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SIL Manufacturer's Declaration

Functional safety of inductive proximity sensors acc. to IEC 61508:2001; PF15CERT1624D

1. Safety Evaluation

Pepperl+Fuchs GmbH, Lilienthalstrasse 200, 68307 Mannheim

declares as manufacturer, that for the inductive proximity sensors, types mentioned below, the calculated PFD_{avg} values for low demand mode of operation are within the allowed range for SIL 2 according to IEC 61508-1:2001 table 2 and do fulfil the requirement not to claim more than 25% of this range for a low demand application, i.e. to be better than or equal to $2.5 \cdot 10^{-3}$.

For high demand mode of operation, the PFH is within the allowed range for SIL 2 according to IEC 61508-1:2001 table 3 and fulfils the requirement to not claim more than 25% of this range, i.e. to be better than or equal to $2.5 \cdot 10^{-7}$ 1/h.

2. Products

Inductive proximity sensors with NAMUR interface in accordance with IEC 60947-5-6:1999 or EN 60947-5-6:2000, see product list.

Product List, Nominal Sensing Distance (s_n), Assured Release Distance (s_{ar}) and Targets

Part No.	Product Name	s_n	s_{ar}	Reference Target
106331	NJ0.8-4.5-N	0.8 mm	0.56 mm	4.5 x 4.5 x 1 mm^3, Fe 360
106334	NJ0.8-5GM-N	0.8 mm	0.56 mm	4.5 x 4.5 x 1 mm^3, Fe 360
106335	NJ0.8-5GM-N-5M	0.8 mm	0.56 mm	4.5 x 4.5 x 1 mm^3, Fe 360
106336	NJ0.8-5GM-N-10M	0.8 mm	0.56 mm	4.5 x 4.5 x 1 mm^3, Fe 360
106350	NJ1.5-6.5-N	1.5 mm	1.05 mm	6.5 x 6.5 x 1 mm^3, Fe 360
106351	NJ1.5-6.5-N-15M	1.5 mm	1.05 mm	6.5 x 6.5 x 1 mm^3, Fe 360
106352	NJ1.5-6.5-N-5M	1.5 mm	1.05 mm	6.5 x 6.5 x 1 mm^3, Fe 360
129729	NJ1.5-6.5-N-Y10514	1.5 mm	1.05 mm	6.5 x 6.5 x 1 mm^3, Fe 360
180670	NJ1.5-6.5-N-Y10514-10M	1.5 mm	1.05 mm	6.5 x 6.5 x 1 mm^3, Fe 360
106361	NJ1.5-8GM-N	1.5 mm	1.05 mm	8 x 8 x 1 mm^3, Fe 360
106362	NJ1.5-8GM-N-10M	1.5 mm	1.05 mm	8 x 8 x 1 mm^3, Fe 360
106363	NJ1.5-8GM-N-5M	1.5 mm	1.05 mm	8 x 8 x 1 mm^3, Fe 360
106364	NJ1.5-8GM-N-V1	1.5 mm	1.05 mm	8 x 8 x 1 mm^3, Fe 360
106369	NJ1.5-8GM-N-Y18488	1.5 mm	1.05 mm	8 x 8 x 1 mm^3, Fe 360
106377	NJ2-11-N	2.0 mm	1.40 mm	11 x 11 x 1 mm^3, Fe 360
106378	NJ2-11-N-G	2.0 mm	1.40 mm	11 x 11 x 1 mm^3, Fe 360
106379	NJ2-11-N-G-15M	2.0 mm	1.40 mm	11 x 11 x 1 mm^3, Fe 360
106380	NJ2-11-N-G-5M	2.0 mm	1.40 mm	11 x 11 x 1 mm^3, Fe 360
106389	NJ2-12GK-N	2.0 mm	1.40 mm	12 x 12 x 1 mm^3, Fe 360
106390	NJ2-12GK-N-5M	2.0 mm	1.40 mm	12 x 12 x 1 mm^3, Fe 360
106394	NJ2-12GM-N	2.0 mm	1.40 mm	12 x 12 x 1 mm^3, Fe 360
106395	NJ2-12GM-N-10M	2.0 mm	1.40 mm	12 x 12 x 1 mm^3, Fe 360
120527	NJ2-12GM-N-25M	2.0 mm	1.40 mm	12 x 12 x 1 mm^3, Fe 360
106636	NJ2-12GM-N-5M	2.0 mm	1.40 mm	12 x 12 x 1 mm^3, Fe 360
106397	NJ2-12GM-N-V1	2.0 mm	1.40 mm	12 x 12 x 1 mm^3, Fe 360
106406	NJ2-V3-N	2.0 mm	1.40 mm	12 x 12 x 1 mm^3, Fe 360
211636	NJ2-V3-N	2.0 mm	1.40 mm	12 x 12 x 1 mm^3, Fe 360

