PEPPERL+FUCHS
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SIL Declaration of Conformity

Functional safety of inductive proximity sensors according to IEC 61508. PF12CERT1329A

Pepperl+Fuchs GmbH, Lilienthalstr. 200, 68307 Mannheim
declares as manufacturer, that for the inductive proximity sensors, types mentioned below, the calculated PFDavg values are within the allowed range for SIL 3 according to IEC 61508-1 table 2 and do fulfill the requirement to not claim more than 25% of this range, i.e. to be better than or equal to $2.5 \cdot 10^{-4}$.

Product List

Part No.	Product Name	Remarks
182214	PL2-F25-SN4-K	without solenoid valve connection
182213	PL3-F25-SN4-K	with 3-pin solenoid valve connection and valve drive LED

General

This Declaration of Conformity is based on the test report no. P+F 03/11-10 R015 from exida.com GmbH concerning NCN3-F25-SN4 (Version V9 in the report). It is only valid when the sensors are connected to a qualified fail safe interface, e.g. Pepperl+Fuchs KFD2-SH-EX1.

The valve connection circuit is not part of this functional safety declaration.

The failure rates are based on the Siemens standard SN 29500. According to IEC 61508-1 table 2 the average *PFD* for systems operating in low demand mode has to be lower than 10^{-3} for SIL 3 safety functions. However, as the module under consideration is only one part of an entire safety function it should not claim more than 25 % of this range, i.e. it should be better than or equal to $2.5 \cdot 10^{-4}$.

The sensor is considered to be Type A component. Therefore the *SFF* has to be more than 90 % according to IEC 61508-2 table 2 for SIL 3 (sub-) systems with a hardware fault tolerance of 0.

Characteristics (valid for one sensor circuit without valve connection circuit)

Parameter	Symbol	Condition [1)]	Value	Unit
Component Type			A	
Hardware Fault Tolerance	*HFT*		0	
Safe Failure Rate	λ_{safe}		2.69E-8	1 / h
No Effect Failure Rate	$\lambda_{no\ effect}$		4.74E-9	1 / h
Dangerous Failure Rate	$\lambda_{dangerous}$		9.00E-11	1 / h
Total Failure Rate	λ_{total}		3.17E-8	1 / h
Total Safe Failure Rate	λ_S		3.16E-8	1 / h
Total Dangerous Failure Rate	λ_D		9.00E-11	1 / h
Safe Failure Fraction	*SFF*		99.72	%
Mean Time To Failure	*MTTF*		3.15E+7	h

Parameter	Symbol	Condition [1)]	Value	Unit
Average Probability of Failure on Demand	PFD_{avg}	T_{proof} = 1 year	3.94E-07	
Average Probability of Failure on Demand	PFD_{avg}	T_{proof} = 2 years	7.88E-07	
Average Probability of Failure on Demand	PFD_{avg}	T_{proof} = 5 years	1.97E-06	
Probability of Dangerous Failure per Hour	*PFH*		9.00E-11	1/h
Safety Integrity Level	*SIL*		3	
Useful Lifetime			20	a
Diagnostic Coverage	*DC*		0	%

[1)] Assumptions and conditions

The following assumptions have been made during the Failure Mode Effect and Diagnostic Analysis (FMEDA):

General:

- Failure rates are constant, wear out mechanisms are not included.
- Propagation of failures is not relevant.
- All component failure modes are known.
- The repair time after a safe failure is 8 hours.
- The average temperature over a long period of time is 40 °C.
- The stress levels are average for an industrial environment and can be compared to the Ground Fixed classification of MIL-HDBK-217F. Alternatively, the assumed environment is similar to IEC 60645-1, Class C (sheltered location) with an average temperature over a long period of time of 40 °C.
- The sensor is operated in the low demand mode of operation.
- The sensor is connected to a fail safe interface which is qualified by Pepperl+Fuchs for use in this application (e.g. a Pepperl+Fuchs SH fail safe interface) and which is also tested according IEC 61508 SIL 3.
- For the high impedance off-state the target is within the assured release distance ($s < s_{ar} = 0.6 \cdot s_n$). (For details see section “Targets and Assured Release Distance”.)
- The 2-wire connection cable between the sensor and the switching amplifier must meet the qualities as follows: Line resistance $R_{series} < 50\ \Omega$ (both leads in series); Insulation resistance $R_{insulation} > 1\ M\Omega$.

