SD02480D/06/EN/02.21
71528765
2021-07-01
Valid as of version
01.00.zz (Device firmware)

Products   Solutions   Services

Special Documentation
Proline t-mass 500
Modbus RS485

Heartbeat Verification + Monitoring application package

Endress+Hauser

People for Process Automation

Table of contents

1 Manufacturer Declaration

Manufacturer Declaration

Endress+Hauser Flowtec AG, Kägenstrasse 7, 4153 Reinach

Declares as a manufacturer that the flow meters of the product lines

Proline t-mass 300 (6F3B, 6I3B)
Proline t-mass 500 (6F5B, 6I5B)

with the application package Heartbeat Technology complies with the following requirements:

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

Referenced documents:
IEC 61508-2:2010 Appendix C
IEC 61508-3:2010 Section 6
ISO 9001:2015, Section 7.1.5/7.1.5.2 a), Monitoring and measuring resources
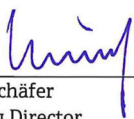
Result:
Heartbeat Verification verifies the function on demand within the specified measuring tolerance with a total test coverage ("TTC") of TTC > 95%.

Heartbeat Technology[TM] complies with the requirements for traceable verification according to ISO 9001:2015 – Section 7.1.5/7.1.5.2 a) " Monitoring and measuring resources ". In accordance with this standard, the user is responsible for providing a definition of the verification interval that satisfies the particular requirements.

Reinach, October 20th, 2020

Endress+Hauser Flowtec AG

Dr. B.-J. Schäfer
Managing Director

i.V.
M. Karolzak
Senior Expert Functional Safety

Endress+Hauser
People for Process Automation

Anforderungen gemäß DIN EN ISO 9001
Die Heartbeat Technology™ erfüllt auch die Anforderungen an die rückführbare Verifikation gemäß DIN EN ISO 9001: 2015 - Kapitel 7.6 a) "Lenkung von Überwachungs- und Messmitteln". Gemäß Norm obliegt dem Anwender die anforderungsgerechte Festlegung des Verifikationsintervalls.

2   About this document

2.1   Document function

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

2.2   Content and scope

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

- Application-specific parameters
- Advanced technical specifications

2.3   Symbols

2.3.1   Safety symbols

⚠ DANGER

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

⚠ WARNING

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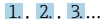
⚠ CAUTION

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

NOTICE

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

2.3.2   Symbols for certain types of information

Symbol	Meaning
✔	**Permitted** Procedures, processes or actions that are permitted.
✘	**Forbidden** Procedures, processes or actions that are forbidden.
ℹ	**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

Symbol	Meaning
 A0028662	Operation via local display
 A0028663	Operation via operating tool
 A0028665	Write-protected parameter

2.3.3   Symbols in graphics

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

2.4   Documentation

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

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

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

Measuring device	Documentation code
t-mass F 500	BA01998D
t-mass I 500	BA01999D

2.5   Registered trademarks

Modbus®
Registered trademark of SCHNEIDER AUTOMATION, INC.

3 Product features and availability

3.1 Product features

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

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

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

λ_{TOT}:   Rate of all theoretically possible failures

λ_{du}:   Rate of dangerous undetected failures

Only the dangerous undetected failures are not diagnosed by the device diagnostics. If these failures occur, they can distort the measured value that is displayed or interrupt the output of measured values.

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

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

3.2 Availability

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

3.2.1 Order code

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

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

3.2.2 Activation

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

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

3.2.3   Access

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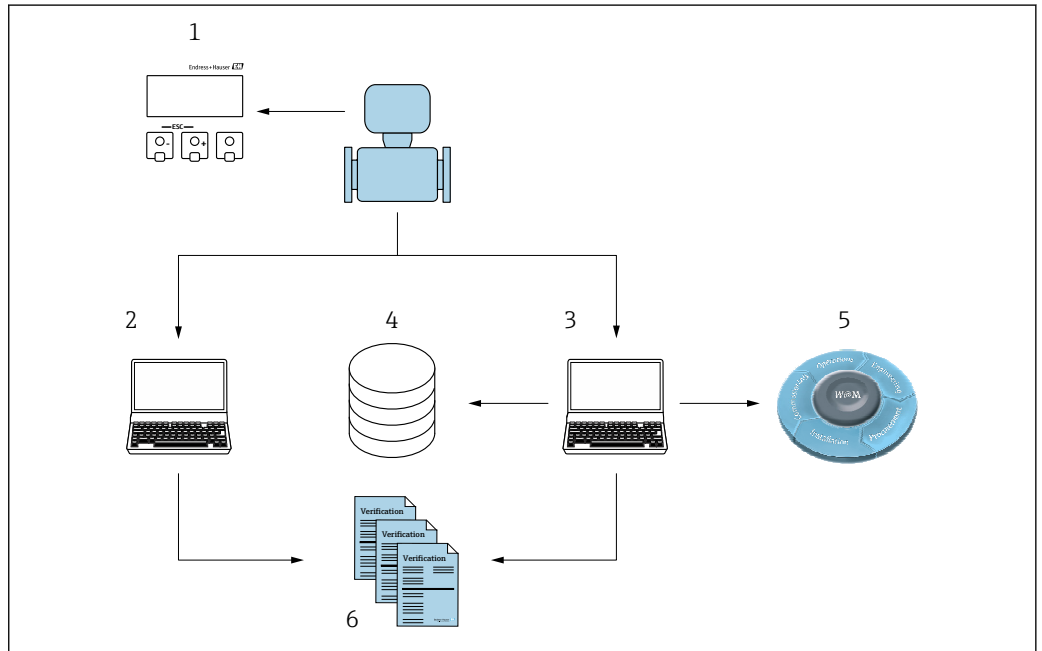
4   System integration

The **Heartbeat Technology** features are available via the local display module and the digital interfaces. The features can be used via an asset management system and the automation infrastructure (e.g. PLC).
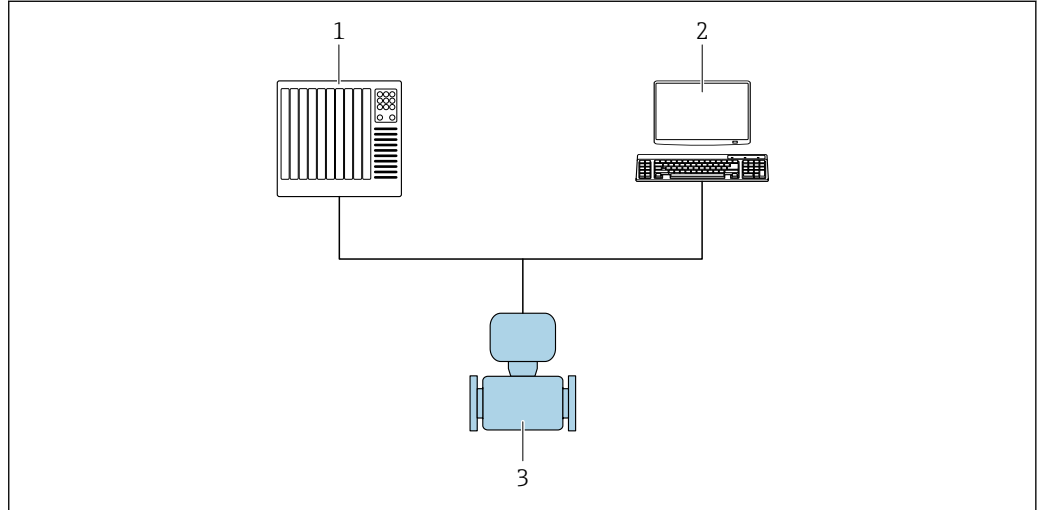
A0020248

1   PLC
2   Asset Management System
3   Measuring device

A0031421

1   Local display
2   Web browser
3   FieldCare
4   Data archive in the device
5   W@M Portal
6   Verification report

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

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

The detailed results of the verification (8 data records) are saved in the device and provided in the form of a verification report.

Verification reports can be created using the device DTM and the Web server integrated in the measuring device or the FieldCare plant asset management software from Endress+Hauser.

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

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

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

4.1   Automated data exchange

• Instrument check via self-monitoring
• Start verification and verification status

The verification function integrated in the measuring device can be activated by a control system and the results can be checked.

📖 For more information on "System integration", see the Operating Instructions (documentation code)

The following procedure must be implemented for this purpose:
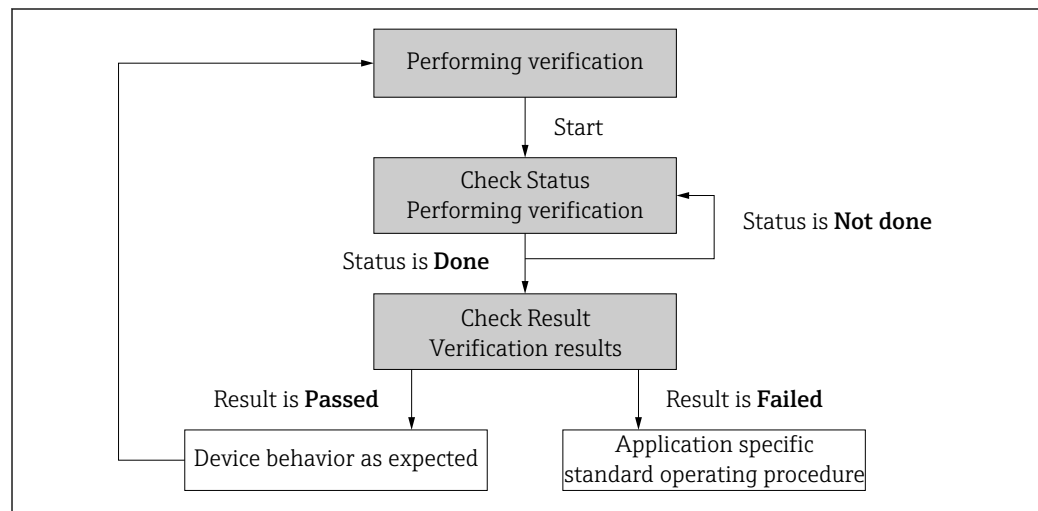
A0020258-EN

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

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

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

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

4.3 Data management

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

The results can be documented in the form of a verification report using the Web server integrated in the measuring device or the Endress+Hauser asset management software, FieldCare.

