FIELD DEVICES – ***INSTRUMENTS***

SIL – Safety information

11.2019 **TI EML0710 S-(EN)**

244LD LevelStar — Intelligent Buoyancy Transmitter for Level, Interface and Density with Torque Tube and Displacer – Functional Safety –

Safety **I**ntegrity **L**evel

SIL 2 certified

acc. to IEC 61508 / IEC 61511

The intelligent transmitter 244LD LevelStar measures the level, interface and density of liquids continuously in processes of all industrial applications which meet the particular demands on safety equipment required according to IEC 61508 / IEC 61511-1.

FEATURES

- Functional safety in compliance with IEC 61508 / IEC 61511-1
- Suitable for use up to SIL 2, independently assessed by exida.com
- Explosion protection (depending on the version)
- Electromagnetic compatibility to EN 61326 and NAMUR recommendation NE21

Schneider Electric

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1 SCOPE OF APPLICATION

1.1 General

The scope of application encompasses the intelligent transmitters for level, interface and density of type 244LD LevelStar (HART and 4-20 mA without communications) for continuous measurement.

The measurement is based on the Archimedes buoyancy principle. The devices can be conveniently and reliably accessed and adjusted remotely using a PC or hand terminal, but can also be adjusted by conventional means with pushbuttons. The transmitters are suitable for use in explosion hazard zones.

Other features:
- Continuous self-diagnosis
- Configurable safety level
- Software locking for pushbuttons and reconfiguration
- Simple commissioning
- Measurements are virtually independent of the product properties

The intelligent transmitters for level, interface and density 244LD LevelStar can be employed in applications with low or high demand rates.

More technical information like product specification, master instruction is available within the documents PSS [Ref. 5] and MI [Ref. 4].

1.2 Identification

This safety manual is valid for all devices 244LD LevelStar:

- Model Code: 244LD-xxxxxxNxxxxx-Q
- Revision: 6.2.x with Software 8.29.x (Communication HART 5)
- Revision: 7.0.x with Software 9.29.x (Communication HART 7)
- DMU DTM Version 3.5.1 or higher (Communication HART 5)
- LevelStar DTM Version 1.1.0 or higher (Communication HART 7)

1.3 Requirements

The following requirements must be taken into account for applications under the specific demands on safety equipment according to IEC 61508 / IEC 61511-1:

1.3.1 Project Planning

- It must be observed that the technical data specified in [Ref. 5], particularly with regard to the application and ambient conditions, are fulfilled by the transmitters.
- The average operating temperature for the amplifier over longer periods is not higher than 40 °C.

1.3.2 HART Communication

- In case of using a DCS for HART configuration it is necessary to ensure using the correct HART communication link e.g. by checking the tag number and write protection status.

1.3.3 Commissioning

- After project planning with the transmitters, a function test must be conducted. The necessary tests must be specified in the safety manual of the system. The following tests should be conducted:
- Zero point verification
- Measured value verification
- Simulation of various measured values
- Verification of the preset safety values
- The above function tests should also be conducted for remote adjustment of the parameters relevant to measurements.

1.3.4 Entering safety mode

- Before the safety mode is put into operation a verification of all parameters must be performed:
- Restarting the device via DTM or power cycle.
- Uploading all data within DTM.
- Verification and Confirmation of the configuration / all parameters by using the confirmation screen within the DTM.
- Locking the HART communications and local operation by activating the write protection / entering the safety mode.

1.3.5 Regular function tests

- Regular function tests (see recurring tests) must be conducted

1.3.6 Other

- The infrared service interface is intended for special authorized Foxboro Eckardt personnel for debug purposes only.

2 GENERAL

2.1 Relevant standards

- DIN EN 61508 Parts 1 to 7: Functional safety-related electric/electronic/programmable electronic systems
- DIN IEC 61511 Parts 1 to 3: Functional safety – Safety instrumented systems for industrial processes

2.2 Terms

The terms listed below are defined according to [Ref. 1], Part 4 and [Ref. 2], Part 1.

