



► About guard locking devices

Whitepaper
July 2025

PILZ
THE SPIRIT OF SAFETY

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At a glance

Guard locking devices can be found in the most diverse range of applications in production plants and manufacturing machinery. They are often indispensable in order to minimise risk on plant and machinery. That's why they are often also referred to as safety locking devices. The characteristics of a guard locking device on the market vary greatly, and not every product is the right one for an application.

EN ISO 14119:2025 is available to help you select your guard locking device. What EN ISO 14119:2025 only addresses in basic terms and in principle is described in this white paper with reference to specific guard locking devices.

This white paper does not include all normative aspects in their entirety. For this reason, the standard itself must be consulted for a plant's conformity declarations, for example.

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1. Guard locking safety function and structures of interlocking devices with guard locking

Guard locking is a safety function in plant and machinery, which is understood to be a chain of sensor, logic and actuator technology.

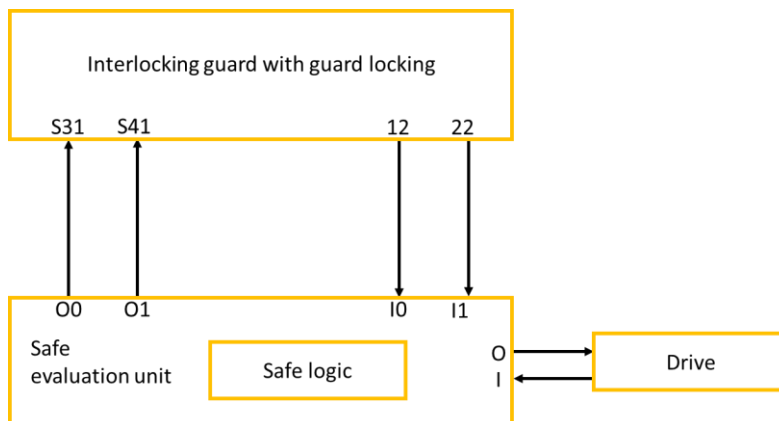


Figure 1 Guard locking safety function

It is quickly apparent that the “guard locking” safety function consists of several connected installations or devices. To avoid misunderstandings, the standard uses the term “interlocking device with guard locking” for the device.

In the information below, the term here is limited to guard locking, so you can tell from the context whether it concerns a device, the safety function or a subsystem of the safety function.

As the term used in the standard suggests, guard locking devices are part of the interlocking and guard locking functions. The different subfunctions and their technical principles are described in detail in the sections that follow.

1.1. Interlocking and guard locking functions

Interlocking and guard locking are two different functions and should be understood as follows:

- ▶ Interlocking prevents the operation of hazardous machine functions under specified conditions. For example, this means that the machine will not restart if a gate, and therefore also the interlocking device on the gate, is not closed.
- ▶ The job of a guard locking device is to lock a guard, e.g. a gate, in position. The guard locking device is activated and evaluated by the machine control system.

Put simply, this means:

- ▶ An interlocking device detects whether or not a gate or flap is closed.
- ▶ A guard locking device locks a gate or flap in the closed position.

Both functions are typically features of one device, but do not have to be: for example, a pneumatic cylinder can assume the guard locking function, and the interlock is implemented using a magnetic safety switch.

Even when both functions are accommodated in one device, interlocking and guard locking are shown separately in the block diagram for guard locking devices:

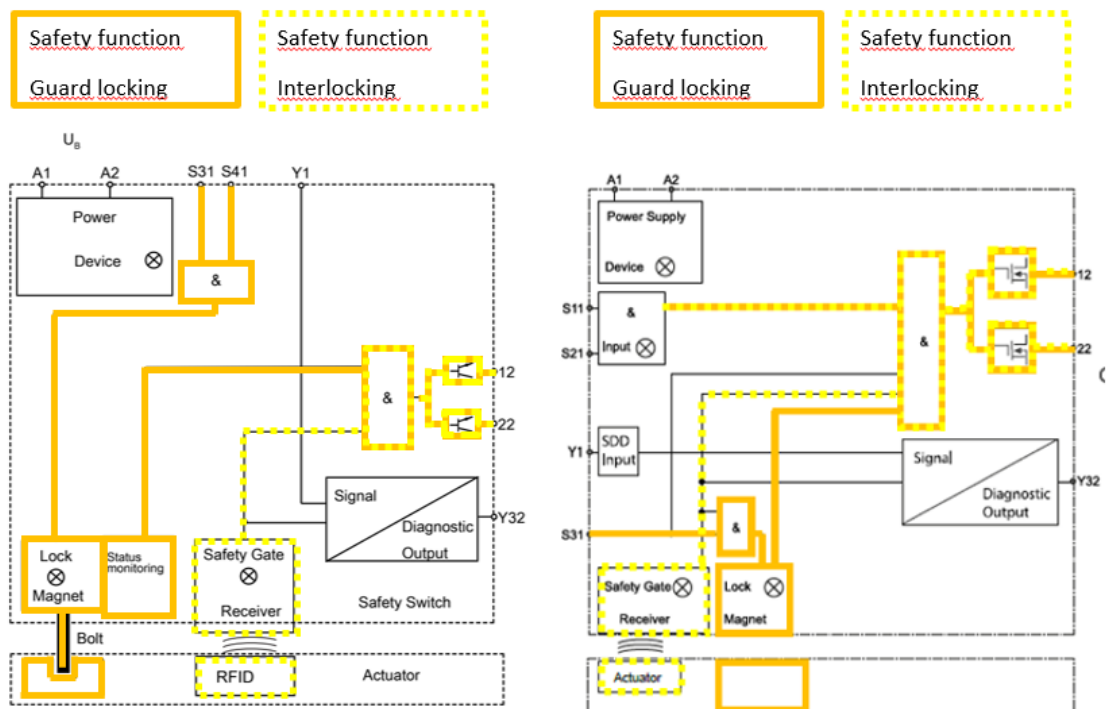


Figure 2: Interlocking and guard locking, using block diagrams for the guard locking device PSEN mIm ba (left) and PSEN sl2-G (right) as an example

You can see in Figure 2 that both functions affect outputs 12 and 22. However, the inputs and logic within this device are different, so that both functions must be considered as separate from each other.

1.2. Interlocking

Mechanics or an RFID transponder section are generally used for the interlocking.

1.2.1. Mechanical approach to interlocking

Interlocks of this type have electromechanical contacts, which are operated via a single-channel, mechanical, direct-acting control element. The control element is moved by inserting the actuator, and remains latched within the switch. As a result, the gate remains in position without using any other component, including where there is vibration.

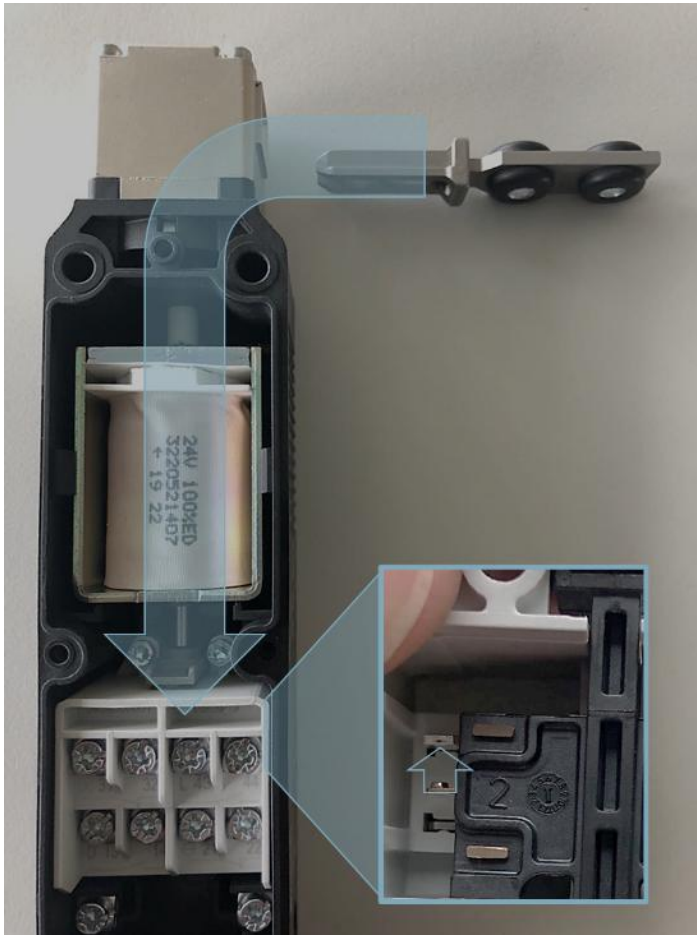


Figure 3: Contact block and contacts, plus control element of a mechanical switch, using the PSEN me5 from Pilz as an example

Different contacts are provided for both interlocking and guard locking. These should also be evaluated separately. This has the advantage that different operating modes can be run for interlocking and guard locking, such as slow and fast operation for example. The status can be communicated to the operator via illuminated buttons, for example.

