FY01070F/00/EN/02.22-00
71613867
2023-05-03

01.00.zz (Device firmware)

Functional Safety Manual
Liquiphant FTL64 with electronic insert FEL60H

Vibronic

Endress+Hauser
People for Process Automation

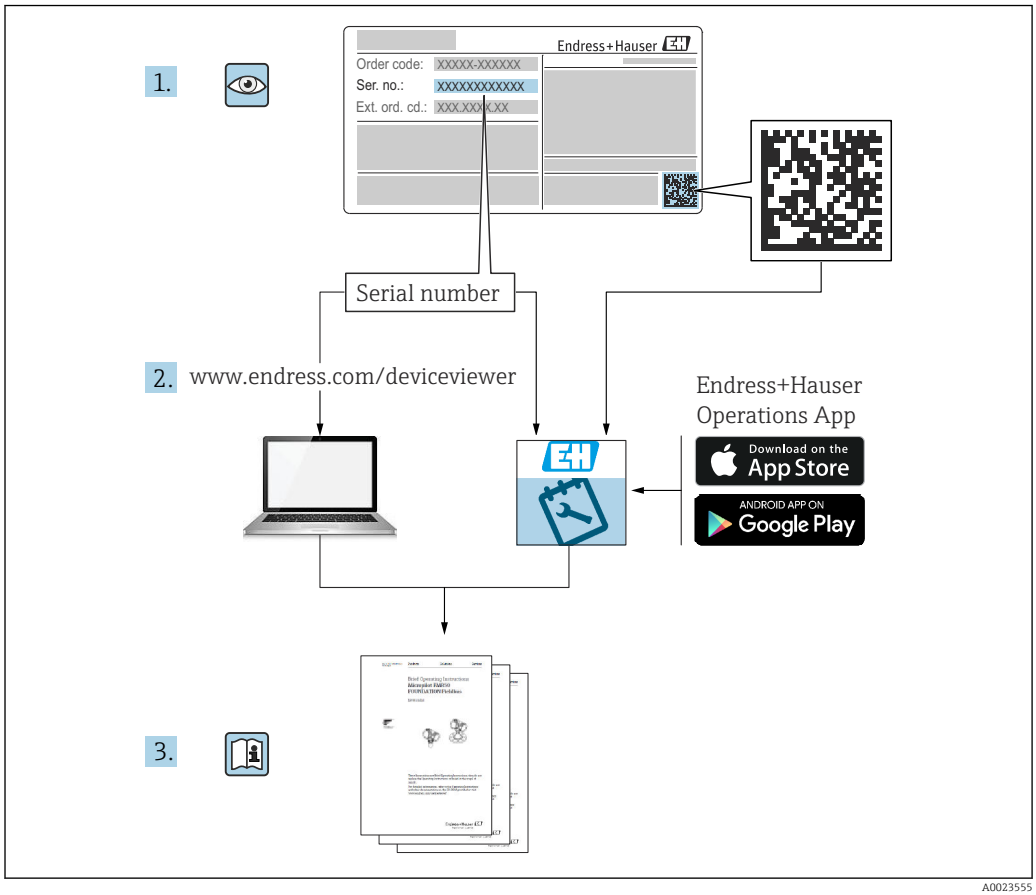

1.
Endress+Hauser
Order code: XXXXX-XXXXXX
Ser. no.: XXXXXXXXXXX
Ext. ord. cd.: XXX XXX XX
Serial number
2. www.endress.com/deviceviewer
Endress+Hauser
Operations App
Download on the App Store
ANDROID APP ON Google Play
3.
A0023555

Table of contents

1 Declaration of Conformity

SIL_00513_01.23

Endress+Hauser
People for Process Automation

Declaration of Conformity

Functional Safety according to IEC 61508
Based on NE 130 Form B.1

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

being the manufacturer, declares that the product

Liquiphant FTL51B / FTL62 / FTL63 / FTL64 (FEL60H)

is suitable for the use in safety-instrumented systems according to IEC 61508. The instructions of the corresponding functional safety manual must be followed.

This declaration of conformity is exclusively valid for the listed products and accessories in delivery status.

Maulburg, February 3, 2023
Endress+Hauser SE+Co. KG

i. V.

E-SIGNED by Thorsten Springmann
on 07 February 2023 08:29:48 CET

Thorsten Springmann
Dept. Man. R&D Devices Level Limit
Research & Development

i. V.

E-SIGNED by Manfred Hammer
on 07 February 2023 08:15:43 CET

Manfred Hammer
Dept. Man. R&D Quality Management/FSM
Research & Development

A0052151

1.1 Safety-related characteristic values

SIL_00513_01.23

Endress+Hauser
People for Process Automation

General			
Device designation and permissible types [1]	Liquiphant FTL51B / FTL62 / FTL63 / FTL64 ** BA * * * * * * ** ** *** + [LA] (FEL60H)		
	/		
Safety-related output signal	8 / 16 mA		
Fault signal	< 3.6 mA / ≥ 21 mA		
Process variable/function	Level switch for liquids		
Safety function(s)	MIN / MAX		
Device type acc. to IEC 61508-2	☐ Type A	☒ Type B	
Operating mode	☒ Low Demand Mode	☒ High Demand Mode	
Valid hardware version	01.00.ww (ww: any double number)		
Valid software version	01.00.zz (zz: any double number)		
Safety manual	FTL51B: FY01068F / FTL62: FY01069F / FTL63: FY01091F / FTL64: FY01070F		
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 – report/certificate no.	TÜV Rheinland 968/FSP1388		
Test documents	Development documents	Test reports	Data sheets

SIL – Integrity			
Systematic safety integrity		☐ SC 2	☒ SC 3
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} [2),3)]	42 FIT	26 FIT	/
λ_{DD} [2),3)]	1173 FIT	1139 FIT	/
λ_S [2),3)]	542 FIT	593 FIT	/
SFF	98%	99%	/
PFD_{avg} (T_1 = 1 year)[3)] (single channel architecture)	$1.83 \cdot 10^{-4}$	$1.15 \cdot 10^{-4}$	/
PFH	$4.17 \cdot 10^{-8}$ 1/h	$2.63 \cdot 10^{-8}$ 1/h	/
PTC [4)] A / B / C	94% / 35% / 35%	93% / 56% / 56%	/
Diagnostic test interval [5)]	≤ 60 s, RAM check ≤ 10 min	≤ 60 s, RAM check ≤ 10 min	/
Fault reaction time [6)]	≤ 5 s	≤ 5 s	/

Comments
ISO 13849-1: demand rate ≤ 1/(100 · diagnostic test interval)

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

[1)] Valid order codes and order code exclusions are maintained in the E+H ordering system
[2)] FIT = Failure In Time, number of failures per 10^9 h
[3)] 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
[4)] PTC = Proof Test Coverage
[5)] All diagnostic functions are performed at least once within the diagnostic test interval
[6)] Maximum time between error recognition and error response

A0052152

2 About this document

2.1 Document function

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 to the protection function are described in this safety manual.

