SD00326F/00/EN/21.18
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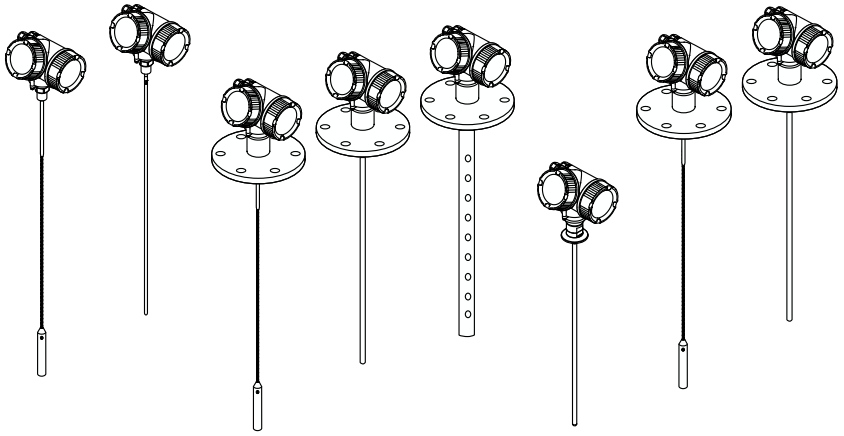
2018-01-15

Special Documentation
Levelflex
FMP50/51/52/53/54/55/56/57

Functional Safety Manual



Guided radar for liquids and bulk solids with 4 to 20 mA output signal

Endress+Hauser
People for Process Automation

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Declaration of Conformity

SIL-14005c/00

Endress+Hauser
People for Process Automation

Declaration of Conformity

Functional Safety according to IEC 61508:2010
Supplement 1 / NE130 Form B.1

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

declares as manufacturer, that the following guided level radar device

Levelflex FMP50/51/52/53/54/55/56/57

is suitable for the use in safety-instrumented systems up to SIL3 according to IEC 61508:2010.

In safety instrumented systems according IEC 61508 and IEC 61511, the instructions of the Safety Manual have to be followed.

Maulburg, 10-June-2016
Endress+Hauser GmbH+Co. KG

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SIL-14005c/00

Endress+Hauser
People for Process Automation

General			
Device designation and permissible types	Guided level radar, Levelflex FMP5x-**y**********+LA		
Order code selection	x = 0...7, y = A, B, C, K		
Safety-related output signal	4...20 mA		
Fault current	≤ 3.6 mA ; ≥ 21 mA		
Process variable/function	Level or interface measurement		
Safety function(s)	MIN, MAX, Range		
Device type acc. to IEC 61508-2	☐ Type A	☒ Type B	
Operating mode	☒ Low Demand Mode	☒ High Demand Mode	☐ Continuous Mode
Valid hardware version	As of manufacturing date after January 28, 2011		
Valid software version	As of version V01.01.ZZ		
Safety manual	SD00326F		
Type of evaluation (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 IEC 61508-2 for devices w/o software		
Evaluation through / certificate no.	TÜV Rheinland Industry Service GmbH - report no. 968/EL 733.02/16		
Test documents	Development 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	MIN, MAX, Range
λ_{DU} [1),2)]	197 FIT
λ_{DD} [1),2)]	2504 FIT
λ_{SU} [1),2)]	801 FIT
λ_{SD} [1),2)]	54 FIT
λ_{total} [1),2)]	3556 FIT
SFF (Safe Failure Fraction)	94 %
PFD_{avg} (T_1 = 1 year) [2)] (single channel architecture)	$8.82 \cdot 10^{-4}$
PFD_{avg} (T_1 = 3 years) [2)] (single channel architecture)	$2.61 \cdot 10^{-3}$
PFH	$1.97 \cdot 10^{-7}\ h^{-1}$
PTC [3)]	99 %
MTBF [4)]	56 years
Diagnostic test interval [5)]	30 min
Fault reaction time [6)]	30 s

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 failures per 10^9 h
2) Valid for average ambient temperature up to +40 °C (+104 °F)
For continuous operation at ambient temperature close to +60 °C (+140 °F), a factor of 2.1 should be applied
3) PTC = Proof Test Coverage
4) MTBF (Mean Time Between Failures) is the predicted elapsed time between inherent failures of a system during operation in accordance to Siemens SN29500. Considered are failures of the electronics with functional relevance.
5) All diagnostic functions are performed at least once within the diagnostic test interval
6) Maximum time between error recognition and error response

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Other safety-related characteristic values

Characteristics as per IEC 61508

System reaction time as per DIN EN 61298-2

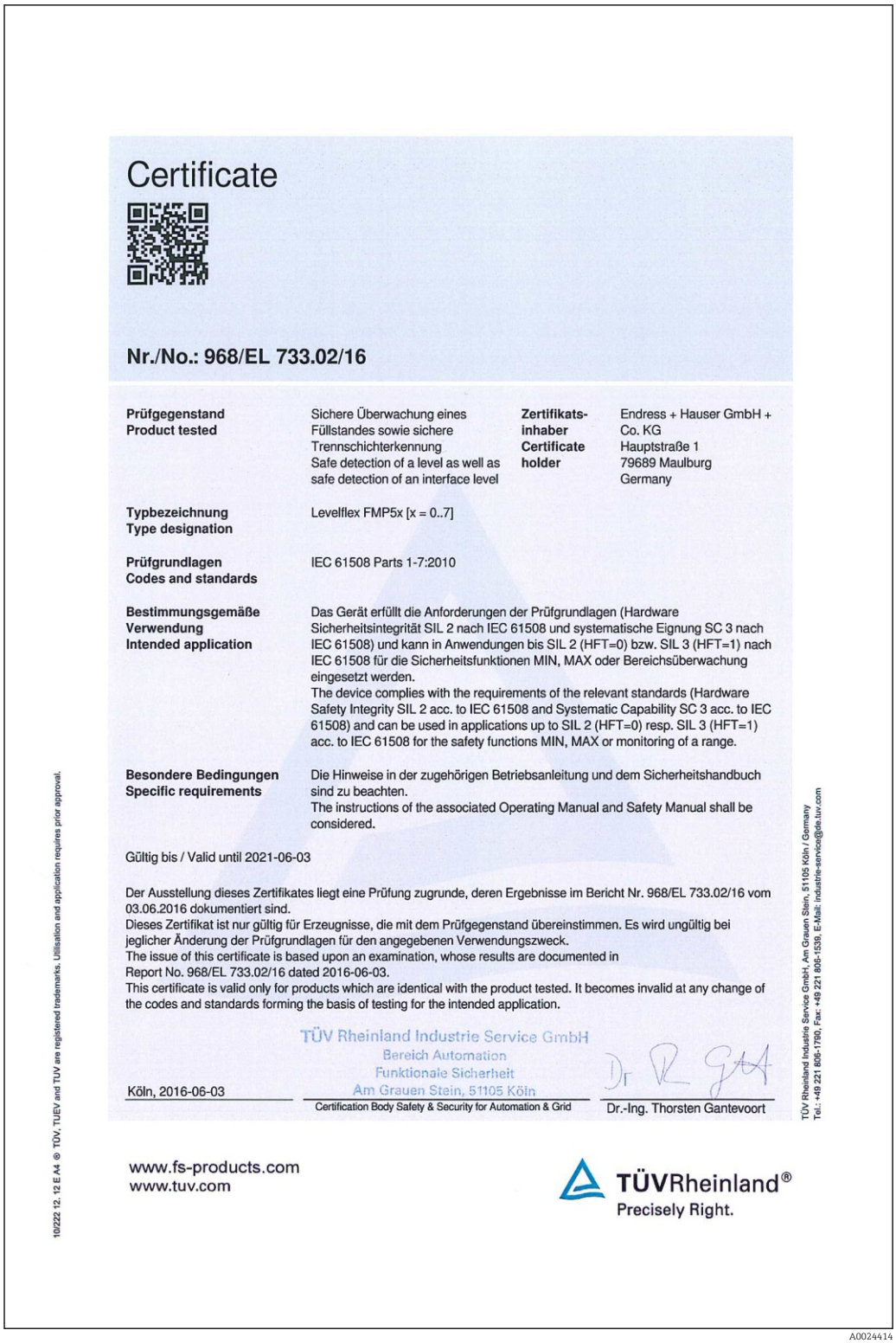
In "Increased safety mode":
In "Increased safety mode":
- For "Medium type = Liquid": < 15 s
- For "Medium type = Solid": <90 s