Name	Description
Actor	Component of a safety instrumented system which executes actions in the process to achieve a safe situation.
Failure	Loss of the ability of a functional unit to execute the required function.
Diagnostic coverage	Ratio of the failure rate of the faults detected by diagnostic tests to the overall failure rate of the components or subsystem. The diagnostic rate does not include faults detected by recurring tests.
Fault	Abnormal situation which can cause an impairment or loss of the ability of a functional unit to execute a required function.
Functional safety	Part of overall safety relating to the process and BPCS and dependant on the intended function of the SIS and other safety levels.
Functional unit	Unit consisting of hardware or software or both which is suitable to execute a defined task.
Dangerous failure	Failure with the potential of putting the safety instrumented system in a hazardous or dysfunctional condition.
Safety	Freedom of disproportionate risks
Safety function	Function executed by an SIS, a safety-related system of other equipment or external facilities to reduce risks with the objective of achieving or upholding the safe conditions of a process, taking account of a defined, dangerous event.
Safety integrity	Mean probability that a safety instrumented system will execute the required safety functions under all defined conditions within a defined period.
Safety integrity level (SIL)	One of four discreet stages to specify the requirements for the safety integrity of the safety functions assigned to the safety instrumented system, in which safety integrity level 4 represents the highest degree of safety integrity and safety integrity 1 represents the lowest.
Safety instrumented system (SIS)	Safety instrumented system to execute one or more safety functions. An SIS consists of one or more sensors, a logic system and actor(s).
Non-dangerous failure	Failure without the potential of putting the safety instrumented system in a hazardous or dysfunctional condition.

2.3 Abbreviations

Abbreviation	Description
BPCS	Basic process control system
DC	Diagnostic coverage
HFT	Hardware fault tolerance
PFD	Probability of failure on demand
PFD_{avg}	Average probability of failure on demand
SFF	Safe failure fraction
SIL	Safety integrity level
SIS	Safety instrumented system

2.4 Design tables

The tables below are used to determine the safety integrity level (SIL).

2.4.1 Mean probability of a failure on demand (PFD_{avg})

This table reflects the achievable safety integrity level (SIL) in dependency on the mean probability of a failure on demand. The specified failure tolerances in this case apply to a safety function operated in the **mode with low demand rate** (see [Ref. 1] Part 1, Chapter 7.6.2.9).

Safety integrity level (SIL)	**PFD_{avg} with low demand rate**
4	$\geq 10^{-5}$ to $< 10^{-4}$
3	$\geq 10^{-4}$ to $< 10^{-3}$
2	$\geq 10^{-3}$ to $< 10^{-2}$
1	$\geq 10^{-2}$ to $< 10^{-1}$

2.4.2 Probability of a dangerous failure per hour (PFH)

If the requirement rate is more than once per year or greater than twice the frequency of recurring tests, the measurement system must be employed in the **mode with high demand rate** (see [Ref. 1] Part 1, Chapter 3.5.12).

Safety integrity level (SIL)	**PFH with high demand rate** Probability of a dangerous failure per hour
4	$\geq 10^{-9}$ to $< 10^{-8}$
3	$\geq 10^{-8}$ to $< 10^{-7}$
2	$\geq 10^{-7}$ to $< 10^{-6}$
1	$\geq 10^{-6}$ to $< 10^{-5}$

2.4.3 Safety integrity of the hardware

This table shows the achievable safety integrity level (SIL) in dependency on the proportion of non-dangerous failures (SFF) and the fault tolerance of the hardware (HFT) for safety-related type B sub-systems (see [Ref. 1] Part 2, Chapter 7.4.3.1.4).

