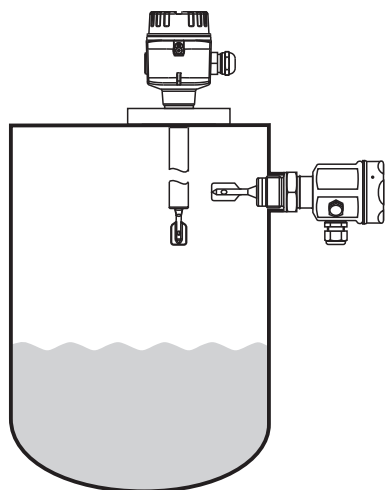


Special Documentation

Liquiphant M/S with electronic insert FEL54

Functional safety manual

Level Limit Measuring System



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-03005b/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 FEL54**

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 +FEL54
Schutzfunktion/Safety Function	Überfüllsicherung/overfill protection
SIL	2
Prüfintervall/Proof test interval	≤ 1 Jahr/year
Gerätetyp/Device Type	B
HFT ¹⁾	0 (einkanalige Verwendung/single channel use)
SFF	> 77 %
PFD _{av} ²⁾	< 0,05x10 ⁻²
λ _{du}	110 FIT
λ _{dd}	0,1 FIT
λ _{su}	324 FIT
λ _{sd}	52 FIT
MTBF _{tot} ³⁾	232 Jahre/years

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

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

³⁾ 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



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 FEL54 (relay 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).

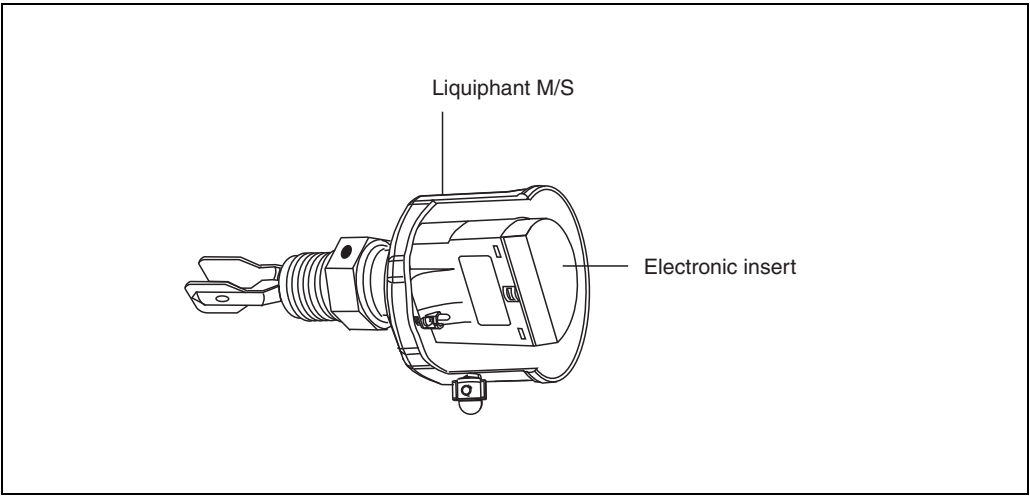
SFF	HFT		
	0	1 (0) ¹⁾	2 (1) ¹⁾
< 60 %	not allowed	SIL 1	SIL 2
60 % ... < 90 %	SIL 1	SIL 2	SIL 3
90 % ... < 99 %	SIL 2	SIL 3	
≥ 99 %	SIL 3		

- 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 FEL54.

Structure of the measuring system with Liquiphant M/S with FEL54

Level limit measuring system

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



Safety function

The safety function only applies to MAX safety (overfill protection) and use of the relay NO contacts working simultaneously.

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 level relay always works in quiescent current safety; i.e. the relay releases when:

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

In addition to the level relay, 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 FEL54 for the safety function

The following combinations are permitted for the measuring system:

Liquiphant M with (FEL54)	Liquiphant S with (FEL54)
FTL50-#####4###* FTL51-#####4###* FTL50H-#####4###* FTL51H-#####4###* FTL51C-#####4###*	FTL70-#####4###* FTL71-#####4###*

Permitted instrument types (# = all instrument versions permitted); * 4 = FEL54

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 ≤ 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	Special version documentation
Liquiphant M	Types FTL50, FTL51, FTL50H, FTL51H: TI00328F	Types FTL50, FTL51: KA00143F	Technical special products (TSP) with remote electronics: SV01222F
		Types FTL50, FTL51: KA00163F (with aluminium housing/ separate terminal compartment)	
		Types FTL50H, FTL51H: KA00144F	
		Types FTL50H, FTL51H: KA00164F (with aluminium housing/ separate terminal compartment)	
	Type FTL51C: TI00347F	Type FTL51C: KA00162F	
		Type FTL51C: KA00165F (with aluminium housing/ separate terminal compartment)	
Liquiphant S	For all instrument types: TI00354F	Types FTL70, FTL71: KA00172F	
		Types FTL70, FTL71: KA00173F (with aluminium housing/ separate terminal compartment)	
Relevant contents	Connection data, Installation instructions	Setting, configuration, remarks, function tests	Additional installation instructions

Settings and installation instructions

Installation instructions

Please refer to the Compact Instructions

(KA) for information regarding the correct installation of Liquiphant M/S with FEL54.