General information on functional safety (SIL) is available at:
www.endress.com/SIL

2.2 Symbols used

2.2.1 Safety symbols

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

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

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

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

2.2.2 Symbols for certain types of information and graphics

Tip
Indicates additional information

Reference to documentation

Reference to graphic

▶
Notice or individual step to be observed

1., 2., 3.
Series of steps

Result of a step

1, 2, 3, ...
Item numbers

A, B, C, ...
Views

2.3 Supplementary device documentation

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

The following document types are available in the download area of the Endress+Hauser website (www.endress.com/downloads):

2.3.1 Further applicable documents

- TI01663F
- BA02215F
- KA01559F

2.3.2 Technical Information (TI)

Planning aid
The document contains all the technical data on the device and provides an overview of the accessories and other products that can be ordered for the device.

2.3.3 Operating Instructions (BA)

Your reference guide
These Operating Instructions contain all the information that is required in various phases of the life cycle of the device: from product identification, incoming acceptance and storage, to mounting, connection, operation and commissioning through to troubleshooting, maintenance and disposal.

2.3.4 Brief Operating Instructions (KA)

Guide that takes you quickly to the 1st measured value
The Brief Operating Instructions contain all the essential information from incoming acceptance to initial commissioning.

2.3.5 Certificate

The associated certificate is available in the Endress+Hauser W@M Device Viewer (Section 2.3) or can be found in the Declaration of Conformity (Section 1) of the applicable Functional Safety Manual. This certificate must be valid at the time of delivery of the device.

3 Design

3.1 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 subsequent versions can also be used for safety functions.

A modification process according to IEC 61508:2010 is applied for any device modifications.

Any exemptions from possible combinations of features are saved in the Endress +Hauser ordering system.

Valid device versions for safety-related use:

3.1.1 Order codes

"FTL64"

Feature: 010 "Approval"
Version: all

Feature: 020 "Output"
Version:
BA: FEL60H, 2-wire 8/16mA HART+test button

Feature: 030 "Display; Operation"
Version: all

Feature: 040 "Housing; Material"
Version: all

Feature: 050 "Electrical connection"
Version: all

Feature: 060 "Application"
Version: all

Feature: 080 "Surface finish"
Version: all

Feature: 085 "Probe design"
Version: all

Feature: 090 "Sensor length; Material"
Version: all

Feature: 105 "Process connection; Sealing surface"
Version: all

Feature: 110 "Process connection"
Version: all

Feature: 590 "Additional approval"
Version: all
- LA: SIL
- Version **"LA"** must be selected for use as a safety function as per IEC 61508.

Valid versions
- Firmware: from 01.00.zz (→ device nameplate)
- Hardware (electronics): from 01.00.ww (→ device nameplate)

3.2 Identification marking

SIL-certified devices are marked with the SIL logo on the nameplate.

3.3 Safety function

The device's safety functions are:
- Maximum level monitoring (overfill protection, MAX detection)
- Minimum level monitoring (dry running protection, MIN detection)

3.3.1 Safety-related output signal

The safety-related output signal consists of a 4 to 20 mA current signal according to DIN EN 60947-5-6 or IEC 60974-5-6.

NOTICE

In an alarm condition

▶ Ensure that the equipment under control achieves or maintains a safe state.

3.3.2 Limit value monitoring

The safety function of the measuring system is point level monitoring.

It is possible to perform either:
- Maximum point level monitoring (e.g. overfill protection) or
- Minimum point level monitoring (e.g. pump protection).

The safety-related signal is the analog output signal 4 to 20 mA. The dependency of the output signal on the operating mode and the state of the measuring point is illustrated below.

MIN operating mode
- Tuning fork covered: OK status is reported, 16 mA [1)]
- Tuning fork uncovered: demand mode is reported, 8 mA [1)]
- Fault: alarm is reported, < 3.6 mA
- Short-circuit: alarm is reported, > 21 mA

MAX operating mode
- Tuning fork covered: demand mode is reported, 8 mA [1)]
- Tuning fork uncovered: OK status is reported, 16 mA [1)]
- Fault: alarm is reported, < 3.6 mA
- Short-circuit: alarm is reported, > 21 mA

3.3.3 Safe measurement

The transmitter safety function consists of outputting a current at the output that corresponds to the point level. In this case, the current corresponds to the state of the device. A distinction is made between "OK" (MAX: overfill protection uncovered or MIN: dry running protection covered) and "Demand mode" (MAX: overfill protection covered or MIN: dry running protection uncovered). The OK status corresponds to 16 mA, the demand mode corresponds to 8 mA.

3.3.4 Redundant configuration of multiple sensors

This section provides additional information regarding the use of homogeneously redundant sensors e.g. in a 1oo2 or 2oo3 architecture. The failure rates for HFT = 1 are based on an analysis in accordance with:

DIN EN 61508-6: 2011-02, Table D.4, "Using the β-factor to calculate the probability of failure in an E/E/PE safety-related system due to common cause failures."

The device meets the requirements for SIL 3 in homogeneously redundant applications. The following common cause factors β and βD can be used for the design.

Minimum value ß with homogeneous redundant use	5 %
Minimum value $ß_D$ with homogeneous redundant use	2 %

The system-specific analysis can produce other values depending on the specific installation and use of additional components.

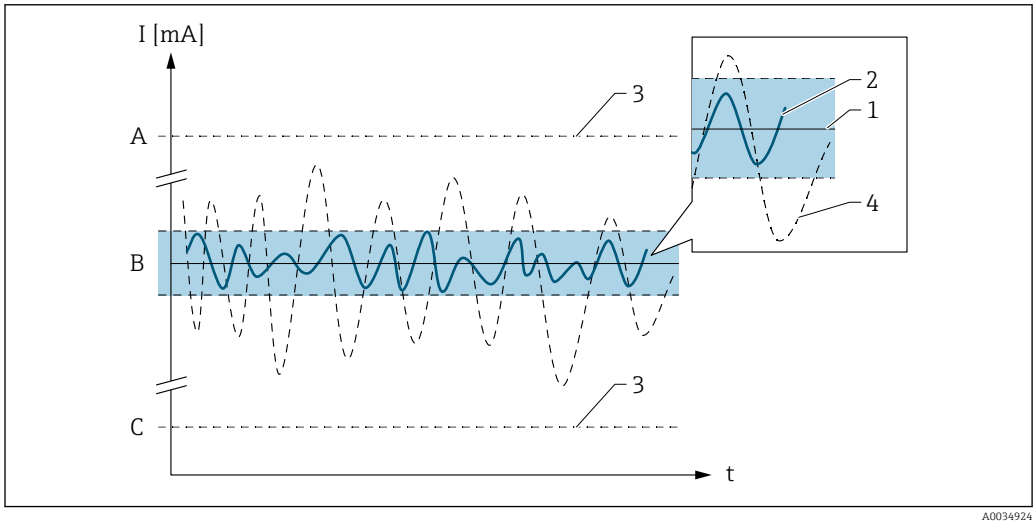
1) For the following safety function, it suffices to program the current threshold between the OK status and demand mode at 12 mA.

