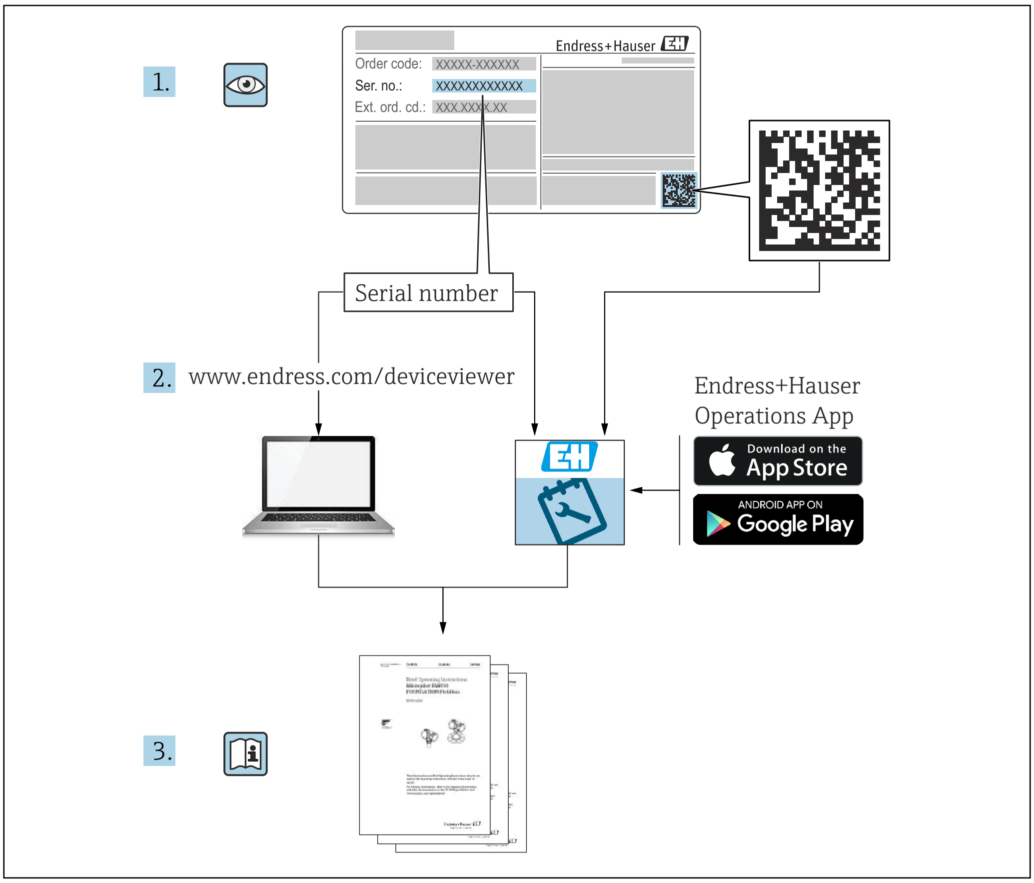
FY01078F/00/EN/02.23-00
71613869
2023-04-24

01.00.zz (Device firmware)

Functional Safety Manual
Liquiphant FailSafe FTL81 with Nivotester FailSafe FTL825

Vibronic

Endress+Hauser
People for Process Automation


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

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1 Declaration of Conformity

1.1 Liquiphant FailSafe with Nivotester FailSafe

SIL_00494_01.22

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 FailSafe FTL8x (FTL825)

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, May 2, 2022
Endress+Hauser SE+Co. KG

i. V.

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Research & Development

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1.1.1 Safety-related characteristic values

SIL_00494_01.22

Endress+Hauser
People for Process Automation

General

Device designation and permissible types 1)	Liquiphant FailSafe FTL8x ** S * * * A,B,C,D,N,P,T * A,N,P,Q,R,T ** *** (FTL825)		
	x = 0, 1, 5		
Safety-related output signal	Relay		
Fault signal	Safety contacts open, signaling contact closed		
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 or Continuous Mode	
Valid hardware version	as of 01.00.ww (ww: any double number)		
Valid software version	01.00.zz (zz: any double number)		
Safety manual	FY01077F / FY01078F / FY01079F		
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/EL 676		
Test documents	Development documents	Test reports	Data sheets

SIL – Integrity

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

FMEDA

Safety function	MIN	MAX	RANGE
λ_{DU} 2),3)	5 FIT	5 FIT	/
λ_{DD} 2),3)	120 FIT	120 FIT	/
λ_{SU} 2),3)	105 FIT	105 FIT	/
λ_{SD} 2),3)	1280 FIT	1280 FIT	/
SFF	99,7%	99,7%	/
PFD_{avg} (T_1 = 1 year) 3) (single channel architecture)	$2.08 \cdot 10^{-5}$	$2.08 \cdot 10^{-5}$	/
PFH	$4.74 \cdot 10^{-9}$ 1/h	$4.74 \cdot 10^{-9}$ 1/h	/
PTC 4) A / B	90% / 34%	90% / 34%	/
λ_{total} 2),3)	1510 FIT	1510 FIT	/
Diagnostic test interval 5)	≤ 60 s / ≤ 30 min	≤ 60 s / ≤ 30 min	/
Fault reaction time 6)	≤ 2.5s	≤ 2.5s	/

Comments

Max. 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 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

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1.2 Liquiphant FailSafe

SIL_00495_01.22

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 FailSafe FTL8x

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, May 2, 2022
Endress+Hauser SE+Co. KG

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Manfred Hammer
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Research & Development

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1.2.1 Safety-related characteristic values

SIL_00495_01.22

Endress+Hauser

People for Process Automation

General			
Device designation and permissible types 1)	Liquiphant FailSafe FTL8x ** S * * * A,B,C,D,N,P,T * A,N,P,Q,R,T ** ***		
	x = 0, 1, 5		
Safety-related output signal	4... 20 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 or Continuous Mode	
Valid hardware version	as of 01.00.ww (ww: any double number)		
Valid software version	01.00.zz (zz: any double number)		
Safety manual	FY01077F / FY01078F / FY01079F		
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/EL 676		
Test documents	Development documents	Test reports	Data sheets
SIL – Integrity			
Systematic safety integrity		☐ SIL 2 capable	☒ SIL 3 capable
Hardware safety integrity	Single channel use (HFT = 0)	☐ SIL 2 capable	☒ SIL 3 capable
	Multi channel use (HFT ≥ 1)	☐ SIL 2 capable	☒ SIL 3 capable
FMEDA			
Safety function	MIN	MAX	RANGE
λ_{DU} 2),3)	3 FIT	3 FIT	/
λ_{DD} 2),3)	63 FIT	63 FIT	/
λ_{SU} 2),3)	19 FIT	19 FIT	/
λ_{SD} 2),3)	782 FIT	782 FIT	/
SFF	99.6%	99.6%	/
PFD_{avg} (T_1 = 1 year) 3) (single channel architecture)	$1.39 \cdot 10^{-5}$	$1.39 \cdot 10^{-5}$	/
PFH	$3.17 \cdot 10^{-9}$ 1/h	$3.17 \cdot 10^{-9}$ 1/h	/
PTC 4) A | B	90% | 4%	90% | 4%	/
λ_{total} 2,3)	867 FIT	867 FIT	/
Diagnostic test interval 5)	≤ 60 s / ≤ 30 min	≤ 60 s / ≤ 30 min	/
Fault reaction time 6)	≤ 2.5s	≤ 2.5s	/
Comments			
ISO 13849-1: demande 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)
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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

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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

