Type	Safety as per ISO 13849-1	Performance Level	Category	$MTTF_d$-level	$MTTF_d$ [Years]	DC_{avg}-level	DC_{avg} [%]	B_{10d} [× 10^6]	Response time [ms]
SG-SUE 41X4 NA for E-Stop switch	ISO 13849-1:2006 Category 4 PL e	e	4	high	246	medium	90	2 [1)]	25
SG-SUE 41X4 NA for SM, SL or SB	ISO 13849-1:2006 Category 3 PL d	d	3	high	246	medium	90	2 [1)]	25
SG-EFS 104/4L	ISO 13849-1:2006 Category 3 PL d	d	3	high	62,8	medium	90	2 [1)]	30
SG-EFS 1X4 ZK2/1 (8k2)	ISO 13849-1:2006 Category 3 PL d	d	3	high	313,3	medium	90	2 [1)]	10
SG-EFS 1X4 ZK2/1 L20ms (LR)	ISO 13849-1:2006 Category 3 PL d	d	3	high	313,3	medium	90	2 [1)]	30
SG-SLE X4-0X1	ISO 13849-1:2006 Category 3 PL d	d	3	high	279	medium	90	2 [1)]	15
SG-AS-i-1k2/XXX	ISO 13849-1:2006 Category 3 PL d	d	3	high	538	medium	90	2 [1)]	5
SG-AS-i-8k2/XXX	ISO 13849-1:2006 Category 3 PL d	d	3	high	538	medium	90	2 [1)]	5
SG-OSL	ISO 13849-1:2006 Category 3 PL d	d	3	high	196	medium	90	2 [1)]	20
SG-TRS 208/XXX	ISO 13849-1:2006 Category 3 PL d	d	3	high	246	low	60	2 [1)]	20
SG-RST 153	ISO 13849-1:2006 Category 2 PL c	c	2	high	56	low	65	2 [1)]	5
SG-RED 1X3	ISO 13849-1:2006 Category 1 PL c	c	1	high	300	–	–	2 [1)]	20
SG-EFS 2X0	ISO 13849-1:2006 Category 1 PL c	c	1	high	306,5	–	–	2 [1)]	20
SG-RS 204	–	–	–	–	–	–	–	–	–
SG-RS 1X1	–	–	–	–	–	–	–	–	15
Safety Mats SM	–	–	–	[3)]	[3)]	–	–	6	8
Safety Mats TS	–	–	–	[3)]	[3)]	–	–	6	8
Safety Edges SL	–	–	–	[3)]	[3)]	–	–	4	[4)]
Safety Edges SL/NC II	–	–	–	[3)]	[3)]	–	–	2	[4)]
Mini Safety Edges EKS	–	–	–	[3)]	[3)]	–	–	2	[4)]
Safety Bumper SB	–	–	–	[3)]	[3)]	–	–	2	[4)]
Safety Bumper SB/K	–	–	–	[3)]	[3)]	–	–	2	[4)]

[1)] assumed parameter: d_{op} = 365 d/a, h_{op} = 24 h/d, t_{Zyklus} = 600 s
[2)] Data not yet available; will be supplied at a later date from TÜV NORD.
[3)] MTTFd-level and-value depend on application (see page 3).
[4)] depends on profile

Determine PL

If Category, DC_{avg} and $MTTF_d$ are known, the Performance Level (PL) can be determined in accordance with the table.

