

PSEN me5 Fault Exclusion



Product

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Manufacturer: Pilz GmbH & Co. KG, Safe Automation

Document

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July 2021

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Abbreviations

Abbreviation / term	Description	Source
AN	Application Note	www.pilz.com > AN content (1002400)
PSEN	Pilz Sensors	PSEN website
NC	Normally Closed	
NO	Normally Open	
PL	Performance Level	
MTTFd	Mean Time To Failure dangerous	
DC	Diagnostic Coverage	
CCF	Common Cause Failure	

Definition of Symbols

► Information that is particularly important is identified as follows:



CAUTION!

This refers to a hazard that can lead to a less serious or minor injury plus material damage, and also provides information on preventive measures that can be taken.



NOTICE

This describes a situation in which the product or devices could be damaged and also provides information on preventive measures that can be taken.
It also highlights areas within the text that are of particular importance.



INFORMATION

This gives advice on applications and provides information on special features.

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1 Useful documentation

Reading the documentation listed below is necessary for understanding this Application Note. The availability of the software used, and its safe handling are also presupposed for the user.

1.1 Documentation from Pilz GmbH & Co. KG

No.	Description	Item No. /Download
1	Pilz international homepage, download section	www.pilz.com
2	Operation manual PSENme5	PSEN me5 Operat_Man
3	Operation manual PSEnb5/me5	PSEN b5me5 Operat_Man
4	Operation manual PSEN cs bracket stop swinging door	PSEN cs bracket stop swinging door Man

1.2 Documentation from other sources of information

No.	Description	Item No. / Download
1	EN ISO 13849-1	European Standard
2	EN ISO 13849-2	European Standard
3	IEC 62061	European Standard
4	EN ISO 14119	European Standard
5	EN 60947-5-1	European Standard
6	Functional safety of machine controls	BGIA- Report 2/2017
7	Auswahl und Anbringung von Verriegelungseinrichtungen	DGUV Information 203-079 (German only, 2015)
8		
9		
10		

2 Used hardware and software

2.1 Pilz products

No.	Descriptions	Order number	Version	Amount
1	PSEN me5S NC-NO.NC-NO 1switch	6L000016	-	1
2	PSEN b5/me5	6L000023	-	1
3	PSEN cs bracket stop swinging door	532108		1
4				

3 Category considerations for PSEN me5 in accordance with EN ISO 13849-1 and -2

- ▶ As a general rule, when considered individually these products are mechanically single-channel and technically may only be used up to Category 1, in other words up to a maximum of PL c.
- ▶ For higher categories or PLs, technically two mechanical channels must be provided, i.e. two switches.
- ▶ If necessary, information about the category of a position switch can be taken from the C standards!
- ▶ When position switches have two N/C contacts, a dual-channel design can be assumed for the electrical system. However, as there is just one actuator that interacts with the switch, the actuator area has a single-channel mechanical design, technically we are back to Category 1.
- ▶ Under certain conditions it is possible to use a mechanical safety switch up to Category 3, max. PL d. However, this requires fault exclusion in the switch actuation system. Fault exclusion is achieved by controlling a variety of error sources, such as:
 - Wear / corrosion
 - Fracture
 - Loosening
 - Deformation
 - Sticking
- ▶ The following points should therefore be considered in any practical application:
 - 1) Environmental influences such as temperature, aggressive chemicals, air pressure, dust, EMC (Electromagnetic compatibility), etc.
 - 2) The actuating mechanism should be protected so that it can't be blocked by foreign particles or be manipulated.
 - 3) The actuating travel, forces and tolerances must be maintained during the whole application's life cycle.
- ▶ The way, in which these are controlled must be documented appropriately. Fault exclusion must also be validated in accordance with EN ISO 13849-2:2012.
- ▶ The fault exclusion procedure is based on EN ISO 13849-1:2015, 7.3 and EN ISO 13849-2:2012, Annex A Table A.4. An example of a fault exclusion for an interlock with guard locking is described on the following pages.
- ▶ PL e can only ever be achieved through mechanical and electrical redundancy. In other words, two physical switches are required.

4 Application description

The example described in this document shows how fault exclusion for an interlocking device with guard locking can be used to achieve **PL d with one safety switch PSEN me5**.

It's assumed that all requirements for PL d (MTTFd, Category, DC, CCF) are fulfilled for the whole interlocking device. Performance-Level d generally requires a universal dual-channel structure. In this example, there is no second position switch on the safety gate. That means, the mechanical operation of the guard locking device has only a single-channel structure of the mechanical part. To justify its use for PL d, fault exclusions are done. These fault exclusions accept an unsafe failure from mechanical parts of the guard locking device under certain conditions.

