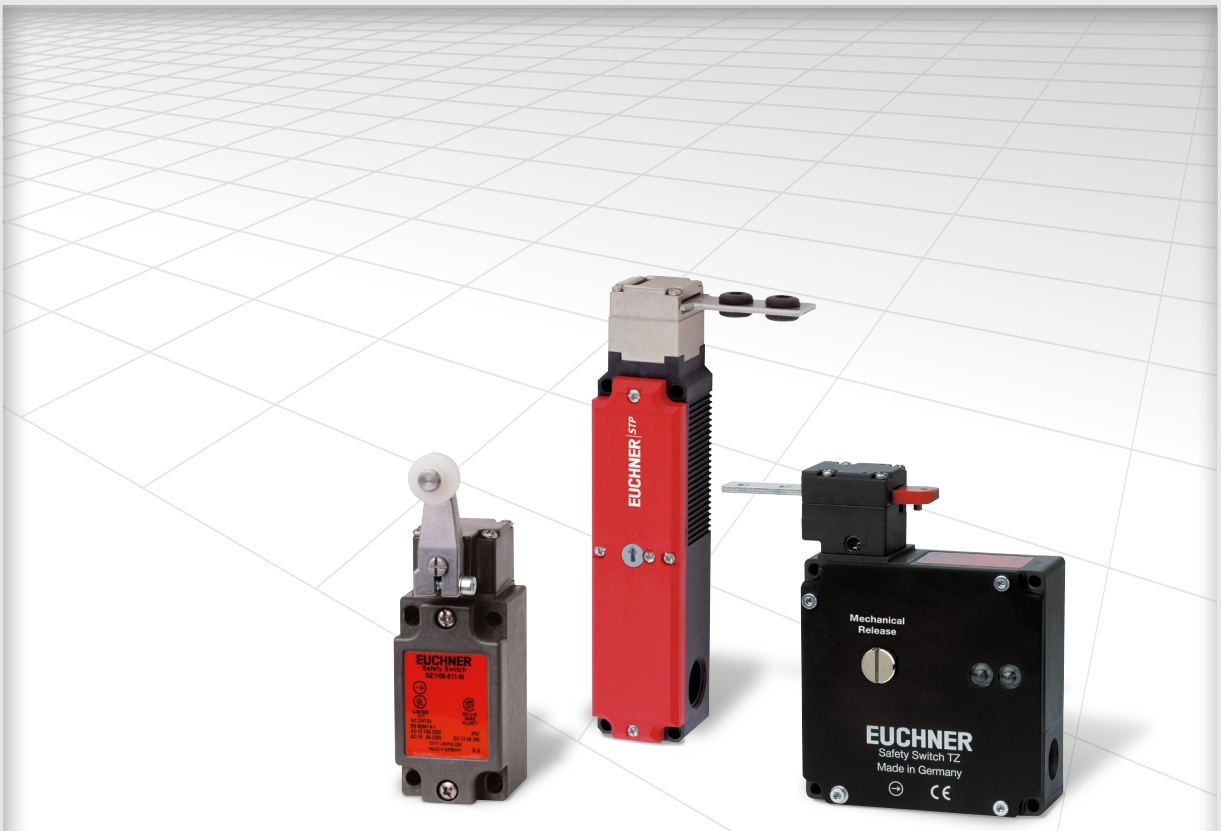


Machinery directive 2006/42/EG ✔
EN ISO 13849-1:2015 ✔
EN ISO 14119:2013 ✔

Proven Systems – Proven Safe

Categories and Performance Levels acc. to EN ISO 13849-1

EUCHNER
More than safety.

Which PL can be achieved with which product?

		Mechanical Safety Switches		
		With integrated actuator	With separate actuator	
			Without guard locking	With guard locking and guard locking monitor
				
