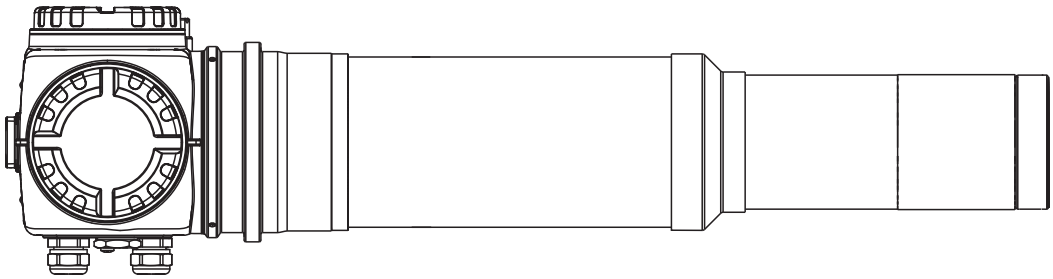
Functional safety manual

Gammapilot M FMG60

Radiometric measurement technology
Minimum point level detection



Application
Minimum point level detection of liquids and bulk solids of all kinds in vessels that are to satisfy the special requirements of safety technology in accordance with IEC 61508.

The measuring device fulfills the requirements concerning:
- Functional safety in accordance with IEC 61508
- Explosion protection (depending on version)
- Electromagnetic compatibility in accordance with EN 61326 and NAMUR recommendation NE 21
- Electrical safety in accordance with IEC/EN 61010-1

Your benefits
- Minimum point level detection up to SIL 3
  - Independently assessed (Functional Safety Assessment) by TÜV Rheinland in accordance with IEC 61508
- Continuous self-monitoring
- Safe parameterization concept
- "Low demand mode" and "High demand mode"

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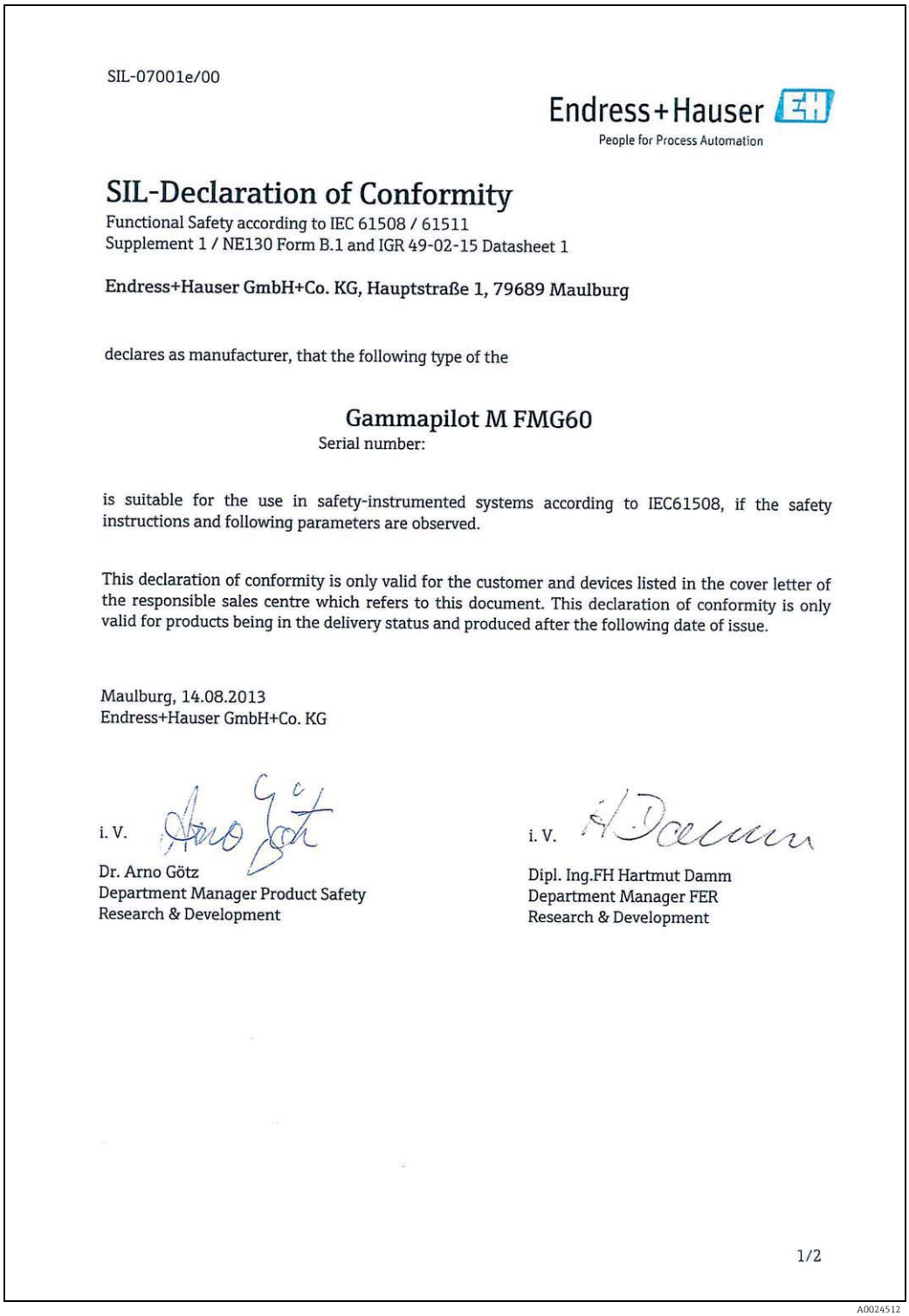
SIL Declaration of Conformity

The binding document is included in the scope of supply when ordering the Gammapilot M with the "SIL Declaration of conformity" option.



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SIL-Declaration of Conformity

Functional Safety according to IEC 61508 / 61511
Supplement 1 / NE130 Form B.1 and IGR 49-02-15 Datasheet 1

Endress+Hauser GmbH+Co. KG, Hauptstraße 1, 79689 Maulburg

declares as manufacturer, that the following type of the

Gammapilot M FMG60
Serial number:

is suitable for the use in safety-instrumented systems according to IEC61508, if the safety instructions and following parameters are observed.

This declaration of conformity is only valid for the customer and devices listed in the cover letter of the responsible sales centre which refers to this document. This declaration of conformity is only valid for products being in the delivery status and produced after the following date of issue.