Mechanical switches generally have one connection chamber. Due to the narrow mounting area and the many possible connection points, the mounting must be concentrated. Some manufacturers also offer M12 plug-in connectors to simplify and speed up the connection, although often at higher prices.

The advantage of the connection chamber also comes into play with series connection. In the field, switches can be connected in series without any additional wiring aids. However, it's precisely here that potential fault masking should also be taken into consideration. Fault masking means that a fault is not rectified, but is concealed by operating another switching element in series, see EN ISO 14119:2025.

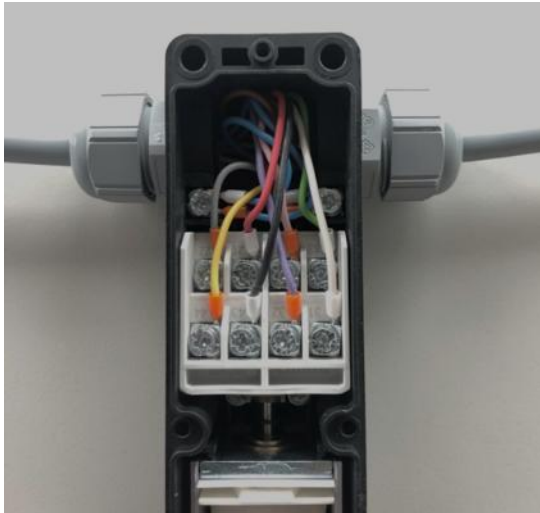


Figure 4: Series connection PSEN me5

Differences in the actuators are sometimes substantial. Simple actuators are lasered metal parts and have very low tolerances of 0.5mm horizontally and vertically. But actuators may be cast in 3D form and may also be fitted with compensation rings or even sprung mountings.

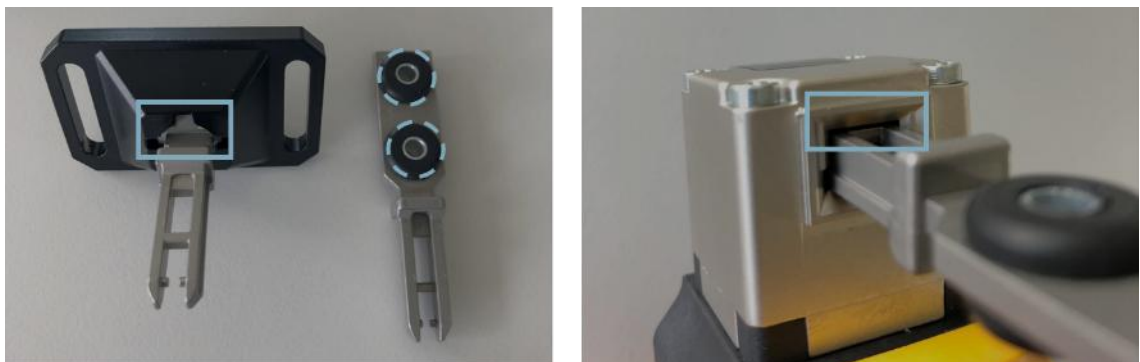


Figure 5 Tolerances on mechanical actuators

The coding level is usually low on mechanical interlocking devices. The barrier against manipulation via the spare actuator is rather low, if switches are installed within direct reach, for example, and an actuator can be carried relatively easily on a key ring. A latching mechanism on the actuator makes manipulation even easier. To counter manipulation, the installation of switches can be concealed. Also, in accordance with the GS-ET-19 E principles of testing, it shall not be possible to use simple tools, such as two screwdrivers for example, for interlocking.

Benefits of mechanical interlocking devices

- Simple, cost-effective design
- Simple series connection in the field, possible through wiring
- EMC-immune
- Contacts can withstand a wide voltage and current range, i.e. 24V, as well as 110V or 230 VDC or VAC. The limiting thermal current at 24V is in the range of a few ampere, typically 2...5A.

Note:

- Minimum contact current: The background is the high density of inputs on evaluation units. This results in minimal currents, in order to control the waste heat and work in an energy-efficient manner. On the switch side, lowest currents on mechanical contacts are a challenge for clean closing.
- Mechanical contact bounce: Input filter may be required particularly with fast control and, in this case, as a programmed filter.
- Fault masking
- Performance level limited due to single-channel structure
- Low level of security against manipulation
- Usually really low tolerances. In the case of a larger gate offset, damage may occur, leading to the loss of safety.
- Susceptible to dirt, dust and gases
- Injury risk in the case of simple actuators
- It is not possible to determine the injury risk generally, but heavily worn actuators made of thin metal may present an injury risk.

1.2.2. RFID approach to interlocking

Electronic guard locking devices generally use RFID for interlocking. This means that an electric coil in the switch transmits energy, and an electric coil in the actuator captures this energy and sends back a signal with information.

125kHz RFID signals are generally used. 13.56 MHz RFID systems enable faster and more comprehensive data exchange in comparison with 125kHz systems. However, 125kHz systems have a more robust switching characteristic with different mounting positions and assembly materials.

Electronic inputs and outputs, as well as RFID for interlocking, have the following benefits:

- Non-wearing
- Very low probability of faults
- Series connection capability, also in interlocking, up to PL e in accordance with EN ISO 13849-1:2023, free from fault masking in the series connection
- No partial operation in the sensor section – partial operation only through inputs and outputs, and wiring errors
- It is possible to achieve a very high level of manipulation protection
- Higher mechanical offset possible, typically +/- 2...5mm on guard locking devices

Note:

- Design not so cost-effective
- Voltage drop in the event of long cables and series connection
- EMC disturbances can limit availability



Figure 6: Actuator: Offset with RFID actuators, electromagnetic guard locking

1.3. Guard locking devices

Guard locking is another function alongside interlocking. Guard locking means that the switch can hold an actuator in the closed position.

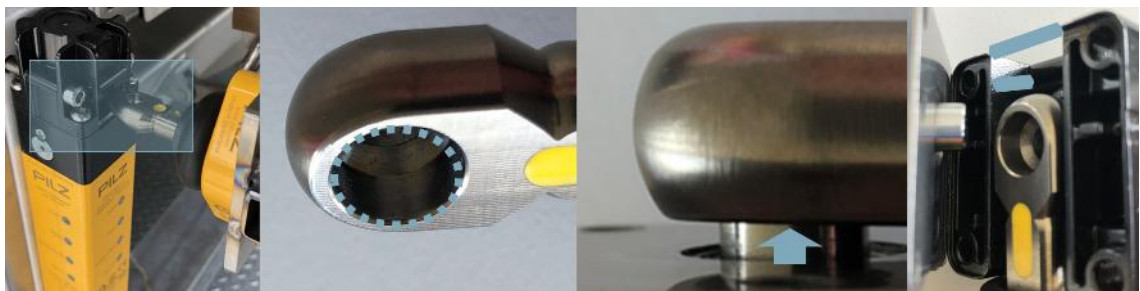


Figure 7 Mechanical guard locking: Tongue, pin, insertion shaft

In addition to mechanical guard locking devices, which work electronically or electrically, there are also electromagnetic guard locking devices.

As interlocking and guard locking are two different functions, the result after the risk assessment will be two different required performance levels PLr. For this reason, different safety-related values should be listed per function in the details for the guard locking device.

However, guard locking may only be activated when the switch is interlocked. This condition is called faulty closure protection: It is guaranteed that guard locking can only occur when the actuator is inserted and the gate is actually locked.

