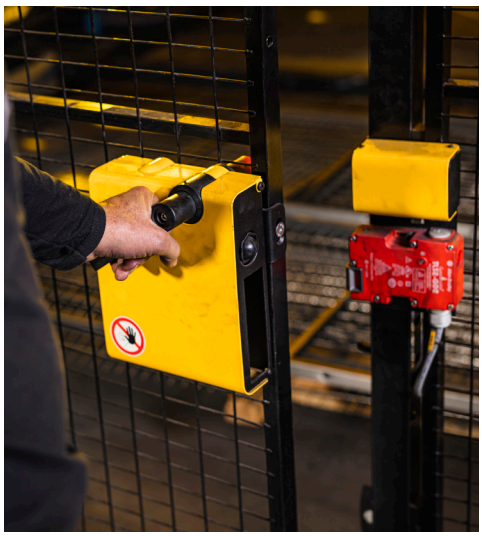
Door with safety switch
instead of a removable panel



Guard fencing and stationary machine housings are the most reliable safeguards offering protection from mechanical hazards such as crushing, shearing, and entanglement. However, they need to be removed for maintenance work and troubleshooting.
In some applications machine guards may even need to be opened frequently to make adjustments during operation or to insert parts. In such cases, standards require using a movable guard (door) with interlocking, guard locking or a trapped key. What are the rules? And what is the right solution for your application?

When to use a door with a safety switch instead of removable panel

One of the most frequently asked questions in machinery safety is this: When do we need to use a door with safety switch instead of a removable panel? For many years, the answer was quoted from EN ISO 12100:

"As the need for frequency of access increases, this inevitably leads to the fixed guard not being replaced." (6.3.2.1). In simple words: If users must remove guards often, it is likely that they will get tired of reinstalling them. So, after some time, the machine might operate without the guard. To prevent this guards will have to be monitored if they need to be removed for "frequent access".

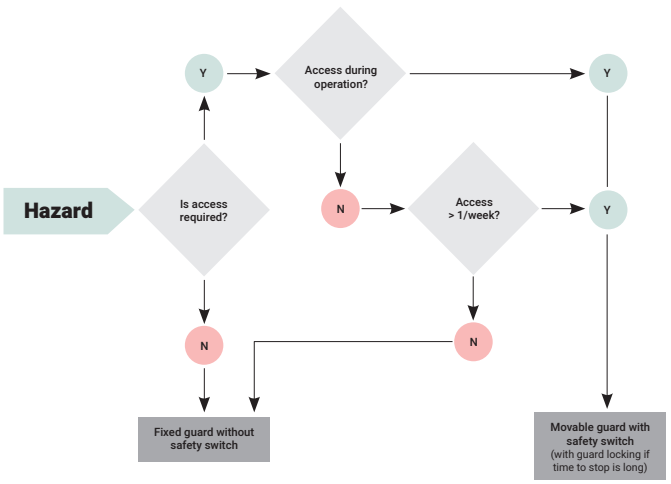
Frequent access requires a safety switch

While this is easy to understand and sadly confirmed by daily experience, it is also unclear. What is "frequent access"? There were many conflicting ideas about this and – because of the resulting uncertainty – strict customers required (and still require) monitoring by safety switches even for panels that are removed only a few times a year.
If there is a hinge on a panel and a quarter-turn (sash) fastener or cylinder lock to hold it closed, they almost always require monitoring by a safety switch.

What is the reason for accessing the machine? EN ISO 14120 determines the standard!

Since 2015, however, EN ISO 14120 in section 6.4.4 follows a more reasonable approach to the issue. On one hand it completely forbids use of removable guards without monitoring switches when access is required during working cycles, e.g., to insert material or to correct settings (compare section 6.4.4.2). However, if the reason for access is process correction (remedy of a failure) or maintenance, removable guards without monitoring switches are allowed, provided they are not removed more than once a week (compare section 6.4.4.1 and the decision flowchart below). Additionally, removal is allowed only under a so called "safe system of work", that is, a formal procedure which results from systematic examination of a task to identify all the hazards.
It defines safe methods to ensure that hazards are eliminated, or risks minimised. In most cases this will include a "lock-out and tag-out" procedure that must be followed to safely shut down a machine before any panels may be removed.

Decision flow chart stationery or movable guard with monitoring function



Interlocking or guard locking?

Once you have decided for a door with monitoring by the control system you need to select the type of monitoring function. There are two options:

- interlocking
- guard locking (which includes interlocking)

What is the meaning of these terms and how do they differ? What are the functions used for? Unfortunately, the terminology is a bit confusing and needs explaining.

Interlocking

Interlocking includes the following functionality:

- The machine's control system "knows" the status of the door (open or closed).
- One can open an interlocked guard at any time, even while the machine is running at full speed.
- The hazard source behind the movable guard must end or stop as quickly as possible.
  (Some engineers configure the function to stop the machine entirely or to cause an emergency stop.)
- While the door is open, the hazardous function cannot resume.
- The operator needs to close the guard and then restart the hazardous operation or the entire machine by actuating a control that is meant to cause start. Often machines are programmed to prompt the operator to press a push-button or touch a field on a touchscreen to reset the monitoring function before he can press a start button. However, with movable guards this is optional. Itis mandatory only for light curtains, laser scanners and other sensitive protective equipment.

