

Functional Safety Manual

Liquiphant FTL63

with electronic insert FEL64,

FEL64DC

Vibronic





A0023555

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1 Declaration of Conformity

1.1 FEL64 wiring, 1001

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People for Process Automation

Declaration of Conformity

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

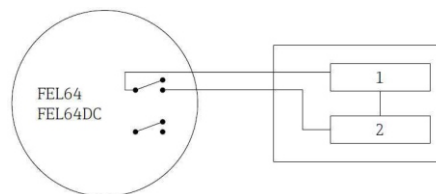
Endress+Hauser SE+Co. KG, Hauptstraße 1, 79689 Maulburg

being the manufacturer, declares that the product

Liquiphant FTL51B / FTL62 / FTL63 / FTL64 (FEL64)

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 valid for wiring variant 1001, with one of the NO contacts in use.



1: Power supply , 2: Additional safety equipment

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

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1.1.1 Safety-related characteristic values, FEL64, 1001

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General			
Device designation and permissible types ¹⁾	Liquiphant FTL51B / FTL62 / FTL63 / FTL64 ** A4 * * * * * ** * * * * + [LA] (FEL64)		
	/		
Safety-related output signal	Relay		
Fault signal	Relay de-energized		
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	01.01.zz (zz: any double number)		
Safety manual	FTL51B: FY01002F / FTL62: FY01017F / FTL63: FY01094F / FTL64: FY01022F		
Type of evaluation (check only <u>one</u> 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/FSP 1388		
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
$\lambda_{DU}^{2),3)}$	53 FIT	38 FIT	/
$\lambda_{DD}^{2),3)}$	140 FIT	106 FIT	/
$\lambda_S^{2),3)}$	315 FIT	367 FIT	/
SFF	90%	93%	/
$PFD_{avg} (T_1 = 1 \text{ year})^3)$ (single channel architecture)	$2.32 \cdot 10^{-6}$	$1.65 \cdot 10^{-6}$	/
PFH	$5.3 \cdot 10^{-8} \text{ 1/h}$	$3.76 \cdot 10^{-8} \text{ 1/h}$	/
PTC ⁴⁾ A / B	96% / 50%	97% / 71%	/
Diagnostic test interval ⁵⁾	≤ 60 s, RAM check ≤ 10 min	≤ 60 s, RAM check ≤ 10 min	/
Fault reaction time ⁶⁾	≤ 3 s	≤ 3 s	/
Comments			
Demand rate ≤ 1 per week			
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 system²⁾ FIT = Failure In Time, number of failures per 10⁹ h³⁾ 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 Coverage⁵⁾ All diagnostic functions are performed at least once within the diagnostic test interval⁶⁾ Maximum time between error recognition and error response

1.2 FEL64 wiring, 1oo2

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Declaration of Conformity

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

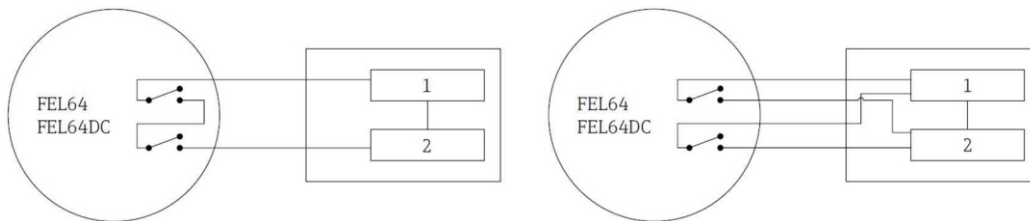
Endress+Hauser SE+Co. KG, Hauptstraße 1, 79689 Maulburg

being the manufacturer, declares that the product

Liquiphant FTL51B / FTL62 / FTL63 / FTL64 (FEL64)

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 valid for wiring variants 1oo2, with both of the NO contacts in use.



1: Power supply , 2: Additional safety equipment

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

Maulburg, February 3, 2023
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A0052137

1.2.1 Safety-related characteristic values, FEL64, 1oo2

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General			
Device designation and permissible types ¹⁾	Liquiphant FTL51B / FTL62 / FTL63 / FTL64 ** A4 * * * * * ** * * * * + [LA] (FEL64)		
	/		
Safety-related output signal	Relay		
Fault signal	Relay de-energized		
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	01.01.zz (zz: any double number)		
Safety manual	FTL51B: FY01002F / FTL62: FY01017F / FTL63: FY01094F / FTL64: FY01022F		
Type of evaluation (check only <u>one</u> 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/FSP 1388		
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
$\lambda_{DU}^{2),3)}$	29 FIT	14 FIT	/
$\lambda_{DD}^{2),3)}$	140 FIT	106 FIT	/
$\lambda_S^{2),3)}$	539 FIT	591 FIT	/
SFF	96%	98%	/
$PFD_{avg} (T_1 = 1 \text{ year})^{3)}$ (single channel architecture)	$1.28 \cdot 10^{-6}$	$6.07 \cdot 10^{-5}$	/
PFH	$2.92 \cdot 10^{-8} \text{ 1/h}$	$1.39 \cdot 10^{-8} \text{ 1/h}$	/
PTC ⁴⁾ A / B	94% / 11%	94% / 22%	/
Diagnostic test interval ⁵⁾	≤ 60 s, RAM check ≤ 10 min	≤ 60 s, RAM check ≤ 10 min	/
Fault reaction time ⁶⁾	≤ 3 s	≤ 3 s	/
Comments			
Demand rate ≤ 1 per week			
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 system²⁾ FIT = Failure In Time, number of failures per 10⁹ h³⁾ 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 Coverage⁵⁾ All diagnostic functions are performed at least once within the diagnostic test interval⁶⁾ Maximum time between error recognition and error response