The technical design of guard locking devices widely in use today is based on an internal magnet, which

- a) acts against a spring and blocks or releases a pin. Depending on the design and position of the spring, the talk is of spring type interlocking / power to unlock / closed circuit current principle or magnet type interlocking / power to lock / open circuit current principle.
- b) remains in 2 end positions and is therefore called bistable. It also drives a pin.

The pin is therefore the key element in the safety architecture. Electromagnetic guard locking devices are an exception, where the magnet itself is the key element.

Characteristic values for a guard locking device

1. Force F_{1max} , up to which a guard locking device remains closed
2. Force F_{ZH} is force F_{1max} reduced by a safety factor, which must correspond to the design of the gate
3. Actuation force needed to close a gate
4. Retention force needed to open a gate that is latched, in other words closed, but no longer guard locked.
5. Number of mechanical switching cycles before a fault occurs and specified guard locking values are still achieved
6. Minimum gate radius
7. Current requirement in the open state, in the closed state and when the state changes

1.3.1. Safety factor for forces and benefits of maintenance

In accordance with EN ISO 14119:2025 safety factors of at least 1.3 should be accepted. Some guard locking devices consider a safety factor of 2.0. The regular check of the switch's function, including of the switch's intact appearance and intact mounting, is omitted.

A new feature in EN ISO 14119:2025 clause 9.2.2.5 is that if the guard locking device manufacturer makes a fault exclusion for the guard locking device, a safety factor of 2.0 must be accepted for mechanical elements in the switch.

From EN ISO 14119:2025 onwards, the manufacturer's fault exclusions must also be listed in the operating manual.

1.3.2. Forces

The holding force of a guard locking device, including the lever and material tolerances on the guard locking product, should be dimensioned in such a way that one person cannot deliberately overcome it. There may be great leverage forces, particularly on swing gates. EN

ISO 14119:2025, Annex H, provides reference values for the forces that one person can apply: For example, one-handed grip pulling vertically 700N, and two-handed grip pulling vertically 1100N. The maximum force stated is 1400N. The size and position of the gate handles play a role here, as do the support points for the person.



Figure 8 Leverage on a guard locking device on gates

Most guard locking devices on the market operate with a single tongue and make a fault exclusion for PL d and PL e assessments in accordance with EN ISO 13849-1:2023. If necessary, manufacturers must list limitations in the operating manual.

There are differences in the way the RFID tag is positioned on actuators. If the RFID tag is housed directly in the tongue, guard locking devices can generally be built more closely together. In many cases, such a design subsequently offers a high degree of manipulation protection. The guard locking, and consequently the output signal switching devices (OSSDs), only become active when the actuator is actually in the target position, in other words engaged, and the guard locking is actually holding the gate closed.

1.3.3. Need for guard locking

EN ISO 14119:2025 regulates the need for guard locking (to be understood as a safety function) in clause 7.2.1: If the system's overall stopping performance is greater than the access time, then a safe guard locking device is required.

1.3.3.1. Stopping performance and access time on gates and flaps

Stopping performance

EN ISO 13855:2025 clause 5.4 defines the stopping performance: The reaction times of the safe interlocking device, safe evaluation and drive are taken into account.

$$T_{\text{StoppingPerformance}} = T_{\text{Interlocking device}} + T_{\text{Stopping time evaluation and drive}} + T_{\text{Tolerance factor}}$$

Formula for stopping performance

Access time

Clause 12 of EN ISO 13855:2025 explains the access time on gates and flaps in accordance with the usual formula: $S = (K \times T) + D_{GT}$, where S is the minimum distance and $K = 1600 \text{ mm/s}$, D_{GT} is the minimum distance for reaching through and T is $T_{\text{StoppingPerformance}}$. D_{GT} can be disregarded if the gap dimensions of the gates are less than 4 mm. Where the gap dimensions are larger, refer to Table 4 of EN ISO 13857:2019. Access delays after the interlocking device has been activated are no longer taken into account in the 2025 edition. Nevertheless, it is sometimes obvious that delays occur. For example, these could be: a forced movement when opening the gate, two-handed opening due to the size or weight of the gate or handle, overcoming force due to latching device. They can only then be considered via an individual risk assessment.

An example of a latching device is the integrated magnetic latching on the PSENSlock 2, whose force of 30N, 110N or 200N must be overcome. The magnetic force decreases exponentially with distance, and after a few millimetres is close to 0N. This sudden drop in the latching force when opening the gate is so abrupt that the operator needs coordination time before they can reach into the danger zone, see section 1.7.

1.3.4. Electromechanical guard locking devices

The structure of such a guard locking device looks as follows, for example:



Figure 9 Interior view of electromechanical guard locking device PSEN me5

A control element is moved due to the magnetic force of a coil against a spring. The currents flowing through the coil are between 2.5VA to 8VA. The coils are also optimised for different voltage ranges, so there are different versions of the switch. For example, there is a 24V version and another 230V version.

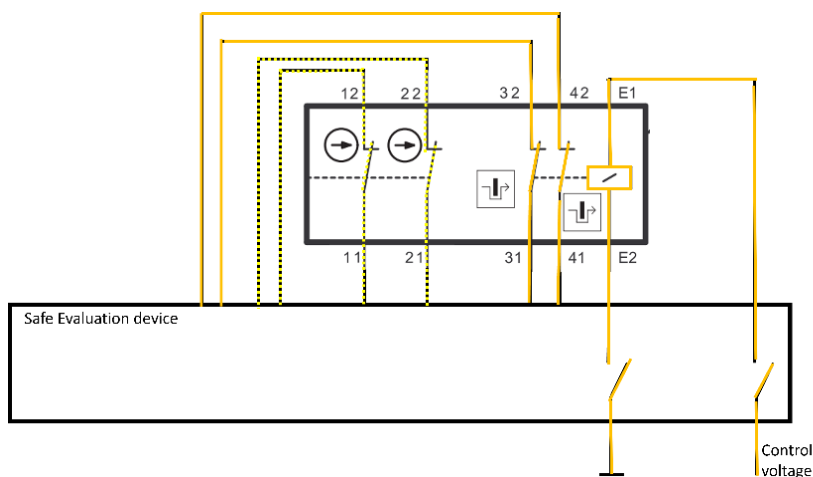


Figure 10 Block diagram for electromagnetic guard locking

Mechanical guard locking devices are made up of simple components. External, safe evaluation and control are required in order to form the safety functions.

This means that a B10_D value is stated for these components. Often, the devices' operating manuals state the same value here for interlocking and guard locking.

For a partial safety function with regard to safe guard locking and safe monitoring of the guard locking position, correctly speaking, fault exclusion should be implemented via the locking system, so that it cannot assume the released state on its own, see GS-ET-19 E, clause 5.6.1.1.

For the partial guard locking function it is important that the contacts for monitoring guard locking have a form-fit connection to the position of the locking bolt. In order to correctly calculate the guard locking subsystem, the switch's B10_D value for the guard locking function must also be taken separately. This calculation takes wiring, common cause failures and environmental influences into account, among others. For this reason, manufacturers state B10_D values, despite partial fault exclusions.

As described in section 1.3 above, it is essential to check whether faulty closure protection is already implemented mechanically. Otherwise, this must be implemented via the controller as a safety function, if appropriate.

The performance level that can be achieved for electromechanical guard locking devices is limited by the single-channel structure of the control element. Fault exclusions can be made in certain applications through a leading bolt and an end stop. With 2-channel evaluation, therefore, a maximum PL d Category 3 in accordance with EN ISO 13849:2023 can be achieved. Pilz provides an application note for this, see References.

