

Special Documentation

GammapiLOT FMG50

HART

Application package
Heartbeat Verification + Monitoring



1 About this document

1.1 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.

1.2 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

1.3 Symbols used

1.3.1 Safety symbols

CAUTION

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

DANGER

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

NOTICE

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

WARNING

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

1.3.2 Symbols for certain types of information and graphics



Warns against radioactive substances or ionizing radiation



Permitted

Procedures, processes or actions that are permitted



Preferred

Procedures, processes or actions that are preferred



Forbidden

Procedures, processes or actions that are forbidden

**Tip**

Indicates additional information



Reference to documentation



Reference to page



Reference to graphic



Notice or individual step to be observed

1., 2., 3.

Series of steps



Result of a step



Operation via local display



Operation via operating tool



Write-protected parameter

1, 2, 3, ...

Item numbers

A, B, C, ...

Views

**Safety instructions**

Observe the safety instructions contained in the associated Operating Instructions

1.4 Documentation



For an overview of the scope of the associated Technical Documentation, refer to the following:

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

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

Detailed information: Operating Instructions, additional documentation, Device Viewer.

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



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1.5 Registered trademarks

HART®

Registered trademark of the FieldComm Group, Austin, Texas, USA

2 Product features and availability

2.1 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 measuring devices in the application.

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

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

λ_{TOT} : Rate of all theoretically possible failures

λ_{du} : Rate of undetected dangerous failures

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

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

The TTC is at least:

- 98% for the current output
- 95% for HART communication



The current value for the TTC depends on the configuration and integration of the measuring device. The values indicated above were determined under the following conditions:

- Integration of the measuring device for measured value output via 4 to 20mA HART output
- Simulation operation not active
- Error behavior, current output set to **Minimum alarm** or **Maximum alarm** and evaluation unit recognizes both alarms
- Settings for diagnostic behavior correspond to factory settings

2.2 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.

2.2.1 Order code

If ordering directly with the device or subsequently as a retrofit kit:

Order code 540 "Application package", option EH "Heartbeat Verification + Monitoring"

The availability of the application package can be checked as follows:

- Order code with breakdown of the device features on the delivery note
- On the Web using the Device Viewer: enter the serial number from the nameplate and check whether the order code is displayed
- In the operating menu : The menu indicates whether the application package is activated.

2.2.2 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.

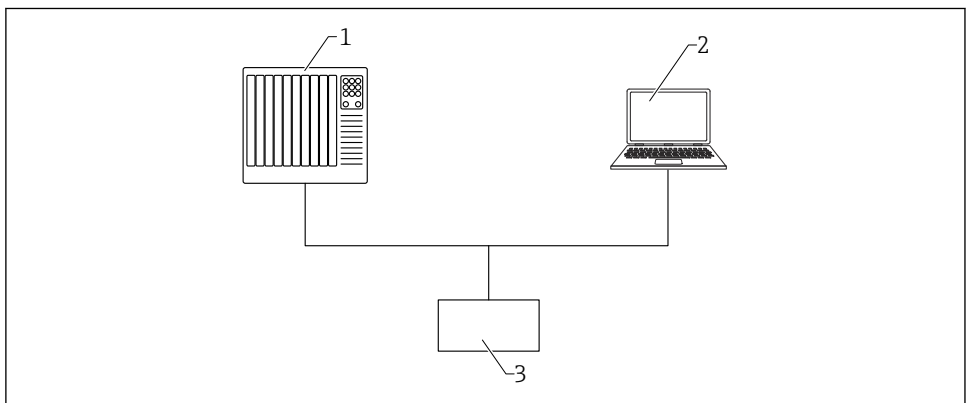
System → Software configuration → Activate SW option

2.2.3 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.