In "Expert mode":
Free configurable, shortest response time:
- For level measurement: 0.8 s
- For interface measurement: 2.2 s

Useful lifetime of electric components

The established failure rates 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



Certificate

Nr./No.: 968/EL 733.02/16

Prüfgegenstand **Product tested**	Sichere Überwachung eines Füllstandes sowie sichere Trennschichterkennung Safe detection of a level as well as safe detection of an interface level	**Zertifikats-inhaber** **Certificate holder**	Endress + Hauser GmbH + Co. KG Hauptstraße 1 79689 Maulburg Germany
Typbezeichnung **Type designation**	Levelflex FMP5x [x = 0..7]		
Prüfgrundlagen **Codes and standards**	IEC 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 SC 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, MAX oder Bereichsüberwachung eingesetzt werden. The device complies with the requirements of the relevant standards (Hardware Safety Integrity SIL 2 acc. to IEC 61508 and Systematic Capability SC 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, MAX or monitoring of a range.		
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.		

Gültig bis / Valid until 2021-06-03

Der Ausstellung dieses Zertifikates liegt eine Prüfung zugrunde, deren Ergebnisse im Bericht Nr. 968/EL 733.02/16 vom 03.06.2016 dokumentiert sind.
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 issue of this certificate is based upon an examination, whose results are documented in Report No. 968/EL 733.02/16 dated 2016-06-03.
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
Bereich Automation
Funktionale Sicherheit
Am Grauen Stein, 51105 Köln

Köln, 2016-06-03

Certification Body Safety & Security for Automation & Grid

Dr.-Ing. Thorsten Gantevoort

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Document information

Document function

The document is part of the Operating Instructions and serves as 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

Using this document

Information on the document structure

For the arrangement of the parameters as per the **Operation** menu, **Setup** menu, **Diagnostics** menu, along with a short description, see the Operating Instructions for the device

Symbols used

Safety symbols

Symbol	Meaning
DANGER	**DANGER!** This symbol alerts you to a dangerous situation. Failure to avoid this situation will result in serious or fatal injury.
WARNING	**WARNING!** This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in serious or fatal injury.
CAUTION	**CAUTION!** This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in minor or medium injury.
NOTICE	**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.
	Reference to documentation
	Reference to page
	Reference to graphic
1., 2., 3...	Series of steps

Symbols in graphics

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

Supplementary device documentation

Levelflex FMP50, FMP51, FMP52, FMP53, FMP54, FMP55, FMP56, FMP57

Documentation	Comment
Technical Information: ▪ TI01000F/00 (FMP50) ▪ TI01001F/00 (FMP51/52/54) ▪ TI01002F/00 (FMP53) ▪ TI01003F/00 (FMP55) ▪ TI01004F/00 (FMP56/57)	The documentation is available on the Internet: → www.endress.com
Operating Instructions (HART): ▪ BA01000F/00 (FMP50) ▪ BA01001F/00 (FMP51/52/54) ▪ BA01002F/00 (FMP53) ▪ BA01003F/00 (FMP55) ▪ BA01004F/00 (FMP56/57)	The documentation is available on the Internet: → www.endress.com
Brief Operating Instructions (HART): ▪ KA01053F/00 (FMP50) ▪ KA01077F/00 (FMP51/52/54) ▪ KA01078F/00 (FMP53) ▪ KA01060F/00 (FMP55) ▪ KA01061F/00 (FMP56/57)	▪ The document is provided with the device. ▪ The documentation is available on the Internet: → www.endress.com
Description of Device Parameters: GP01000F/00	The documentation 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 ATEX 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 devices 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; Output	▪ A: 2-wire; 4-20 mA HART ▪ B [1]: 2-wire; 4-20 mA HART, switch output ▪ C [2]: 2-wire; 4-20 mA HART, 4-20 mA ▪ K: 4-wire 90-253 VAC; 4-20 mA HART
030	Display; Operation	all
040	Housing	all
050	Electrical connection	all
060	Probe	all
090	Seal (no for FMP52/55)	all
100	Process connection	all
500	Additional Operation Language	all
540	Application Package	all
550	Calibration	all
570	Service	all
580	Test; Certificate (not for FMP56)	all
590	Additional Approval	LA [3]: SIL
600	Probe Design	all
610	Accessory Mounted	all
620	Accessory Enclosed	all
850	Firmware version	If no version is selected here, the latest SIL-enabled SW is supplied. Alternatively, the following SW version may be selected : ▪ 75: 01.01.zz, HART 6, DevRev02 ▪ 74: 01.02.zz, HART 6, DevRev03 ▪ 71: 01.03.zz, HART 7, DevRev04

1) For this version with one current output and one switching output, only the current output (terminals 1 and 2) is suitable for safety functions. The switching output can, if necessary, be wired for non-safety-oriented purposes.
2) For this version with 2 current outputs, only the first output (terminals 1 and 2) is suitable for safety functions. The second output can, if necessary, be wired for non-safety-oriented purposes.
3) An additional selection of any further versions is possible.

- Valid firmware version: as of 01.01.zz (→ nameplate of the device)
- Valid hardware version (electronics): as of date of production 28.01.2011 (→ nameplate of the device)

SIL label on the nameplate

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

Safety function

Definition of the safety function

The device's safety functions are:
- Maximum level limit monitoring (overfill protection)
- Minimum level limit monitoring (dry run protection)
- Level range monitoring

The safety functions include level measurement of a liquid or bulk solid or measurement of the interface between two liquids.

Safety-related signal

The safety-related signal is the analog output signal: 4 to 20 mA. All safety measures refer to this signal exclusively.

For devices with current output and switch output (ordering feature 020 "Power Supply; Output", option B "2-wire; 4-20 mA HART, switch output"), only the current output (terminals 1 and 2) is approved for safety functions. The switch output (terminals 3 and 4) can, if necessary, be wired for non-safety-oriented purposes.

For devices with two current outputs (ordering feature 020 "Power Supply; Output", option C "2-wire; 4-20 mA HART + 4-20 mA analog"), only the first current output (terminals 1 and 2) is approved for safety functions. The second output (terminals 3 and 4) can, if necessary, be wired for non-safety-oriented purposes.

The device additionally communicates for information only via HART and contains all HART features with additional device information.