1.3 FEL64DC wiring, 1oo1

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Declaration of Conformity

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

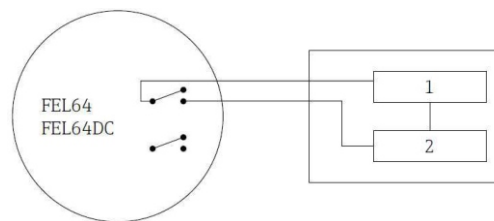
Endress+Hauser SE+Co. KG, Hauptstraße 1, 79689 Maulburg

being the manufacturer, declares that the product

Liquiphant FTL51B / FTL62 / FTL63 / FTL64 (FEL64DC)

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 valid for wiring variant 1oo1, with one of the NO contacts in use.



1: Power supply , 2: Additional safety equipment

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

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1.3.1 Safety-related characteristic values, FEL64DC, 1oo1

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General			
Device designation and permissible types ¹⁾	Liquiphant FTL51B / FTL62 / FTL63 / FTL64 ** A3 * * * * * * * * * * + [LA] (FEL64DC)		
	/		
Safety-related output signal	Relay		
Fault signal	Relay de-energized		
Process variable/function	Level switch for liquids		
Safety function(s)	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	01.01.zz (zz: any double number)		
Safety manual	FTL51B: FY01002F / FTL62: FY01017F / FTL63: FY01094F / FTL64: FY01022F		
Type of evaluation (check only <u>one</u> box)	☒	Complete HW/SW evaluation parallel to development incl. FMEDA and change request acc. to IEC 61508-2, 3	
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	☐	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/FSP 1388		
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
$\lambda_{DU}^{2),3)}$	/	38 FIT	/
$\lambda_{DD}^{2),3)}$	/	106 FIT	/
$\lambda_S^{2),3)}$	/	351 FIT	/
SFF	/	92%	/
PFD _{avg} (T ₁ = 1 year) ³⁾ (single channel architecture)	/	$1.65 \cdot 10^{-4}$	/
PFH	/	$3.76 \cdot 10^{-8}$ 1/h	/
PTC ⁴⁾ A / B	/	97% / 71%	/
Diagnostic test interval ⁵⁾	/	≤ 60 s, RAM check ≤ 10 min	/
Fault reaction time ⁶⁾	/	≤ 3 s	/
Comments			
Demand rate ≤ 1 per week			
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 system²⁾ FIT = Failure In Time, number of failures per 10⁹ h³⁾ 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 Coverage⁵⁾ All diagnostic functions are performed at least once within the diagnostic test interval⁶⁾ Maximum time between error recognition and error response

1.4 FEL64DC wiring, 1oo2

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People for Process Automation

Declaration of Conformity

Functional Safety according to IEC 61508

Based on NE 130 Form B.1

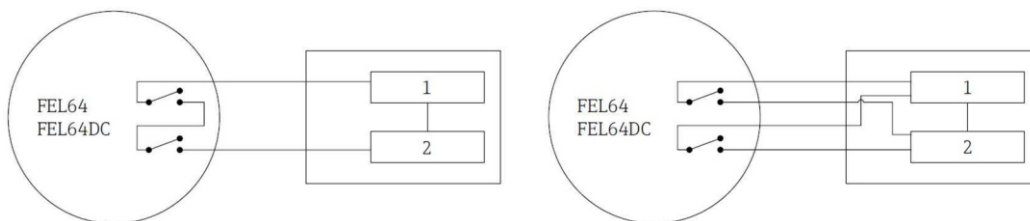
Endress+Hauser SE+Co. KG, Hauptstraße 1, 79689 Maulburg

being the manufacturer, declares that the product

Liquiphant FTL51B / FTL62 / FTL63 / FTL64 (FEL64DC)

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 valid for wiring variants 1oo2, with both of the NO contacts in use.



1: Power supply , 2: Additional safety equipment

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

Maulburg, February 3, 2023

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A0052141

1.4.1 Safety-related characteristic values, FEL64DC, 1oo2

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People for Process Automation

