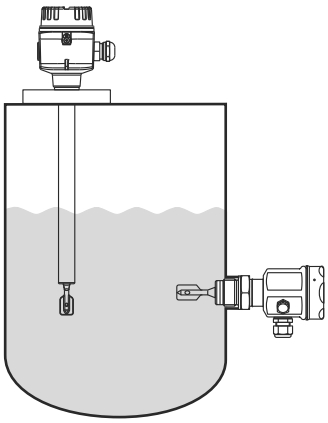
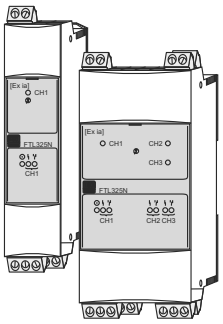
Functional safety manual
Liquiphant M/S with FEL57 and Nivotester FTL325P





Level Limit Measuring System

Application
Dry running protection or operating minimum detection of all types of liquids in tanks to satisfy particular safety systems requirements as per IEC 61508.

The measuring device fulfills the requirements concerning
- Safety functions up to SIL 2
- Explosion protection by means of intrinsic safety
- EMC to EN 61326 and NAMUR Recommendation NE 21.

Your benefits
- For minimum detection up to SIL 2
  – Independently assessed (Functional Assessment) by *exida.com* as per IEC 61508
- Permanent automatic monitoring
- No calibration
- Insensitive to external vibration
- Easy commissioning
- Space-saving switching unit
- Testing of the measuring system at the push of a button
- Fail-safety by means of PFM technology

Endress+Hauser
People for Process Automation

Table of contents

SIL declaration of conformity

SIL-14003a/00

Endress+Hauser
People for Process Automation

SIL-Declaration of Conformity

Functional Safety according to IEC 61508 / 61511
Supplement 1 / NE130 Form B.1 and IGR 49-02-15 Datasheet 1

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

declares as manufacturer, that the following type of the

Liquiphant M/S with PFM output FEL57
and Nivotester FTL325P for applications with MIN detection

is suitable for the use in safety-instrumented systems according to IEC61508, if the safety instructions and following parameters are observed.

This declaration of conformity is only valid for the customer listed in the cover letter of the responsible Endress+Hauser sales center and for the listed products in delivery status.

Maulburg, 30.01.2014
Endress+Hauser GmbH+Co. KG

i. V.
Dr. Arno Götz
Dept. Manager Product Safety
Research & Development

i. V.
Dr. Dietmar Frühauf
Dept. Manager Level Limit Switch
Research & Development

1/2

SIL06005a

SIL-14003a/00

Endress+Hauser
People for Process Automation

General			
Device designation and permissible types	Liquiphant M/S with PFM output FEL57 and Nivotester FTL325P For more details please have a look at the safety manual SD00231F		
Safety-related output signal	Relais		
Fault current	-		
Process variable/function	Dry running protection or operating minimum detection		
Safety function(s)	MIN detection		
Device type acc. to IEC 61508-2	☐ Typ A	☒ Typ B	
Operating mode	☒ Low Demand Mode	☐ High Demand or Continuous Mode	
Valid Hardware-Version	FTL325P from V01.00; Liquiphant M/S from V01.01		
Valid Software-Version	Liquiphant M/S from V01.00.01		
Safety manual	SD00231F		
Type of evalutation (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 IEC61508-2 for devices w/o software	
Evaluation through – report no.	exida E+H 03/03-22 R038		
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		
	FEL57 [3]	FEL57 with Nivotester FTL325P [4]
Safety function	MIN detection	MIN detection
λ_{DU} *1)	44.9 FIT	58.5 FIT
λ_{DD} *1)	0.3 FIT	0.3 FIT
λ_{SU} *1)	204 FIT	517 FIT
λ_{SD} *1)	118 FIT	118 FIT
SFF - Safe Failure Fraction	87 %	91 %
PTC *2)	28 %	22 %
λ_{total} *1)	367 FIT	694 FIT
Diagnostic test interval	-	-
Fault reaction time	-	-

Comments

[3] This information based on the configuration 1 [CONF 1] in the exida test report
[4] This information based on the configuration 3 [CONF 3] in the exida test report

Declaration

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

*1) FIT = Failure In Time, Number of failures per 10^9 h
*2) PTC = Proof Test Coverage (Diagnostic coverage for proof test)

