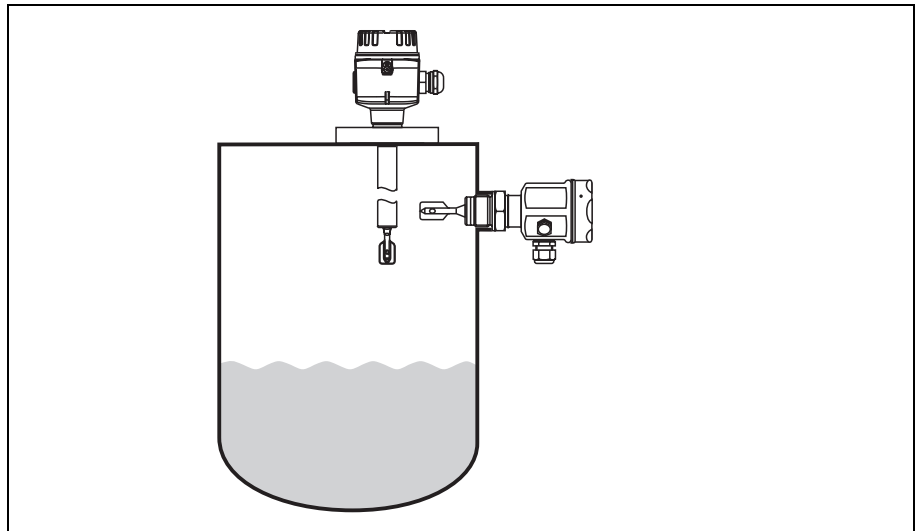


# Level Limit Measuring System *liquiphant M/S with electronic insert FEL 52*

## Functional safety manual



### Application

Overfill protection or operating maximum detection of all types of liquids in tanks to satisfy particular safety systems requirements to IEC 61508/IEC 61511-1.

The measuring device fulfils the requirements concerning

- Safety functions up to SIL 2
- Explosion protection by intrinsic safety or flameproof enclosure
- EMC to EN 61326 and NAMUR Recommendation NE 21.

### Your benefits

- For overfill protection up to SIL 2
  - Independently assessed (Functional Assessment) by *exida.com* to IEC 61508/IEC 61511-1
- Monitoring for corrosion on the tuning fork of the sensor
- No calibration
- Protected against outside vibration
- Easy commissioning

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## SIL declaration of conformity

SIL-03007b/00/a2

### SIL Konformitätserklärung SIL Declaration of Conformity

**Funktionale Sicherheit nach IEC 61508/IEC 61511**  
**Functional safety according to IEC 61508/IEC 61511**

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

erklärt als Hersteller, dass der Füllstandgrenzscher für Flüssigkeiten  
declares as manufacturer, that the level limit switch for liquids

**Liquiphant M/S FTL5.-, FTL5.H-, FTL51C-, FTL7.-**  
**+Electronic insert FEL52**

für den Einsatz in Schutzeinrichtungen entsprechend der IEC 61511-1 geeignet ist,  
wenn die Sicherheitshinweise und nachfolgende Parameter beachtet werden:  
is suitable for the use in safety-instrumented systems according to IEC 61511-1, if the  
safety instructions and following parameters are observed:

Product	Liquiphant M/S +FEL52
Schutzfunktion/Safety Function	Überfüllsicherung/overfill protection
SIL	2
Prüfintervall/Proof test interval	≤ 1 Jahr/year
Gerätetyp/Device Type	B
HFT <sup>1)</sup>	0 (einkanalige Verwendung/single channel use)
SFF	> 81,5 %
PFD <sub>av</sub> <sup>2)</sup>	< 3,2x10 <sup>-4</sup>
λ <sub>du</sub>	72 FIT
λ <sub>dd</sub>	0,1 FIT
λ <sub>su</sub>	266 FIT
λ <sub>sd</sub>	51 FIT
MTBF <sub>tot</sub> <sup>3)</sup>	291 Jahre/years

<sup>1)</sup> gemäß Absatz/according to clause 11.4.4 of IEC 61511-1

<sup>2)</sup> die Werte entsprechen SIL 2 nach ISA S84.01/ the values comply with SIL2 according to ISA S84.01.

