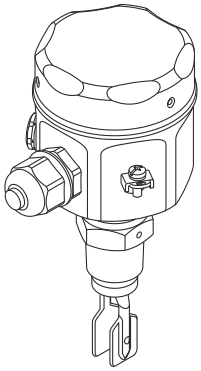
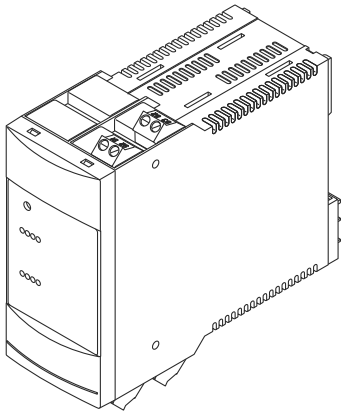
Functional safety manual
Liquiphant FailSafe FTL80/81/85 with Nivotester FailSafe FTL825





Level Limit Measuring System with 4 to 20 mA output signal or relay

Application
Operating minimum (e.g. dry run protection) and maximum monitoring (e.g. overfill protection) of all types of liquids in vessels to satisfy particular safety systems requirements as per IEC 61508 Edition 2.0

The measuring device fulfils the requirements concerning
- Functional safety as per IEC 61508 Edition 2.0
- Explosion protection (depending on the version)
- Electromagnetic compatibility as per EN 61326 and NAMUR recommendation NE 21.
- Electrical safety as per IEC/EN 61010-1

Your benefits
- Used for level monitoring (MIN, MAX)
  - up to SIL 3 according to IEC 61508 Edition 2.0
  - SIL CL 3 according to IEC 62061
  - Performance Level PL e according to EN ISO 13849-1

  independently assessed (Functional Safety Assessment) by TÜV Rheinland
- Certified Functional Safety Management according to IEC 61508:2010
- Permanent self-monitoring
- No calibration
- Easy commissioning

Endress+Hauser
People for Process Automation

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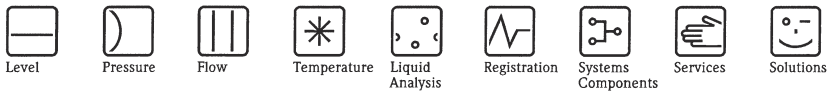
SIL Declaration of Conformity



SIL-12040c/00/A2

SIL-Konformitätserklärung

Funktionale Sicherheit nach IEC 61508

SIL Declaration of Conformity

Functional safety according to IEC 61508

Endress+Hauser GmbH+Co. KG, Hauptstraße 1, 79689 Maulburg
erklärt als Hersteller, dass das Gerät
declares as manufacturer, that the device

Liquiphant FailSafe FTL80/81/85 + FTL80/81/85 mit/with Nivotester FTL825

für den Einsatz in Schutzeinrichtungen entsprechend der IEC 61508 Edition 2.0 geeignet ist, wenn das Handbuch zur Funktionalen Sicherheit und die Kenngrößen in der folgenden Tabelle beachtet werden:
is suitable for the use in safety-instrumented systems according to IEC 61508 Edition 2.0, if the functional safety manual and the characteristics specified in the following table are observed:

Gerät/Product	**FTL80/81/85**	**FTL80/81/85 mit/with Nivotester FTL825**
Handbuch zur Funktionalen Sicherheit/ Functional safety manual	SD00350F	SD00350F
Sicherheitsfunktion/Safety function	MIN , MAX	MIN , MAX
SIL/SC/SIL CL [4]	3	3
PL [3]	e	—
HFT / SFF (Sensor FTL8x)	0 / 99.3 %	0 / 99.3 %
HFT / SFF (Signalverarbeitung+Ausgang FTL8x/signal processing+output FTL8x)	1 / 99.8 %	1 / 99.8 %
SFF (System)	99.6 %	99.7 %
Gerätetyp/Device type	B	B
Betriebsart/mode of operation	Low demand mode, high demand mode	Low demand mode
PFD_{avg} [2] (T_1 = 1 Jahr/year)	1.39×10^{-5}	2.08×10^{-5}
PFD_{avg} [2] (T_1 = 12 Jahre/years)	1.66×10^{-4}	2.49×10^{-4}
PFH	3.17×10^{-9} 1/h	—
DC_{avg} [3]	95.2 %	96.0 %
$MTTF_d$ [3]	100 Jahre/years	—
λ_{sd} [2]	782 FIT	1280 FIT
λ_{su} [2]	19 FIT	105 FIT
λ_{dd} [2]	63 FIT	120 FIT
λ_{du} [2]	3 FIT	5 FIT
λ_{tot} [2]	867 FIT	1509 FIT
MTBF [1]	132 Jahre/years	76 Jahre/years

[1] Gemäß Siemens SN 29500, einschließlich Fehlern, die außerhalb der Sicherheitsfunktion liegen./ According to Siemens SN 29500, including faults outside the safety function.
[2] Gemäß Siemens SN 29500.Wenn die durchschnittliche Temperatur der Elektronik im kontinuierlichen Gebrauch über +50 °C (122 °F) oder unterhalb -50 °C (- 58 °F) ist, sollte ein Faktor von 1.3 berücksichtigt werden/ According to Siemens SN 29500.Where the average temperature of the electronics when in continuos use is above +50 °C (122 °F) or below -50 °C (-58 °F), a factor of 1.3 should be taken into account
[3] Gemäß EN ISO 13849-1 / according to EN ISO 13849-1
[4] Gemäß IEC 62061 / according to IEC 62061

Das Gerät wurde in einem vollständigen Functional Safety Assessment unabhängig bewertet.
The device was assessed independently in a complete Functional Safety Assessment.

Maulburg, 01.08.2013

i.V.
(Dr. Arno Götz)
Leitung Produktsicherheit/
Manager Product Safety

i.V.
(Dr.Dietmar Frühauf)
Leitung Füllstandgrenzschalter/
Manager Level Limit Switch

Endress+Hauser
People for Process Automation

SIL_12040c

Introduction

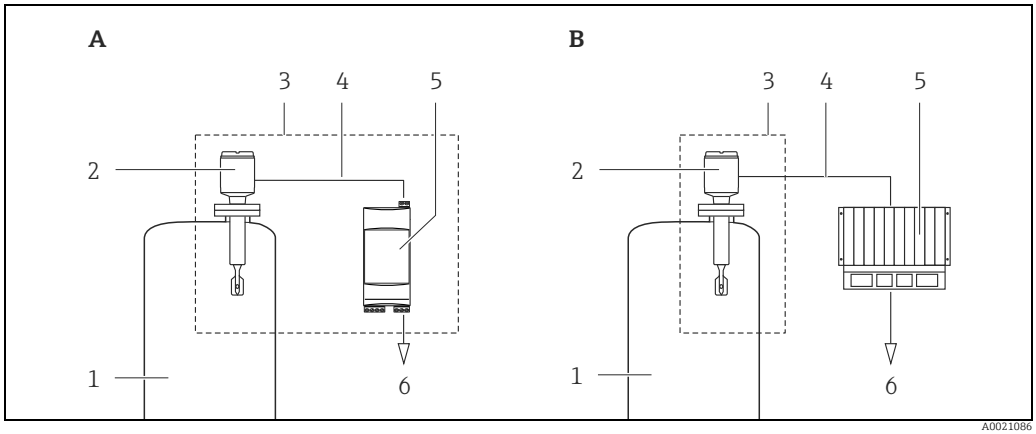
General information on functional safety (SIL) is available at:
www.de.endress.com/SIL (German) or www.endress.com/SIL (English) and in Competence Brochure CP01008Z/11/EN. "Functional Safety in the Process Industry - Risk Reduction with Safety Instrumented Systems".

Structure of the measuring system

System components

The system consists of a number of components which can be operated as two versions:
- *Version I (Liquiphant FailSafe with Nivotester FailSafe)*
  With Liquiphant FailSafe (sensor) and Nivotester FailSafe (switching unit) to activate for example an actuator or a safety-related PLC via the contacts of the safety paths.
- *Version II (only Liquiphant FailSafe)*
  With Liquiphant FailSafe (sensor) for the direct activation of a switching unit (e.g. transmitter or safety-related PLC) via the 4 to 20 mA interface.

The following diagram shows an example of the measuring system in use.



1

A *Version I*
B *Version II*

1 *Process*
2 *Liquiphant FailSafe FTL8x with electronic insert FEL85*
3 *System boundary*
4 *2-wire line, 4 to 20 mA*
5 *for version I: Nivotester FailSafe FTL825*
for version II: e.g. safety-related PLC
6 *Actuator*

A level-dependent discrete signal (4 to 20 mA) is generated in the sensor and this signal is fed to a downstream logic unit (e.g. Nivotester FailSafe, safety-related PLC, etc.) where it is monitored to check if it exceeds or undershoots a specified limit value.

Liquiphant FailSafe FTL80/81/85

The Liquiphant FailSafe acts as a safety-related point level switch and detects whether the tuning fork is covered or exposed. It outputs a current in accordance with the standard NAMUR NE43 (4 to 20 mA signal).

Nivotester FailSafe FTL825

The Nivotester FailSafe acts as a switching unit to monitor the input current as well as a dynamic signal (LIVE signal), which is transmitted by the Liquiphant FailSafe FTL8x. The two safety relays are opened in the event of a demand mode or if faults are detected. In addition to the safety contacts a signaling contact is closed.
In the case of a device error a separate fault-signaling contact switches.

Description of use as a protective system

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

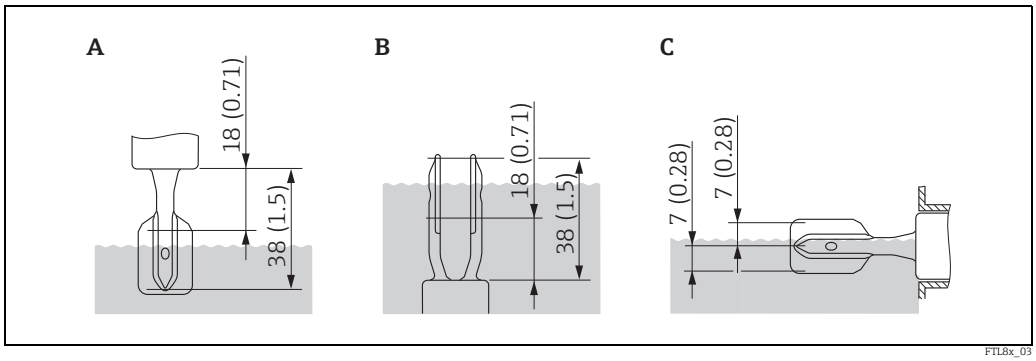
Two modes of operation are available for selection:

MIN detection
The measuring system is used to protect against a level that is too low, e.g. for pump protection or dry running protection, protection against an insufficient level of filling.
– During normal operation, the tuning fork is covered with liquid, the measuring system reports status "OK". If the level is too low, the device goes into safe mode and reports a demand mode.
(For an explanation of the status "OK" and the demand mode → 8)

MAX detection
The measuring system is used to prevent too high a level, e.g. overfill protection.
– During normal operation, the fork is free of liquid, the measuring system reports status "OK". If the fork is covered, the device goes into safe mode and reports a demand mode.
(For an explanation of the status "OK" and the demand mode → 8)

Please pay attention to the atmosphere above the liquid ("Density of the medium", → 9)!

