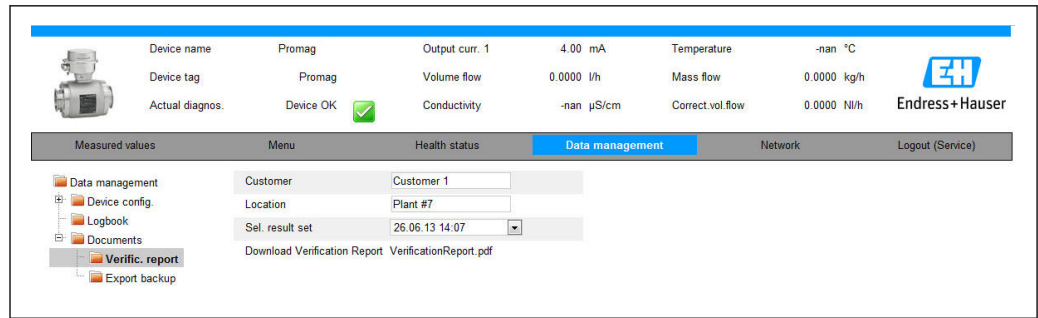
A0020878-EN

Export of verification results

The verification results (raw data) can be exported to a CSV file using the "Backup export → Export parameter" function. Clicking on "Parameters.csv" generates a file in CSV format. This format can be easily converted to a spreadsheet.
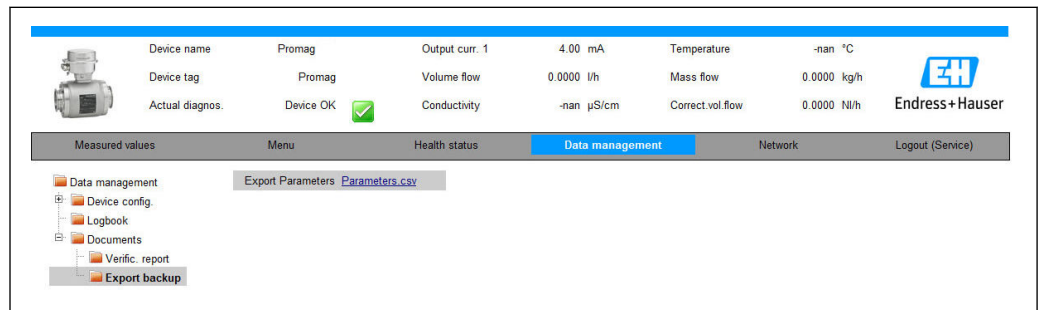
A0020886-EN

7.3.2   Data management with Verification DTM

Description

A special DTM for **Heartbeat Verification** is also available in addition to the standard device DTM. This Verification-DTM offers advanced capabilities for performing the verification and managing the results.

Basic functions

The following basic functions are provided:

A0020273	Start uploading the verification data sets from the measuring device to the asset management tool (FieldCare)
A0020274	Reset the DTM to the initial state
A0020275	Open saved archive files
A0020276	Save data sets to an existing archive file or initial saving of data sets to a new archive file

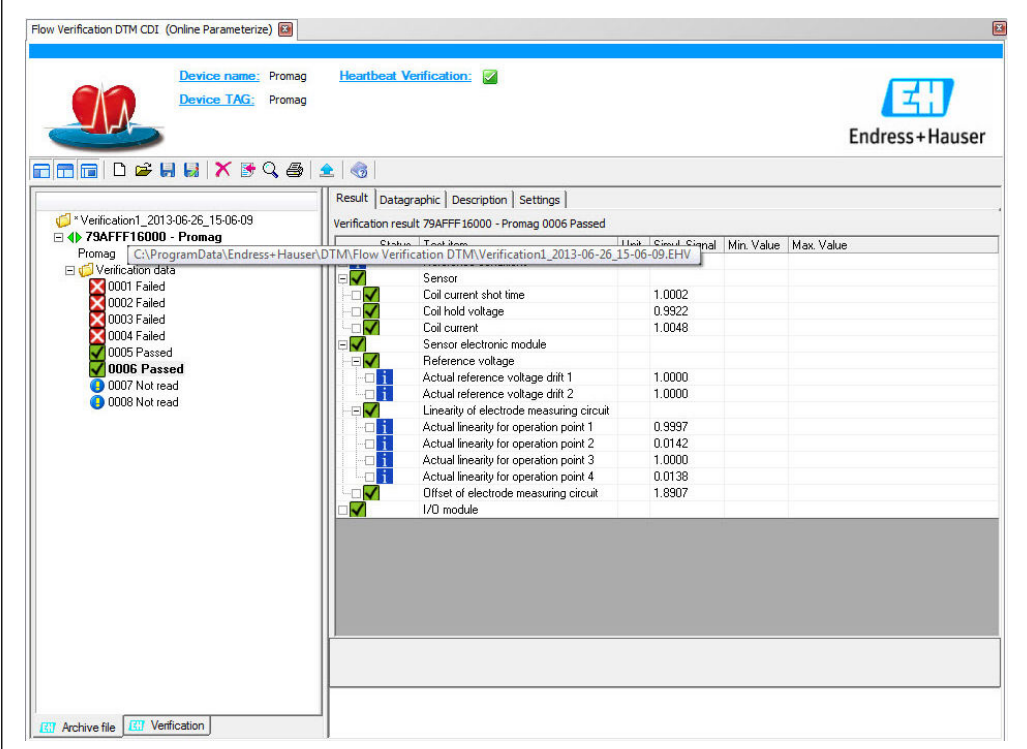| A0020277	Save the data sets under a new file name; a new archive file is created in this case
A0020278	Create a verification report in PDF format