Part No.	Product Name	s_n	s_{ar}	Reference Target
250497	NJ2-V3-N-0.075M	2.0 mm	1.40 mm	12 x 12 x 1 mm^3, Fe 360
106407	NJ2-V3-N-V5	2.0 mm	1.40 mm	12 x 12 x 1 mm^3, Fe 360
211638	NJ2-V3-N-V5	2.0 mm	1.40 mm	12 x 12 x 1 mm^3, Fe 360
106413	NJ4-12GK-N	4.0 mm	2.80 mm	12 x 12 x 1 mm^3, Fe 360
106414	NJ4-12GK-N-10M	4.0 mm	2.80 mm	12 x 12 x 1 mm^3, Fe 360
106415	NJ4-12GK-N-5M	4.0 mm	2.80 mm	12 x 12 x 1 mm^3, Fe 360
106422	NJ4-12GM-N	4.0 mm	2.80 mm	12 x 12 x 1 mm^3, Fe 360
106423	NJ4-12GM-N-10M	4.0 mm	2.80 mm	12 x 12 x 1 mm^3, Fe 360
106424	NJ4-12GM-N-20M	4.0 mm	2.80 mm	12 x 12 x 1 mm^3, Fe 360
106425	NJ4-12GM-N-5M	4.0 mm	2.80 mm	12 x 12 x 1 mm^3, Fe 360
106426	NJ4-12GM-N-V1	4.0 mm	2.80 mm	12 x 12 x 1 mm^3, Fe 360
106434	NJ5-11-N-15M	5.0 mm	3.50 mm	15 x 15 x 1 mm^3, Fe 360
106435	NJ5-11-N-5M	5.0 mm	3.50 mm	15 x 15 x 1 mm^3, Fe 360
106437	NJ5-11-N-G	5.0 mm	3.50 mm	15 x 15 x 1 mm^3, Fe 360
106438	NJ5-11-N-G-10M	5.0 mm	3.50 mm	15 x 15 x 1 mm^3, Fe 360
106439	NJ5-11-N-G-5M	5.0 mm	3.50 mm	15 x 15 x 1 mm^3, Fe 360
106440	NJ5-11-N-G-6M	5.0 mm	3.50 mm	15 x 15 x 1 mm^3, Fe 360

3. Safety Function

The safe state is reached when the active face is covered with a target within the assured release distance s_{ar}. In this case the sensor is in the high impedance state ('off state'). It is important that the gap size between the target (damping material) and the active face of the sensor is narrower than s_{ar}.

This evaluation is only valid for using amplifiers/safety functions that rely on the 'off state' as safe state.

Sensor respective amplifier output	Sensor condition (see Conditions and Assumptions)
On state	active face uncovered and sensor functioning
Off state	active face covered or sensor defective

The nominal sensing distance s_n and therefore the assured release distance s_{ar} depends on the dimensions and the material of the target.

If customized targets are used it must be guaranteed that the distance between the damping material and the active face of the sensor is closer than 0.7 times the individual measured real sensing distance or 0.6 times the real sensing distance measured at an even reference sensor.

4. Safety Characteristic Values

Parameter	Symbol	Condition [2)]	Value	Unit
Type			A	
Hardware Fault Tolerance	*HFT*		0	
Total Failure Rate	λ_{total}		2.90E-08	1 / h
Total Safe Failure Rate	λ_{safe}		2.21E-08	1 / h
Total Dangerous Failure Rate	$\lambda_{dangerous}$		6.91E-09	1 / h
Safe Failure Fraction	*SFF*		76.19	%
Mean Time to Failure	*MTTF*		3.45+07	h

Parameter	Symbol	Condition [2]	Value	Unit
Average Probability of Failure on Demand	PFD_{avg} [1]	T_{proof} = 1 year	3.02E-05	
Average Probability of Failure on Demand	PFD_{avg} [1]	T_{proof} = 2 years	6.05E-05	
Average Probability of Failure on Demand	PFD_{avg} [1]	T_{proof} = 5 years	1.51E-04	
Probability of Dangerous Failure per Hour	*PFH* [1]		6.91E-09	1 / h
Safety Integrity Level	*SIL*		2	
Useful lifetime	T_M		20	a
Diagnostic Coverage	*DC*		0	%

[1] 1oo1 structure

5. Conditions and Assumptions

The sensor is connected to a NAMUR interface in accordance with EN 60947 5 6:2000. The failure rates are based on the Siemens standard SN 29500. According to IEC 61508-1:2001 table 2, the average *PFD* for systems operating in low demand mode of operation has to be lower than 10^{-2} for SIL 2 safety functions. However, as the sensor 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 $2.5 \cdot 10^{-3}$.

For high demand mode of operation, the PFH has to be lower than 10^{-6} 1/h for SIL 2 safety functions. However, as the sensor 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 $2.5 \cdot 10^{-7}$ 1/h.

The sensor is considered to be Type A component. Therefore the *SFF* has to be 60 % to 90 % according to IEC 61508-2:2001 table 2 for SIL 2 (sub-) systems with a hardware fault tolerance of 0.