Maulburg, 14.08.2013
Endress+Hauser GmbH+Co. KG

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General			
Device designation and permissible types	Gammapilot M FMG60		
	PVT Scintillator 200 and 400 mm		
Safety-related output signal	4...20mA		
Fault current	<3,6mA / >21mA		
Process variable/function	level limit detection		
Safety function(s)	maximum or minimum level limit detection		
Device type acc. to IEC 61508-2	☐ Typ A	☒ Typ B	
Operating mode	☒ Low Demand Mode	☒ High Demand or Continuous Mode	
Valid Hardware-Version	all hardware since 30. April 2007 for max level limit and all hardware since 1. June 2010 for min level limit		
Valid Software-Version	01.02.00 and 01.02.02		
Safety manual	SD00230F/00 (max)/ SD00324F/00 (min)		
Type of evalutation (check only one box)	☒	Complete HW/SW evaluation parallel to development incl. FMEDA and change request acc. to IEC 61508-2, 3	
	☐	Evaluation of "Proven-in-use" performance for HW/SW incl. FMEDA and change request acc. to IEC 61508-2, 3	
	☐	Evaluation of HW/SW field data to verify „prior use" acc. to IEC 61511	
	☐	Evaluation by FMEDA acc. to IEC61508-2 for devices w/o software	
Evaluation through – report no.	TÜV Rheinland		
Test documents	develop. documents	test reports	data sheets

SIL - Integrity			
Systematic safety integrity		☒ SIL 2 capable	☒ SIL 3 capable
Hardware safety integrity	Single channel use (HFT = 0)	☒ SIL 2 capable	☐ SIL 3 capable
	Multi channel use (HFT ≥1)	☐ SIL 2 capable	☒ SIL 3 capable

FMEDA		
Safety function	maximum level limit detection	minimum level limit detection
λ_{DU} *1)	92 FIT	96 FIT
λ_{DD} *1)	1316 FIT	1638 FIT
λ_{SU} *1)	655 *3) / 99 *4) FIT	611 *3) / 15 *4) FIT
λ_{SD} *1)	577 FIT	344 FIT
SFF - Safe Failure Fraction	96 %	94 %
PTC *2)	98 %	98 %
λ_{total} *1)	3303 FIT	3303 FIT
Diagnostic test interval / fault reaction time	15 min / 6 sec	15 min / 6 sec

Declaration	
☒	Our internal company quality management system ensures information on safety-related systematic faults which become evident in the future

*1) FIT = Failure In Time, Number of breakdown per 10^9 h
*2) PTC = Proof Test Coverage (Diagnostic coverage for manual proof tests)
*3) previous value according IEC61508 Ed. 1
*4) according IEC61508 ED. 2

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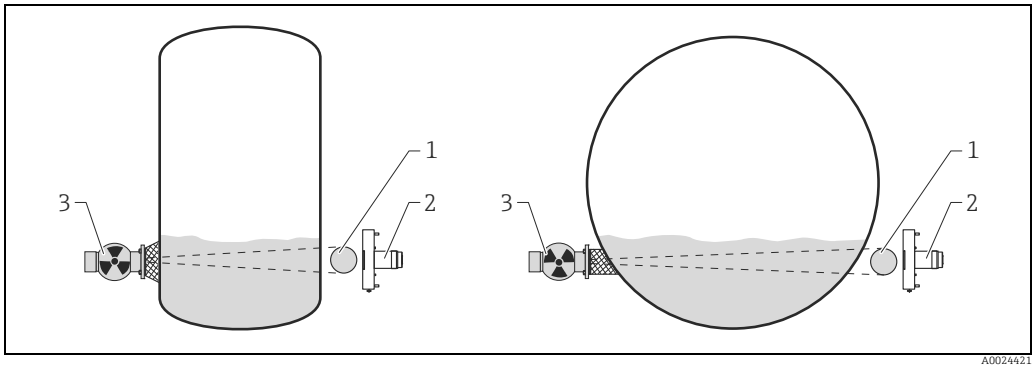
General information

General information about functional safety (SIL) is available at www.endress.com/SIL and in the Competence brochure CP01008Z/11 "Functional safety in the Process Industry - risk reduction with Safety Instrumented Systems".

Structure of measuring system with Gammapilot M FMG60

Level limit measuring system

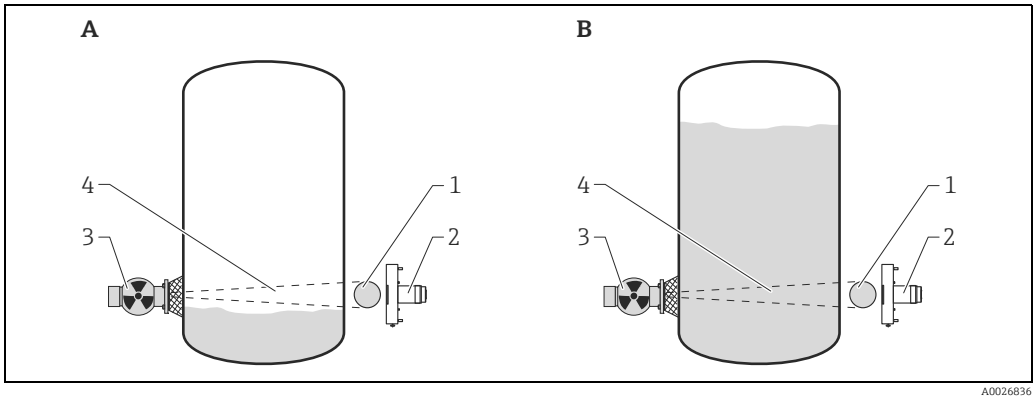
The following diagram shows an example of the measuring system in use.



1 Gammapilot M FMG60
2 Reference source
3 Operating source

Level limit detection

The measuring system consists of a sensor, a gamma radiation source (operating source) and another gamma radiation source (reference source). Level limit detection takes place when a guided gamma ray from the operating source ceases to be interrupted by the medium which is being monitored.
Typical measurement setup:



In the transmitter (Gammapilot M), an analog signal (4 to 20 mA) proportional to the radiation is generated. This signal is sent to a logic unit located downstream from the transmitter (e.g. PLC, limit signal transmitter) and is monitored there to ensure it does not fall below a minimum value. Minimum point level detection requires a weak radiation source (reference source) for reliable function monitoring.
An individual operating source and reference source are recommended for each level limit monitor. The radiation path of the operating source should be adapted to the dimension of the measuring length used.
When using multiple detectors with 1oo2 or 2oo3 architectures, the height of the detector arrangement with regard to the switch point must also be taken into account (→ 14).