Liquiphant
- TI01026F
- BA01037F
- KA00152F
- KA00153F
- KA00154F

Nivotester
- TI01027F
- BA01038F

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

Liquiphant

Feature: 010 "Approval"
Version: all

Feature: 020 "Electronics; output"
Version:
S: FEL85; 2-wire 4-20 mA

Feature: 030 "Display; operation"
Version: all

Feature: 040 "Housing"
Version: all

Feature: 050 "Electrical connection"
Version: all

Feature: 060 "Application"
Version:
- A: Process max. 150 °C (302 °F), 64 bar (928 psi)
- B: Process max. 150 °C (302 °F), 100 bar (1 450 psi)
- C: Process max. 230 °C (446 °F), 100 bar (1 450 psi) incl. gas-tight feedthrough (second line of defense)
- D: Process max. 280 °C (536 °F), 100 bar (1 450 psi) incl. gas-tight feedthrough (second line of defense)

Feature: 070 "Sensor material"
Version: all

Feature: 080 "Surface finish"
Version:
A: Standard Ra < 3.2 µm (126 µin)

Feature: 090 "Sensor type"
Version: all

Feature: 100 "Process connection"
Version: all

Feature: from 500 "Optional specifications"
Version: all

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

Nivotester FailSafe

Feature: 010 "Approval"
Version: all

Feature: 020 "Housing"
Version: all

Feature: 030 "Power supply"
Version: all

Feature: 040 "Switch output"
Version: all

Feature: from 500 "Optional specifications"
Version: all

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

- Version I (Liquiphant FailSafe with Nivotester FailSafe)
  The safety-related output signal consists of two safety contacts:
  "Safety contact 1: terminal no. 13 and 14",
  "Safety contact 2: terminal no. 23 and 24".
  They are closed in the OK state and open in the demand mode or if a fault is detected. Depending on the parameter configuration (locking/automatic restart) of the Nivotester, the safety contacts either close automatically when the OK state is reached again or only when the demand mode/fault is acknowledged by the operator.
- Version II (Liquiphant)
  The safety-related signal is the analog output signal 4 to 20 mA

NOTICE

In an alarm condition
- ▶ Ensure that the equipment under control achieves or maintains a safe state.

3.3.2 Limit value monitoring

MIN operating mode
- Tuning fork is covered: OK state is reported including the LIVE signal [1], 18.5 mA [2]
- Tuning fork uncovered: demand mode is reported, 9 mA [1]
- Fault: alarm is reported, < 3.6 mA
- Short-circuit: alarm is reported, > 21 mA

1) LIVE signal: A square wave signal of 0.25 Hz and ±0.5 mA amplitude is modulated on the current in the OK state.
2) For SIL1 or SIL2 applications, it suffices to program the current threshold to 12 mA. (<12 mA: demand mode; >12 mA: OK state.

MAX operating mode
- Tuning fork covered: demand mode is reported, 6 mA [2)]
- Tuning fork uncovered: OK state is reported incl. LIVE signal [1)], 13.5 mA [2)]
- 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).

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 based on an analysis in accordance with:
IEC 61508-6: 2010, Appendix 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.

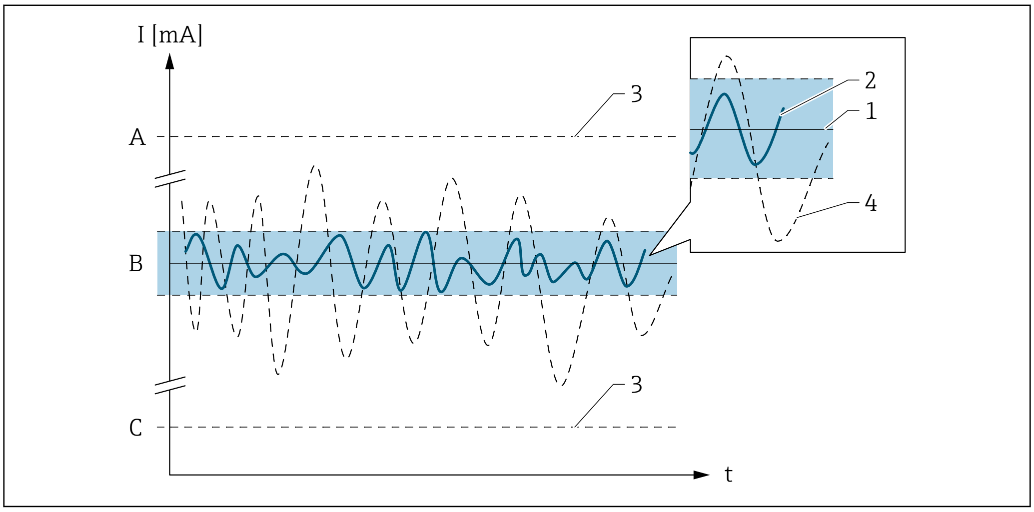
The device meets the requirements for SIL 3 in homogeneously redundant applications. The following common cause factors β and βD can be used for the design.

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

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 Safety measured error

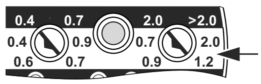
The device is tested according to IEC 61326-3-2 and is therefore suitable for general industrial safety-related applications. If the specified electromagnetic ambient conditions are exceeded, the switch status might not be reliably detected. An unshielded cable with up to 1 000 m (3 281 ft) can be used between the devices in these environmental conditions. Electromagnetic interference immunity can be further improved by using shielded cables.

3.4.3 Restrictions for safety-related use

Density

Operation is only permitted with liquids:
- that have a density within the permitted density range
- where the gas phase above the liquid does not exceed the maximum permitted density value.

The possible density ranges depend on the selected operating mode.



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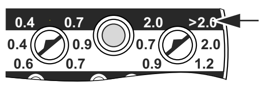
1 *MIN operating mode (white area)*

Density range 1
- Density ρ_{LOW}: 0.4 g/cm³
- Density ρ_{High}: 0.7 g/cm³
- Type of liquid: liquefied gas

Density range 2
- Density ρ_{LOW}: 0.6 g/cm³
- Density ρ_{High}: 0.9 g/cm³
- Type of liquid: e.g. alcohol

Density range 3
- Density ρ_{LOW}: 0.7 g/cm³
- Density ρ_{High}: 1.2 g/cm³
- Type of liquid: e.g. aqueous solutions

Density range 4
- Density ρ_{LOW}: 0.9 g/cm³
- Density ρ_{High}: 2.0 g/cm³
- Type of liquid: e.g. acid



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2 *MAX operating mode (black area)*

Density range 1
- Density ρ_{LOW}: 0.4 g/cm³
- Density ρ_{High}: 2.0 g/cm³
- Type of liquid: liquefied gas

Density range 2
- Density ρ_{LOW}: 0.7 g/cm³
- Density ρ_{High}: >2.0 g/cm³
- Type of liquid: other liquids

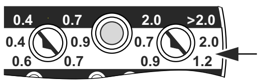
Irrespective of the selected operating mode (MIN/MAX detection), the permitted density range of the gas phase above the liquid depends on the temperature of the process and the selected density range. For the Liquiphant FailSafe to function correctly, a sufficient difference between the densities of the gas phase and the liquid is required.