The following must be taken into account during installation:
- Sensors installed in a physically separate location
- Cables routed separately
- Separate protection from environmental influences, e.g.:
  - Impact
  - Sunshine
- EMC and/or overvoltage

3.4 Basic conditions for use in safety-related applications

The measuring system must be used correctly for the specific application, taking 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. The specifications in the Operating Instructions and the Technical Information must not be exceeded.

3.4.1 Safety-related failures according to IEC / EN 61508



A HI alarm ≥ 21 mA
B SIL error range ±2%
C LO alarm ≤ 3.6 mA

No device error
- No failure
- Implications for the safety-related output signal:
  None (1) and measuring uncertainty is within the specified range (TI, BA)

λ_S (Safe)
- Safe failure
- Implication for the safety-related output signal:
  The current measured value is output (2) or adopts the safe state (3) and measuring uncertainty is within the specified safety measured errors (see Section 3.4.2)

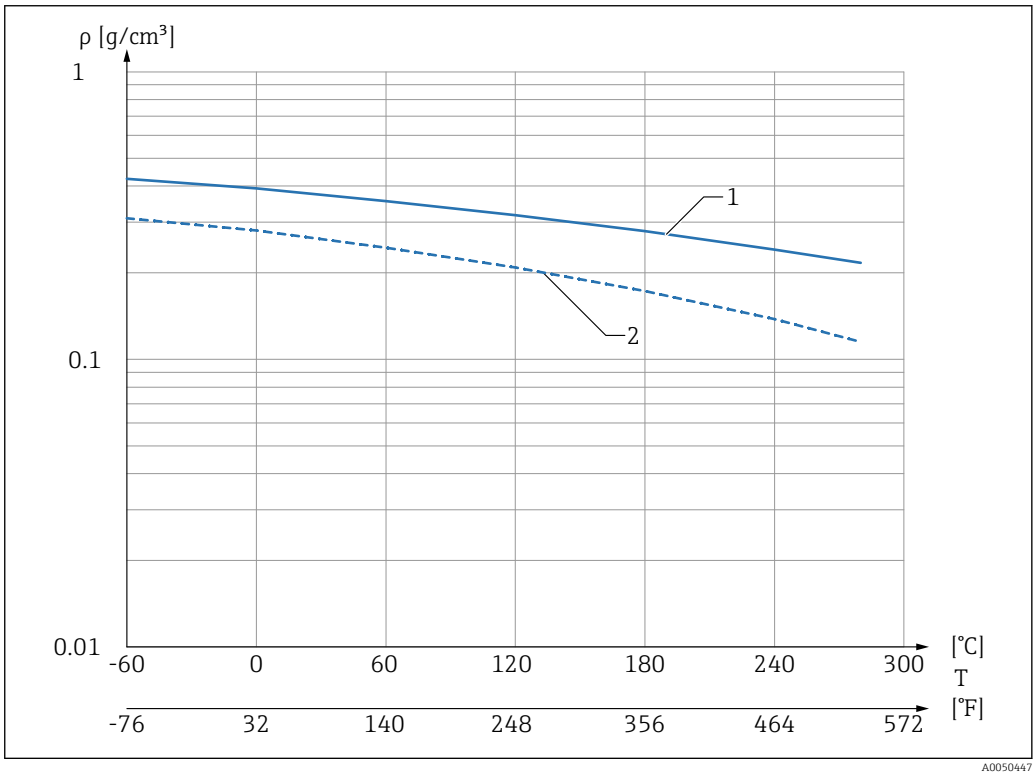
λ_{DD} (Dangerous detected)
- Dangerous but detectable failure
- Implication for the safety-related output signal:
  Results in a failure mode at the output signal (3) and the measuring uncertainty can exceed the specified safety measured error (see Section 3.4.2).

λ_{DU} (Dangerous undetected)
- Dangerous and undetectable failure
- Implication for the safety-related output signal:
  The current measured value is output (4) and the measuring uncertainty can exceed the specified safety measured error (see Section 3.4.2).

3.4.2 Restrictions for safety-related use

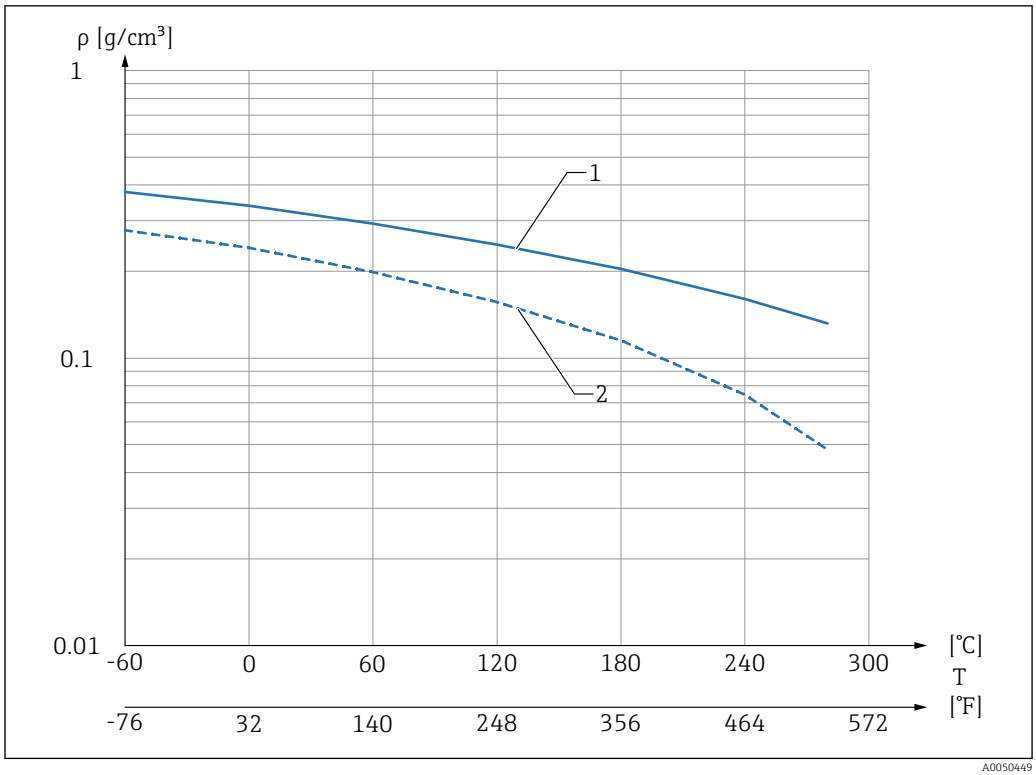
Density

Operation is only permitted with liquids:
- Depending on the configuration of the density setting, the density of the liquid must be as follows:
  - over 0.7 g/cm³ if switch position is > 0.7 (common water- or oil-based liquids)
  - over 0.5 g/cm³ if switch position is > 0.5 (e.g. liquefied gas, isopentane, benzine)
- The gas phase above the liquid may not exceed a maximum permitted density value. The maximum possible gas density depends on the temperature and the device