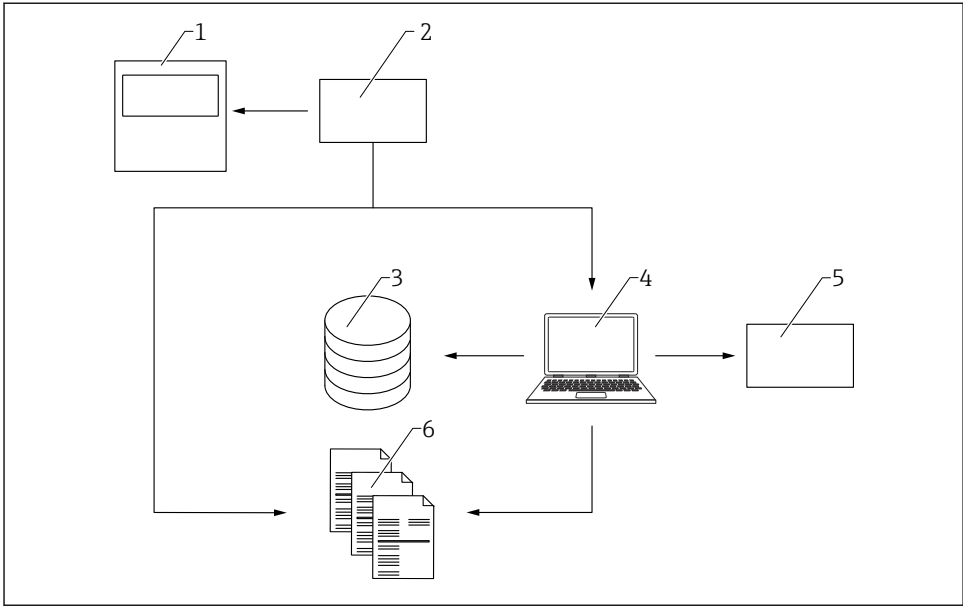
3 System integration

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



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- 1 PLC
- 2 Asset management system
- 3 Measuring device



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- 1 Local display
- 2 Measuring device
- 3 Data archive
- 4 FieldCare
- 5 Netilion Library or W@M Portal
- 6 Verification report

Run the **Heartbeat Verification** via one of the following interfaces:

- System integration interface of a higher-level system
- 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 are saved in the device and provided in the form of a verification report.

Verification reports can be created using Endress+Hauser's FieldCare plant asset management software.

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

Heartbeat Monitoring

- Configuration of the monitoring function: specify which monitoring parameters are output continuously via the system integration interface.
- The user can read the monitoring measured variables in the operating menu.

Heartbeat Verification

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

3.2 Data management

The result of a **Heartbeat Verification** is saved as a non-volatile parameter set in the measuring device memory:

New verification results overwrite old data following the FIFO ¹⁾ principle

3.2.1 Verification report

Print verification report

A verification report is created in PDF format.



Prerequisite: A verification has already been performed.

3.2.2 File management

W@M Portal

Endress+Hauser's W@M Portal allows users to save Heartbeat Verification reports electronically and assign them to the tested device. In this way, the reports are online, easy to find, automatically assigned to their digital twin, and always accessible.

Netilion Library

Heartbeat Verification reports can be saved in Netilion with the Netilion Library www.netilion.endress.com. In this way, the reports are online, automatically assigned to their digital twin, even easier to find, and always accessible. They can be uploaded by notebook, smartphone or a Field Xpert tablet



The stored reports are always available and easy to find for everyone requiring access to the reports. Both tools allow document forwarding and linking, and notification.

1) First In – First Out

4 Heartbeat Verification

Heartbeat Verification uses the self-monitoring function of the measuring devices 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.

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

The total test coverage (TTC) is at least:

- 98% for the current output
- 95% for HART communication

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



Operation continues while the reference data are being recorded.

4.1 Performance characteristics

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

The verification confirms on demand the device function with the specified total test coverage (TTC).

4.2 Operation

4.2.1 Device behavior and interpretation

Result Passed

All test results are within the specifications.

Result Failed

One or more test results are outside the specifications.

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

4.2.2 Internal verification

Performing internal verification

Guidance → Heartbeat Technology → Heartbeat Verification

Select the "START" option here

Displaying the verification status and result

The result of the verification is displayed in the **Overall result** parameter

4.2.3 Verification results

Access to the verification results via:
Operating tool

Classification of results

Individual 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** option" if the result of an individual test is "**Not done** option" and the result of all other tests is "**Passed** option".