<sup>3)</sup> gemäß Siemens SN29500, einschließlich Fehlern, die außerhalb der Sicherheitsfunktion liegen  
according to Siemens SN29500, including faults outside the safety function

Das Gerät einschließlich Software und Änderungsprozess wurde auf Basis der  
Betriebsbewährung bewertet.

The device including the software and the modification process was assessed on the  
basis of prior use.

Maulburg, 05.09.2003

Endress+Hauser GmbH+Co. KG

i.V.  
Leiter Zertifizierung  
Manager Certification

i.V.  
Projektleiter  
Projectmanager

**Endress + Hauser**  
The Power of Know How



L00-FEL52xxx-01-06-xx-a2-001

## Introduction

### General depiction of a safety system (protection function)

### Parameter tables for determining Safety Integrity Level (SIL)

The following tables are used to define

- The reachable SIL
- The requirements pertaining to the "Average Probability of Dangerous Failure on Demand" ( $PFD_{av}$ )
- The "Hardware Fault Tolerance" (HFT)
- The "Safe Failure Fraction" (SFF)

of a measuring system suitable for the safety function.

The specific values for the Liquiphant M/S measuring system with FEL 52 (PNP version) can be found in the Appendix.

Permitted probabilities of dangerous failures on demand of the complete safety related system dependent on the SIL (e.g. exceeding a defined MAX level/switch point)  
(Source: IEC 61508, Part 1):

SIL	$PFD_{av}$
4	$\geq 10^{-5} \dots < 10^{-4}$
3	$\geq 10^{-4} \dots < 10^{-3}$
2	$\geq 10^{-3} \dots < 10^{-2}$
1	$\geq 10^{-2} \dots < 10^{-1}$

The following table shows the achievable Safety Integrity Level (SIL) as a function of the probability fraction of safety-oriented failures and the "hardware fault tolerance" of the complete safety system for type B systems (complex components, not all faults are known or can be described).

SFF	HFT		
	0	1 (0) <sup>1</sup>	2 (1) <sup>1</sup>
< 60 %	not allowed	SIL 1	SIL 2
60 % ... < 90 %	SIL 1	<b>SIL 2</b>	SIL 3
90 % ... < 99 %	SIL 2	SIL 3	
$\geq 99$ %	SIL 3		

1) In accordance with IEC 61511-1 (FDIS) (Section 11.4.4), the HFT can be reduced by one (values in brackets) if the devices used fulfil the following conditions:

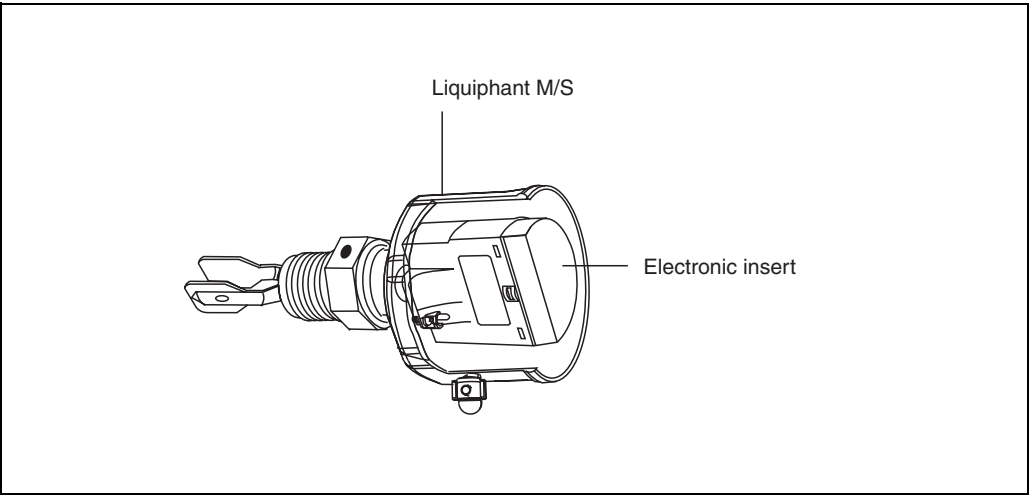
- The device is proven in use,
- Only process-relevant parameters can be changed at the device (e.g. measuring range, ... ),
- Changing the process-relevant parameters is protected (e.g. password, jumper, ... ),
- The safety function requires less than SIL 4.