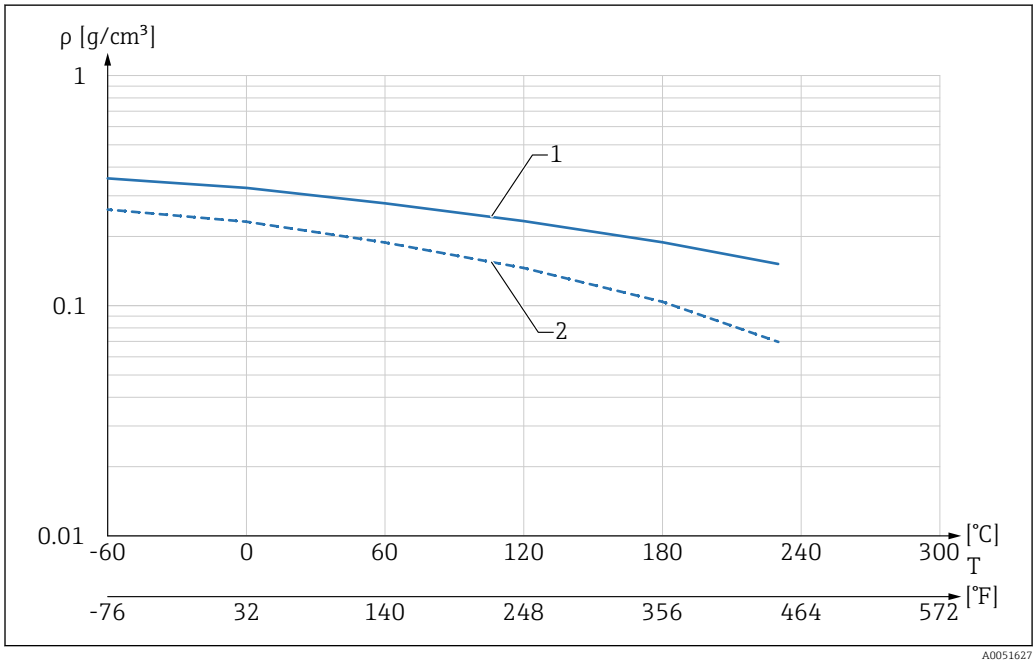
1 *Alloy C22*

1 *Switch position for density 0.7 g/cm³*
2 *Switch position for density 0.5 g/cm³*



2 *Duplex 318L*

1 *Switch position for density 0.7 g/cm³*
2 *Switch position for density 0.5 g/cm³*



3 *PFA, up to 230 °C (446 °F)*

1 *Switch position for density 0.7 g/cm³*
2 *Switch position for density 0.5 g/cm³*

NOTICE

The "Uncovered" state is not recognized and the "Covered" state is always reported.
Gas density is exceeded!
- There is no minimum density for the gas phase.
- Operation in a vacuum is permitted.
- There is no maximum density for the liquid.

For more information on the levels of diagnostic coverage, refer to IEC 61508-2:2010 Appendix A.2, Comment 2 and Table A.1.

Buildup: only MIN detection

The device may only be used in media that do not tend to cause buildup.

Buildup is detected with a low diagnostic coverage.

Solid particles - heterogeneous mixtures

The medium may not contain solid particles with a diameter greater than 5 mm (0.2 in). Solid particles lodged between the tines of the tuning fork can have the effect that the demand mode of the safety function is not detected and the device will not switch as intended.

- Only for MIN detection
- Lodged solid particles are detected with low diagnostic coverage.

Wall distance

The distance between the tuning fork and the wall of the vessel containing medium (e.g. tank, pipe) must be at least 10 mm (0.39 in).

Corrosion

The device may only be used in media to which the parts in contact with the process are resistant. Corrosion can have the effect that the demand mode of the safety function is not detected and the device will not switch as intended.

Corrosion is detected with low diagnostic coverage.

Abrasion

It is not permitted to use the device with abrasive media. Material abrasion on the tuning fork can result in the device malfunctioning.

Abrasion is detected with low diagnostic coverage.

Flow velocity

In the case of flowing media, the flow velocity in the area around the tuning fork may not exceed max. 5 m/s. Higher flow velocities can have the effect that the demand mode is not detected and the sensor signals that it is free (uncovered).

External vibration

In systems exposed to strong external vibrations, e.g. in the 400 to 1 200 Hz range (acceleration spectral density >1 $(m/s^2)^2/Hz$) or ultrasound with cavitation, the safety function must be verified by simulating a demand mode prior to operation. Accidental switchings may sporadically occur if a strong frequency from an external source is superimposed on the frequency of the tuning fork.

EMC compatibility

The device is tested according to IEC 61326-3-1 and is therefore suitable for general industrial safety-related applications. If the specified electromagnetic ambient conditions are exceeded, the switch status might not be reliably detected. An unshielded cable can be used between the devices in these environmental conditions. Electromagnetic interference immunity can be further improved by using shielded cables.

Mounting with sliding sleeve

Coated sensor

NOTICE

Mechanical damage to coating

Corrosion protection and adequate sealing are no longer guaranteed. Device could be destroyed.

- ▶ Coated sensors must not be mounted with a sliding sleeve.