Permitted device types

The details pertaining to functional safety in this manual relate to the device versions listed below and are valid as of the specified soft- and hardware version. Unless otherwise specified, all subsequent versions can also be used for safety instrumented systems. A modification process according to IEC 61508 is applied for device changes. Valid device versions for safety-related use:

Ordering feature	Designation	Option	
010	Approval	all	
020	Power Supply	all	
030	Connect. Power Supply; Connect. Output	all	
040	Output	1	4-20 mA, HART
050	Scintillator, Measuring Range	G	PVT; 200 mm
		H	PVT; 200 mm + cooling tube
		J	PVT; 400 mm
		K	PVT; 400 mm + cooling tube
060	Housing, Pipe; Operation	all	
070	Cable Entry Power Supply	all	
080	Cable Entry Output	all	
090	Additional Option	B	SIL
995	Marking	all	

Valid firmware version: 01.02.00 and 01.02.02
Valid hardware version (electronics): June 1st, 2010 or newer

Supplementary device documentation

Documentation	Contents	Note
Technical Information TI00363F/00/EN (Gammapilot M FMG60)	– Technical data – Information on accessories	
Operating Instructions BA00236F/00/EN (Gammapilot M FMG60)	– Identification – Mounting – Wiring – Operation – Commissioning – Maintenance – Accessories – Troubleshooting – Technical data – Appendix: Diagram of menus	
Operating Instructions BA00287F/00/EN (Gammapilot M FMG60) Description of device functions	– Description of operating concept – Description of device functions	This document can be found in the form of a PDF file on the "FieldCare DS Package" DVD provided.
KA00202F/00 /EN (Remote operating and display unit FHX40)	– Usage – Mounting – Commissioning	Use of the separate display/ operating unit is optional.
KA00253F/00/EN (Mounting device FHG60 for Gammapilot M FMG60)	– Usage and application guidelines	To ensure safe, mechanical attachment, the mounting device FHG60 is recommended for safety-related applications. Alternative, equivalent devices are used at the operator's risk.
Safety information depending on the type of certificate chosen	– Safety, mounting and operating instructions for devices suitable for use in hazardous areas or as overflow protection (WHG).	For certified device versions, additional safety information (XA, XB, XC, ZE, ZD) is provided. The nameplate indicates which safety information applies to your device version.
▪ Technical Information TI00435F/00/EN (FQG61/ FQG62) ▪ Operating Instructions BA00223F/00/EN (QQ2000) ▪ Technical Information TI00445F/00/EN (FQG60)	– Technical data – Mounting – Commissioning – Operation	Which source container should be used depends on the isotope and the activity of the emitter.
Mounting Instructions SD00343F/00/EN (Installation of FQG60 as a reference source for SIL Min-Safety)	– Technical data – Mounting	FQG60 as reference source can be installed directly on the pipe of the Gammapilot M using the clamping device. **Caution**: FQG60 is available only for the isotope Cs137.

Description of safety requirements and boundary conditions

Safety function

The safety function of the measuring system is the minimum point level detection. The radiometric measuring system does not come into contact with the medium.

To activate the safety functions, the Gammapilot M must be locked directly after calibration (see Section "Method for parameterization of devices" → 16).

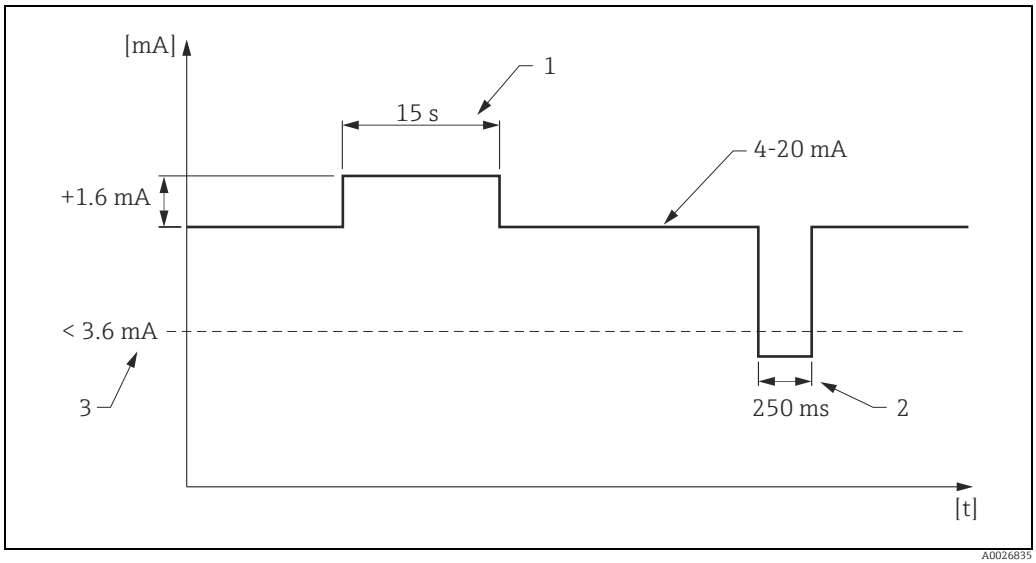
Safety-related signal:

The safety-related signal of the Gammapilot M FMG60 is the analog output signal 4 to 20 mA.
All safety measures are based exclusively on this output.
In addition, the Gammapilot M communicates non safety-related information via HART and contains all
HART characteristics with additional device information.

The Gammapilot M generates an analog signal (4 to 20 mA) proportional to the pulse rate. 4 mA corresponds to the "free" state, 20 mA corresponds to the "covered" state. This signal is sent to a logic unit located downstream, e.g. a programmable logic controller or a limit signal transmitter, and monitored there to establish if:

- a predefined level limit is undershot
- an error occurs, e.g. error current in accordance with NE 43 (≤ 3.6 mA; ≥ 21 mA, interruption or short-circuiting of signal line).

In addition to the analog signal path for the output current, the Gammapilot M has a redundant, internal, digital signal path. Both paths are monitored continuously by the Gammapilot M. This results in the following behavior of the output current:



1 Analog signal path test
2 Digital signal path test
3 < 3.6 mA (typically 2.4 mA)

- **Electronic partial stroke test (analog signal path test):**
  This is a cyclical life test of the analog signal path. For this test, the output current is increased by 10% of the measuring range (1.6 mA) up to a maximum of 20 mA every 2 minutes for 15 seconds. Safe level limit detection is not affected by the hysteresis which must be configured in the PLC (see "Configuration of switch point and hysteresis" → 19).
  This signal path can be used to continuously monitor and detect the correct safety-related configuration and correct functioning of the Gammapilot M.

- **Digital signal path test:**
  This is a cyclical life test of the digital signal path. For this test, the output current is set to a value < 3.6 mA (typically 2.4 mA) every 2 minutes for 250 ms. The evaluation unit located downstream must be configured in such a way that this test is not interpreted as a signal on alarm.
  According to NE 43 §7, for example, a signal on alarm is not to be recognized as such unless it lasts at least 4 seconds.

Restrictions for use in safety-related applications

Application, mounting, installation

- The use of the Gammapilot M is permitted for minimum point level detection with a PVT scintillator of 200 mm or 400 mm length.
- For permitted mounting positions, see "Orientation" → 14.
- Sustained or temporary vibrations and shocks may influence the measuring signal and should therefore be avoided if possible. This can, for example, be done by mounting the Gammapilot M in such a way that it is decoupled from the source of vibration.
- In order to ensure freedom from interference, interconnection for HART multidrop mode is not permitted .
- In the case of pressurized tanks, the effect of the pressure on the safety function must be considered separately. Pressurized gas phases may affect the absorption of radiation due to the change in their density.
- Strong magnetic fields in proximity to the Gammapilot M may result in a reduction of the pulse rate. If necessary, protective measures must be taken.
- The suitability of the measurement method must be checked separately for applications that are subject to external influences (e.g. heavy soiling, heavy buildup, cornices that break off, buildup within the water cooling jacket of the Gammapilot M) on the radiation path.
- The mechanical attachment of the Gammapilot M and the source containers must be designed in such a way that the devices are prevented at all times from moving or shifting.
- The Modulator FHG65 for suppression of interference radiation is suitable only for maximum point level detection and must not be used for minimum point level detection.