- **Not done**

No test has been performed for this test group. For example, because this parameter is not available in the current device configuration.

Overall results:

- **Failed**

At least one test group was outside the specifications.

- **Passed**

All verified test groups complied with the specifications (result "**Passed** option").

The overall result is also "**Passed** option" if the result for an individual test group is "Not done" and the result for all other test groups is "**Passed** option".



Heartbeat Verification confirms the device function within the specified measuring tolerance on demand with a TTC ²⁾ of 98 %.

4.2.4 Verification report

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

2) Total Test Coverage

Verification report, Section 1

Measuring point identification, identification of the verification results and confirmation of completion:

- System operator
 - Customer reference
- Device information
 - Information on the place of operation
 - Device name
 - Management of the information in the device
 - Firmware and hardware version
- Calibration
 - Configuration: operating mode, isotope, background radiation and other configuration parameters
- Verification information
 - Operating time for the unique allocation of the verification results for the purpose of the traceable documentation of the verification
 - The system time is indicated in addition to the current operating time in the measuring device
- Verification result
 - The overall result of the verification is "passed" if all of the individual results are "passed"

Verification report, Section 2

Details on the individual results for all test groups:

- Device and verification information
- Test groups
 - Prerequisite for the verification
 - Mainboard module
 - Sensor module

Verification report, Section 3

Details with values for the individual tests from Section 2

Verification report, Section 4

Additional data that can influence the assessment of the measurement results or the appraisal of the process conditions. Information regarding:

- Process conditions (at the time of the verification)
 - Sensor temperature
 - HART signal quality
- Min/max values of the measuring device
 - Temperature
 - Pulse rate
 - Terminal voltage
- Sensor history
 - Gammagraphy counter
 - Gammagraphy duration
 - Expected operating life of the photomultiplier and the useful life of the radiation source.
The useful life displayed for the radiation source depends on the configured device operating mode.
- Photomultiplier
Additional values dependent on the operating mode

Example of a verification report

Heartbeat Technology verification report

Endress+Hauser

People for Process Automation



Device and verification information

Serial number	P7007C0119F
Device tag	FMG50
Operating time	6d07h08m38s
Plant operator	



Device information

Location	
Device name	FMG50
Order code	FMG50-1186/0
Firmware version	01.00.02
Hardware version	01.00.02

Calibration / Configuration

Measurement mode	Level
Isotope	Caesium 137
Beam type	not modulated
Background radiation	168 cnt/s
Damping output	6.0 s
Lower range value output	0.00 %
Upper range value output	100.00 %

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Heartbeat Technology verification report

Endress+Hauser

People for Process Automation



Device and verification information	
Serial number	P7007C0119F
Device tag	FMG50
Operating time	6d07h08m38s
Plant operator	

Verification information	
Operating time	6d07h08m38s
Date/time	11/1/2021, 10:41:36

Verification result	
Overall result	Passed

Notes

Notes

Confirmation

Heartbeat Verification verifies the function of the device over the useful lifetime with a total test coverage (TTC) from 98 % and meets the requirements for measurement traceability according to ISO 9001. Details to the TTC values and the inspection certificate can be found in the special documentation (SD02414F).

Date

Operator's signature

Inspector's signature

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Heartbeat Technology verification report

Endress+Hauser

People for Process Automation

Device and verification information

Serial number	P7007C0119F
Device tag	FMG50
Operating time	6d07h08m38s
Plant operator	



Verification results

Verification pre-condition

System status	 Passed
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Mainboard module

Terminal voltage	 Passed
Output current	 Passed
Software integrity	 Passed
RAM check	 Passed
ROM check	 Passed

Sensor module

Real time clock	 Passed
Photomultiplier High Voltage	 Passed
Sensor integrity	 Passed

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Heartbeat Technology verification report