Uncoated sensor

NOTICE

Mounting the device with pipe extension and sliding sleeve

The switch point may be tampered with by pipe extension with sliding sleeve

- ▶ Ensure that the switch point is not tampered with, or that any tampering is reliably detected

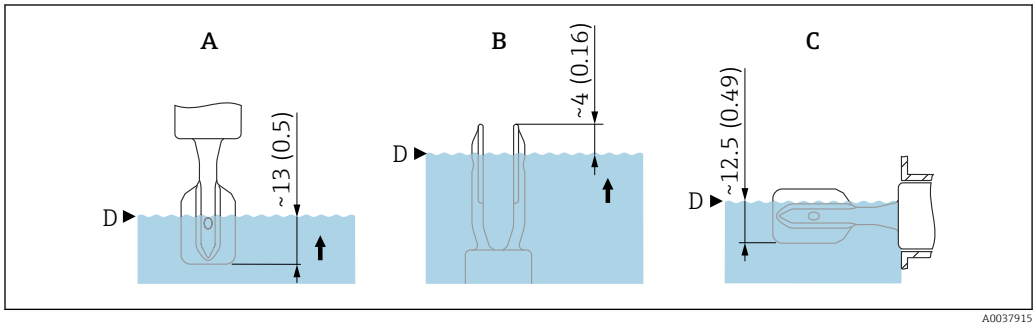
Display with Bluetooth

The device may be operated with the following displays when used as a safety function:

- VU112A
- VU113A

Display and Bluetooth modules may only be used for information purposes but may not be used as part of the safety function. They do not have any effect on the safety function.

3.4.3 Safety measured error



4 *Switch point depending on the installation position. Unit of measurement mm (in)*

A Installation from above
B Installation from below
C Installation from the side

3.5 Dangerous undetected failures in this scenario

An incorrect output signal that deviates from the value specified in this manual but is still in the 4 to 20 mA range is considered a dangerous undetected failure.

3.6 Useful lifetime of electrical 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.

4 Commissioning (installation and configuration)

4.1 Requirements for personnel

The personnel for installation, commissioning, diagnostics and maintenance must fulfill the following requirements:

- Trained, qualified specialists must have a relevant qualification for this specific function and task.
- Personnel must be authorized by the plant owner/operator.
- Be familiar with federal/national regulations.
- Before starting work: personnel must read and understand the instructions in the manual and supplementary documentation as well as the certificates (depending on the application).
- Personnel must follow instructions and comply with general policies.

The operating personnel must fulfill the following requirements:

- Personnel are instructed and authorized according to the requirements of the task by the facility's owner-operator.
- Personnel follow the instructions in this manual.

4.2 Installation

The mounting and wiring of the device and the permitted orientations are described in the Operating Instructions pertaining to the device.

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

4.3 Commissioning

The commissioning of the device is described in the Operating Instructions pertaining to the device.

Prior to operating the device in a safety instrumented system, verification must be performed by carrying out a test sequence as described in **Section 6 Proof testing**.

4.4 Operation

The operation of the device is described in the Operating Instructions pertaining to the device.

4.5 Parameter configuration for safety-related applications

4.5.1 Calibration of the measuring point

NOTICE

After commissioning the measuring system, changes to the settings can impact the protective function.

The protective function can be compromised.

- ▶ After changing the settings, perform a proof test to ensure that the safety function is working correctly.
- ▶ Device settings must not be changed in the active SIL mode.
- ▶ The configuration of the measuring point is described in the Operating Instructions.

4.5.2 Device protection

The devices can be protected against external influences as follows:

- Hardware write protection
- Software write protection

4.5.3 Configuration methods

The following operating methods are possible to configure the safety function:

- DTM-based software such as Field Care or Device Care
- MSD-based software SmartBlue (App)
- Operation via display
- EDD-based software such as PDM / FDI /AMS

The safety function can be commissioned in a number of ways:

- Configured onsite without the operating menu
- Configured using the wizard
- Expert setting

4.5.4 Locking in "Increased safety mode"

Configured onsite without the operating menu

Recommended for initial commissioning.

Reset the device according to the Operating Instructions. This resets all parameters to defined values (factory settings or customized settings).

1. Check the position of DIP switch 1 on the electronic insert, set to "OFF" if necessary.
2. Configure the device as specified in the Operating Instructions.
3. Lock the device using DIP switch 1 on the electronic insert.

A function test is necessary before the device is used in the SIL mode. This can be done, for example, using one of the methods described for the proof test.

Confirmation of parameter configuration using the wizard

Recommended for initial commissioning.

By limiting the possibilities during parameter configuration, this method offers added safety against incorrect settings.

1. Reset the device according to the Operating Instructions. This resets all parameters to defined values (factory settings or customized settings).

2. Check the position of DIP switch 1 on the electronic insert, set to "OFF" if necessary.
3. Carry out the configuration as described in the Operating Instructions. Observe the restrictions (see below). The **Simulation** parameter must be set to the **Off** option.
4. Guidance → Safety operating mode
5. Under the SIL preparation enter screen, enter the SIL locking code "7452".

Status locking: option temporarily locked

A temporary lock is only implemented if all of the following restrictions regarding configuration options are implemented:
- The customer-specific option is NOT selected for the "Current range output" parameter
- The Activate option is selected for the "Loop current mode" parameter
- The Off option is selected for the "Simulation" parameter
- The Point level detection option is selected for the "Assign PV" parameter

6. Go through the Safety mode wizard step by step. Under the SIL locking wizard, enter "7452" again as the SIL locking code.
7. Once all the pages are completed, click the Finish button in order to close the wizard.

Status locking: safety-locked option

Optionally, it is also possible to lock via DIP switch 1 on the electronic insert.

A function test is necessary before the device is used in the SIL mode. This can be done, for example, using one of the methods described for the proof test.

At the end of the activation sequence, the current CRC device configuration is saved and the device is safety-locked. If a device is unlocked and locked again, the current CRC device configuration is compared against the "Saved CRC device configuration" parameter. If there is no difference in the configuration, the device is safety-locked immediately. If there is a difference in the configuration, the safety-related parameter settings must be confirmed again.

If the wizard is cancelled, the device is in the safety-unlocked state again. All the necessary wizard pages must be processed again.

4.5.5 Locking in Expert mode

Offers the expert all the device configuration options.

Recommended for initial commissioning.

1. Reset the device according to the Operating Instructions. This resets all parameters to defined values (factory settings or customized settings).
2. Check the position of DIP switch 1 on the electronic insert, set to "OFF" if necessary.
3. Carry out the configuration as described in the Operating Instructions. Restrictions: The "Simulation" parameter must be set to the "Off" option. The Point level detection option is selected for the "Assign PV" parameter and the Activate option is selected for the "Loop current mode" parameter
4. Lock the device using DIP switch 1 on the electronic insert.
5. Check and document the device settings. Documentation option: print function in FieldCare

A function test is necessary before the device is used in the SIL mode. This can be done, for example, using one of the methods described for the proof test.

4.5.6 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 optionally by a hardware write protection switch (DIP switch 1 on the electronic insert). The device must be unlocked in order to change parameters and to reset self-sustaining diagnostic messages.