Calibration, adjustment

Calibrating the measuring point→ 16

- Background radiation must not exceed 8,000 cps
- The maximum pulse rate for the "free" calibration must not exceed 60,000 cps.
- The pulse rate, which is generated only by the reference source (reference pulse rate), must be greater than 1000 cps.
- For correct function monitoring, the pulse rate of the "free" calibration must not be greater than 1.5 times the pulse rate of the covered calibration.

  Example:
  "Covered" calibration: 3750 cps (the "reference pulse rate > 1000 cps" condition is met)
  "Free" calibration: ≤ 5625 cps (the "free pulse rate ≤ (1500 cps x 1.5)" condition is met)

  Example of application for a reference source:
  Reference source: Gamma source container FQG60, equipped with isotope ^{137}Cs of activity 1.85 MBq.
  The Gamma source container is mounted directly to the Gammapilot M.
  Expected reference impulse rate: 3750 cps.
  Order data:
  – Gamma source container: FQG60-xxx1RTA1xxxx
  – Gamma source: FSG60-RTA1
  – Mounting parts: Parts no.: 71130143

- The minimum value of the reference pulse rate must not be undershot during the entire useful life. When setting up the reference source, the decay of the gamma radiation source during the useful life must be taken into account.

  Additional information:
  Half-life ^{60}Co: approx. 5.3 years
  Half-life ^{137} Cs: approx. 30 years

$$\text{Permitted useful life} = -\frac{\text{Half-life}}{0.7} \cdot \ln\left(\frac{1000\ \text{cps}}{\text{Covered calibration (cps)}}\right)$$

  Example:

$$\text{Permitted useful life} = -\frac{30\ \text{a}}{0.7} \cdot \ln\left(\frac{1000\ \text{cps}}{3750\ \text{cps}}\right) = 56\ \text{years}$$

- The pulse rate for the "covered" calibration must always be lower than the pulse rate for the "free" calibration.

Operating conditions, radiation sources

- To ensure the reliability of decay compensation, only ^{137}Cs or ^{60}Co radiation sources, which do not contain any foreign isotopes with longer or shorter half-lives, may be used.
- Measurements are not permitted on radiating media.
- To enable correct decay compensation, the operating source isotope and the reference source isotope must be identical. For both sources, use either ^{137}Cs or ^{60}Co.
- For safety reasons, only manually operated source containers may be used for minimum point level detection.
- Influences that cause attenuation of the radiation from the reference or operating source (e.g. soiling) must be effectively eliminated.
- **Caution:**
  Switching off the source containers while the measuring system is in operation can cause undetectable safety-critical errors and must be prevented by suitable organizational measures in order to maintain safety.
  The ON position of the source containers must be secured so that they cannot be switched OFF by accident.

Operating conditions, detector

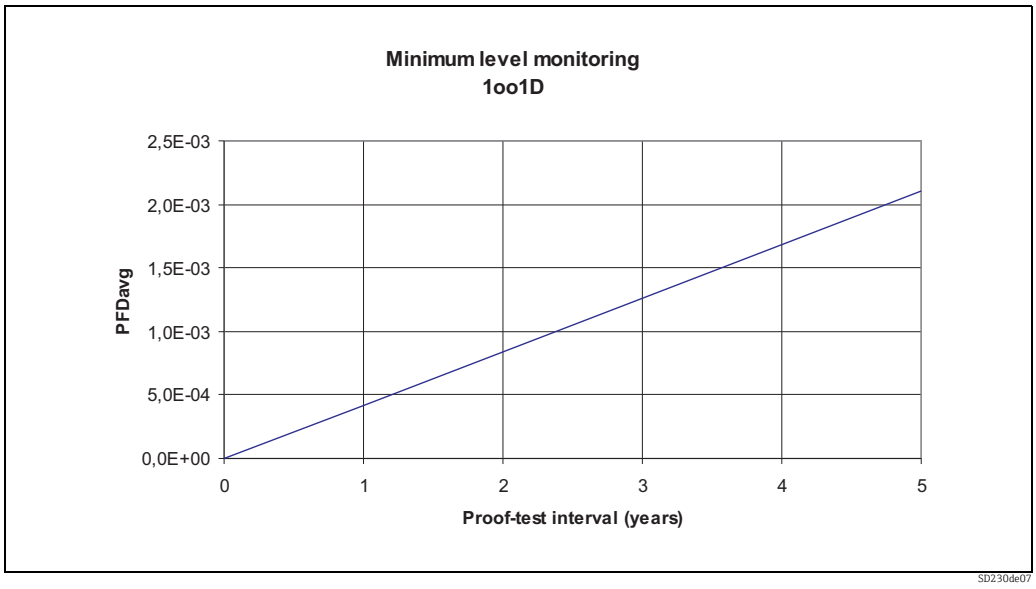
- The Gammapilot M may only be used in "stand alone" mode or in "level limit" mode. The interconnection of several detectors in a cascade is not permitted.
- The Modulator FHG65 is not suitable for the minimum point level detection. For this reason, always select the "standard" setting for the "type of radiation" function.

Functional safety characteristics (SIL 2)

The table shows the specific functional safety characteristics for single-channel device operation *3:

Characteristic according to IEC 61508	Value	
Protection function	Minimum point level detection	
SIL	Hardware: 2	Software: 3
HFT	0	
Device type	B	
Mode of operation	Low demand mode, High demand mode	
SFF	94%	
MTTR	8 h	
T_1	Interval between recurrent tests; see chart	
λ_{sd}	344 FIT	
λ_{su}	611 FIT*6 / 15 FIT*5	
λ_{dd}	1638 FIT	
λ_{du}	96 FIT	
λ_{tot} *1	3303 FIT	
PFD_{avg} for T_1 = 1 year *2	4.21×10^{-4}	
PFD_{avg} for T_1 = 5 years *2	2.10×10^{-3}	
PFH *2	96×10^{-9} 1/h	
MTBF *1	35 years	
Diagnosis test interval	15 min	
Error response time *4	6 s	

*1 In accordance with Siemens SN29500.
*2 For an average continuous operation temperature near 50 °C (+122 °F), a factor of 1.3 should be taken into account.
*3 For multichannel device operation, see the "Appendix", → 🖹 21.
*4 The error response time is the time between the detection of an internal error and the setting of the corresponding error current (≤ 3.6 mA or ≥ 21 mA).
*5 In accordance with IEC 61508 Ed.2
*6 In accordance with IEC 61508 Ed.1



Proof-test interval

Dangerous undetected failures in this scenario:

A dangerous, undetected failure is defined as an incorrect output signal which deviates from the real measured value by more than 10 %, with the output signal remaining within the range of 4 to 20 mA.