Endress+Hauser


People for Process Automation

Device and verification information

Serial number	P7007C0119F
Device tag	FMG50
Operating time	6d07h08m38s
Plant operator	



Verification results – values	Unit	Actual	Min.	Max.
Mainboard module				
Output current				
Output current deviation	mA	-0.0246	-0.5000	0.5000
Terminal voltage				
Terminal voltage value	V	16.2	10.5000	35.0000
Sensor module				
Photomultiplier High Voltage				
High voltage output value	V	565	0	1300
Process condition	Unit	Actual	Min.	Max.
Sensor temperature	°C	16.0	-40.0	85.0
Device history	Unit	Actual	Min.	Max.
Electronics temperature	°C	20.0	19.8	32.5
Sensor temperature	°C	16.0	14.0	25.0
Pulse rate	cnt/s	60	0	1208
Terminal voltage value	V	16.2	15.4	22.6

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Heartbeat Technology verification report

Endress+Hauser

People for Process Automation



Device and verification information

Serial number	P7007C0119F
Device tag	FMG50
Operating time	6d07h08m38s
Plant operator	



Sensor history	Unit	Value
Gammagraphy counter		0
Gammagraphy duration	s	0
Expected source operating time	y	12.8
Expected photomultiplier life time	y	20

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4.2.5 Test criteria for the test objects

 Applies for all operating modes

Prerequisite for the verification

Test: **System status** parameter
Function: Checks active measurement device errors at diagnostical behavior 'alarm'. If an active error is detected, then verification will be performed but the overall result will always be 'Failed'.

Mainboard module

- Test: **Terminal voltage** parameter
Function: Checks whether the voltage at the supply terminals is within the specified limits. Exceeding the maximum terminal voltage can damage the device. If the supply voltage is permanently in the maximum range, the useful life of the device can be reduced. If the terminal voltage falls below the minimum, the device can fail.
If the maximum terminal voltage is exceeded, this can damage the device. If the supply voltage is constantly in the maximum range, this can reduce the operating life of the device. A device failure can occur if the terminal voltage drops below the minimum terminal voltage level.
- Test: **Output current** parameter
Function: Checks whether read-back current at the output matches the current set by the device.
- Test: **Software integrity** parameter
Function: Checks whether the function blocks of the software are executed in the correct order.
- Test: **RAM check** parameter
Function: Checks the correct function of the RAM (Random Access Memory).
- Test: **ROM check** parameter
Function: Checks the correct function of the ROM memory (Read-Only-Memory).

Sensor module

- Test: **Real time clock** parameter
Function: Checks the functions related to the quartz in the real time clock. In addition it checks the plausibility of the time compared to an internal redundant real-time clock and the voltage at the buffer battery.
- Test: **Photomultiplier High Voltage** parameter
Function: Checks the value and the control of the high voltage of the photomultiplier in regards to plausibility and stability.
- Test: **Sensor integrity** parameter
Function: The sensor-controller evaluates the internal sensor diagnostics and transmits the data cyclical to the transmitter-controller. As long as the sensor specific diagnostics e.g. monitoring of sensor voltage and high voltage of Photomultiplier are within certain limits, the sensor integrity will be confirmed.

4.2.6 Additional verification information

Process conditions at the time of the verification

- **Sensor temperature indicator**
Function: current temperature and permitted min/max range
- **HART signal quality indicator**
Function: share of defective data frames in relation to the total number of data frames received.
Possible reasons for poor signal quality include:
 - EMC influence
 - A defective device on the same bus
 - Poor contacts
 - A resistor of the wrong size

Device history

Current value and min/max values for:

- Electronics temperature
- Sensor temperature
- Pulse rate
- Terminal voltage

Sensor history

■ > **Gammagraphy counter**

Function: The number of detected gammagraphy events. An event is counted if it has lasted longer than the configured gammagraphy dwell time. Shorter events are not counted.

■ > **Gammagraphy duration**

Function: The total time in which the device detected a gammagraphy alarm or warning.

The time is not reset if the device is reset to factory settings.