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

4.3.1 Data management via Web browser

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

Printing a verification report

A verification report is created in PDF format.

Prerequisite: A verification has already been performed.

User interface in the Web browser following login:

A0031439
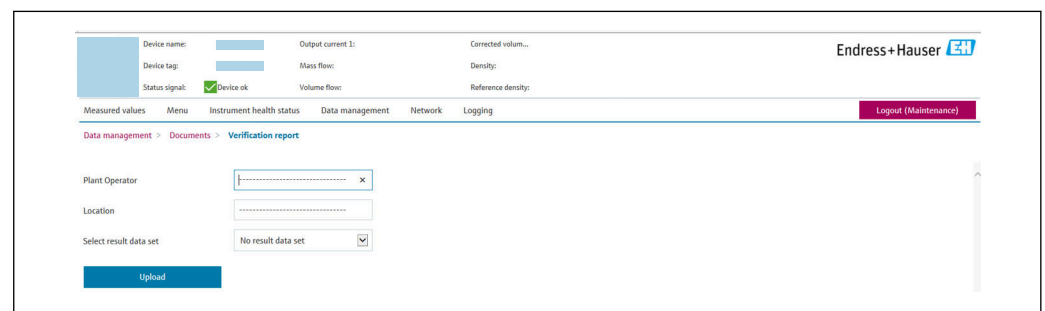
1. Click the navigation buttons **Data management** → **Documents** → **Verification report**.
   ↳ The input area for downloading verification reports is displayed.

2. Enter the necessary information in the **Plant operator** and **Location** fields.
   ↳ The information entered here appears in the verification report.

---

1) First In – First Out

3. Select the result data set.
   ↳ A result data set is indicated as a time stamp in the drop-down list.
     If no verification has been performed, the message "No result data set" is
     displayed here.
4. Click **Upload**.
   ↳ The Web server generates a verification report in PDF format.

4.3.2 Data management via Flow Verification DTM

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

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

Device name   Xxxxxxxx   Heartbeat Verification: ☑
Device tag   Xxxxxxxx

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.
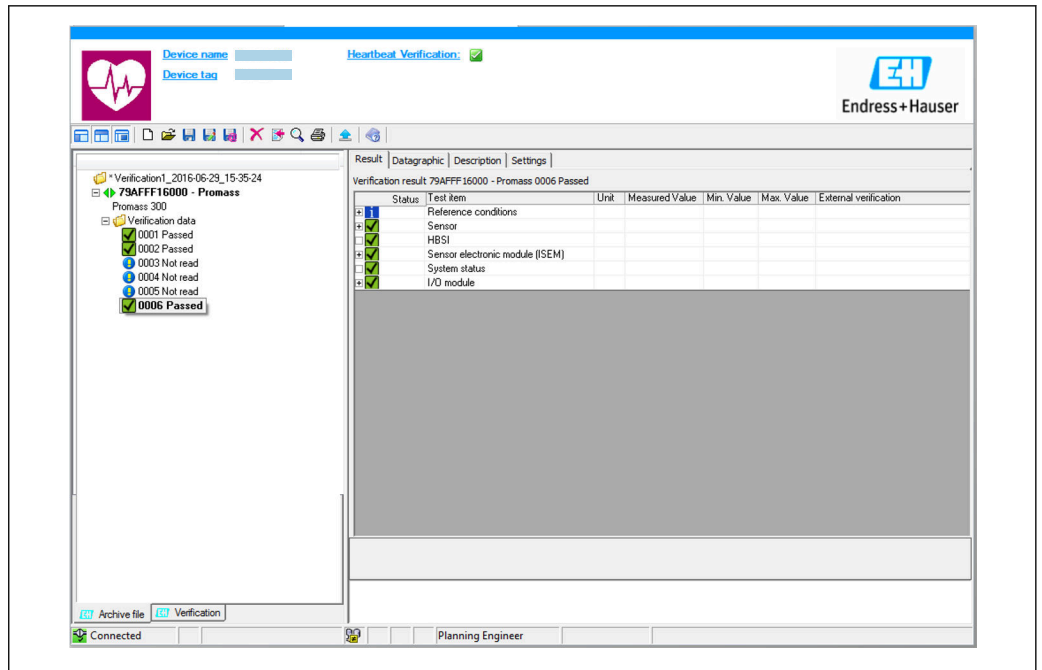
A0031426

🖳 *1   Sample graphic*

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

Verification results

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

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

Saving to an archive file

Save the data to an archive after upload.
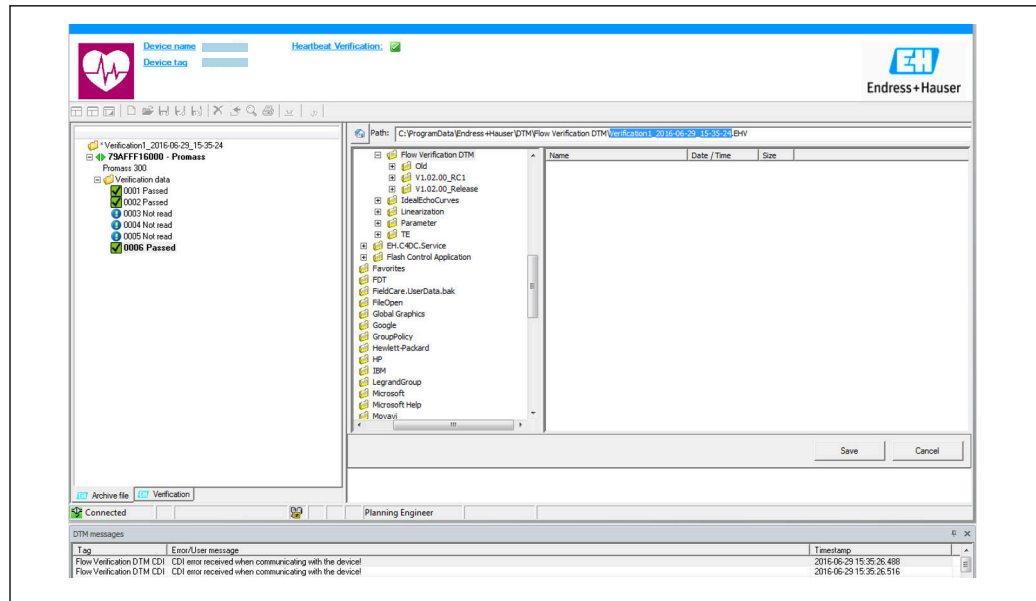
⊞ 2   Sample graphic

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

Opening the archive file

Open archive files already available.

▶   Click the 📂 icon.
  ↳ The archive data are uploaded to the Flow Verification DTM.

Configuring visualization and trending

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

Selecting the measured variables
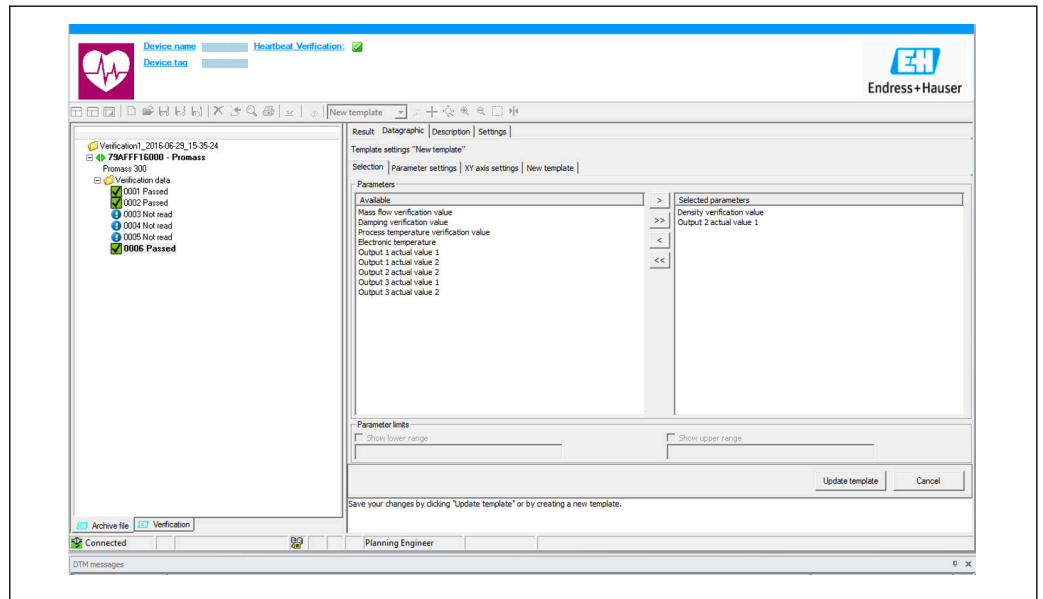
🖼 *3   Sample graphic*

▶ Select the measured variables using the list displayed.