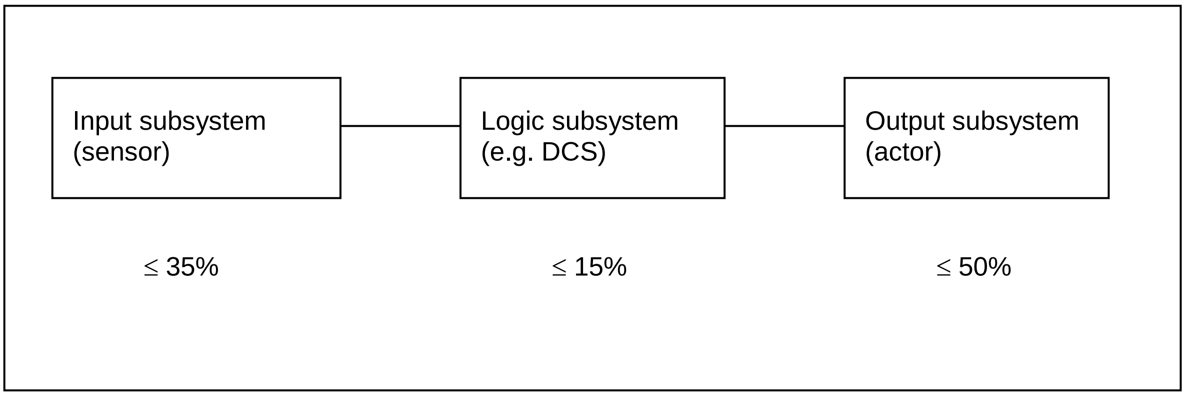
Proportion of non-dangerous failures (SFF)	**Fault tolerance of the hardware (HFT)**		
	0	**1 (0)**[1]	**2**
< 60%	Not permitted	SIL 1	SIL 2
60% - < 90%	SIL 1	SIL 2	SIL 3
90% - < 99%	SIL 2	SIL 3	SIL 4
≥ 99%	SIL 3	SIL 4	SIL 4

1) According to [Ref. 2] Part 1, Chapter 11.4.4, the fault tolerance of the hardware (HFT) may be reduced by one (values in brackets) in subsystems such as sensors and actors if the employed device fulfils all of the following conditions:

- The device is validated in practice
- Only process-relevant parameters can be changed at the device
- Changes of the process-relevant parameters are protected (e.g. password, jumpers etc.)
- The function has a required safety integrity level lower than 4

2.4.4 Safety-related system

A safety-related system usually consists of the three subsystems input subsystem (sensor), logic subsystem (PLC or control system) and output subsystem (actuator). The mean probability of a failure on demand is usually divided as follows:



3 SAFETY FUNCTION, RESTRICTIONS AND BEHAVIOUR

3.1 Safety Function

The safety related output signal is the 4-20 mA analogue output signal. All safety measures refer to this output signal exclusively.

The logic subsystem (e.g. DCS) must scan the field device with a scan rate of <500 ms for proper fault detection of the transmitter.

While running a safety application, the additional HART communication can be used to get additional diagnostic information.

3.2 Restrictions for use in safety related applications

The requirements described in Chapter 1.3 as well as all specifications for correct operation of the device must be fulfilled carefully for usage of the device within a safety related application.

The dangerous failure mode within the meaning of the safety characteristics given by Chapter 5.2 is given by all failures leading to output accuracy worse than 2%.

3.3 Behaviour in operation and at malfunctions

The behaviour in operation and at malfunctions is described in the commissioning and maintenance instructions MI EML0610 A-(de) and MI EML0710 A-(de) [Ref. 4].

For malfunctions the behaviour of the output is defined according NAMUR recommendation NE43:

- For Up-scale the output current will be ≥ 21 mA
- For Down-scale the output current will be ≤ 3.6 mA

Down Scaling will be used in case of a serious fault, where the internal watchdog of the device is no longer be triggered.

Up Scaling will be used in case of a detected fault where the output can be controlled by the internal software. Examples for these detections are:

- Temperature out of range
- Internal Reference Voltages out of range
- Output Current not correct
- AD-Converter not working correctly
- ...