2/2

SIL06005a

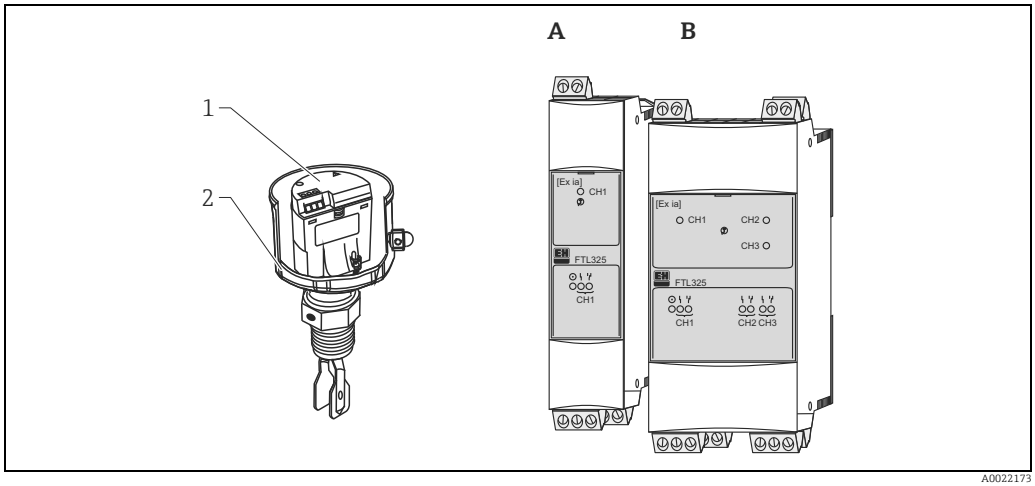
Introduction

General information about Functional Safety (SIL) can be obtained at: www.de.endress.com/SIL and in the competence brochure CP01008Z/11/EN "Functional safety in the Process Industry – risk reduction with Safety Instrumented Systems"

Structure of the measuring system

Level limit measuring system

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



1 FEL - Electronic insert
2 Liquiphant M/S
A Nivotester FTL325P (One-channel)
B Nivotester FTL325P (Three-channel)

Safety function

The safety-related signal of the measuring system is the level relay of the Nivotester. All safety functions refer exclusively to this signal.
The safety function applies to settings in MIN safety (dry running protection) and use of the NO contacts of the level relays.

The MIN safety setting has the effect that the level relay always works in quiescent current safety; i.e. the relay opens if:
- The switch point is undershot (level is below response height)
- A fault occurs
- The power supply voltage fails

In addition to the level relay, the alarm relay works in operating current safety and closes the contact if:
- One of the following faults occurs:
  - the sensor connection is interrupted
  - the sensor connection short circuits
  - the corrosion alarm of the sensor is triggered
- An internal error is detected
- The power supply voltage fails

The measuring range of the Liquiphant M/S is dependent on the installation site and fork length.

The detection range is located within the fork length and is dependent on the density of the medium.

Alternative measures must be taken during device configuration and maintenance work on the Liquiphant M/S + Nivotester FTL325P to guarantee process safety.

The following settings are permitted for the safety function:

Device	Setting	As-delivered state
Liquiphant	Density switch setting: 0,7	Density switch setting: 0,7
	Test mode "EXT"	Test mode "STD"
Nivotester FTL325P-#3#3	MIN safety	MAX safety
	All settings **except** "ΔS function" (see section "Settings and installation instructions")	Three-channel operation
Nivotester FTL325P-#1#1	MIN safety	MAX safety
	One-channel operation	One-channel operation

- When the alarm relay releases, the level relay also releases.
- The alarm relay is not part of the safety function!

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 M FTL50, FTL50H, FTL51, FTL51C, FTL51H

Feature	Designation	Option model
010	Approval	all
020	Process connection	all
030	Probe length; Type	all
040	Electronics; Output	7 FEL57; SIL 2-wire PFM
050	Housing; Cable entry	all
060	Additional options	all

Valid firmware version: as of 01.00.01
Valid hardware version (electronics): as of 01.01

Valid device versions for safety-related use:

Liquiphant S FTL70, FTL71

Feature	Designation	Option model
010	Approval	all
020	Process connection	all
030	Probe length	all
040	Electronics; Output	7 FEL57; SIL 2-wire PFM
050	Housing; Cable entry	all
060	Additional option	all
070	Application	all

Valid firmware version: as of 01.00.01
Valid hardware version (electronics): as of 01.01

Valid device versions for safety-related use:

Nivotester FTL325P

Feature	Designation	Option model
010	Approval	G ATEX II 3(1)G Ex nC/A (ia) IIC T4, SIL, IECEx Zone 2 H ATEX II (1)GD (Ex ia) IIC, WHG, SIL, IECEx (Ex ia) IIC (Liquiphant M / Liquiphant S) N NEPSI (Ex ia) IIC, SIL (Liquiphant M / Liquiphant S) P FM IS Cl. I, II, III Div. 1 Gr. A-G, SIL (Liquiphant M / Liquiphant S) T CSA IS Cl. I, II, III Div. 1 Gr. A-G, SIL (Liquiphant M / Liquiphant S) W TIIS Ex ia IIC, SIL, labeling in Japan
020	Housing	all
030	Power Supply	all
040	Switch output	all

Valid hardware version (electronics): as of 01.00

Safety function data

- Please note that the safety-related signal of the measuring system is not available until 60 s after the power supply voltage for the safety function has been switched on.
- The **mandatory settings** and data for the safety function can be found in the Appendix (→ 12).
- In the case of watery media, the reaction time of the measuring system is 2 s.

