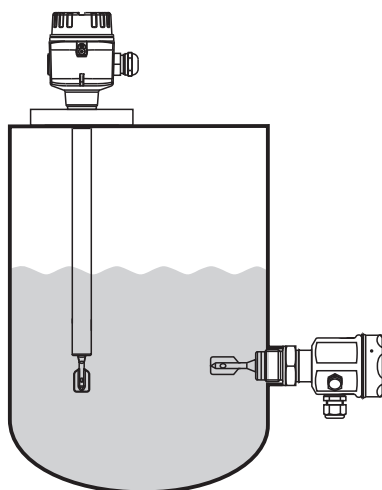


Special Documentation

Liquiphant M/S with electronic insert FEL55

Functional safety manual

Level Limit Measuring System



Application

Minimum detection (also dry running protection) 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

- Explosion protection by intrinsic safety or flameproof enclosure
- EMC to EN 61326 and NAMUR Recommendation NE 21
- Electrical safety in accordance with IEC/EN 61010-1

Your benefits

- Suited for minimum detection 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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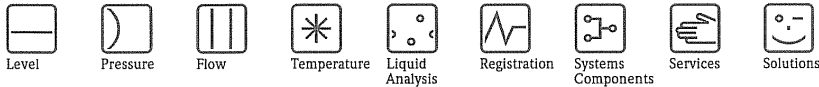
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SIL declaration of conformity



SIL-08004a/00/a2

SIL-Konformitätserklärung

Funktionale Sicherheit nach IEC 61508 / IEC 61511

SIL Declaration of Conformity

Functional safety according to IEC 61508 / IEC 61511

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

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

Liquiphant M/S FTL5.-, FTL5.H-, FTL51C-, FTL7.-
+Electronic insert FEL55

für den Einsatz in Schutzeinrichtungen entsprechend der IEC 61508 / 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 61508 / IEC 61511-1, if the
safety instructions and following parameters are observed:

Gerät / Product	Liquiphant M/S +FEL55
Schutzfunktion/Safety function	Trockenlaufschutz/Minimum Detection
SIL ⁴⁾	2
HFT	0
Gerätetyp/Device type	B
SFF	78 %
PFDA _{avg} ¹⁾ (T ₁ = 1 Jahr/year)	3,76 × 10 ⁻⁴
Prüfintervall/Proof test interval	T ₁ ≤ 1 Jahr/year
λ _{sd} ²⁾	54 FIT
λ _{ext} ²⁾	220 FIT
λ _{dd} ²⁾	47 FIT
λ _{du} ²⁾	86 FIT
MTBF _{tot} ³⁾	248 Jahre/years
¹⁾ Die Werte entsprechen SIL 2 nach ISA S84.01. PFD _{avg} -Werte für andere T ₁ -Werte siehe Handbuch zur Funktionalen Sicherheit. / The values comply with SIL 2 according to ISA S 84.01. PFD _{avg} -values for other T ₁ -values see Functional Safety Manual. ²⁾ Gemäß Siemens SN29500 / according to Siemens SN29500 ³⁾ Gemäß Siemens SN29500, einschließlich Fehlern, die außerhalb der Sicherheitsfunktion liegen / according to Siemens SN29500, including faults outside the safety function ⁴⁾ Betrachtung gemäß IEC61511-1 Kap.11.4.4 / consideration according to IEC61511-1 chap.11.4.4	

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, 08.07.2008

Endress+Hauser GmbH+Co. KG

i.V.

(Dr. Arno Götz)

Leitung Zertifizierung/Manager Certification

i.V.

(V. Dreyer)

Leitung Projekt / Project Manager

Endress+Hauser 
People for Process Automation

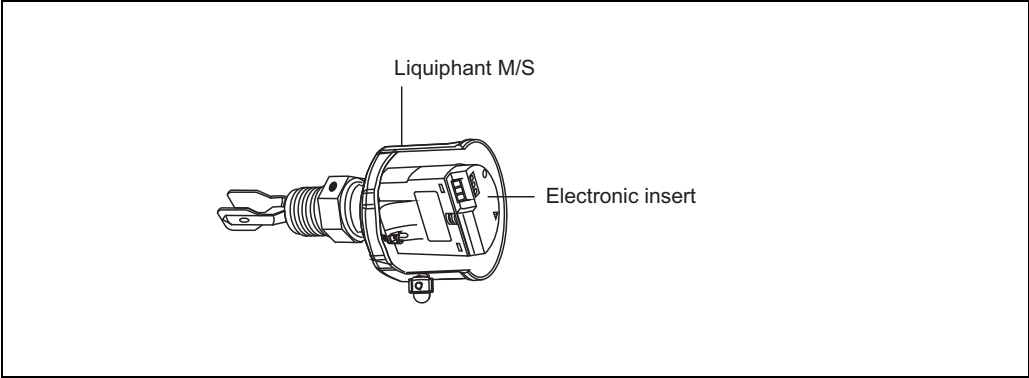
General information

Note!
General information on functional safety (SIL) is available at: www.de.endress.com/SIL (German) or www.endress.com/SIL (English) and in the Competence Brochure CP002Z "Functional Safety in the Process Industry - Risk Reduction with Safety Instrumented Systems".