All conditions apply to Liquiphant M/S with FEL 52.

**Structure of the measuring system with Liquiphant M/S with FEL 52**

**Level limit measuring system**

The measuring system is displayed in the following diagram (example).



**Safety function**

The safety function only applies to MAX safety (overflow protection).

The following settings are permitted for the safety function:

Instrument	Setting	As-delivered state
Liquiphant M/S	Density switch setting: 0.5 Density switch setting: 0.7	Density switch setting: 0.7
	"MAX" safety	"MAX" safety

The transistor output is blocked when:

- The switch point is exceeded (level exceeds response height)
- A fault occurs
- The mains voltage fails

In addition to the transistor output, a red LED indicates the following:

- Level alarm (fork covered) - red LED illuminated
- Corrosion alarm or detected electrical fault - red LED flashes (1 Hz)

**Permitted versions of the Liquiphant M/S with FEL 52 for the safety function**

The following combinations are permitted for the measuring system:

Liquiphant M with FEL 52	Liquiphant S with FEL 52
FTL 50-#####2###* FTL 51-#####2###* FTL 50 H-#####2###* FTL 51 H-#####2###* FTL 51 C-#####2###*	FTL 70-#####2###* FTL 71-#####2###*

Permitted instrument types (# = all instrument versions permitted); \* 2 = FEL 52

**Safety function data**

The **mandatory settings** and data for the safety function can be found in the Appendix (Page 9).

The measuring system reacts in  $\leq 0.9$  s.



Note!

MTTR is set at 8 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**

The following must be available for the measuring system:

	Technical Information	Operating Instructions
<b>Liquiphant M</b>	Types FTL 50, FTL 51, FTL 50 H, FTL 51 H: TI 328F	Types FTL 50, FTL 51: KA 143F
		Types FTL 50, FTL 51: KA 163F (with aluminium housing/separate terminal compartment)
		Types FTL 50 H, FTL 51 H: KA 144F
		Types FTL 50 H, FTL 51 H: KA 164F (with aluminium housing/separate terminal compartment)
	Type FTL 51 C: TI 347F	Type FTL 51 C: KA 162F  Type FTL 51 C: KA 165F (with aluminium housing/separate terminal compartment)
<b>Liquiphant S</b>	For all instrument types: TI 354F	Types FTL 70, FTL 71: KA 172F
		Types FTL 70, FTL 71: KA 173F (with aluminium housing/separate terminal compartment)
<b>Relevant contents</b>	Connection data, Installation instructions	Setting, configuration, remarks, function tests

## Settings and installation instructions

### Installation instructions

Please refer to the Compact Instructions (KA) for information regarding the correct installation of Liquiphant M/S with FEL 52. Since the application conditions have an effect on the safety of the measurement, pay attention to the notes in the Technical Information (TI) and Compact Instructions (KA).

Refer to the following documentation for instructions on setting the instruments:

Instrument	Setting description in documentation:
Liquiphant M/S with FEL 52	KA 143F, KA 163F, KA 144F, KA 164F, KA 162F, KA 165F, KA 172F, KA 173F, *

(\* type-dependent, see Table: Supplementary device documentation, Page 6)

### Settings for Liquiphant M/S with FEL 52:

- The **density switch setting** must be configured according to the density range of the medium.
- The setting of the **safety mode** has an effect on the function. The DIL switch must be set to MAX in a SIL application.



Caution!  
Load (connectable)  
Load switched via transistor and separate PNP connection.  
Transient (1 s) max. 1 A, max. 55 V (cyclical overload and short circuit protection);  
Continuous max. 350 mA;  
Max, 0.5 µF at 55 V, max. 1.0 µF at 24 V;  
Residual voltage < 3 V (with transistor connected through);  
Residual current < 100 mA (with blocked transistor)



Caution!  
Changes to the settings at the electronic insert FEL 52 after measuring system start-up can impair the protection function!