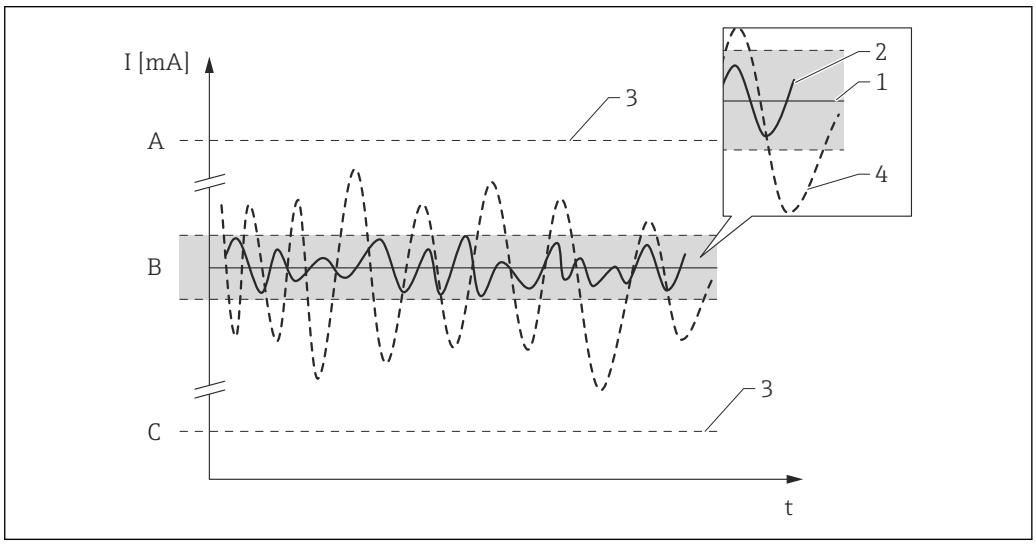
The safety-related output signal is fed to a downstream logic unit, e.g. a programmable logic controller or a limit signal transmitter where it is monitored for the following:
- Exceed and/or fall below a specific level limit.
- The occurrence of a fault, e.g. failure current (≤3.6 mA, ≥21.0 mA, interruption or short-circuit of the signal line).

In case of fault it must be ensured that the equipment under control achieves or maintains a safe state.

Restrictions for use in safety-related applications

- The measuring system must be used correctly for the specific application, taken into account the medium properties and ambient conditions. Carefully follow instructions pertaining to critical process situations and installation conditions from the Operating Instructions. The application-specific limits must be observed.
- Information on the safety-related signal, (→ 10).
- The specifications from the Operating Instructions must not be exceeded, (→ 8).
- The following restrictions also applies to safety-related use:
  - Strong, pulse-like EMC interference on the power supply line can cause transient (< 1 s) deviations ≥ ±2% in the output signal. For this reason, filtering with a time constant of ≥ 1 s should be performed in the downstream logic unit.
  - The error range is device specific and is defined according to FMEDA (Failure Modes, Effects and Diagnostic Analysis) on delivery. It includes all influential factors described in the Technical Information (e.g. non-linearity, non-repeatability, hysteresis, zero drift, temperature drift, EMC influences).
    According to IEC / EN 61508 the safety related failures are classified into different categories, see the following table. The table shows the implications for the safety related output signal and the measuring uncertainty.

Safety related error	Explanation	Implications for the safety related output signal	Implications for the measuring uncertainty (Position, see figure→ 🖹 11
No device error	Safe: No error	None	1 Is within the specification (see TI, BA, ...)
λ_{SD}	Safe detected: Safe failure which can be detected	Causes the output signal to signal the failsafe mode (see, → 🖹 12)	3 No implications
λ_{SU}	Safe undetected: Safe failure which cannot be detected	Is within the defined error range	2 May be beyond the specification
λ_{DD}	Dangerous detected: Dangerous failure which can be detected (Diagnostic within the device)	Causes the output signal to signal the failsafe mode (see, → 🖹 12)	3 No implications
λ_{DU}	Dangerous undetected: Dangerous failure which cannot be detected	May be outside the defined error range	4 May be outside the defined error range



A HI-Alarm ≥21 mA
B Error range ±2 %
C LO-Alarm ≤3.6 mA

Dangerous undetected failures in this scenario

An incorrect output signal that deviates from the real value by more than 2 % but is still in the range of 4 to 20 mA is considered a dangerous, undetected failure.

Use in protective systems

Device behavior during operation

Device behavior in SIL-locked state

After SIL locking, additional diagnostics are active and critical parameters in the safety path are set to safe values→ 16. Therefore, the behavior of the device in the "SIL-locked state" may deviate from the "non-SIL-locked state". If a test phase takes place before the system is finally put into production, it is recommended that this test phase be run in the locked state in order to obtain the most conclusive results possible.

Device behavior during power-up

Once switched on, the device runs through a diagnostic phase of approx. 15 seconds. The current output is set to failure current during this time. For approx. 5 seconds of this diagnostic phase, this current is ≤3.6 mA. After that, depending on the setting of the "Start-up mode" parameter, the current is:

- at the MIN value: ≤3.6 mA
- at the MAX value : ≥21.0 mA

During the diagnostic phase, no communication is possible via the service interface (CDI) or via HART.

Device behavior in safety function demand mode

The device outputs a current value corresponding to the limit value to be monitored. This value must be monitored and processed further in an attached logic unit.

Device behavior in event of alarms and warnings

The output current on alarm can be set to a value ≤3.6 mA or ≥21.0 mA.

In some cases (e.g. failure of power supply, a cable open circuit and faults in the current output itself, where the failure current ≥21.0 mA cannot be set), output currents ≤3.6 mA irrespective of the configured failure current can occur.

In some other cases (e.g. short circuit of cabling), output currents of ≥21.0 mA occur irrespective of the configured failure current.

For alarm monitoring, the downstream logic unit must be capable of detecting failure currents of the upper level for signal on alarm (≥21.0 mA) and the lower level for signal on alarm (≤3.6 mA).

Alarm and warning messages

Additional information is provided by the alarm and warning messages in the form of error codes and associated clear text messages.

The following table shows the correlation between the error code and the current output:

Error code [1]	Current output (message type)	Note
Fxxx	≥21.0 mA or ≤3.6 mA	xxx = three-digit number
Mxxx	corresponding to measuring mode	xxx = three-digit number
Cxxx	corresponding to measuring mode	xxx = three-digit number
Sxxx	corresponding to measuring mode	xxx = three-digit number

1) The error codes are listed in the Operating Instructions.

Exceptions:

Error code [1]	Current output (message type)	Note
M272	≥21.0 mA or ≤3.6 mA	Main electronic failure
C484	≥21.0 mA or ≤3.6 mA	Simulation failure mode
S942	≥21.0 mA or ≤3.6 mA	In safety distance

1) The error codes are listed in the Operating Instructions.

When SIL locking is active on the device, additional diagnostics are activated (e.g. a comparison between the readback-current with the nominal value). If one of these diagnostics results in an error message (e.g. F803 loop current) and the SIL locking is then deactivated, the error message remains while the error persists, even it the diagnostic is no longer active in the unlock state. In this case, the device must be disconnected briefly from the power supply (e.g. by unplugging the terminals). When the device is then restarted, a self-check is carried out, and the error message is reset where applicable.

Parameter configuration for safety-related applications

Calibration of the measuring point

The adjustment of the measuring point is described in the Operating Instructions → 📄 8.

Check th initial factory setting of the E (zero point) and F (range) parameters in accordance with the desired measuring range and correct if necessary.

Methods of device configuration

When using the devices in process control safety systems, the device configuration must comply with two requirements:
- Confirmation concept:
  Proven, independent testing of safety-related parameters entered.
- Locking concept:
  Locking of the device following parameter configuration (as per IEC 61511-1 : 2016 Section 11.6.3).