The following assessment focuses on the safety switch and the actions needed for fault exclusion, from the machine designer's perspective. This document does not consider or describe the required safety-related evaluation of the interlocking switch and guard locking device in accordance with PL d.

For further information regarding the safety-related evaluation please refer to EN ISO 13849-1 or IEC 62061, EN ISO 14119, the IFA Report 2/2017 entitled "Functional safety of machine control systems", or the DGUV's "Selection and positioning of interlocking devices"(only German), for example.

Fault exclusion should be performed on the mechanical parts of an interlocking device with guard locking in accordance with EN ISO 13849-1:2015, 7.3 and EN ISO 13849-2:2012, Annex A Table A.4.

This example assumes that PL r = d is required for the safety function of the interlocking device as well as the guard locking device.

Caution

The requirements in relevant standards (e.g. C standards) may be different to those, described in this document. Fundamental is that each application needs its own justified fault exclusion. The whole application must be validated in accordance with EN ISO 13849-2.

4.1 Safety functions

Interlocking device

Prevention of unexpected start-up when a safety gate is open.

Guard locking device

Locks a safety gate in closed position and thus prevents access to the dangerous zone while the danger is present.

Releasing the guard locking device

The safety gate can only be opened when the hazard is no longer present.

4.2 Function description

A movable guard (safety gate) and interlocking device with guard locking (safety gate system PSEN b5/me5) is used to prevent access to a dangerous area as long as the hazard is present.

Guard locking on the safety gate is based on form-fitting mechanical blocking of the actuator by a spring-force operated solenoid bolt. The solenoid bolt acts positively on the contacts of the interlocking and guard locking device

The hazard behind the safety gate can only be activated when the safety gate is closed, and the actuator is locked and held in position by the solenoid bolt.

Inside the PSENme5 integrated position switches are monitoring the position of the solenoid locking bolt as well as the position of the actuator.

The integrated failsafe locking device prevents an unexpected start-up while the gate is open. Due to the failsafe locking device, the solenoid bolt can only reach the locked position when the gate is closed, i.e. the actuator is engaged

4.3 Design requirements

The PSEN me5 interlocking device with guard locking is tested and certified by DGUV in accordance with GS-ET-19 and complies at least Category B of DIN EN ISO 13849-1. The two integrated positive-opening N/C contacts for monitoring the guard locking function comply with EN 60947-5-1 Annex K.

Fundamental safety principles as well as the requirements of Category B in accordance with EN ISO 13849-1 are fulfilled. The evaluation and logic used to unlock the guard locking device comply at least with the required PL.

The evaluation device that monitors the contacts of the guard locking switch complies at least with Category 3, PL d.

The interlocking switch of the guard locking device is mounted at the door frame with a so called "frame plate" and the actuator is mounted at the sliding bolt with handle, mounted to the door with the so called "door plate". To ensure the system is mounted properly, use the manuals of the PSEN b5/me5 and PSEN me5 as well as the standards EN ISO 12100-2 and EN ISO 14119.

The switch and actuator are never used as stop block; All mechanical forces are absorbed by the PSEN b5/me5.



Figure 1: PSEN me5 with bolt PSEN b5/me5

All technical data (like: max. permitted holding force, temperature range, protection type, screw torques, mechanical life, e.g.), stated in the documentation for the guard locking switch are followed.

For all external mechanical components, a fault exclusion has been made, based on the following reasons:

- ▶ A damage of the guard locking as well as the actuator is prevented, because of the way the actuator is designed and mounted.

1) A mechanical stop is included that prevents a movement too far against the switch.



Figure 2: Back view of door plate

2) The guard locking bolt will always close the door before the actuator will get in contact with the sensor. The bolt will align the door and the frame except the door is warped, or it has too much offset.

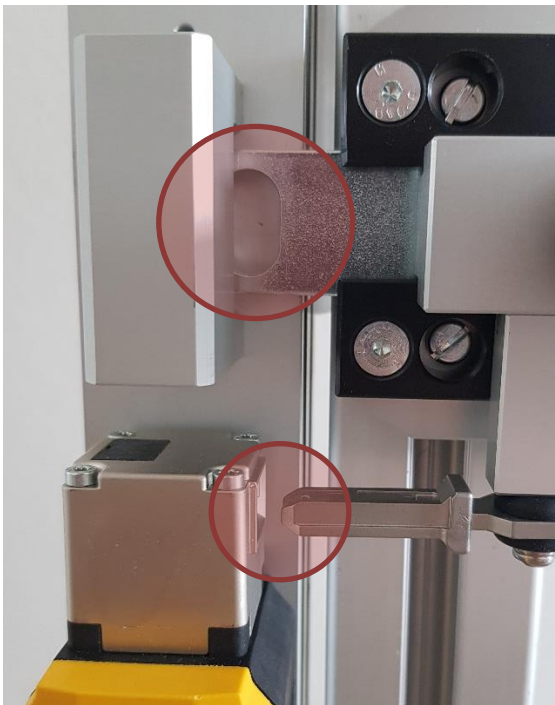


Figure 3: Guard locking bolt closes first

- 3) Because of the mechanical assembly of the bolt and its' counterpart at the frame plate, and because its' mechanical strength, the guard locking device can withstand forces in all directions, even if the door drops due to misaligned mounting or aging. Mechanical stress for switch or actuator will not be present.