3.4 Safety relevant configuration parameters

While entering the safety mode the following parameters have to be verified by using the confirmation screen as describe in chapter 1.3.4:

Name	Description
Smart Smoothing Damping	Integration Time of Smart Smoothing
Smart Smoothing Deadband	Deadband of Smart Smoothing
Zeropoint Mode	Mode of Zeropoint offset correction
Zeropoint Basic	Zeropoint of the sensor
Zeropoint Offset	Zeropoint Offset used in automode
Zeropoint Special Offset	Special zeropoint offset used in manual mode
Upper Range Value	Lower Range Value of measuring range (i.e. weight of the displacer in case of an empty tank)
Lower Range Value	Upper Range Value of measuring range
Characterization	Characterization of the output
Output Damping	Damping of the output signal

4 RECURRING TESTS OF THE TRANSMITTER FOR LEVEL, INTERFACE AND DENSITY

4.1 Safety tests

According to IEC 61508/61511, the safety function of the entire safety loop must be tested regularly. The test intervals necessary for this purpose are defined in the calculation of the respective safety loop.

4.2 Function test

The orderly function of the transmitter for level, interface and density must be tested regularly every 5 years. The test may be conducted by the manufacturer or an authorised workshop. The following work must be conducted:

- Dismantle the sensor
- Examine the torsion tube to detect corrosion and leaks (replace if necessary)
- Examine the sandwich housing support for dirt (clean or replace if necessary)
- Examine the ball bearing in base plate for easy action
- Replace the sealing rings in the sensor (use Cu-based grease)
- Examine the sealing rings in the amplifier and replace as necessary (apply grease)
- Observe the tightening torques for the screws specified in the MI when assembling
- Power on the device to initiate self test procedure
- Adjust the transmitter as described in MI EML0710 G-en, Chapter 8
- Adjust the safety range
- Verify all adjustments by setting to the zero point, the end value, a medium value (e.g. 50% value) and the safety settings. In case of using a non-linear characterization curve the relevant points have to be verified.
- Verify the temperature measurement of the sensor and electronics
- Verify the alarm levels according Chapter 3 with the DTM-function “Error State Test”.
- Lock the settings by entering the Safety Mode as described in Chapter 1.3.4.

The transmitter for level, interface and density of types 244LD LevelStar is subject to the pressure equipment directive (DGRL 97/23/EC). The intervals for recurring tests specified in the safety operating instructions Ex EML0010 A-(de) must therefore be observed (according to German BertrSichV dated 27.09.2002). [Rev.6]

4.3 Repairs

Defective units should be sent to the repair department of Foxboro Eckardt GmbH with a precise description of the fault and the cause.

5 SAFETY CHARACTERISTICS

Information not included in this summary is contained in Chapter 8.

5.1 Assumptions

The specified characteristics are applicable under the following assumptions:

- The requirements stated in Chapter 1.3 are fulfilled.
- The repair time (MTTR) after a device has failed is 24 hours.
- Test interval: ≤ 5 years.
- Diagnostic time: < 5 min

5.2 Characteristics

Unit type	HFT	SFF	PFD_{avg}	PFH	λ_{du}	λ_{dd}	λ_{su}	λ_{sd}
B	0	92%	1.02E-03	< 0.42E-07	42 FIT	502FIT	0 FIT	0 FIT

The probability of a dangerous failure per hour (PFH) is based on an error response time < 5 min and a demand rate of > 500 min.

The failure rates are valid for the useful life of the instrument. According to section 7.4.7.4 note 3 of DIN EN 61508 part 2 [Ref. 1], experience has shown that the useful lifetime often lies within a range of 8 to 12 years.

6 LITERATURE

[Ref. 1] DIN EN 61508 Teil 1-7
Beuth-Verlag, Berlin

[Ref. 2] DIN IEC 61511 Teil 1-3
Beuth-Verlag, Berlin

[Ref. 3] Functional safety and IEC 61508 – A basic guide, November 2002
IEC

[Ref. 4] 244LD LevelStar Intelligent Buoyancy Transmitter with Torque tube for Level, Interface and Density– HART-Version
Inbetriebnahmeanleitung
Foxboro Eckardt GmbH, MI EML0710 G

[Ref. 5] 244LD LevelStar Intelligent Buoyancy Transmitter for Liquid Level, Interface and Density with Torque tube – HART-Version
Product Specification
Foxboro Eckardt GmbH, PSS EML0710 G-(en)

[Ref. 6] Safety Instructions for 140 Series Devices 141GP, 142AP, 143DP, 144FP, 144LVD, 144LD, 244LD, 244LVP
Foxboro Eckardt GmbH, EX EML0010 A