1. Check the position of DIP switch 1 on the electronic insert, set to "OFF" if necessary.
2. Click the "Guidance → Safety mode → Disable safety" menu to run the wizard.
3. Under the SIL preparation enter screen, enter "7452" as the Enter safety unlocking code parameter.

Status locking: safety unlocked

⚠ CAUTION

Device is unlocked

The protection function is not guaranteed

► Take suitable measures to guarantee the safety of the facility.

4.6 Parameters and default settings for SIL mode

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!

Application → Sensor setting

- Safety mode
- Density setting
- Switching delay

The following settings are not permitted for the SIL mode:

- "Simulation" parameter
  - Fork state
  - Sensor frequency
  - Current output
  - Diagnostic event simulation
- "Loop current mode" parameter: disable

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 settings of other parameters.

⚠ CAUTION

The current output adopts a fixed value

► Do not operate the device in HART Multidrop during the SIL mode

5 Operation

5.1 Device behavior during power-up

Once switched on, the device runs through a diagnostic phase. For the first 5 s of the diagnostic phase, this current is ≤ 3.6 mA. After that, depending on the setting of the "Failure behavior current output" 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.

5.2 Device behavior in safety function demand mode

MIN operating mode
- Tuning fork covered: OK status is reported, 16 mA [2)]
- Tuning fork uncovered: demand mode is reported, 8 mA [2)]

MAX operating mode
- Tuning fork covered: demand mode is reported, 8 mA [2)]
- Tuning fork uncovered: OK status is reported, 16 mA [2)]

5.3 Behavior of device in the event of an alarm and warnings

MIN and MAX operating mode
- Fault: alarm is reported, < 3.6 mA
- Short-circuit: alarm is reported, >21.0 mA

For alarm monitoring, the downstream logic unit must be able to detect both HI alarms (≥ 21.0 mA) and LO alarms (≤ 3.6 mA).

5.4 Alarm and warning messages

The behavior of the device in the event of an alarm and warnings is described in the relevant Operating Instructions.

Correlation between the error code and the current that is output:

Error code "Fxxx"
- Current output: ≥ 21.0 mA or ≤ 3.6 mA
- Comment: xxx - three-digit number

Error code "Mxxx" / "Cxxx" / "SXXX"
- Current output: as per measured value
- Comment:
  - xxx - three-digit number
  - Overview of output signals depending on the diagnostic state (warning and alarm).

2) For the following safety function, it suffices to program the current threshold between the OK status and demand mode at 12 mA.

6 Proof testing

The safety-related functionality of the device in the SIL mode must be verified during commissioning, when changes are made to safety-related parameters, and also at appropriate time intervals. This enables this functionality to be verified within the entire safety instrumented system. The time intervals must be specified by the operator.

CAUTION

The safety function is not guaranteed during a proof test

Suitable measures must be taken to guarantee process safety during the test.

- The safety-related output signal 4 to 20 mA must not be used for the safety instrumented system during testing.
- A completed test must be documented; the reports provided in the Appendix can be used for this purpose (see Section 8.2).
- The operator specifies the test interval and this must be taken into account when determining the probability of failure PFD_{avg} of the sensor system.

If no operator-specific proof testing requirements have been defined, the following is a possible alternative for testing the transmitter depending on the measured variable used for the safety function. The individual proof test coverages (PTC) that can be used for calculation are specified for the test sequences described below.

Overview of the proof tests:

- Test sequence A
  Simulation of the alarm currents and by approaching the level or by removing and immersing in a medium of similar density and viscosity
- Test sequence B
  Simulation using proof test button on the device
- Test sequence C
  Simulation of the alarm currents or simulation of the demand mode by tooling (app/display etc.)

Test sequence A and B can be performed both with and without tooling (app/display etc.). Test sequence C only with tooling.

Note the following for the test sequences:

- The individual proof test coverages (PTC) that can be used for calculation are specified in the Declaration of Conformity.
- Test sequences B and C are not permitted for a commissioning test.
- The accuracy of a device used must meet the transmitter specifications.
- A demand mode or a fault takes absolute precedence over the proof test and in the measuring system safety path. The demand mode must first be ended or the fault rectified before the proof test can commence.
- The proof test can only be performed if the device status is OK.
- The status of the individual output signal is indicated by a device or a downstream component of the safety path (e.g. PLC, actuator). It suffices to evaluate the response of downstream parts of the safety function. If the different states are correctly identified there, the device has passed the test steps.
- For troubleshooting, refer to the Operating Instructions.

6.1 Test sequence A

Simulation of the alarm currents and by approaching the level or by removing and immersing in a medium of similar density and viscosity

Proof testing procedure with tooling (app/display...)

1. Select Guidance → Proof test
2. Confirm the warning message

3. Perform a visual inspection and confirm
4. Confirm the device information
5. Confirm selection of test sequence A and device settings (MAX/MIN, density etc.)
6. Confirm settings for high alarm current, simulate high alarm current, confirm triggering of subsequent safety instrumented system, confirm read-back current
   ↳ These currents must be determined by the response of the SIS or by measuring at the terminal.
7. Simulate the low alarm current and confirm the triggering of the subsequent safety instrumented system
   ↳ These currents must be determined by the response of the SIS or by measuring at the terminal.
8. Confirm the OK status at the tuning fork and the read-back current 16 mA
   ↳ These currents can be determined by the read-back value in the tooling system (app/display, etc.).
9. Change the status of the tuning fork so that the demand mode is active and confirm the read-back current 8 mA
   ↳ These currents can be determined by the read-back value in the tooling system (app/display, etc.).
10. Change the status of the tuning fork so that an OK status is active and confirm the read-back current 16 mA
    ↳ These currents can be determined by the read-back value in the tooling system (app/display, etc.).
11. On the "Assessment of reviewer" page, enter "Passed" or "Failed". If "Passed" is entered, the date of the last proof test is updated.

The device has passed the proof test once all the steps have been performed successfully.

Proof test procedure without tooling (manual)

1. Perform the visual inspection
2. Ensure an OK status at the tuning fork and check current 16 mA
   ↳ These currents must be determined by the response of the SIS or by measuring at the terminal.
3. Change the status of the tuning fork so that the demand mode is active and check current 8 mA
   ↳ These currents must be determined by the response of the SIS or by measuring at the terminal.
4. Change the status of the tuning fork so that an OK status is active and check current 16 mA
   ↳ These currents must be determined by the response of the SIS or by measuring at the terminal.

The device has passed the proof test once all the steps have been performed successfully.

6.2 Test sequence B

- No change of level in the tank is necessary for this proof test.
- Test sequence B is not permitted for a commissioning test!

Proof testing procedure with tooling (app/display...)