General			
Device designation and permissible types ¹⁾	Liquiphant FTL51B / FTL62 / FTL63 / FTL64 ** A3 * * * * * ** * * * * + [LA] (FEL64DC)		
Safety-related output signal	Relay		
Fault signal	Relay de-energized		
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	01.01.zz (zz: any double number)		
Safety manual	FTL51B: FY01002F / FTL62: FY01017F / FTL63: FY01094F / FTL64: FY01022F		
Type of evaluation (check only <u>one</u> 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/FSP 1388		
Test documents	Development documents	Test reports	Data sheets
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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
$\lambda_{DU}^{2),3)}$	29 FIT	14 FIT	/
$\lambda_{DD}^{2),3)}$	140 FIT	106 FIT	/
$\lambda_S^{2),3)}$	523 FIT	575 FIT	/
SFF	96%	98%	/
$PFD_{avg} (T_1 = 1 \text{ year})^{3)}$ (single channel architecture)	$1.28 \cdot 10^{-6}$	$6.07 \cdot 10^{-5}$	/
PFH	$2.92 \cdot 10^{-8} \text{ 1/h}$	$1.39 \cdot 10^{-8} \text{ 1/h}$	/
PTC ⁴⁾ A / B	94% / 11%	94% / 22%	/
Diagnostic test interval ⁵⁾	≤ 60 s, RAM check ≤ 10 min	≤ 60 s, RAM check ≤ 10 min	/
Fault reaction time ⁶⁾	≤ 3 s	≤ 3 s	/
Comments			
Demand rate ≤ 1 per week			
Declaration			
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For continuous operation at ambient temperature close to +60 °C (+140 °F), a factor of 2.1 should be applied

⁴⁾ PTC = Proof Test Coverage⁵⁾ All diagnostic functions are performed at least once within the diagnostic test interval⁶⁾ Maximum time between error recognition and error response

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



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



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



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



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



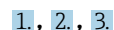
Reference to documentation



Reference to graphic



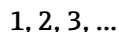
Notice or individual step to be observed



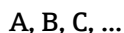
Series of steps



Result of a step



Item numbers



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

- TI01713F
- BA02287F
- KA01642F

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 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.

2.3.4 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.

2.3.5 Safety Instructions (XA)

Depending on the approval, the following Safety Instructions (XA) are supplied with the device. They are an integral part of the Operating Instructions.



The nameplate indicates the Safety Instructions (XA) that are relevant to 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 is applied for device changes.

Valid device versions for safety-related use:

3.1.1 Order codes

FTL63-

Feature: 010 "Approval"

Version: all

Feature: 020 "Output"

Version:

- A3; FEL64DC, low-voltage supply, relay DPDT 9-20VDC contact 253V/6A + test button
- A4; FEL64, relay DPDT 19-253VAC/19-55VDC contact 253V/6A + 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 refinement"

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: LA

Advanced diagnostic measures are only implemented in this version. This version must be selected for use as a safety function as per IEC 61508.

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 (overflow prevention, MAX detection)
- Minimum level monitoring (dry running protection, MIN detection)

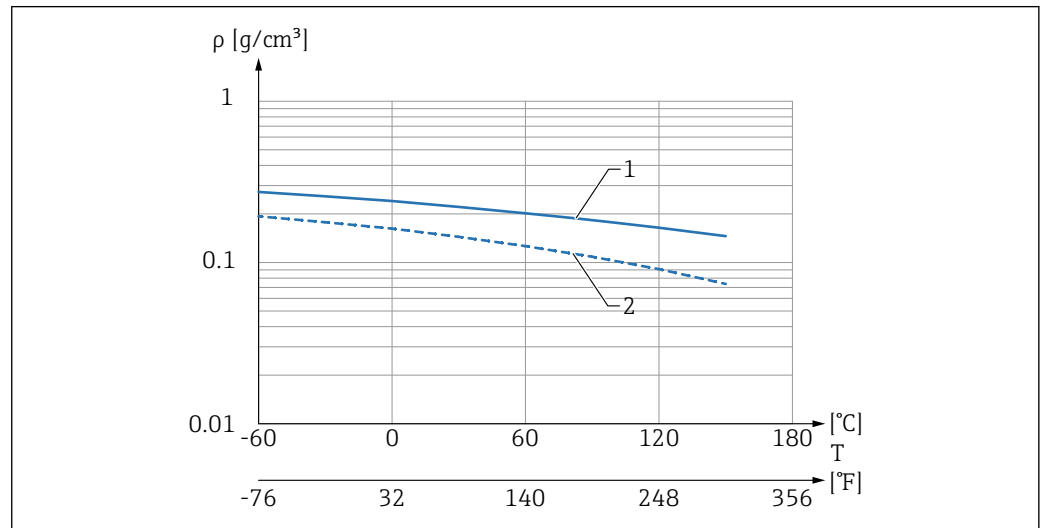
3.4 Basic conditions for use in safety-related applications

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 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, benzene)
- 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



A0052046

1 316L stainless steel, polished

1 Switch position for density 0.7 g/cm³

2 Switch position for density 0.5 g/cm³

CAUTION

Permitted gas density is exceeded!

The "Uncovered" state can no longer be detected reliably. The "Covered" state is reported.

- Comply with the permitted gas density according to the diagram above.

- i** ■ There is no minimum density for the gas phase.
- Operation in a vacuum is permitted.
- There is no maximum density for the liquid.

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

3.4.2 Buildup: only MIN detection

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

- i** Buildup is detected with a low diagnostic coverage.

3.4.3 Solid particles - heterogeneous mixtures (only for MIN detection)

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.

- i** Lodged solid particles are detected with low diagnostic coverage.

3.4.4 Wall distance

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

3.4.5 Corrosion

The device may only be used in media to which the wetted parts used 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.

When using coated sensors, make sure the sensor is not damaged during installation and operation.

3.4.6 Abrasion

It is not permitted to use the device with abrasive media. The removal of material from the sensor as a result of abrasion can result in sensor failure.