The switch point depends on installation and is within the fork tine range → 2.



2 *Dimensions: mm (in)*

A *Mounting from above*
B *Mounting from below*
C *Mounting from the side*

Please refer to the Technical Information ("Supplementary device documentation", → 7) for further information on the switch point under reference operating conditions.

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

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 version.
Unless otherwise specified, all subsequent versions can also be used for safety instrumented systems. A modification process according to IEC 61508 is applied for device changes.

Valid device versions for safety-related use:

Liquiphant FailSafe FTL80, FTL81, FTL85

Feature	Designation	Option model
010	Approval	all
020	Electronics; Output	S FEL85; 2-wire 4-20 mA
030	Display; Operating	all
040	Housing	all
050	Electrical Connection	all
060	Application	A Process max. 150 °C (302 °F), 64 bar (928 psi) B Process max. 150 °C (302 °F), 100 bar (1450 psi) C Process max. 230 °C (446 °F), 100 bar (1450 psi); incl. gas-tight feed through (Second Line of Defence) D Process max. 280 °C (536 °F), 100 bar (1450 psi); incl. gas-tight feed through (Second Line of Defence) N ECTFE, Process max. 120 °C (248 °F), 40 bar (580 psi) P PFA, Process max. 150 °C (302 °F), 40 bar (580 psi) T Enamel, Process max. 150 °C (302 °F), 25 bar (362 psi)
070	Sensor Material	all
080	Surface Refinement	A Standard Ra <3,2 µm/126 µin N Coating ECTFE P Coating PFA (Edlon) Q Coating PFA (RubyRed) R Coating PFA (conductive) T Coating Enamel
090	Sensortype	all
100	Process Connection	all
≥ 500	optional specifications	all

The restrictions for use in safety-related applications must be taken into account, → 9!

Valid firmware version: as of 01.00.00
Valid hardware version (electronics): as of 01.00

Valid device versions for safety-related use:

Nivotester FailSafe FTL825

Feature	Designation	Option model
010	Approval	all
020	Housing	all
030	Power supply	all
040	Switch output	all
≥ 500	optional specifications	all

Valid firmware version: as of 01.00.00
Valid hardware version (electronics): as of 01.00

Supplementary device documentation

Liquiphant FailSafe FTL80, FTL81, FTL85

Documentation	Contents	Comment
Technical Information TI01026F/00	– Technical data – Accessories	– The documentation is available on the Internet → www.endress.com.
Operating Instructions BA01037F/00	– Installation – Wiring – Operation – Commissioning – Troubleshooting – Repairs – Maintenance	– The documentation is supplied with the device. – The documentation is available on the Internet → www.endress.com.
Safety instructions depending on the selected version "Approval"	Safety, installation and operating instructions for devices, which are suitable for use in potentially explosive atmospheres or as overfill protection (WHG, German Water Resources Act).	Additional safety instructions (XA, ZE) are supplied with certified device versions. Please refer to the nameplate for the relevant safety instructions.

Nivotester FailSafe FTL825

Documentation	Contents	Comment
Technical Information TI01027F/00	– Technical data – Accessories	– The documentation is available on the Internet → www.endress.com.
Operating Instructions BA01038F/00	– Installation – Wiring – Operation – Commissioning – Troubleshooting – Repairs – Maintenance	– The documentation is supplied with the device. – The documentation is available on the Internet → www.endress.com.
Safety instructions depending on the selected version "Approval"	Safety, installation and operating instructions for devices, which are suitable for use in potentially explosive atmospheres or as overfill protection (WHG, German Water Resources Act).	Additional safety instructions (XA, ZE) are supplied with certified device versions. Please refer to the nameplate for the relevant safety instructions.

Description of the safety requirements and boundary conditions

Safety function

The measuring system's safety function is point level detection (→ 🖹 5).

It can be implemented either as:
- Maximum point level detection (e.g. overfill protection) or
- Minimum point level detection (e.g. pump protection).

For information on selecting the mode of operation (MIN or MAX detection), → 🖹 23, "Operation".

Safety-related signal:

- *Version I (Liquiphant FailSafe with Nivotester FailSafe)*
  The safety-related output signal consists of two safety contacts:
  – Safety contact 1: terminal no.s 13 and 14
  – Safety contact 2: terminal no.s 23 and 24
  They are closed when the status is "OK" and open in demand mode or when a fault is detected. Depending on the configuration (locking/automatic restart) of the Nivotester FailSafe FTL825, the safety contacts either close automatically when status "OK" is reached again or after demand mode/ the fault is acknowledged by the operator, "Device configuration", → 🖹 26.
- *Version II (only Liquiphant FailSafe)*
  The safety-related signal is the analog 4 to 20 mA output signal. The tables below show how the output signal depends on the mode of operation and the status of the measuring point:

Mode of operation MIN

Measuring point status	Message	Current output (nominal)
Fork covered	Status "OK", incl. LIVE signal *1	18,5 mA*2
Fork free	Demand	9,0 mA*2
Fault	Alarm	< 3,6 mA
Short-circuit	Alarm	> 21,0 mA

Mode of operation MAX

Measuring point status	Message	Current output (nominal)
Fork free	Status "OK", incl. LIVE signal *1	13,5 mA*2
Fork covered	Demand	6,0 mA*2
Fault	Alarm	< 3,6 mA
Short-circuit	Alarm	> 21,0 mA

*1 LIVE signal means that, when the status is "OK", the current is modulated by a square-wave signal of 0.25 Hz and an amplitude of ±0.5 mA, → 🖹 20, "Behavior of device during operation and in case of error".

*2 For an application in SIL 1 or SIL 2, it is sufficient to program a current threshold of 12 mA (<12 mA: demand mode; > 12 mA: status "OK").

Restrictions 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.

For detailed specifications on the diagnostic coverage refer to IEC 61508-2:2010, Annex A.2, Note 2 and Table A.1.

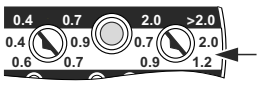
The specifications from the Operating Instructions ("Supplementary device documentation", → 7) must not be exceeded.

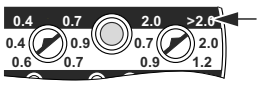
The following restriction also applies to safety-related use:

Density of the medium

The measuring system may only be used with liquids if:
- the density of the liquid is within the permitted density range and
- the gas phase above the liquid does not exceed the maximum permitted density value.

The permitted density ranges depend on the mode of operation selected.

Mode of operation MIN (white area)	Density range	Density ρ_{Low}	Density ρ_{High}	Type of liquid
 A0021084	1	0,4 g/cm³	0,7 g/cm³	liquified gas
	2	0,6 g/cm³	0,9 g/cm³	e.g. alcohol
	3	0,7 g/cm³	1,2 g/cm³	e.g. water
	4	0,9 g/cm³	2,0 g/cm³	e.g. acid

Mode of operation MAX (black area)	Density range	Density ρ_{Low}	Density ρ_{High}	Type of liquid
 A0020804	1	0,4 g/cm³	2,0 g/cm³	liquified gas
	2	0,7 g/cm³	> 2,0 g/cm³	other liquids

For information on exact settings "Operation", → 23.

The permitted density range of the gas phase above the liquid depends on the temperature of the process and the selected density range irrespective of the selected mode of operation (MIN/MAX detection).

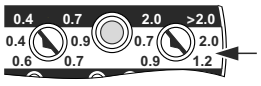
For the Liquiphant FailSafe to work correctly, a minimum differnce of the densities of the gas phase and the liquid phase is required.

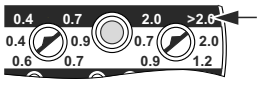
Process temperature	Maximum gas phase with density range			Feature 060, "Application", → 🖹 6
	1	2, 3	4	
−60 °C (−76 °F)	0,14 g/cm³	0,24 g/cm³	0,30 g/cm³	only C or D
−30 °C (−22 °F)	0,13 g/cm³	0,22 g/cm³	0,28 g/cm³	all
0 °C (+32 °F)	0,11 g/cm³	0,20 g/cm³	0,26 g/cm³	all
+20 °C (+68 °F)	0,10 g/cm³	0,19 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	only C or D
+230 °C (+446 °F)	not applicable	0,10 g/cm³	0,16 g/cm³	only C or D
+280 °C (+536 °F)	not applicable	0,07 g/cm³	0,12 g/cm³	only D

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

Process temperature

The temperature range within which safety-related operation is permitted depends on the density range selected.

Mode of operation MIN (white area)	Density range	Density ρ_{Low}	Density ρ_{High}	Temperature range	
				minimum	maximum
 A0021084	1	0,4 g/cm³	0,7 g/cm³	−50 °C (−58 °F)	+60 °C (+140 °F)
	2	0,6 g/cm³	0,9 g/cm³	according to Feature 060, "Application", → 🖹 6	
	3	0,7 g/cm³	1,2 g/cm³		
	4	0,9 g/cm³	2,0 g/cm³		

Mode of operation MAX (black area)	Density range	Density ρ_{Low}	Density ρ_{High}	Temperature range	
				minimum	maximum
 A0020804	1	0,4 g/cm³	2,0 g/cm³	−50 °C (−58 °F)	+60 °C (+140 °F)
	2	0,7 g/cm³	> 2,0 g/cm³	according to Feature 060, "Application", → 🖹 6	

Viscosity: MIN detection

The maximum permitted viscosity of the medium depends on the device version of Feature 060, "Application", → 🖹 6.

Maximum permitted viscosity	Feature 060, "Application"
350 mPA s	A, B
100 mPA s	C, D, N, P, T

A higher viscosity can have the effect that the fork no longer vibrates and the measuring system (FailSafe) reports a fault.
– The fault is detected with a high diagnostic coverage.

Viscosity: MAX detection

The viscosity of the medium must not exceed 10,000 mPa s. The Liquiphant FailSafe only reports the change of state from "covered" to "free" once enough viscous medium has flown off.
A medium with a higher viscosity can thus result in the switching times being exceeded (→ 🖹 13 and → 🖹 19).

Buildup: MIN detection only

The Liquiphant FailSafe FTL8x may only be used in media where buildup is not likely to occur.
Any deposit greater than 0.5 mm (0.02 in) in thickness is considered buildup. Buildup can have the effect that a demand mode of the safety function is not detected and the Liquiphant will not switch as intended.
– Buildup from 0.5 mm (0.02 in) is detected with low to medium diagnostic coverage.

