Proven Systems –
Proven Safe

Categories and Performance Levels acc. to EN ISO 13849-1
### Which PL can be achieved with which product?

<table>
<thead>
<tr>
<th>Valid for the following products</th>
<th>All safety switches with integrated actuator NZ, N1, NB01, NM, ESH</th>
<th>All safety switches with separate actuator NZX, N1X, NX, NMX, NQ, NP, GP, SGP</th>
<th>All safety switches with separate actuator and with guard locking TZ, TX, TP, TQ, STP, STA, STM, TK*</th>
</tr>
</thead>
<tbody>
<tr>
<td>The products comply with the requirements of the following standards</td>
<td>EN 60947-5-1, Annex K positively driven contacts</td>
<td>EN ISO 14119</td>
<td></td>
</tr>
<tr>
<td>What is required to achieve a certain category / PL?</td>
<td>For category 1/PL c according to EN ISO 13849-1</td>
<td>Solution a) 1 EUCHNER Safety switch 1 Safety relay (e.g. ESM)</td>
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<tr>
<td></td>
<td>Solution b) 2 EUCHNER Safety switches 1 Safety relay (e.g. ESM)</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>For category 3/PL d according to EN ISO 13849-1</td>
<td>Solution a) 1 EUCHNER Safety switch 1 Safety relay (e.g. ESM)</td>
<td>Fault exclusion or Solution b) 2 EUCHNER Safety switches 1 Safety relay (e.g. ESM)</td>
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<tr>
<td></td>
<td>Solution b) 2 EUCHNER Safety switches 1 Safety relay (e.g. ESM)</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>For category 4/PL e according to EN ISO 13849-1</td>
<td>Solution a) 1 EUCHNER Safety switch 1 Safety relay (e.g. ESM)</td>
<td>Fault exclusion or Solution b) 2 EUCHNER Safety switches 1 Safety relay (e.g. ESM)</td>
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### Examples

#### 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.

### Does the solution require a fault exclusion?

#### Information to exclude faults (see EN ISO 13849-1 and EN ISO 13849-2)

### What helps for validation?

- Do not use safety switch as end stop
- Actuator and safety switch have to be mounted positively
- 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
### Evaluation units CMS and Safety relays ESM with corresponding CMS-read heads type 4

- EN 60947-5-2
- EN 60947-5-3
- EN ISO 14119

**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

---

### Evaluation units CES with read heads CES-A-L... and read heads with guard locking CEM, CET-AX type 4

- EN 60947-5-2
- EN 60947-5-3
- EN ISO 14119

**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

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### Safety Switch CES-A-.5, CES-AH, CES-AP, CET-AP, CTP-AP as well as MGB-AP with and without guard locking type 4

**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

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### Safety Switch CES-AR, CET-AR, CTP-AR, CEM-AR, CET-AR, CTP-AR as well as MGB-AR with and without guard locking type 4

**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

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### 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, CES-AH, CES-AP, CET-AP, CTP-AP, MGB-AP

### System families CES-AR, CET-AR, CTP-AR, CEM-AR, MGB-AR-AR

### Non-Contact Safety Engineering

#### System family CES-AZ
(System consisting of read head and evaluation unit with relay outputs)

### System families CES-AR, CET-AR, CTP-AR, CEM-AR, MGB-AR-AR

### Exclusion of liability

EUCHNER does not assume any liability for the correctness, up-to-dateness, completeness or quality of the information provided. Claims of compensation against EUCHNER or its employees on the basis of the information provided are excluded, beside gross carelessness or intention can be verified. All information or examples provided in this folder do not excuse the design engineer from his risk evaluation or analysis.

* depending on the product used for the application
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

**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.

**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 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 electrical design is dual-channel, category 3

**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!
# 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

<table>
<thead>
<tr>
<th></th>
<th>Are the requirements of category B on the safety components fulfilled?</th>
<th>Does the safety switch withstand the forces to be expected at the safety guard?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>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.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>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)?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Can forces which lie above the safety switch's locking force arise by beating the door back when the guard locking is already closed?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Possibilities for validation of mechanical systems EN ISO 13849-2:2013</td>
<td>See also EN ISO 13849-2:2013 Table A.1 and Table A.4</td>
</tr>
<tr>
<td></td>
<td>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.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Is the safety switch protected against external forces?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Note: Can for example a fork-lift damage the safety switch? Are forces that act dynamically on the switch, sufficiently limited?</td>
</tr>
<tr>
<td></td>
<td>See section 6.2.2 of EN ISO 14119:2013</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th></th>
<th>Is the wiring done according to the chosen category?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Is the wiring protected against short circuits or is every fault recognized?</td>
</tr>
<tr>
<td></td>
<td>Is the wiring protected against earth fault or is every fault recognized?</td>
</tr>
<tr>
<td></td>
<td>See table D.7 Multi-Pin Connector EN ISO 13849-2:2013</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Is the diagnosis sufficiently high?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>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.</td>
</tr>
<tr>
<td></td>
<td>Has this been considered in the diagnostic coverage?</td>
</tr>
</tbody>
</table>

## 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 (PLr) 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

3. Determination of MTTFD values for electromechanical safety components
   - Use B10D values for calculation of MTTFD. 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 (dop)
     - Number of hours per day on which the machine is running (hop)
     - Mean time of switching (tcycle)

4. Calculation of average diagnostic coverage (DCavg)
   - The DC must only be considered from category 2
   - The DC must be defined for every element in the chain
   - The DCavg 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 PLr

When PL ≥ PLr, the goal is achieved!