Abrasion is detected with low diagnostic coverage.

3.4.7 Flow velocity

In the case of flowing media, the flow velocity in the area around the tuning fork may not exceed 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).

3.4.8 External vibration

In systems exposed to strong external vibrations, e.g., in the 400 to 1 200 Hz range (acceleration spectral density $>1 \text{ (m/s}^2\text{)}^2/\text{Hz}$) 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.

3.4.9 EMC compatibility

The device is certified in accordance with IEC 61326-3-1 and is thus 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.

3.4.10 Mounting with sliding sleeve

NOTICE

Mounting the device with a pipe extension and sliding sleeve

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

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

3.4.11 COM interface

When used as a safety function, only one of the additional modules mentioned below may be connected, as an option, to the COM interface.

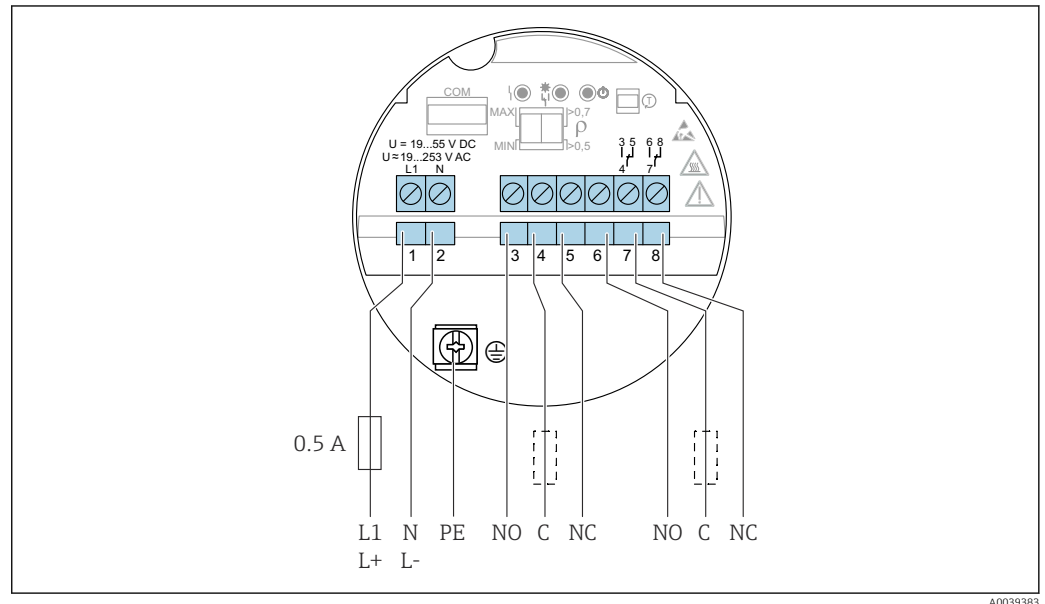
- Bluetooth: BT module VU121
- Optical display: LED module VU120

Both modules may be used for informational purposes only but not as part of the safety function. They do not have a modifying effect on the safety function.

A proof test must be performed after the LED module is installed.

3.4.12 Relay contacts

The electronic inserts FEL64 and FEL64DC have a relay with two change-over contacts.

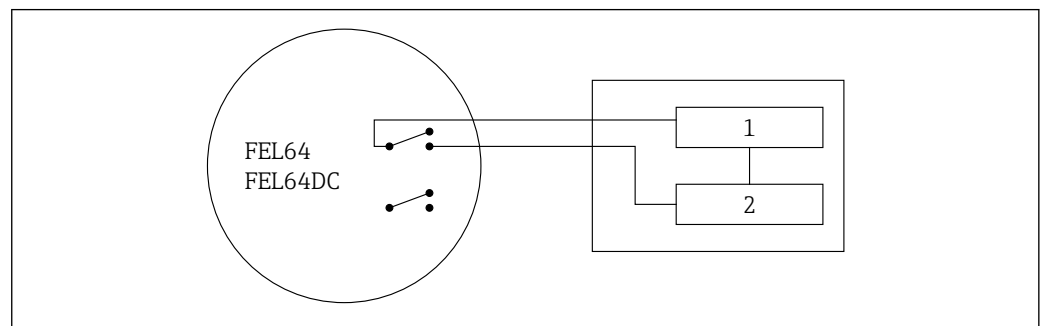


When used as a safety function, the following conditions must be satisfied:

- Only terminals 3 and 4 or 6 and 7 (NO <> C) may be used as a safety contact (quiescent current principle).
- The maximum permitted load current is 4 A. If this load current is exceeded, the electronic insert may no longer be used as a safety function.