Solid particles (heterogeneous mixtures): MIN detection only

The medium must not contain solid particles with a diameter greater than 5 mm (0.2 in).
A demand mode of the safety function may not be recognized and the Liquiphant will not switch as intended if solid deposits become jammed between the fork tines.
– Jamming is detected with medium diagnostic coverage.

Wall distance

The distance between the tuning fork of the Liquiphant FailSafe FTL8x and the wall of the tank or pipe containing the medium must be at least 10 mm (0.39 in).

Corrosion

The Liquiphant FailSafe FTL8x may only be used in media to which the process-wetted parts are resistant. Corrosion can have the effect that a demand mode of the safety function is not detected and the Liquiphant will not switch as intended.
- Mode of operation MIN detection: corrosion is detected with low diagnostic coverage.
- Mode of operation MAX detection: corrosion is detected with medium diagnostic coverage.

If coated sensors are used, measures must therefore be taken to ensure that there is no damage during installation and operation

Coating	Feature 080, "Surface Refinement", → 🖹 6
None	A
ECTFE	N
PFA (Edlon)	P
PFA (RubyRed)	Q
PFA (conductive)	R
Enamel	T

Abrasion

The Liquiphant FailSafe FTL8x must not be used or cleaned with media which are abrasive. Material removal can have the effect that a demand mode is not detected.
- Mode of operation MIN detection: abrasion is detected with low diagnostic coverage.
- Mode of operation MAX detection: 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 must not exceed 5 m/s. A stronger flow can have the effect that a demand mode is not detected and the sensor reports the state "free".

Vibrations from an external source

In systems exposed to strong external vibrations, e.g. in the 400 Hz 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.

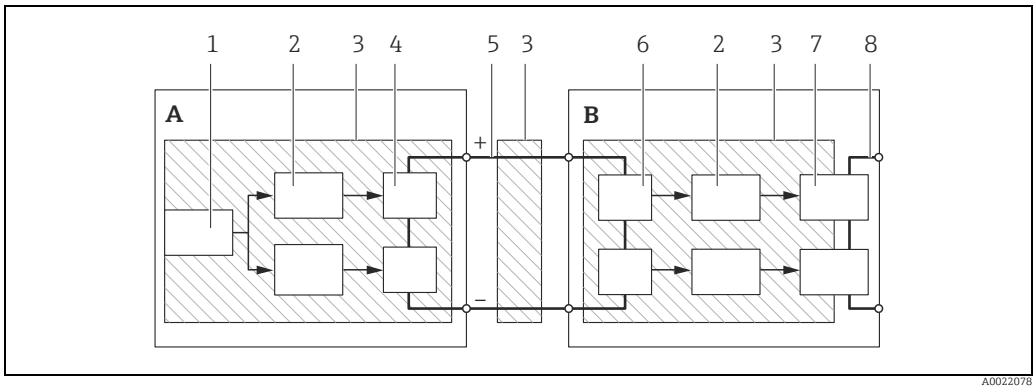
Electromagnetic compatibility

The FailSafe measuring system is checked in accordance with EN 61326-3-2 and is thus suitable for safety-related, industrial applications in a specified electromagnetic environment. The switching status may not be reliably detected if the specified electromagnetic environmental conditions are exceeded. An unshielded cable with a length of up to 1,000 m (3,281 ft) can be used between the Liquiphant FailSafe and Nivotester FailSafe FTL825 in these environmental conditions.
The use of shielded cables ensure a greater level of electromagnetic interference immunity.

Mounting the FTL81 with sliding sleeve

Particular care is required when mounting the Liquiphant FailSafe with an extension pipe in conjunction with a sliding sleeve. The operator must take measures to ensure that the switch point is not tampered with or that any tampering is reliably detected.

Information on Version I (Liquiphant FailSafe with Nivotester FailSafe)



3

A *Liquiphant FailSafe FTL8x*
B *Nivotester FailSafe FTL825*

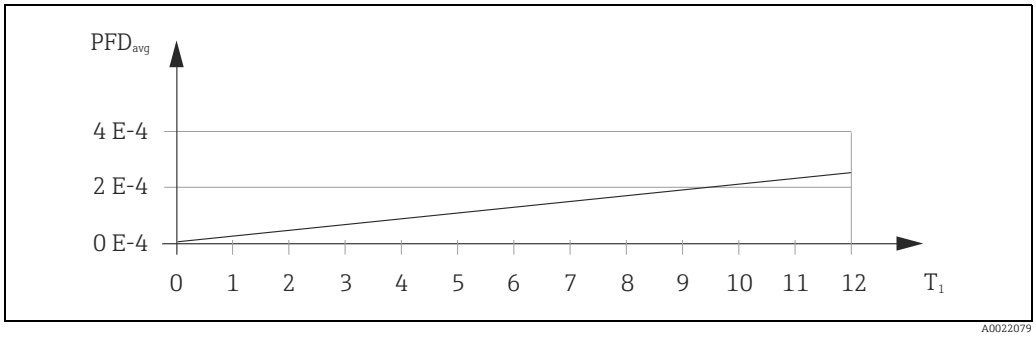
1 Sensor
2 Signal processing
3 Diagnosis
4 Output
5 4 to 20 mA Signal
6 Input
7 Relay
8 Safety contact

Functional safety figures

The following table show specific figures for functional safety.

Characteristic as per IEC 61508	Liquiphant FailSafe FTL80/81/85 with Nivotester FailSafe FTL825	
Safety functions	MIN	MAX
SIL / SC / SIL CL	3	
HFT / SFF (sensor FTL8x)	0 / 99,3%	
HFT / SFF (signal processing + output FTL8x)	1 / 99,8%	
HFT / SFF (FTL825)	1 / 99,7%	
Device type	B	
Mode of operation	Low demand mode	
SFF	99,7%	
λ_{sd}	1280 FIT	
λ_{su}	105 FIT	
λ_{dd}	120 FIT	
λ_{du}	5 FIT	
λ_{tot} *1	1509 FIT	
PFD_{avg} for T_1 = 1 year*2	$2{,}08 \times 10^{-5}$	
PFD_{avg} for T_1 = 12 years*2	$2{,}49 \times 10^{-4}$	
DC_{avg} *7	96,0%	
MTBF*1	76 years	
Expected life	Minimum 100000 switching cycles at the Nivotester	
Diagnostic test interval*4: HFT = 0 / HFT = 1	≤ 60 s / ≤ 30 min	
Fault reaction time*5	≤ 2,5 s	
System reaction time*6	≤ 1 s (±0,2)	≤ 0,5 s (±0,2)
Minimum value ß with homogeneous redundant use*3	5%	
Minimum value β_D with homogeneous redundant use*3	5%	

*1 According to Siemens SN29500. This value takes into account all failure types.
*2 Where the average temperature of the electronics when in continuous use is above +50 °C (+122 °F) or below −50 °C (-58 °F) a factor of 1.3 should be taken into account.
*3 Multichannel device operation ("Appendix", → 37).
*4 During this time, all diagnostic functions are executed at least once.
*5 Time between error detection and error response.
*6 Step response time as per DIN EN 61298-2.
*7 Calculated according to EN ISO 13849-1:2008 + AC:2009



4

T_1 Time interval for proof testing (years)

Dangerous undetected failures in this scenario:

An incorrect output signal, which results in a demand mode being reported as status "OK", is considered a dangerous undetected failure.

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.

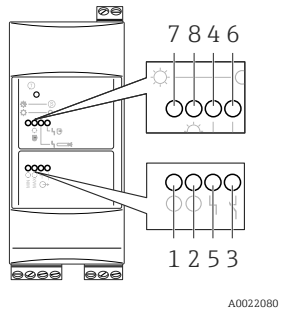
In accordance with DIN EN 61508-2, note N3), appropriate measures taken by the manufacturer and operator can extend the useful lifetime.

Behavior of device during operation and in case of error

The behavior of the device during operation and in the case of error is described in the Operating Instructions.

The tables on the following pages specify the status of the LEDs at the Nivotester FailSafe.

Arrangement of these LEDs:



5

LED	Number	Color
Monitoring LED	7	yellow
Covered status LED	8	yellow
Fault LED wiring	4	red
Fault LED Liquiphant FailSafe	6	red
Operating status LED MIN	1	green
Operating status LED MAX	2	green
Fault LED Nivotester FailSafe	5	red
Safety contact LED	3	yellow

Behavior of device when switched on

The device runs through a diagnostic phase of maximum 6 seconds after it is switched on.

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	open	closed	Safety function
Safety contact 1	13 <> 14	X		yes
Safety contact 2	23 <> 24	X		
Signaling contact	31 <> 32		X	no
Fault-signaling NC contact	6 <> 5		X	
Fault-signaling NO contact	4 <> 5	X		

The Nivotester FailSafe also displays the following LEDs for informational purposes (→ 14, 5):

LED	Number	Color	on	off	flashes
Monitoring LED	7	yellow		X	
Covered status LED	8	yellow		X	
Fault LED wiring	4	red		X	
Fault LED Liquiphant FailSafe	6	red		X	
Operating status LED MIN	1	green	X		
Operating status LED MAX	2	green	X		
Fault LED Nivotester FailSafe	5	red		X	
Safety contact LED	3	yellow		X	

- Both of the green operating status LEDs are on simultaneously, all of the others are off.

Behavior of device when the status is "OK"

Status "OK":
- 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	open	closed	Safety function
Safety contact 1	13 <> 14		X	yes
Safety contact 2	23 <> 24		X	
Signaling contact	31 <> 32	X		no
Fault-signaling NC contact	6 <> 5	X		
Fault signaling NO contact	4 <> 5		X	

The Nivotester FailSafe also displays the following LEDs for informational purposes (→ 14, 5):

LED	Number	Color	on	off	flashes
Monitoring LED	7	yellow			X
Covered status LED	8	yellow	MIN *1	MAX *1	
Fault LED wiring	4	red		X	
Fault LED Liquiphant FailSafe	6	red		X	
Operating status LED MIN	1	green	MIN *1	MAX *1	
Operating status LED MAX	2	green	MAX *1	MIN *1	
Fault LED Nivotester FailSafe	5	red		X	
Safety contact LED	3	yellow	X		

*1 Depends on the selected mode of operation (MIN detection or MAX detection) in each case

- The yellow monitoring LED flashes.

Behavior of device on demand

On demand:
- 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	open	closed	Safety function
Safety contact 1	13 <> 14	X		yes
Safety contact 2	23 <> 24	X		
Signaling contact	31 <> 32		X	no
Fault-signaling NC contact	6 <> 5	X		
Fault-signaling NO contact	4 <> 5		X	

The Nivotester FailSafe also displays the following LEDs for informational purposes (→ 14, 5):

LED	Number	Color	on	off	flashes
Monitoring LED	7	yellow		X	
Covered status LED	8	yellow	MAX *1	MIN *1	
Fault LED wiring	4	red		X	
Fault LED Liquiphant FailSafe	6	red		X	
Operating status LED MIN	1	green	MIN *1	MAX *1	
Operating status LED MAX	2	green	MAX *1	MIN *1	
Fault LED Nivotester FailSafe	5	red		X	
Safety contact LED	3	yellow		X	

*1 Depends on the selected mode of operation (MIN detection or MAX detection) in each case

- The yellow safety contact LED is off, only one of the green operating status LEDs is on.