[Ref. 7] Namur-Empfehlung NE 43
NAMUR Geschäftsstelle, Leverkusen

[Ref. 8] Failure Modes, Effects and Diagnostic Analysis for Intelligent Buoyancy Transmitter 244LD LevelStar
exida, Report No.: Foxboro Eckardt 07/07-019 R008 Version V2, Revision R0; July 2015

7 DECLARATION OF CONFORMITY

SIL Konformitätserklärung
Declaration of conformity

Foxboro.
by Schneider Electric

Foxboro Eckardt GmbH Stammheimer Str. 10 D-70806 Kornwestheim

Stuttgart, 22.01.2018

Funktionale Sicherheit nach IEC 61508 / IEC 61511
Functional Safety according to IEC 61508 / IEC 61511

Wir erklären, dass die Geräte
We declare, that the devices

244LD LevelStar
244LVP LevelStar

für den Einsatz in einer sicherheitsgerichteten Anwendung entsprechend der IEC 61511-1 geeignet sind, wenn die Sicherheitshinweise und die nachfolgenden Parameter beachtet werden:
are suitable for use in a safety related application according IEC 61511-1, if the safety instructions and the following parameters are observed:

Produkt / Product	244LD LevelStar	244LVP LevelStar
Device Revision	6.2.x, 7.0.x	6.2.x, 7.0.x
SIL	2	2
Prüfintervall / Proof test interval	≤ 5 Jahre / Years	
Gerätetyp / Device Type	B	B
HFT	0 [1] (einkanalige Verwendung / single channel using)	
SFF	92%	92%
PFD_{avg}	$1{,}02 \times 10^{-3}$	$9{,}85 \times 10^{-4}$
PFH [2]	$< 0{,}42 \times 10^{-7}$	$< 0{,}40 \times 10^{-7}$
λ_{du}	42 FIT	40 FIT
λ_{dd}	502 FIT	450 FIT
λ_{su}	0 FIT	0 FIT
λ_{sd}	0 FIT	0 FIT
MTTF [3]	210 Jahre / Years	233 Jahre / Years
DC_D	92%	92%

[1] gemäß Kapitel / according to chapter 11.4.4 of IEC 61511-1
[2] Diagnosezeit / Error response time < 5min
[3] für / for MTTR = 8h

Hans-Otto Lang
Registered Manager
Foxboro Eckardt GmbH

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Development Manager
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8 MANAGEMENT SUMMARY

Failure Modes, Effects and Diagnostic Analysis

Project:
Intelligent Buoyancy Transmitter 244LD LevelStar

Customer:
Foxboro Eckardt GmbH
Stuttgart
Germany

Contract No.: Foxboro Eckardt 07/07-019
Report No.: Foxboro Eckardt 07/07-019 R008
Version V2, Revision R0; July 2015
Stephan Aschenbrenner

Management summary

This report summarizes the results of the hardware assessment carried out on the Intelligent Buoyancy Transmitter 244LD LevelStar with software version V8.29 and hardware versions as listed in the circuit diagrams referenced in section 2.4.1.

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.

For safety applications only the described configurations of the device were considered. All other possible output variants or electronics are not covered by this report.

Failure rates used in this analysis are basic failure rates from the Siemens standard SN 29500. For mechanical components experience-based *exida* data and field failure evaluations from Foxboro Eckardt GmbH were used.

Foxboro Eckardt GmbH and *exida* did a qualitative analysis (see [R1]) of the (electro-)mechanical components of the Intelligent Buoyancy Transmitter 244LD LevelStar. This analysis was used to calculate the failure rates of the (electro-)mechanical components of the Intelligent Buoyancy Transmitter 244LD LevelStar using experience-based *exida* data and field failure evaluations from Foxboro Eckardt GmbH.

A user of the Intelligent Buoyancy Transmitter 244LD LevelStar 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 is presented in section 4.3.1 along with all assumptions.

The Intelligent Buoyancy Transmitter 244LD LevelStar is considered to be a Type B[1] element with a hardware fault tolerance of 0.