Visualizing a graph
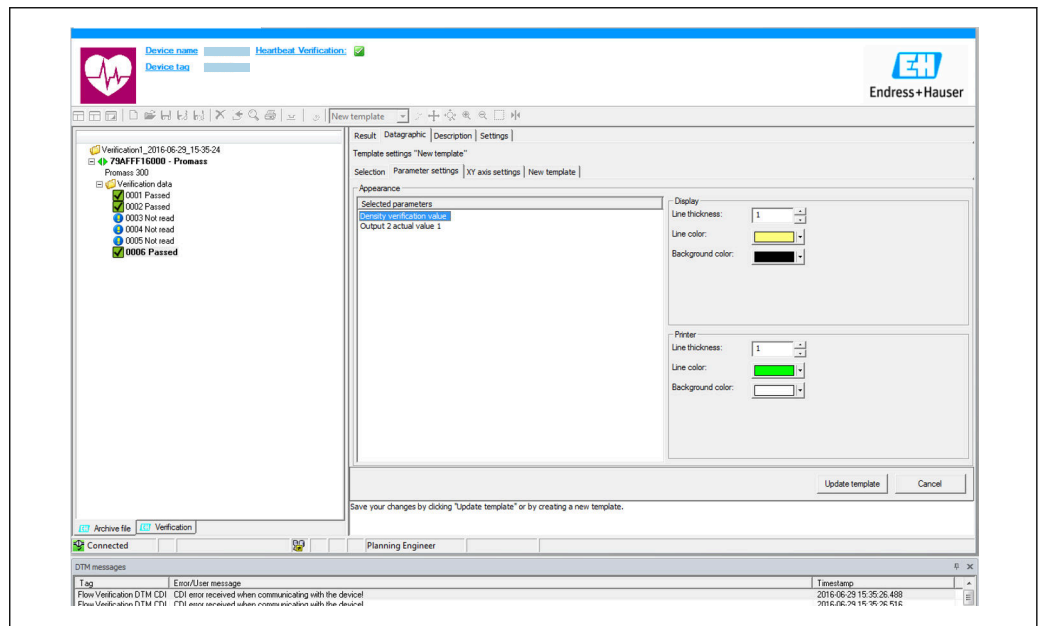
🖼 4   *Sample graphic*

▶ Assign properties for visualization of the graph.

Configuring the Y-axis
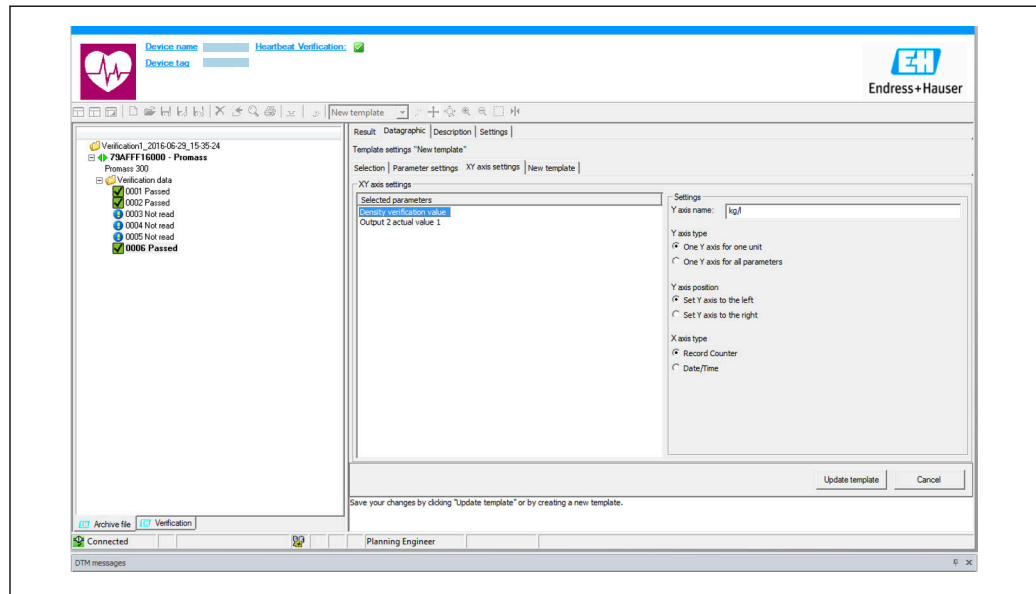
 5   Sample graphic

▸ Assign the measured variables of the Y-axis.

Updating template or creating new template
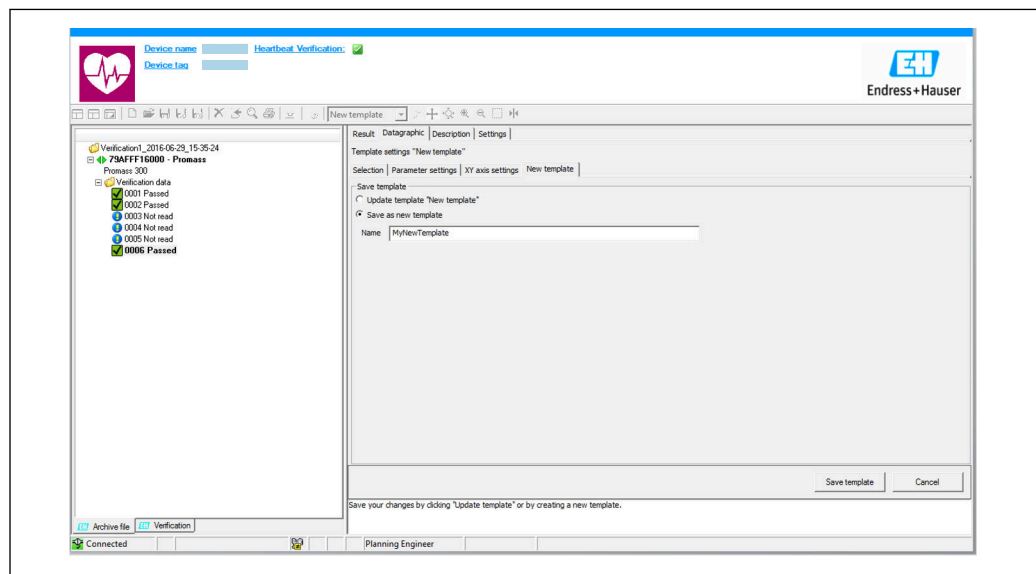
 6   Sample graphic

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

Showing the visualization trend
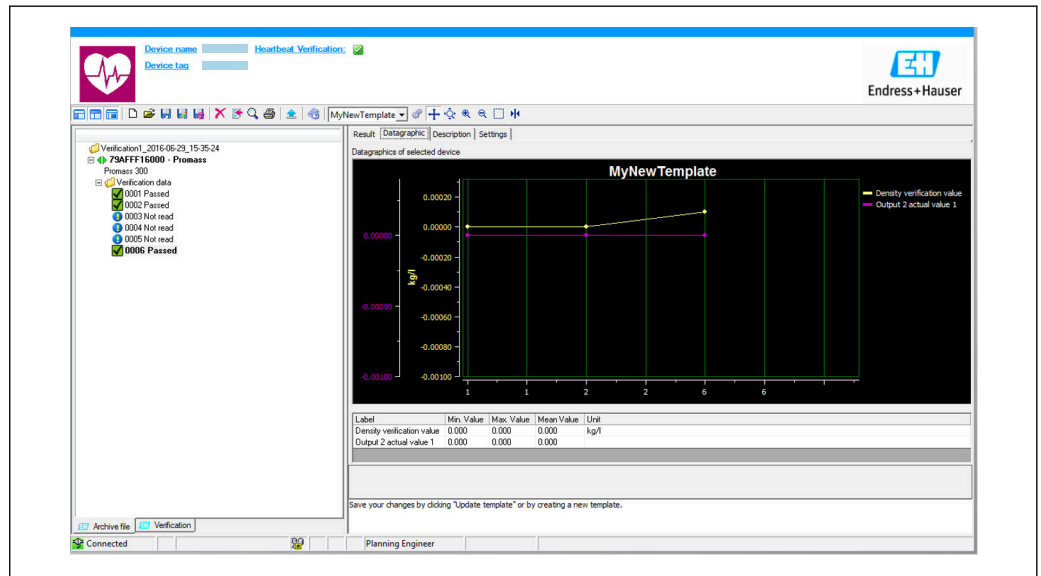
⊞ *7   Sample graphic*

▶ Display the template.

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

Creating a verification report

1. Click the 🖨 icon.

2. Select the data set.

  ↳ A verification report is generated.

5   Heartbeat Verification

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

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

Heartbeat Technology offers two ways to perform Heartbeat Verification:
- Standard verification → 🖺 20
  Verification is performed by the device without manual checking of external measured variables.
- Extended verification → 🖺 24
  Verification also includes the entry of external measured variables.

5.1   Performance characteristics

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

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

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

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

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

5.2   Commissioning

ℹ️ Recommendation: Perform initial verification when commissioning the device (and all other verifications in the life cycle) under process or reference conditions. → 🖺 11.

The results are saved as an initial situation in the measuring device life cycle up until the 8th verification; from the 9th verification onwards an upload using the verification DTM is recommended.