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 (FEL54)	KA00143F, KA00163F, KA00144F, KA00164F, KA00162F, KA00165F, KA00172F, KA00173F, *

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

Settings for Liquiphant M/S (FEL54):

- 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!

Observe the following for FEL54: The operator must use suitable measures

(e.g. current limiter, fuse) to ensure the relay contact characteristics are not exceeded:

- $U \leq 253 \text{ V AC } 50/60 \text{ Hz}$, $I \leq 6 \text{ A}$, $P \leq 1500 \text{ VA}$ at $\cos \geq 0.7$ or
- $U \leq 30 \text{ V DC}$, $I \leq 6 \text{ A}$, $P \leq 80 \text{ W}$



Caution!

Changes to the settings at the electronic insert FEL54 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 (FEL54)	KA00143F, KA00163F, KA00144F, KA00164F, KA00162F, KA00165F, KA00172F, KA00173F, *

(* 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:

- Relay contact switching can be checked by using a hand multimeter at the terminals or by observing the overfill protection elements (e.g. horn, adjuster).
- During the recurrent test, all existing relay contacts must be tested.
- 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.**

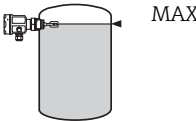
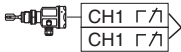
Appendix

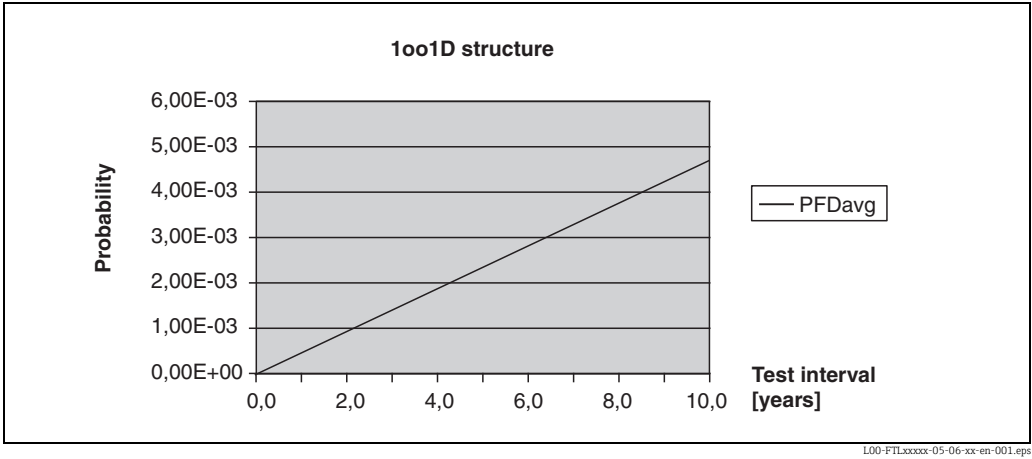
Specific values and wiring options for the measuring system
Liquiphant M/S with FEL54

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

Note!
Note the following points on the tables below:

- The PFD_{av} value applies to alarms with NO contacts. Using NC contacts instead of NO contacts requires further consideration.

1oo1 architecture	
Liquiphant (FEL54) Settings	1) density 0.7 / 0.5 2) MAX safety
Evaluated transmitter (FEL54)	 L00-FTL325Nx-14-06-xx-xx-010
SIL	SIL 2
HFT	0
SFF	> 77 %
PFD_{av}	$< 0.03 \times 10^{-2}$
Wiring scheme	 L00-FTLxxxx-04-06-xx-xx-001.eps Twin contacts DPDT
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 relay output FEL 54 with software version V1.0 for applications with MAX detection.

The hardware assessment consists of a Failure Modes, Effects and Diagnostics Analysis (FMEA). A FMEA is one of the steps taken to achieve functional safety assessment of a device per IEC 61508. From the FMEA, 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 $\geq 10^{-3}$ to $< 10^{-2}$ 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 should 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 relay output FEL 54 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 relay output FEL 54 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 relay output FEL 54

TTProof = 1 year	TTProof = 5 years	TTProof = 10 years	SFF
PFD _{avg} = 4,82E-04	PFD _{avg} = 2,41E-03	PFD _{avg} = 4,80E-03	> 77 %

$$\lambda_{ad} = 5,18E-08 \text{ 1/h}$$

$$\lambda_{pu} = 3,24E-07 \text{ 1/h}$$

$$\lambda_{dt} = 1,13E-10 \text{ 1/h}$$

$$\lambda_{du} = 1,10E-07 \text{ 1/h}$$

The boxes marked in yellow (■) mean that the calculated PFD_{avg} values are within the allowed range for SIL 2 according to table 2 of IEC 61508-1 but do not fulfill the requirement to not claim more than 35% of this range, i.e. to be better than or equal to 3,5E-03. 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 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 3,5E-03.

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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FMEA including SFF determination and PFD_{avg} calculation

Project:

Level limit switch Liquiphant M/S with relay output FEL 54
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 R007

Version V0, Revision R1.0, February 2003

Stephan Aschenbrenner

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The functional assessment according to IEC 61508 has shown that Liquiphant M/S with relay output FEL 54 has a PFD_{avg} 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 > 77%. 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.

A user of Liquiphant M/S with relay output FEL 54 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.



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