Process temperature	Gas phase maximum with density range			Feature 060
	1	2, 3	4	Version
−60 °C (−76 °F)	0.14 g/cm³	0.24 g/cm³	0.30 g/cm³	C, D
−30 °C (−22 °F)	0.13 g/cm³	0.22 g/cm³	0.28 g/cm³	All
0 °C (+32 °F)	0.11 g/cm³	0.20 g/cm³	0.26 g/cm³	All
+20 °C (+68 °F)	0.10 g/cm³	0.19 g/cm³	0.25 g/cm³	All
+40 °C (+104 °F)	0.09 g/cm³	0.18 g/cm³	0.24 g/cm³	All
+60 °C (+140 °F)	0.08 g/cm³	0.17 g/cm³	0.22 g/cm³	All
+90 °C (+194 °F)	Not applicable	0.15 g/cm³	0.20 g/cm³	All
+120 °C (+248 °F)	Not applicable	0.13 g/cm³	0.18 g/cm³	All
+150 °C (+302 °F)	Not applicable	0.11 g/cm³	0.16 g/cm³	All
+180 °C (+356 °F)	Not applicable	0.13 g/cm³	0.19 g/cm³	C, D
+230 °C (+446 °F)	Not applicable	0.10 g/cm³	0.16 g/cm³	C, D
+280 °C (+536 °F)	Not applicable	0.07 g/cm³	0.12 g/cm³	D

There is no minimum density for the gas phase. Operation in a vacuum is permitted!

Process temperature

The temperature range in which safety-related operation is permitted depends on the selected density range:



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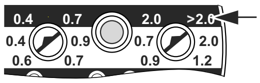
3 *MIN operating mode (white area)*

Density range 1
- Density ρ_{LOW}: 0.4 g/cm³
- Density ρ_{High}: 0.7 g/cm³
- Temperature range: −50 to +60 °C (−58 to +140 °F)

Density range 2
- Density ρ_{LOW}: 0.6 g/cm³
- Density ρ_{High}: 0.9 g/cm³
- Temperature range: as per feature 060

Density range 3
- Density ρ_{LOW}: 0.7 g/cm³
- Density ρ_{High}: 1.2 g/cm³
- Temperature range: as per feature 060

Density range 4
- Density ρ_{LOW}: 0.9 g/cm³
- Density ρ_{High}: 2.0 g/cm³
- Temperature range: as per feature 060



4 *MAX operating mode (black area)*

Density range 1
- Density ρ_{LOW}: 0.4 g/cm³
- Density ρ_{High}: 2.0 g/cm³
- Temperature range: –50 to +60 °C (–58 to +140 °F)

Density range 2
- Density ρ_{LOW}: 0.7 g/cm³
- Density ρ_{High}: >2.0 g/cm³
- Temperature range: as per feature 060

Viscosity

MIN detection

The maximum permissible viscosity of the medium depends on the device version:

- Maximum permissible viscosity: 350 mPa·s
  Feature 060; version A, B
- Maximum permissible viscosity: 100 mPa·s
  Feature 060, version C, D

A higher viscosity can have the effect that the tuning fork no longer vibrates and the measuring system reports a fault.

The fault is detected with high diagnostic coverage.

MAX detection

The viscosity of the medium may not exceed 10 000 mPa·s. The device only reports the transition from "Covered" to "Not covered" when sufficient medium sticking to the fork has drained off. Therefore a very viscous medium can cause the switching time to be exceeded.

Buildup: only MIN detection

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

Buildup is detected with low to medium diagnostic coverage.

Solid particles (heterogeneous mixtures): only 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.

Lodged solid particles are detected with medium 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.

- MIN detection operating mode: corrosion is detected with low diagnostic coverage.
- MAX detection operating mode: corrosion is detected with medium diagnostic coverage.

Abrasion

The device may not be used in or cleaned with media that are abrasive. Material removal can have the effect that the demand mode is not detected.

- MIN detection operating mode: abrasion is detected with low diagnostic coverage.
- MAX detection operating mode: abrasion is detected with low to medium 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.

Mounting with sliding sleeve

Extreme caution must be taken if mounting a device with a pipe extension in conjunction with a sliding sleeve and the user must take measures that prevent, or reliably detect, any tampering with the switch point.

3.5 Dangerous undetected failures in this scenario

An incorrect output signal where a demand mode is reported as an OK state is considered to be 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 Device configuration for safety-related applications

4.5.1 Configuration methods

Version I (Liquiphant FailSafe with Nivotester FailSafe)

The Nivotester FailSafe can be configured in such a way that - following a system start, a demand mode or a fault - it remains in this state even if the OK state is reached (locking). It only returns to the OK state when the user acknowledges the message by short-circuiting terminals 50 (COM) and 51 (restart).

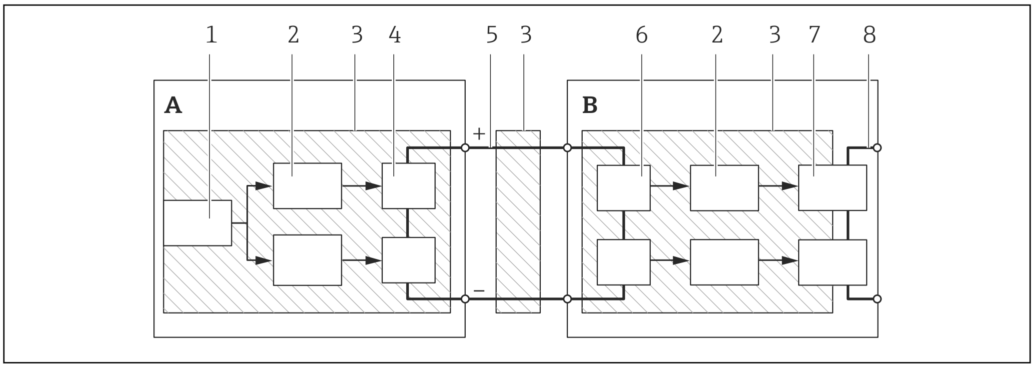
The configuration is performed via the hook switch behind the front flap of the Nivotester FailSafe.

Parameter configuration
- Locked (demand mode or self-holding fault): hook switch "open"
- Automatic restart (in OK state): hook switch "closed"

If neither a demand mode nor an alarm is present and terminals 50 and 51 are jumpered, then the output of the Nivotester FailSafe goes immediately to the OK state. The automatic restart also occurs when the hook switch is open.

This can be used to be able to perform the parameter configuration externally, e.g. via a switch in a control console. However, if this behavior is not desired or if it can result in a dangerous state, it is important to ensure that the two terminals cannot be short-circuited either accidentally or by a fault.

5 Operation



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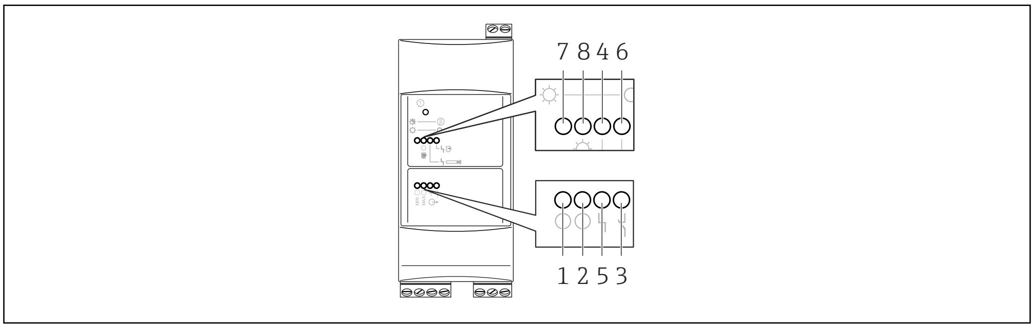
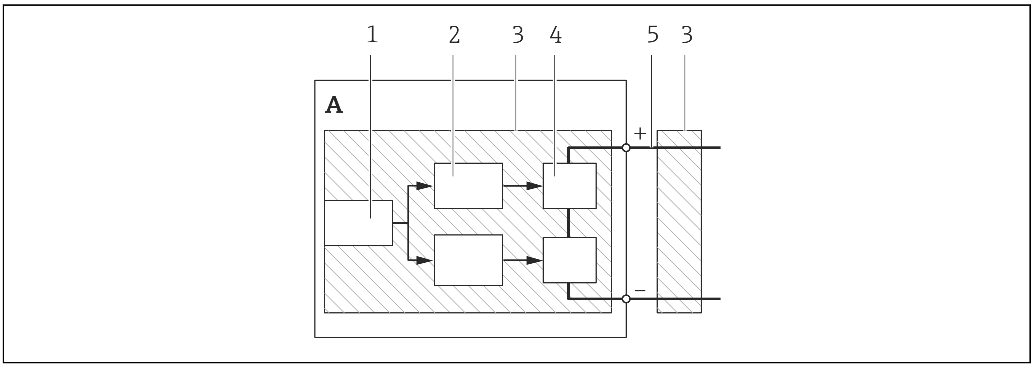
5 *Version I (Liquiphant FailSafe with Nivotester FailSafe)*