DTM header

The following basic functions are provided:

A0020887	The header refers to the top display area of the DTM. It contains information about the device TAG

"Upload" function

Upload the data from the measuring device to the asset management software. This is initiated via the icon. This function transmits selected data sets, which are saved in the measuring device, to the asset management software and visualizes them.


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Verification results

Details for the verification results are displayed in the "Data area". The data area is split into three tabs:
• "Results": 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

Once uploaded, the data can be saved to an archive file. This is initiated via the 🖫 or 🖫 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 Verification-DTM and is therefore also suitable for analysis by a third party (e.g. Endress +Hauser service organization).
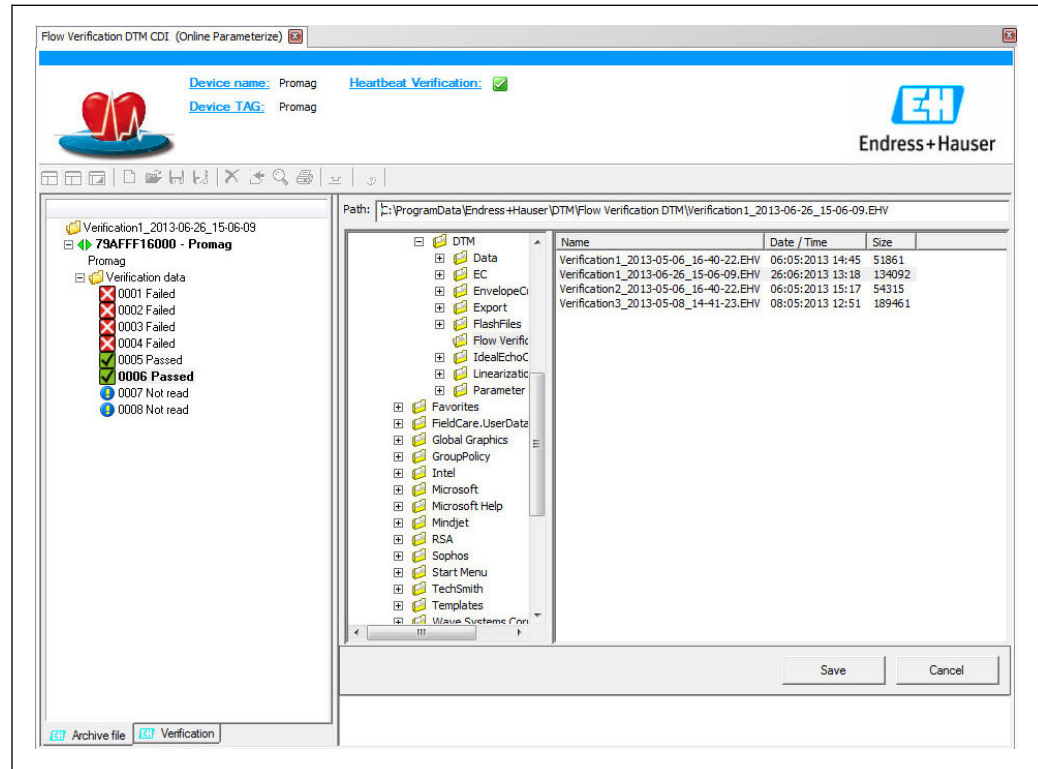
A0020890-EN

Opening archive files

Archive files that are already available can be opened via the 🖙 function. Here the archive data are loaded in the Verification-DTM.