Diagnosis test interval:

The internal diagnosis test interval of the Gammapilot M is 15 minutes. During this time, all internal safety functions are executed at least once.

Useful lifetime of electrical components:

The established failure rates of electrical components apply within the useful lifetime as per IEC 61508-2, section 7.4.9.5 note 3.

- In accordance with DIN EN 61508-2, Note NA4, appropriate measures taken by the manufacturer and operator can extend the useful lifetime.
- Correct installation is key to the safe operation of the Gammapilot M.

Behavior of device when in operation and in case of failure

Behavior of device when switched on

Once it has been switched on, every Gammapilot M goes through a diagnosis phase lasting maximum 120 seconds.
During this time, the current output is at error current ≤ 3.6 mA.
During the diagnosis phase, communication via the display interface or via HART is not possible.

Once the diagnosis phase has been successfully completed, a device which has not yet been calibrated sets the current output to error current ≥ 21 mA and retains this value until calibration has been completed.
Once calibration has been successfully completed, the device switches to measuring mode (current output: 4 to 20 mA). If an internal device error is detected during the diagnosis phase, the current output remains at error current ≤ 3.6 mA. If an internal device error is detected during the calibration, the current output remains at error current ≥ 21 mA.
An already calibrated device passes into operation after successful completion of the diagnosis phase (current output: 4 to 20 mA), otherwise it remains at the error current ≤ 3.6 mA.

- If a calibrated Gammapilot M is cut off from its power supply, the internal clock is buffered for at least 6 days. *After* this time, it may be necessary to re-enter the current date and time. This is indicated by error current ≥ 21 mA and error message A635.
  To enter the date and time, the device must be unlocked and then locked again (see Operating Instructions BA00236F/00/EN, Appendix "Operating menu for level limit detection").
- To activate the safety functions, the Gammapilot M must be locked directly after calibration (see "Method for parameterization of devices" → 16).

Behavior of device on demand

Once the minimum level is reached, the radiation is no longer absorbed by the medium in the tank. The output current is set to 4 mA. The rise time corresponds to the configured output damping τ (1 to 999 s; default value 6 s) *plus* the device-internal dead time.

Setting the "Basic Setup" menu selection, "Type of radiation" function	Device-internal dead time
Standard[1)]	1 s

1) The "modulated" setting is not intended for minimum point level detection.

Please also note the Section "Output damping" in the Operating Instructions BA00236F/00/EN.

Behavior of device during continuous operation

⚠ CAUTION
The operating source must not be switched OFF during safety-related operation, since then the "free" state (i.e., for example, emptying a vessel) can no longer be detected. If it is necessary to switch off the operating source, other measures must be taken to maintain safety.

NOTICE
Switching off the reference source triggers the "Interference radiation detection" function.

Behavior of device in the event of alarms and warnings

Error current

The output current in the event of an alarm is fixed at a value ≥ 21 mA.

In some cases output currents ≤ 3.6 mA may occur (e.g. if the power supply fails or a line breaks or if there is an error in the current output itself and the error current ≥ 21 mA can not be set).
For alarm monitoring, the logic unit must therefore be able to detect HI alarms (≥ 21 mA) and LO alarms (≤ 3.6 mA).

Alarm and warning messages

The alarm and warning messages, which are output in the form of error codes, provide additional information. The following table shows the correlation between the error code and the current output:

Error code *1	Current output (message type)	Note
Axxx	≥ 21 mA or ≤ 3.6 mA (alarm)	xxx = three-digit number
Wxxx	corresponding to measuring mode	xxx = three-digit number
A692	≥ 21 mA (alarm)	Gammagraphy detected (alarm)
W693	3.8 mA ± 0.05 mA (warning)	Gammagraphy detected (warning)
W640	≤ 3.6 mA (SIL lock device W640)	Locking sequence in operation

*1 The error codes are listed in the Operating Instructions BA00236F/00/EN, Section "Error codes".

Interference radiation detection

With minimum level limit detection, the "Gammagraphy detection" function serves exclusively for function monitoring of the Gammapilot M.

⚠ CAUTION

The "Gammagraphy detection" function can be triggered by interference radiation. In this process, the output current is first set to 3.8 mA (warning) and, once the (gammagraphy) hold time has expired, to 22 mA (alarm). During the (gammagraphy) hold time, a current of 3.8 mA is output, which corresponds to the "free" state. The emptying of a vessel cannot be detected during this time.

If x-ray tests are carried out within the facility or in its immediate vicinity, or if any other sources of interference are present, alternative measures must be taken to maintain safety during the hold time.

⚠ CAUTION

The "Interference radiation detection" function (gammagraphy) is used simultaneously for monitoring the reference source. Modifications to the reference source can trigger the "Gammagraphy detected" message (alarm or warning).

Installation

Mounting, wiring and commissioning

The mounting, wiring and commissioning of the Gammapilot M is described in the Operating Instructions BA00236F/00/EN.

- When the device is being used in safety-related applications, the "Cascade in", "Cascade out" and "PT100" terminals must not be wired (for terminal assignment, see BA00236F/00/EN, Section "Terminal assignment").
- To ensure system safety, it is recommended that safety-related and non-safety-related devices and functions be kept strictly separate.

Orientation

Permitted orientation:
- Horizontal and at right angles to the direction of radiation (recommended due to higher sensitivity)

The Gammapilot M must be positioned in the radiation path in such a way that the scintillator is completely irradiated by the operating source. The position and length of the scintillator is indicated by markings on the housing pipe.

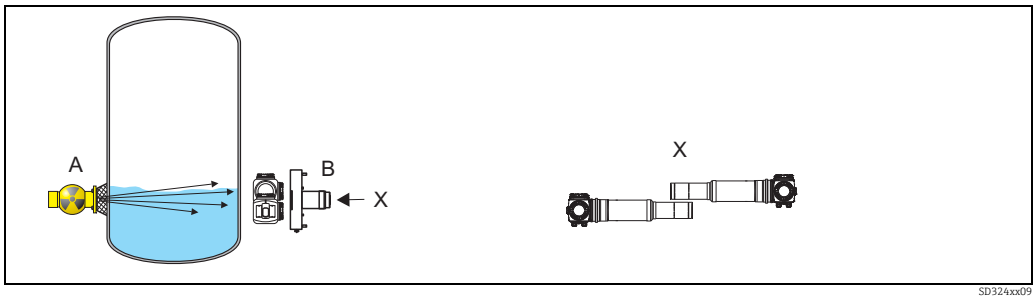
It is permitted to use a water cooling jacket or additional coverings on the detector as protection from the sun or weather. As additional coverings can affect the measuring signal due to backscatter, the measuring point must not be calibrated until installation is complete.
The water cooling jacket must be filled completely during calibration. The flow values and limit temperature values listed for water cooling in the Operating Instructions must be observed.