Structure of the measuring system with Liquiphant M/S with FEL55

Level limit measuring system

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



SD279en02

Safety function

The safety function only applies to MIN safety (monitoring of the covered state).

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
	"MIN" safety	"MAX" safety

The current output carries:

- 8 mA ± 6 % when the dry run protection is triggered (fork free).
- 16 mA ± 5 % when the fork is covered.

The switching threshold for the current threshold of the safety function must be ≥ 12 mA.

The output signal for mains voltage failure and sensor fault is < 3.6 mA.

LED display

In addition to the current output, a red LED indicates the following (not part of the safety function):

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

Permitted versions of the Liquiphant M/S with FEL55 for the safety function

The following combinations are permitted for the measuring system:

Liquiphant M with FEL55	Liquiphant S with FEL55
FTL50-#####5*** FTL51-#####5*** FTL50H-#####5*** FTL51H-#####5*** FTL51C-#####5***	FTL70-#####5*** FTL71-#####5***

Permitted instrument types (# = all instrument versions permitted); * 5 = FEL55

Safety function data

The **mandatory settings** and data for the safety function can be found in the Appendix (Page 8).

The measuring system reacts in $\leq 1,4$ 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 + FEL55.
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 FEL55	KA00143F, KA00163F, KA00144F, KA00164F, KA00162F, KA00165F, KA00172F, KA00173F, *

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

Settings for Liquiphant M/S with FEL55:

- 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 MIN in a SIL application.



Caution!
The FEL55 is connected to a separate switching unit (e.g. PLC, isolation amplifier). Ask the manufacturer in question for the safety-relevant parameters of these devices.



Caution!
Changes to the settings at the electronic insert FEL 55 after measuring system start-up can impair the protection function!



Caution!
Load (connectable)
$$R \leq \frac{V \text{ DC power supply } -15 \text{ V}}{22 \text{ mA}}$$

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 FEL55	KA00143F, KA00163F, KA00144F, KA00164F, KA00162F, KA00165F, KA00172F, KA00173F, *

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

Proof tests of the measuring system

The operativeness of the minimum detection must be checked annually 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 minimum detection functions perfectly in interaction with all components. This is guaranteed when the response height is lowered in an emptying process. If it is not practical to empty 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.

In the case of proof tests, each permitted setting must be checked, particularly as to whether the detection of a cable open circuit or a short circuit causes the safety function to be triggered.



Caution!

Note the following points for the function test:

- Current output switching can be checked by using a hand multimeter at the terminals or by observing the dry running protection elements (e.g. horn, adjuster).
- As a positive test result, a free tuning fork must be detected and trigger the alarm for dry running protection.
- **If free fork is not detected during the proof 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 FEL55



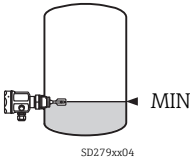
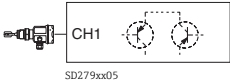
The table shows the safety-related parameters for the measuring system.

Note!
Note the following points on the tables below:

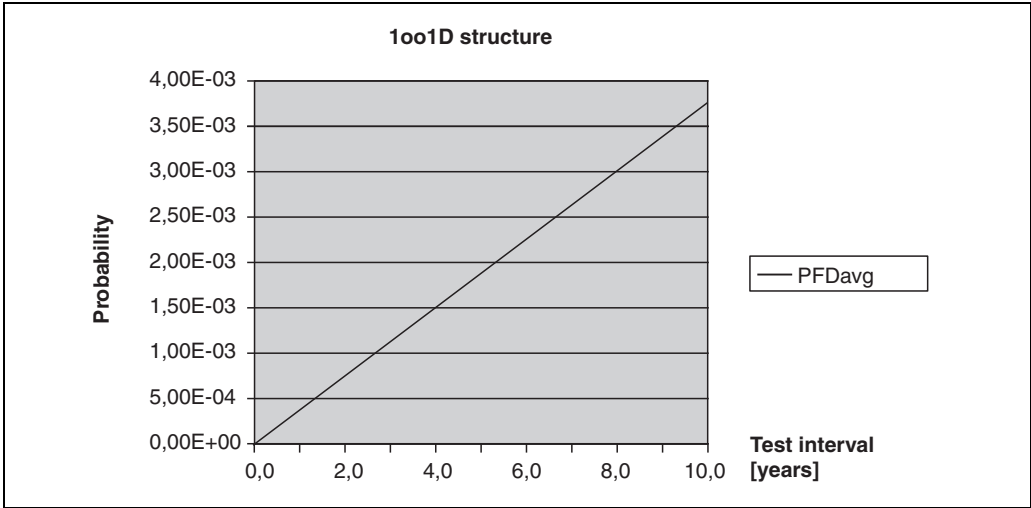
- The PFD_{avg} value applies to the electronic insert FEL55.
- The detection of a cable open circuit ($I \leq 3.6 \text{ mA}$) and short circuit ($I \geq 22 \text{ mA}$) must be switched on in the downstream evaluation unit (PLC, isolating switch repeater etc.).
This detection must cause the safety function to be triggered.