Example 1:
SG-EFS 1X4 ZK2/1
Category 3
DC_{avg} = 90% => DC_{avg} medium
$MTTF_d$ = 313.3 Years => $MTTF_d$ high
Result: => **PL d**

Example 2:
SG-EFS 2X0
Category 1
DC_{avg} not known => DC_{avg} none
$MTTF_d$ = 306.5 Years => $MTTF_d$ high
Result: => **PL c**

Simplified method for determining the PL							
Category	B	1	2	2	3	3	4
DC_{avg}	none	none	low	medium	low	medium	high
$MTTF_d$ low	**a**	**–**	**a**	**b**	**b**	**c**	**–**
$MTTF_d$ medium	**b**	**–**	**b**	**c**	**c**	**d**	**–**
$MTTF_d$ high	**–**	**c**	**c**	**d**	**d**	**d**	**e**

DC_{avg}-Table

Designation DC_{avg}	Range
none	$DC_{avg} < 60\%$
low	$60\% \leq DC_{avg} < 90\%$
medium	$90\% \leq DC_{avg} < 99\%$
high	$99\% \leq DC_{avg}$

$MTTF_d$-Table

Designation $MTTF_d$	Range
–	–
low	3 years < $MTTF_d$ < 10 years
medium	10 years ≤ $MTTF_d$ < 30 years
high	30 years ≤ $MTTF_d$ < 100 years

PL => SIL

Performance Level (ISO 13849)	Safety Integrity Level (IEC 61508)	Probability of a hazardous failure [1/h]
PL a	–	$10^{-4} > X \geq 10^{-5}$
PL b	SIL1	$10^{-5} > X \geq 3 \times 10^{-6}$
PL c	SIL1	$3 \times 10^{-6} > X \geq 10^{-6}$
PL d	SIL2	$10^{-6} > X \geq 10^{-7}$
PL e	SIL3	$10^{-7} > X \geq 10^{-8}$

Determine Sensor-$MTTF_d$

$$MTTF_d = \frac{B_{10d}}{0.1 \times n_{op}}$$

Example 3:
Safety Mat installation in processing centre with 30s tact, 3 shifts for 250 days per year.
n_{op} = 120 actuations/h × 24 h/day × 250 days = 720 000 actuations/a
$MTTF_d = B_{10d} / (0.1 \times n_{op}) = 6\,000\,000 / (0.1 \times 720\,000) = 83.3$ Years => **$MTTF_d$high**

Example 4:
NC Safety Edge installation in sliding gate with 2 actuations/day (morning and evening) on 365 days per year.
n_{op} = 2 actuations/day × 365 days = 730 actuations/a

$MTTF_d = B_{10d} / (0.1 \times n_{op}) = 2\,000\,000 / (0.1 \times 730) = 27\,397.3$ Years => **$MTTF_d$high**

Determine total-$MTTF_d$

$$\frac{1}{MTTF_d} = \frac{1}{MTTF_dSG} + \frac{1}{MTTF_dSensor}$$

Example 5:
As example 3; **Safety mat SM** connected to **SG-EFS 1X4 ZK2/1**.
$MTTF_d$SG = 313.3 Years
$MTTF_d$SM = 83.3 Years

$$\frac{1}{MTTF_d} = \frac{1}{313.3\ \text{Years}} + \frac{1}{83.3\ \text{Years}}$$

$MTTF_d$ = 65.8 Years => **$MTTF_d$high**

Note:
This represents a significantly simplified description that shows the determination of the total-$MTTF_d$ in a very limited fashion.
Other items to be considered:
+ lines between sensor and SG
+ varying channels
+ lines between SG and machine
+ connection methods

Glossary

B_{10d}	Number of cycles until 10% of the components fail dangerously (for electromechanical components)
DC_{avg}	average diagnostic coverage range; measurement for effectiveness of the diagnostics that can be determined as the rate of the failure rate of the dangerous failure noticed in comparison with the failure rate of all dangerous failures
$MTTF_d$	mean time to the danger bringing failure
n_{op}	mean quantity of actuations/a: $n_{op} = (3600\ s/t_{zyklus})/h \times h_{op} \times d_{op}$
PL	Performance Level; discrete level that specifies the capability of safety relevant parts of a control system, to carry out a safety function under foreseeable conditions
SIL	Safety Integrity Level; discrete level for the specification of the safety integrity of the safety functions