To activate the SIL mode, the device must run through an operating sequence, during which the device can be operated by means of the device display or any asset management tool (FieldCare, Pactware, AMS, PDM, Field Communicator 375/475, ...) for which integration is available.

Two methods of configuring the device are provided, which differ mainly with regard to the confirmation concept:
- "Increased safety mode"
  While running through the commissioning sequence here, critical parameters which control functions in the safety path are either set automatically by the device to safe values or transferred to the display/operating tool via an alternative data format, to enable checking of the setting. This mode can be used for standard applications. As there are only a few safety-related parameters which can be freely configured, the risk of operating errors is greatly reduced, and the level in the tank does not need to be changed during commissioning in order to check the settings.
- "Expert mode"
  A larger number of safety-related parameters can be freely configured here. This means that the device can be adapted to difficult applications. However, the settings must be checked by directly approaching the level in the tank or a similar method.

A detailed description of both modes is provided in the following sections.

It is only in the case of SIL devices (ordering feature 590 "Additional Approval", option LA "SIL") that the SIL commissioning sequence is visible on the display and in external operating tools. For this reason, SIL locking can only be activated on these devices.

Locking in "Increased safety mode"

To commission the device, carry out and document the following steps in the order shown→ 🖹 31.

1. Reset device. This resets all parameters to defined values. To do this, select:
   - With firmware version 01.01.zz
     "Diagnostics > Device reset > To factory defaults" or
     "Diagnostics > Device reset > To delivery settings"
   - With firmware version 01.02.zz and 01.03.zz
     "Setup > Advanced setup > Administration > Device reset > To factory defaults" or
     "Setup > Advanced setup > Administration > Device reset > To delivery settings"
2. Carry out configuration. The configuration procedure and the meaning of the individual parameters are described in the Operating Instructions → 🖹 8. Observe the following parameter settings→ 🖹 16.
3. Carry out "Device check". Activate the "Diagnostics > Device check > Start device check" parameter (more information available in the Operating Instructions→ 🖹 8). The signal quality is tested here and possible installation errors are detected.
4. Start SIL/WHG confirmation sequence. To do this, enter the appropriate locking code (WHG: 7450; SIL: 7452; SIL and WHG: 7454) in the "Setup > Advanced setup > SIL/WHG confirmation > Set write prot." parameter.

   In this way, forbidden parameter changes (e.g. via external operating tools if the confirmation sequence is performed at the device display) are prevented already during the SIL/WHG confirmation sequence.
5. For "Commissioning" select the "Increased safety" entry from the list. The device checks the parameter settings in accordance with the table and forces the switching of parameters if necessary. Once testing is complete, "SIL/WHG prepar.: Finished" is displayed, and the commissioning sequence can continue.

   - If configuration was not performed in accordance with the specifications in point 2, only "Expert mode" can be selected at this point.
   - The commissioning mode must not be changed during completion of the SIL confirmation sequence. If the wrong option has been selected, the sequence must be canceled and started again.
6. Simulate the distance values using the "Value sim. dist." parameter checking that the current output responds as it should. For MIN monitoring and MAX monitoring, in each case simulate a distance directly above and below the switch point. For range monitoring, 5 distance values should be simulated which cover the entire measuring range.

   ⚠ CAUTION

   During distance simulation, the loop current does not correspond to the measured value.

   ▶ It must be ensured that there is no risk of danger arising from this.
7. Confirm that the distance simulation is correct. To do so, select the "Yes" value for the "Sim. correct" parameter.
8. Compare the character string which is now output ("0123456789+-,.") with the reference string printed here, and confirm if the output is correct.
9. The parameters previously configured and which require confirmation are transferred via an independent data format to the display/operating tool. Check the parameters one after the other and confirm if correct.
10. Enter the locking code (WHG: 7450; SIL: 7452; SIL and WHG: 7454) once again under "Set write prot.". The locking status must be checked after SIL locking: The parameter "Setup > Advanced setup > Locking status > SIL locked" must be confirmed with an "✗".
11. As an option, hardware locking can also be activated (via the dip switch marked "WP" on the main electronics).

Locking in "Expert mode"

To commission the device, carry out and document the following steps in the order shown→ 🖹 31.

1. Reset device. This resets all parameters to defined values. To do this, select:
   - With firmware version 01.01.zz
     "Diagnostics > Device reset > To factory defaults" or
     "Diagnostics > Device reset > To delivery settings"
   - With firmware version 01.02.zz and 01.03.zz
     "Setup > Advanced setup > Administration > Device reset > To factory defaults" or
     "Setup > Advanced setup > Administration > Device reset > To delivery settings"
2. Carry out configuration. The configuration procedure and the meaning of the individual parameters are described in the Operating Instructions→ 🖹 8. Observe the following parameter settings→ 🖹 16.
3. Carry out "Device check". Activate the "Diagnostics > Device check > Start device check" parameter (more information available in the Operating Instructions→ 🖹 8). The signal quality is tested here and possible installation errors are detected.
4. Start SIL/WHG confirmation sequence. To do this, enter the appropriate locking code (WHG: 7450; SIL: 7452; SIL and WHG: 7454) in the "Setup > Advanced setup > SIL/WHG confirmation > Set write prot." parameter.
5. For "Commissioning" select the "Expert mode" entry from the list. The device checks the parameter settings in accordance with the table and forces the switching of parameters if necessary. Once testing is complete, "SIL/WHG prepar.: Finished" is displayed, and the commissioning sequence can continue.

   The commissioning mode must not be changed during completion of the SIL confirmation sequence. If the wrong option has been selected, the sequence must be canceled and started again.
6. Carry out function test. For MIN and MAX monitoring, at least one level below (MIN monitoring) or above (MAX monitoring) the switch point must be approached. For range monitoring, 5 distance values should be approached which cover the entire measuring range. Verify in each case that the response of the current output is correct.
   If it is not possible to approach the required level values, a test in accordance with test sequence C (proof test→ 🖹 24) can be performed prior to locking. However, this does not detect all possible errors (e.g. insufficient adjustment). For this reason, we recommend that the measured values be tested and documented in accordance with test sequence A (proof test→ 🖹 22) at a time when the required point level/levels have been reached.
7. Confirm that the function test has been successful. To do so, select the "Yes" entry for "Conf. funct. test".
8. Enter the locking code (WHG: 7450; SIL: 7452; SIL and WHG: 7454) once again under "Set write prot.". The locking status must be checked after SIL locking: The parameter "Setup > Advanced setup > Locking status > SIL locked" must be confirmed with an "✗".
9. As an option, hardware locking can also be activated (via the dip switch marked "WP" on the main electronics).

   For step 6: In accordance with IEC 61508-1 : 2010, Section 7.14, this test is included in the "Overall safety validation" and is the responsibility of the operator.

Further parameter settings

The following parameters affect the safety function. However, they may be freely configured in accordance with the application. In increased safety mode, it is necessary to confirm the configured values during the remainder of the commissioning process. Confirmation is not required in expert mode. It is recommended to note down the configured values!