Behavior of device when locking is enabled

When locking is enabled following a demand mode, when the voltage returns or after an alarm:
- 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	open	closed	Safety function
Safety contact 1	13 <> 14	X		yes
Safety contact 2	23 <> 24	X		
Signaling contact	31 <> 32		X	no
Fault-signaling NC contact	6 <> 5	X		
Fault-signaling NO contact	4 <> 5		X	

The Nivotester FailSafe also displays the following LEDs for informational purposes (→ 14, 5):

LED	Number	Color	on	off	flashes
Monitoring LED	7	yellow	X		
Covered status LED	8	yellow	MIN *1	MAX *1	
Fault LED wiring	4	red		X	
Fault LED Liquiphant FailSafe	6	red		X	
Operating status LED MIN	1	green	MIN *1	MAX *1	
Operating status LED MAX	2	green	MAX *1	MIN *1	
Fault LED Nivotester FailSafe	5	red		X	
Safety contact LED	3	yellow		X	

*1 Depends on the selected mode of operation (MIN detection or MAX detection) in each case

- The yellow monitoring LED is on.

Device response in the event of alarms or warnings
The safety contacts are open if a fault occurs. Alarms and warnings are treated in the same way.
A distinction is made between the following
- Fault on the Nivotester FailSafe
- Incorrect wiring
- Fault on 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	open	closed	Safety function
Safety contact 1	13 <> 14	X		yes
Safety contact 2	23 <> 24	X		
Signaling contact	31 <> 32		X	no
Fault-signaling NC contact	6 <> 5		X	
Fault-signaling NO contact	4 <> 5	X		

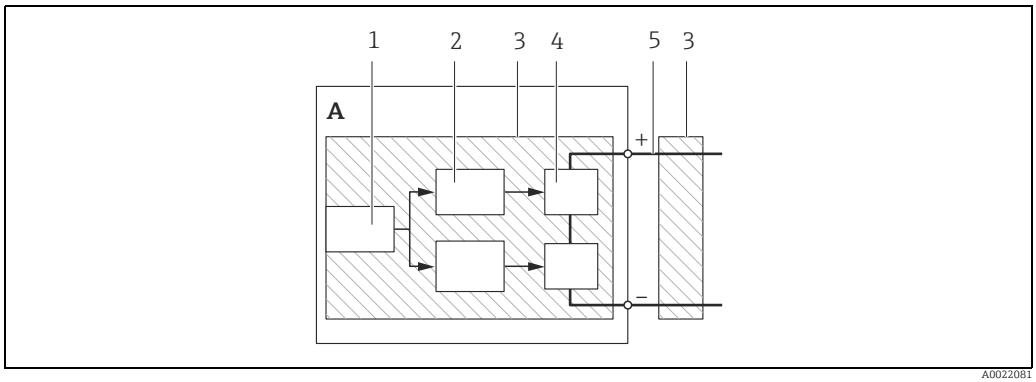
The Nivotester FailSafe also displays the following LEDs for informational purposes (→ 14, 5):

LED	Number	Color	on	off	flashes
Monitoring LED	7	yellow		X	
Covered status LED	8	yellow	*1	*1	
Fault LED wiring	4	red	*1	*1	*1
Fault LED Liquiphant FailSafe	6	red	*1	*1	*1
Operating status LED MIN	1	green	*1	*1	
Operating status LED MAX	2	green	*1	*1	
Fault LED Nivotester FailSafe	5	red	*1	*1	*1
Safety contact LED	3	yellow		X	

*1 Depends on the cause of the fault → Operating Instructions, "Troubleshooting" section.

- At least one of the red LEDs is on or is flashing.

Information on Version II (only Liquiphant FailSafe)



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A *Liquiphant FailSafe FTL8x*

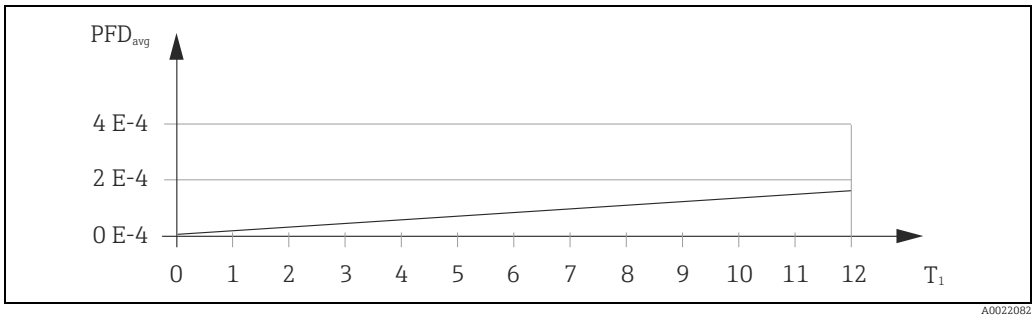
1 *Sensor*
2 *Signal processing*
3 *Diagnosis*
4 *Output*
5 *4 to 20 mA loop*

Functional safety figures

The following table show specific figures for functional safety.

Characteristic as per IEC 61508	Liquiphant FailSafe FTL80/81/85	
Safety functions	MIN	MAX
SIL / SC / SIL CL	3	
HFT / SFF (sensor FTL8x)	0 / 99,3%	
HFT / SFF (signal processing + output FTL8x)	1 / 99,8%	
Device type	B	
Mode of operation	High demand mode, Low demand mode	
SFF	99,6%	
λ_{sd}	782 FIT	
λ_{su}	19 FIT	
λ_{dd}	63 FIT	
λ_{du}	3 FIT	
λ_{tot} *1	867 FIT	
PFD_{avg} for T_1 = 1 year*2	$1{,}39 \times 10^{-5}$	
PFD_{avg} for T_1 = 12 years*2	$1{,}66 \times 10^{-4}$	
PFH*7	$3{,}17 \times 10^{-9}$ 1/h	
DC_{avg} *7	95,2%	
$MTTF_d$ *7	100 years	
MTBF*1	132 years	
Diagnostic test interval*4: HFT = 0 / HFT = 1	≤ 60 s / ≤ 30 min	
Fault reaction time*5	≤ 2,5 s	
System reaction time*6	≤ 1 s (±0,2)	≤ 0,5 s (±0,2)
Minimum value ß with homogeneous redundant use*3	5%	
Minimum value β_D with homogeneous redundant use*3	5%	

*1 According to Siemens SN29500. This value takes into account all failure types.
*2 Where the average temperature of the electronics when in continuous use is above +50 °C (+122 °F) oder below −50 °C (-58 °F) a factor of 1.3 should be taken into account.
*3 Multichannel device operation ("Appendix", → 37).
*4 During this time, all diagnostic functions are executed at least once.
*5 Time between error detection and error response.
*6 Step response time as per DIN EN 61298-2.
*7 Calculated according to EN ISO 13849-1:2008 + AC:2009



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T_1 *Time interval for proof testing (years)*

Dangerous undetected failures in this scenario:

An incorrect output signal, which results in a demand mode being reported as status "OK", is considered a dangerous undetected failure. (For an explanation of the status "OK" and the demand mode → 8).

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.

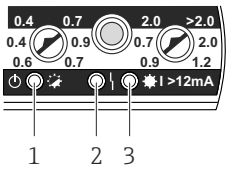
In accordance with DIN EN 61508-2, note NA4, appropriate measures taken by the manufacturer and operator can extend the useful lifetime.

Behavior of device during operation and in case of error

The behavior of the device during operation and in the case of error is described in the Operating Instructions ("Supplementary device documentation", → 7).

The tables on the following pages specify the status of the LEDs at the Liquiphant FailSafe.

Arrangement of these LEDs:



LED	Number	Color
Operating status LED	1	green
Fault LED	2	red
Current output LED	3	yellow

Behavior of device when switched on

The device runs through a diagnostic phase of maximum 6 seconds after it is switched on. During this time, the current output is set to error current ≤ 3.6 mA.

The Liquiphant FailSafe also displays the following LEDs for informational purposes:

LED	Number	Color	on	off	flashes
Operating status LED	1	green	X		
Fault LED	2	red		X	
Current output LED	3	yellow		X	

- The green operating status LED is on.

Behavior of device when the status is "OK"

When the device has status "OK", the current output is in the range between 12 mA and 20 mA. Two different current ranges are used to ensure that downstream components are able to automatically check the mode of operation.

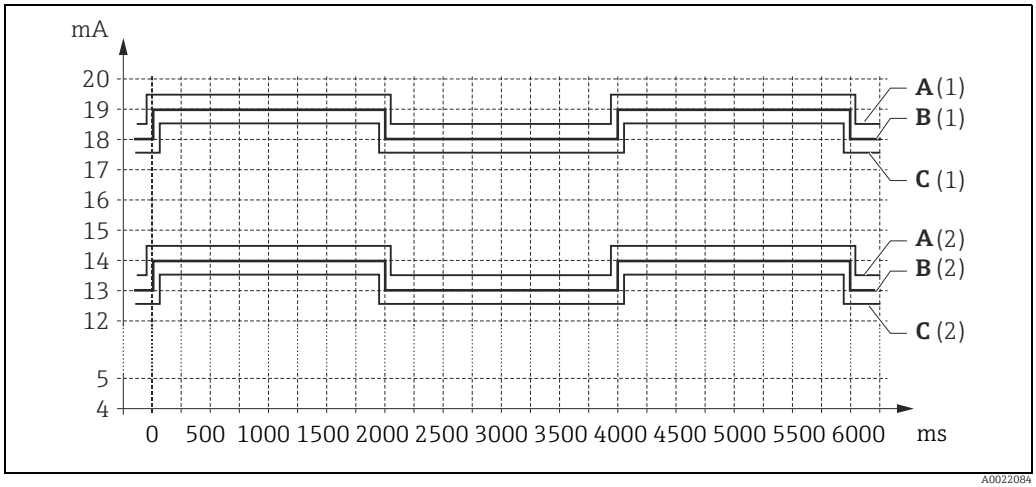
MIN detection
From 17,5 mA to 19,5 mA.

MAX detection
From 12,5 mA to 14,5 mA.

It is possible for downstream components to check automatically if a Liquiphant FailSafe FTL8x is connected. A LIVE signal is modulated within the ranges for this purpose.
This is a square-wave signal of 0.25 Hz and ±0.5 mA amplitude (the signal changes every 2,000 ms ±50 ms by 1 mA).