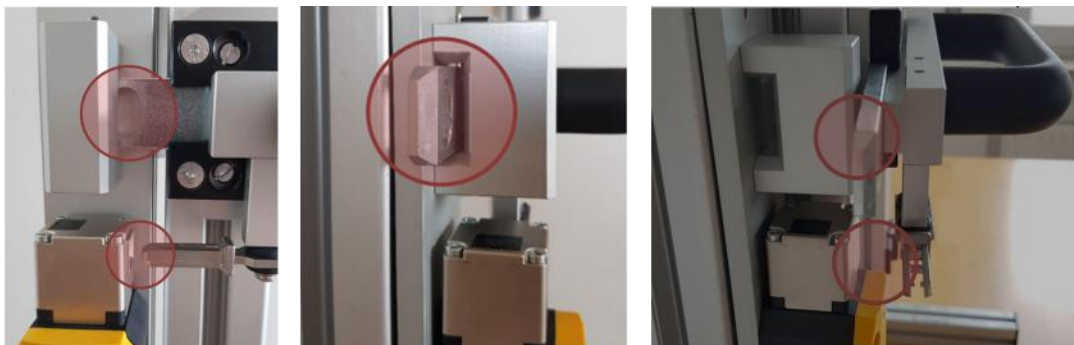


Figure 11 Fault exclusion due to leading bolt

Alongside the stated advantages and disadvantages for interlocking, you can add the following for guard locking separately:

- ▶ Advantages
 - 230V control possible
- ▶ Disadvantages
 - Risk of injury due to strong self-heating. Switch surface temperatures of well over 50°C are possible

1.3.5. Electronic guard locking devices

In this case, interlocking and guard locking are two separate systems by design.

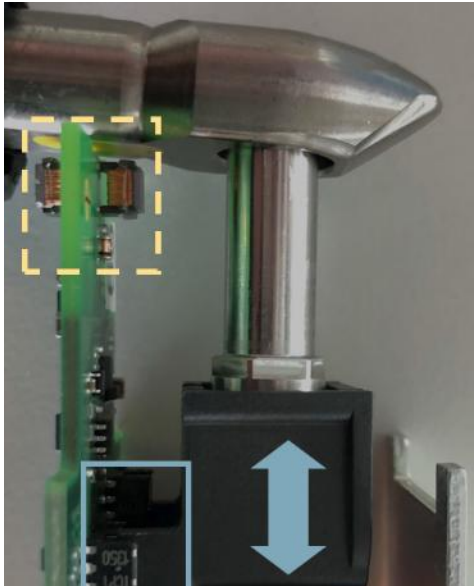


Figure 12 Yellow: RFID interlock / Blue: Guard locking device with light barriers using PSENmlock as an example

Interlocking is generally implemented with RFID. As shown previously, an antenna coil and an RFID tag are used. In this case, the RFID tag is in the yellow cast.

In contrast to electromechanical switches, guard locking is implemented separately from interlocking. Irrespective of the RFID tag, a pin is positioned and safely monitored via light barriers, for example.

In the electronics, the logic connection between RFID and guard locking occurs in a microcontroller.

Due to the complex structure, a performance level and a PFHD value are stated for these devices in accordance with EN ISO 13849-1:2023.

Operating mode	EN ISO 13849-1: 2015 PL	EN ISO 13849-1: 2015 Category
1-ch. guard locking	PL d	Cat. 2
2-ch. guard locking	PL e	Cat. 4
2-ch. OSSD	PL e	Cat. 4
Escape release		Cat B

Figure 13 Statement of safety-related characteristic data, using PSEnMlock as an example

Alongside the stated advantages and disadvantages for RFID interlocking, you can add the following for guard locking separately:

► Particular advantages

- Guard locking to PL e possible in accordance with EN ISO 13849-1:2023
- Low current consumption and low surface temperature possible with bistable guard locking devices
- Minimum dimensions possible
- Long series connection chains possible through intelligent forwarding of the guard locking signals

1.3.6. Electromagnetic guard locking device

With magnetic guard locking devices, interlocking and guard locking are also two separate systems.

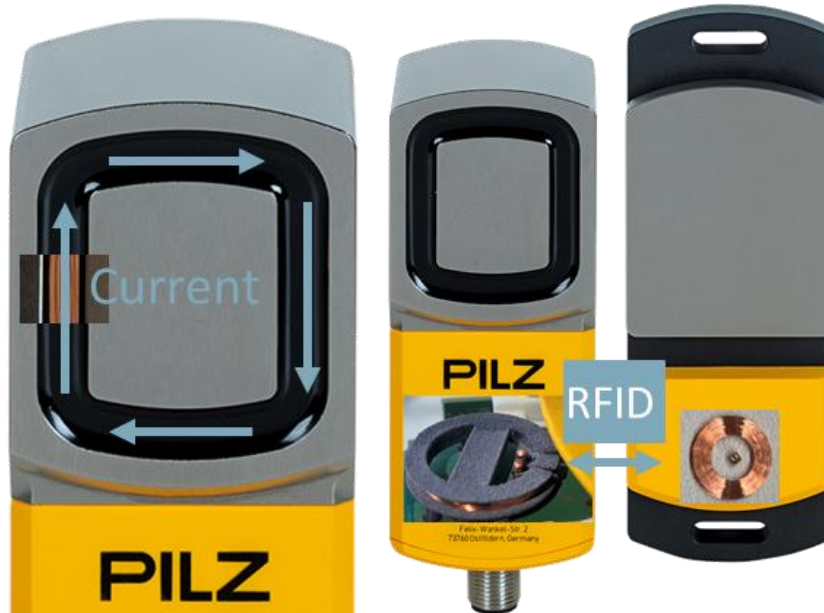


Figure 14: Example of PSENslock 2 with current loops for guard locking and RFID transmission for interlocking

Guard locking is achieved via electromagnetic forces. Due to the space requirement of the coils and the ferromagnetic body, the forces are rather lower in comparison with mechanical guard locking. For example, F_{1max} is identified on the PSENslock 2 as electromagnetic guard locking with 2,000N, and on the PSENmlock with up to 15,000N. In this case, it is even more important to evaluate the necessary forces correctly, see Figure 8.

Cyclical measurements are required for safe, electromagnetic guard locking devices. A single measurement, as in the case of non-safety related guard locking devices, is not sufficient. During the measurements, several current and voltage parameters are monitored and controlled.

► Particular advantages

- Low-wearing
- Wash-down best suited
- Mechanically robust guard locking devices
 - Highest mechanical offsets in all directions
 - Highest mechanical impact energy: mechanical stop
 - No protruding moving parts (no tongue)

► Disadvantages

- Adhesive layers of dirt can reduce availability
- Typically only power-to-lock guard locking principle

1.4. Control of guard locking devices

With mechanical guard locking devices, the control signals impact directly on the magnet, which activates or deactivates the guard locking. That means the control signals must be power signals, i.e. there are higher current flows, generally $>>100\text{mA}$.

Electronic guard locking devices allow the control signal to be isolated from the current that flows through the locking magnets. In other words, electronic guard locking devices mostly have a control signal, and the required energy comes via the voltage supply. You can also use quiescent current control signals, for example, and bistable magnets to activate and deactivate the guard locking.

The advantage of control signals is that they only need to produce low levels of power and are therefore cheaper.

The advantage of power signals to sensor manufacturers is that the sensors can have smaller dimensions and less heat is generated.

1.5. Operating principles of guard locking devices

Most guard locking devices have a bistable or monostable magnet to activate and deactivate the guard locking. EN ISO 14119:2025 clause 6.6.1 requires energy to be fed in for the deactivation of the guard locking, see table below, prescribed normative approach, bistable magnet and monostable magnet with quiescent current control.

On some applications, however, it is necessary that access to plant and machinery in a de-energised state must be guaranteed, in order to avoid or contain damage. For example, this might be the case on plants in which the moving goods are highly flammable or the process operates with high heat or fire. In this case, monostable magnets with operating current control are selected.

The need for a risk analysis for each individual machine is apparent, one which looks into the various states of a machine and the behaviour of the guard locking:

Magnet type	Bistable*		Monostable	
Product examples	PSENmlock	PSENmlock mini	PSENm5	PSENm5 M/ PSENslock 2
Prescribed normative application	Yes	Yes	Yes	Only with evidence through risk analysis
Control	Pulse	Quiescent current	Quiescent current	Operating current
Activation of guard locking	Can be defined through user program	When actuator is detected	When actuator is detected	After operating command
Deactivation of guard locking	After operating command			
Voltage drop	Last state		Closed	Open
Shutdown	Choice, open or closed		Closed	Open
Auxiliary release	Necessary			Can be implemented via power supply
Risk analysis de-energised state	If necessary Fire considered → emergency release			Open gate considered
Increased power requirement	Only in change of state		Opened gate	Closed gate
0V Machine run-up	Last state remains	Closed	Closed	Open
Series connection	More devices		Potential limitation due to circular connector	
Process guard locking / OSSD only on interlock	Possible			
Safe guard locking	Possible			
Safe monitoring of guard locking position	Possible			

* bistable means that guard locking cannot change its activated or deactivated state without power (fault exclusion on manufacturer's side).