MTTR is set at eight hours.
Safety systems **without a self-locking function** must be monitored or set to an otherwise safe state after carrying out the safety function within MTTR.

Supplementary device documentation

Liquiphant M FTL50, FTL50H, FTL51, FTL51H, FTL51C

Documentation	Contents	Comment
Technical Information ▪ FTL50, FTL50H, FTL51, FTL51H: TI00328F/00/EN ▪ FTL51C: TI00347F/00/EN	– Technical data – Accessories	– The documentation is available on the Internet: → www.endress.com.
Operating Instructions ▪ FTL50, FTL51: KA00143F/00/A6 KA00163F/00/A6[1)] ▪ FTL50H, FTL51H: KA00144F/00/A6 KA00164F/00/A6[1)] ▪ FTL51C: KA00162F/00/A6 KA00165F/00/A6[1)]	– Installation – Wiring – Operation – Commissioning – Troubleshooting – Repair – Maintenance	– The documentation is supplied with the device. – The documentation is also 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.

1) with aluminium housing / separate terminal compartment.

Liquiphant S FTL70, FTL71

Documentation	Contents	Comment
Technical Information TI00354F/00/EN	– Technical data – Accessories	– The documentation is available on the Internet: → www.endress.com.
Operating Instructions KA00172F/00/A6 KA00173F/00/A6[1)]	– Installation – Wiring – Operation – Commissioning – Troubleshooting – Repair – Maintenance	– The documentation is supplied with the device. – The documentation is also 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.

1) with aluminium housing / separate terminal compartment

Nivotester FTL325P

Documentation	Contents	Comment
Technical Information TI00350F/00/EN	– Technical data – Accessories	– The documentation is available on the Internet: → www.endress.com.
Operating Instructions ▪ One-channel device: KA00167F/00/A6 ▪ Three-channel device: KA00168F/00/A6	– Installation – Wiring – Operation – Commissioning – Troubleshooting – Repair – Maintenance	– The documentation is supplied with the device. – The documentation is also 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.

Settings and installation instructions

Installation instructions

Please refer to the Operating Instructions (BA) for information regarding the correct installation of the Liquiphant M/S with FEL57 and Nivotester FTL325P. Since the application conditions have an effect on the safety of the measurement, pay attention to the notes in the Technical Information (TI) and Operating Instructions (BA).

The ambient conditions for the Nivotester FTL325P must correspond to IP54 (in accordance with EN 60529).

The manuals on setting the devices can be found in the section "Supplementary device documentation", → 8.

Settings for electronic insert FEL57

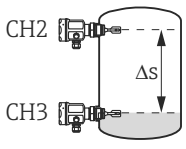
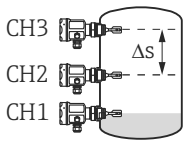
For SIL 2 operation, the following settings are mandatory for the electronic insert FEL57:
- Recurrent function test setting = EXT
- Setting for density switch = 0,7

After commissioning the measuring system, changes to the settings at the electronic insert FEL57 can impair the safety function!

The SIL evaluation of the Liquiphant M/S comprises the entire device including electronic insert, tuning fork with drive, process connection and internal wiring.

Settings for Nivotester FTL325P-#3#3 (three-channel version)

It is recommended that the shift elements following the dry running protection be left in a safe state after responding until the alarm signal has been acknowledged.

Setting	Description	Caution!
	Channel 2+3 in ΔS function	This setting is not permitted for the safety function!
	Channel 1, independent	Channel 1 is permitted for the safety function!
	Channel 2+3 in ΔS function	Channels 2 and 3 in this setting are not permitted for the safety function!

Observe the following for the Nivotester FTL325P:
The operator must use suitable measures (e.g. current limiter, fuse) to ensure the relay contact characteristics are not exceeded:
- U ≤ 253 V AC 50/60 Hz , I ≤ 2 A, P ≤ 500 VA at cos φ ≥ 0,7 or
- U ≤ 40 V DC, I ≤ 2 A, P ≤ 80 W

Changes to the measuring system and its settings after commissioning can impair the safety function!

Response in operation and failure

The response in operation and failure is descriped in the documentation, which can be found in the section "Supplementary device documentation", → 8.