A *Liquiphant FailSafe*
B *Nivotester FailSafe*
1 *Sensor*
2 *Signal processing*
3 *Diagnostics*
4 *Output*
5 *4 to 20 mA signal*
6 *Input*
7 *Relay*
8 *Safety contact*



A0022080

1 *Operation LED MIN; color: green*
2 *Operation LED MAX; color: green*
3 *Safety contact LED; color: yellow*
4 *Fault LED wiring; color: red*
5 *Fault LED Nivotester FailSafe; color: red*
6 *Fault LED Liquiphant FailSafe; color: red*
7 *Monitoring LED; color: yellow*
8 *Covered LED; color: yellow*



A0022081

6 *Version II (only Liquiphant FailSafe)*

A Liquiphant FailSafe
1 Sensor
2 Signal processing
3 Diagnostics
4 Output
5 4 to 20 mA signal

5.1 Device behavior during power-up

5.1.1 Version I (Liquiphant FailSafe with Nivotester FailSafe)

Once switched on, the device runs through a diagnostic phase lasting max. 6 s. During this time:
- the contacts of the safety path are open
- the signaling contact is closed
- the relay of the fault-signaling contacts is de-energized

Relay	Terminal pair	State	Safety function
Safety contact 1	13 <> 14	Open	Yes
Safety contact 2	23 <> 24	Open	
Signaling contact	31 <> 32	Closed	No
Fault-signaling NC contact	6 <> 5	Closed	
Fault-signaling NO contact	4 <> 5	Open	

In addition, the Nivotester FailSafe also shows the following LED indicators for information purposes:

LED	Number	Color	State
Operation LED MIN	1	Green	On
Operation LED MAX	2	Green	On
Safety contact LED	3	Yellow	Off
Fault LED wiring	4	Red	Off
Fault LED Nivotester FailSafe	5	Red	Off
Fault LED Liquiphant FailSafe	6	Red	Off
Monitoring LED	7	Yellow	Off
Covered LED	8	Yellow	Off

The two green operation LEDs (number 1 and 2) are on simultaneously, all others are off.

5.1.2 Version II (only Liquiphant FailSafe)

Once switched on, the device runs through a diagnostic phase lasting max. 6 s. The current output is set to failure current ≤3.6 mA during this time.

In addition, the Liquiphant FailSafe also shows the following LED indicators for information purposes:

LED	Number	Color	State
Operation LED	1	Green	On
Fault LED	2	Red	Off
Current output LED	3	Yellow	Off

The green operation LED (number 1) is on.

5.2 Device behavior in safety function demand mode

5.2.1 Version I (Liquiphant FailSafe with Nivotester FailSafe)

In the demand mode
- the contacts of the safety path are open
- the signaling contact is closed
- the relay of the fault-signaling contacts is energized

Relay	Terminal pair	State	Safety function
Safety contact 1	13 <> 14	Open	Yes
Safety contact 2	23 <> 24	Open	
Signaling contact	31 <> 32	Closed	No
Fault-signaling NC contact	6 <> 5	Open	
Fault-signaling NO contact	4 <> 5	Closed	

In addition, the Nivotester FailSafe also shows the following LED indicators for information purposes:

LED	Number	Color	State
Operation LED MIN	1	Green	▪ MIN detection: on ▪ MAX detection: off
Operation LED MAX	2	Green	▪ MAX detection: on ▪ MIN detection: off
Safety contact LED	3	Yellow	Off
Fault LED wiring	4	Red	Off
Fault LED Nivotester FailSafe	5	Red	Off
Fault LED Liquiphant FailSafe	6	Red	Off
Monitoring LED	7	Yellow	Off
Covered LED	8	Yellow	▪ MAX detection: on ▪ MIN detection: off

The yellow safety contact LED (number 3) is off, only one of the green operation LEDs is on.

5.2.2 Version II (only Liquiphant FailSafe)

In the demand mode the current output is in the range between 4 mA and 12 mA. Two different current ranges are used to allow downstream components to automatically check the operating mode:
- MIN detection: from 8 to 10 mA
- MAX detection: from 5 to 7 mA

In addition, the Liquiphant FailSafe also shows the following LED indicators for information purposes:

LED	Number	Color	State
Operation LED	1	Green	Flashes
Fault LED	2	Red	Off
Current output LED	3	Yellow	Off

The green operation LED (number 1) is on.

5.3 Safe states

5.3.1 Version I (Liquiphant FailSafe with Nivotester FailSafe)

In the OK state:
- the contacts of the safety path are closed
- the signaling contact is open
- the relay of the fault-signaling contacts is energized

Relay	Terminal pair	State	Safety function
Safety contact 1	13 <> 14	Closed	Yes
Safety contact 2	23 <> 24	Closed	
Signaling contact	31 <> 32	Open	No
Fault-signaling NC contact	6 <> 5	Open	
Fault-signaling NO contact	4 <> 5	Closed	

In addition, the Nivotester FailSafe also shows the following LED indicators for information purposes:

LED	Number	Color	State
Operation LED MIN	1	Green	▪ MIN detection: on ▪ MAX detection: off
Operation LED MAX	2	Green	▪ MAX detection: on ▪ MIN detection: off
Safety contact LED	3	Yellow	On
Fault LED wiring	4	Red	Off
Fault LED Nivotester FailSafe	5	Red	Off
Fault LED Liquiphant FailSafe	6	Red	Off

LED	Number	Color	State
Monitoring LED	7	Yellow	Flashes
Covered LED	8	Yellow	▪ MIN detection: on ▪ MAX detection: off

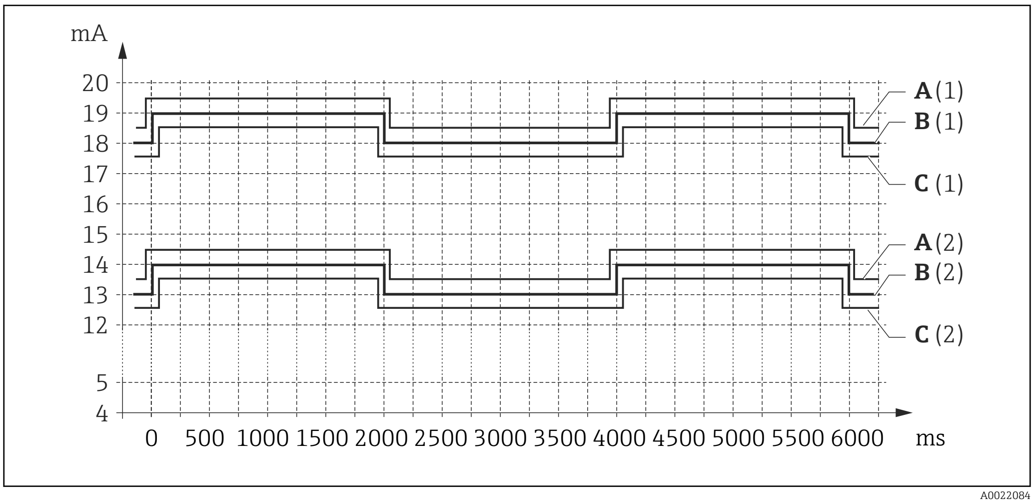
The yellow monitoring LED (number 7) flashes.