Warning!
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 $> 5,0 \text{ mm}$.
- Corrosion within the scope of the media compatibility with regard to fork material and coating.

1oo1 architecture	
Liquiphant M/S with FEL55 Settings	1) Density 0.7 / 0.5 2) MIN safety
Evaluated transmitter	
SIL ¹⁾	SIL 2
HFT	0
SFF	78 %
PFD _{avg}	3.76×10^{-4}
Wiring scheme	
Proof test e.g. approaching level	TI (test interval) = annual

¹⁾ Consideration according to IEC 61511-1, Chapter 11.4.4



Exida Management Summary



Management summary

This report summarizes the results of the hardware assessment according to IEC 61508 with proven-in-use consideration carried out on Liquiphant M/S with 16 / 8 mA current output FEL 55 with software version V01.00.01 for applications with MIN detection.

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.

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

Liquiphant M/S with 16 / 8 mA current output FEL 55 is considered to be a Type B' subsystem with a hardware fault tolerance of 0. For Type B subsystems with a hardware fault tolerance of 0 the SFF shall be > 90% for SIL 2 subsystems according to table 3 of IEC 61508-2.

As Liquiphant M/S with 16 / 8 mA current output FEL 55 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. The proven-in-use investigation was based on field return data collected and analyzed by Endress+Hauser GmbH+Co.KG.

According to the requirements of IEC 61511-1 First Edition 2003-01 section 11.4.4 and the *exida* proven-in-use assessment described in section 5, Liquiphant M/S with 16 / 8 mA current output FEL 55 with a SFF of < 90% might also be used for a SIL 2 safety function. The decision on the usage of proven-in-use devices, however, is always with the end-user.

The listed SN29500 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 (25°C ambient temperature plus internal self heating). 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 (daily fluctuation of > 15°C) must be assumed.

The failure rates do not include failures resulting from incorrect use of Liquiphant M/S with 16 / 8 mA current output FEL 55, in particular humidity entering through incompletely closed housings or inadequate cable feeding through the inlets.

Assuming that a connected safety logic solver can detect both over-range (fail high) and under-range (fail low), the following tables show how the above stated requirements are fulfilled.

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

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Stephan Aschenbrenner

e+h 07-11-29 r049 v1r0.doc, July 2, 2008
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FMEDA and Proven-in-use Assessment

Project:
Level limit switch Liquiphant M/S with 16 / 8 mA current output FEL 55
Applications with level limit detection in liquids (MIN detection)

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

Contract No.: E+H 07/11-29
Report No.: E+H 07/11-29 R049
Version V1, Revision R0, July 2008
Stephan Aschenbrenner

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Table 1 : Summary – Failure rates per IEC 61508

Failure category	Failure rates (in FIT)
Fail Safe (λ_{SD})	54
Fail low	54
Fail Safe (λ_{SU})	220
Fail safe undetected	86
Residual	129
Annunciation undetected	5
Fail Dangerous Detected (λ_{DD})	47
Fail dangerous detected	1
Fail high	46
Fail Dangerous Undetected (λ_{DU})	86
Fail dangerous undetected	86
No part	54
Total failure rate (safety function)	407 FIT
SFF	78%
DCo	54%
MTBF = MTTF + MTTR	248 years

The hardware assessment has shown that Liquiphant M/S with 16 / 8 mA current output FEL 55 has a Safe Failure Fraction (SFF) of > 78%. The "proven-in-use information" may be used to assist an end user in completing a prior-use justification per IEC 61511-1.

A user of Liquiphant M/S with 16 / 8 mA current output FEL 55 can utilize these failure rates in a probabilistic model or 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 4.4.1.

It is important to realize that the "residual" failures are included in the "safe" failure category according to IEC 61508. Note that these failures on their own will not affect system reliability or safety, and should not be included in spurious trip calculations.

The failure rates are valid for the useful life of Liquiphant M/S with 16 / 8 mA current output FEL 55 (see Appendix 2).



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