5.2.1   Recording reference data

It is possible to manually record reference data relating to the operator and the location. These reference data appear on the verification report.
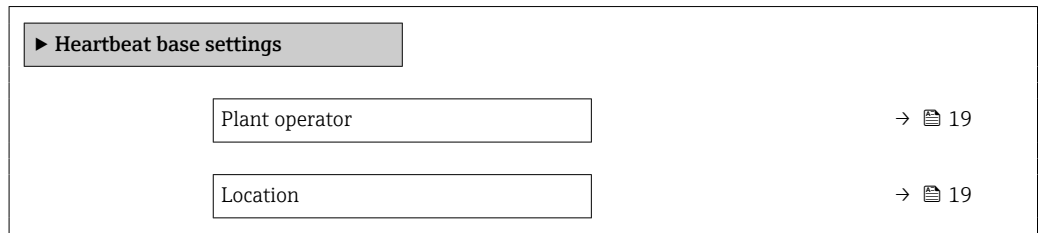
ℹ️ Operation continues while the reference data are being recorded.

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

Navigation

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

▸ Heartbeat base settings		
	Plant operator	→ 🖹 19
	Location	→ 🖹 19

Parameter overview with brief description

Parameter	Description	User entry
Plant operator	Enter the plant operator.	Max. 32 characters such as letters, numbers or special characters (e.g. @, %, /)
Location	Enter the location.	Max. 32 characters such as letters, numbers or special characters (e.g. @, %, /)

5.3   Operation

5.3.1   General information

Initial verification

▸ When commissioning the measuring device:
    Perform an initial verification to save the results as an initial situation in the life cycle of the measuring device. From the ninth verification onwards, an upload using the Verification DTM is recommended.

Initial verification can be performed in 2 ways:
- Standard verification → 🖹 20
- Extended verification → 🖹 24

Device behavior and interpretation

Result "Passed"

All test results are within the specifications.

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

Verification generally delivers the result Passed in most applications.

Result "Failed"

One or more test results are outside the specifications.

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

1. Establish defined and stable process conditions.
   ↳ Ensure a constant process temperature.
      Avoid wet gases, pulsating flow, pressure shock and very high flow rates.

2. Repeat verification.

   ↳ Repeat verification "Passed"
   If the result of the second verification is "Passed", the result of the first verification can be ignored. In order to identify possible deviations, compare the current process conditions with the process conditions of a previous verification.

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

1. Take remedial action on the basis of the verification results and the diagnostic information of the measuring device.

   ↳ The cause of the error can be narrowed down if the test group that "Failed" the verification is identified.

2. Provide Endress+Hauser Service with the verification result with the current process conditions.

3. Check the calibration or calibrate the measuring device.

   ↳ The calibration has the advantage that the "as found" measuring device state is recorded and the actual measured error is determined.

5.3.2   Standard verification

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

Diagnostic behavior

The device signals that standard verification is in progress: ⚠**C302 Device verification in progress** diagnostic message
- Factory setting for diagnostic behavior: warning
- The device stops measuring and outputs the value 0.
- The verification time can range from 10 seconds to several minutes. A longer verification time is possible for lower flow velocities.
- The totalizers are not affected.

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

📖 For detailed information on diagnostics and troubleshooting and for diagnostic information and associated remedial measures, see the Operating Instructions → 📖 6.

Performing standard verification

Before verification starts

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

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

1. Enter date and time.

Select the verification mode

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

Starting the verification test

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

Displaying the verification status and result

The current status of the standard verification is indicated in the **Status** parameter
(→ 🖺 24):
- Done
  The verification test is finished.
- Busy
  The verification test is running.
- Not done
  A verification has not yet been performed on this measuring device.
- Failed
  A precondition for performing the verification has not been met; verification cannot start (e.g. due to unstable process parameters) → 🖺 19.

The result of the verification is displayed in the **Overall result** parameter (→ 🖺 24):
- Passed
  All the verification tests were successful.
- Not done
  A verification has not yet been performed on this measuring device.
- Failed
  One or more verification tests were not successful → 🖺 19.

🛈 • The overall result of the last verification can always be accessed in the menu.
  • Navigation:
    Diagnostics → Heartbeat Technology → Verification results
  • Detailed information on the result of the verification (test groups and test status) is also provided in the verification report in addition to the overall result → 🖺 35.
  • If the device does not pass the verification, the results are saved nonetheless and indicated in the verification report.
  • This helps users to perform a targeted search for the cause of the error → 🖺 19.

"Performing verification" submenu

Navigation
"Diagnostics" menu → Heartbeat Technology → Performing verification

▸ Performing verification	
Year	→ 🖺 22
Month	→ 🖺 22
Day	→ 🖺 22
Hour	→ 🖺 22
AM/PM	→ 🖺 22

Minute	→ 🖹 22
Verification mode	→ 🖹 23
External device information	→ 🖹 23
Start verification	→ 🖹 23
Progress	→ 🖹 23
Measured values	→ 🖹 23
Output values	→ 🖹 24
Status	→ 🖹 24
Overall result	→ 🖹 24

Parameter overview with brief description

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

Parameter	Prerequisite	Description	User entry / Selection / User interface	Factory setting
Verification mode	ⓘ Can be edited if Heartbeat Verification is not active.	Select the verification mode. Standard verification Verification is performed automatically by the device and without manual checking of external measured variables.	• Standard verification • Extended verification	–
External device information	With the following conditions: • The **Extended verification** option is selected in the **Verification mode** parameter. • Can be edited if the verification status is not active.	Record measuring equipment for extended verification.	Free text entry	–
Start verification	–	Start the verification. Start the verification with the **Start** option.	• Cancel • Start • Output 1 low value * • Output 1 high value * • Output 2 low value * • Output 2 high value * • Output 3 low value * • Output 3 high value * • Output 4 low value * • Output 4 high value * • Frequency output 1 * • Pulse output 1 * • Frequency output 2 * • Pulse output 2 * • Frequency output 3 * • Double pulse output *	–
Progress	–	Shows the progress of the process.	0 to 100 %	–
Measured values	In the **Start verification** parameter (→ 🖹 23), one of the following options is selected: • Output 1 low value • Output 1 high value • Output 2 low value • Output 2 high value • Output 3 low value • Output 3 high value • Output 4 low value • Output 4 high value • Frequency output 1 • Pulse output 1 • Frequency output 2 • Pulse output 2 • Frequency output 3	Displays the references for the external measured variables. • Current output: Output current in [mA] • Pulse/frequency output: Output frequency in [Hz]	Signed floating-point number	–

Parameter	Prerequisite	Description	User entry / Selection / User interface	Factory setting
Output values	–	Displays the references for the external measured variables. • Current output: Output current in [mA]. • Pulse/frequency output: Output frequency in [Hz].	Signed floating-point number	–
Status	–	Displays the current status of the verification.	• Done • Busy • Failed • Not done	–
Overall result	–	Displays the overall result of the verification. ⓘ Detailed description of the classification of the results: → 🖺 34	• Passed • Not done • Failed	–

*   Visibility depends on order options or device settings

5.3.3 Extended verification

Extended verification extends the standard verification by additionally outputting a number of different measured variables and by verifying the sensors using a test kit [material no. 71097625 for DN 15 to 65 (½ to 2½") or 50093274 for DN 50 to 4000 (2 to 160")]. During the verification process, these measured variables are recorded manually with the help of external measuring equipment and entered into the measuring device (e.g. actual value at current output). The value entered is checked and verified by the measuring device to ensure that it complies with the factory specifications. A status (Passed or Failed) is issued accordingly and is documented as an individual result of the verification and taken into account in the overall result.

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

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

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

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

Measuring equipment requirements

Recommendations for the measuring equipment

DC current measuring uncertainty	±0.2 %
DC current resolution	10 µA

DC voltage measuring uncertainty	±0.1 %
DC voltage resolution	1 mV
Frequency measuring uncertainty	±0.1 %
Frequency resolution	1 Hz
Temperature coefficient	0.0075 %/℃

Connecting the measuring equipment in the measuring circuit

> ⚠️ **WARNING**
>
> **Danger to persons from non-approved equipment in the hazardous area!**
> ▶ Only use intrinsically safe measuring equipment in hazardous zones.
> ▶ Measure intrinsically safe circuits with approved equipment only.
> ▶ Outputs (passive) for the hazardous area may only be connected to suitable intrinsically safe circuits.

Determining the terminal assignment for the outputs

The terminal assignment depends on the specific device version.