5.3.2 Version II (only Liquiphant FailSafe)

In the OK state the current output is in the range between 12 mA and 20 mA. Two different current ranges are used to allow downstream components to automatically check the operating mode:
- MIN detection: from 17.5 to 19.5 mA
- MAX detection: from 12.5 to 14.5 mA

It is possible for downstream components to automatically check whether a Liquiphant FailSafe is connected. A LIVE signal is modulated within the range limits for this purpose. This is a square wave signal of 0.25 Hz and ±0.5 mA amplitude (the signal changes by 1 mA every 2 000 ms ±50 ms.

This LIVE signal is modulated in the OK state only. The absence of the LIVE signal can be caused by the simultaneous occurrence of several errors as well as by the connection of a standard Liquiphant. The failure rate λ_{du} of the measuring system itself is not reduced by monitoring the LIVE signal. Monitoring can, however, help detect an error in other components downstream.



7 *Current output Liquiphant FailSafe in OK state*

A Operating mode MIN (1), operating mode MAX (2): upper tolerance
B Operating mode MIN (1), operating mode MAX (2): normal
C Operating mode MIN (1), operating mode MAX (2): lower tolerance

In addition, the Liquiphant FailSafe also shows the following LED indicators for information purposes:

LED	Number	Color	State
Operation LED	1	Green	Flashes
Fault LED	2	Red	Off
Current output LED	3	Yellow	On

The yellow current output LED (number 3) is on.

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

5.4.1 Version I (Liquiphant FailSafe with Nivotester FailSafe)

In the event of a fault, the safety contacts are open; an alarm or warning are treated in the same way. A distinction is made between:
- Errors at the Nivotester FailSafe
- Incorrect wiring
- Errors at the Liquiphant FailSafe

In the event of a fault:
- the contacts of the safety path are open
- the signaling contact is closed
- the relay of the fault-signaling contacts is de-energized

Relay	Terminal pair	State	Safety function
Safety contact 1	13 <> 14	Open	Yes
Safety contact 2	23 <> 24	Open	
Signaling contact	31 <> 32	Closed	No
Fault-signaling NC contact	6 <> 5	Closed	
Fault-signaling NO contact	4 <> 5	Open	

In addition, the Nivotester FailSafe also shows the following LED indicators for information purposes:

LED	Number	Color	State
Operation LED MIN	1	Green	▪ On [1)] ▪ Off [1)]
Operation LED MAX	2	Green	▪ On [1)] ▪ Off [1)]
Safety contact LED	3	Yellow	Off
Fault LED wiring	4	Red	▪ On [1)] ▪ Off [1)] ▪ Flashing [1)]
Fault LED Nivotester FailSafe	5	Red	▪ On [1)] ▪ Off [1)] ▪ Flashing [1)]
Fault LED Liquiphant FailSafe	6	Red	▪ On [1)] ▪ Off [1)] ▪ Flashing [1)]

LED	Number	Color	State
Monitoring LED	7	Yellow	Off
Covered LED	8	Yellow	▪ On [1)] ▪ Off [1)]

1) Depends on the cause of the fault. → See Operating Instructions.

- The state depends on whether MIN or MAX detection is selected as the operating mode
- At least one of the red LEDs (number 4, 5 or 6) is on or flashing.

5.4.2 Version II (only Liquiphant FailSafe)

In the event of a fault the current output is in the range below 3.6 mA. Short-circuits are an exception: in this case, the current output is in the range above 21 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). No distinction is made between an alarm and a warning.

In addition, the Liquiphant FailSafe also shows the following LED indicators for information purposes:

LED	Number	Color	State
Operation LED	1	Green	▪ On [1)] ▪ Off [1)] ▪ Flashing [1)]
Fault LED	2	Red	▪ On [1)] ▪ Off [1)]
Current output LED	3	Yellow	Off

1) Depends on the cause of the fault. → See Operating Instructions.

- Depends on the operating mode selected: MIN or MAX detection.
- The green operation LED (number 1) is on.

5.5 Alarm and warning messages

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

5.6 Behavior of device when locked

5.6.1 Liquiphant FailSafe with Nivotester FailSafe

In the locked state following a demand, an alarm or after voltage returns:
- the contacts of the safety path are open
- the signaling contact is closed
- the relay of the fault-signaling contacts is energized

Relay	Terminal pair	State	Safety function
Safety contact 1	13 <> 14	Open	Yes
Safety contact 2	23 <> 24	Open	
Signaling contact	31 <> 32	Closed	No

Relay	Terminal pair	State	Safety function
Fault-signaling NC contact	6 <> 5	Open	
Fault-signaling NO contact	4 <> 5	Closed	

In addition, the Nivotester FailSafe also shows the following LED indicators for information purposes:

LED	Number	Color	State
Operation LED MIN	1	Green	▪ MIN detection: on ▪ MAX detection: off
Operation LED MAX	2	Green	▪ MAX detection: on ▪ MIN detection: off
Safety contact LED	3	Yellow	Off
Fault LED wiring	4	Red	Off
Fault LED Nivotester FailSafe	5	Red	Off
Fault LED Liquiphant FailSafe	6	Red	Off
Monitoring LED	7	Yellow	On
Covered LED	8	Yellow	▪ MIN detection: on ▪ MAX detection: off

The yellow safety contact LED (number 3) is on.

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.

NOTICE

Before the test is started, the device is in a fault state, i.e. an alarm is output

- First rectify the cause of the fault before starting the proof test.

Overview of the proof tests:
- Test sequence A:
  Approach the level or remove and immerse in a medium of the same density and viscosity
  - Version I (Liquiphant FailSafe with Nivotester FailSafe), MIN detection
  - Version I (Liquiphant FailSafe with Nivotester FailSafe), MAX detection
  - Version II (Liquiphant FailSafe), MIN detection
  - Version II (Liquiphant FailSafe), MAX detection
- Test sequence B:
  Activate simulation by pressing the test button on the Liquiphant FailSafe or Nivotester FailSafe
  - Version I (Liquiphant FailSafe with Nivotester FailSafe)
  - Version II (Liquiphant FailSafe), MIN detection
  - Version II (Liquiphant FailSafe), MAX detection

Note the following for the test sequences:
A component that displays the status of the relevant output signal is required for proof testing. For example, this can be a downstream component of the safety path (e.g. a safety PLC (SPLC) or the actuator), or a measuring device.

6.1 Test sequence A

6.1.1 Version I (Liquiphant FailSafe with Nivotester FailSafe), MIN detection

Preparatory steps

1. Approach the level or
2. Remove and immerse in a medium of the same density and viscosity

Proof testing procedure, Step 1

1. Raise the level or immerse the tuning fork of the removed sensor 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 comparable density and viscosity must be used.
2. If the Nivotester FailSafe is configured to "locking", acknowledge the locking.
3. Check the status of the safety contacts.
   ↳ Terminals 13 and 14 (safety contact 1) and terminals 23 and 24 (safety contact 2) must be closed.