	Valid for the following products	All safety switches with integrated actuator NZ, N1A, NB01, NM, ESH	All safety switches with separate actuator NZ.VZ, NX, NM.VZ, NQ, NP, GP, SGP	All safety switches with separate actuator and with guard locking TZ, TX, TP, TQ, STP, STA, STM, TK*
Which standards have been observed when developing the product?	The products comply with the requirements of the following standards	▶ EN 60947-5-1, Annex K positively driven contacts ▶ EN ISO 14119		
		Examples		
What is required to achieve a certain category / PL?	For category 1 / PL c according to EN ISO 13849-1	▶ 1 EUCHNER Safety switch ▶ 1 Safety relay (e.g. ESM)	▶ 1 EUCHNER Safety switch ▶ 1 Safety relay (e.g. ESM)	▶ 1 EUCHNER Safety switch ▶ 1 Safety relay (e.g. ESM)
	For category 3 / PL d according to EN ISO 13849-1	**Solution a)** ▶ 1 EUCHNER Safety switch ▶ 1 Safety relay (e.g. ESM) ▶ Fault exclusion or **Solution b)** ▶ 2 EUCHNER Safety switches ▶ 1 Safety relay (e.g. ESM)	**Solution a)** ▶ 1 EUCHNER Safety switch ▶ 1 Safety relay (e.g. ESM) ▶ Fault exclusion or **Solution b)** ▶ 2 EUCHNER Safety switches ▶ 1 Safety relay (e.g. ESM)	**Solution a)** ▶ 1 EUCHNER Safety switch ▶ 1 Safety relay (e.g. ESM) ▶ Fault exclusion or **Solution b)** ▶ 2 EUCHNER Safety switches ▶ 1 Safety relay (e.g. ESM)
	For category 4 / PL e according to EN ISO 13849-1	▶ 2 EUCHNER Safety switches ▶ 1 Safety relay (e.g. ESM)	▶ 2 EUCHNER Safety switches ▶ 1 Safety relay (e.g. ESM)	▶ 2 EUCHNER Safety switches ▶ 2 Safety relays (e.g. ESM)
Does the solution require a fault exclusion?	Information to exclude faults (see EN ISO 13849-1 and EN ISO 13849-2)	**Why is a fault exclusion allowed?** According to clause 7.3 of EN ISO 13849-1:2015 a fault exclusion can be made. **Who makes the fault exclusion?** Only the design engineer of a machine / plant is able to make a fault exclusion. **How do you proceed appropriately?** Step 1: Justify (Why was the fault excluded?) Step 2: Validate (Does the solution fulfill all requirements?) Step 3: Document (Is it possible to follow at any time why the fault exclusion has been made and also under which conditions the solution has reached the necessary safety level?) **Tip:** ▶ For the above mentioned steps use the checklist in this folder ▶ The SISTEMA-Software, which can be downloaded from the IFA homepage, helps you with the calculation and the documentation.		
What helps for validation?	Basic facts which have to be observed when designing the machine (see additionally **EN ISO 14119** and **EN ISO 13849 part 1 and 2**)	▶ Do not use safety switch as end stop ▶ Trip dogs and safety switches have to be mounted positively ▶ Electrical evaluation unit designed dual-channel	▶ Do not use safety switch as end stop ▶ Actuator and safety switch have to be mounted positively ▶ Observe actuator guide and insertion depth ▶ Electrical evaluation unit designed dual-channel	▶ Do not use safety switch as end stop ▶ Actuator and safety switch have to be mounted positively ▶ Observe actuator guide and insertion depth ▶ Observe maximum locking force ▶ Electrical evaluation unit designed dual-channel

* Product has no failsafe locking mechanism

Non-Contact Safety Engineering

Magnet Coding	Transponder Coding		
System family CMS (System consisting of readhead and evaluation unit with relay outputs)	System family CES-AZ (System consisting of read head and evaluation unit with relay outputs)	System families CES-A-.5, CES-AH, CES-AP, CET-AP, CTP-AP, MGB-AP	System families CES-AR, CET-AR, CTP-AR, CEM-AR, MGB-...-AR
			
