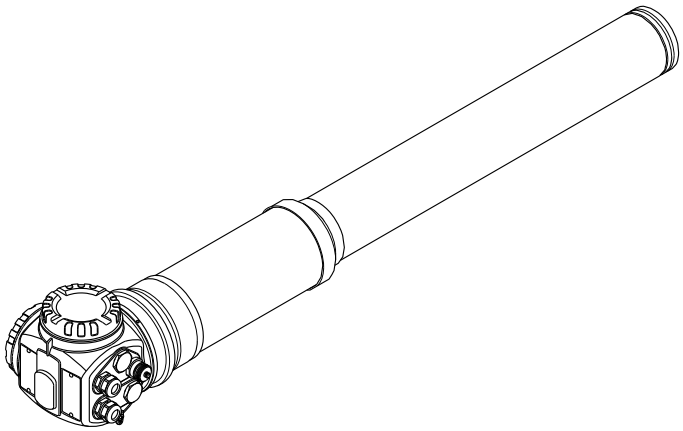
Special documentation
Gammapilot M FMG60
Functional Safety Manual



Radiometric maximum point level detection

Endress+Hauser
People for Process Automation

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Declaration of Conformity

The SIL declaration of conformity is serial number specific. Therefore only an example is represented in this document.

SIL-07001e/00

Endress+Hauser
People for Process Automation

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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SIL-07001e/00

Endress+Hauser
People for Process Automation

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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Additional safety-related figures

Specific functional safety parameters:

Characteristics as per IEC 61508	Value	
Safety function	Maximum point level detection	
SIL	Hardware: 2	Software: 3
HFT	0	
Device type	B	
Mode of operation	Low demand mode, High demand mode	
SFF	96%	
MTTR	8 h	
λ_{sd}	577 FIT	
λ_{su}	655 FIT[1] / 99 FIT[2]	
λ_{dd}	1316 FIT	
λ_{du}	92 FIT	
λ_{tot} [3]	3303 FIT	
PFD_{avg} for T_1 = 1 year [4]	4.04×10^{-4}	
PFD_{avg} for T_1 = 5 years [4]	2.02×10^{-3}	
PFH [4]	9.2×10^{-8} 1/h	
MTBF [3]	35 years	
Diagnostic test interval	15 min	
Fault reaction time [5]	6 s	

1) In accordance with IEC 61508 Ed.1

2) In accordance with IEC 61508 Ed.2

3) This value takes into account failure types relevant to the function of the electronic components according to Siemens SN29500.

4) Where the average temperature when in continuous use is in the region of +50 °C (+122 °F), a factor of 1,3 should be taken into account.

5) Time between error detection and error response.

Useful lifetime of electronic components

The established failures of electrical components apply within the useful lifetime as per IEC 61508-2:2010 section 7.4.9.5 note 3.

In accordance with DIN EN 61508-2:2011 section 7.4.9.5 national footnote N3, appropriate measures taken by the manufacturer and operator can extend the useful lifetime.

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
Postfach 91 09 51, 51101 Köln

Köln, 2011-02-09

Certification Body for FS-Products

Dipl.-Ing. Stephan Häb

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Zertifikat_968_EL_425_05_11_de_en_el

Document information

Document function

The document ist part of the Operating Instructions and serves a reference for application-specific parameters and notes.

- General information about functional safety: SIL
- General information about SIL is available:
  In the Download Area of the Endress+Hauser Internet site: www.de.endress.com/SIL

Symbols

Safety symbols

Symbol	Meaning
 A0011189-DE	**DANGER!** This symbol alerts you to a dangerous situation. Failure to avoid this situation will result in serious or fatal injury.
 A0011190-DE	**WARNING!** This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in serious or fatal injury.
 A0011191-DE	**CAUTION!** This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in minor or medium injury.
 A0011192-DE	**Note!** This symbol contains information on procedures and other facts which do not result in personal injury.