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

Proof testing procedure, Step 2

1. Lower the level or remove the tuning fork of the removed sensor from the medium until the tuning fork is completely free.
2. Check the status of the safety contacts.
   ↳ Terminals 13 and 14 (safety contact 1) and terminals 23 and 24 (safety contact 2) must be open.

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

Proof testing procedure, Step 3

1. Raise the level or immerse the tuning fork of the removed sensor into the medium until the tuning fork is fully covered.

2. If the Nivotester FailSafe is configured for "Immediate switch to the OK state", continue with Step 4.
3. If the Nivotester FailSafe is configured for "Locking", terminals 13 and 14 (safety contact 1) and terminals 23 and 24 (safety contact 2) must be open.
4. Acknowledge locking.

If the safety contacts are closed, a fault in the self-locking function has occurred. If this is necessary for the safety function, the proof test is assessed as failed and must be aborted.

Proof testing procedure, Step 4

▶ Check the status of the safety contacts.
  ↳ Terminals 13 and 14 (safety contact 1) and terminals 23 and 24 (safety contact 2) must be closed.

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

Proof testing procedure, Step 5

1. Re-install the sensor that was removed and restore the OK state.
2. Press the test button to restart the Nivotester FailSafe.
   ↳ Wait until the automatic internal diagnosis has been performed completely (min. 8 s)
3. If the Nivotester FailSafe is configured for "Immediate switch to the OK state", continue with Step 6.
4. If the Nivotester FailSafe is configured for "Locking", terminals 13 and 14 (safety contact 1) and terminals 23 and 24 (safety contact 2) must be open.
5. Acknowledge locking

If the safety contacts are closed, a fault in the self-locking function has occurred. If this is necessary for the safety function, the proof test is assessed as failed and must be aborted.

Proof testing procedure, Step 6

▶ Check the status of the safety contacts.
  ↳ Terminals 13 and 14 (safety contact 1) and terminals 23 and 24 (safety contact 2) must be closed.

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

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

- This type of test checks the entire safety path, including the interaction between the medium and tuning fork.
- In addition to a diagnostic coverage (DC) of 96 % for internal diagnostics, this proof test detects over 90 % (PTC = Proof Test Coverage) of the remaining dangerous undetected failures. This results in a total coverage of over 99 %.

6.1.2 Version I (Liquiphant FailSafe with Nivotester FailSafe), MAX detection

Preparatory steps

1. Approach the level or
2. Remove and immerse in a medium of the same density and viscosity

Proof testing procedure, Step 1

1. Lower the level or remove the tuning fork of the removed sensor from 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 comparable density and viscosity must be used.
2. If the Nivotester FailSafe is configured to "Locking", no demand mode is present but the safety contacts are open, you must check whether the last demand mode has already been acknowledged. Acknowledge the demand mode again if necessary.
3. Check the status of the safety contacts.
   ↳ Terminals 13 and 14 (safety contact 1) and terminals 23 and 24 (safety contact 2) must be closed.

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

Proof testing procedure, Step 2

1. Raise the level or immerse the tuning fork of the removed sensor into the medium until the tuning fork is fully covered.
2. Check the status of the safety contacts.
   ↳ Terminals 13 and 14 (safety contact 1) and terminals 23 and 24 (safety contact 2) must be open.

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

Proof testing procedure, Step 3

1. Lower the level or remove the tuning fork of the removed sensor from the medium until the tuning fork is completely free.
2. If the Nivotester FailSafe is configured for "Immediate switch to the OK state", continue with Step 4.
3. If the Nivotester FailSafe is configured for "Locking", terminals 13 and 14 (safety contact 1) and terminals 23 and 24 (safety contact 2) must be open.
4. Acknowledge locking.

If the safety contacts are closed, a fault in the self-locking function has occurred. If this is necessary for the safety function, the proof test is assessed as failed and must be aborted.

Proof testing procedure, Step 4

▸ Check the status of the safety contacts.
  ↳ Terminals 13 and 14 (safety contact 1) and terminals 23 and 24 (safety contact 2) must be closed.

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

Proof testing procedure, Step 5

1. Re-install the sensor that was removed.
2. Press the test button to restart the Nivotester FailSafe.
   ↳ Wait until the automatic internal diagnosis has been performed completely (min. 8 s)
3. If the Nivotester FailSafe is configured for "Immediate switch to the OK state", continue with Step 6.
4. If the Nivotester FailSafe is configured for "Locking", terminals 13 and 14 (safety contact 1) and terminals 23 and 24 (safety contact 2) must be open.
5. Acknowledge locking

If the safety contacts are closed, a fault in the self-locking function has occurred. If this is necessary for the safety function, the proof test is assessed as failed and must be aborted.

Proof testing procedure, Step 6

- ▶ Check the status of the safety contacts.
  - ↳ Terminals 13 and 14 (safety contact 1) and terminals 23 and 24 (safety contact 2) must be closed.

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

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

- This type of test checks the entire safety path, including the interaction between the medium and tuning fork.
- In addition to a diagnostic coverage (DC) of 96 % for internal diagnostics, this proof test detects over 90 % (PTC = Proof Test Coverage) of the remaining dangerous undetected failures. This results in a total coverage of over 99 %.

6.1.3 Version II (Liquiphant FailSafe), MIN detection

Preparatory steps

1. Approach the level or
2. Remove and immerse in a medium of similar density and viscosity

Proof testing procedure, Step 1

1. Raise the level or immerse the tuning fork of the removed sensor 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 current consumption of the Liquiphant FailSafe (17.5 to 19.5 mA).

If the current is outside the target values, a fault has occurred in the safety path. The proof test has not been passed and must be aborted.

Proof testing procedure, Step 2

1. Lower the level or remove the tuning fork of the removed sensor from the medium until the tuning fork is completely free.
2. Check the current consumption of the Liquiphant FailSafe (8.0 to 10.0 mA).

If the current is outside the target values, a fault has occurred in the safety path. The proof test has not been passed and must be aborted.

Proof testing procedure, Step 3

- ▶ Raise the level or immerse the tuning fork of the removed sensor into the medium until the tuning fork is fully covered.

Proof testing procedure, Step 4

- ▶ Check the current consumption of the Liquiphant FailSafe (17.5 to 19.5 mA).

If the current is outside the target values, a fault has occurred in the safety path. The proof test has not been passed and must be aborted.

Proof testing procedure, Step 5

1. Re-install the sensor that was removed and restore the OK state.

2. Press the test button to restart the Liquiphant FailSafe.
   ↳ Wait until the automatic internal diagnosis has been performed completely (min. 8 s)

Proof testing procedure, Step 6

▸ Check the current consumption of the Liquiphant FailSafe (17.5 to 19.5 mA).

If the current is outside the target values, a fault has occurred in the safety path. The proof test has not been passed and must be aborted.

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

- This type of test checks the entire safety path, including the interaction between the medium and tuning fork.
- In addition to a diagnostic coverage (DC) of 95.2 % for internal diagnostics, this proof test detects over 90 % (PTC = Proof Test Coverage) of the remaining dangerous undetected failures. This results in a total coverage of over 99 %.

6.1.4 Version II (Liquiphant FailSafe), MAX detection

Preparatory steps

1. Approach the level or
2. Remove and immerse in a medium of the same density and viscosity

Proof testing procedure, Step 1

1. Lower the level or remove the tuning fork of the removed sensor from 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 comparable density and viscosity must be used.
2. Check the current consumption of the Liquiphant FailSafe (12.5 to 14.5 mA).