Repair

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

Recurrent function tests of the measuring system

Liquiphant M/S		Nivotester	Test	
Setting for density switch	Setting for test mode	Setting	Test interval	Description of the test procedure
Setting 0,7	EXT	Every permitted setting and fault message CH1 -> ON when channel 1 is connected to a sensor	▪ Function test with test button; annually ▪ Complete function test, e.g. approaching the level; after 5 years at the latest	KA167F/00/A6 KA168F/00/A6

The operativeness of the dry running protection must be checked periodically if the PFD_{avg} values given in the Appendix are used.
The check must be carried out in such a way that it is proven that the dry running protection functions perfectly in interaction with all components. This is guaranteed if the response height is approached in a draining process. If it is not practical to drain until the response height is reached, suitable simulation of the level must be used to make the level sensor respond e.g. through the use of a lockable bypass. If the operativeness of the level sensor/transmitter can be determined otherwise (exclusion of faults that impair function), the check can also be completed by simulating the corresponding output signal.

Note the following points for the function test:
- Every channel must be tested individually by pressing the respective test key.
- Relay contact switching must be checked electrically, e.g. using a hand multimeter at the terminals.
- In multi-channel instruments, all channels which do not carry out a safety function must be included in the recurrent function tests if faulty functioning cannot be detected by any other means.
- As a positive test result, the system reaction must correspond to the specified description.
- **If the system reaction does not correspond to the described procedure, the monitored process must be set to a safe state by means of additional or other measures and/or kept in the safe state until the safety system is repaired.**

Failure rates of electrical components

The underlying failure rates of electrical components apply within the usable service life IEC 61508-2 Section 7.4.7.4 Note 3

Appendix

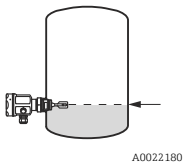
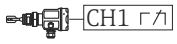
Specific values and wiring options for the measuring system

The tables show the specific values and wiring options for the measuring system.

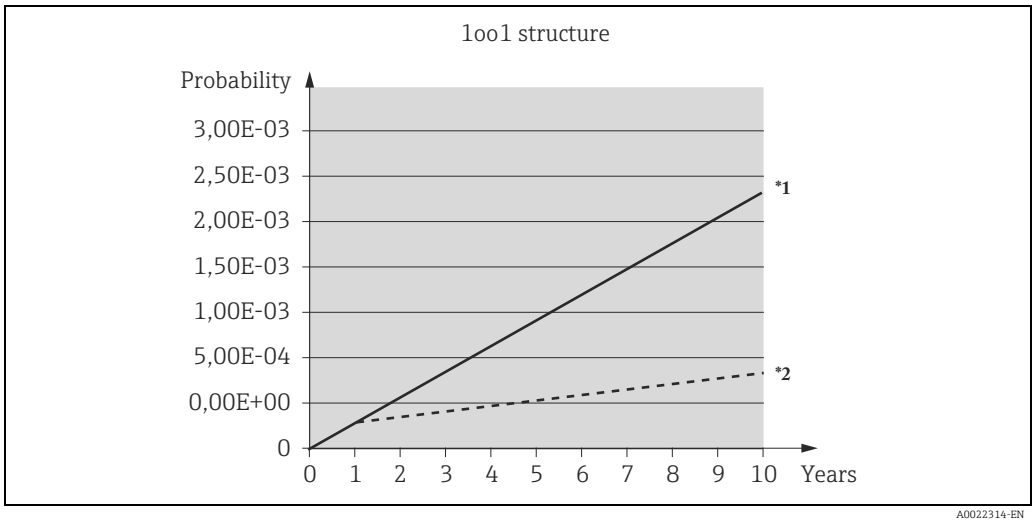
Note the following points on the tables below:
- A common cause factor β = 5% has been assumed for the calculations specified below.
- The PFD_{avg} values for multi-channel systems already contain common cause failures for the associated wiring scheme.
- The PFD_{avg} values are only valid for the associated wiring scheme. They are not suitable for deducing calculations for other wiring schemes. Using NC contacts instead of NO contacts requires further consideration of the installation means.
- The wiring scheme shows the number of instruments (Liquiphant and Nivotester) and the limit relay contact circuits (open, when the Liquiphant signals covering).
- With several instruments in a wiring scheme, they all indicate the same displayed settings.
- The tables show safety-relevant values and wiring options for the measuring system.
- FIT = Failure in Time, 1 FIT = 10^{-9} 1/h

For safety related use of the Liquiphant M/S for MIN detection, the following application errors must be excluded:
- Permanent and/or heavy build-up or "non-Newtonian media"
- Solid proportions of the medium with a diameter > 5,0 mm (0.2 in)
- Corrosion: The Liquiphant may only be used in media to which the process-wetted parts are resistant. If coated sensors are used, measures must therefore be taken to ensure that there is no damage during installation and operation.