Symbols for certain types of information

Symbol	Meaning
 A0011193	**Tip** Indicates additional information.
 A0011194	**Reference to documentation** Refers to the corresponding device documentation.
 A0011195	**Reference to page** Refers to the corresponding page number.
 A0011196	**Reference to graphic** Refers to the corresponding graphic number and page number.
1. , 2. , 3. , ...	Series of steps

Symbols in graphics

Symbol	Meaning
1, 2, 3, 4, ...	Item numbers
1. , 2. , 3. , ...	Series of steps
A, **B**, **C**, **D**, ...	Views

Supplementary device documentation

Gammapilot M FMG60

Documentation	Comment
Technical Information: ▪ TI00363F/00	The document is available on the internet: → www.endress.com
Operating Instructions: ▪ BA00236F/00	The documentation is available on the internet: → www.endress.com
Brief Operating Instructions: ▪ KA01092F/00	▪ The document is provided with the device. ▪ The document is available on the internet: → www.endress.com
Safety instructions depending on the selected option "Approval"	Additional safety instructions (XA, ZE) are supplied with certified device version. Please refer to the nameplate for the relevant safety instructions.

This supplementary Safety Manual applies in addition to the Operating Instructions, Technical Information and Safety Instructions. The supplementary device documentation must be observed during installation, commissioning and operation. The requirements specific for the protection function are described in this Safety Manual..

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 firmware and hardware versions. Unless otherwise specified, all the following versions can also be used for protective systems. A modification process according to IEC 61508 is applied for device changes.

Valid device versions for safety-related use: Gammapilot M FMG60

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; 200mm ▪ H PVT; 200mm + cooling tube ▪ J PVT; 400mm ▪ K PVT; 400mm + 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: from 30.04.2007

SIL label on the nameplate

SIL certified devices are marked with the following symbol on the nameplate: (SIL)

Safety function

Definition on the safety function

The measuring system's safety function is:
- Maximum point level monitoring (overfill protection)

To activate the safety functions, the device must be locked directly after calibration (→ 14).

Restrictions for use in safety-related applications

Application, mounting, installation

- The use of the device is permitted only for maximum point level detection with a PVT scintillator of length 200 mm (7.87 in) and 400 mm (15.7 in).
- The permitted mounting positions are described in the relevant Operating Instructions (→ 8).
- 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 device in such a way that it is decoupled from the source of vibration.
- In order to ensure interference freeness, series connection is not permitted in HART multidrop mode.
- 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 device may result in a reduction in the pulse rate. If necessary, protective measures must be taken.
- 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.

Calibration, adjustment

- The change of the pulse rate between covered and free depends on the absorption of the radiation by the content of the vessel. The absorption is determined on the basis of the number of half-value layers of the content. The less the absorption the higher the pulse rate has to be at empty calibration. The following table defines the minimum pulse rate values for empty calibration in conjunction with the number of absorbing half-value layers.

Number of half-value layers	Minimum pulse rate at empty calibration
>3	500 cps
>2 to ≤3	1000 cps
≥1 to ≤2	1500 cps

- The pulse rate value at empty calibration must not fall below the values given in the table. When setting up the radiation source, the decay of the gamma radiation source during the service life must be taken into account.

$$\text{Permitted useful life} = -\frac{\text{Half-life}}{0.7} \cdot \ln\left(\frac{\text{Minimum pulse rate at empty calibration (cps)}}{\text{Empty calibration (cps)}}\right)$$

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

Example:
- Number of half-value layers: 3.2; i. e. minimum pulse rate at empty calibration: 500 cps
- Empty calibration: 1500 cps
- Half-life ^{60}Co: approx. 5.3 years
- Permitted service life: 8.3 years

- Background radiation must not exceed 8,000 cps.
- The maximum pulse rate for empty calibration must not exceed 60,000 cps.
- The pulse rate for full calibration must always be lower than the pulse rate for empty calibration.

Operating conditions, radiation sources

- To ensure the reliability of decay compensation, only ^{137}Cs and ^{60}Co radiation sources, which do not contain any foreign isotopes with longer or shorter half-lives, may be used.
- Measurements of self-emitting media are permitted only in modulated mode (using modulator FHG65).

Operating conditions, detector

The device may only be used in "stand-alone" mode or in "level limit" mode. The interconnection of several detectors in a cascade is not permitted.

Dangerous undetected failures in this scenario

An incorrect output signal that deviates from the real value by more than 10%, but is still in the range of 4...20 mA, is considered a dangerous, undetected failure.

Use in protective systems

Device behavior during operation

Device behavior during power-up

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, an uncalibrated device 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 calibration, the current output remains at error current ≥ 21 mA.
Once the diagnosis phase has been successfully completed, an already calibrated device switches to measuring mode (current output: 4 to 20 mA). Otherwise, it remains at error current ≤ 3.6 mA.