Wiring options - change-over contacts

A NO contact is used (1001)



2 Wiring 1001, NO contact

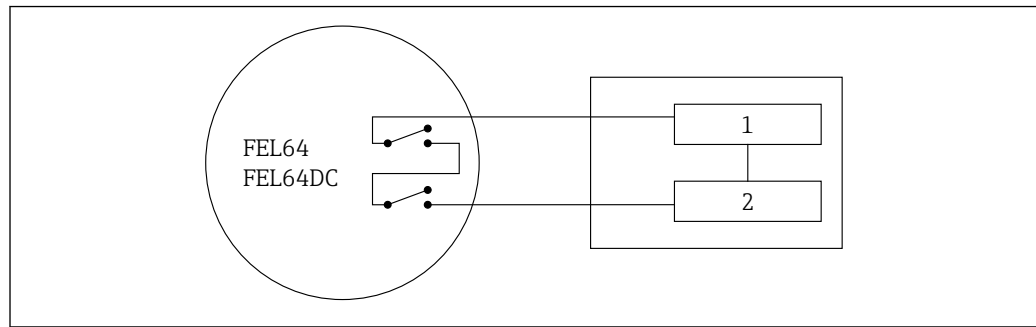
1 Power supply

2 Additional safety equipment

For the FEL64DC electronic insert in MIN mode, λ_{Total} is 493 FIT and λ_{DU} is 53 FIT, resulting in a Safe Failure Fraction (SFF) of 89 %.

The device is not suitable for SIL 2 if a SFF ≥ 90 % is required.

Both NO contacts are used (1002), connected in series



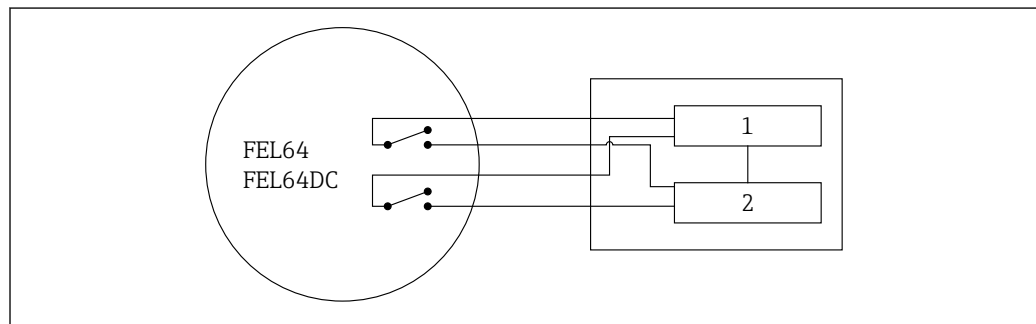
A0039385

3 Wiring 1002, both NO contacts connected in series

- 1 Power supply
- 2 Additional safety equipment

Compared to option 1001, λ_{Total} increases by 200 FIT and λ_{DU} reduces by 24 FIT, resulting in a Safe Failure Fraction (SFF) of 96 % in MIN mode and 98 % in MAX mode.

Alternatively, the wiring can be implemented as two channels and the 1002 assessment can be performed in the additional safety function. This increases the reliability of the wiring (detection of short-circuit in a cable).

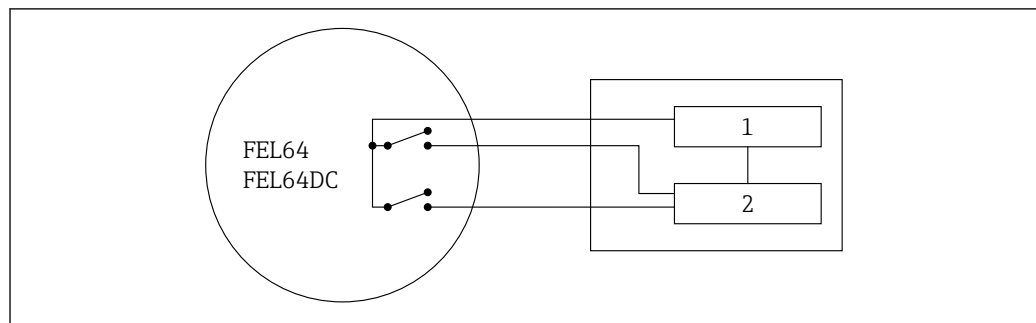


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4 Wiring 1002, both NO contacts, two-channel wiring

- 1 Power supply
- 2 Additional safety equipment

Both NO contacts are used (2002), connected in parallel



A0039387

5 Wiring 2002, both NO contacts connected in parallel

- 1 Power supply
- 2 Additional safety equipment

Compared to option 1001, λ_{Total} increases by 200 FIT and λ_{DU} by 25 FIT, resulting in a Safe Failure Fraction (SFF) of 89 %.

The device is not suitable for SIL 2 if a SFF $\geq 90\%$ is required. This also applies when the wiring is implemented as two channels and the 2oo2 assessment is performed in the additional safety function.

3.5 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 Safe states

The device settings may not be changed if SIL operation is in progress.

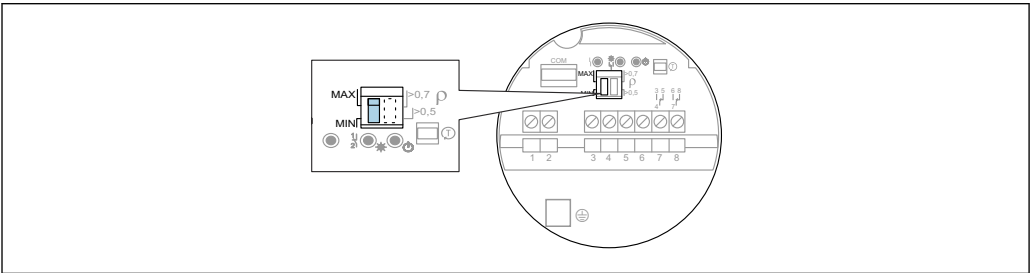
NOTICE

The protective function can be impaired

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

- After changing the settings, perform a proof test to ensure that the safety function is working correctly