This LIVE signal is only modulated when the status is "OK" (→ 8)!
The connection of a standard Liquiphant as well as the occurrence of several faults simultaneously can cause this LIVE signal to fail.
The λ_{du} failure rate of the FailSafe measuring system itself does not decrease by monitoring of the LIVE signal. However, monitoring can serve to detect an error in other downstream components.

Liquiphant FailSafe current output when the status is "OK"



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A *Mode of operation MIN (1), Mode of operation MAX (2): upper tolerance*
B *Mode of operation MIN (1), Mode of operation MAX (2): nominal*
C *Mode of operation MIN (1), Mode of operation MAX (2): lower tolerance*

The Liquiphant FailSafe also displays the following LEDs for informational purposes:

LED	Number	Color	on	off	flashes
Operating status LED	1	green			X
Fault LED	2	red		X	
Current output LED	3	yellow	X		

- The yellow current output LED is on.

Behavior of device on demand

In demand mode, the current output is in the range between 4 mA and 12 mA.
Two different current ranges are used to ensure that downstream components are able to automatically check the mode of operation

MIN detection
From 8,0 mA to 10,0 mA.

MAX detection
From 5,0 mA to 7,0 mA.

The Liquiphant FailSafe also displays the following LEDs for informational purposes:

LED	Number	Color	on	off	flashes
Operating status LED	1	green			X
Fault LED	2	red		X	
Current output LED	3	yellow		X	

- Only the green operating status LED flashes.

Device response in the event of alarms or warnings

If a fault occurs, the current output is in the range below 3.6 mA.
Short-circuits are an exception to this: in this case, the current output is in the range above 21 mA

The logic unit must be able to detect HI alarms (≥ 21,0 mA) and LO alarms (≤ 3,6 mA) for the purpose of alarm monitoring. No distinction is made between alarms and warnings.

The Liquiphant FailSafe also displays the following LEDs for informational purposes:

LED	Number	Color	on	off	flashes
Operating status LED	1	green	*1	*1	*1
Fault LED	2	red	*1		*1
Current output LED	3	yellow		X	

*1 Depends on the cause of the fault. → Operating Instructions, "Troubleshooting" section.

- The red fault LED is on or flashes.

Installation

Installation, wiring, commissioning

Installation, wiring and commissioning of the device is described in the accompanying Operating Instructions ("Supplementary device documentation", → 🖹 7).

It is recommended to check the safety function before use. This can be done using a proof test, preferably following test sequence A ("Proof test", → 🖹 27).

Specific national regulations must be observed for the functional test of an overfill protection system. Note the relevant information in the certificates.

Mounting orientation

The permitted mounting orientations of the device are described in the Operating Instructions ("Supplementary device documentation", → 🖹 7).

Operation

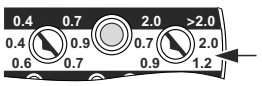
Selecting the mode of operation

The mode of operation (MIN or MAX detection) is chosen by selecting the terminals.
If Version I (Liquiphant FailSafe with Nivotester FailSafe) is used, both components must be operated in the same mode. A non-permitted combination of the Liquiphant FailSafe and Nivotester FailSafe will result in a fault; the Nivotester FailSafe will go to safe alarm mode and the fault LED "Wiring" lights up.

Mode of operation of the Liquiphant FailSafe FTL80, FTL81, FTL85

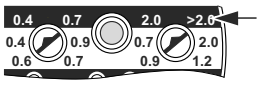
MIN detection

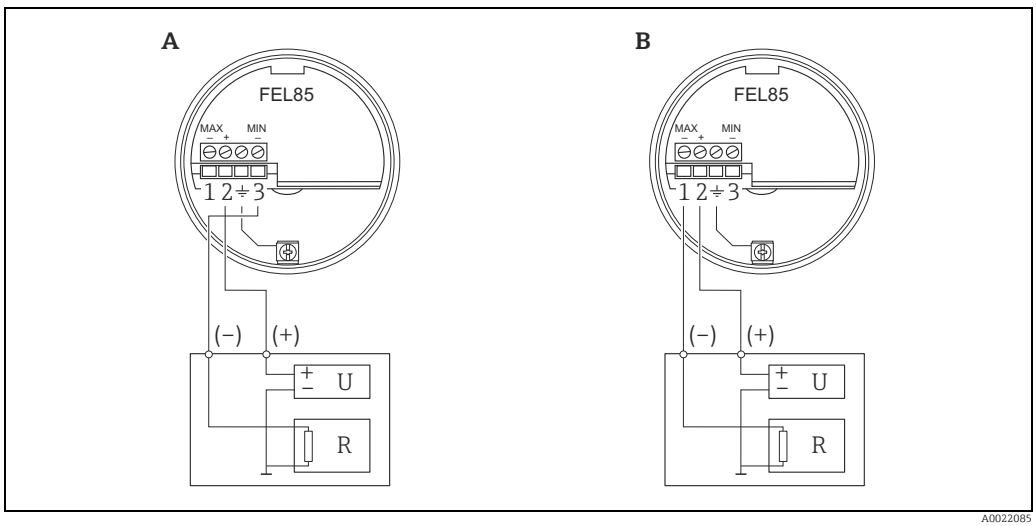
To select the mode of operation MIN, connect the minus wire of the 4 to 20 mA interface with terminal 3 (MIN −) and the plus wire with terminal 2 (+) on the Liquiphant FailSafe.
Terminal 1 (MAX −) must not be used

Mode of operation MIN (white area)	Density range	Density ρ_{Low}	Density ρ_{High}	Terminal		
				1	2	3
 A0021084	1	0,4 g/cm³	0,7 g/cm³	open	+	–
	2	0,6 g/cm³	0,9 g/cm³	open	+	–
	3	0,7 g/cm³	1,2 g/cm³	open	+	–
	4	0,9 g/cm³	2,0 g/cm³	open	+	–

MAX detection

To select the mode of operation MAX, connect the minus wire of the 4 to 20 mA interface with terminal 1 (MAX −) and the plus wire with terminal 2 (+) on the Liquiphant FailSafe.
Terminal 3 (MIN −) must not be used

Mode of operation MAX (black area)	Density range	Density ρ_{Low}	Density ρ_{High}	Terminal		
				1	2	3
 A0020804	1	0,4 g/cm³	2,0 g/cm³	–	+	open
	2	0,7 g/cm³	> 2,0 g/cm³	–	+	open



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A *MIN safety circuit*
B *MAX safety circuit*

Mode of operation of the Nivotester FailSafe FTL825

MIN detection

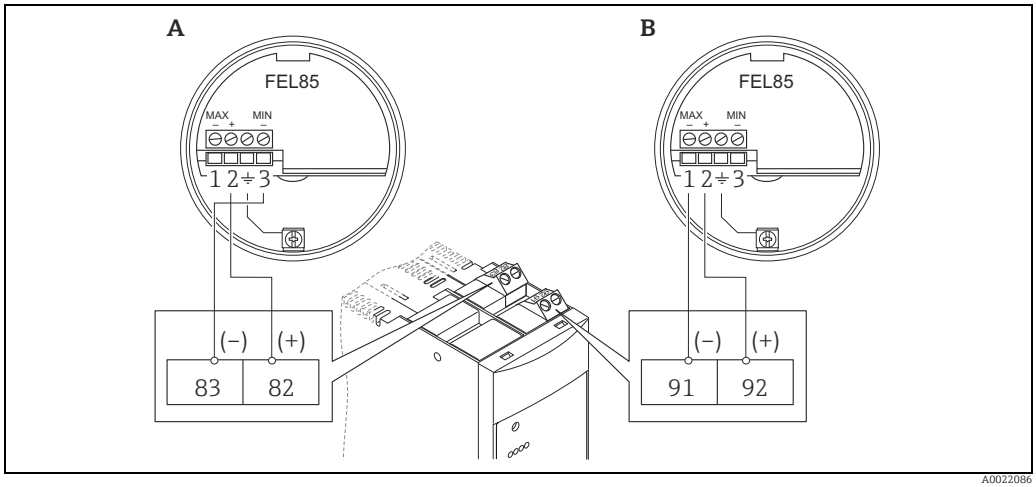
To select the mode of operation MIN, connect the minus wire of the 4 to 20 mA interface with terminal 3 (MIN –) on the Liquiphant FailSafe and with terminal 83 (MIN –) on the Nivotester FailSafe. Connect the plus wire of terminal 2 (+) on the Liquiphant FailSafe with terminal 82 (MIN +) on the Nivotester FailSafe. Terminal 1 (MAX –) on the Liquiphant FailSafe and terminals 91 (MAX –) and 92 (MAX +) must not be used

Terminal on the Liquiphant FailSafe			Terminal on the Nivotester FailSafe FTL825			
1	2	3	83	82	91	92
open	+	–	–	+	open	open

MAX detection

To select the mode of operation MAX, connect the minus wire of the 4 to 20 mA interface with terminal 1 (MAX –) on the Liquiphant FailSafe and terminal 91 (MAX –) on the Nivotester FailSafe. Connect the plus pipe of terminal 2 (+) on the Liquiphant FailSafe with terminal 92 (MAX +) on the Nivotester FailSafe. Terminal 3 (MIN –) on the Liquiphant FailSafe and terminals 83 (MIN –) and 82 (MIN +) must not be used

Terminal on the Liquiphant FailSafe			Terminal on the Nivotester FailSafe FTL825			
1	2	3	83	82	91	92
–	+	open	open	open	–	+



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A *MIN safety circuit*
B *MAX safety circuit*

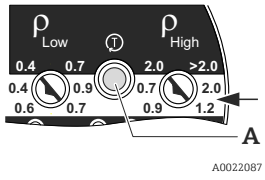
Selecting the density range

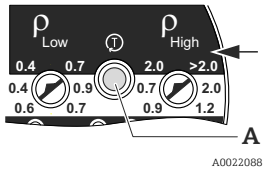
The setting on the density switch must be adjusted in accordance with the density range of the medium.

The density is set using two shuttle dials, ρ_{Low} and ρ_{High}, on the electronic insert of the Liquiphant FailSafe FTL8x.

The shuttle dials must always be parallel to one another (→ Operating Instructions)!

Confirm any changes to the configured density using the test button (**A**).

Mode of operation MIN (white area)	Density range	Density ρ_{Low}	Density ρ_{High}	Type of liquid
 *A* *Test button*	1	0,4 g/cm³	0,7 g/cm³	liquified gas
	2	0,6 g/cm³	0,9 g/cm³	e.g. alcohol
	3	0,7 g/cm³	1,2 g/cm³	e.g. water
	4	0,9 g/cm³	2,0 g/cm³	e.g. acid

Mode of operation MAX (black area)	Density range	Density ρ_{Low}	Density ρ_{High}	Type of liquid
 *A* *Test button*	1	0,4 g/cm³	2,0 g/cm³	liquified gas
	2	0,7 g/cm³	> 2,0 g/cm³	other liquids

Any change to the shuttle dial triggers an alarm, i.e. the output current becomes ≤ 3,6 mA and the red LED flashes. The readjustment is only active the next time the Liquiphant FailSafe is restarted.