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

- Failure rates are constant, wear out mechanisms are not included (T_M = 20a)
- Propagation of failures is not relevant.
- All component failure modes are known (Type A).
- 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 ºC.
- For the high impedance state the object is within the assured release distance ($s < s_{ar} = 0.7 \cdot s_n$, see table "Product List, Nominal Sensing Distance (s_n), Assured Release Distance (s_{ar}) and Targets").
- The 2-wire connection cable between the sensor and the switching amplifier must meet the qualities as follows: Line resistance R_{series} < 50 Ω (both leads in series); Insulation resistance $R_{insulation}$ > 1 MΩ.
- PFD and PFH values are calculated for use in a 1oo1 structure.
- 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.

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6. Definitions

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

Application according to EN 60947-5-6:2000 (DC interface for proximity sensors and switching amplifiers (NAMUR)):

Fail-Safe State	The fail-safe state is defined as the output being below 1.2 mA (high impedance).
Fail Safe	Failure that causes the module / (sub)system to go to the defined fail-safe state without a demand from the process.
Fail Dangerous	Failure leading to an output current above 1.2 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 that 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:

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

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

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

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

$\lambda_D = \lambda_{dangerous}$

The failure categories listed above expand on the categories listed in IEC 61508:2001 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 61508:2001.

Note that these failures on its own will not affect system reliability or safety, and should not be included in spurious trip calculations.

Reg. Nr. 000760 QM08

Hersteller-Unterschrift / Signature of manufacturer:	ppa. Wolfgang Helm	i. V. Ulrich 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
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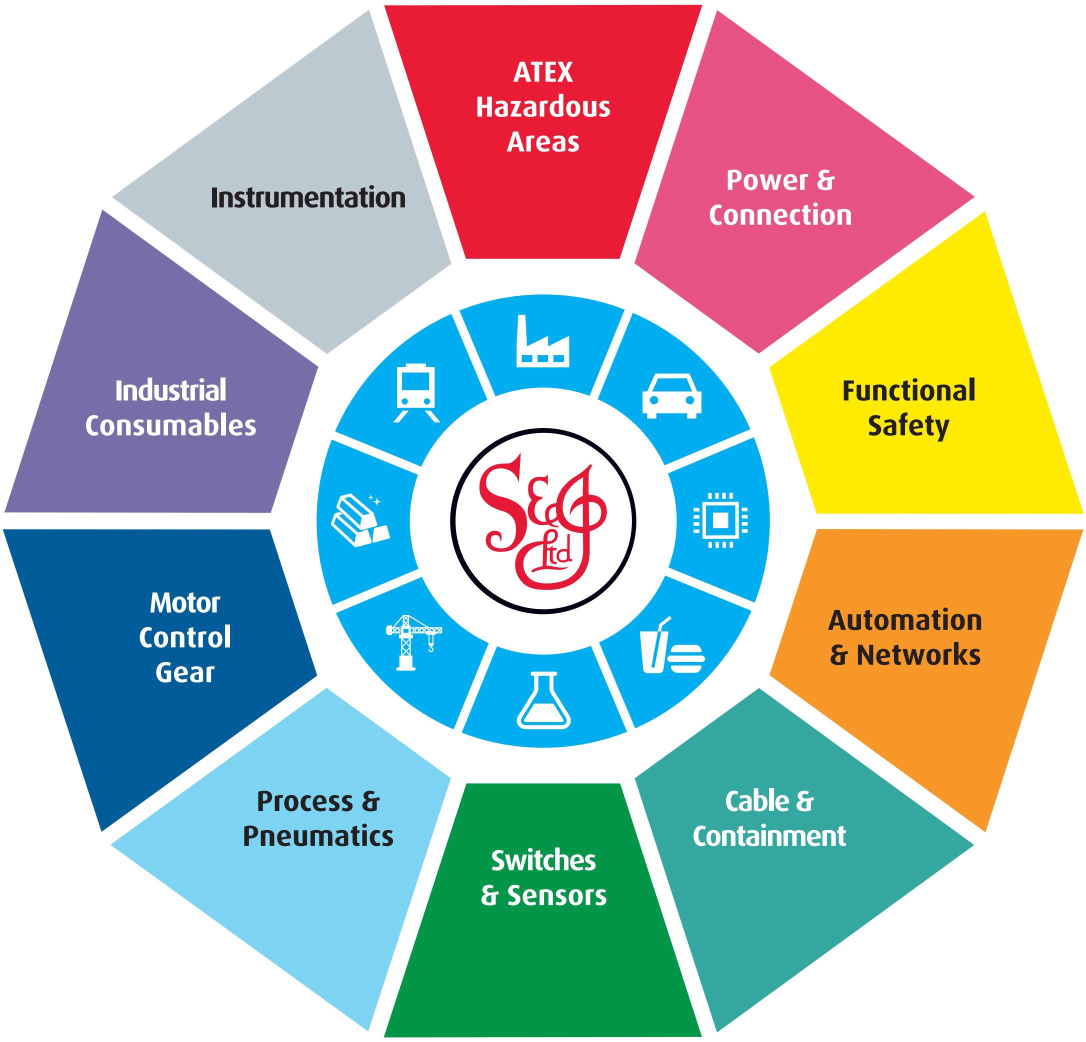

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