- If a calibrated device 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 reenter 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 Appendix "Operating menu for point level detection").
- To activate the safety functions, the device must be locked directly after calibration (see "Methods of configuration" → 14).

Device behavior in safety function demand mode

Once the maximum level is reached, the radiation is absorbed by the medium in the tank. The output current is set to 20 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. The device-internal dead time is dependent on the configuration of the "Beam type" function.

Setting Menu selection "Basic setup", Function "Beam type"	Device-internal dead time
Standard	1 s
Modulated	4 s

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

Device behavior during alarm and warning messages

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 as error codes, provide additional information. The following table shows the correlation between the error code and the current output:

Error code[1] *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, Section "Error codes".

Behavior of device in the event of interference radiation

The device provides two methods for dealing with interference radiation caused by non-destructive material testing for example.

Detection of interference radiation (gammagraphy)

When the device is used in safety-related applications, the pulse rate is monitored to ensure that it stays within the calibrated range. If the pulse rate is greater than the calibration value for "free" or less than the calibration value for "covered", the current output switches to 3.8 mA for the duration of the configured hold time of maximum 999 s.

⚠ CAUTION

An overfill can not be detected during this time

If the pulse rate is still outside the calibrated range when the hold time elapses, the device switches to alarm condtion until the pulse rate is again inside the calibrated range between full and empty calibration.

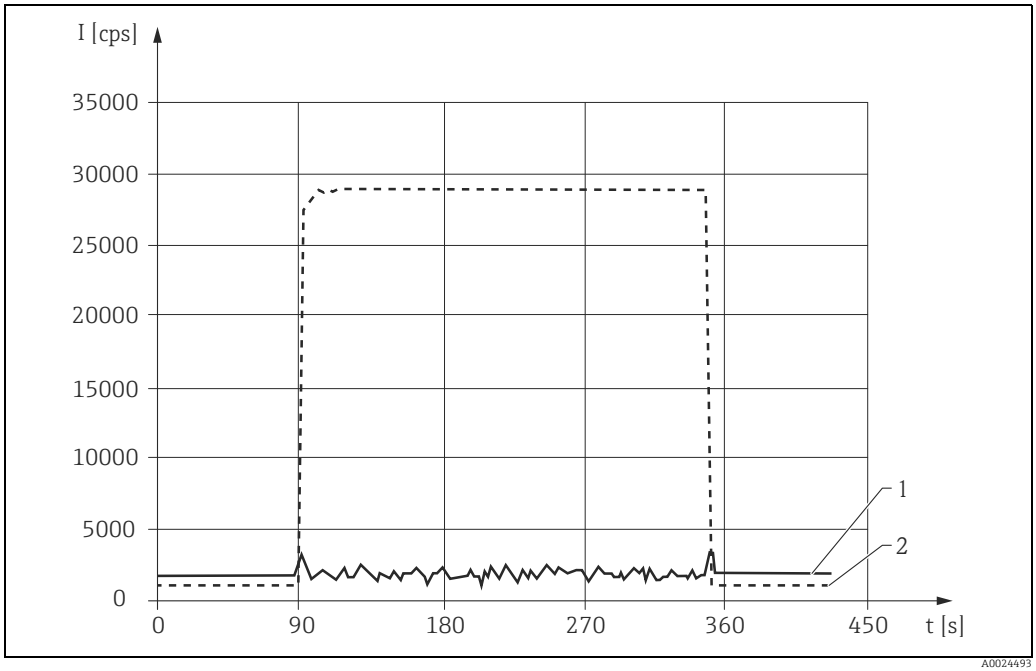
⚠ CAUTION

If x-ray tests are carried out within the sytem 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

Suppression of interference radiation using the Gamma-Modulator FHG65

The device can suppress interference radiation when used in conjunction with the Gamma-modulator FHG65. The useful radiation is switched on and off periodically by the modulator using a fixed frequency. The device can filter this alternating portion out of the total radiation as a measured value. This does not entail any interruption to measurement or point level detection as in the case of basic gammagraphy detection. The following diagram shows, for example, a comparison between pulse rates with and without the suppression of interference radiation.