Table 1: Operating principles of guard locking devices

This results in a variety of timing diagrams:

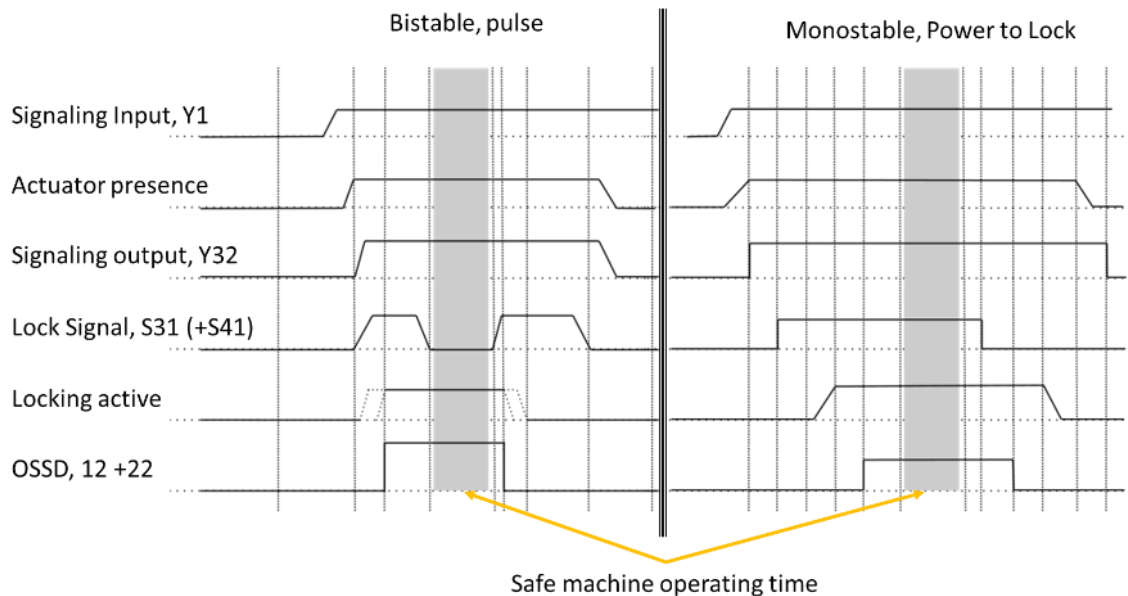


Figure 15 Timing diagrams of bistable and monostable guard locking devices

You can see that, on both versions, the actuator rests when guard locking is active. There should be no dynamic forces through rebounding of the gate. These forces can place a substantial load on switches; even EN ISO 14119:2025 refers to it in clause 7.2.2, and see clause 1.3.

In particular, pulse control has the additional feature that neither voltage loss nor a controller restart can cause the guard locking device to open. The assumption here is that when a controller is restarted, outputs are not briefly switched to “high” and correspond to an opening pulse.

With pulse control, in a series connection the problem could occur that guard locking devices do not activate or deactivate guard locking synchronously. The problem can be resolved by offsetting the pulses on both control signals, see PSEN ml sa types for example.

1.6. Limitations of the partial guard locking safety function

There is a wide range of devices on the market on which the safe outputs only react to the presence of the actuator, irrespective of whether or not guard locking is active. In this case, the safety function is reduced to the safe interlocking device.

1.7. Latching

A latching device is not a guard locking device and so does not represent any minimisation of risk. However, latching devices are essential for the smooth-running process on the machines: The guard locking devices on several gates are opened, but the gates do not spring open immediately because they remain latched. Machine operators can make their way alongside the gates. That explains the requirement from EN ISO 14120:2015, clauses 5.3.12 and 5.3.13, that

the opening of a gate must be a deliberate act and that a closed gate must be held in position, irrespective of whether or not a guard locking device is used.

Even when closing a gate, the gates should be held in the correct position for the specific insertion of the guard locking pin. Actuator detection is also maintained steadily through a good latching device.

Latching devices operate mechanically, against a spring for example, or they may be implemented magnetically. They usually have a force of between 10N and 200N; higher values are generally implemented through an additional supply.

To minimise strain and physical effort for the machine operator, EN ISO 14120:2015 clause 5.2.5.3 requires low operating forces. Reference is also made to EN ISO 12100:2010. Clause 6.2.8 of this standard says that account shall be taken of body sizes of the operator, strengths and postures, movement amplitudes, and the frequency of cyclic actions.

This means that, for frequent usage, unfavourable ergonomic conditions and high retention forces, other locking mechanisms may make more sense than latching via guard locking: a clamping lever, for example.



Figure 16: PSENSlock 2 with adjustable latching force of 30Nm, 110Nm or 200Nm

1.8. Series connection

On many machines, safety locking devices are connected in series. There are the following reasons for connecting guard locking devices in series:

- Save on inputs and outputs at control level, even with IP67 I/O modules
- Simplified logic at control level: FS PLC: simple PLC program, FS configurable relays: easier interconnection of configuration blocks, safety relays: no need for complex series connection of relays
- Thickness of cable harnesses is reduced if series connection is implemented in the field
- Wiring on the terminal strips in the control cabinet is reduced if series connection is implemented in the field with a wiring aid

Safety-related aspects with series connection

Various aspects must be considered, depending on the technological approach of the guard locking device.

Electromechanical guard locking devices:

Reduction in diagnostic coverage. As the devices in series do not process the signals electrically or electronically, but only transmit them electrically, only the B10D value of the respective switch is taken. However, there is fault masking to consider, which limits risk minimisation: fault masking due to series connection of the contacts. A switch contact has a fault that is detected by the evaluation device. Nevertheless, it is possible to restart the machine by operating the contact in series with another functional switch. The simplified limitation is specified in EN ISO 14119:2025 Table J.1.

Electronic guard locking devices:

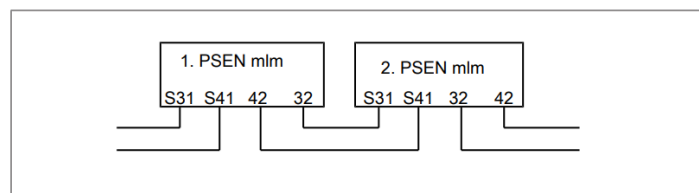
Increase in the probability of failure. The signals are processed electrically or electronically, and these processing operations increase the probability of failure. It is therefore necessary to consider the entire chain and calculate this in a tool such as Sistema. This is because the entire chain must always be taken into account, including the evaluation device and actuator technology. For the sensor technology, in this case the series-connected guard locking devices, the specified PFH value already takes into account the maximum configuration; in some cases, it must be taken separately for each switch in series.

Electrical aspects when guard locking devices are connected in series

Guard locking device: Here there are various options for controlling the series connection:

- Parallel wiring results in synchronous switching: the advantage is that all doors are opened immediately; the disadvantage is that the current peak during the switching process of the locking pins on all sensors overlap: Y-junctions and power supplies quickly reach their limits. The current peaks usually range between 0.5-1.5A, so between 2A and 6A are generated in the case of 4 sensors.
- Series connection with sequential switching: The advantage is that the current load caused by the switching process of the locking pin is reduced to one switch. The disadvantage is that the sensor requires additional outputs.

► Series connection of the lift magnet control



► Series connection of the OSSD outputs

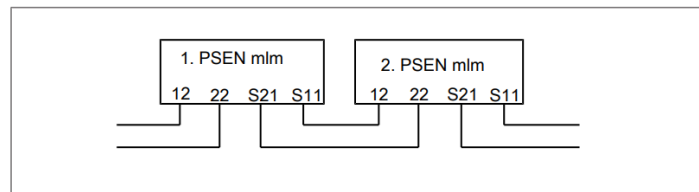


Figure 17 Example of PSEN m1m for sequential switching in a series connection

Additional functional aspects with series connection

There are differences between the guard locking devices, which result purely from functional aspects such as cable length and series connection, not only on the terminal strip but also in the field.