If several radiometric measuring points are in use, pay attention to the orientation of the sources and the arrangement of the detectors to ensure that they do not interfere with each other.

Notes on the redundant use of multiple detectors

This section provides additional information on the use of multiple detectors in 1oo2 or 2oo3 architectures for safety-related level limit detection:
- Only one operating source and one reference source per measuring point may be used with identical isotopes.
- Identical measuring lengths must be used when using multiple detectors.
- The following parameters must be configured identically when using multiple detectors:
  Isotope, beam type, gammagraphy hold time, output damping, current date.
  For background calibration as well as "covered" and "free" calibration, the same requirements that apply for single-channel arrangement apply for each detector.

Installation with 1oo2 architecture and detectors arranged one above the other

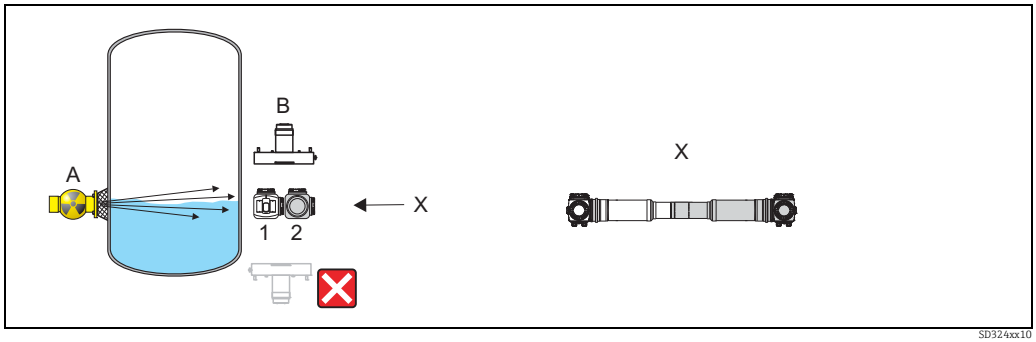


SD324xx09

A Operating source
B Reference source

The position of the lower detector determines the most unfavorable switch point.

Installation with 1oo2 architecture and detectors arranged horizontally side by side:

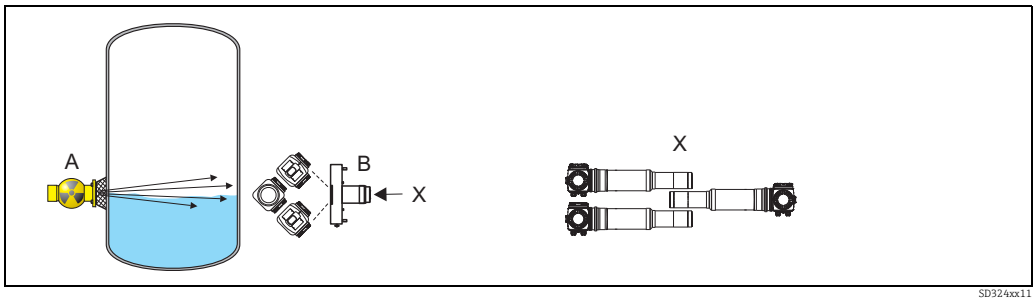


A Operating source
B Reference source
1 Detector 1 (close to the tank)
2 Detector 2 (facing away from the tank)

- Due to the limited beam path geometry, this detector arrangement can be advantageous for small vessel diameters.
- The Gammapilot close to the tank (detector 1) partially screens off the Gammapilot facing away from the tank (detector 2). This must be taken into consideration when planning the activity of the source. The following table provides approximate information on the absorption:

	Percentage pulse rate available at detector 2	
Source	Detector without water cooling	Detector with water cooling
^{137}Cs	approx. 60 %	approx. 36 %
^{60}Co	approx. 70 %	approx. 48 %

Installation with 2oo3 architecture in preferred arrangement:



A Operating source
B Reference source

The position of the lower detector determines the most unfavorable switch point.

Operation

NOTICE

The term calibration, which is often used in the context of radiometric measuring systems, refers to the calibration process of the measuring point installed in the system. The measuring point comprises a detector and radiation sources.

⚠ CAUTION

When using detectors with water cooling, this must be operating during calibration of the measuring point.

Calibrating the measuring point

- Once the basic settings (mode of operation, measurement method, date, type of radiation, source of radiation, output damping) have been made, the actual calibration is performed.
- To ensure that the Gammapilot M can compensate correctly for background radiation, the background calibration must always be performed first.
- For the "Type of radiation" function, the "standard" setting must be selected. The "modulated" setting is not permitted for minimum point level detection.
- It is essential to carry out the calibration in the following sequence:
  1. Background calibration (operating source OFF, reference source OFF)
  2. Switch ON reference source; carry out "covered" calibration.
  3. Switch ON operating source; reference source remains switched ON; carry out "free" calibration. During "free" calibration, the radiation path of the operating source must be free (e.g. vessel empty).
  4. Select (gammagraphy) hold time of 10 seconds.

⚠ CAUTION

Observe the instructions for "Interference radiation detection" (→ 🖹 13).

NOTICE

Once calibration has been completed, the Gammapilot M is operational and can *be used in non-safety-related applications*. **For use** *in safety-related applications,* **the device must be locked in order to activate the safety functions (see "Method for parameterization of devices", → 🖹 16).**

Method for parameterization of devices

The device can be operated using the display FHX40, HART Communicator DXR375, 475 or FieldCare©.
To configure the operating parameters and to operate the Gammapilot M, please proceed in accordance with the Operating Instructions BA00236F/00/EN and the description of the device functions for level limit detection BA00287F/00/EN.
During calibration, a log must be kept to document the configuration values (→ 🖹 22).

⚠ CAUTION

Following calibration, the Gammapilot M must be locked in order to activate the safety functions. The Gammapilot M may be operated in safety-related applications only when it is in locked mode.

Locking procedure:

Step	Description	Parameter displayed
1	For this, please select the function "Safety locking (S22)" in the function group "Safety settings (S2)". Once the selection has been confirmed, an output current of ≤ 3 mA is output immediately.	
2	Enter individual 4-digit password.	
3	Confirmation of output current ≤ 3.0 mA. Verification of output current using measurement	[Iout ≤ 3 mA]
4	The following character string appears 0 1 2 3 4 5 6 7 8 9 . - This character string is used to test the transmission of data to the operator device. If the display is not correct, there is an error in the Gammapilot M or in the operator device.	
Compare calibration values and configuration values with the calibration log and confirm individually:		
5	Background pulse rate	[Backg: _ _ _ cps]
6	"Covered" calibration point "Free" calibration point	[Full : _ _ _ cps] [Empty: _ _ _ cps]
7	Isotope (^{137}Cs or ^{60}Co) type of radiation (standard)[1)]	[Source: _ _ _] [Beam: **Standard**]
8	Time response Output damping	[GammaHld: **10 s**] [Integr.: _ _ _ s]
9	Current date Calibration date	[Pres.: _ _ _] [Calib: _ _ _]
10	Detector length (measurement length in mm)	[_ _ _ mm]
11	Once the calibration values have been checked, the password must be confirmed once again to complete the safety-related locking procedure. Once it has been successfully locked, the device switches to measuring mode after a diagnosis phase.	[_ _ _ _]
12	A test must then be carried out to verify whether the Gammapilot M is actually locked. This is done by monitoring the output current. Following an interval of approx. 2 minutes, the current increases by approx. 1.6 mA for 15 seconds (see also Chapter "**Safety function**" Section "**Electronic partial stroke test**"). This signal change indicates that the Gammapilot M is locked. If there is no signal change, there was an error in the transmission of data for the confirmation. In this case, the operator device should be replaced and the locking procedure repeated.	