This can be triggered in two ways:
- Activate the test button on the Liquiphant FailSafe FTL80, FTL81, FTL85.
- Disconnect the measuring system (FailSafe) from the supply voltage (approx. 1 second or longer).

After the restart, if the red LED continues to flash (after more than 6 seconds), the following may be the reasons:
- The tuning fork is locked in the mode of operation MIN.
- The device is operated beyond the permitted range of density or viscosity.
- The combination of the density range is not permitted.
  Example: mode of operation MIN from 0,4 kg/l to 1,2 kg/l
- The device is disabled.
  Both of the shuttle dials are pointing vertically upwards; this is the position when delivered.
- The mode of operation selected using the terminals does not correspond to the selected density combination ("Selecting the mode of operation", → 23).

For information on terminal assignment and shuttle dial settings → 23 (Liquiphant FailSafe) and → 24 (Nivotester FailSafe).

If the incorrect density range is selected, status "OK" may be reported as a demand mode or a fault.

Device configuration

Version I (Liquiphant FailSafe with Nivotester FailSafe)

The Nivotester FailSafe FTL825 can be configured so that, following a
– system start
– demand mode
– fault,

it remains in this status even if status "OK" is reached (locking enabled).
It only returns to status "OK" if the operator acknowledges the message by short-circuiting terminals 50 (COM) and 51 (restart).

Configuration is carried out using the hook switch behind the front flap of the Nivotester FailSafe FTL825 (→ Operating Instructions).

Configuration	Hook switch
Locked (demand mode or self-latching fault)	open
Automatic restart (to status "OK")	closed

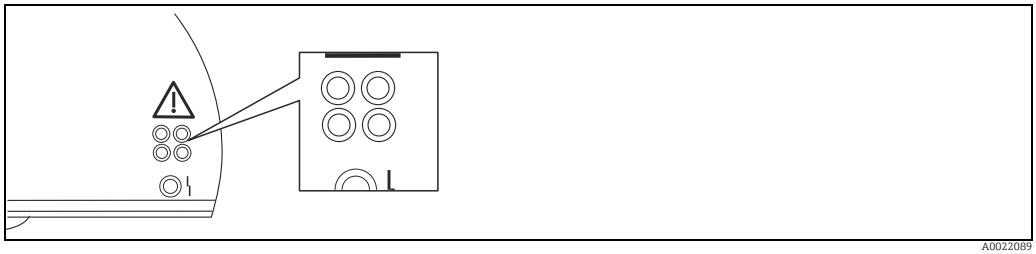
Provided acknowledgment occurs, i.e. terminals 50 and 51 are bridged, the Nivotester FailSafe changes to status "OK" immediately - even if the hook switch is open!
This can be used in order to be able to perform configuration externally, e.g. using a switch in an operation panel. However, if this response is not desired, or should it result in a dangerous state, care must be taken to ensure that the two terminals are not short-circuited either by accident or by a fault

Maintenance

As a general rule, the measuring system (FailSafe) does not require maintenance.

However, depending on usage conditions, it is recommended to visually check the tuning fork, cable entries and cover seal for external damage, e.g. bending, corrosion, buildup, etc.

The diagnostic socket at the electronics insert FEL85 of the Liquiphant FailSafe FTL8x enables the indication of the measured frequency of the fork, for example with a frequency counter or an oscilloscope. However, care must be taken that no electrical power supply units or any other devices which might supply electrical energy are connected



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- The diagnostic socket may only be used if the person responsible for doing so has been trained beforehand by Endress+Hauser!
- The usage of the diagnostic socket during functional safety operations is not permitted!

Proof test

Proof test

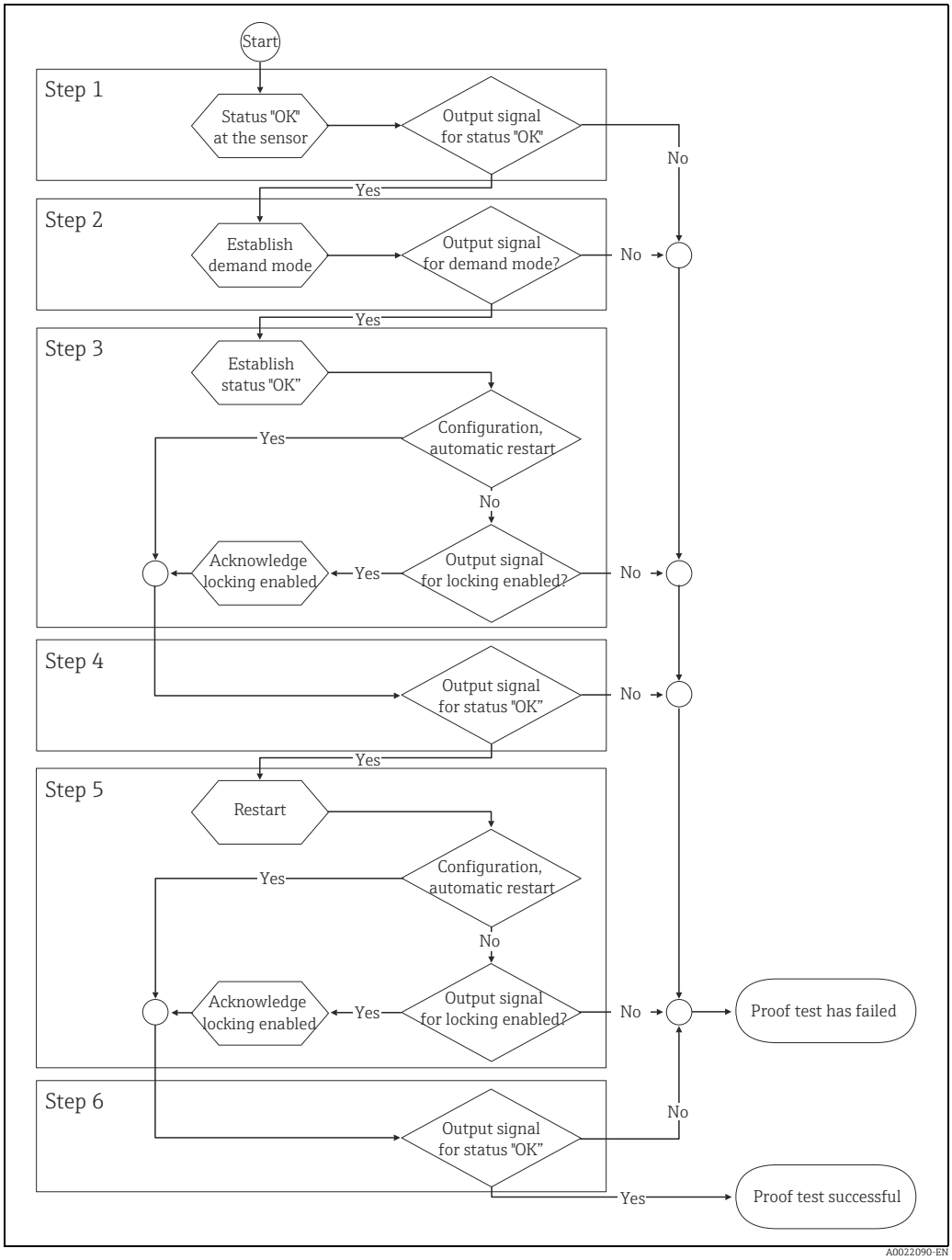
Check the operativeness and safety of safety functions at appropriate intervals.
The operator must determine the time intervals. The values and diagrams in the "Functional safety indicators" section (→ 🖹 13, "Information on Version I" and → 🖹 19, "Information on Version II") can be used for this purpose.

The test must be carried out in such a way that it verifies correct functioning of the protective system in conjunction with all of the components.

Proof testing of the device can be carried out as follows:
- Approaching the level or removing and immersing in a medium of the same density (→ Test sequence A).
- Simulation on the Liquiphant FailSafe or the Nivotester FailSafe by activating the test button (→ Test sequence B).

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

Process for proof testing



Preparation:
A demand mode or a fault always takes absolute precedence in the safety path of the FailSafe measuring system - even ahead of the proof test. For this reason, the fault must first be rectified or the demand mode completed.

The proof test can only and must only be carried out when the system has status "OK".

For the proof test, a component is required which shows the status of the relevant output signal. This can be a downstream component of the safety path (e.g. a safety-related PLC or the actuator), or a measuring device. For information on the type of output signal "System components", → 4.
It is recommended to record the steps of the proof test.
For information on the form "Commissioning or proof test protocol for Version I", → 37 or "Commissioning or proof test protocol for Version II", → 38.

Version I (Liquiphant FailSafe with Nivotester FailSafe)

	Mode of operation	
	MIN	**MAX**
▪ Approaching the level or ▪ Removing and immersing in a medium of comparable density	Test sequence I A, MIN, → 29	Test sequence I A, MAX, → 30
Simulation on the Liquiphant FailSafe by activating the test button	Test sequence I B, → 31	
Simulation on the Nivotester FailSafe by activating the test button		

Version II (only Liquiphant FailSafe)

	Mode of operation	
	MIN	**MAX**
▪ Approaching the level or ▪ Removing and immersing in a medium of comparable density	Test sequence II A, MIN, → 32	Test sequence II A, MAX, → 33
Simulation on the Liquiphant FailSafe by activating the test button	Test sequence II B, MIN, → 34	Test sequence II B, MAX, → 35

If one of the test criteria from the test sequences described above is not fulfilled, the device may no longer be used as part of a safety instrumented system.
The purpose of proof testing is to detect random device failures. The impact of systematic faults on the safety function is not covered by this test and must be assessed separately.
Systematic faults can be caused, for example, by process material properties, operating conditions, buildup or corrosion

Information on Version I (Liquiphant FailSafe with Nivotester FailSafe)

Test sequence I A, MIN

Approaching the level or removing and immersing in a medium of comparable density.

Step 1
- Raise the level or immerse the tuning fork of the sensor that has been removed in the medium until it is fully covered. If this is not possible with the original medium, use a medium with the same density and viscosity
- If the Nivotester FailSafe is configured to "Locking enabled", acknowledge this now.
- 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, there is a fault in the safety path. The proof test has failed and must be canceled.

Step 2
- 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.
- 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, there is a fault in the safety path. The proof test has failed and must be canceled.

Step 3
- Raise the level or immerse the tuning fork of the sensor that has been removed in the medium until it is fully covered.
- If the Nivotester FailSafe is configured to "Immediate change to status OK", continue with step 4.
- If the Nivotester FailSafe is configured to "Locking enabled", terminals 13 and 14 (safety contact 1) and terminals 23 and 24 (safety contact 2) must now be open.
  If the safety contacts are closed, there is a fault in the self-latching mechanism. If this is required for the safety function, the proof test is deemed unsuccessful and must be canceled.
- Acknowledge locking enabled.