Parameter	Parameter name
Setup	Operating mode [1]
	Tank type [2] [3]
	Tube diameter [4]
	Bin type [5] [2]
	Tank level [1]
	DC value [1]
	Empty calibration
	Full calibration
	Advanced setup → Level → Medium type [6]
	Advanced setup → Level → Medium property [7]
	Advanced setup → Interface → Process property [2]
	Advanced setup → Level → Advanced process conditions [2]
	Advanced setup → Interface → Blocking distance [1] [6]
	Advanced setup → Probe settings → Present probe length [8]
	Advanced setup → Current output 1 → Assign current output [1]

1) Only for interface measurement
2) From firmware 01.02.00
3) Only for liquids
4) Only for coated probes (FMP52, FMP55) in a bypass/pipe
5) Only for bulk solids
6) Firmware 01.01.10, 01.01.16 and 01.01.18.
7) Only for level measurement.
8) Where possible use the function for automatic redefinition of the probe length ("Setup > Advanced setup > Prob.length corr.") after shortening the probe. If the probe length is not determined automatically, but is entered manually in the device, only expert mode is possible.

The following parameters affect the safety function and are not freely configurable in the increased safety mode. Instead, they are automatically changed by the device at the start of the SIL/WHG confirmation to the safety-oriented values mentioned. If these parameters are to be set to other values, expert mode must be selected.

Parameter	Preset value
Setup → Advanced setup → Display → Backlight	Disable
Setup → Advanced setup → Level → Process property	Standard < 1 m (40in) /min
Setup → Advanced setup → Level → Level correction	0
Setup → Advanced setup → Interface → DC value lower medium	80
Setup → Advanced setup → Interface → Level correction	0
Setup → Advanced setup → Linearization → Linearization type	None
Setup → Advanced setup → Current output 1 → Current span	Fixed current
Setup → Advanced setup → Current output 1 → Damping output	0 s
Expert → Sensor → Level → Distance offset	0 m
Expert → Sensor → Level → L max. drain speed	0
Expert → Sensor → Level → L max. fill speed	0

Parameter	Preset value
Expert → Sensor → Level → I max. drain speed	0
Expert → Sensor → Level → I max. fill speed	0
Expert → Sensor → Level → Level limit mode	Off
Expert → Sensor → Level → Output mode	Level linearized
Expert → Sensor → Sensor diagnostics → Broken probe detection	On
Expert → Sensor → Safety settings → Delay time echo lost	▪ 1 s (Firmware 01.01.10 and 01.01.16) ▪ 3 s (from firmware 01.01.18)
Expert → Sensor → Envelope curve → Additional measurement range	0
Expert → Sensor → Envelope curve → Additional number of envelope points	0
Expert → Output → Current output 1 → Turn down	Off
Expert → Output → Current output 1 → Measuring mode	Standard
Expert → Communication → Configuration → HART address	0

The following parameters affect the safety function and are automatically adapted by the device when configuring higher-ranking parameters (known as application parameters). This indirect setting is permitted in increased safety mode. However, it is not permitted to change the parameters directly. If these parameters were changed directly, only expert mode is available for selection in the SIL/WHG confirmation.

Parameter	Parameter name
Setup	Distance to upper connection [1) 2)]
	Advanced setup → Level → Medium type [2)]
	Advanced setup → Level → Blocking distance [3) 2)]
	Advanced setup → Interface → Blocking distance [1) 2)]
Expert	Sensor → Medium → DC value [3)]
	Sensor → Distance → Dead time
	Sensor → Distance → Integration time
	Sensor → Distance → Max. integration time
	Sensor → Distance → Delta at integration time
	Sensor → Distance → Blocking distance evaluation mode
	Sensor → Gas phase compensation → GPC mode [3) 2)]
	Sensor → Sensor diagnostics → BP reflect fact. [2)]
	Sensor → Safety settings → Jump delay echo lost
	Sensor → Safety settings → Draining speed
	Sensor → Safety settings → Filling speed
	Sensor → Mapping → Map gap to LN [2)]
	Sensor → Envelope curve → Envelope statistics down
	Sensor → Envelope curve → Envelope statistics up
	Sensor → First echo factor → First echo mode
	Sensor → First echo factor → First echo factor
	Sensor → EOP evaluation → EOP level evaluation [2)]
	Sensor → EOP evaluation → EOP search mode
	Sensor → EOP evaluation → In upper area
	Sensor → EOP evaluation → EOP range upper area

Parameter	Parameter name
	Sensor → EOP evaluation → Reflection factor near
	Sensor → EOP evaluation → Attenuation constant
	Sensor → EOP evaluation → Reflection factor far
	Sensor → EOP evaluation → Thin interface [2)]
	Sensor → Echo tracking → Evaluation mode
	Sensor → Echo tracking → Window size tracking
	Sensor → Echo tracking → Maximal track counter
	Sensor → Interface → Empty capacitance

1) Only for interface measurement..
2) From firmware 01.02.00.
3) Only for level measurement.

The following parameters affect the safety function and cannot be freely configured in the increased safety mode or in the expert mode. Instead they are automatically changed by the device at the start of the SIL/WHG confirmation to the safety-oriented values mentioned.

Parameter	Preset value
Setup → Advanced setup → Safety settings → Output echo lost	Alarm
Diagnostics → Simulation → Assign measurement variable	Off
Diagnostics → Simulation → Simulation current output 1	Off
Diagnostics → Simulation → Simulation device alarm	Off
Expert → Sensor → Distance → Hysteresis	0 m
Expert → Output → Current output 1 → Trim	Off
Expert → Diagnostics → Simulation → Simulation diagnostic event	65533

The following parameters affect the safety function. If the settings differ from the as-delivered state of the device, only the expert mode is available for selection in the SIL/WHG confirmation.

Parameter	Parameter name
Setup	Advanced setup → Probe settings → Probe grounded [1)]
	Advanced setup → Current output 1 → Assign current output [2) 3)]
Expert	Sensor → Sensor properties → Sensor type
	Sensor → Sensor properties → Microfactor
	Sensor → Sensor properties → Ideal signal near
	Sensor → Sensor properties → Ideal signal attenuation
	Expert → Sensor → Sensor properties → Ideal signal far
	Sensor → Sensor properties → Antenna zero distance
	Sensor → Sensor properties → Cable zero distance
	Sensor → Sensor properties → Electronics zero distance
	Sensor → Sensor properties → Fine zero distance
	Sensor → Sensor properties → Fine zero distance window left
	Sensor → Sensor properties → Fine zero distance window right
	Sensor → Sensor properties → Threshold fine zero distance
	Sensor → Sensor properties → Present fine zero distance correction
	Sensor → Sensor properties → Inactive length

Parameter	Parameter name
	Sensor → Sensor diagnostics → UBD broken probe [1]
	Sensor → Sensor diagnostics → LBD broken probe
	Sensor → Sensor diagnostics → HF cable failure
	Sensor → Safety settings → Echo lost window right
	Sensor → Safety settings → Echo lost window left
	Sensor → Echo threshold → Threshold near
	Sensor → Echo threshold → Threshold far
	Sensor → Echo threshold → Threshold attenuation constant
	Sensor → Echo threshold → Weight area
	Sensor → Echo threshold → Echo threshold inactive length [1]
	Sensor → Mapping → Map gap to LN [3]
	Sensor → First echo factor → Fix factor EWC
	Sensor → Echo fine adjustment → Fine adjustment mode [1]
	Sensor → Echo fine adjustment → Merge echo distance [1]
	Sensor → Echo fine adjustment → Merging echo window [1]
	Sensor → Echo fine adjustment → Merging ratio [1]
	Sensor → Echo fine adjustment → Parabolic fit window size
	Sensor → EOP evaluation → EOP level evaluation [3]
	Sensor → Echo tracking → Lower level area [1]
	Expert → Sensor → Interface → Ratio amplitude interface/level
	Sensor → Interface → Interface reflection factor near
	Sensor → Interface → Interface reflection factor far
	Sensor → Interface → Diameter insulated probe
	Sensor → Interface → Diameter probe
	Sensor → Interface → Measuring range capacitance
	Sensor → Interface → DC value insulation
	Expert → Communication → Output → Assign PV [3]

1) From firmware 01.02.00.
2) Only for level measurement.
3) Firmware 01.01.10, 01.01.16 and 01.01.18.