Visualization and trend analysis

The verification data can be visualized in the "Data 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.
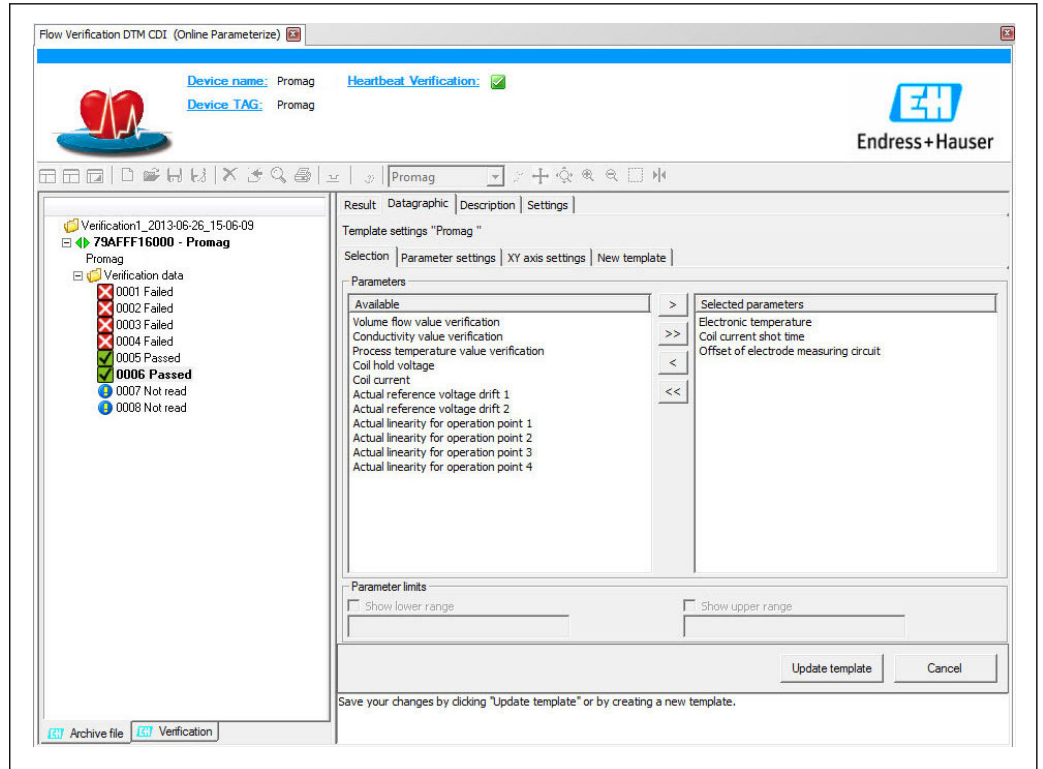
A0020892-EN