1) The "modulated" type of radiation is not intended for minimum point level detection.

⚠ CAUTION

If one of the parameters displayed does not correspond to the values logged during calibration, or if the character string (step 4) is not displayed correctly, this parameter must be registered as not valid. The Gammapilot M then automatically cancels the locking procedure. The status of the Gammapilot M is then "unlocked". Calibration can then be repeated. If this is not successful, the device must not be used for safety-related applications.

Behavior of current output during locking sequence:

At the start of the locking sequence, the detector outputs the error current ≤ 3.0 mA and remains at this value until the sequence has been run through completely and the safety-related locking procedure has been completed by confirming the password. The output current value must be measured during the locking procedure and confirmed in the operating menu.
The current must be measured with an accuracy of ± 0.1 mA.
Following the correct locking procedure, the Gammapilot M executes all internal diagnosis tests. During this time, (max. 60 s), the current output is at error current ≤ 3.6 mA.
Following completion of the diagnosis phase, the present current value (4 to 20 mA) is available at the output. If a device error is detected during a diagnosis test, the current signal maintains the error value ≤ 3.6 mA.

- The lock is not canceled if the power supply is switched off or if it fails.
- After it is locked, the detector can not be reset using the Reset (333) function.
- If you have forgotten the password, please contact Endress+Hauser Service.

List of configuration parameters which must be confirmed

The following parameters can be configured by the user and must therefore be confirmed during the locking procedure:

1.	Background pulse rate (cps)
2.	"Free" calibration point (cps)
3.	"Covered" calibration point (cps)
4.	Isotope (Cs or Co)
5.	Type of radiation (standard)[1)]
6.	(Gammagraphy) hold time
7.	Output damping
8.	Current date
9.	Calibration date

1) The "modulated" type of radiation is not intended for minimum point level detection.

List of preconfigured parameters

The following parameters can not be freely defined by the user.
The Gammapilot M configures them to the following initial settings by executing the locking function:

1.	Covered	=	100% → 20 mA
2.	Free	=	0% → 4 mA
3.	Output in case of alarm	=	22 mA
4.	Gammagraphy detection	=	ON
5.	(Gammagraphy) Span time	=	0 seconds (no dynamic monitoring)
6.	Output for gammagraphy	=	3.8 mA
7.	Gammagraphy sensitivity	=	9 ("standard" type of radiation)[1)]
8.	Low output limit	=	OFF
9.	Current output mode	=	standard
10.	Communication address	=	0
11.	Service parameters	=	Preset values
12.	Simulation	=	OFF
13.	Release code	=	SIL locked

1) The "modulated" type of radiation is not intended for minimum point level detection.

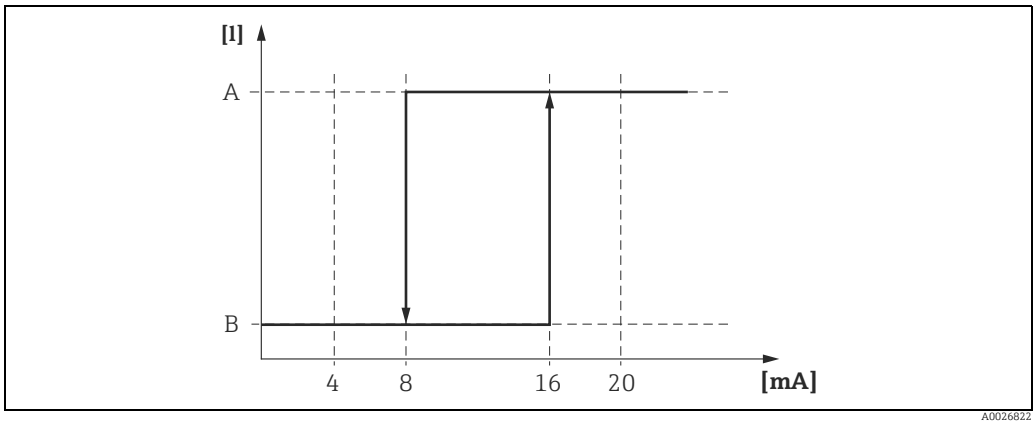
- If the supply voltage of the Gammapilot M fails during the locking or unlocking procedure or during the locking sequence, no alarm or warning message will be output after reapplying the supply voltage; however, for safety reasons the current output is set and kept at an error current of ≤ 3.6 mA.
- To recommission the device, the "Safety locking (S22)" function must be selected in the "Safety settings (S2)" function group and the safety locking must be carried out.

Configuration of switch point and hysteresis

The Gammapilot M converts the pulse rate linearly into the output current.
This makes it necessary to configure the switch point and hysteresis in the evaluation unit located downstream.

The following switch points must be configured in the evaluation unit:

1. 16 mA → Transition from "free" to "covered"
2. 8 mA → Transition from "covered" to "free"



A Covered
B Free

Maintenance, recalibration

Instructions for maintenance and recalibration can be found in the Operating Instructions BA00236F/00. During parameterization and maintenance work on the Gammapilot M, alternative monitoring measures must be taken to ensure process safety.

⚠ CAUTION

The Gammapilot M must be recalibrated in the following circumstances: If, following calibration of the measuring point, changes to the system are made in the immediate vicinity of the measuring point which may affect the measuring signal due to scattering, or if changes are made to the measuring point itself which alter the radiation conditions.

A check can be carried out by verifying the pulse rate with a free radiation path and comparing it to the calibration protocol → 22.

Recurrent testing

Recurrent testing

Safety functions must be tested at appropriate intervals to ensure that they are functioning correctly and are safe. The time intervals must be defined by the operator.

Recurrent testing of the Gammapilot M must be carried out in accordance with the following procedure. If several detectors are used in X out of Y architectures, the recurrent test described here must be performed separately for each detector. In addition, checks must be carried out to ensure that all cover seals and cable entries are sealing correctly.

Testing of internal clock

The device must display the correct date. If the indicated date differs from the real date by more than one day, it must be corrected to ensure correct decay compensation.
Please see also the note in the Section "Behavior of device when switched on" → 12.