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

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

Active current output
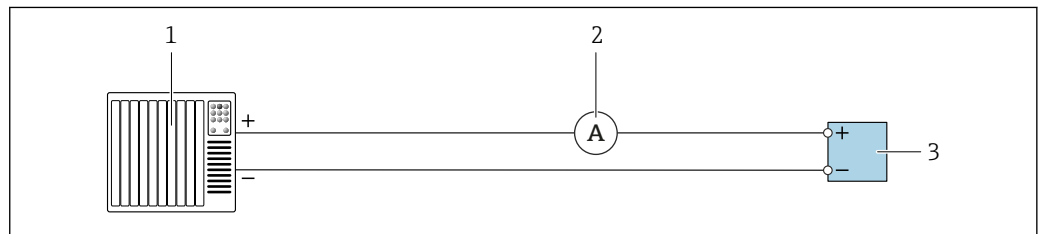
🖼 *8   Extended verification of the active current output*

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

Extended verification of the active current output

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

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

1. Disconnect the output cables of the current output (+/−) from the automation system.

2. Short the output cables of the current output (+ / -).

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

Passive current output
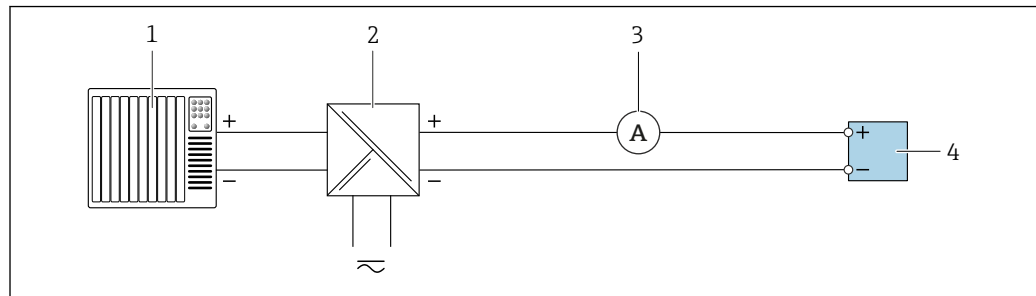
9   Extended verification of the passive current output

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

Extended verification of the passive current output

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

2. Connect the power supply unit.

Active pulse/frequency/switch output
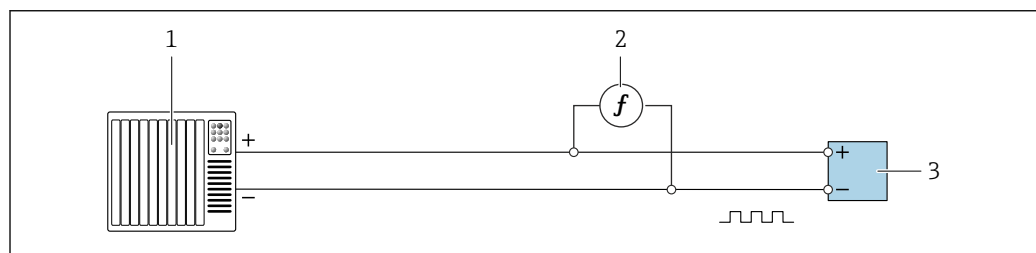
10   Extended verification of the active pulse/frequency output

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

Extended verification of the active pulse/frequency output

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

Passive pulse/frequency/switch output
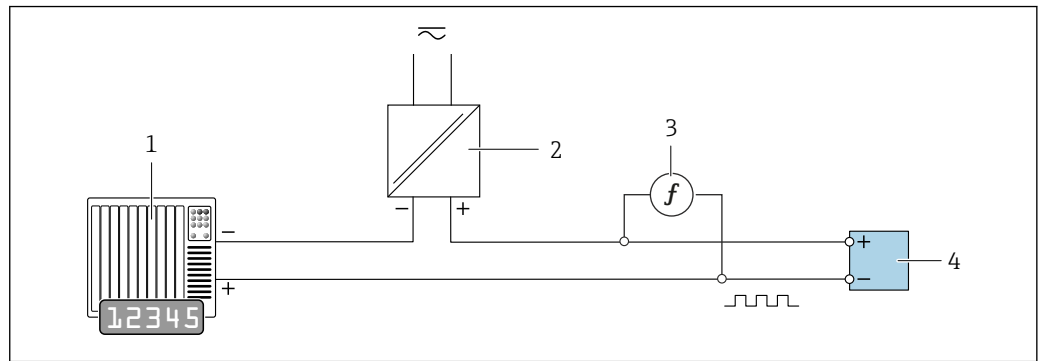
⊠ *11   Extended verification of the passive pulse/frequency output*

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

Extended verification of the passive pulse/frequency output

1. Connect the power supply unit

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

Diagnostic behavior

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

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

The following diagnostic event is displayed if the **Start** option is selected in the **Start verification** parameter (part 2 of the external verification): ⚠**C302 Device verification in progress** diagnostic message

- Factory setting for diagnostic behavior: warning
- The device stops measuring and outputs the value 0.
- The verification time can range from 10 seconds to several minutes. A longer verification time is possible for higher flow velocities.
- The totalizers are not affected.

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

📖 For detailed information on diagnostics and troubleshooting and for diagnostic information and associated remedial measures, see the Operating Instructions → 📖 6.

Performing extended verification

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

> **NOTICE**
>
> **Extended verification is not possible if no connection has been established and the ammeter is looped in during verification.**
> ▸ Establish a connection before extended verification starts.
> ▸ Loop in ammeter before extended verification starts.

Before verification starts

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

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

1. Enter date and time.

Select the verification mode

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

Further parameter settings

3. In the **External device information** parameter, enter a unique ID (e.g. serial number) for the measuring equipment used (max. 32 characters).

4. In the **Start verification** parameter, select one of the available options (e.g. the **Output 1 low value** option).

5. In the **Measured values** parameter, enter the value displayed on the external measuring equipment.

6. Repeat steps 4 and 5 until all the output options are checked.

7. Adhere to the sequence indicated and enter the measured values.

The duration of the process and number of outputs depend on the device configuration, on whether the output is switched on and on whether the output is active or passive.

The value displayed in the **Output values** parameter (→ 🖺 24) indicates the value simulated by the device at the selected output.→ 🖺 25 .

Starting the verification test

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

Displaying the verification status and result

The current status of the standard verification is indicated in the **Status** parameter (→ 🖺 24):
- Done
  The verification test is finished.
- Busy
  The verification test is running.
- Not done
  A verification has not yet been performed on this measuring device.
- Failed
  A precondition for performing the verification has not been met; verification cannot start (e.g. due to unstable process parameters) → 🖺 19.

The result of the verification is displayed in the **Overall result** parameter (→ 🖺 24):
- Passed
  All the verification tests were successful.
- Not done
  A verification has not yet been performed on this measuring device.
- Failed
  One or more verification tests were not successful → 🖺 19.

🄰 • The overall result of the last verification can always be accessed in the menu.
   • Navigation:
     Diagnostics → Heartbeat Technology → Verification results
   • Detailed information on the result of the verification (test groups and test status) is also provided in the verification report in addition to the overall result → 🖺 35.
   • If the device does not pass the verification, the results are saved nonetheless and indicated in the verification report.
   • This helps users to perform a targeted search for the cause of the error → 🖺 19.

"Performing verification" submenu

Navigation
"Diagnostics" menu → Heartbeat Technology → Performing verification

▸ Performing verification	
Year	→ 🖺 30
Month	→ 🖺 30
Day	→ 🖺 30
Hour	→ 🖺 30
AM/PM	→ 🖺 30

Minute		→ 🖹 30
Verification mode		→ 🖹 31
External device information		→ 🖹 31
Start verification		→ 🖹 31
Progress		→ 🖹 31
Measured values		→ 🖹 31
Output values		→ 🖹 32
Status		→ 🖹 32
Overall result		→ 🖹 32

Parameter overview with brief description

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

Parameter	Prerequisite	Description	User entry / Selection / User interface	Factory setting
Verification mode	ⓘ Can be edited if Heartbeat Verification is not active.	Select the verification mode. Extended verification Standard verification is extended by the additional entry of external measured variables: **Measured values** parameter.	Extended verification	–
External device information	With the following conditions: • The **Extended verification** option is selected in the **Verification mode** parameter. • Can be edited if the verification status is not active.	Record measuring equipment for extended verification.	Free text entry	–
Start verification	–	Start the verification. To carry out a complete verification, select the selection parameters individually. Once the external measured values have been recorded, verification is started using the **Start** option.	• Cancel • Start • Output 1 low value * • Output 1 high value * • Output 2 low value * • Output 2 high value * • Output 3 low value * • Output 3 high value * • Output 4 low value * • Output 4 high value * • Frequency output 1 * • Pulse output 1 * • Frequency output 2 * • Pulse output 2 * • Frequency output 3 *	–
Progress	–	Shows the progress of the process.	0 to 100 %	–
Measured values	In the **Start verification** parameter (→ 🖺 23), one of the following options is selected: • Output 1 low value • Output 1 high value • Output 2 low value • Output 2 high value • Output 3 low value • Output 3 high value • Output 4 low value • Output 4 high value • Frequency output 1 • Pulse output 1 • Frequency output 2 • Pulse output 2 • Frequency output 3	Displays the references for the external measured variables. • Current output: Output current in [mA] • Pulse/frequency output: Output frequency in [Hz]	Signed floating-point number	–

Parameter	Prerequisite	Description	User entry / Selection / User interface	Factory setting
Output values	–	Displays the references for the external measured variables. • Current output: Output current in [mA]. • Pulse/frequency output: Output frequency in [Hz].	Signed floating-point number	–
Status	–	Displays the current status of the verification.	• Done • Busy • Failed • Not done	–
Overall result	–	Displays the overall result of the verification. ℹ Detailed description of the classification of the results: → 🖹 34	• Passed • Not done • Failed	–

*   Visibility depends on order options or device settings

5.3.4   Verification results

Access to the verification results:
In the operating menu via the local display, operating tool or Web browser
• Diagnostics → Heartbeat Technology → Verification results
• Expert → Diagnostics → Heartbeat Technology → Verification results

▸ Verification results

Date/time	→ 🖹 33
Verification ID	→ 🖹 33
Operating time	→ 🖹 33
Overall result	→ 🖹 33
Sensor	→ 🖹 33
Sensor electronic module (ISEM)	→ 🖹 33
I/O module	→ 🖹 33
System status	→ 🖹 33