☑ 6   "Selection": Select the desired parameters using the parameter list
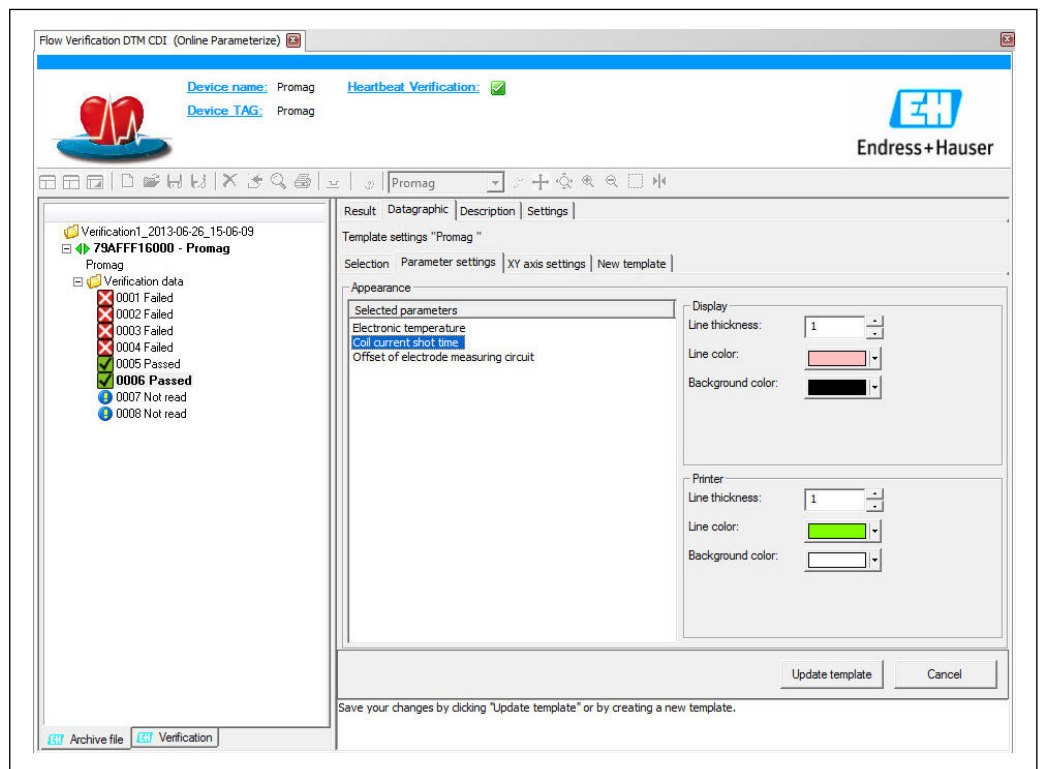
A0020893-EN

☑ 7   "Parameter settings": Assign the properties for visualization in the graph
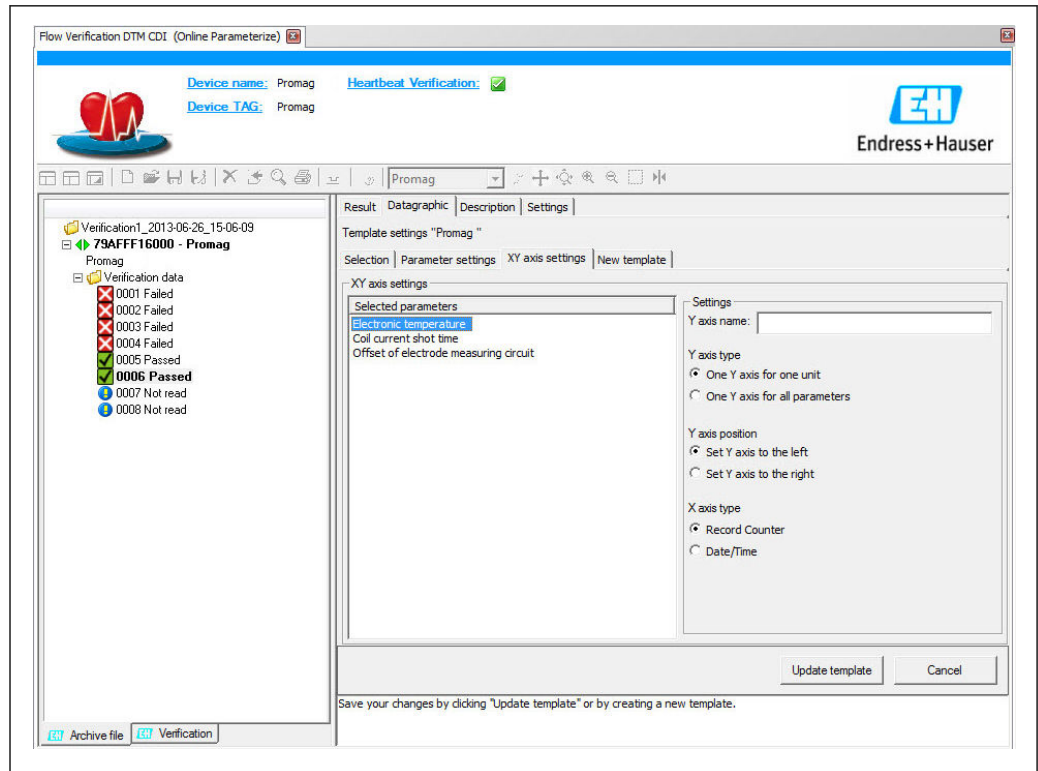
⊠ 8   "Y-axis settings": Assign the parameters to the y-axis