1. Select Guidance → **Proof test** wizard
2. Confirm the warning message
3. Perform a visual inspection and confirm

4. Confirm the device information
5. Confirm selection of test sequence B and device settings (MAX/MIN, density etc.)
6. Confirm the OK status at the tuning fork and current 16 mA
   ↳ These currents must be determined by the response of the SIS or by measuring at the terminal.
7. Press the key at the device (> 3 s): confirm demand mode and current 8 mA
   ↳ These currents must be determined by the response of the SIS or by measuring at the terminal.
8. Release the key: confirm the OK status and current 16 mA
   ↳ These currents must be determined by the response of the SIS or by measuring at the terminal.

The simulation of the demand mode takes at least 10 s even when the key is pressed for a shorter time. If the key is pressed for longer > 10 s, the simulation is active until the key is released.

9. On the "Assessment of reviewer" page, enter "Passed" or "Failed". If "Passed" is entered, the date of the last proof test is updated.

The device has passed the proof test once all the steps have been performed successfully.

Proof test procedure without tooling (manual)

1. Perform the visual inspection
2. Ensure an OK status at the tuning fork and check current 16 mA
   ↳ These currents must be determined by the response of the SIS or by measuring at the terminal.
3. Press the key at the device: check demand mode and current 8 mA
   ↳ These currents must be determined by the response of the SIS or by measuring at the terminal.
4. Release the key: check the OK status and current 16 mA
   ↳ These currents must be determined by the response of the SIS or by measuring at the terminal.

The device has passed the proof test once all the steps have been performed successfully.

The simulation of the demand mode takes at least 10 s even when the key is pressed for a shorter time. If the key is pressed for longer > 10 s, the simulation is active until the key is released.

6.3 Test sequence C

- No change of level in the tank is necessary for this proof test.
- Test sequence C is not permitted for a commissioning test!

Proof testing procedure with tooling (app/display...)

1. Select Guidance → Proof test
2. Confirm the warning message
3. Perform a visual inspection and confirm
4. Confirm the device information
5. Confirm selection of test sequence C and device settings (MAX/MIN, density etc.)

6. Confirm settings for high alarm current, simulate high alarm current, confirm triggering of subsequent safety instrumented system, confirm read-back current
   ↳ These currents must be determined by the response of the SIS or by measuring at the terminal.
7. Simulate the low alarm current and confirm the triggering of the subsequent safety instrumented system
   ↳ These currents must be determined by the response of the SIS or by measuring at the terminal.
8. Confirm the OK status at the tuning fork and the read-back current 16 mA
   ↳ These currents can be determined by the read-back value in the tooling system (app/display, etc.).
9. Start simulation of the demand mode: confirm the demand mode and read-back current 8 mA
   ↳ These currents can be determined by the read-back value in the tooling system (app/display, etc.).
10. Demand mode is ended: confirm the OK status and the read-back current 16 mA
    ↳ These currents can be determined by the read-back value in the tooling system (app/display, etc.).
11. On the "Assessment of reviewer" page, enter "Passed" or "Failed". If "Passed" is entered, the date of the last proof test is updated.

The device has passed the proof test once all the steps have been performed successfully.

6.4 Verification criterion

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 dangerous undetected device failures (λ_{DU}).
- This test does not cover the impact of systematic faults on the safety function, which must be assessed separately.
- Systematic faults can be caused, for example, by process material properties, operating conditions, build-up or corrosion.
- As part of the visual inspection, for example, ensure that all of the seals and cable entries provide adequate sealing and that the device is not visibly damaged.

7 Repair and error handling

7.1 Maintenance

Maintenance instructions and instructions regarding recalibration may be found in the Operating Instructions pertaining to the device.

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

7.2 Repair

Repair means restoring functional integrity by replacing defective components.

Only original Endress+Hauser spare parts may be used for this purpose.

Document the repair with the following information:
- Serial number of the device
- Date of the repair
- Type of repair
- Person who performed the repair

Components may be repaired/replaced by the customer's specialist staff if **original Endress+Hauser spare parts** (which can be ordered by the end customer) are used, and if the relevant installation instructions are followed.

A proof test must always be performed after every repair.

- Process seals
  Device inspection following repair: proof test, test sequence A, B or C
- Display
  Device inspection following repair: visual inspection confirming whether all the parts are present and mounted correctly and whether the status of the device is OK
- Electronic insert
  Device inspection following repair: proof test, test sequence A, B or C
- Housing cover
  Device inspection following repair: visual inspection confirming whether all the parts are present and mounted correctly and whether the status of the device is OK
- Cable gland
  Device inspection following repair: proof test, test sequence A, B or C
- Seal kits for housing covers
  Device inspection following repair: visual inspection confirming whether all the parts are present and mounted correctly and whether the status of the device is OK
- Housing securing clamp
  Device inspection following repair: visual inspection confirming whether all the parts are present and mounted correctly and whether the status of the device is OK
- Housing
  Device inspection following repair: proof test, test sequence A, B or C

Installation Instructions are supplied with the original spare part and can also be accessed in the Download Area at www.endress.com

Send in replaced components to Endress+Hauser for fault analysis.

When returning the defective component, always enclose the "Declaration of Hazardous Material and Decontamination" with the note "Used as SIL device in a safety instrumented system.

Information on returns: http://www.endress.com/support/return-material

7.3 Modification

Modifications are changes to SIL devices that are already delivered or installed:
- **Modifications to SIL devices by the user are not permitted as they can impair the functional safety of the device**
- Modifications to SIL devices may be performed onsite at the user's plant following approval by the Endress+Hauser manufacturing center
- Modifications to SIL devices must be performed by staff who have been authorized to perform this work by Endress+Hauser
- Only **original spare parts** from Endress+Hauser must be used for modifications
- All modifications must be documented in the W@M Device Viewer (www.endress.com/deviceviewer)
- All modifications require a modification nameplate or the replacement of the original nameplate.

7.4 Decommissioning

When decommissioning, the requirements according to IEC 61508-1:2010 section 7.17 must be observed.

7.5 Disposal

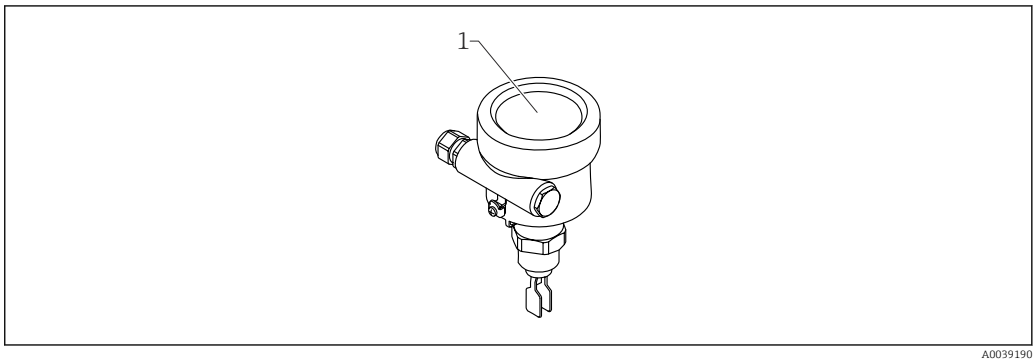
If required by the Directive 2012/19/EU on waste electrical and electronic equipment (WEEE), the product is marked with the depicted symbol in order to minimize the disposal of WEEE as unsorted municipal waste. Do not dispose of products bearing this marking as unsorted municipal waste. Instead, return them to the manufacturer for disposal under the applicable conditions.