The following parameters affect the safety function. If the settings differ from the permitted values mentioned, the SIL/WHG confirmation is canceled automatically, and the device cannot be locked neither in increased safety mode nor in expert mode.

Parameter	Preset value
Setup → Advanced setup → Current output 1 → Assign current output [1] [2]	
Setup → Advanced setup → Current output 1 → Failure mode	Min. or Max.

Parameter	Preset value
Expert → Output → Current output 1 → Start-up mode	Defined value
Expert → Communication → Output → Assign PV [2)]	

1) Only for level measurement.
2) From firmware 01.02.00.

- Those parameters which are not mentioned do not affect the safety function and can be configured to any meaningful values. The visibility of the parameters mentioned in the operating menu depends in part on the user role, the SW options ordered and on the configuration of other parameters.
- If gas phase compensation is activated ("GPC mode" parameter set to "On" or "Const. GPC factor"), this results in a differing specification for accuracy→ 🖹 8).
  Coaxial probes with gas phase compensation are precalibrated ex works and may be commissioned either in increased safety mode or in expert mode.
  When using a rod probe with gas phase compensation, expert mode must be selected, and the correct setting of the "Reference distance" parameter must be verified during commissioning.
- In the SIL mode, the device must not be operated in HART-Multidrop mode, as otherwise the current output will assume a fixed value. For this reason, only the setting "Expert > Communication > HART address = 0" is permitted in the SIL mode and in the combined SIL/WHG mode when in the increased safety mode. In pure WHG mode, HART Multidrop is permitted in the expert mode as long as the HART signal is evaluated in an external switching unit (e.g. Tank Side Monitor NRF590) that complies with the approval principles as per WHG.

Unlocking a SIL-device

When SIL locking is active on a device, the device is protected against unauthorized operation by means of a locking code and, as an additional option, by means of a hardware write protection switch. The device must be unlocked in order to change the configuration for proof tests as per test sequence B → 🖹 23 or test sequence C→ 🖹 24, as well as to reset self-holding diagnostic messages.

⚠ CAUTION

Unlocking the device deactivates diagnostic functions, and the device may not be able to carry out its safety function when unlocked.

► Therefore, independent measures must be taken to ensure that there is no risk of danger while the device is unlocked.

To unlock, proceed as follows:

1. Check the position of the hardware write protection switch (dip switch marked "WP" on main electronics), and set this switch to "Off".
2. Select "Setup > Advanced setup > Deactiv. SIL/WHG" and enter the appropriate unlocking code (WHG: 7450; SIL: 7452; SIL and WHG: 7454) for the "Res. write prot." parameter.
   ↳ The "End of sequence" message indicates that the device was successfully unlocked.

Proof-testing

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

The values and graphics in the "Additional safety-related characteristics" section can be used for this purpose → 📄 4. The test must be carried out in such a way that it verifies the correct operation of the protective system in interaction with all of the components.

In a single-channel architecture, the PFD_{avg} value to be used depends on the diagnostic rate of coverage for the proof-test (PTC = Proof Test Coverage) and the intended lifetime (LT = Lifetime), as specified in the following formula:

$$PFD_{avg} = \frac{1}{2} \bullet PTC \bullet \lambda_{DU} \bullet T_I + \lambda_{DD} \bullet MTTR + \frac{1}{2} \bullet (1 - PTC) \bullet \lambda_{DU} \bullet LT$$

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For the proof-tests described as follows, the respective proof test coverages are specified, which may be used for calculation.

Proof-testing of the device can be performed as follows:

1. Approaching the level in the original tank (→ test sequence A).
2. Removing the device and immersing in a medium with comparable properties (→ test sequence B).
3. Device self-test and level simulation (→ test sequence C). No change of level in the tank is necessary for this sequence.

You must also check that all cover seals and cable entries are sealing correctly.

⚠ CAUTION

To ensure process safety.

- ▶ During the proof-test, alternative monitoring measures must be taken to ensure process safety.

If one of the test criteria from the following test sequences is not fulfilled, the device may no longer be used as part of a protective system. The purpose of proof-testing is to detect random device failures (λ_{du}). The impact of systematic faults on the safety function is not covered by this test and must be assessed separately. Systematic faults can be caused, for example, by process material properties, operating conditions, build-up or corrosion.

Test sequence A

Preparation

1. Connect suitable measuring device (recommended accuracy better than ±0.1 mA) to the current output.
2. Determine the safety setting (level limit or range monitoring).

Procedure for level limit monitoring

1. Check safety function: Approach one level immediately above (MAX monitoring) or below (MIN monitoring) the limit to be monitored.
2. Check safety function: Read the output current, record it and assess for accuracy.
3. If (as an option) the function of the measuring point is to be checked immediately in front of the switch point: Checks the function in front of MIN or MAX switch point: Approach level immediately below (MAX monitoring) or above (MIN monitoring) the limit to be monitored. Read the output current, record it and assess for accuracy. This does not check the safety function of the device.
4. The test is to be considered successful if the current values trigger or ensure the required function.

Procedure for range monitoring

1. Approach five levels within the range to be monitored.
2. Read the output current at each level value, record it and assess for accuracy.
3. The test is to be considered successful if the current values in step 2 are within the required level of accuracy.

The proof-test is to be considered to have failed if the expected current value deviates for a specific level by > ±2 %. For troubleshooting, refer to the Operating Instructions→ 🖹 8. 99 % of dangerous, undetected failures are detected using this test (Proof test coverage, PTC = 0.99).

Test sequence B

Preparation

1. Prepare a test tank with test medium (dielectric constant comparable to that of the medium to be measured). For installation instructions, refer to the Operating Instructions→ 🖹 8.
2. Deactivate SIL mode. To do so, enter the appropriate unlocking code (WHG: 7450; SIL: 7452; SIL and WHG: 7454) in the "Setup > Advanced setup > Deactiv. SIL/WHG" operating menu.
3. Remove the device and mount it in the test tank.
4. Connect suitable measuring device (recommended accuracy better than ±0.1 mA) to the current output.
5. Perform interference echo mapping if the shape and size of the test tank is different.
6. Determine the safety setting (level limit or range monitoring).

Procedure for level limit monitoring

1. Approach a level directly below (MAX monitoring) or directly above (MIN monitoring) the level limit to be monitored.
2. Read the output current, record it and assess for accuracy.
3. Approach the level directly above (MAX monitoring) or directly below (MIN monitoring) the level limit to be monitored.
4. Read the output current, record it and assess for accuracy.
5. The test is to be considered successful if the current in step 2 does not result in activation of the safety function but the current in step 4 does.

Procedure for range monitoring

1. Approach five levels within the range to be monitored.
2. Read the output current at each level value, record it and assess for accuracy.
3. The test is to be considered successful if the current values in step 2 are within the required level of accuracy.

The proof-test is to be considered to have failed if the expected current value deviates for a specific level by > ±2 %. For troubleshooting, refer to the Operating Instructions→ 🖹 8. 99 % of dangerous, undetected failures are detected using this test (Proof test coverage, PTC = 0.99).

⚠ CAUTION

Re-installation in the original tank

SIL mode is not activated.