Parameter overview with brief description

Parameter	Prerequisite	Description	User interface	Factory setting
Date/time	The verification has been performed.	Date and time.	dd.mmmm.yyyy; hh:mm	1 January 2010; 12:00
Verification ID	The verification has been performed.	Displays consecutive numbering of the verification results in the measuring device.	0 to 65 535	–
Operating time	The verification has been performed.	Indicates how long the device has been in operation up to the verification.	Days (d), hours (h), minutes (m), seconds (s)	–
Overall result	–	Displays the overall result of the verification. ℹ Detailed description of the classification of the results: → 🖺 34	• Passed • Not done • Failed	–
Sensor	In the **Overall result** parameter, the **Failed** option was displayed.	Displays the result for the sensor. ℹ Detailed description of the classification of the results: → 🖺 34	• Passed • Not done • Failed	–
Sensor electronic module (ISEM)	In the **Overall result** parameter, the **Failed** option was displayed.	Displays the result for the sensor electronics module (ISEM). ℹ Detailed description of the classification of the results: → 🖺 34	• Passed • Not done • Failed	–
I/O module	In the **Overall result** parameter, the **Failed** option was displayed.	Displays the result for I/O module monitoring of the I/O module. • For current output: Accuracy of the current • For pulse output: Accuracy of pulses • For frequency output: Accuracy of frequency • Current input: Accuracy of the current • Relay output: Number of switching cycles ℹ Detailed description of the classification of the results: → 🖺 34	• Passed • Not done • Not plugged • Failed	–
System status	In the **Overall result** parameter, the **Failed** option was displayed.	Displays the system condition. Tests the measuring device for active errors. ℹ Detailed description of the classification of the results: → 🖺 34	• Passed • Not done • Failed	–

Classification of results

Individual results

Result	Description
Failed	At least one individual test in the test group was outside the specifications.
Passed	All individual tests in the test group complied with the specifications. The result is also "Passed" if the result of an individual test is "Check not done" and the result of all other tests is "Passed".
Not done	No test has been performed for this test group. For example, because this parameter is not available in the current device configuration.
Not plugged	The result is displayed if no I/O module is plugged into the slot.
Off	The result is displayed if a universal module is plugged into the slot and has not been configured. This is equivalent to the slot in question being "deactivated".

Overall results

Result	Description
Failed	At least one test group was outside the specifications.
Passed	All verified test groups complied with the specifications (result "Passed"). The overall result is also "Passed" if the result for an individual test group is "Check not done" and the result for all other test groups is "Passed".
Not done	No verification was performed for any of the test groups (result for all test groups is "Check not done").
Not plugged	The result is displayed if no I/O module is plugged into the slot.
Off	The result is displayed if a universal module (U300) is plugged into the slot and has not been configured. This is equivalent to the slot in question being "deactivated".

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

Test groups

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

> Test groups and individual tests → 🔖 35.

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

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

Limit values

I/O module

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

5.3.5　Detailed verification results

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

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

Process conditions

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

Process conditions	Description
Mass flow	Current measured value for mass flow
Medium temperature	Current measured value for medium temperature
Pressure	Current value for pressure
Density	Current value for density
Reference density	Current value for reference density
Sensor raw signal standard deviation	Current standard deviation of the sensor raw signal
Process stability	Current value for process stability
Electronics temperature	Current measured value for the electronic temperature in the transmitter

Individual test group results

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

Sensor

Parameter/individual test	Description	Result/limit value	Interpretation/cause/corrective measures; service ID
Thermal integrity	Check of the relative change in the thermal properties of the sensor in relation to a reference value determined at the factory.	Value range ±1 • Failed • Passed • Not checked [1]	1003 Deviations of the thermal integrity value indicate a change in the internal sensor structure, which can be caused by excessively high process temperatures, mechanical influences or aging, for example. If the result is "Failed", the sensor is seriously impaired and must be checked or replaced.
Electrical sensor drift	Check of the sensor elements for electrical drift.	Value range ±1 • Failed • Passed • Not checked [2]	1002 Replace sensor.
Sensor connection	Monitoring of the sensor connection for short-circuits and interruptions.	• Failed • Passed	1005, 1006 • Check connecting cable between sensor and transmitter. • Replace sensor.
Sensor leak current	Check of the sensor elements for short-circuits in relation to one another or the sensor housing. Relative deviation in relation to the permitted tolerance range.	Value range ±1 • Failed • Passed • Check not done	1004 Replace sensor.

1) Is only checked under the following conditions: flow range 5 to 20% of calibrated full scale value (in air). Medium temperature range −5 to +75 ℃ (+23 to +167 ℉), stable temperature and flow.
2) Is only checked under the following conditions: flow range 5 to 100% of calibrated full scale value (option SA, SH), 5 to 20% of calibrated full scale value (option SB, SC). Medium temperature range −20 to +80 ℃ (−4 to +176 ℉), only possible in forward direction.

Sensor electronics module (ISEM)

Parameter/individual test	Description	Result/limit value	Interpretation/cause/corrective measures; service ID
Supply voltage	Monitoring of the main supply voltage and reference voltage of the sensor electronic module. Monitoring of the supply voltage and reference voltage for the sensor electronics module guarantees that the system is functioning correctly.	No value range • Failed • Passed	281, 362 • Sensor electronics (ISEM) faulty • Replace sensor electronics (ISEM)
Reference vibration frequency	Monitoring of the reference clock of the internal measured data converter. Deviation in % in relation to the reference value.	Value range ±5% • Failed • Passed	212 • Sensor electronic (ISEM) faulty • Replace sensor electronics (ISEM)
Signal path integrity	Monitoring of the sensor signal path for interruptions or short-circuits in the sensor electronics module.	No value range • Failed • Passed	993 • Sensor electronics (ISEM) faulty • Replace sensor electronics (ISEM)
Measuring current	Monitoring of the generation of measuring current to measure sensor resistance values. Deviation in % in relation to the reference value.	Value range ±10% • Failed • Passed	996 • Sensor electronic (ISEM) faulty • Replace sensor electronics (ISEM)

Parameter/individual test	Description	Result/limit value	Interpretation/cause/corrective measures; service ID
Heating current	Monitoring of the generation of heating current to heat the sensor elements. Relative deviation in relation to the permitted tolerance range.	Value range ±1 • Failed • Passed	995 • Sensor electronic (ISEM) faulty • Replace sensor electronics (ISEM)
Reference resistance	Monitoring of the sensor resistance measurement using internal reference resistance values. Relative deviation in relation to the permitted tolerance range.	Value range ±1 • Failed • Passed	997 • Sensor electronic (ISEM) faulty • Replace sensor electronics (ISEM)

System condition

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

I/O modules

Parameter/individual test	Description	Result/limit value	Interpretation/cause/remedial measures
Output 1 to n	Checks all the input and output modules installed at the measuring device→ 🖹 18	No value range • Passed • Failed • Not done ℹ Limit values → 🖹 35	**Causes** • Output values outside the specifications • I/O modules defective **Corrective action** ▶ Check cabling. ▶ Check connections. ▶ Check load (current output). ▶ Replace I/O module.

5.3.6   Verification report

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

First page: identification → 🕮 37

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

Second page: test results → 🕮 37

Details on the individual results for all test groups:
- System operator
- Test groups → 🕮 18
  - Sensor
  - Sensor electronics module (ISEM)
  - System condition
  - I/O module

Third page (and subsequent pages): measured values and visualization → 🕮 37

Numerical values and graphic presentation of all the values recorded:
- System operator
- Test object
- Unit
- Current: measured value
- Min.: lower limit
- Max.: upper limit
- Visualization: graphic presentation of the measured value, within the lower and upper limits.

Last page: process conditions

Information on the process conditions that applied during the verification:
- Mass flow
- Medium temperature
- Pressure
- Density
- Reference density
- Sensor raw signal standard deviation
- Process stability
- Electronics temperature

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

Verification report

Endress+Hauser
People for Process Automation

Plant operator:

Device information

Location	Location 14
Device tag	M-745
Module name	ProXXX
Nominal diameter	DNxx
Device name	ProXXX
Order code	XXXXXX-XXX
Serial number	1234567890
Firmware version	01.01.00

Calibration

Calibration factor	2.10
Compensated calibration factor	10

Verification information

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

Overall verification result*

☑ Passed	Details see next page

*Result of the complete device functionality test via Heartbeat Technology

Confirmation

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

Notes

Date	Operator's signature	Inspector's signature

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A0031154-EN

🖼 *12   Example of a verification report (Page 1: identification)*

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

ℹ️ Individual test groups and description of individual tests: → 🗎 35

Verification report

Endress+Hauser [EH]

People for Process Automation

Plant operator

Device identification and verification identification

Serial number	452633345
Device tag	M-745
Verification ID	17

Heartbeat Technology

Sensor	☑ **Passed**
Shot time symmetry	☑ Passed
Hold voltage symmetry	☑ Passed
Coil current loss	☑ Passed
Coil current stability	☑ Passed
Coil resistance	☑ Passed
Electrode circuit 1	☑ Passed
Electrode circuit 2	☑ Passed
Electrode EPD circuit	☑ Passed

Sensor electronic module (ISEM)	☑ **Passed**
Supply voltage	☑ Passed
External reference voltage	☑ Passed
Linearity and reference voltage	☑ Passed
Offset of electrode measuring circuit	☑ Passed
Hold voltage feedback	☑ Passed
Shot voltage feedback	☑ Passed
Electronic current loss	☑ Passed
Coil circuit measurement	☑ Passed
Shot control circuit	☑ Passed
Electrode signal integrity	☑ Passed

System status	☑ **Passed**

I/O module		☑ **Passed**
Input/output 1	26/27 (I/O 1)	☑ Passed*
Input/output 2	24/25 (I/O 2)	☑ Passed*
Input/output 3	22/23 (I/O 3)	☑ Passed*
Input/output 4	20/21 (I/O 4)	◻ Not plugged