*⊠ 9   "New template, update template": Adds the selected parameter configuration to the template; "New
template, save as new template": Saves the selected parameter configuration under a new template name*
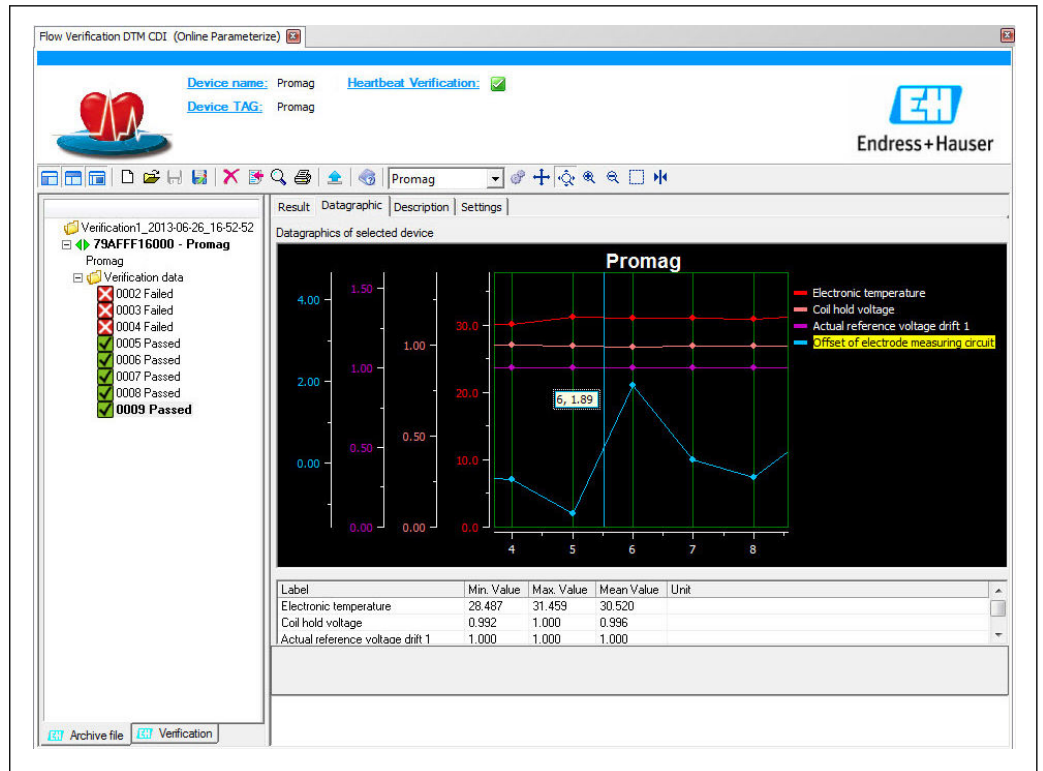
A0020896-EN

⊞ *10* *"Trend visualization": Template shows the data in chronological order; the data points are referenced by the verification ID (X-axis), the Y-axis is displayed as defined in the configuration*

Creating a verification report

A data set can be selected using the 🖨 function and used to create a verification report.