[1] Type B element: "Complex" element (using micro controllers or programmable logic); for details see 7.4.4.1.3 of IEC 61508-2.

Table 1 Summary – IEC 61508 failure rates

Failure category	SN29500 [FIT]
Fail Safe Detected (λ_{SD})	**0**
Fail Safe Undetected (λ_{SU})	**0**
Fail Dangerous Detected (λ_{DD})	**502**
Fail Dangerous Detected (λ_{dd}), detected by internal diagnostics	332
Fail Annunciation Detected (λ_{AD}) , detected by internal diagnostics	24
Fail High (λ_{H}), detected by safety logic solver	10
Fail Low (λ_{L}), detected by safety logic solver)	136
Fail Dangerous Undetected (λ_{DU})	**42**
Fail Annunciation Undetected (λ_{AU})	0
No effect	154
No part	277
Total failure rate of the safety function (λ_{Total})	**544**
Safe failure fraction (SFF) [2]	**92%**
DC_D	**92%**
SIL AC [3]	**SIL 2**

The failure rates are valid for the useful life of the Intelligent Buoyancy Transmitter 244LD LevelStar (see Appendix 2).

[2] The complete sensor subsystem will need to be evaluated to determine the overall Safe Failure Fraction. The number listed is for reference only.

[3] SIL AC (architectural constraints) will need to be evaluated on sensor subsystem level. The indicated value if is for reference only and means that the calculated values are within the range for hardware architectural constraints for the corresponding SIL but does not imply all related IEC 61508 requirements are fulfilled.

9 PFD_{AVG} CALCULATION

5 Using the FMEDA results

The following section describes how to apply the results of the FMEDA.

It is the responsibility of the Safety Instrumented Function designer to do calculations for the entire SIF. *exida* recommends the accurate Markov based exSILentia tool for this purpose.

The following results must be considered in combination with PFD_{AVG} values of other devices of a Safety Instrumented Function (SIF) in order to determine suitability for a specific Safety Integrity Level (SIL).

5.1 Example PFD_{AVG} calculation

An average Probability of Failure on Demand (PFD_{AVG}) calculation is performed for the Intelligent Buoyancy Transmitter 244LD LevelStar considering a proof test coverage of 95% (see Appendix 1.1) and a mission time of 10 years. The failure rate data used in this calculation are displayed in sections 0.

For SIL2 applications, the PFD_{AVG} value needs to be < 1.00E-02.

Table 2: Intelligent Buoyancy Transmitter 244LD LevelStar

T[Proof] = 1 year	T[Proof] = 2 years	T[Proof] = 5 years
PFD_{AVG} = 2.92E-04	PFD_{AVG} =4.75E-04	PFD_{AVG} =1.02E-03

Figure 6 shows the time dependent curve of PFD_{AVG} for the Intelligent Buoyancy Transmitter 244LD LevelStar.

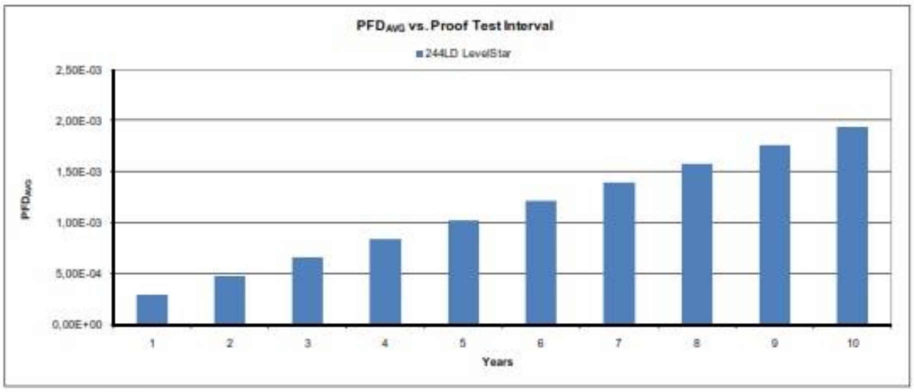

Figure 3: PFD_{AVG}(t)

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