*External verification

Information about the external verification

Fluke 2354, Cal: 10.03.2015

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A0034799-EN

⊡ *13*   *Example of a verification report (Page 2: test results)*

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

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

Verification report

Endress+Hauser
People for Process Automation

Plant operator:

Device identification and verification identification

Serial number	1234567890
Device tag	M-745
Verification ID	17

Heartbeat Technology

Test item	Unit	Actual	Min.	Max.	Visualization
Sensor					
Shot time symmetry deviation		0.9997	0.9000	1.1000	
Hold voltage symmetry deviation		1.0000	0.9000	1.1000	
Coil current loss deviation	%	0.0000	-10.000	10.0000	
Coil current offset	%	-0.02	-0.1	0.1	
Coil current deviation	%	0.00	-0.1	0.1	
Coil resistance value	Ohm	85.9	50.0	240.0	
Electrode impedance 1	Ohm	100.00			
Electrode impedance 2	Ohm	100.00			
EPD electrode impedance	Ohm	100.00			
E1/E2 electrode impedance on E1	Ohm	100.00			
E1/E2 electrode impedance on E2	Ohm	100.00			
Sensor electronic module (ISEM)					
External reference voltage 1	V	NaN			
Linearity and reference voltage 1		1.0000			
Linearity and reference voltage 2		1.0000			
Measuring point offset		0.0000	-100.00	100.000	
Hold voltage feedback value	%	-9.63	-10.0	10.0	
Shot voltage feedback value	%	0.00	-20.0	20.0	
Electronic current loss deviation	%	0.00	-10.000	10.0000	
Coil circuit value	%	-0.17	-1.0	1.0	
Shot control circuit value	%	0.00	-10.0	10.0	
Electrode signal integrity deviation	%	0.00	-40.0	40.0	
System status					
I/O module					
I/O module 1 terminal numbers	26-27 (I/O 1)				
Output 1 value 1		4.0040	-0.1400	0.1400	
Output 1 value 2		0.0000	0.0000	0.0000	
I/O module 2 terminal numbers	24-25 (I/O 2)				
Output 2 value 1		1.0000	0.9995	1.0005	
Output 2 value 2		0.0000	0.0000	0.0000	
I/O module 3 terminal numbers	22-23 (I/O 3)				
Output 3 value 1		0.0000	0.0000	0.0000	
Output 3 value 2		0.0000	0.0000	0.0000	

www.endress.com   Verification DTM

A0038014-EN

🖻 *14   Example of a verification report (Page 3 and subsequent pages: measured values and visualization)*

5.3.7   Interpreting and using the verification results

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

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

Here, the function checks device-internal parameters that are correlated with flow measurement (secondary measured variables, comparative values).

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 is are documented and traceable in the verification report. To ensure that the measuring device complies with the factory specification, this value must these values must match those of the last calibration or repeated calibration.

- Confirmation of compliance with the flow specifications with a total test coverage of 100 % is only possible by verifying the primary measured variable (flow) by recalibrating or by proving the value.
- **Heartbeat Verification** confirms the device function within the specified measuring tolerance on demand.

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

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

This applies in particular if the individual tests of the **Sensor** test group are concerned, as a process-related influence is then possible.

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

The process conditions of the previous verification are documented on the last page of the verification report or can be accessed using the Flow Verification DTM . → 🖺 35

Stabilize or stop flow, ensure that process temperature is stable, drain the sensor if possible.

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

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

For detailed information on diagnostics and troubleshooting and for diagnostic information and associated remedial measures, see the Operating Instructions → 🖺 6.

6 Heartbeat Monitoring

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

6.1 Commissioning

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

Enabling or disabling Heartbeat Monitoring
The output of the diagnostic parameters is switched on or off in the operating menu:
→ 🖺 46

6.1.1 Description of the monitoring measured variables/parameters

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

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

Measured variable	Description	Value range
Process stability	Monitoring of the process stability using peak detection. Can be configured with Event 979.	0 to 1
Sensor raw signal standard deviation	Monitoring of the standard deviation of the sensor raw signal.	0 to 1

Process stability

Process stability is one of two parameters that are available in Heartbeat Monitoring. It can be used to monitor the measuring operation and to warn the user if the measuring signal is influenced by application-related sources of disturbance, such as condensation, pulsating flow, acoustic waves or a disrupted flow profile.

Process stability can only detect that a disturbance is present but is unable to detect the source of the disturbance. The user must find the source of the disturbance himself so that suitable countermeasures can be taken.

Process stability works by monitoring for anomalies in the measuring signal. Anomalous measuring signals are usually expressed in the form of signal peaks (spikes). Erratic signal peaks occasionally occur in an application and are not necessarily an indication of an irregularity. However, if the signal peaks recur frequently, this is normally an indicator that something negative is affecting the process. These disturbances can negatively impact the process and the integrity of the measuring signal.

In the graphic below, the measuring signal is plotted over time as a function of the heater power. Below this signal trend, we have the visualization of a droplet of water (green) forming at the base of the sensor (gray) and moving along the length of the sensor to the sensor tip. The effect of this droplet of water on the energy input is illustrated as a light-brown curve in the diagram. This light-brown curve reaches its peak between 96 to 100 s and then drops again to almost its starting point of approx. 145 mW, where it then stabilizes. The formation of the signal peak corresponds to the movement of the droplet of

water along the sensor to the tip. During this process, the output of the sensor must be increased to compensate for the higher thermal conductivity of the water in relation to the gas, as the water takes more energy from the sensor than the gas does. At the same time, a decrease in the measured temperature (red) can be observed, which is attributable to the cooling effect of the water.
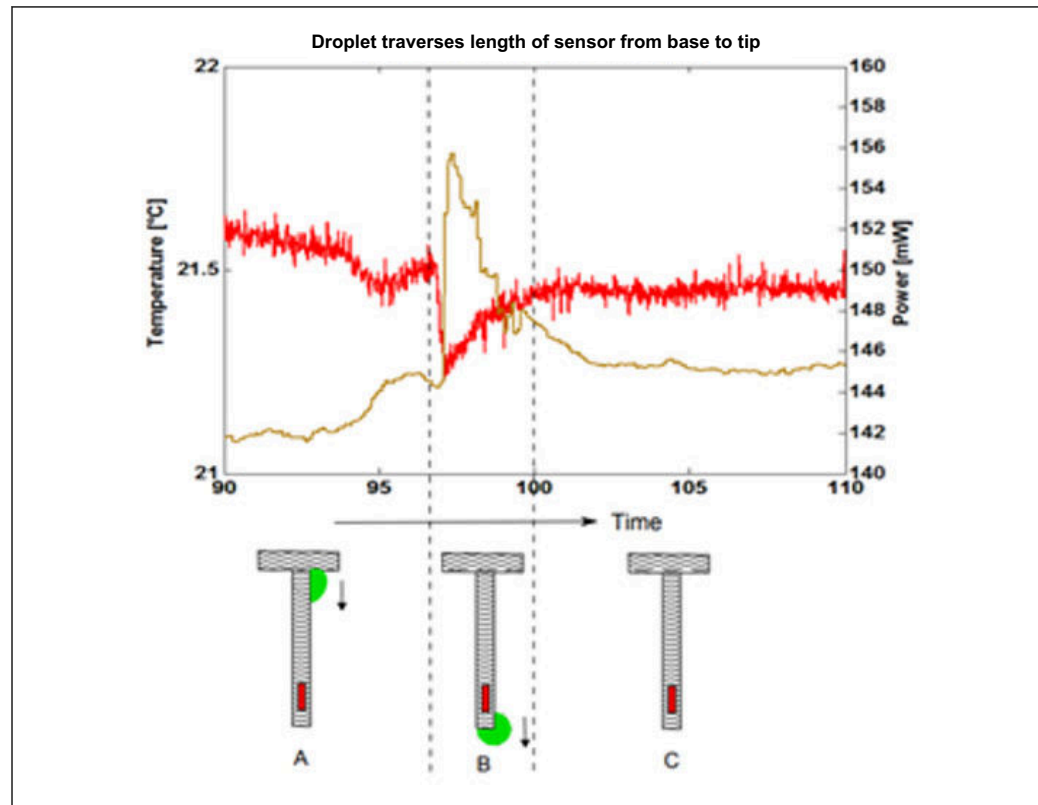
🖾 *15 Effect of a droplet on the heating capacity and temperature*

A statistical method is used to detect a signal peak (or signal instability). Two timeframes are evaluated (one before and one after the signal peak). A certain number of signal scans are performed in these timeframes. The maximum peak within this timeframe is identified and evaluated according to specific statistical criteria to determine whether the peak is caused by a disturbance in the process.

If the results of these criteria exceed a defined limit, this confirms that a disturbance is present in the process. In this context, the extent of the disturbance is known as the **"Fluctuation Level"**. The user can define how Heartbeat should react to the process disturbance by assigning a warning, an alarm, a logbook entry or nothing (function is off).

The user can define the limit of the fluctuation level by setting the so-called "**Sensitivity"** parameter. This parameter has a range between 1 and 9 (maximum sensitivity setting), with 8.9 the default setting. The selected default setting is very sensitive to ensure that Heartbeat Monitoring is very likely to detect a process disturbance and alert the user if it is put into operation.

Ultimately, the sensitivity depends on the application and the expectations of the user and must therefore be specified individually during commissioning.