■ > **Achieved stability of measurement** parameter (only the density/concentration/interface operating mode)

Function: The stability of a detector influences the repeatability of a signal over time and temperature changes. The stability depends on the used scintillator material and the half-value layer thickness of the application.

The measuring stability of the detector influences the accuracy over the operating time and temperature changes.

The measuring stability largely depends on the scintillator type used: NaI(Tl) or PVT. The following applies for the scintillator:

- $\pm 0.1\%$ for NaI(Tl)
- $\pm 0.5\%$ for PVT

The function calculates the achieved stability of measurement as a % at an average pulse rate $I_N = (I_{MAX} + I_{MIN})/2$ and with a measuring range span $\Delta I = I_{MAX} - I_{MIN}$ (the difference between the min pulse rate I_{MIN} and the max pulse rate I_{MAX}).

Stability:

- NaI(Tl): $\pm 0.1\% \times I_N / \Delta I$
- PVT: $\pm 0.5\% \times I_N / \Delta I$

- > **Standard deviation** parameter (only the density/concentration/interface operating mode)

Function: The standard deviation is calculated as $\pm 2/\sqrt{I_N \tau}$ with an average pulse rate I_N and an integration time τ . This corresponds to the statistical uncertainty of measurement according to VDI/VDE 3618-11.

The statistical uncertainty of measurement can be reduced by:

- Increasing the integration time τ
 - Increasing the optical path length (e.g. diagonal irradiation of a pipe)
 - Using a stronger radiation source
 - > **Expected source operating time** parameter
- Function: The intensity of the radiation source decreases over time. The expected operating time of the radiation source is calculated from the current difference in the pulse rates for "Full" and "Empty" or "Covered" and "Free" and the configured damping. The end of the operating time is reached if the distance between the calibration values has reached the following value:
- For level applications: $\Delta I = 1500 \text{ cnt}/\tau$
 - For point level applications $\Delta I = 150 \text{ cnt}/\tau$
- The damping time τ can be increased to increase the operating time.
- The **Expected source operating time** parameter is calculated in years [y]
- > **Expected operating life of the photomultiplier**
- Function: The operating life of the photomultiplier tube is estimated over the operating duration of the device by integrating the detected pulse rate
- The expected operating life of the photomultiplier is calculated in years [y]

4.2.7 Heartbeat Technology in safety instrumented systems

The device verification (Heartbeat Verification) enables the documentation of the current device diagnostic or the device status as proof of testing.

This supports the documentation of proof tests according to IEC 61511-1, Section 16.3.3, "Documentation of proof tests and inspections".

Heartbeat Verification is based on device-specific test sequences that are performed automatically. From a safety perspective, Heartbeat Verification cannot replace the proof-testing of a sensor, as random errors are generally not detected.

Nevertheless Heartbeat Verification can be a useful step in a proof-test scenario within the context of flexible proof testing according to NA 106. The verification report can be considered a supplement to the proof-test report.

4.2.8 Recommendations in the event of a verification with the verification result: "Failed" option

Verification result parameter: If the result of a verification is **Failed** option, it is advisable to repeat the verification.

- Establish defined and stable process conditions to rule out any influence from the process as much as possible.
- When repeating the verification, the current process conditions must be compared with the process conditions of the previous verification in order to identify any deviations.
- Take remedial action on the basis of the diagnostic information of the measuring device.

5 Heartbeat Monitoring

The Heartbeat Monitoring Wizard can be used to define the correct damping. Additional monitoring parameters can also be output.

5.1 Heartbeat Monitoring Wizard

Guidance → Heartbeat Technology → Heartbeat Monitoring

This Wizard can be used to define the correct damping. The expected operating life of the radiation source is determined for level and point level applications based on the selected damping. The expected stability and standard deviation are determined for an average pulse rate for density and concentration applications. .

 This Wizard does not support the Slave and Interface operating modes.

5.2 Commissioning

Assign the monitoring parameters to the outputs for commissioning. After commissioning, these parameters are continuously available at the outputs.