"Interlocking" thus connects the status of a guard to the status of the machine function. However, it does not involve any mechanical locking of the guard. Safety technicians also refer to this as a "2-state-door" (see the table below). It must only be used, if the hazard or the machine itself can be stopped very quickly, so the operator cannot reach the hazard source anymore.

Generally, the time to stop should not exceed 0.2 seconds, otherwise the operator might still reach moving parts after opening the guard.

Guard locking

Guard locking adds a mechanical or electromagnetic lock function to "interlocking":

- While the machine is running, the movable guard cannot be opened. It is held in place by a bar or lock (operated electromagnetically or pneumatically) or a strong electromagnet.
- The operator needs to "tell" the machine that he wants to enter the hazard zone. He will push a handle, press a push-button or touch a field on a touchscreen. The machine will then go to a safe condition (e. g., stop). Only then will the guard be unlocked so the operator can open it.
- Restart will only be possible when the door is closed AND locked.

Table 1 - Door monitoring functions

STATE	2-STATE DOOR	3-STATE DOOR	4-STATE-DOOR
1	Door is closed	Door is closed and locked	Door is closed and locked
Operator action	Operator pulls door open	Operator presses button or moves handle to release lock	Operator presses button to release lock
2	Machine stop is initiated (moving parts can still be reached)	Door unlocks, but remains closed, machine stops	Controller waits for machine to stop (timer, position, zero-speed, etc.)
3		Operator pulls door open (moving parts might still be reached if time to stop is long)	When machine parts have stopped, door unlocks, but remains closed
4			Operator pulls door open

Guard locking is often combined with a condition for unlocking

That is, the control system will wait for a delay time to pass or until moving parts have stopped or reached their end position. This can become a rather complex function involving position switches and rotation sensors, etc. Safety technicians are often making a difference between a "3-state-door" and a "4-state-door" (*see Table 1 - Door monitoring functions*).

Guard locking is needed to prevent doors from opening accidently (e. g., when they are meant to hold back an ejected part). 4-state guard locking is mandatory if it takes a relatively long time to end a hazard or stop the machine (more than 0.5 s). It may also be used to keep operators from "disturbing" a process by making it impossible for them to open any covers or doors before the machine has stopped.

Trapped keys

And what is door monitoring by means of "trapped keys"? A trap holds something so you cannot remove it. In this case it is a key that can be used to unlock a movable guard. There are many different setups. One that is often used functions roughly as follows:

- A lock on the movable guard/door can only be unlocked with a special key.
- This key, however, is inserted in a switch at the control cabinet of the machine. While the machine is running, the key cannot be removed (it is "trapped" in the control switch).
- Thus, as long as the machine is running, the guard cannot be opened.
- To remove the key, the operator must stop the machine and turn the switch to the "off" position.
- Then only can the operator remove the key and use it to open the lock on the movable guard.
- When the operator has opened the guard, he can no longer remove the key (it is now "trapped" at the guard).
- Thus, as long as the door is open, the key cannot be used to reactivate the machine.

This type of system is also sometimes referred to as a "key transfer" system because one transfers the key from the controller to the guard and back. The main purpose is to prevent operators from side-stepping guards and from unintentionally starting a machine while a door is open. Trapped key systems are often used in large plant systems where maintenance staff can virtually "disappear" in the work environment. That brings up the risk of another person restarting the machine while staff is still working in the hazard zone but is not in sight.

Trapped key systems are very popular in some parts of the world and virtually unknown in others. There are new sophisticated electronic versions with RFID-coded switches that may store the operators staff ID and/or which may allow access to some areas only while preventing access to others. The key may also allow the operator to select only some of the operating modes of the machine, while preventing use of others.
There are numerous ways of controlling access to hazardous areas. Choose what is best for your application, based on careful risk assessment and the hints in the table below.

Table 2 - Some criteria for selection of monitoring functions

TYPE OF GUARD RECOMMENDED	ACCESS	SYSTEM SIZE	TIME TO STOP HAZARD
Stationary, no monitoring	Infrequent < 1/week, for maintenance only	Any	Not relevant (Machine stopped and secured under a "safe system of work")
Movable with interlocking (2-state)	Frequent ≥ 1/week	Small to medium (with good overview)	Short < 0.2 s
Movable with guard locking, unconditional unlocking (3-state)	Frequent ≥ 1/week	Small to large	Medium < 0.5 s (Unlocking of guard takes more time than stopping the hazard)
Movable with guard locking, conditional unlocking (4-state)	Frequent ≥ 1/week	Small to large	Long > 0.5 s
Trapped key system	Frequent ≥ 1/week	Large, many persons working	Long > 0.5 s