8 Appendix

8.1 Structure of the measuring system

8.1.1 System components

The measuring system's devices are shown in the following diagram (example).



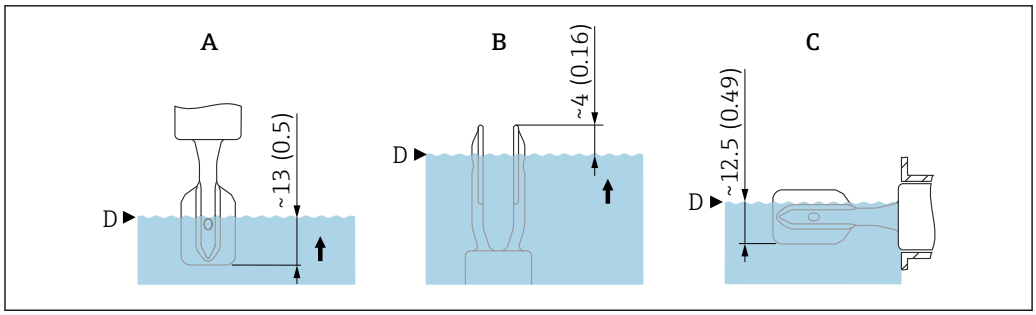
5 System components

1 Device/sensor

8.1.2 Description of use as a protective system

The sensor's tuning fork vibrates at its intrinsic frequency. The vibration frequency decreases as the density increases. This change in the frequency causes the current signal to change.

The switch point is in the range of the tuning fork and depends on the installation position.



6 *Switch point depending on the installation position. Unit of measurement mm (in)*

A Installation from above
B Installation from below
C Installation from the side

- For information on the switch point under reference operating conditions, see the Technical Information.
- Correct installation is a prerequisite for safe operation of the device.

8.1.3 Installation conditions

The installation conditions for various measurements are described in the Technical Information for the device.

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

8.1.4 Measurement function

Choice of operating modes:
- MIN detection
  The measuring system is used to prevent the level becoming too low (e.g. dry running protection for pumps, empty running protection or protection against underfills). In normal operation, the tuning fork is covered by liquids and the measuring system reports the OK status. When the tuning fork is uncovered, the device adopts the safe state and reports the demand mode.
- MAX detection
  The measuring system is used to prevent the level becoming too high (e.g. overfill protection). In normal operation, the tuning fork is not covered by liquids and the measuring system reports the OK status. When the tuning fork is covered, the device adopts the safe state and reports the demand mode.

8.2 Commissioning or proof test report

The following device-specific test report acts as a print/master template and can be replaced or supplemented any time by the customer's own SIL reporting and testing system.

8.2.1 Test Report - Page 1 -

Device information
Facility
Device tag
Device name/Order code
Serial number
Firmware version
Hardware revision

Test information
Company/contact person
Performed by
Date/time
Inspector

Verification result	
Overall result	
☐ Passed ☑	☐ Failed ☒

Comment

Date Signature Signature of tester

8.2.2 Test Report - Page 2 -

Device information
Facility
Device tag/TAG No.
Serial number

Information on verification
Date/time

Safety function - Limit value monitoring	
☐ MIN	☐ MAX

Density range setting	
☐ > 0.7	☐ > 0.5

Proof test
☐ Test sequence A, simulation of alarm currents and wet approach
☐ Test sequence B, simulation of output using proof test button
☐ Test sequence C, simulation of alarm currents and output with tooling

Protocol of test sequence A and C			
Test step	**Target output current**	**Actual value**	**Result**
Read out max alarm current	≥ 21.0 mA		☐ Passed ☐ Failed
Max alarm current / safety instrumented system is triggered	≥ 21.0 mA/alarm		☐ Passed ☐ Failed
Min alarm current / safety instrumented system is triggered	≤ 3.6 mA/alarm		☐ Passed ☐ Failed ☐ Not applicable
Output current	15.2 to 16.8 mA		☐ Passed ☐ Failed ☐ Not applicable
Output current	7.6 to 8.4 mA		☐ Passed ☐ Failed
Output current	15.2 to 16.8 mA		☐ Passed ☐ Failed ☐ Not applicable

Device information
Facility
Device tag/TAG No.
Serial number

Information on verification
Date/time

Report for test sequence B			
Test step	**Target output current**	**Actual value**	**Result**
Output current	15.2 to 16.8 mA		☐ Passed ☐ Failed ☐ Not applicable
Output current	7.6 to 8.4 mA		☐ Passed ☐ Failed
Output current	15.2 to 16.8 mA		☐ Passed ☐ Failed ☐ Not applicable

8.2.3 Parameter settings for the SIL mode

Device information
Facility
Device tag/TAG No.
Serial number

Information on verification
Date/time

Parameter name	Factory setting	Set value	Checked
Enter access code	0		☐ Passed ☐ Failed
Failure current	22.5 mA		☐ Passed ☐ Failed
Failure mode	Low alarm		☐ Passed ☐ Failed ☐ Not applicable
Operating mode	Point level detection		☐ Passed ☐ Failed ☐ Not applicable
Safety mode	MAX		☐ Passed ☐ Failed ☐ Not applicable
Density setting	> 0.7 g/cm³		☐ Passed ☐ Failed ☐ Not applicable
Switching time from uncovered to covered	0.5 s		☐ Passed ☐ Failed ☐ Not applicable
Switching time from covered to uncovered	1 s		☐ Passed ☐ Failed ☐ Not applicable
Corrosion warning	On		☐ Passed ☐ Failed ☐ Not applicable

8.3 Version history

FY01070F; Version 02.22
- Firmware version: from 01.00.zz (zz: any double number)
- Hardware version: from 01.00.ww (ww: any double number)
- Changes:
  - Declaration of Conformity updated
  - Adjustments to text
  - Adjustments to graphics

FY01070F ; Version 01.21
- Firmware version: from 01.00.zz (zz: any double number)
- Hardware version: from 01.00.ww (ww: any double number)
- Changes:
  First version

www.addresses.endress.com

Endress+Hauser

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