If the current is outside the target values, a fault has occurred in the safety path. The proof test has not been passed and must be aborted.

Proof testing procedure, Step 2

1. Raise the level or immerse the tuning fork of the removed sensor into the medium until the tuning fork is fully covered.
2. Check the current consumption of the Liquiphant FailSafe (5.0 to 7.0 mA).

If the current is outside the target values, a fault has occurred in the safety path. The proof test has not been passed and must be aborted.

Proof testing procedure, Step 3

▸ Lower the level or remove the tuning fork of the removed sensor from the medium until the tuning fork is completely free.

Proof testing procedure, Step 4

▸ Check the current consumption of the Liquiphant FailSafe (12.5 to 14.5 mA).

If the current is outside the target values, a fault has occurred in the safety path. The proof test has not been passed and must be aborted.

Proof testing procedure, Step 5

1. Re-install the sensor that was removed.
2. Press the test button to restart the Liquiphant FailSafe.
   ↳ Wait until the automatic internal diagnosis has been performed completely (min. 8 s)

Proof testing procedure, Step 6

▶ Check the current consumption of the Liquiphant FailSafe (12.5 to 14.5 mA).

If the current is outside the target values, a fault has occurred in the safety path. The proof test has not been passed and must be aborted.

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

- This type of test checks the entire safety path, including the interaction between the medium and tuning fork.
- In addition to a diagnostic coverage (DC) of 95.2 % for internal diagnostics, this proof test detects over 90 % (PTC = Proof Test Coverage) of the remaining dangerous undetected failures. This results in a total coverage of over 99 %.

6.2 Test sequence B

6.2.1 Version I (Liquiphant FailSafe with Nivotester FailSafe)

Valid for MIN and MAX detection!

Preparatory steps

▶ Activate simulation at the Liquiphant FailSafe or Nivotester FailSafe by pressing the test button

Proof testing procedure, Step 1

1. Check the status of the safety contacts.
   ↳ Terminals 13 and 14 (safety contact 1) and terminals 23 and 24 (safety contact 2) must be closed.
2. If the Nivotester FailSafe is configured to "Locking", no demand mode is present but the safety contacts are open, you must check whether the last demand mode has already been acknowledged. Acknowledge the demand mode again if necessary.

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

Proof testing procedure, Step 2

1. Press and hold the test button on the Liquiphant FailSafe or Nivotester FailSafe.
   ↳ If the test button is released, 5 s still remain for the test. If more time is needed, the button can be pressed permanently.
2. Check the status of the safety contacts.
   ↳ Terminals 13 and 14 (safety contact 1) and terminals 23 and 24 (safety contact 2) must be open.

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

Proof testing procedure, Step 3

1. Press the test button on the Nivotester FailSafe.
   ↳ Wait until the automatic internal diagnosis has been performed completely (min. 8 s)
2. If the test button on the Liquiphant FailSafe has been pressed, restart the Nivotester FailSafe by pressing the test button.
   ↳ Wait until the automatic internal diagnosis has been performed completely (min. 8 s)

3. If the Nivotester FailSafe is configured for "Immediate switch to the OK state", continue with Step 6.
4. If the Nivotester FailSafe is configured for "Locking", terminals 13 and 14 (safety contact 1) and terminals 23 and 24 (safety contact 2) must be open.
   ↳ If the safety contacts are closed, a fault in the self-locking function has occurred. If this is necessary for the safety function, the proof test is assessed as failed and must be aborted.
5. Acknowledge locking.

Proof testing procedure, Step 4

▶ Check the status of the safety contacts.
  ↳ Terminals 13 and 14 (safety contact 1) and terminals 23 and 24 (safety contact 2) must be closed.

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

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

- If a simulation is performed by pressing the test button, a failure rate of 3 FIT remains due to the untested parts of the safety path.
- This type of test only tests the electrical safety path.
- In addition to a diagnostic coverage (DC) of 96 % for internal diagnostics, this proof test detects over 34 % (PTC = Proof Test Coverage) of the remaining dangerous undetected failures. This results in a total coverage of over 97.4 %.
- To increase the total diagnostic coverage to over 99 %, the switch point accuracy can also be checked, see the Operating Instructions.

6.2.2 Version II (Liquiphant FailSafe), MIN detection

Preparatory steps

▶ Perform a simulation at the Liquiphant FailSafe by pressing the test button

Proof testing procedure, Step 1

▶ Check the current consumption of the Liquiphant FailSafe (17.5 to 19.5 mA).

If the current is outside the target values, a fault has occurred in the safety path. The proof test has not been passed and must be aborted.

Proof testing procedure, Step 2

1. Press and hold the test button on the Liquiphant FailSafe.
   ↳ If the test button is released, 5 s still remain for the test. If more time is needed, the button can be pressed permanently.
2. Check the current consumption of the Liquiphant FailSafe (8.0 to 10.0 mA).

If the current is outside the target values, a fault has occurred in the safety path. The proof test has not been passed and must be aborted.

Proof testing procedure, Step 3

▶ Press the test button on the Liquiphant FailSafe.
  ↳ Wait until the automatic internal diagnosis has been performed completely (min. 8 s)

Proof testing procedure, Step 4

▶ Check the current consumption of the Liquiphant FailSafe (17.5 to 19.5 mA).

If the current is outside the target values, a fault has occurred in the safety path. The proof test has not been passed and must be aborted.

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

- If a simulation is performed by pressing the test button, a failure rate of 3 FIT remains due to the untested parts of the safety path.
- This type of test only tests the electrical safety path and the downstream system parts.
- In addition to a diagnostic coverage (DC) of 95.2 % for internal diagnostics, this proof test detects over 4 % (PTC = Proof Test Coverage) of the remaining dangerous undetected failures. This results in a total coverage of over 95.4 %.
- To increase the total diagnostic coverage to over 99 %, the switch point accuracy can also be checked. See the Operating Instructions.

6.2.3 Version II (Liquiphant FailSafe), MAX detection

Preparatory steps

▶ Perform a simulation at the Liquiphant FailSafe by pressing the test button

Proof testing procedure, Step 1

▶ Check the current consumption of the Liquiphant FailSafe (12.5 to 14.5 mA).

If the current is outside the target values, a fault has occurred in the safety path. The proof test has not been passed and must be aborted.

Proof testing procedure, Step 2

1. Press and hold the test button on the Liquiphant FailSafe.
   ↳ If the test button is released, 5 s still remain for the test. If more time is needed, the button can be pressed permanently.
2. Check the current consumption of the Liquiphant FailSafe (5.0 to 7.0 mA).

If the current is outside the target values, a fault has occurred in the safety path. The proof test has not been passed and must be aborted.

Proof testing procedure, Step 3

▶ Press the test button on the Liquiphant FailSafe.
   ↳ Wait until the automatic internal diagnosis has been performed completely (min. 8 s)

Proof testing procedure, Step 4

▶ Check the current consumption of the Liquiphant FailSafe (12.5 to 14.5 mA).

If the current is outside the target values, a fault has occurred in the safety path. The proof test has not been passed and must be aborted.

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

- If a simulation is performed by pressing the test button, a failure rate of 3 FIT remains due to the untested parts of the safety path.
- This type of test only tests the electrical safety path and the downstream system parts.
- In addition to a diagnostic coverage (DC) of 95.2 % for internal diagnostics, this proof test detects over 4 % (PTC = Proof Test Coverage) of the remaining dangerous undetected failures. This results in a total coverage of over 95.4 %.
- To increase the total diagnostic coverage to over 99 %, the switch point accuracy can also be checked. See the Operating Instructions.