1 Without suppression of interference radiation
2 With suppression of interference radiation

This function suppresses all sources of interference radiation, regardless of the source of useful radiation in use, up to a local dose rate of approx. 50 µSv/h at the device (depending on detector length and the source of interference involved).
Higher local dose rates can lead to a reduction in the detected pulse rate due to the statistical superposition of pulses. This means that, for example, non-destructive material testing using gamma sources in the direct vicinity of the device may lead to an overflow signal. Therefore, in these cases too, the device is guaranteed to behave in a fail-safe manner.

- The failure of the modulator (e.g. due to power failure) in this mode of operation, results in the device having a higher output current (max. 20.5 mA) and is therefore fail-safe.
- In this operating mode of the device, modulator failure during the calibration of the measuring point may cause the error message A692 "Gammagraphy detected" in the subsequent measuring mode.

Parameter configuration for safety-related applications

Calibration of 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 device can compensate correctly for background radiation, the background calibration must always be performed first. This is followed by empty and full calibration, in no particular order.

Once calibration has been completed, the device 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 "Methods of configuration" → 14).

Methods of configuration

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

⚠ CAUTION

The device may be operated in safety-related applications only when it is in locked mode.

- ▸ Following calibration, the device must be locked in order to activate the safety functions.

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 device 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	[Covered: _ _ _ cps] [Free: _ _ _ cps]
7	Isotope (^{137}Cs or ^{60}Co) Beam type (standard or modulated)	[Source: _ _ _] [Beam: _ _ _]
8	Time response (default value 10 s if "modulated" beam type was selected) Output damping	[GammaHld: _ _ _ 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 device 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 "**Electronic partial stroke test**", → 21). This signal change indicates that the device 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.	

⚠ CAUTION

Safety-related applications

- 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 device then automatically cancels the locking procedure. The status of the device 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 a accuracy of ± 0.1 mA.
Following the correct locking procedure, the device 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 diagnosis, the current signal remains in a fault state ≤ 3.6 mA.

- The lock is not cancelled if the power supply is switched off or if it fails.
- After it is locked, the detector cannot 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.	Beam type (standard or modulated)
6.	(Gammagraphy) hold time (default value "10" for "modulated" beam type)
7.	Output damping
8.	Current date
9.	Calibration date

List of preconfigured parameters

The following parameters cannot be freely defined by the user. The device 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 (Beam type "standard"); 20 (Beam type "modulated")
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

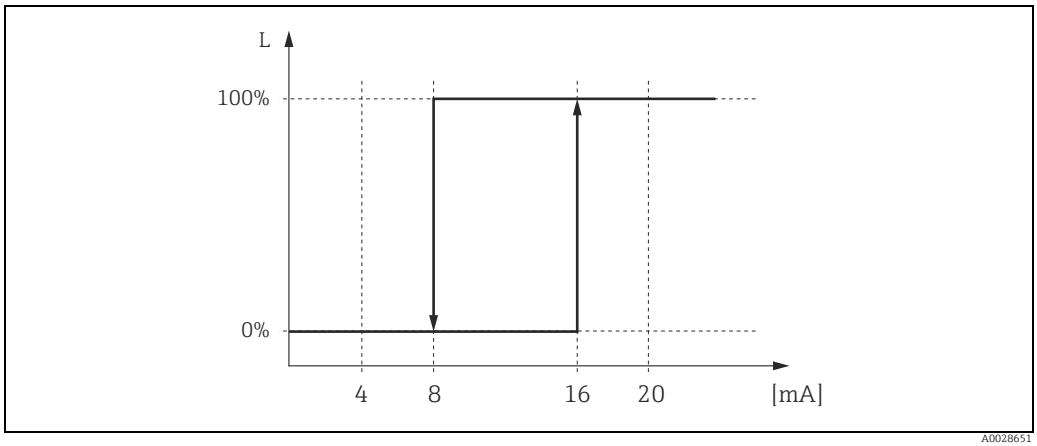
- If the supply voltage for the device fails during the locking or unlocking procedure or during the locking sequence, an alarm or warning is not output when the supply voltage is reapplied. For safety reasons, however, the current output is set to error current ≤ 3.6 mA and held.
- To restart, the "safety locking (S22)" function has to be selected in the "safety settings (S2)" function group and security locking has to be performed.

Configuration of switch point and hysteresis

The device converts the pulse rate linearly into the output current. This requires configuration of 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"



Hysteresis to be configured in the control unit

Proof test

Check the operativeness and safety of safety functions at appropriate intervals! The operator must determine the time intervals.