Evaluation units CMS and Safety relays ESM with corresponding CMS-read heads type 4	Evaluation units CES with read heads CES-A-L... and read heads with guard locking CEM, CET-AX type 4	Safety Switch CES-A-.5, CES-AH, CES-AP, Safety Switch with guard locking CET-AP, CTP-AP as well as MGB-AP with and without guard locking type 4	Safety Switch CES-AR, ESL-AR, Safety Switch with guard locking CET-AR, CEM-AR, CTP-AR as well as MGB-AR with and without guard locking type 4
▸ EN 60947-5-2 ▸ EN 60947-5-3 ▸ EN ISO 14119	▸ EN 60947-5-2 ▸ EN 60947-5-3 ▸ EN ISO 14119		
Examples			
▸ 1 Read head ▸ 1 Evaluation unit CMS or 1 Safety relay ESM*	▸ 1 Read head ▸ 1 Evaluation unit CES	▸ 1 Safety switch CES, CTP, CET, MGB	▸ 1 Safety switch CES, CET, ESL, CTP, CEM or 1 MGB
▸ 1 Read head ▸ 1 Evaluation unit CMS or 1 Safety relay ESM*	▸ 1 Read head ▸ 1 Evaluation unit CES	▸ 1 Safety switch CES, CTP, CET, MGB	▸ 1 Safety switch CES, CET, ESL, CTP, CEM or 1 MGB
▸ 1 Read head ▸ 1 Evaluation unit CMS or 1 Safety relay ESM*	▸ 1 Read head ▸ 1 Evaluation unit CES*	▸ 1 Safety switch CES*, CTP, CET, MGB	▸ 1 Safety switch CES, CET, ESL, CTP, CEM or 1 MGB
No fault exclusion necessary			
Important: The evaluation unit has relay contacts. Depending on the application this can have an impact on the achievable PL. ▸ Observe maximum number of operating cycles ▸ Restrict the switching current	**Important:** The evaluation unit has relay contacts. Depending on the application this can have an impact on the achievable PL. ▸ Observe maximum number of operating cycles ▸ Restrict the switching current		

* depending on the product used for the application

Example calculation of the PL for an electromechanical safety switch as door position sensor

What is SISTEMA?

SISTEMA provides developers and testers of safety related machine controls support in the evaluation of safety in the context to EN ISO 13849-1.The tool enables to model the structure of safety-related control components based upon the designated architectures, thereby permitting automated calculation of the reliability values.
The SISTEMA program may be downloaded and distributed to third parties free of charge. The software was published by IFA www.dguv.de/ifa.

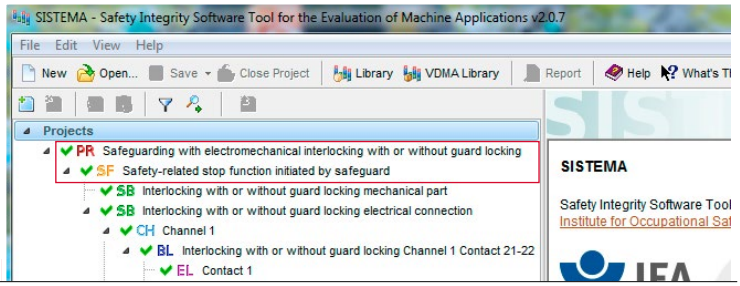
A library with safety values for EUCHNER products can be downloaded from https://www.euchner.de/en-us/Service/Downloads/Software/Sistema.

Precondition / Procedure:

- In this example project just the door position sensor is demonstrated (A logic as well as a safety output have to be added later for the calculation of the complete system)
- The electromechanical door position sensor is separated in two subsystems:
  · Subsystem mechanics with fault exclusion
  · Subsystem electrical system, dual-channel designed in category 3

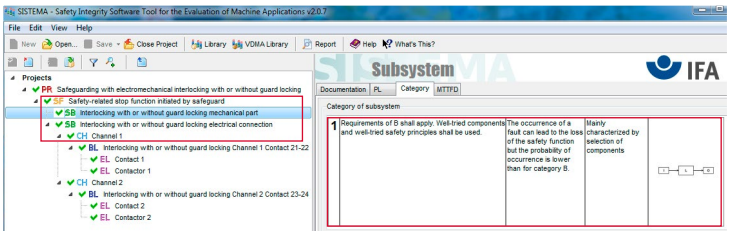
Step 1

Create new SISTEMA project and new safety function



Step 2

Create a subsystem for the mechanical part of the switch.
The mechanical part is single channel, category 1

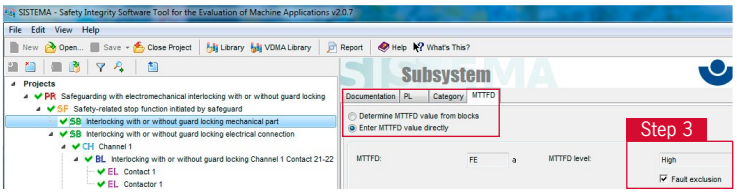


Step 2

Step 3

Enter a fault exclusion on subsystem level for the mechanical part

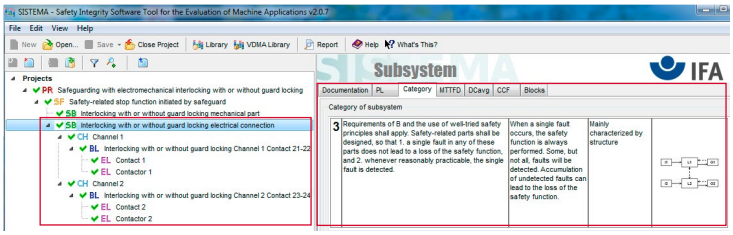
Tip:
For the documentation of the fault exclusion the overleaf checklist in SISTEMA can be linked (e.g. as PDF-document)