The errors may cause that the demand mode of the safety function is not detected and the Liquiphant will not switch as intended.

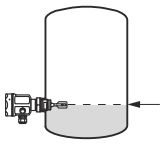
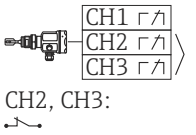
1oo1 architecture [CONF 2]	
Liquiphant M/S - Setting	Density 0,7
Nivotester FTL325P-#1#1 Setting (One-channel device)	MIN fail safe mode  A0022180
SIL	SIL 2
HFT	0
SFF[1)]	91%
PFD_{avg}[1)] (low demand mode of operation)	0,024 x 10^{-2}
λ_{sd}[1)]	137 FIT
λ_{su}[1)]	457 FIT
λ_{dd}[1)]	0,3 FIT
λ_{du}[1)]	56 FIT
MTBF	133 years
Wiring scheme	 A0022181
Function test with test button	annually
Complete function test, e.g. approaching the level	after 5 years at the latest

[1)] Source: Management summary of the exida.com test report (see appendix).

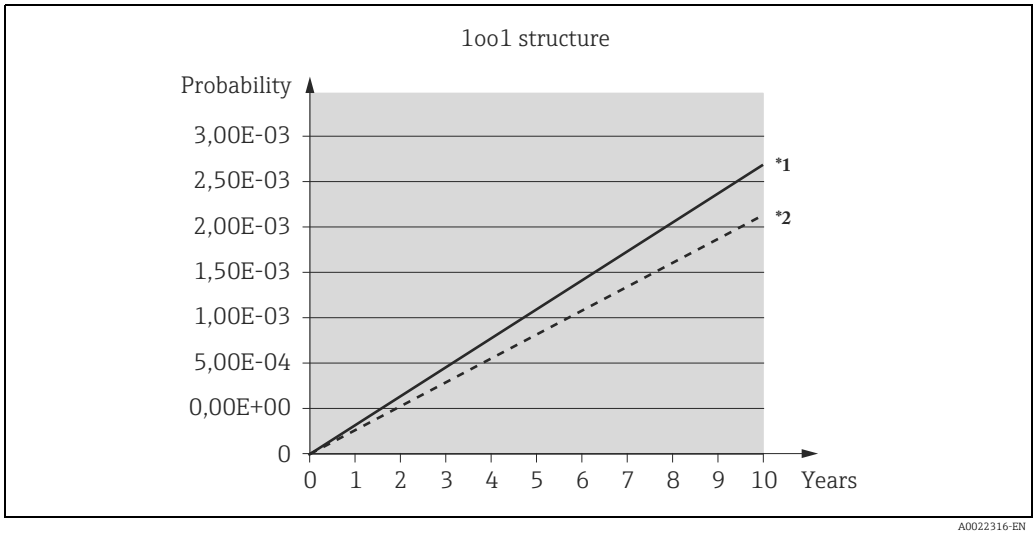


A0022314-EN

**1 without annual function test with test button*
**2 with annual function test with test button*

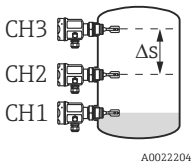
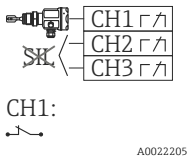
1oo1 architecture [CONF 3]	
Liquiphant M/S - Setting	Density 0,7
Nivotester FTL325P-#3#3 Setting (Three-channel device)	MIN fail safe mode  A0022180
SIL	SIL 2
HFT	0
SFF[1)]	91%
PFD_{avg}[1)] (low demand mode of operation)	$0{,}025 \times 10^{-2}$
λ_{sd}[1)]	118 FIT
λ_{su}[1)]	517 FIT
λ_{dd}[1)]	0,3 FIT
λ_{du}[1)]	59 FIT
MTBF	122 years
Wiring scheme	 A0022193
Function test with test button	annually
Complete function test, e.g. approaching the level	after 5 years at the latest

[1)] Source: Management summary of the exida.com test report (see appendix).