The values and diagrams in the "Additional safety-related figures" section can be used for this purpose (→ 5). The test must be carried out in such a way it verifies correct functioning of the protective system in conjunction with all of the components.

Proof-testing of the device must be carried out in accordance with the following procedure.
If several detectors are used in MooN votings, the proof-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 date is out by more than one day, it must be corrected to ensure correct decay compensation.

Please see also the note in the Section "Device behavior during power-up" → 12.

Testing of the device to ensure its safe functioning

During safety testing of the device, the radiation path of the measuring point must be clear.
For testing, the source of radiation is switched off. As a result, the output current changes from 4 mA to 20 mA.
In a second step, the source is switched back on, and the current then changes from 20 mA to 4 mA.
This must be checked by measuring the current using a calibrated measuring device with a 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" → 19.

Life cycle

Requirements for the personnel

The personnel for installation, commissioning, diagnostics, repair and maintenance must meet the following requirements:
- Trained, qualified specialists must have a relevant qualification for this specific function and task
- Are authorized by the plant owner/operator
- Are familiar with federal/national regulations
- Before beginning work, the specialist staff must have read and understood the instructions in the manuals and supplementary documentation as well as in the certificates (depending on the application)
- Follow instructions and comply with basic conditions

The operating personnel must meet the following requirements:
- Are instructed and authorized according to the requirements of the task by the facility's owner-operator
- Follow the instructions in this manual

Installation

The installation of the device is described in the relevant Operating Instructions (→ 8).

Commissioning

The commissioning of the device is described in the relevant Operating Instructions (→ 8).

Operation

The operation of the device is described in the relevant Operating Instructions (→ 8).

Maintenance

The maintenance of the device is described in the relevant Operating Instructions (→ 8).

Alternative monitoring measures must be taken to ensure process safety during configuration, proof-testing and maintenance work on the device.

⚠ CAUTION

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.

▸ The device must be recalibrated in the following circumstances.

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

Repair

Repair means restoring functional integrity by replacing defective components. Components of the same type must be used for this purpose. We recommend documenting the repair. This includes specifying the device serial number, the repair date, the type of repair and the individual who performed the repair.

The following components may be replaced by the customer's technical staff if genuine spare parts are used and the appropriate installation instructions are followed:

Component	Installation Instructions	Checking the device after repair
Cover	▪ EA01062F/00 ▪ EA01114F/00 (terminal compartment)	Proof test, see the "Proof test" (→ 17).

Installation Instructions: see the Download Area at www.endress.com.

The replaced component must be sent to Endress+Hauser for the purpose of fault analysis if the device has been operated in a protective system and a device error cannot be ruled out. In this case, always enclose the "Declaration of Hazardous Material and Decontamination" with the note "Used as SIL capable device in protection system" when returning the defective device. Please also refer to the "Return" section in the Operating Instructions (→ 8).

Modification

Modifications are changes to SIL capable devices already delivered or installed.

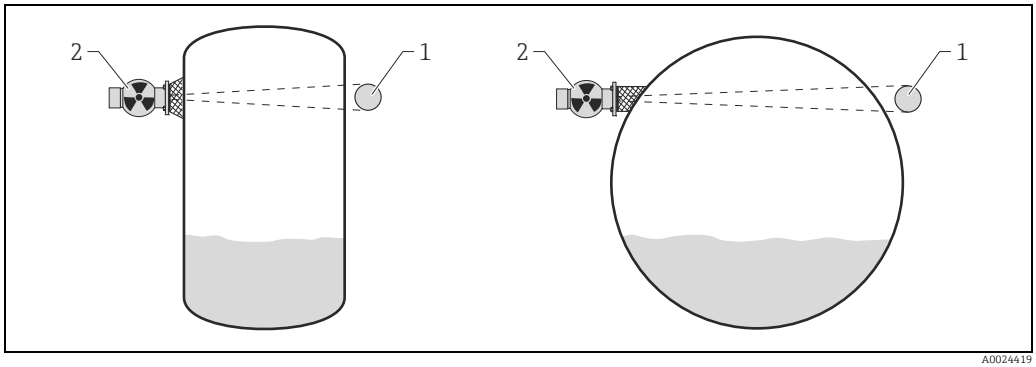
Modifications to SIL capable devices are usually performed in the Endress+Hauser manufacturing center. Modifications to SIL capable devices onsite at the user's plant are possible following approval by the Endress+Hauser manufacturing center. In this case, the modifications must be performed and documented by an Endress+Hauser service technician.
Modifications to SIL capable devices by the user are not permitted.