- ▶ SIL mode must be reactivated→ 🖹 13.
- ▶ If an interference echo mapping was performed in the test tank, it is necessary following installation in the original tank to carry out another interference echo mapping that is valid for that tank.

Test sequence C

Preparation

1. Deactivate SIL mode. (WHG: 7450; SIL: 7452; SIL and WHG: 7454) in the "Setup > Advanced setup > Deactiv. SIL/WHG" operating menu.
2. Connect suitable measuring device (recommended accuracy better than ±0.1 mA) to the current output.
3. Determine the safety setting (level limit or range monitoring).

Procedure for level limit monitoring

1. Perform device self-check. To do so, select the value "Yes" in the "Expert > Sensor > Sensor diag. > Start self check" list. After performing the test, read the test results in the "Expert > Sensor > Sensor diag. > Result self check" parameter. This part of the test has been passed only when "OK" is displayed here.
2. Simulate a level directly below (MAX monitoring) or directly above (MIN monitoring) the level limit to be monitored. To do so, select the value "Level" in the operating menu in the "Diagnostics > Simulation > Assign meas. var." list. Alternatively, in the case of interface measurement, select the values "Interface" or "Upper interface thickness" if applicable, and enter the value in the "Diagnostics > Simulation > Process variable value" parameter.
3. Read the output current, record it and assess for accuracy.
4. Simulate a level directly above (MAX monitoring) or directly below (MIN monitoring) the level limit to be monitored.
5. Read the output current, record it and assess for accuracy.
6. The test is to be considered successful if the current in step 2 does not result in activation of the safety function but the current in step 4 does.

When selecting the "Expert" menu group, a prompt for the access code appears on the display. If an access code was defined under "Setup > Advanced setup > Def. access code" this must be entered here. If no access code was defined, the prompt can be acknowledged by pressing the "E" key.

Procedure for range monitoring

1. Perform device self-check. To do so, select the value "Yes" in the "Expert > Sensor > Sensor diag. > Start self check" list. After performing the test, read the test results in the "Expert > Sensor > Sensor diag. > Result self check" parameter. This part of the test has been passed only when "OK" is displayed here.
2. Simulate five levels within the range to be monitored. Procedure, → Limit value monitoring, step 2.
3. Read the output current at each level value, record it and assess for accuracy.
4. The test is to be considered successful if the current values in step 2 are within the required level of accuracy.

- When selecting the "Expert" menu group, a prompt for the access code appears on the display. If an access code was defined under "Setup > Advanced setup > Def. access code" this must be entered here. If no access code was defined, the prompt can be acknowledged by pressing the "E" key.
- The proof-test is to be considered to have failed if the expected current value deviates for a specific level by > ±2 %. For troubleshooting, refer to the Operating Instructions→ 🖹 8. 95 % (for the FMP55: 78 %) of dangerous, undetected failures are detected using this test (Proof test coverage, PTC = 0.95 (for the FMP55: 0.78)).
  A number of sensor (probe) faults are not detected.
- If one of the test criteria from the test sequences described above is not fulfilled, the device may no longer be used as part of a safety instrumented system. The purpose of proof-testing is to detect random device failures (λ_{du}). The impact of systematic faults on the safety function is not covered by this test and must be assessed separately. Systematic faults can be caused, for example, by process material properties, operating conditions, build-up or corrosion.

⚠ CAUTION

Once test sequence C has been completed, the SIL mode is no longer activated.

- The SIL mode must be activated again in accordance with "Device parameter configuration for safety-related applications" → 13
- The following steps do not need to be performed again in this case: Steps 1 and 2 were performed in the context of (initial) commissioning/configuration. Steps 3 and 6 were performed in the context of this proof test with the relevant diagnostic coverage.

Life cycle

Requirements for 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

Please refer to the relevant Operating Instructions for information on maintenance and recalibration→ 🖹 8.

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

Repairs

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
Probe with process connection	EA00045F/00	Proof check; test sequence A or B
Probe without process connection	EA00047F/00 (FMP54/56/57)	▪ With change of the probe length: – Unlock the device – Recalibrate the probe length according to EA00047F/00/A2 – Check the measurement at an arbitrary level – Lock the device ▪ Without change of the probe length: – Check the probe length, e.g. using a measuring tape – Visual inspection to check whether all parts are present and properly mounted – After remounting: Check the measurement at an arbitrary level
Weights of rope probes	EA00042F/00	Visual inspection to check whether all parts are present and properly mounted
Nord-lock washers and lock nuts for probe mounting	EA00048F/00 (FMP51/54/56/57)	Visual inspection to check whether all parts are present and properly mounted
Seal kits for probes	EA00044F/00 (FMP50/51)	▪ Visual inspection to check whether all parts are present and properly mounted ▪ After remounting: Check the measurement at an arbitrary level
Process connection adapter	EA00054F/00 (FMP53)	Visual inspection to check whether all parts are present and properly mounted
HF coaxial cable of separate version	EA00056F/00 (FMP53) EA00057F/00 (FMP50/51/52/54/55/56/57)	▪ Visual inspection to check whether all parts are present and properly mounted ▪ After remounting: Check the measurement at an arbitrary level
Display SD02/ SD03	EA00102D/06	Visual inspection to check whether all parts are present and properly mounted
Transmitter electronics of the remote display FHX50	EA01064F/00	Visual inspection to check whether all parts are present and properly mounted
Cable of the remote display FHX50	General safety data sheet: EA01062F/00	Visual inspection to check whether all parts are present and properly mounted

Component	Installation Instructions	Checking the device after repair
Main electronics	EA00041F/00	▪ Visual inspection to check whether all parts are present and properly mounted ▪ Unlock the device ▪ For devices without "gas phase compensation" (ordering feature 540 "Application Package", option "EF" or "EG" not selected): Navigate to: Menu "Setup" > "Mapping" > "Confirm distance". Compare the displayed distance to the actual value in order to start the recording of a map, if required. ▪ For FMP54 with "gas phase compensation" (ordering feature 540 "Application Package", option model "EF" or "EG" selected): Check and correct reference distance if necessary (refer to BA01001F/00/EN, Chapter "Commissioning", section "Check reference distance"). ▪ Lock the device
I/O-Module	EA00039F/00	▪ Visual inspection to check whether all parts are present and properly mounted ▪ Check the measurement at an arbitrary level
Overvoltage protection OVP10/20	SD01090F/00	▪ Visual inspection to check whether all parts are present and properly mounted ▪ Check the measurement at an arbitrary level
Terminals for I/O modules	EA00040F/00	▪ Visual inspection to check whether all parts are present and properly mounted ▪ After remounting: Check the measurement at an arbitrary level
Housing cover	EA00035F/00	Visual inspection to check whether all parts are present and properly mounted
Seal kits for housing covers	EA00036F/00	Visual inspection to check whether all parts are present and properly mounted
Housing filters (vent plugs)	EA00037F/00	Visual inspection to check whether all parts are present and properly mounted
Safety clamps, housing	EA00038F/00	Visual inspection to check whether all parts are present and properly mounted

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 device in protection system" when returning the defective device. In this case, please refer to the "Return" section of 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.