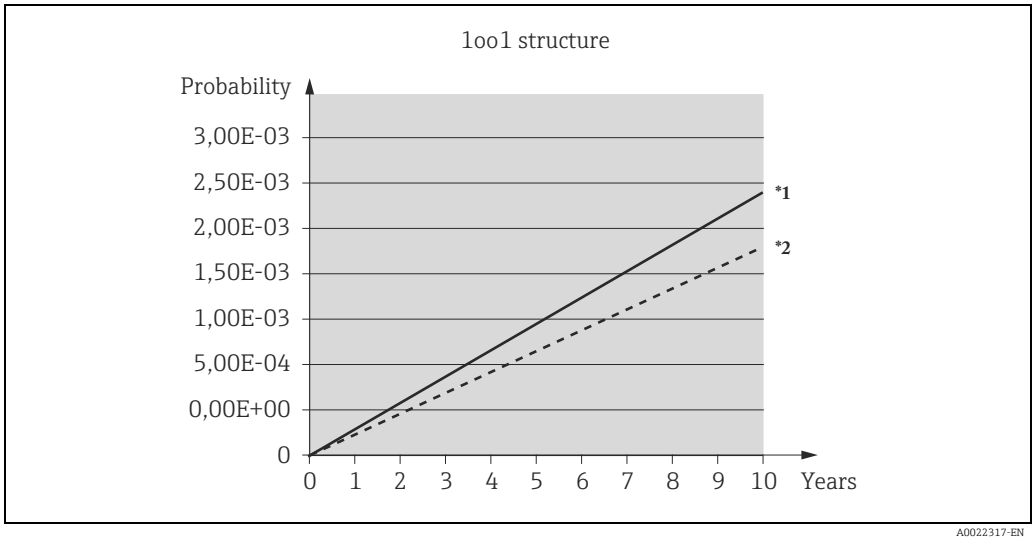


A0022316-EN

**1 without annual function test with test button*
**2 with annual function test with test button*

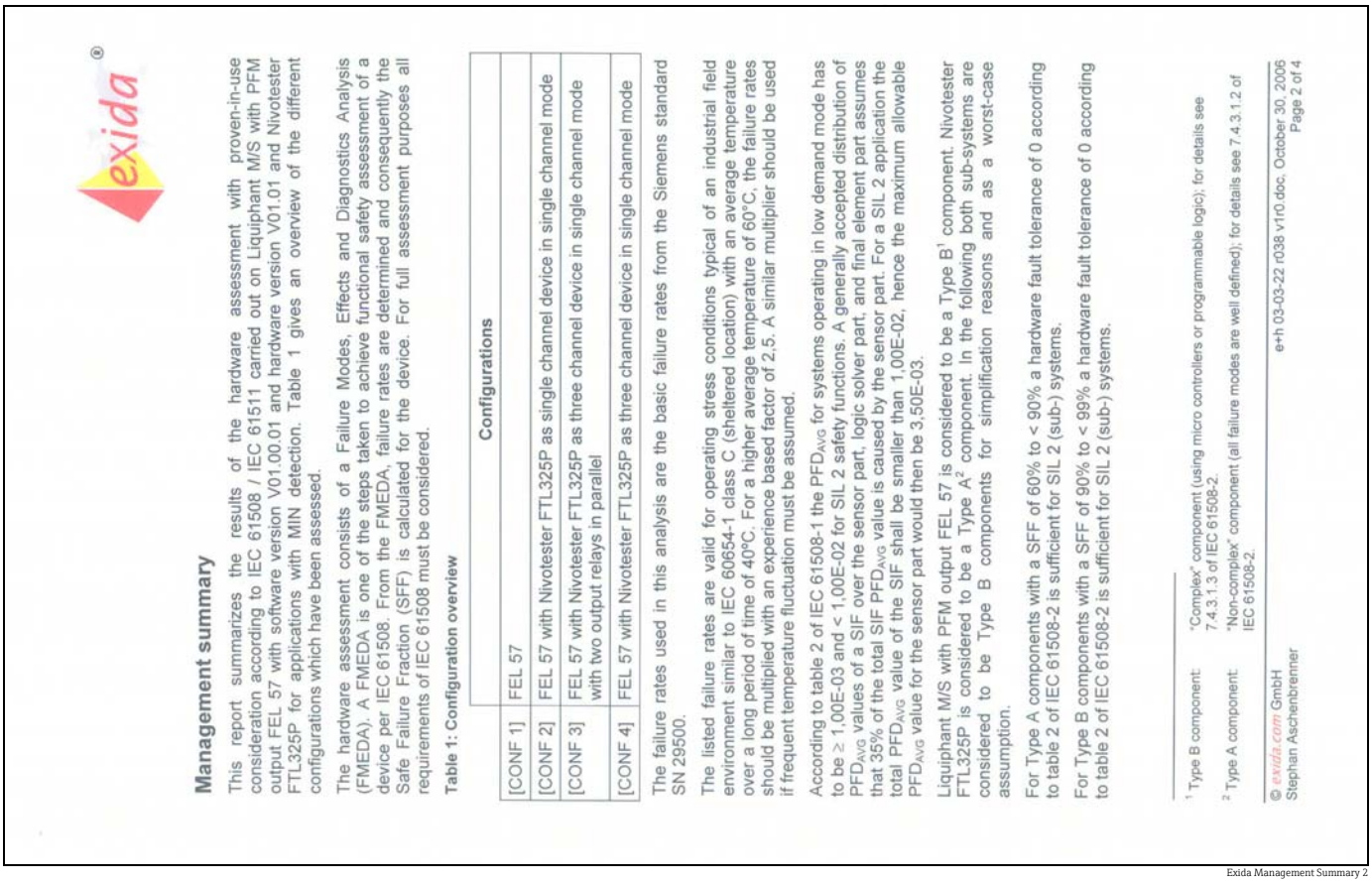
1oo1 architecture [CONF 4]	
Liquiphant M/S - Setting	Density 0,7
Nivotester FTL325P-#3#3 Setting (Three-channel device)	MIN fail safe mode 
SIL	SIL 2
HFT	0
SFF[1)]	91%
PFD_{avg}[1)] (low demand mode of operation)	0,024 x 10^{-2}
λ_{sd}[1)]	137 FIT
λ_{su}[1)]	457 FIT
λ_{dd}[1)]	0,3 FIT
λ_{du}[1)]	56 FIT
MTBF	133 years
Wiring scheme	
Function test with test button	annually
Complete function test, e.g. approaching the level	after 5 years at the latest