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, there is a fault in the safety path. The proof test has failed and must be canceled.

Step 5
- If the sensor was removed, it must now be refitted and status "OK" established once again.
- Restart the Nivotester FailSafe by pressing its test button and wait until it completes the automatic, internal diagnostic phase (at least 8 s).
- If the Nivotester FailSafe is configured to "Immediate change to status OK", continue with step 6.
- If the Nivotester FailSafe is configured to "Locking enabled", terminals 13 and 14 (safety contact 1) and terminals 23 and 24 (safety contact 2) must now be open.
  If the safety contacts are closed, there is a fault in the self-latching mechanism. If this is required for the safety function, the proof test is deemed unsuccessful and must be canceled.
- Acknowledge locking enabled.

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, there is a fault in the safety path. The proof test has failed and must be canceled.

If all of the steps have been completed successfully, the proof test is successful!

This type of test checks the entire safety path including the interaction between the medium and the tuning fork!

In addition to the diagnostic coverage (DC) of 96% of the internal diagnostic events, more than 90% (PTC = Proof Test Coverage) of the remaining dangerous undetected device failures are detected by this proof-test. This results in a total diagnostic coverage of more than 99%.

For troubleshooting → Operating Instructions ("Supplementary device documentation", → 7), "Troubleshooting" section.

Test sequence I A, MAX

Approaching the level or removing and immersing in a medium of comparable density.

Step 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 this is not possible with the original medium, use a medium with the same density and viscosity
- If the Nivotester FailSafe is configured to "Locking enabled", there is no demand mode yet the safety contacts are nevertheless open, you must check if the last demand mode was acknowledged. If necessary, acknowledge once again.
- 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, there is a fault in the safety path. The proof test has failed and must be canceled

Step 2
- Raise the level or immerse the tuning fork of the sensor that has been removed into the medium until it is fully covered.
- 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, there is a fault in the safety path. The proof test has failed and must be canceled

Step 3
- 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 the Nivotester FailSafe is configured to "Immediate change to status OK"continue with step 4.
- If the Nivotester FailSafe is configured to "Locking enabled", terminals 13 and 14 (safety contact 1) and terminals 23 and 24 (safety contact 2) must now be open. If the safety contacts are closed, there is a fault in the self-latching mechanism. If this is required for the safety function, the proof test is deemed unsuccessful and must be canceled.
- Acknowledge locking enabled.

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, there is a fault in the safety path. The proof test has failed and must be canceled.

Step 5
- If the sensor was removed, it must now be refitted.
- Restart the Nivotester FailSafe by pressing its test button and wait until it completes the automatic, internal diagnostic phase (at least 8 s).
- If the Nivotester FailSafe is configured to "Immediate change to status OK", continue with step 6.
- If the Nivotester FailSafe is configured to "Locking enabled", terminals 13 and 14 (safety contact 1) and terminals 23 and 24 (safety contact 2) must now be open. If the safety contacts are closed, there is a fault in the self-latching mechanism. If this is required for the safety function, the proof test is deemed unsuccessful and must be canceled.
- Acknowledge locking enabled.

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, there is a fault in the safety path. The proof test has failed and must be canceled.

If all of the steps have been completed successfully, the proof test is successful!

This type of test checks the entire safety path including the interaction between the medium and the tuning fork!

In addition to the diagnostic coverage (DC) of 96% of the internal diagnostic events, more than 90% (PTC = Proof Test Coverage) of the remaining dangerous undetected device failures are detected by this proof-test. This results in a total diagnostic coverage of more than 99%.

For troubleshooting → Operating Instructions ("Supplementary device documentation", → 7), Troubleshooting" section.

Test sequence I B

Simulation on the Liquiphant FailSafe or Nivotester FailSafe by pressing the test button.

Step 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. If the safety contacts are open, there is a fault in the safety path. The proof test has failed and must be canceled ▪ If the Nivotester FailSafe is configured to "Locking enabled", there is no demand mode yet the safety contacts are nevertheless open, check if the last demand mode was already acknowledged. If necessary, acknowledge once more.
Step 2	▪ Activate the test button on the Liquiphant FailSafe or on the Nivotester FailSafe. If the test button is released, 5 seconds remain for checking. If more time is required, keep the button pressed ▪ 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, there is a fault in the safety path. The proof test has failed and must be canceled.
Step 3	▪ not applicable
Step 4	▪ not applicable
Step 5	▪ If the test button on the Nivotester FailSafe was activated, you must wait until the automatic, internal diagnostic phase has been completed (at least 8 s). If the test button on the Liquiphant FailSafe was activated, restart the Nivotester FailSafe by pressing its test button and wait until it completes the automatic, internal diagnostic phase (at least 8 s). ▪ If the Nivotester FailSafe is configured to "Immediate change to status OK", continue with step 6. ▪ If the Nivotester FailSafe is configured to "Locking enabled", terminals 13 and 14 (safety contact 1) and terminals 23 and 24 (safety contact 2) must now be open. If the safety contacts are closed, there is a fault in the self-latching mechanism. If this is required for the safety function, the proof test is deemed unsuccessful and must be canceled. ▪ Acknowledge locking enabled..
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, there is a fault in the safety path. The proof test has failed and must be canceled.

If all of the steps have been completed successfully, the proof test is successful!

This type of test only checks the electrical safety path!

When simulating by pressing the test button an error rate of 3 FIT remains due to the untested parts of the safety path.

In addition to the diagnostic coverage (DC) of 96% of the internal diagnostic events, approx. 34% (PTC = Proof Test Coverage) of the remaining dangerous undetected device failures are detected by this proof-test. This results in a total diagnostic coverage of more than 97.4%.

In order to increase the total diagnostic coverage to more than 99%, the accuracy of the switch point can also be checked → Operating Instructions, "Installing the Liquiphant FailSafe" section.

For troubleshooting → Operating Instructions ("Supplementary device documentation", → 7), "Troubleshooting" section.

Information on Version II (only Liquiphant FailSafe)

Test sequence II A, MIN

Approaching the level or removing and immersing in a medium of comparable density.

Step 1	▪ Raise the level or immerse the tuning fork of the sensor that has been removed in the medium until it is fully covered. If this is not possible with the original medium, use a medium with the same density and viscosity. ▪ Check the current consumption of the Liquiphant FailSafe (17.5 mA to 19.5 mA). If the current is not within this range, there is a fault in the safety path. The proof test has failed and must be canceled.
Step 2	▪ 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. ▪ Check the current consumption of the Liquiphant FailSafe (8.0 mA to 10.0 mA). If the current is not within this range, there is a fault in the safety path. The proof test has failed and must be canceled.
Step 3	▪ Raise the level or immerse the tuning fork of the sensor that has been removed in the medium until it is fully covered.
Step 4	▪ Check the current consumption of the Liquiphant FailSafe (17.5 mA to 19.5 mA). If the current is not within this range, there is a fault in the safety path. The proof test has failed and must be canceled.
Step 5	▪ If the sensor was removed, it must now be refitted and status "OK" established. ▪ Restart the Liquiphant FailSafe by pressing its test button and wait until it completes the automatic, internal diagnostic phase (at least 8 s).
Step 6	▪ Check the current consumption of the Liquiphant FailSafe (17.5 mA to 19.5 mA). If the current is not within this range, there is a fault in the safety path. The proof test has failed and must be canceled.

If all of the steps were completed successfully, the proof test is successful!

This type of test checks the entire safety path including the interaction between the medium and the tuning fork!!

In addition to the diagnostic coverage (DC) of 95.2% of the internal diagnostic events, more than 90% (PTC = Proof Test Coverage) of the remaining dangerous undetected device failures are detected by this proof-test. This results in a total diagnostic coverage of more than 99%.

For troubleshooting → Operating Instructions ("Supplementary device documentation", → 7), Troubleshooting" section.

Test sequence II A, MAX

Approaching the level or removing and immersing in a medium of comparable density.

Step 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 this is not possible with the original medium, use a medium with the same density and viscosity. ▪ Check the current consumption of the Liquiphant FailSafe (12.5 mA to 14.5 mA). If the current is not within this range, there is a fault in the safety path. The proof test has failed and must be canceled.
Step 2	▪ Raise the level or immerse the senor that has been removed in the medium until it is fully covered. ▪ Check the current consumption of the Liquiphant FailSafe (5.0 mA to 7.0 mA). If the current is not within this range, there is a fault in the safety path. The proof test has failed and must be canceled.
Step 3	▪ 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.
Step 4	▪ Check the current consumption of the Liquiphant FailSafe (12.5 mA to 14.5 mA). If the current is not within this range, there is a fault in the safety path. The proof test has failed and must be canceled.
Step 5	▪ If the sensor was removed, it must now be refitted. ▪ Restart the Liquiphant FailSafe by pressing its test button and wait until it completes the automatic, internal diagnostic phase (at least 8 s).
Step 6	▪ Check the current consumption of the Liquiphant FailSafe (12.5 mA to 14.5 mA). If the current is not within this range, there is a fault in the safety path. The proof test has failed and must be canceled.

If all of the steps were completed successfully, the proof test is successful!

This type of test checks the entire safety path including the interaction between the medium and the tuning fork!!

In addition to the diagnostic coverage (DC) of 95.2% of the internal diagnostic events, more than 90% (PTC = Proof Test Coverage) of the remaining dangerous undetected device failures are detected by this proof-test. This results in a total diagnostic coverage of more than 99%.

For troubleshooting → Operating Instructions ("Supplementary device documentation", → 7), "Troubleshooting" section.

Test sequence II B, MIN

Simulation on the Liquiphant FailSafe by pressing the test button.

Step 1	▪ Check the current consumption of the Liquiphant FailSafe (17.5 mA and 19.5 mA). If the current is not within this range, there is a fault in the safety path. The proof test has failed and must be canceled.
Step 2	▪ Activate the test button on the Liquiphant FailSafe. If the test button is released, 5 seconds remain for checking. If more time is required, keep the button pressed. ▪ Check the current consumption of the Liquiphant FailSafe (8.0 mA and 10.0 mA). If the current is not within this range, there is a fault in the safety path. The proof test has failed and must be canceled.
Step 3	▪ not applicable
Step 4	▪ not applicable
Step 5	▪ Wait until the Liquiphant FailSafe has completed the automatic, internal diagnostic phase (at least 8 s).
Step 6	▪ Check the current consumption of the Liquiphant FailSafe (17.5 mA and 19.5 mA). If the current is not within this range, there is a fault in the safety path. The proof test has failed and must be canceled.

If all of the steps were completed successfully, the proof test is successful!

This type of test only checks the electrical safety path and the subsequent parts of the plant!

By simulating using the test button, an error rate of 3 FIT remains due to the untested parts of the safety path.