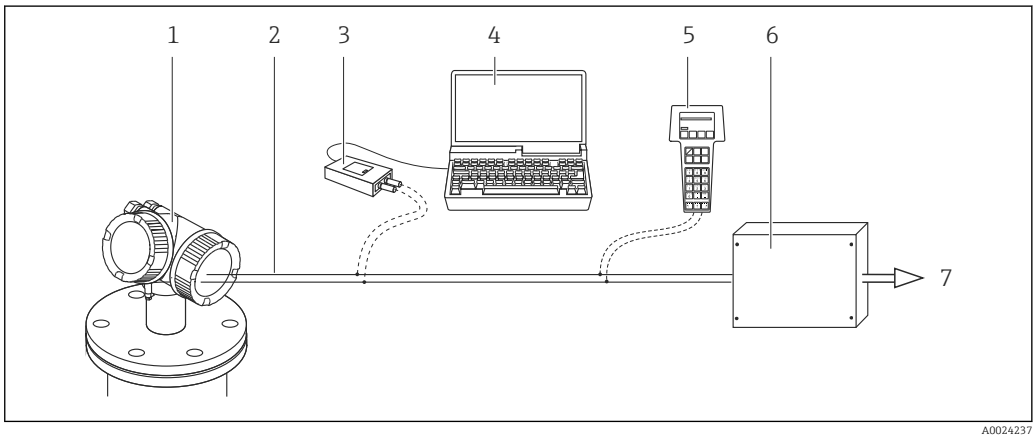
Modifications to SIL capable devices by the user are not permitted.

Appendix

Structure of the measuring system

System components

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



1 *Levelflex (optional with display module SD02/SD03)*
2 *4 to 20 mA line*
3 *Commubox FXA191/195*
4 *Computer with operating tool, e.g. FieldCare*
5 *Field Communicator 375/475*
6 *Logic Unit, e.g. PLC, limit signal transmitter*
7 *Actuator*

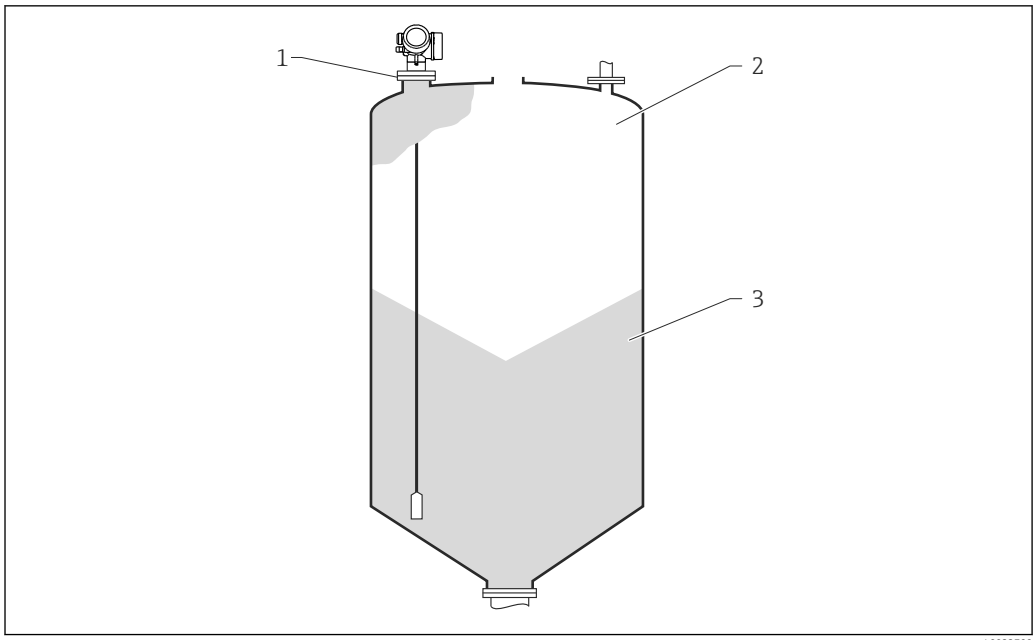
An analog signal (4 to 20 mA) in proportion to the level is generated in the transmitter. This is sent to a downstream logic unit (e.g. PLC, limit signal transmitter, ...)where it is monitored to determine whether it is below or above a specified limit value.

For fault monitoring, the logic unit must recognize both HI-alarms (≥21.0 mA) and LO-alarms (≤3.6 mA).

Description of use as a protective system

The Levelflex is a "downward-looking" measuring system, operating based on the time-of-flight method (ToF). The distance from the reference point (process connection of the measuring device) to the product surface is measured. High-frequency pulses are injected to a probe and led along the probe. The pulses are reflected by the product surface, received by the electronic evaluation unit and converted into level information. This method is also known as TDR (time domain reflectometry).

Typical measuring arrangement:



1 Flange: Reference point of measurement
2 20 mA, 100%
3 4 mA, 0%

The device can be used in this arrangement in safety instrumented systems for MIN safety, MAX safety and range monitoring.

For interface measurement of two different phases (e.g. oil on water), two echos are analyzed in accordance with the TDR method described above. Alternatively, in the case of a multi-parameter sensor (FMP55), the above mentioned TDR method is combined with a capacitance measurement. Only one probe is needed to carry out both the TDR measurement and the capacitance measurement. This capacitance is an indicator for the level, as the dielectric constant and/or the conductivity of the products cause an increase in capacitance. This additional information enables a high degree of accuracy, even in tough application conditions (e.g. emulsification).

Correct installation is a prerequisite for safe operation of the device.

Proof-testing

System-specific data		
Company		
Measuring point/TAG no.		
Facility		
Device type/Order code		
Serial number of device		
Name		
Date		
Access code (if individual to each device)		
Locking code used	WHG SIL SIL and WHG	❑ 7450 ❑ 7452 ❑ 7454
Signature		

For firmware version: 01.01.zz

Device-specific commissioning parameters (only in “Increased safety mode”)	
Empty calib.	
Full calibration	
Blocking distance	
Mode of operation	
Assign current (interface measurement)	
Medium type	
Present length	
Pipe diameter	
Tank level (interface measurement)	
DC value (interface measurement)	
Medium property (level measurement)	

For firmware version: 01.02.zz and 01.03.zz

Device-specific commissioning parameters (only in “Increased safety mode”)	
Empty calib.	
Full calibration	
Operating mode (interface measurement)	
Assign current (interface measurement)	
Tank type (liquids)	
Bin type (bulk solids)	
Process property	
Adv. conditions	
Present length	
Tube diameter (interface measurement)	
Tank level (interface measurement)	
DC value (interface measurement)	
Medium property (level measurement)	

Proof-test protocol		
Test step	Set point	Actual value
1. Current value 1		
2. Current value 2		
3. Current value 3 (if necessary)		
4. Current value 4 (if necessary)		
5. Current value 5 (if necessary)		

Notes on the redundant use of multiple sensors

This section provides additional information regarding the use of homogeneous redundancy sensors e.g. 1oo2 or 2oo3 architectures.

The common cause factors ß and $ß_D$ indicated in the table below are minimum values for the Micropilot. These must be used when designing the sensor subsystem.

Minimum value ß with homogeneous redundant use	2 %
Minimum value $ß_D$ with homogeneous redundant use	1 %

The device meets the requirements for SIL 3 in homogeneous redundancy.

The following must be taken into account during installation:
- Install rod and rope probes in separate reference vessels (bypasses, stilling wells), to prevent them from interfering with each other. When installing in the same tanks, the sensor axes must be a minimum distance of 100 mm (3.94 in) apart. Coaxial probes may be installed at any distance.
- Application limits of measuring systems in contact with the process must be observed! In particular, in the case of highly viscous, build-up forming or crystallizing media.

The following must be taken into account in proof-testing:
If an error is detected in one of the redundantly operated devices, the other devices must be checked to see if there is the same error.

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 "Functional Safety in the Process Industry- Risk Reduction with Safety Instrumented Systems".

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