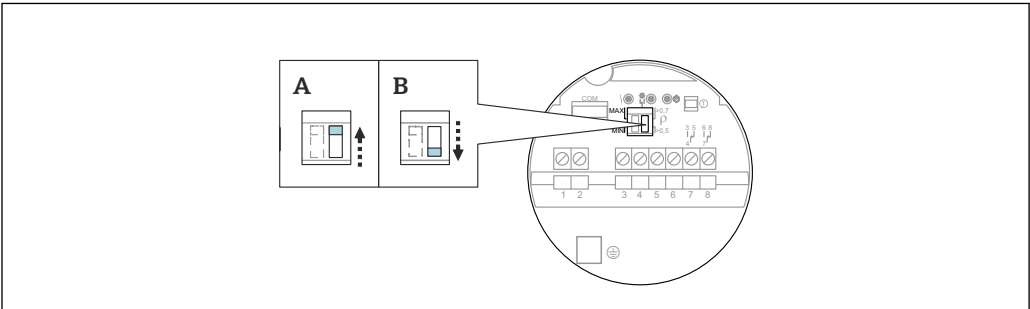
4.5.1 MIN/MAX detection mode



A0039676

6 Selection of MIN/MAX detection mode

4.5.2 Density mode



A0039677

7 Selection of density mode

- A Default setting (density >0.7 g/cm³); always use this setting where possible
- B Special setting (density >0.5 g/cm³); extremely light liquids (e.g., liquefied natural gas, isopentane, petroleum ether)

5 Operation

5.1 Device behavior during power-up

The behavior of the device when switched on is described in the relevant Operating Instructions.

5.2 Device behavior in safety function demand mode

The safety-related output signal consists of the contacts of a relay.

- When the status is OK, the contacts between terminal 3 and 4 and also between 6 and 7 are closed.
- In demand mode, or if a fault is detected in the device, the contacts between terminal 3 and 4 and between 6 and 7 are open.

5.3 Device behavior in the event of an alarm

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

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.

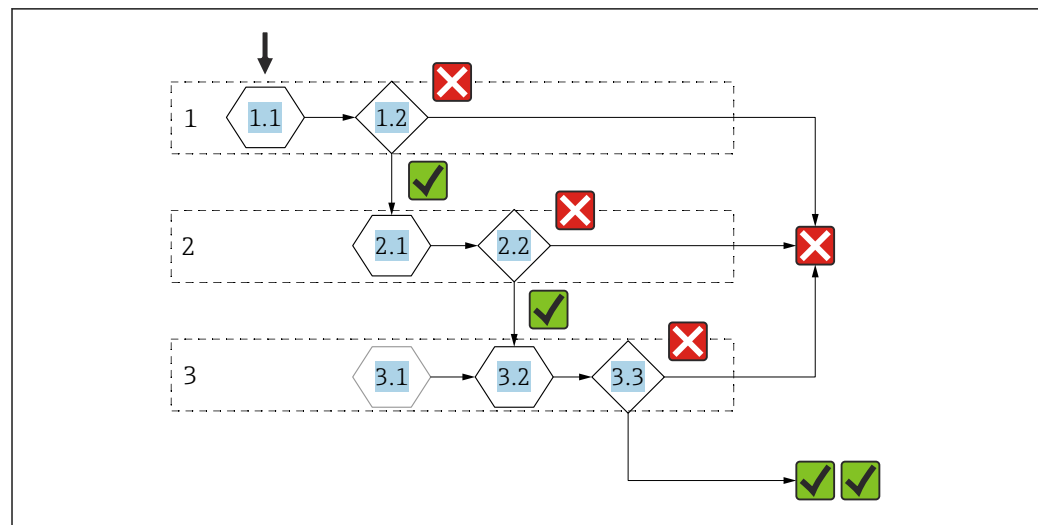
- ▶ The safety-related output signal 4 to 20 mA must not be used for the safety instrumented system during testing.
- ▶ A completed test must be documented; the reports provided in the Appendix can be used for this purpose (see Section 8.2).
- ▶ The operator specifies the test interval and this must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

Proof testing of the device can be performed as follows:

- Test sequence A: Approach the level, or remove and immerse in a medium of similar density and viscosity
 - Test sequence A, MIN detection
 - Test sequence A, MAX detection
- Test sequence B: simulation using test button on Liquiphant

-  Note the following for the test sequences:
- A demand mode or a fault takes absolute precedence over the proof test and in the measuring system safety path. For this reason, the demand mode must first be ended or the fault rectified before the proof test can commence.
 - The proof test can and may only be performed if the device status is OK.
 - The status of the individual output signal is indicated by a measuring device or a downstream component of the safety path (e.g., PLC, actuator).
 - The individual proof test coverages (PTC) that can be used for calculation are specified in the Declaration of Conformity.
 - To monitor the safety-related output signal, it is sufficient to evaluate the response of downstream components of the safety function. If the different states are correctly identified there, the test steps are passed.