6.3 Additional possibilities to test the non-SIL assessed function

You can also test the non-SIL assessed outputs and displays during the proof test. This is optional and not necessary for safety-related use. If an error is detected in these functions, the device may continue to be operated but a replacement is advisable at the earliest opportunity.

6.3.1 Liquiphant FailSafe

When the test button is pressed, the green and red LEDs are lit alternately (rhythm: 1 left / 1 right) and the yellow LED is off. The yellow LED is lit permanently in Step 1 and Step 6.

6.3.2 Nivotester FailSafe

- The behavior of the signaling contact (terminal 31 and 32) is the opposite of the safety contacts.
- The fault-signaling NO contact is closed in Step 1 and Step 6.
- The fault-signaling NC contact is only closed briefly while the measuring system is restarted.

When the test button is pressed, the 8 LEDs are lit alternately (rhythm: 4 top / 4 bottom).

The yellow safety contact LEDs are lit in Step 1 and Step 6. This safety contact LED indicates the status of the safety contact, with the exception of the phase in which all LEDs flash alternately.

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 technical staff if **original Endress+Hauser spare parts** are used (they can be ordered by the end user), and if the relevant installation instructions are followed.

A proof test must always be performed after every repair.

Components for repair/replacement:
- Cover
- Cover seal
- Cable gland
- Electronic insert FEL85

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 to SIL devices by the user are not permitted as they can impair the functional safety of the device**
- Modifications to SIL devices on site at the user's plant are possible 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 Endress+Hauser W@M Device Viewer
- 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 Endress+Hauser for disposal under the applicable conditions.

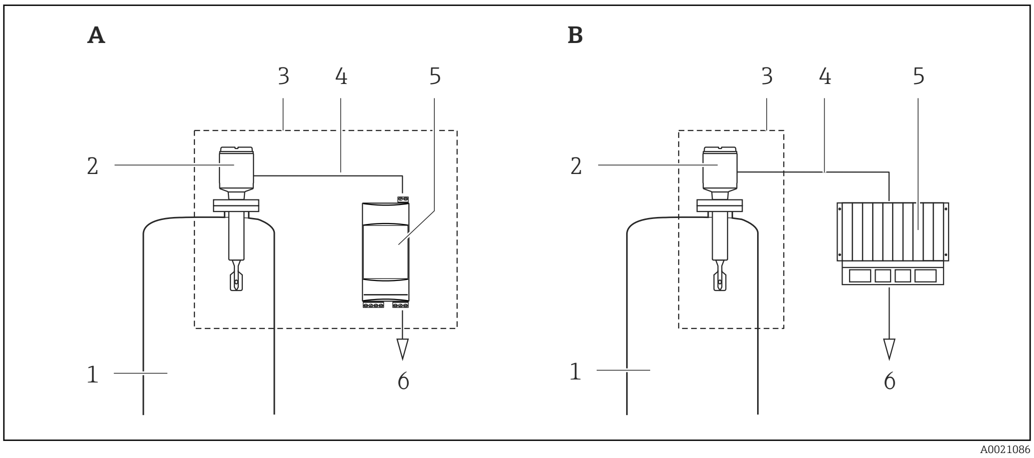
8 Appendix

8.1 Structure of the measuring system

8.1.1 System components

The system consists of several components that can be operated in two different versions:
- Version I
  With Liquiphant FailSafe (sensor) and Nivotester FailSafe (evaluation unit) to control an actuator or a safety PLC (SPLC), for example, via the contacts of the safety paths.
- Version II
  With Liquiphant FailSafe (sensor) for the direct activation of an evaluation unit (e.g. transmitter, SPLC) via the 4 to 20 mA interface.

An example of the devices in the measuring system is shown in the following graphic.



A Version I
B Version II
1 Process
2 Liquiphant FailSafe with FEL85 electronic insert
3 System limit
4 2-wire cable, 4 to 20 mA
5 For version I: Nivotester FailSafe; for version II: e.g. SPLC
6 Actuator

A discrete signal (4 to 20 mA) that depends on the level is generated in the sensor. The signal is supplied to the downstream logic unit (e.g. Nivotester FailSafe, SPLC, etc.) where it is monitored to determine if it exceeds or falls below a predefined limit value.

Liquiphant FailSafe

The Liquiphant FailSafe acts as a safety-related point level switch and distinguishes between a covered and uncovered tuning fork. It outputs a current according to NAMUR Guideline NE43 (4 to 20 mA signal).

Nivotester FailSafe

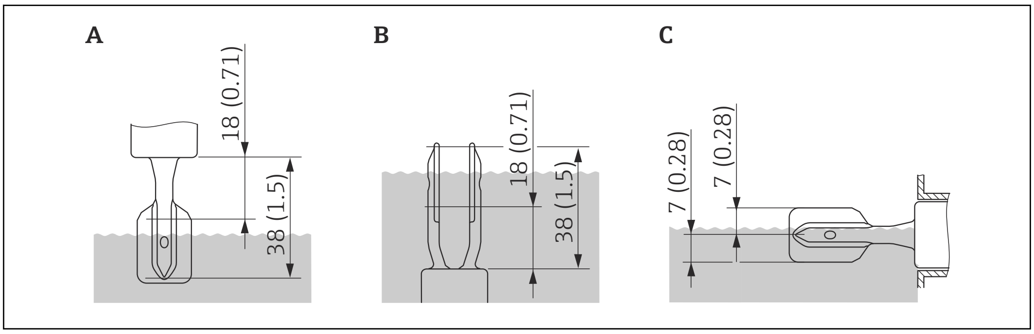
Acting as the evaluation unit, the Nivotester FailSafe monitors the input current and a dynamic signal (LIVE signal), which are provided by the Liquiphant FailSafe. The two safety contacts are opened in the demand mode or if a fault is detected. Additionally, a signaling contact is closed.

A separate fault-signaling contact switches in the event of a device error.

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.



Unit of measurement mm (in)

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

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

There is a choice of two operating modes:
- MIN detection
- MAX detection

MIN detection

The measuring system is used to prevent the level becoming too low, e.g. for dry running protection for pumps, empty running protection or protection against underfills.

In normal operation, the tuning fork is covered by liquid and the measuring system reports the OK state. If the level is too low, 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 liquid and the measuring system reports the OK state. If the tuning fork is covered, the device assumes the safe state and signals the demand mode.

Pay attention to the atmosphere above the liquid!

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 -

Company/contact person	
Tester	

Device information
Facility
Device tag
Device name/Order code
Serial number

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
Device name/Order code
Serial number

Test information
Date/time

Type of safety function
☐ Limit value monitoring MIN
☐ Limit value monitoring MAX

Density range setting
☐ >0.7
☐ >0.5

Commissioning check - 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 or magnet at Liquiphant FailSafe

Terminal 2, check current			
Test step	**Target value**	**Actual value**	**Result**
Step 1	2.2 to 3.8 mA		☐ Passed ☐ Failed
Step 2	0.4 to 1.0 mA		☐ Passed ☐ Failed
Step 3	2.2 to 3.8 mA		☐ Passed ☐ Failed

8.3 Version history

FY01078F; version 02.23
- Firmware version: 01.00.zz (zz: any double number)
- Hardware version: from 01.00.ww (ww: any double number)
- Changes:
  Adjustments to text

FY01078F; version 01.22
- Firmware version: 01.00.zz (zz: any double number)
- Hardware version: from 01.00.ww (ww: any double number)
- Changes: certificate renewed
- Predecessor: SD00350F
  Liquiphant FailSafe FTL80/81/85 with Nivotester FailSafe FTL825

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