[1)] Source: Management summary of the exida.com test report (see appendix).



**1 without annual function test with test button*
**2 with annual function test with test button*

Exida Management Summary



exida®

Management summary

This report summarizes the results of the hardware assessment with proven-in-use consideration according to IEC 61508 / IEC 61511 carried out on Liquiphant M/S with PFM output FEL 57 with software version V01.00.01 and hardware version V01.01 and Nivotester FTL325P for applications with MIN detection. Table 1 gives an overview of the different configurations which have been assessed.

The hardware assessment consists of a Failure Modes, Effects and Diagnostics Analysis (FMEDA). A FMEDA is one of the steps taken to achieve functional safety assessment of a device per IEC 61508. From the FMEDA, failure rates are determined and consequently the Safe Failure Fraction (SFF) is calculated for the device. For full assessment purposes all requirements of IEC 61508 must be considered.

Table 1: Configuration overview

	Configurations
[CONF 1]	FEL 57
[CONF 2]	FEL 57 with Nivotester FTL325P as single channel device in single channel mode
[CONF 3]	FEL 57 with Nivotester FTL325P as three channel device in single channel mode with two output relays in parallel
[CONF 4]	FEL 57 with Nivotester FTL325P as three channel device in single channel mode

The failure rates used in this analysis are the basic failure rates from the Siemens standard SN 29500.

The listed failure rates are valid for operating stress conditions typical of an industrial field environment similar to IEC 60654-1 class C (sheltered location) with an average temperature over a long period of time of 40°C. For a higher average temperature of 60°C, the failure rates should be multiplied with an experience based factor of 2,5. A similar multiplier should be used if frequent temperature fluctuation must be assumed.

According to table 2 of IEC 61508-1 the PFD_{AVG} for systems operating in low demand mode has to be ≥ 1,00E-03 and < 1,00E-02 for SIL 2 safety functions. A generally accepted distribution of PFD_{AVG} values of a SIF over the sensor part, logic solver part, and final element part assumes that 35% of the total SIF PFD_{AVG} value is caused by the sensor part. For a SIL 2 application the total PFD_{AVG} value of the SIF shall be smaller than 1,00E-02, hence the maximum allowable PFD_{AVG} value for the sensor part would then be 3,50E-03.

Liquiphant M/S with PFM output FEL 57 is considered to be a Type B[1] component. Nivotester FTL325P is considered to be a Type A[2] component. In the following both sub-systems are considered to be Type B components for simplification reasons and as a worst-case assumption.

For Type A components with a SFF of 60% to < 90% a hardware fault tolerance of 0 according to table 2 of IEC 61508-2 is sufficient for SIL 2 (sub-) systems.

For Type B components with a SFF of 90% to < 99% a hardware fault tolerance of 0 according to table 2 of IEC 61508-2 is sufficient for SIL 2 (sub-) systems.

[1] Type B component: "Complex" component (using micro controllers or programmable logic); for details see 7.4.3.1.3 of IEC 61508-2.

[2] Type A component: "Non-complex" component (all failure modes are well defined); for details see 7.4.3.1.2 of IEC 61508-2.