6.1 Basic test sequence



A0039241

8 Basic test sequence

- 1.1 Status OK
- 1.2 Output signal for status OK?
- 2.1 Establish demand mode
- 2.2 Output signal for demand mode?
- 3.1 Re-install the sensor that was removed (optional)
- 3.2 Establish status OK
- 3.3 Output signal for status OK?

The output signal can be evaluated based on the response of the following components of the safety function.

6.2 Test sequence A, MIN detection

- Approach the level or
- Remove and immerse in a medium of similar density and viscosity

- The terminals to be checked are dependent on the wiring.
- All the contacts used between terminal 3 and 4 or between terminal 6 and 7 must always be tested.
 - For series connection (1002), a separate check must be carried out in step 2 to verify that the safety contacts between terminal 3 and 4 and also between terminal 5 and 6 are open!

Step 1

1. Raise the level or immerse the tuning fork of the sensor that has been removed into the medium until the tuning fork is fully covered.
 - ↳ If it is not possible to do this with the original medium, a medium of a similar density and viscosity must be used.
2. Check the status of the safety contacts.
 - ↳ The contacts to be checked must be closed.

If the safety contacts are open, there is a fault in the safety path. The proof test has not been passed and must be aborted.

Step 2

1. Lower the level or take the tuning fork of the sensor that has been removed out of the medium until the tuning fork is completely free.
 - ↳ Wait for the switching delay to elapse (1 s, unless ordered otherwise)
2. Check the status of the safety contacts.
 - ↳ The contacts to be checked must be open.

 If the safety contacts are closed, there is a fault in the safety path. The proof test has not been passed and must be aborted.

Step 3

1. Re-install the sensor that was removed (optional).
 - ↳ Wait for power-up (10 s).
2. Restore the status OK by fully covering the tuning fork.
 - ↳ Wait for the switching delay to elapse (1 s, unless ordered otherwise).
3. Check the status of the safety contacts.
 - ↳ The contacts to be checked must be closed.

 If the safety contacts are open, there is a fault in the safety path. The proof test has not been passed and must be aborted.

6.3 Test sequence A, MAX detection

- Approach the level or
- Remove and immerse in a medium of similar density and viscosity

 The terminals to be checked are dependent on the wiring.

- All the contacts used between terminal 3 and 4 or between terminal 6 and 7 must always be tested.
- For series connection (1002), a separate check must be carried out in step 2 to verify that the safety contacts between terminal 3 and 4 and also between terminal 5 and 6 are open!

Step 1

1. Lower the level or take the tuning fork of the sensor that has been removed out of the medium until the tuning fork is completely free.
 - ↳ If it is not possible to do this with the original medium, a medium of a similar density and viscosity must be used.
2. Check the status of the safety contacts.
 - ↳ The contacts to be checked must be closed.

 If the safety contacts are open, there is a fault in the safety path. The proof test has not been passed and must be aborted.

Step 2

1. Raise the level or immerse the tuning fork of the sensor that has been removed into the medium until the tuning fork is fully covered.
 - ↳ Wait for the switching delay to elapse (1 s, unless ordered otherwise)
2. Check the status of the safety contacts.
 - ↳ The contacts to be checked must be open.

 If the safety contacts are closed, there is a fault in the safety path. The proof test has not been passed and must be aborted.

Step 3

1. Re-install the sensor that was removed (optional).
 - ↳ Wait for power-up (10 s).
2. Restore the status OK by fully exposing the tuning fork.
 - ↳ Wait for the switching delay to elapse (1 s, unless ordered otherwise).
3. Check the status of the safety contacts.
 - ↳ The contacts to be checked must be closed.

 If the safety contacts are open, there is a fault in the safety path. The proof test has not been passed and must be aborted.

6.4 Test sequence B, simulation with test button or test magnet on Liquiphant

No change of level in the vessel is necessary for this sequence.

Note the following for the test sequences:

Test sequence B (simulation) is not permitted for a commissioning test.

-  The terminals to be checked are dependent on the wiring.
- All the contacts used between terminal 3 and 4 or between terminal 6 and 7 must always be tested.
 - For series connection (1002), a separate check must be carried out in step 2 to verify that the safety contacts between terminal 3 and 4 and also between terminal 5 and 6 are open!

Step 1

- ▶ Check the status of the safety contacts.
 - ↳ The contacts to be checked must be closed.

 If the safety contacts are open, there is a fault in the safety path. The proof test has not been passed and must be aborted.

Step 2

1. Press the test button or apply the test magnet.
 - ↳ The device restarts (3 s).
If the button is pressed (or magnet applied) for a short period, the demand mode is maintained for 7 s afterwards.
If the button is pressed (or magnet applied) for a longer period, the demand mode is maintained as long as the button remains pressed or the test magnet is applied.
2. Check the status of the safety contacts.
 - ↳ The contacts to be checked must be open.

 If the safety contacts are closed, there is a fault in the safety path. The proof test has not been passed and must be aborted.

Step 3

1. Release the test button or remove the test magnet.
 - ↳ Wait for the switching delay to elapse (1 s, unless ordered otherwise).
2. Check the status of the safety contacts.
 - ↳ The contacts to be checked must be closed.

 If the safety contacts are open, there is a fault in the safety path. The proof test has not been passed and must be aborted.

6.5 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.