If Heartbeat Monitoring has detected a process disturbance, either an alarm or warning is issued or simply an entry is made in the logbook. The user is free to define which action is taken. Ideally, the user would identify the possible causes of the disturbance.

For example, is there condensate in the application? There is a strong likelihood that water is causing the disturbance. If there is no water in the application, other sources of disturbance must be considered, such as pulsating flow for example. It may be necessary to

use additional measuring data to determine whether pulsating flow could be causing the problem. For example, can correlations with process pressure variations be identified in the same period? Is there any relationship between the time of the recorded event and the start up of a compressor?

If these questions can be answered in the affirmative, then it could indicate that there is pulsating flow or that rapid profile changes are occurring.

It can also be the case that a process disturbance is present but there are no practical solutions to address the problem. If this is the case, the user can proceed as follows:

- The factory setting is 8.9. If this setting is too high and causes undesired warnings, it can be set to a less sensitive value in steps of 0.5. The user can first set the setting to 8.4 and check whether this brings any improvement.
- Does Heartbeat Monitoring continue to display a warning? If it does, the value should be set to 7.9.
- The user can continue in this way until Heartbeat Monitoring stops displaying a warning.

Adjustments to the sensitivity settings are not always immediately noticeable. Therefore, after lowering the value wait approximately 3 to 4 minutes to see whether the warning indicating a process disturbance disappears again. If the warning does not disappear after this time, lower the sensitivity setting again by 0.5.

The user can apply this procedure to determine the **process stability** of his own process by gradually adjusting the sensitivity to find the correct application-specific setting. If the new process stability declines again over time, a warning message will notify the user accordingly.

Heartbeat Monitoring can therefore act as a kind of predictive maintenance system. For example, if condensate results in potential corrosion in a piping system, Heartbeat can be used as an effective preventative tool.

Sensor raw signal standard deviation

The sensor raw signal standard deviation indicates the relative standard deviation of the sensor raw signal (power coefficient). Changes in the standard deviation during constant flow could be an indication of noise in the sensor's raw measurement signal. If these changes occur over time, they may be attributable to wear in the facility (such as in a fan or compressor). The standard deviation for the sensor raw signal can be read out via HART or bus communication.

6.1.2   Configuration of the outputs and local display

With the application package "Heartbeat Verification + Monitoring", the user has additional monitoring parameters available → 🗎 43 . The following examples illustrate how a monitoring measured variable is assigned to a current output or is shown on the local display.

Example: Configuring the current output

Select the monitoring measured variable for current output

1. Prerequisite:

   Setup → I/O configuration

   ↳ Configurable I/O module displays the **I/O module type** parameter with **Current output** option

2. Setup → Current output

3. Select the monitoring measured variable for the current output in the **Assign current output** parameter

Navigation

"Setup" menu → Current output → Assign current output

Example: Configuring the local display

Select the measured value that is shown on the local display

1. Setup → Display → Value 1 display

2. Select the measured value.

6.2   Operation

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

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

Condition Monitoring focuses on measured variables which indicate a change in the performance of the measuring device brought about by process-related influences. There are two difference categories of process-specific influences:
- Temporary process-specific influences that impact the measuring function directly and therefore result in a higher level of measuring uncertainty than would normally be expected (e.g. measurement of multiphase fluids). These process-specific influences generally do not affect the integrity of the device but do impact measuring performance temporarily.
- Process-related 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 build-up 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:
- Condensation on the sensor
- Droplets in gas pipe
- Pressure pulsation in gas pipe
- Unstable process conditions (pressure/temperature)

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

6.2.1   Overview of the monitoring parameters

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

Monitoring parameter	Possible reasons for deviation
Process stability	• Droplets • Shock waves (compressor, pressure-reducing valve) • Alternating flow profile
Sensor raw signal standard deviation	• Loose connection • EMC interference

7   Modbus RS485 register information

7.1   Notes

7.1.1   Structure of the register information

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

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

> **NOTICE**
>
> **If non-volatile device parameters are modified via the MODBUS RS485 function codes 06, 16 or 23, the change is saved in the EEPROM of the measuring device.**
> The number of writes to the EEPROM is technically restricted to a maximum of 1 million.
> ▸ Make sure to comply with this limit since, if it is exceeded, data loss and measuring device failure will result.
> ▸ Avoid constantly writing non-volatile device parameters via the MODBUS RS485.

7.1.2   Address model

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

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

Depending on the function code used, a number is added at the start of the register address with this specification:
• "3" → "Read" access
• "4" → "Write" access

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

7.2   Overview of the Heartbeat operating menu

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

Navigation
"Expert" menu → Diagnostics → Heartbeat

⌐ Expert	
▸ Diagnostics	→ 🗎 49
▸ Heartbeat	→ 🗎 49
▸ Heartbeat base settings	→ 🗎 49
Plant operator (2754)	→ 🗎 49
Location (2755)	→ 🗎 49
▸ Performing verification	→ 🗎 50
Year (2846)	→ 🗎 50
Month (2845)	→ 🗎 50
Day (2842)	→ 🗎 50
Hour (2843)	→ 🗎 50
AM/PM (2813)	→ 🗎 50
Minute (2844)	→ 🗎 50
Verification mode (12105)	→ 🗎 50
External device information (12101)	→ 🗎 50
Start verification (12127)	→ 🗎 50

Progress (2808)	→ 🖹 50	
Measured values (12102)	→ 🖹 50	
Output values (12103)	→ 🖹 50	
Status (12153)	→ 🖹 50	
Overall result (12149)	→ 🖹 50	
► Verification results	→ 🖹 51	
Date/time (12142)	→ 🖹 51	
Verification ID (12141)	→ 🖹 51	
Operating time (12126)	→ 🖹 51	
Overall result (12149)	→ 🖹 51	
Sensor (12152)	→ 🖹 51	
Sensor electronic module (ISEM) (12151)	→ 🖹 51	
I/O module (12145)	→ 🖹 51	
System status (12109)	→ 🖹 51	

7.3 Register information

7.3.1 "Diagnostics" submenu

"Heartbeat" submenu

"Heartbeat base settings" submenu

Navigation: Expert → Diagnostics → Heartbeat → Heartbeat base settings					
Parameter	Register	Data type	Access	Selection / User entry / User interface	→ 🖹
Plant operator (2754)	3414 to 3429	String	Read / Write	Max. 32 characters such as letters, numbers or special characters (e.g. @, %, /)	19
Location (2755)	3430 to 3445	String	Read / Write	Max. 32 characters such as letters, numbers or special characters (e.g. @, %, /)	19

"Performing verification" submenu

Navigation: Expert → Diagnostics → Heartbeat → Performing verification					
Parameter	Register	Data type	Access	Selection / User entry / User interface	→ 🗎
Year (2846)	2495	Integer	Read / Write	9 to 99	22
Month (2845)	2494	Integer	Read / Write	0 = January 1 = February 2 = March 3 = April 4 = May 5 = June 6 = July 7 = August 8 = September 9 = October 10 = November 11 = December	22
Day (2842)	2493	Integer	Read / Write	1 to 31 d	22
Hour (2843)	2492	Integer	Read / Write	0 to 23 h	22
AM/PM (2813)	2496	Integer	Read / Write	0 = AM 1 = PM	22
Minute (2844)	2467	Integer	Read / Write	0 to 59 min	22
Verification mode (12105)	2366	Integer	Read / Write	0 = Standard verification 1 = Extended verification	23
External device information (12101)	20493 to 20508	String	Read / Write	Free text entry	23
Start verification (12127)	2270	Integer	Read / Write	0 = Cancel 1 = Start 10 = Output 1 low value [*] 11 = Output 1 high value [*] 12 = Output 2 low value [*] 13 = Output 2 high value [*] 14 = Output 3 low value [*] 15 = Output 3 high value [*] 16 = Output 4 low value [*] 17 = Output 4 high value [*] 20 = Pulse output 1 [*] 21 = Frequency output 1 [*] 22 = Pulse output 2 [*] 23 = Frequency output 2 [*] 24 = Double pulse output [*] 25 = Frequency output 3 [*]	23
Progress (2808)	6797	Integer	Read	0 to 100 %	23
Measured values (12102)	5512 to 5513	Float	Read / Write	Signed floating-point number	23
Output values (12103)	5516 to 5517	Float	Read	Signed floating-point number	24
Status (12153)	2079	Integer	Read	0 = Failed 1 = Done 3 = Not done 8 = Busy	24
Overall result (12149)	2355	Integer	Read	0 = Failed 2 = Passed 3 = Not done	24

*   Visibility depends on order options or device settings

"Verification results" submenu

Navigation: Expert → Diagnostics → Heartbeat → Verification results					
Parameter	Register	Data type	Access	Selection / User entry / User interface	→ 🗏
Date/time (12142)	2372 to 2381	String	Read	dd.mmmm.yyyy; hh:mm	33
Verification ID (12141)	2315	Integer	Read	0 to 65 535	33
Operating time (12126)	3346	String	Read	Days (d), hours (h), minutes (m), seconds (s)	33
Overall result (12149)	2355	Integer	Read	0 = Failed 2 = Passed 3 = Not done	24
Sensor (12152)	2384	Integer	Read	0 = Failed 2 = Passed 3 = Not done	33
Sensor electronic module (ISEM) (12151)	2385	Integer	Read	0 = Failed 2 = Passed 3 = Not done	33
I/O module (12145)	2386	Integer	Read	0 = Failed 2 = Passed 3 = Not done 254 = Not plugged	33
System status (12109)	5790	Integer	Read	0 = Failed 2 = Passed 3 = Not done	33

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