Device specific:

- SN4 devices are containing a pair of independent sensor circuits. This declaration applies to one of the two equal sensor circuits. The valve connection circuit is not part of this functional safety declaration.
- *PFD* and *PFH* values are calculated for a 1oo1 structure.
- The board (with IP00) is mounted inside a box and there is no electrically conducting pollution. Pollution degree 1 according IEC 60664.

- The products are designed for a useful lifetime of 20 years regarding constant failure rates of its components. This is ensured by excluding the use of more rapidly aging components like wet electrolytic capacitors or optical isolators in the safety path. Nonetheless this can be reduced, if the device is driven under harsh working conditions with either excessive mechanical stress (vibration), higher average ambient temperature than assumed or prevalent substantial temperature cycles.

Targets and Assured Release Distance

The nominal sensing distance s_n and therefore the assured release distance s_{ar} depends on the dimensions and the material of the target. **The safety characteristics are evaluated when the target is within the assured release distance s_{ar}. It is important that the gap size between the damping material and the active faces of the sensor is narrower than s_{ar}.** Hint: The typical gap size is 0.8 mm.

Part No.	Target Name	Material	Nom. Sensing Distance s_n	Assured Release Distance s_{ar}	Remarks	On-state Angle (typ.)
212360	BT32XS	1.4057	3.5 mm	2.1 mm	one slot	± 7°
212364	BT32XAS	1.4057	3.5 mm	2.1 mm	two slots	± 7°

If customized targets are used it must be guaranteed that the gap size between the damping material and the active faces of the sensor is closer than 0.6 times the individual measured real sensing distance or 0.5 times the real sensing distance measured at an even reference sensor.

The target, respectively its fastening screw must be protected against loosening with a suitable action, e.g. with threadlocker.

The target must be centered on the shaft stub. If the target BT32XS or BT32XAS is fixed with a smaller screw than M6, it is necessary to use a suitable centering washer.

Definitions

The following definitions for the failure of the product were considered.

The sensors are connected to a qualified fail safe interface, e.g. Pepperl+Fuchs KFD2-SH-EX1.

Fail-Safe State	The fail-safe state is defined as the output being below 1.8 mA or above 6.0 mA.
Fail Safe	Failure that causes the module / (sub)system to go to the defined fail-safe state without an electrically conductive material covering the sensor.
Fail Dangerous	Failure leading to an output current between 1.8 mA and 6.0 mA (i.e. being unable to go to the defined fail-safe state).
Fail No Effect	Failure of a component that is part of the safety function but has no effect on the safety function. For the calculation of the *SFF* it is treated like a safe undetected failure.

For the calculation of the Safe Failure Fraction (*SFF*) the following has to be noted:

$\lambda_{total} = \lambda_{safe} + \lambda_{dangerous} + \lambda_{no\ effect}$

$SFF = 1 - \lambda_{dangerous} / \lambda_{total} = (\lambda_{safe} + \lambda_{no\ effect}) / \lambda_{total}$

The failure categories listed above expand on the categories listed in IEC 61508 which are only safe and dangerous. It is important to realize that the „no effect" failures are included in the „safe" failure category according to IEC 61508. Note that these failures on its own will not affect system reliability or safety, and should not be included in spurious trip calculations.

Although the PFD_{avg} values and the *SFF* of the sensors for applications with (Pepperl+Fuchs) fail safe interface, e.g. KFD2-SH-EX1, are within the allowed range for SIL 3 according to IEC 61508 it depends on the failure rates of the fail safe interface whether they can also be used for SIL 3 safety functions.

For the calculation of the accumulated Failure Rates (λ_S and λ_D) the following has to be noted:

$\lambda_S = \lambda_{safe} + \lambda_{no\ effect}$

$\lambda_D = \lambda_{dangerous}$

Summary

The calculated PFD_{avg} values are within the allowed range for SIL 3 according to of IEC 61508-1 table 2 and do fulfil the requirement to not claim more than 25 % of this range, i.e. to be better than or equal to $2.5 \cdot 10^{-4}$.

Qualitätsmanagement ISO 9001:2008
Reg. Nr. 000760 QM08

Hersteller-Unterschrift/ Signature of manufacturer:	ppa. Helm	i. V. Ehrenfried
Funktion des Unterzeichners/ Function of the signer:	Leiter GF Sensoren Fabrikautomation Manager BU Sensors Factory Automation	Leiter Entwicklung GF Sensoren Fabrikautomation Manager R&D BU Sensors Factory Automation
Datum/Date:	September 2012/September 2012	