Stephan Aschenbrenner

Exida Management Summary 2

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Proven in Use

FMEDA and Proven-in-use Assessment

Project:
Level limit switch Liquiphant M/S
with PFM output FEL 57 and Nivotester FTL325P
Applications with level limit detection in liquids (MIN detection)

Customer:
Endress+Hauser GmbH+Co.KG
Maulburg
Germany

Contract No.: E+H 03/03-22
Report No.: E+H 03/03-22 R038
Version V1, Revision R0, October 2006
Stephan Aschenbrenner

Exida Management Summary 1

As Liquiphant M/S with PFM output FEL 57 and Nivotester FTL325P are supposed to be proven-in-use devices, an assessment of the hardware with additional proven-in-use demonstration for the device and its software was carried out. The proven-in-use investigation was based on field return data collected and analyzed by Endress+Hauser GmbH+Co.KG. This data cannot cover the process connection. The proven-in-use justification for the process connection still needs to be done by the end-user.

According to the requirements of IEC 61511-1 First Edition 2003-01 section 11.4.4 and the assessment described in section 6, Liquiphant M/S with PFM output FEL 57 and Nivotester FTL325P with a hardware fault tolerance of 0 and a SFF of > 60% are considered to be suitable for use in SIL 2 safety functions. The decision on the usage of proven-in-use devices, however, is always with the end-user.

Table 2: Summary for [CONF 1] with density 0,7 g/cm³

	T[Proof] = 1 year	T[Proof] = 5 years
With annual manual test	PFD_{AVG} = 1,97E-04	PFD_{AVG} = 7,64E-04
Without annual manual test	PFD_{AVG} = 1,97E-04	PFD_{AVG} = 9,83E-04

λ_{SD} = 1,18E-07 1/h

λ_{SU} = 2,04E-07 1/h

λ_{DD} = 3,38E-10 1/h

λ_{DU} = 4,49E-08 1/h

SFF = 87%; HFT = 0; DC_{Proof} = 27,84%

Table 3: Summary for [CONF 2] with density 0,7 g/cm³

	T[Proof] = 1 year	T[Proof] = 5 years
With annual manual test	PFD_{AVG} = 2,44E-04	PFD_{AVG} = 8,87E-04
Without annual manual test	PFD_{AVG} = 2,44E-04	PFD_{AVG} = 1,22E-03

λ_{SD} = 1,37E-07 1/h

λ_{SU} = 4,57E-07 1/h

λ_{DD} = 3,38E-10 1/h

λ_{DU} = 5,57E-08 1/h

SFF = 91%; HFT = 0; DC_{Proof} = 34,11%

Table 4: Summary for [CONF 3] with density 0,7 g/cm³

	T[Proof] = 1 year	T[Proof] = 5 years
With annual manual test	PFD_{AVG} = 2,56E-04	PFD_{AVG} = 1,05E-03
Without annual manual test	PFD_{AVG} = 2,56E-04	PFD_{AVG} = 1,28E-03

λ_{SD} = 1,18E-07 1/h

λ_{SU} = 5,17E-07 1/h

λ_{DD} = 3,38E-10 1/h

λ_{DU} = 5,85E-08 1/h

SFF = 91%; HFT = 0; DC_{Proof} = 22,39%

Table 5: Summary for [CONF 4] with density 0,7 g/cm³

	T[Proof] = 1 year	T[Proof] = 5 years
With annual manual test	PFD_{AVG} = 2,44E-04	PFD_{AVG} = 8,87E-04
Without annual manual test	PFD_{AVG} = 2,44E-04	PFD_{AVG} = 1,22E-03

λ_{SD} = 1,37E-07 1/h

λ_{SU} = 4,57E-07 1/h

λ_{DD} = 3,38E-10 1/h

λ_{DU} = 5,57E-08 1/h

SFF = 91%; HFT = 0; DC_{Proof} = 34,11%

The boxes marked in green (▭) mean that the calculated PFD_{AVG} values are within the allowed range for SIL 2 according to table 2 of IEC 61508-1 and do fulfill the requirement to not claim more than 35% of this range, i.e. to be better than or equal to 3,50E-03.

After an operating period of 5 years a proof test without annual manual test is mandatory. This proof test shall be executed by e.g. lowering the liquid level below the switch point or by an equivalent procedure.

A user of Liquiphant M/S with PFM output FEL 57 and Nivotester FTL325P can utilize these failure rates in a probabilistic model of a safety instrumented function (SIF) to determine suitability in part for safety instrumented system (SIS) usage in a particular safety integrity level (SIL). A full table of failure rates for different operating conditions is presented in section 5.1 to 5.4 along with all assumptions.

It is important to realize that the "No Effect" and "Annunciation"[3] failures are included in the "safe undetected" failure category according to IEC 61508, Edition 2000. Note that these failures on their own will not affect system reliability or safety, and should not be included in spurious trip calculations.

[3] In this context "Annunciation" failures are failures of the alarm indication or the manual test circuit. In both cases a malfunction can be detected by the user.

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