Components may be repaired/replaced by the customer's technical staff if **genuine spare parts** from Endress+Hauser are used (they can be ordered by the end user) and the appropriate installation instructions are followed.

 A proof test must always be performed after every repair.

Spare parts are grouped into logical kits with the associated replacement instructions.

Document the repair with the following information:

- Serial number of the device
- Date of the repair
- Type of repair
- Person who performed the repair

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

Return the replaced component 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."

For information on device returns, please see:

<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 are usually performed in the Endress+Hauser manufacturing center.
- Modifications to SIL 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 devices by the user are not permitted.**

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 Endress+Hauser for disposal under the applicable conditions.

7.6 Battery disposal

- In some countries, the end user is legally obliged to return used batteries.
- The end user can return old batteries or electronic assemblies containing these batteries free of charge to Endress+Hauser.



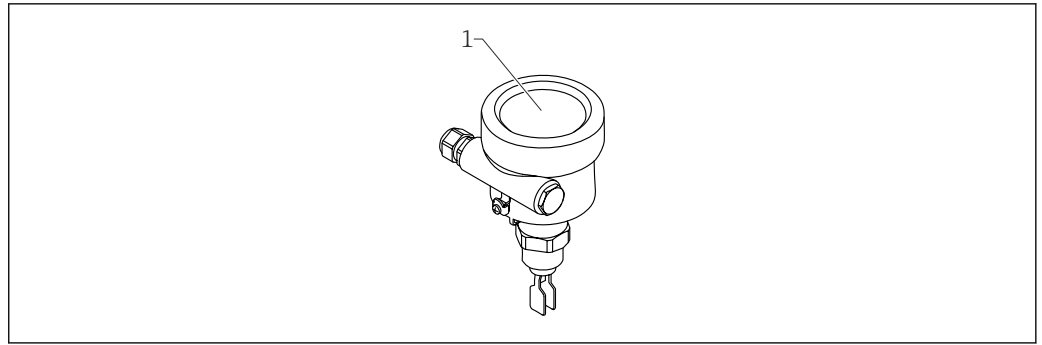
In accordance with German law regulating the use of batteries (BattG §17 Para Number 3), this symbol is used to denote electronic assemblies that must not be disposed of as municipal waste.

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).



A0039190

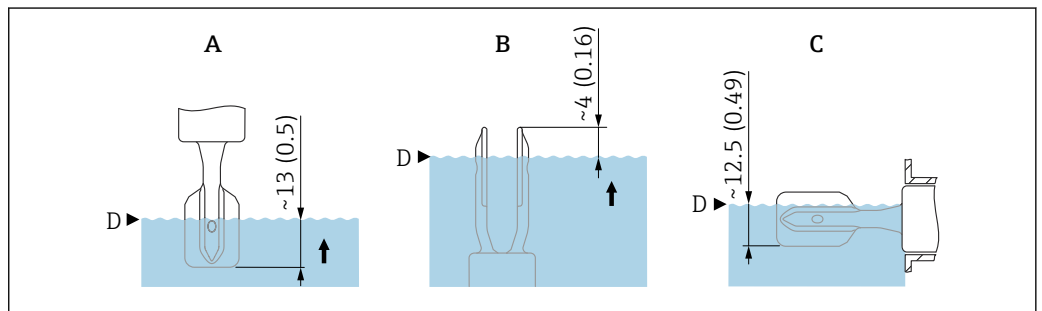
9 System components

1 Measuring device/sensor

8.1.2 Description of use as a safety instrumented 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.



A0037915

10 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 Measurement function

Choice of operating modes:

- MIN detection

The measuring system is used to protect against a level that is too low (e.g. pump dry running protection, protection against emptying or protection against insufficient filling).

In normal operation, the tuning fork is covered by liquid and the measuring system reports the "GOOD" state. If the tuning fork is free, the device assumes the safe state and signals the demand mode.

- MAX detection

The measuring system is used to protect against a level that is too high (e.g. overflow prevention).

In normal operation, the tuning fork is not covered by liquid and the measuring system reports the "GOOD" state. If the tuning fork is covered, the device assumes the safe state and signals 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 SmartBlue app or the customer's own SIL reporting and testing system.

8.2.1 Test Report - Page 1 -

Device information
System
Measuring points/TAG No.
Device type/Order code
Serial number

Verification information
Date / time
Performed by

Verification result
Overall result
☐ Passed ☐ Failed

Notes

Company / contact person
Tester

Date

Signature

Signature of tester

8.2.2 Test Report - Page 2 -

Device information
System
Measuring points/TAG No.
Serial number

Verification information
Date/time

Safety function - Set point monitoring	
☐ MIN	☐ MAX

Density range setting	
☐ >0.7	☐ >0.5

Commissioning test - Test sequence A	
☐ MIN detection	☐ MAX detection

Proof testing
☐ Test sequence A, MIN detection
☐ Test sequence A, MAX detection
☐ Test sequence B, simulation using test button

Terminal 1 and 2, check continuity				
Test stage	Target	Actual value	Result	
			☒	☐
Step 1				
Step 2				
Step 3				

8.3 Version history

FY01094F

- Version :01.23
- Valid as of firmware version:
01.01.zz
- Valid as of hardware version:
01.00.zz
- Changes:
First version



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