Step 4

Create a subsystem for the electrical part of the safety switch

- The electical design is dual-channel, category 3



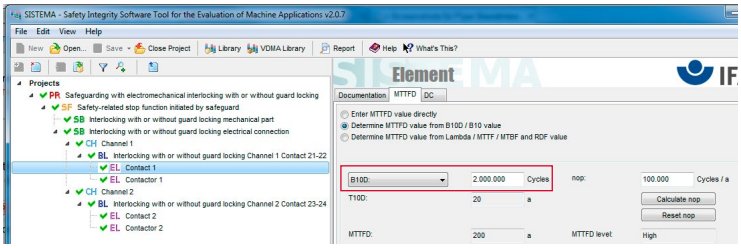
Step 4

Step 5

Enter B_{10D} of the chosen safety switch

- The contacts are calculated individually with the B_{10D} of the selected safety switch

Remark:
The PL e for safety doors should not be based on a fault exclusion!



Step 5

Fault exclusion on an electromechanic safety switch with and without guard locking

Consider the following when working with fault exclusions:

- The fault exclusion should remain restricted to the mechanical parts of a switch.
- The electrical connection should comply with the required category (compare EN ISO 13849-1:2015, section 7.3: „If faults are excluded, a detailed justification shall be given in the technical documentation." and EN ISO 13849-1:2015, section 8: „The design of the SRP/CS shall be validated … . The validation shall demonstrate that the combination of SRP/CS providing each safety function meets all relevant requirements of this part of EN ISO 13849.")
- To fulfill these requirements, EN ISO 13849-2 must be consulted.

Checklist

1.

Fulfilled? ☐

Are the requirements of category B on the safety components fulfilled?
Does the safety switch withstand the forces to be expected at the safety guard?

Notes: Static and dynamic forces can appear. Static forces result for example from pulling at the door handle, at which very big forces may effect on the switch via a lever. Dynamic forces result for example from slamming the door.

- **Are these forces for example caused by misalignment of the door guide on the head of the safety switch (actuator hits in a wrong place or head serves as end stop)?**
- **Can forces which lie above the safety switch's locking force arise by beating the door back when the guard locking is already closed?**

Possibilities for validation of mechanical systems EN ISO 13849-2:2013
See also EN ISO 13849-2:2013 Table A.1 and Table A.4
In EN ISO 13849-2 table D.8 it is mentioned that, for safety doors, the fault exclusion „mechanical fault" is not permitted for the PL e.

2.

Fulfilled? ☐

Is the safety switch protected against external forces?

Note: Can for example a fork-lift damage the safety switch?
Are forces that act dynamically on the switch, sufficiently limited?
See section 6.2.2 of EN ISO 14119:2013

3.

Fulfilled? ☐

Is the wiring done according to the chosen category?

- **Is the wiring protected against short circuits or is every fault recognized?**
- **Is the wiring protected against earth fault or is every fault recognized?**

See table D.4 Conductors/cables EN ISO 13849-2:2013
See table D.6 Terminal Block EN ISO 13849-2:2013
See table D.7 Multi-Pin Connector EN ISO 13849-2:2013

4.

Fulfilled? ☐

Is the diagnosis sufficiently high?

Note: Not all faults can be recognized as no second switch is available for the state comparison. If, for example, only one sheathed cable is connected to the switch, not every short circuit can be recognized.

- **Has this been considered in the diagnostic coverage?**

5.

Fulfilled? ☐

Additional precautions (no influence on the Performance Level):
Have the indications for manipulation of interlocking devices been observed?
See section 7 of EN ISO 14119:2013
Suitable protective measures from avoiding a safety device can be e.g. the following:

- Covered installation
- Actuator mounted non-detachably
- Individual coding of the actuator
- Control engineering measures like a cyclical examination of the switch
- Different operating modes

! This checklist contains only examples and may not be regarded as complete at all. Company EUCHNER assumes no liability for possible faults in this representation. The use of this checklist does not release the user from a check of their own application of a safety switch with or without guard locking.