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

Measured variables:

- **Electronics temperature**
Temperature of the electronics in the set system unit
Range: -50 to +90 °C
- **Pulse rate**
Measured raw pulse rate of the sensor
Range: 0 to 60 000 cnt/s
- **High voltage**
Control voltage of the photomultiplier tube
Range: 400 to 1 300 V

Defining monitoring parameters as HART SV/TV/QV:

1. Application → HART → HART output
2. Select SV/TV/QV
3. Select the monitoring parameter

Selecting the measured value that is shown on the local display:

1. System → Display
2. Select the measured value

6 Certificates and approvals



The availability of approvals and certificates can be called up daily via the Product Configurator.

6.1 Inspection Certificate

Inspektionsbescheinigung

Inspection Certificate



Bescheinigung Nr.
Certificate No

968/INS 298.00/20

Kunde / Bescheinigungs-Inhaber
Client / Certificate Owner

Endress+Hauser SE + Co. KG
Hauptstraße 1
79689 Maulburg
Germany

Produkt
Product

Heartbeat Technology mit Heartbeat Diagnostics und Heartbeat Verification integriert in Gammapilot
Heartbeat Technology including Heartbeat Diagnostics and Heartbeat Verification integrated in Gammapilot

Typbezeichnung
Type designation

FMG50

Grundlagen der Inspektion
Standards applied for inspection

IEC 61508-2:2010 (in extracts)
IEC 61508-3:2010 (in extracts)

Inspektionsergebnis
Inspection Results

Heartbeat Verification bestätigt auf Anforderung die Gerätefunktion vom FMG50 innerhalb der spezifizierten Messtoleranz mit einer dafür definierten Testabdeckung (Total Test Coverage "TTC") TTC = 96% (Stromausgang) und TTC = 95% (HART Kommunikation). Die Heartbeat Technology unterstützt den Anwender bei der Verifizierung gemäß ISO 9001:2008, Kapitel 7.6 a "Lenkung von Überwachungs- und Messmitteln" bzw. ISO 9001:2015, Kapitel 7.1.5.2 a "Messtechnische Rückführbarkeit" umzusetzen, indem die aus der Werkskalibrierung abgeleitete definierte Messtoleranz des Gerätes mit der oben angegebenen Testabdeckung bestätigt wird. Zur Aufrechterhaltung der Genauigkeit ist eine regelmäßige Prüfung des Gerätes erforderlich. Gemäß Norm obliegt dem Anwender die anforderungsgerechte Festlegung des Verifikationsintervalls.

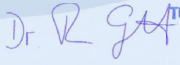
Heartbeat verification confirms on request the device function of the FMG50 within the specified measurement tolerance with a test coverage (Total Test Coverage "TTC") of TTC = 96% (current output) and TTC = 95% (HART communication). The Heartbeat Technology supports the user during the verification process according to ISO 9001:2008, chapter 7.6 a) "Control of monitoring and measuring equipment" and ISO 9001:2015 chapter 7.1.5.2a "Measurement traceability" by confirming the defined measurement tolerance of the device derived from the factory calibration with the test coverage given above. According to the standard, the user is responsible for determining the verification interval in accordance with the requirements.

Zeitraum der Inspektion
Inspection Period

05.05.2020 - 06.10.2020
2020-05-05 - 2020-10-06

Cologne, 2020-12-01

TÜV Rheinland Industrie Service GmbH
Am Grauen Stein,
D-51105 Köln


Dr.-Ing. Thorsten Gantevoort

TÜV Rheinland Industrie Service GmbH
Bereich Automation
Funktionale Sicherheit
Am Grauen Stein, 51105 Köln

Inspection Body of TÜV Rheinland Industrie Service GmbH
Automation - Functional Safety, www.tuvr.com

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TÜV Rheinland Industrie Service GmbH, Am Grauen Stein, 51105 Köln / Germany
Tel.: TÜV Rheinland Industrie Service GmbH +49 221 800-1792 Fax: +49 221 800-1030, E-Mail: industrie-service@tuvr.com

www.tuv.com

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71556111

www.addresses.endress.com