In addition to the diagnostic coverage (DC) of 95.2% of the internal diagnostic events, approx. 4% (PTC = Proof Test Coverage) of the remaining dangerous undetected device failures are detected by this proof-test. This results in a total diagnostic coverage of more than 95.4%.

In order to increase the total diagnostic coverage to more than 99%, the accuracy of the switch point can also be checked → Operating Instructions, "Installing the Liquiphant FailSafe".

For troubleshooting → Operating Instructions ("Supplementary device documentation", → 7), "Troubleshooting" section.

Test sequence II B, MAX

Simulation on the Liquiphant FailSafe by pressing the test button.

Step 1	▪ Check the current consumption of the Liquiphant FailSafe (12.5 mA and 14.5 mA). If the current is not within this range, there is a fault in the safety path. The proof test has failed and must be canceled
Step 2	▪ Activate the test button on the Liquiphant FailSafe. If the test button is released, 5 seconds remain for checking. If more time is required, keep the button pressed.. ▪ Check the current consumption of the Liquiphant FailSafe (5.0 mA and 7.0 mA). If the current is not within this range, there is a fault in the safety path. The proof test has failed and must be canceled.
Step 3	▪ not applicable
Step 4	▪ not applicable
Step 5	▪ Wait until the Liquiphant FailSafe has completed the automatic, internal diagnostic phase (at least 8 s).
Step 6	▪ Check the current consumption of the Liquiphant FailSafe (12.5 mA and 14.5 mA). If the current is not within this range, there is a fault in the safety path. The proof test has failed and must be canceled.

If all of the steps were completed successfully, the proof test is successful!

This type of test only checks the electrical safety path and the subsequent parts of the plant!

By simulating using the test button, an error rate of 3 FIT remains due to the untested parts of the safety path.

In addition to the diagnostic coverage (DC) of 95.2% of the internal diagnostic events, approx. 4% (PTC = Proof Test Coverage) of the remaining dangerous undetected device failures are detected by this proof-test. This results in a total diagnostic coverage of more than 95.4%.

In order to increase the total diagnostic coverage to more than 99%, the accuracy of the switch point can also be checked → Operating Instructions, "Installing the Liquiphant FailSafe" section.

For troubleshooting → Operating Instructions ("Supplementary device documentation", → 7), "Troubleshooting" section.

Additional options for testing non-SIL functions

Non-SIL outputs and non-SIL LED displays can also be tested during proof testing. This is optional and not required for safety-related use.
The device may still be used even if there is an error in these functions. However, it is recommended that it be replaced at the next possible opportunity.

Liquiphant FailSafe

If the test button on the Liquiphant FailSafe is pressed, the green and the red LED light up alternately in the sequence 1 left / 1 right and the yellow LED is off. The yellow LED remains lit in step 1 and step 6.

Nivotester FailSafe

The signaling contact (terminal 31 and 32) reacts in the opposite way to the safety contacts.
The fault-signaling NO contact is closed in step 1 and step 6.
The fault-signaling NC contact is only closed temporarily while the measuring system (FailSafe) is restarting.

When the test button on the Nivotester FailSafe is pressed, the 8 LEDs alternately light up in the sequence of 4 at the top / 4 at the bottom.

The yellow safety contact LED lights up in step 1 and step 6. This safety contact LED shows the status of the safety contacts except in the phase where all of the LEDs alternately flash.

Repairs

Repairs

Repairs on the devices must always be carried out by Endress+Hauser.
Safety functions cannot be guaranteed if repairs are carried out by anybody else.

Exception:
The customer may replace the following components of the measuring system on condition that original replacement parts are used, the member of staff responsible has previously been trained by Endress+Hauser to carry out this task and the relevant Installation Instructions are observed:

- Cover
- Cover seal
- Cable gland
- Electronic insert FEL85

The replaced components must be sent to Endress+Hauser for the purpose of fault analysis.
Once the components have been replaced, a proof test must be carried out preferably as per test sequence A ("Version I ", → 29 or "Version II", → 34).

Return

Return

In the event of failure of a SIL-labeled Endress+Hauser device, which has been operated in a protection function, the "Declaration of Contamination and Cleaning" with the corresponding note "Used as SIL device in protection system" must be enclosed when the defective device is returned.

According to legal regulations, Endress+Hauser, as an ISO-certified company, is required to follow certain procedures when handling returned products that are in contact with medium.

To ensure swift, safe and professional device returns, please read the return procedures and conditions on the Endress+Hauser website at www.services.endress.com/return-material.

Appendix

Notes on the redundant use of multiple sensors

The common cause failure (ß values) specified in the tables (Section "Information on Version I", → 13 and "Information on Version II", → 19) are minimum for the FailSafe measuring system. These must be used when designing the sensor subsystem.

Commissioning or proof test protocol for Version I

Version I (Liquiphant FailSafe with Nivotester FailSafe)

System-specific data			
Company			
Measuring point / TAG no.			
System			
Device type / Order code			
Liquiphant serial no.			
Nivotester serial no.			
Name			
Date			
Signature			
Mode of operation, density range and configuration (tick the appropriate option)			
Mode of operation MIN safety ☐	Density range:	0.4 to 0.7 ☐	
		0.6 to 0.9 ☐	
		0.7 to 1.2 ☐	
		0.9 to 2.0 ☐	
Mode of operation MAX safety ☐	Density range:	0.4 to 2.0 ☐	
		0.7 to >2.0 ☐	
Configuration		Automatic restart ☐	
		Locking enabled ☐	
Protocol for commissioning or proof test			
Test sequence	**I A**	Approaching the level ☐	
		Removing and immersing in a medium of comparable density ☐	
	I B	Simulation on the Liquiphant FailSafe by activating the test button ☐	
		Simulation on the Nivotester FailSafe by activating the test button ☐	
Test step	**Terminal**	**Set point**	**Actual value**
Step 1 (Status "OK")	13 and 14	closed	
	23 and 24	closed	
Step 2 (Demand mode)	13 and 14	open	
	23 and 24	open	
Step 3 *1 *2 (Locking enabled)	13 and 14	open	
	23 and 24	open	
Step 4 *2 (Status "OK")	13 and 14	closed	
	23 and 24	closed	
Step 5 *1 (Restart, locking enabled)	13 and 14	open	
	23 and 24	open	
Step 6 (Restart)	13 and 14	closed	
	23 and 24	closed	

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*1 *Not applicable when "Automatic restart" is configured .*

*2 *Not applicable in the case of simulation on the Liquiphant FailSafe or Nivotester FailSafe by pressing the test button ("Test sequence I B", → 31).*

Commissioning or proof test protocol for Version II

Version II (only Liquiphant FailSafe)

System-specific data			
Company			
Measuring point / TAG no.			
System			
Device type / Order code			
Liquiphant serial no.			
Name			
Date			
Signature			
Mode of operation, density range and configuration (tick the appropriate option)			
Mode of operation MIN safety ☐	Density range:	0.4 to 0.7 ☐	
		0.6 to 0.9 ☐	
		0.7 to 1.2 ☐	
		0.9 to 2.0 ☐	
Mode of operation MAX safety ☐	Density range:	0.4 to 2.0 ☐	
		0.7 to >2.0 ☐	
Protocol for commissioning or proof test			
Test sequence	**II A**	Approaching the level ☐	
		Removing and immersing in a medium of comparable density ☐	
	II B	Simulation on the Liquiphant FailSafe by activating the test button ☐	
Test step	**Set point MIN safety**	**Set point MAX safety**	**Actual value**
Step 1 (Status “OK”)	17.5 to 19.5 mA	12.5 to 14.5 mA	
Step 2 (Demand mode)	8.0 to 10.0 mA	5.0 to 7.0 mA	
Step 3 *[1]	without	without	
Step 4 *[1] (Status “OK”)	17.5 to 19.5 mA	12.5 to 14.5 mA	
Step 5	without	without	
Step 6 (Status “OK”)	17.5 to 19.5 mA	12.5 to 14.5 mA	

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*[1] *Not applicable in the case of simulation on the Liquiphant FailSafe by pressing the test button ("Test sequence II B, MIN", → 🖹34 and "Test sequence II B, MAX", → 🖹35).*

Certificate

Certificate

Nr./No.: 968/EL 676.02/17

Prüfgegenstand **Product tested**	Sichere Überwachung eines Füllstandes Safe detection of a level	**Zertifikats-inhaber** **Certificate holder**	Endress + Hauser GmbH + Co. KG Hauptstraße 1 79689 Maulburg Germany
Typbezeichnung **Type designation**	Variant 1: Liquiphant FailSafe FTL80, FTL81, FTL85 with Nivotester FailSafe FTL825 Variant 2: Liquiphant FailSafe FTL80, FTL81, FTL85		
Prüfgrundlagen **Codes and standards**	IEC 61508 Parts 1-7:2010 IEC 62061:2015		EN ISO 13849-1:2015 ANSI/ISA -84.00.01-1:2004
Bestimmungsgemäße Verwendung **Intended application**	Die Geräte erfüllen die Anforderungen der Prüfgrundlagen (SIL CL 3 nach IEC 61508 / IEC 62061, PL e nach EN ISO 13849-1) und können in Anwendungen bis SIL 3 und PL e eingesetzt werden. The devices comply with the requirements of the relevant standards (SIL CL 3 acc. to IEC 61508 / IEC 62061, PL e acc. to EN SO 13849-1) and can be used in applications up to SIL 3 and PL e.		
Besondere Bedingungen **Specific requirements**	Die Hinweise in dem zugehörigen Handbuch zur funktionalen Sicherheit und der zugehörigen Betriebsanleitung sind zu beachten. The provisions defined in the Functional Safety Manual and the Operating Instructions shall be maintained.		

Gültig bis / Valid until 2022-06-20

Der Ausstellung dieses Zertifikates liegt eine Prüfung zugrunde, deren Ergebnisse im Bericht Nr. 968/EL 676.02/17 vom 20.06.2017 dokumentiert sind.
Dieses Zertifikat ist nur gültig für Erzeugnisse, die mit dem Prüfgegenstand übereinstimmen. Es wird ungültig bei jeglicher Änderung der Prüfgrundlagen für den angegebenen Verwendungszweck.
The issue of this certificate is based upon an examination, whose results are documented in Report No. 968/EL 676.02/17 dated 2017-06-20.
This certificate is valid only for products which are identical with the product tested. It becomes invalid at any change of the codes and standards forming the basis of testing for the intended application.

Köln, 2017-06-20

TÜV Rheinland Industrie Service GmbH
Bereich Automation
Funktionale Sicherheit
Am Grauen Stein, 51105 Köln
Certification Body Safety & Security for Automation & Grid

Dipl.-Ing. Stephan Häb

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TÜV Rheinland Industrie Service GmbH, Am Grauen Stein, 51105 Köln / Germany
Tel.: +49 221 806-1790, Fax: +49 221 806-1539, E-Mail: industrie-service@de.tuv.com

Zertifikat_20-06-2017

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