Appendix

Structure of the measuring system

System components

The measuring system's devices are displayed in the following diagram (example):



1 Gammapilot M FMG60
2 Operating source

The measuring system consists of a sensor and a gamma radiation source.
Point level detection takes place when a guided gamma ray is interrupted or attenuated by the medium which is being monitored and this interruption or attenuation is detected.

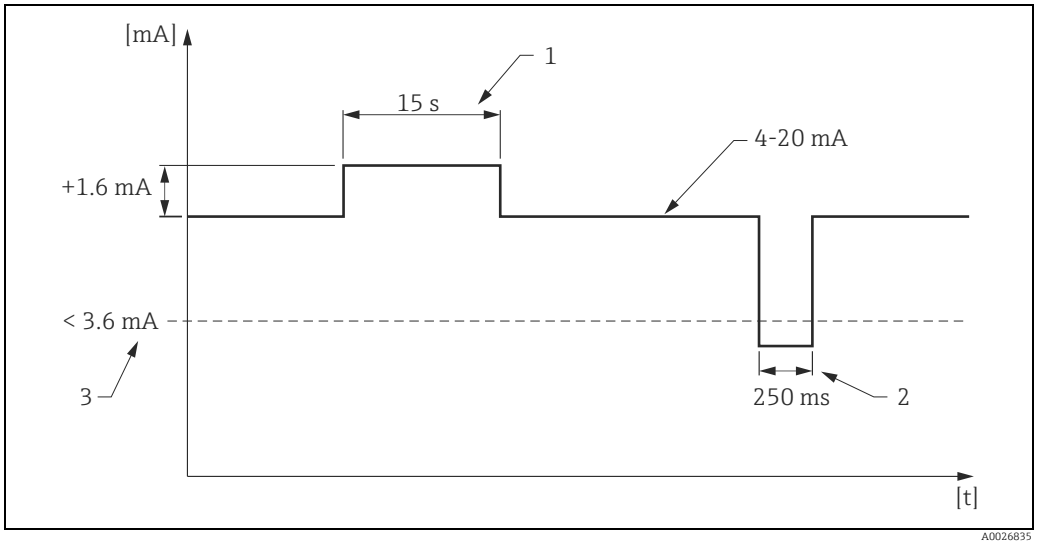
An individual gamma radiation source is recommended for each point level detection. The path of the beam should be adapted to the dimension of the measuring length used.
When using multiple detectors with 1oo2 or 2oo3 votings, the height of the detector arrangement with regard to the switch point must also be taken into account.

Description of use as a protective system

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

The device generates an analog signal (4 to 20 mA) proportional to the pulse rate. 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 exceeded
- 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 permanently by the Gammapilot M. This results in the following behavior of the output current:



1 Analog signal path test
2 Digital signal path test
2 < 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 point level detection is not affected by the hysteresis that has to be configured in the PLC (see "Configuration of switch point and hysteresis" → 17).
  This signal path can be used to permanently monitor and detect the correct safety-related configuration and correct functioning of the device.

- **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, a signal on alarm is not to be recognized as such unless it lasts at least 4 seconds.

Commissioning resp. Proof Test Protocol

System-specific data		
Company		
Measuring point / TAG no.		
Facility		
Device type / Order code		
Serial no.		
Name		
Date		
Password[1)]		
Signature		
Settings and Configuration Parameters of the Gammapilot M FMG60		
Background pulse rate		cps
Calibration point "empty"		cps
Calibration point "full"		cps
Isotope	❑ ^{137}Cs ❑ ^{60}Co	
Beam type	❑ Standard ❑ Modulated	
Gammagraphy hold time		seconds[2)]
Integration time		seconds
Present date		
Calibration date		
Detector length		mm

1) It is recommended to treat the calibration record as confidential after entering the password.

2) Beam type "Modulated": default 10 seconds.

Further information

General information on functional safety (SIL) is available at: www.de.endress.com/SIL (Germany) or www.endress.com/SIL (English) and in the Competence Brochure CP01008Z/11/EN "Functional Safety in the Process Industry- Risk Reduction with Safety Instrumented Systems".

Versions history

Version	Changes	Valid for hardware version
SD00230F/00/EN/14.15	Allgemeine Überarbeitung	from 30.04.2007

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