7.4   Modules

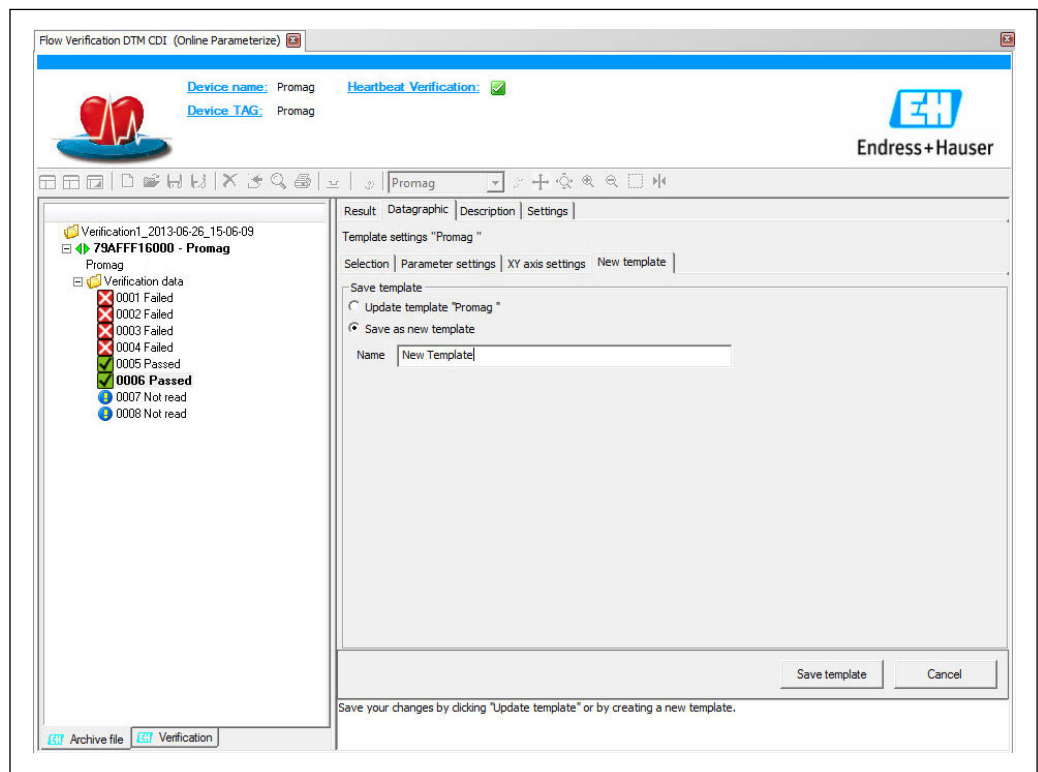Self-monitoring of the measuring device using Heartbeat Technology comprises the measuring chain from the sensor to the outputs. The table below lists the individual modules (test groups) and possible and recognized causes of errors.

Sensor module

Sensor module/test group	Test and recognized causes of errors
Sensor	Electrical testing of excitation system • Testing of coil current with regard to leak current • Testing of symmetry of coil current shot times and their required voltages for both field polarities Establishing • an external magnetic field • Impermissible leak current caused by moisture inside the sensor

Electronics module

Electronic module/test group	Test and recognized causes of errors
Sensor electronic module	Testing • Monitoring of zero point, gain and linearity of measuring circuit in sensor electronic module • Redundant reference voltage monitoring for measuring and exciter circuit in sensor electronic module • Verification of reference voltages for measuring and exciter circuit with external measuring devices (for external verification only) Detection of drift and aging of electronic components due to environmental or process influences (temperature, vibration etc.)
I/O module	Signal feedback for the first current output. Detection of drift and aging of analog output module due to environmental or process influences (temperature, radiation, vibration etc.)

8 Use cases and applications (and interpretation of results)

8.1 Diagnostics

For information about the standard functions, see the "Diagnostics and troubleshooting" section of the Operating Instructions.

8.2 Condition Monitoring

8.2.1 Definition of Condition Monitoring

(→ 🖹 8)

8.2.2 Focus and target applications

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:
- Transient 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 measuring 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. These influences also affect the integrity of the measuring device on the long term.

Flowmeters with **Heartbeat Monitoring** offer a range of parameters that are particularly suitable for monitoring specific, application-related influences. These target applications are:
- Magnetite-containing media
- Multi-phase fluids (gas content in liquid fluids)
- Applications in which the sensor is exposed to a programmed amount of wear
- Applications with cathodic protection systems
- Applications with pipes that are not grounded

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.

8.3 Heartbeat Monitoring – Introduction

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/performed (good knowledge of the application is required). The elimination of process effects that cause misleading warnings/interpretation must also be ensured. For this reason it is important to compare the recorded data against a process reference.

8.3.1 Overview

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

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

8.4 Heartbeat Verification

8.4.1 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 test.

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.

8.4.2 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.

ℹ Confirmation of compliance with the flow specification can only be achieved through validation of the primary measured variable (flow) by means of recalibration or proving.

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" test group are affected, as a process-specific influence is then possible.
In this case, it is advisable to compare the current process conditions to those of a previous verification (→ 🗎 24) 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.

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
Sensor electronic module	Electronic module for exciting the sensor and converting Electronic module drift or defect → replace
I/O electronics 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

For more information on other possible causes and remedial measures, 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.
FieldCare	Software-based asset management system from Endress+Hauser. FieldCare is used for the documentation and analysis of the verification results.
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. ℹ️ 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). ℹ️ 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. ℹ️ **Heartbeat Verification** is not a calibration system.
Verification report	Document in which the results of the **Heartbeat Verification** are recorded.
Dataset	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. ℹ️ 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.

10   Registered trademarks

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