## Response in operation and failure

The response in operation and failure is described in the following documentation:

Instrument	Setting description in documentation:
Liquiphant M/S with FEL 52	KA 143F, KA 163F, KA 144F, KA 164F, KA 162F, KA 165F, KA 172F, KA 173F, *

(\* type-dependent, see Table: Supplementary device documentation, Page 6)

## Recurrent function tests of the measuring system

The operativeness of the overfill protection must be checked annually if the  $PFD_{av}$  values given in the Appendix are used.

The check must be carried out in such a way that it is proven that the overfill protection functions perfectly in interaction with all components. This is guaranteed when the response height is approached in a filling process. If it is not practical to fill to the response height, suitable simulation of the level or of the physical measuring effect must be used to make the level sensor respond. 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.



Caution!

Note the following points for the function test:

- Transistor output switching can be checked by using a hand multimeter at the terminals or by observing the overfill protection elements (e.g. horn, adjuster).
- As a positive test result, a covered tuning fork must be detected and trigger the alarm for overfill protection.
- **If fork covering is not detected during the recurrent test, 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.**



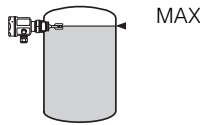
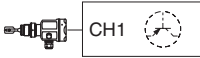
Appendix

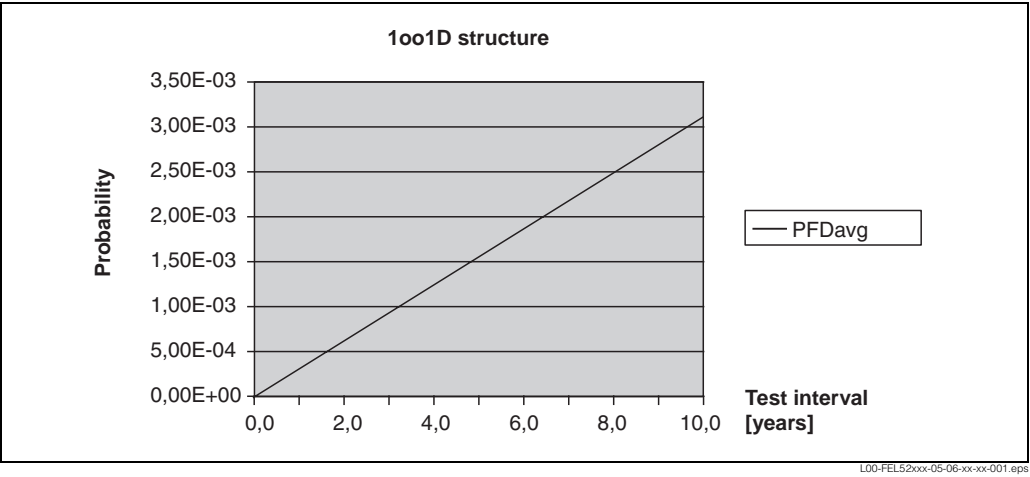
Specific values and wiring options for the measuring system Liquiphant M/S with FEL 52

The tables show values and wiring options relevant to safety for the measuring system.

Note!  
Note the following points on the table below:

- The  $PFD_{av}$  value applies to alarms with blocked transistor switching (high impedance). The use of open transistor switching (low impedance) requires further consideration.

1oo1 architecture	
Liquiphant M/S with FEL 52 Settings	1) density 0.7 / 0.5 2) MAX safety
Evaluated transmitter (FEL 52)	 <small>L00-FTL325Nx-14-06-xx-xx-010</small>
SIL	SIL 2
HFT	0
SFF	81.5 %
$PFD_{av}$	$< 3.1 \times 10^{-4}$
Wiring scheme	 <small>L00-FEL52xxx-04-06-xx-xx-001.eps</small> PNP
Recurrent test e.g. approaching level	TI (test interval) = annual



# Exida Management Summary



## Management summary

This report summarizes the results of the hardware assessment with proven-in-use consideration according to IEC 61508 / FDIS IEC 61511 carried out on Liquiphant M/S with transistor (PNP) output FEL 52 with software version V1.0 for applications with MAX detection.