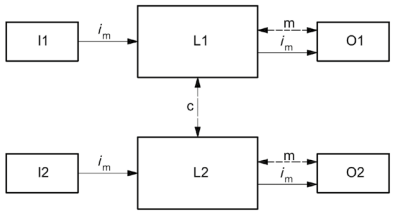
Step-by-step procedure for the determination of the system performance of a SRP/CS

1. Determination of the required PL (PL_r) acc. to EN ISO 13849-1, Annex A

- Determine the risk (use risk graph or, if applicable, C-Standard)
- Work out a (constructive) solution
- Document the remaining risks point them out in the user information

2. Determination of structure (category)

- A structure must be found, with which the determined risk can be minimized

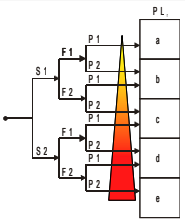


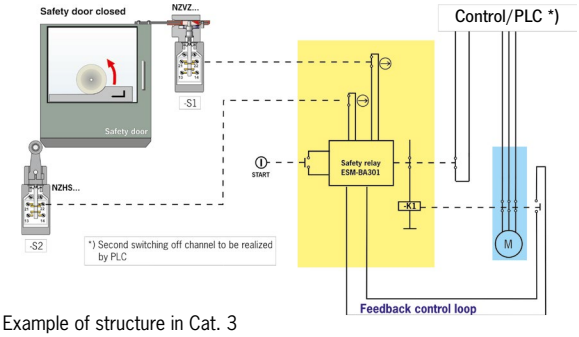
Dashed lines represent reasonably practicable fault detection.

Key

i_m	interconnecting means
c	cross monitoring
I1, I2	input device, e.g. sensor
L1, L2	logic
m	monitoring
O1, O2	output device, e.g. main contactor

Risk diagram





Example of structure in Cat. 3

3. Determination of $MTTF_D$ values for electromechanical safety components

- Use B_{10D} values for calculation of $MTTF_D$. The value for every safety component can normally be requested from the component manufacturer, otherwise from Tab. 1, Annex C of the Standard.
- It must be assumed how many cycles the electromechanical safety component will switch per year (on average). A procedure can be found in Annex C.4 of the standard. Required values:
  - Number of days on which the machine is running (d_{op})
  - Number of hours per day on which the machine is running h_{op}
  - Mean time of switching t_{cycle}

4. Calculation of average diagnostic coverage (DC_{avg})

- The DC must only be considered from category 2
- For estimation of the diagnostic coverage Annex E of EN ISO 13849-1:2015 and Annex E of EN ISO 13849-2:2013 can be used.
- The DC must be defined for every element in the chain
- The DC_{avg} must be defined for every single channel

5. Estimation of CCF (estimation of failures because of common cause)

- The CCF must only be considered from category 2
- Usage of Table F.1
- At least 65 points must be reached

6. Evaluation of software

- Provided that components of the safety solution are based on software, they must also be evaluated

7. Determination of the reached PL

- Use SISTEMA software for determination
- Comparison PL and PL_r

Important:

- The design engineer must assume for what purpose the machine is designed and that the machine is working to full capacity
- The $MTTF_D$ value must be calculated one by one for every channel

$$n_{op} = \frac{d_{op} \times h_{op} \times 3600\,\frac{s}{h}}{t_{cycle}} \qquad MTTF \approx \frac{B_{10D}}{0{,}1 \times n_{op}} \qquad \frac{1}{MTTF_D} = \sum_{i=1}^{N} \frac{1}{MTTF_{Di}}$$

$$DC_{avg} = \frac{\frac{DC_1}{MTTF_{D1}} + \frac{DC_2}{MTTF_{D2}} + \ldots + \frac{DC_n}{MTTF_{Dn}}}{\frac{1}{MTTF_{D1}} + \frac{1}{MTTF_{D2}} + \ldots + \frac{1}{MTTF_{Dn}}}$$

Table F.1 — Scoring process and quantification of measures against CCF

No.	Measure against CCF	Score
1	**Separation/ Segregation**	
	Physical separation between signal paths: separation in wiring/piping, sufficient clearances and creep age distances on printed-circuit boards.	15
2	**Diversity**	
	Different technologies/design or physical principles are used, for example: first channel programmable electronic and second channel hardwired, kind of initiation, pressure and temperature, Measuring of distance and pressure, digital and analog. Components of different manufactures.	20

When PL ≥ PL_r, the goal is achieved!

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