Testing of Gammapilot M to ensure its safe functioning

Test step		Behavior of the detector
1	Switch ON operating source; Switch ON reference source; Induce "covered" operating status (e.g. fill vessel)	
		Output current must be 20 mA.
2	Switch OFF reference source	
		Current output must be set to alarm current 3.8 mA; additionally, the gammagraphy warning (W693) is displayed.
3	Wait out the gammagraphy hold time in accordance with the calibration protocol	
		After the gammagraphy hold time has expired, the current output must be set to alarm current 22 mA; additionally, the gammagraphy alarm (A692) is displayed.
4	Switch ON reference source	
		The current output must be set to 20 mA ("covered" state); the alarm disappears.
5	Induce "free" operating status (e.g. empty vessel)	
		The current output must be set to 4 mA ("free" state).
6	Switch OFF reference source	
		Current output must be set to 3.8 mA; additionally, the gammagraphy warning (W693) is displayed.
7	Wait out the gammagraphy hold time in accordance with the calibration protocol	
		After the gammagraphy hold time has expired, the current output must be set to alarm current 22 mA; additionally, the gammagraphy alarm (A692) is displayed.
8	Switch ON reference source	The current output must be set to 4 mA ("free" state); the alarm disappears.

The output current must be checked by measuring the current using a calibrated measuring device with an accuracy of ± 0.1 mA. If the average value of the current deviates by more than 0.2 mA from the set point, the measuring point must be recalibrated and this test must be repeated.

⚠ CAUTION

If recalibration and testing are not successful, the device must no longer be used as a safety device. Please contact Endress+Hauser Service.

This test detects approx. 98% of all possible dangerous undetected device failures.

Please see also the Section "Maintenance, recalibration" → 19.

Checking the state of the Gammapilot M, the source containers, and their installation:

- Checking the tight mounting of the Gammapilot M and the source containers:
  - Movements or shifts of the devices must be impossible.
  - Components whose state could cause detriment to the reliable mounting of the devices must be replaced.
- Damaged or corroded source containers must be replaced immediately.
- For additional instructions, refer to the associated operating manual (→ 7).

Repair

Repair

All repairs to the Gammapilot M must be carried out by Endress+Hauser.

In the event of failure of a SIL-labeled Endress+Hauser device, which has been operated in a safety function, the "Declaration of Contamination and Cleaning" with the corresponding note "Used as SIL device in protection system" must be enclosed when the defective device is returned
Please note the Operating Instructions BA00236F/00/EN, Section "Return" with regard to this.

If the Gammapilot M is equipped with new software, a reset must be carried out following installation, and the device must be tested to ensure that it is functioning correctly and must also be recalibrated.

Appendix

Instructions for redundant wiring of multiple sensors for SIL 3

The Gammapilot M fulfills the requirements for SIL 3 in a redundant architecture with HFT = 1 (e.g. 1oo2 or 2oo3 architecture).

The common cause factors ß and $ß_D$ specified in the table below are minimum values for the Gammapilot M. These are to be used when calculating the failure probability of redundantly wired Gammapilot M in accordance with IEC 61508-6.
System-specific consideration can yield higher values depending on the respective installation and the use of additional components (e.g. Ex barriers).

Minimum value ß for homogeneously redundant use	5%
Minimum value $ß_D$ for homogeneously redundant use	2%

Minimum point level detection calibration protocol

Calibration Record

Company: _____

Measuring Point: _____

Facility: _____

Device Type: **FMG60 -** _____

Serial Number: _____

Name: _____

Date: _____

Password: _____
(It is recommended to treat the calibration record as confidential after entering the password)

Signature: _____

Settings and Configuration Parameters of the FMG60

1. Background pulse rate: _____ cps
2. Calibration point "free": _____ cps
3. Calibration point "covered": _____ cps
4. Isotope: ^{137}Cs ☐ ^{60}Co ☐
5. Beam type: standard ☐ *
6. Gammagraphy hold time: 10 seconds set ☐
7. Integration time: _____ seconds
8. Present date: _____ (Day) . _____ (Month) . _____ (Year)
9. Calibration date: _____ (Day) . _____ (Month) . _____ (Year)
10. Detector length (Measuring length): _____ (mm)

Abgleichprotokoll_Min

* *The "modulated" type of radiation is not intended for minimum point level detection.*

Certificate

TÜVRheinland®

ZERTIFIKAT
CERTIFICATE

Nr./No.: 968/EL 425.05/11

Prüfgegenstand **Product tested**	Sichere Überwachung eines Füllstandes Safe detection of a level	**Zertifikats-inhaber** **Certificate holder**	Endress + Hauser GmbH + Co. KG Hauptstraße 1 79689 Maulburg Germany
Typbezeichnung **Type designation**	Gammapilot M FMG60	**Hersteller** **Manufacturer**	wie Zertifikatsinhaber see certificate holder
Prüfgrundlagen **Codes and standards forming the basis of testing**	IEC 61508 Parts 1-7:2010 EN 61508 Parts 1-7:2010		
Bestimmungsgemäße Verwendung **Intended application**	Das Gerät erfüllt die Anforderungen der Prüfgrundlagen (Hardware Sicherheitsintegrität SIL 2 nach IEC 61508 und systematische Eignung SIL 3 nach IEC 61508) und kann in Anwendungen bis SIL 2 (HFT=0) bzw. SIL 3 (HFT=1) nach IEC 61508 für die Sicherheitsfunktionen MIN oder MAX Grenzstandsüberwachung eingesetzt werden. The device complies with the requirements of the relevant standards (Hardware safety integrity SIL 2 acc. to IEC 61508 and systematic capability SIL 3 acc. to IEC 61508) and can be used in applications up to SIL 2 (HFT=0) resp. SIL 3 (HFT=1) acc. to IEC 61508 for the safety functions MIN or MAX level limit detection.		
Besondere Bedingungen **Specific requirements**	Die Hinweise in der zugehörigen Betriebsanleitung und dem Sicherheitshandbuch sind zu beachten. The instructions of the associated Operating Manual and Safety Manual shall be considered.		
Dieses Zertifikat ist gültig bis 09.02.2016. This certificate is valid until 2016-02-09.			

Der Prüfbericht-Nr.: 968/EL 425.05/11 vom 09.02.2011 ist Bestandteil dieses Zertifikates.

Dieses Zertifikat ist nur gültig für Erzeugnisse, die mit dem Prüfgegenstand übereinstimmen. Es wird ungültig bei jeglicher Änderung der Prüfgrundlagen für den angegebenen Verwendungszweck.

The test report-no.: 968/EL 425.05/11 dated 2011-02-09 is an integral part of this certificate.

This certificate is valid only for products which are identical with the product tested. It becomes invalid at any change of the codes and standards forming the basis of testing for the intended application.

TÜV Rheinland Industrie Service GmbH
Geschäftsfeld ASI
Automation, Software und Informationstechnologie
Am Grauen Stein, 51105 Köln
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Köln, 2011-02-09

Certification Body for FS-Products

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