Series connection via

- in the control cabinet via terminal strip – cable is laid in star wiring
- in the field via Y-connector in the field
- in the sensor via connection contact block

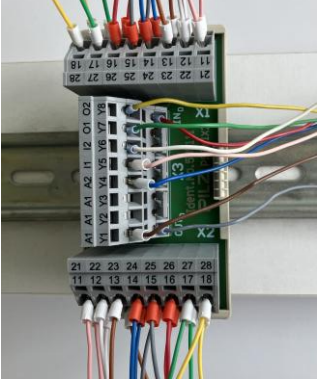

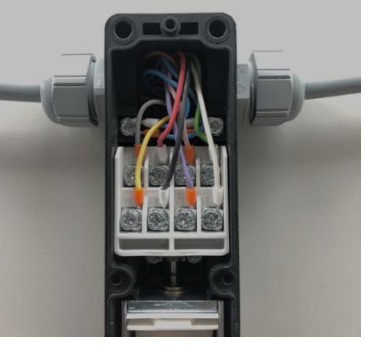
Series connection in the control cabinet	In the field	In the sensor
		
PSEN ix2 F4 code for non-process guarding devices M12/8-pin	IP67 adapter for process guarding devices M12/8-pin PSEN sl2	PSEN me5

Table 2 Overview of series connection options

2. Distinction between safe guard locking, safe position monitoring and process guarding

As explained previously, guard locking and interlocking are two different subfunctions. Now we have the function of guard locking for personnel protection in its different forms: Safe guard locking is a different safety function to that of safe monitoring of the guard locking position. In addition, there is also guard locking for process protection.

A safe guard locking device is understood to be an actuator, which is

- a) activated safely using safe outputs: guard locking device as actuator.
- b) evaluated safely using safe inputs: guard locking device und interlocking device as sensor.

In the case of safe monitoring of the guard locking position, the device is understood as a sensor, which is

- a) evaluated safely using safe inputs: guard locking device und interlocking device as sensor.

2.1. Safe guard locking device

To implement a safe guard locking device as an overall safety function, the safe evaluation device plus safe monitoring of the safe state of the drive (e.g. standstill monitoring) must also be added, EN ISO 14119:2025 clause 9.3:

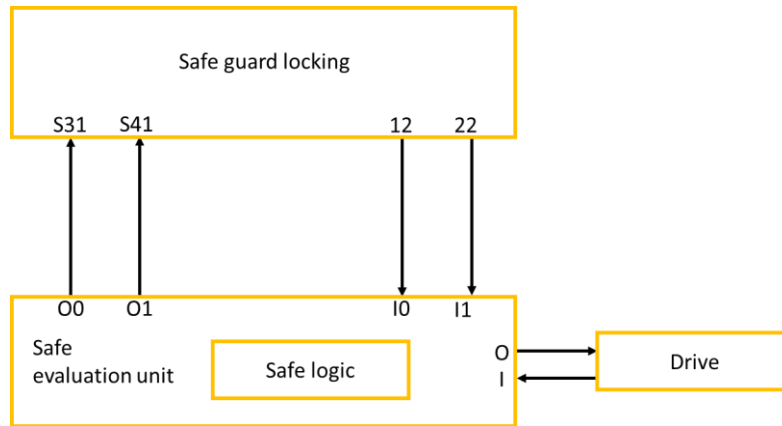


Figure 18 Safe guard locking safety function

Irrespective of the guard locking device, a safe evaluation unit controls the drive, to switch to a safe state. This is monitored by safe logic, for example through a timer or a direct signal exchange. The safe logic then controls the safe inputs on the guard locking device via safe outputs. The inputs and the internal processing within the guard locking device must also be designed to be safety-related.

This means that any faults in the logic, in the outputs or in the cable cores to the sensor will be managed by the evaluation device. Faults from the sensor to the safe logic will be managed in the sensor by the outputs, known as output signal switching devices, OSSD for short.

The different elements in a safe guard locking device are represented in the following diagrams:

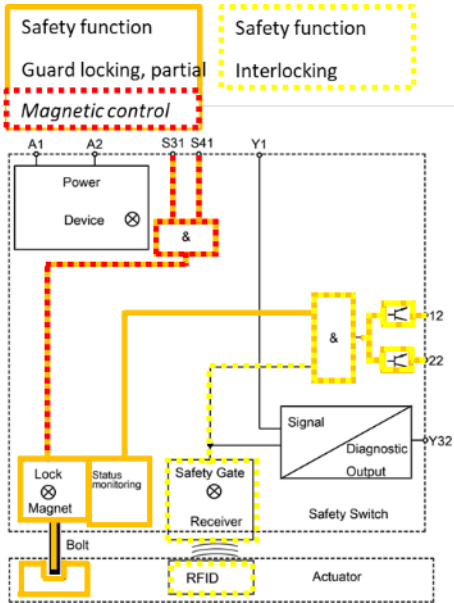


Figure 19 Safety functions: Light yellow dotted line interlocking device, dark yellow including red dotted line the safeguard locking device, using PSEN mlm ba as an example

Implementations of a safe guard locking device are independent of a performance level and independent of the technology. Safe guard locking is therefore available as an overall function with electromechanical, electromagnetic and electronic guard locking devices in the application.

One potential implementation of the control, processing and evaluation of a safe guard locking device is shown below.

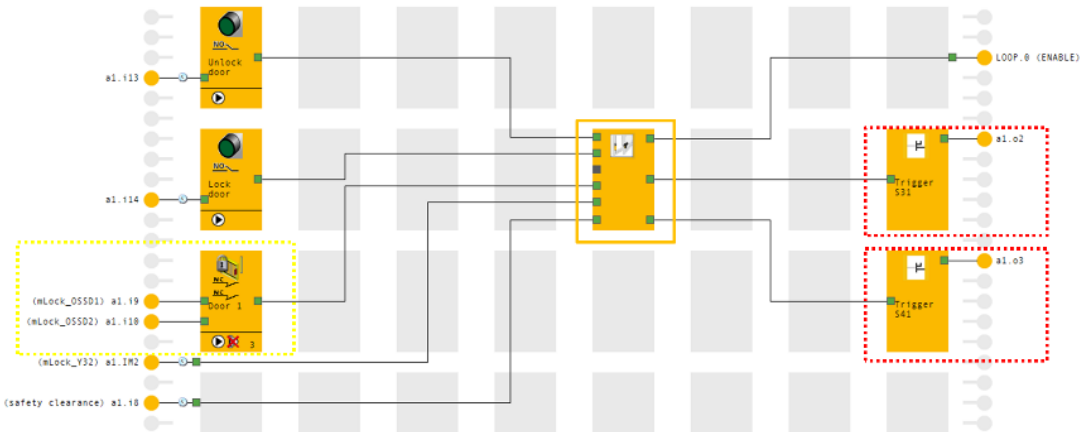


Figure 20: Implementation of safe guard locking at control level, using PNOZmulti Configurator with function block PSENmlock as an example

For example, when considering the sensor and the logic, the calculations for guard locking and interlocking are as follows:

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Projects

- PR Pliz Interlock - Guardlocking
 - SF Interlock (Stellungsabfrage)
 - Türschalter
 - SB PNOZ m EF 8DI4DO
 - SB PNOZ m B1
 - SB PNOZ m EF 8DI4DO
 - SB PNOZ m EF 8DI4DO
 - SB Leistungsschütze
 - SF Guardlock (Zuhaltung)

Context

SF Interlock (Stellungsabfrage)

PLr c

PL c

PFHD [1/h] 1,2E-6

Documentation PLr PL Subsystems

Status	Name	Ref. des.:	PL	PL-Software	PFHD [1/h]
SB	Türschalter	c	n.a.	n.a.	1,1E-6
SB	PNOZ m EF 8DI4DO	d	n.a.	n.a.	2,1E-9
SB	PNOZ m B1	e	n.a.	n.a.	4,2E-10
SB	PNOZ m EF 8DI4DO	e	n.a.	n.a.	2,8E-10
SB	PNOZ m EF 8DI4DO	e	n.a.	n.a.	1,6E-10
SB	Leistungsschütze	e	n.a.	n.a.	2,5E-8

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Projects

- PR Pliz Interlock - Guardlocking
 - SF Interlock (Stellungsabfrage)
 - SF Guardlock (Zuhaltung)
 - SB PNOZ m B1
 - SB PNOZ m EF 8DI4DO
 - SB PNOZ m EF 8DI4DO
 - SB PSEN ml b 1.1

Context

SF Guardlock (Zuhaltung)

PLr c

PL e

PFHD [1/h] 5,1E-9

SB

PL

PFHD [1/h]

Cat.