Figure 4: Robust bolt and bolt-seat

- 4) It's even not possible to damage the sensor or actuator if the door gets closed with an extended bolt, due to a mechanical stop.

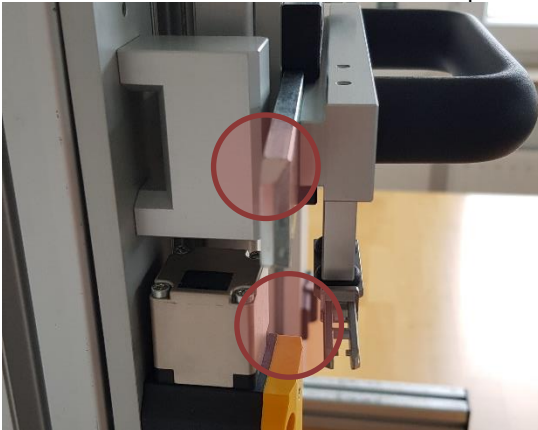


Figure 5: Mechanical stop block protects actuator

- 5) A separate doorstop needs to be installed at the door frame, that limits the movement of the door and prevents that the door can get further behind the door frame. If there is no doorstop, the door can get behind the door frame with a retracted bolt, once it's behind the door frame the bolt can be extended and at the recurring movement the actuator could be damaged.



Figure 6: Doorstop on back side of swinging door

- ▶ Statical mechanical stress and forces that can be applied to the guard locking device, for example through a user, are lower than the holding forces F_{ZH} in accordance with GS-ET-19.
 - 1) The holding force F_{ZH} for the interlocking switch is 1500 N in accordance with the operating instructions.
 - 2) If there is an attempt to open the door by force, regardless if it's locked or not, all mechanical stress only acts on the bolt mechanism and not on the guard locking switch or the actuator.
 - 3) The bolt opening direction is orthogonal to the door opening direction, thus any forces that are applied during an opening attempt with a bolted actuator (locking bolt holds actuator inside of the switch), are smaller than 1300 N ($< F_{ZH}$) in accordance with ISO 14119, Table I1.
- ▶ Dynamic forces cannot be higher, because the movable guard is moved manually, and the guard locking function is only activated when the door position is detected as closed.
 - 1) Due to the integrated fail-safe lock, the guard locking device cannot be activated until the gate is closed and the actuator is detected in the switch.
- ▶ The sliding unit at the door plate with handle, locking bolt and actuator cannot be removed
 - 1) Integrated mechanical stop blocks prevent the sliding mechanism to be removed from the door plate after it's mounted.



Figure 7: Extended bolt stop

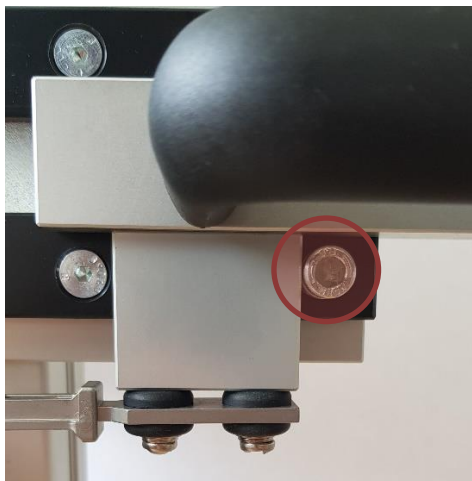


Figure 8: Retracted bolt stop

5 Summary

It is assumed, that all activities and requirements needed to achieve PL d in accordance with EN ISO 13849-1, like:

- Category (structural requirement)
- Mean time to failure dangerous (MTTFd, consisting of B10d and Nop)
- Diagnostic coverage (DC)
- Common cause failure (CCF)

are fulfilled for the integration of the guard locking device as well as for all other parts needed for the safety function.

The safety-related characteristic values of the PSEN me5 can be found in the operating and assembly instructions.

The safety function must be validated in accordance with EN ISO 13849-2.

The implementations of the interlocking device with guard locking on a safety gate, as described in this document, as well as the correct implementation of the overall safety function in accordance with normative requirements, mean that PL d can be achieved for the safety gate's interlocking device and guard locking device

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