The hardware assessment consists of a Failure Modes, Effects and Diagnostics Analysis (FMECA). A FMECA is one of the steps taken to achieve functional safety assessment of a device per IEC 61508. From the FMECA, 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.

The failure rates used in this analysis are based on the Siemens standard SN 29500.

According to table 2 of IEC 61508-1 the average PFD for systems operating in low demand mode has to be  $\geq 10^{-2}$  for SIL 2 safety functions. A generally accepted distribution of PFD<sub>avg</sub> values of a SIF over the sensor part, logic solver part, and final element part assumes that 35% of the total SIF PFD<sub>avg</sub> value is caused by the sensor part. For a SIL 2 application the total PFD<sub>avg</sub> value of the SIF should be smaller than  $1.00E-02$ , hence the maximum allowable PFD<sub>avg</sub> value for the sensor part would then be  $3.50E-03$ .

Liquiphant M/S with transistor (PNP) output FEL 52 is considered to be a Type B' component.

Type B components with a SFF of 60% to < 90% must have a hardware fault tolerance of 1 according to table 3 of IEC 61508-2 for SIL 2 (sub-) systems.

As Liquiphant M/S with transistor (PNP) output FEL 52 is supposed to be a proven-in-use device, an assessment of the hardware with additional proven-in-use demonstration for the device and its software was carried out. Therefore according to the requirements of IEC 61511-1 FDIS Ed 1 27-09-02 section 11.4.4 and the assessment described in section 5.1 a hardware fault tolerance of 0 is sufficient for SIL 2 (sub-) systems being Type B components and having a SFF of 60% to < 90%.

Table 1: Summary for Liquiphant M/S with transistor (PNP) output FEL 52

T[Proof] = 1 year	T[Proof] = 5 years	T[Proof] = 10 years	SFF
PFD <sub>avg</sub> = $3.15E-04$	PFD <sub>avg</sub> = $1.57E-03$	PFD <sub>avg</sub> = $3.14E-03$	> 81 %

$$\lambda_{qd} = 5.14E-08 \text{ 1/h}$$

$$\lambda_{du} = 2.66E-07 \text{ 1/h}$$

$$\lambda_{dd} = 1.13E-10 \text{ 1/h}$$

$$\lambda_{du} = 7.20E-08 \text{ 1/h}$$

The boxes marked in green (■) mean that the calculated PFD<sub>avg</sub> values are within the allowed range for SIL 2 according to table 2 of IEC 61508-1 and table 3.1 of ANSI/ISA-84.01-1996 and do fulfill the requirement to not claim more than 35% of this range, i.e. to be better than or equal to  $3.50E-03$ .

The functional assessment according to IEC 61508 has shown that Liquiphant M/S with transistor (PNP) output FEL 52 has a PFD<sub>avg</sub> within the allowed range for SIL 2 according to table 2 of IEC 61508-1 and table 3.1 of ANSI/ISA-84.01-1996 and a Safe Failure Fraction (SFF) of > 81%. Based on the verification of "prior use" they can be used as a single device for SIL2 Safety Functions in terms of IEC 61511-1 FDIS Ed 1 27-09-02.

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

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## FMECA including SFF determination and PFD<sub>avg</sub> calculation

### Project:

Level limit switch Liquiphant M/S with transistor (PNP) output FEL 52  
Applications with level limit detection in liquids (MAX detection)

### Customer:

Endress+Hauser GmbH+Co.KG  
Maulburg  
Germany

Contract No.: E+H 02/6-16

Report No.: E+H 02/6-16 R008

Version V0, Revision R1.0, March 2003

Stephan Aschenbrenner

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A user of Liquiphant M/S with transistor (PNP) output FEL 52 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 5.2 along with all assumptions.

**Supplementary  
Documentation**

Safety in the Process Industry – reducing risks with SIL  
PK 002Z/11

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