MTTFD [a]

DCavg [%]

CCF

BL

MTTFD [a]

DC [%]

EL

MTTFD [a]

DC [%]

Documentation PLr PL Subsystems

Status	Name	Ref. des.:	PL	PL-Software	PFHD [1/h]
SB	PNOZ m B1	e	n.a.	n.a.	4,2E-10
SB	PNOZ m EF 8DI4DO	e	n.a.	n.a.	2,8E-10
SB	PNOZ m EF 8DI4DO	e	n.a.	n.a.	1,6E-10
SB	PSEN ml b 1.1	e	n.a.	n.a.	4,2E-9

Figure 21 Extract, calculation of guard locking und interlocking using PSENmlock and PNOZmulti as an example, with the help of Sistema Version 2.0.8

You can see that it comes to different values. The guard locking device has different values for both functions. On the safe evaluation device page, different values, even different components, are used. This clearly illustrates again that a distinction must be made between interlocking and guard locking.

2.3. Process guarding

The corresponding block diagram for process guarding can look as follows:

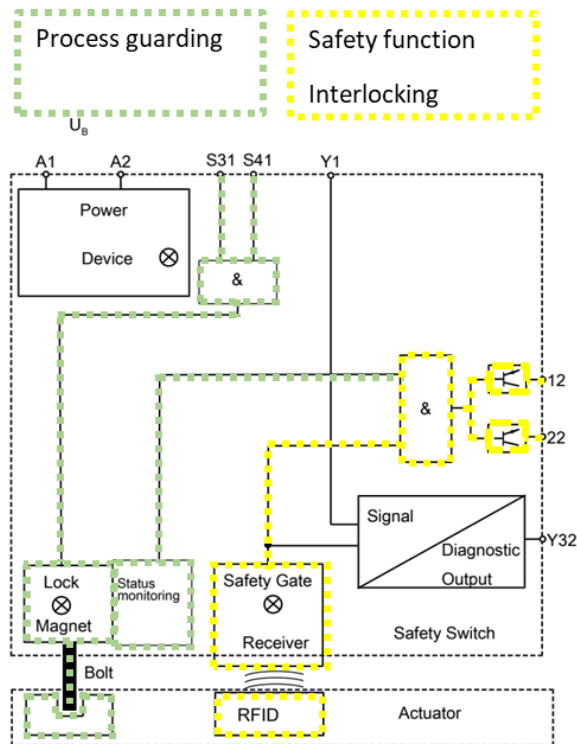





Figure 23 Process guarding with safe interlocking and non-safety-related guard locking, theoretical example

Process guard locking devices are intended to protect the process from the operator. This means that interventions should not occur at just any time, as an uncontrolled stop means long setup times and therefore low availability of the machine.

So with process guarding, only the interlocking is safety-related. There are various versions on the market, on which the guard locking either does or does not affect the outputs on the sensor. From a safety-related perspective, there is no difference here: in both cases, the access time to the hazardous movement must be greater than the time needed by the machine to achieve a safe state / standstill.

However, for the machine operation, it can be an advantage if gates are no longer locked, but the machine continues running and the process can be monitored. The operator can then intervene more quickly in the process, where this is necessary, and otherwise leave the machine running.

2.4. Overview of safe guard locking, safe monitoring of guard locking position and process guarding

	Safe guard locking	Safe monitoring of guard locking position	Process guarding
Product examples	PSENmlock, PSEN sl 2-G, PSENmlock mini, PSEN me5	***	***, PSEN sl 2-D
Safety-related control	Mandatory	Possible	Possible
Fault management	In accordance with performance level	<ul style="list-style-type: none"> a) Incorrect control possible in the event of non-safety-related control. b) Guard locking device opens at the wrong time due to internal sensor error. c) I.e. machine start-up when guard locking is defective is prevented by polling the guard locking device. 	<ul style="list-style-type: none"> a) Incorrect control possible in the event of non-safety-related control. b) Guard locking device opens at the wrong time due to internal sensor error. c) OSSDs do not react to the state of the guard locking device d) I.e. machine start-up is possible when guard locking device is defective.
Typical applications	Access to a danger zone in which a hazardous movement is not immediately apparent and manageable or on which the powertrain needs longer* to come to a standstill.**	Access to a danger zone. Hazard is not directly behind the gate, but is visible, and the powertrain can be brought to a standstill immediately*.	Powertrain can be brought to a standstill in a very short time*.
Examples			

* This relates to the access time and distances to the hazard, which must be determined individually.

** See EN ISO 14119:2025 clause 9.3

*** Products that are suitable for safe guard locking are also suitable for safe monitoring of the guard locking position and for process guarding.

Table 3: Differences in the application of the various forms of a guard locking device

2.5. Summary

This means that only the left-hand column for personnel protection can be used on plants with a significant overrun.

3. Installation on flaps and accessible gates

EN ISO 14120:2015 describes the general requirements for the design and construction of such gates and flaps. Devices for risk reduction must make no distinction in the quality of functional safety. However, there are differences in the load and the necessary equipment.

	Flaps	Accessible gates
Height of the gate	Typically: 25 ...75cm	Typically: 230cm
Gate/flap radius on swing gates	Typically: 10...100cm	Typically: 60...150cm (Sliding gates would be significantly larger)
Offset on swing gates	Typically: +/- 1 mm with each closing process	Typically: +/- 2 mm wear over its lifetime
Weight	Lighter, e.g. <50kg	Heavier, e.g. >50kg
Protection against unexpected restart	Not usually necessary	Mandatory, mechanical or electrical
Escape release	Not usually necessary	To be provided
Integrated buttons	Possibly on sliding flaps	Frequently on swing gates and sliding gates
End stop	Separate, or note values in the switch's technical details	

Table 4: Flaps and accessible gates

Note regarding end stop: EN ISO 14119:2025 states that forces must be specified in the operating manual for the guard locking device and that these forces must not be exceeded in the application. However, especially for large gates, it is predictable that the forces will be exceeded, so that an additional end stop should be fitted. The manufacturer's specifications and also the mounting options offered by the switch and gate have a direct influence on the service life of the switch on the machine.

3.1. Load on flaps

Due to the lower weight, smaller flaps can be well managed with one hand. Hinges are smaller, and the offset can vary from one closing process to the next, depending on the ergonomic position of the operator. For this reason, it's necessary to be aware of an offset due to wear in the hinge or loosening of the fixing screws: If the offset is greater than that stated in the

technical details for the guard locking device, the switch is being operated outside of the specification.

The smaller gate radius represents the particular challenge. If the actuator can no longer find its insertion shaft, the actuator, and possibly also the switch, may be damaged as a result.



Angle adapter and centering ring	Open insertion shaft
	
<p><u>Angle adapter:</u> Optimisation of the insertion angle with small flap radiuses or larger parallel offset of switch and hinge</p> <p><u>Centering ring:</u> On small gate radiuses, limit the offset to reach the insertion shaft</p>	<p>This open design enables very small radiuses in one, and only one, level.</p>

Table 5: Examples of solutions for small gate radiuses

3.2. Load on gates

In comparison with flaps, gates generally have a greater, freely swinging mass of larger dimensions. In other words, the operator generally has no direct influence on the offset and is also limited in their ability to absorb the gates rebounding at the mechanical end stop. In this case, the power to lock and bistable control have the advantage that the guard locking device only closes in the rest position and forces from the rest position can impact on the guard locking device.

Offsettable flexible actuator:

Actuator remains in the offset position and is barely retracted to the centre



Figure 24 Example of tolerance compensation for solutions on large gates

3.3. Protection against unexpected restart

If operators enter a danger zone, they must protect themselves against the machine starting to move again while they are still in the danger zone, particularly in areas of the danger zone with no visibility.





Additional danger zone monitoring through radar or scanner	Mechanical lock in the actuator	Mechanical lock on the switch	Mechanical or electrical key
			
<p>Irrespective of the switch enable, there is a wait for the enable from the radar, for example, before a machine restarts.</p>	<p>Lock prevents the insertion of the actuator and the switch does not provide a safety enable.</p>	<p>Lock prevents the detection of the actuator and the switch does not provide a safety enable.</p>	<p>Irrespective of the switch enable, there is a wait for the enable from the key.</p>
<p>≥1 gate solution</p>	<p>One-gate solution</p>	<p>One-gate solution</p>	<p>Mechanical: 1 gate solution Electrical: ≥1 gate solution</p>
<p>Device fuse protection</p>	<p>Administrative control</p>	<p>Administrative control</p>	<p>Device fuse protection and administrative control</p>

Table 6: Options for protecting against unexpected restart

Protective measures against unexpected restart have been explicitly included in EN ISO 14119:2025, clause 6.8. As the above measures may fail or may not be effective due to user errors, the risk analysis often requires an escape release on the guard locking device, see section 3.4.

Note: A single one of the above options is generally not enough. Particularly with key options, a delayed start with warning signals is required, for example.

Errors in the work stages must often be assumed.

3.4. Auxiliary and escape releases as well as emergency unlocking device

Against the background of failure of the protection against unexpected restart, risk analyses frequently show that accessible gates must be equipped with an escape release. These give operators the option to leave the danger zone via a manual action.

An auxiliary release and emergency unlocking device are also available as additional unlocking options on guard locking devices, in addition to the escape release. If access from outside is required in an emergency, these guard locking devices must also have an emergency unlocking device.

In general, all guard locking devices that have a bistable magnet or a monostable magnet with power to unlock control have an auxiliary release.

3.4.1. Emergency unlocking devices

An emergency unlocking device can be reset using a tool, a repair or at control level. Misuse of the emergency unlocking device as a quick means of access should be prevented.




<p>Emergency unlocking with reset via tool</p>	
<p>Emergency unlocking with manual reset and repair</p>	
<p>Emergency unlocking with manual reset and cancellation at control level. Display on the visualisation</p>	

Table 7: Implementations of emergency unlocking devices

Note: The standard EN ISO 14119:2025 only requires that normal, continued operation is prevented. As a result, access to various machine functions is still possible, only normal continued operation is not.

There are guard locking devices on the market that behave differently in terms of electronic reset. Generally speaking, only devices with power reset may be used for emergency unlocking, to prevent normal, continued operation. Guard locking devices with automatic reset are not equipped with an emergency unlocking device and may only be equipped with an auxiliary and escape release.

3.4.2. Escape release integrated in the actuator/handle

For accessible gates in particular, escape releases can be integrated directly in the actuator or in the handle unit. This has the benefit that there is no need to provide another hole in the gate frame and there is no need to create additional space for access on the gate frame.

On very light gates, a handle weight of over 1kg should be considered. The low holding forces are acceptable, as the handle only allows for one hand and cannot act as a lever. That's why most devices on the market are well above the required static minimum forces of 700N, as per EN ISO 14119:2025 Table H.1.



Figure 25 Escape release integrated in the handle, PSENmlock door handle module (red handle) as example

3.4.3. Escape release on the switch or remote

Escape releases on the switch are significantly cheaper to acquire than an integrated escape release in the handle.

Also, handles are not an option if the switch is to be mounted above 1.7 m, in accordance with EN IEC 60204-1:2016. To satisfy the ease of operation referred to in EN ISO 14119:2025 clause 6.9.1, the escape release must be operated from a distance. In this case, most manufacturers offer an escape release that is connected to the switch via a mechanical cable or cord.



Figure 26 Escape release, using the remote escape release on the PSENmlock as an example

3.5. Protection against manipulation

Manipulation means the defeating of safeguards. The operator is exposed to hazards as a result. This is done to gain an advantage in machine availability, in ergonomics when operating the machine or in productivity in general. Defeating safety gate devices is the most common cause of accidents resulting in personal injury. This led to the special significance of manipulation in ISO 14119. The flow chart in Figure 8 and the measures in Table 5 are therefore a very central point of the standard, and this has also been extended to include guard locking devices in the 2025 edition.

Principles and measures	Type 2, low-level coded	Type 4, low-level coded	Type 4, high-level coded
	PSEN me5	PSEN ml b 1.1	PSEN ml 2.1
Additional switch and plausibility check	R	R	
Mounting out of reach	X	X	
Obstruction/shielding			
Mounting in hidden position			
Status monitoring or periodic testing			
Non-detachable fixing of the actuator	M	M	M
Non-detachable fixing of the position switch	R	R	R
M = Mandatory measure; X = At least one of these measures must be applied; R = Recommended measures;			

Table 8 Extract from Table 5 EN ISO 14119:2025 for electromechanical and electronically coded guard locking devices on minimum measures of protection against manipulation

Table 5 of EN ISO 14119:2025 focuses on manipulation by removing actuators and switches, which is why these should be particularly secure. In addition to gluing screws, the most common and practical implementations for safety devices are non-removable screws and drive locks.




	Screw glue	Non-removable screws	Drive locks
Example images	 Loctite 2700, for example		
Advantage	<ul style="list-style-type: none"> Conventional screws can be used 	<ul style="list-style-type: none"> Easiest handling Stainless steel screws possible 	<ul style="list-style-type: none"> Conventional screws can be used Rapid installation
Disadvantage	<ul style="list-style-type: none"> The screw and drill hole must be clean Time consuming, when the gluing occurs during machine handover for example 	<ul style="list-style-type: none"> Once tightened, cannot be repositioned. 	<ul style="list-style-type: none"> If the screw head protrudes and has a cylinder head, the screw can be turned using pliers at low permitted torques
Potential removal	<ul style="list-style-type: none"> Application of high force High heat Drill out a screw or destroy a fixed device 	<ul style="list-style-type: none"> Some non-removable screws can be removed using special screwdrivers. Drill out a screw or destroy a fixed device 	<ul style="list-style-type: none"> Drill out drive lock Destroy fixed device

Table 9 Practical examples of screw locks

Another way to defeat safety gate devices is to set electrical bridges. This requires knowledge of the switch pinout, which service or maintenance engineers have. Locking the control cabinet and circuit diagrams makes it considerably more difficult to set bridges in the control cabinet. Cable connections can be bridged in the field. The following measures make manipulation in the field more difficult:




Devices with moulded cable	Devices with pigtail and inaccessible connection	M12 or M8 clips
		
<p>PSEN ma1.4a (Safety switch without guard locking)</p>	<p>Guard locking with pigtail</p>	<p>PSEN sl 2 with round connector and clip</p>

Table 10 Practical examples for protecting wiring from manipulation

At this point we should mention the positive contribution of operating mode selector switches. For example, by setting operating modes, slow machine operations with the safety gate open can be permitted for trained personnel. This allows a process to be observed, i.e. a service assignment to be carried out, without being exposed to the danger of machines running in normal operating mode. Machine access, operating mode selection and various machine operations go hand-in-hand.





Access control	Operating mode switch	Logic	Drive
			
<p>PITreader key</p>	<p>PITmode fusion</p>	<p>PNOZmulti</p>	<p>PMC SI6</p>

Table 11 Components for operating mode selection

4. Summary and outlook

In order to implement guard locking devices in compliance with the standards, there are many aspects to consider. There are many possible solutions, each with advantages and disadvantages. This white paper explains the features and properties of guard locking devices, so that normative requirements are better understood and guard locking devices are selected and applied correctly in practice.

New editions of the standards and technological developments will require further issues of this white paper, in order to stay up to date.

Note: At the time of going to press, the 2013 edition of the standard, EN ISO 14119:2013, has been harmonised in Europe and is therefore mandatory. It can be assumed that EN ISO 14119:2025 and its wording will soon be harmonised. That's why this second edition of the white paper has already considered EN ISO 14119:2025.

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6. Documentation

6.1. Normative references

The following references to standards and application notes have been used:

No.	Description
1	EN ISO 13849:2023
2	EN ISO 14119:2013
3	EN ISO 13855:2025
4	EN ISO 13857:2019
5	EN ISO 14120:2015
6	EN ISO 12100:2010
7	ISO/TR 24119:2015
8	GS-ET-19 E
9	https://www.pilz.com/download/open/AN_PSEN_me5_Fault_Exclusion_1005752-EN-01.pdf
10	EN ISO 14119:2025
11	EN IEC 60204-1:2016