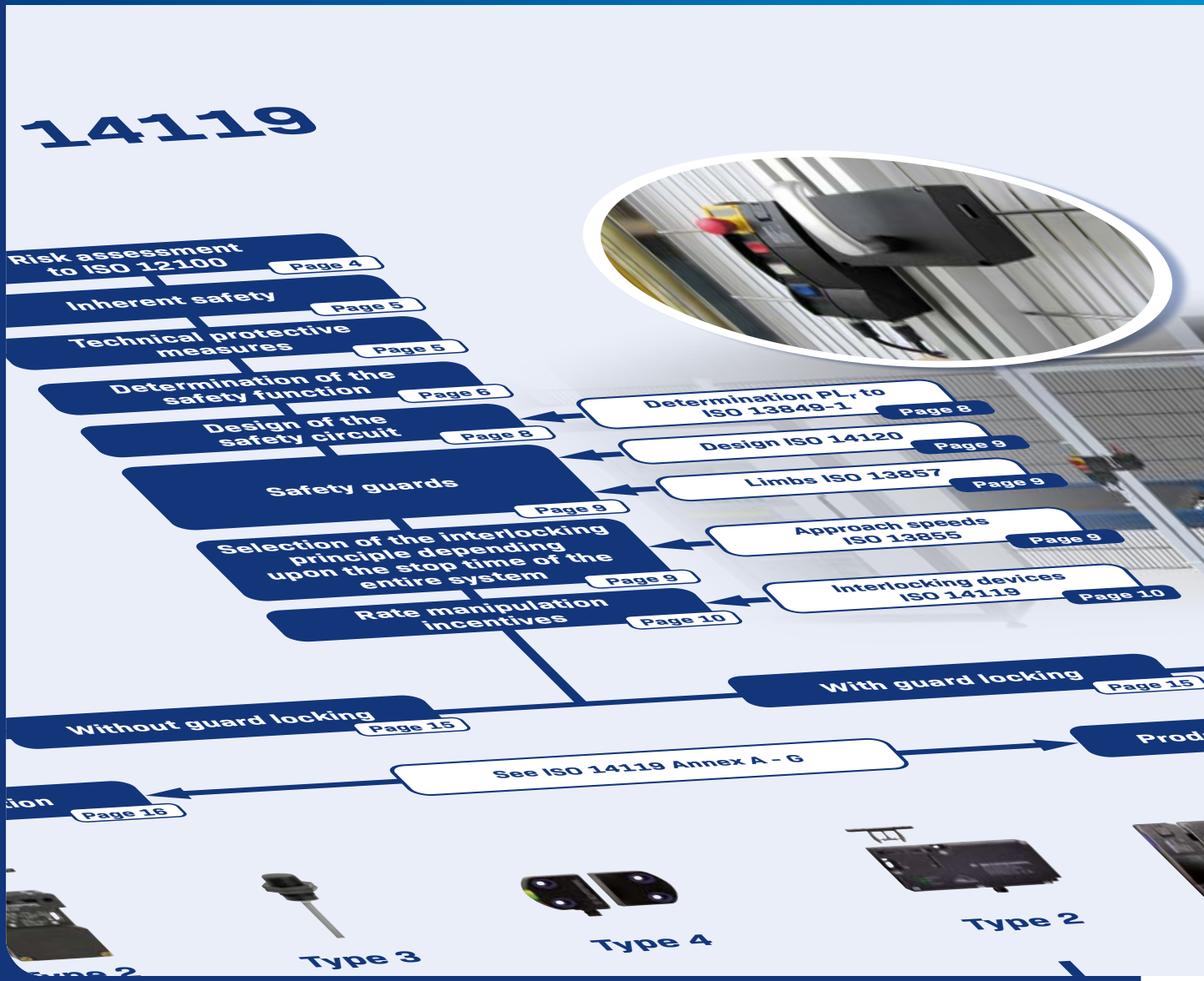
Safety in system:
Protection for man and machine

DESIGN OF SAFETY GUARDS
UNDER OBSERVATION OF ISO 14119



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INTRODUCTION

With the Machinery Directive (MRL) 2006/42/EC and subsequently with the new Machinery Regulation (MVO) EU 2023/1230, as well as the associated standards, the European Union has created a set of rules that must be taken into account in the design of machines and systems. This set of rules is also considered and adapted in markets outside the EU as a basis for machine safety. It contains amongst others, statements concerning the design of the moveable safety guards.

The position monitoring of movable safety guards is described in detail in the standard ISO 14119: "Safety of machinery – Interlocking devices associated with guards – Principles for design and selection". With the new version of ISO 14119:2024-09 (German version: DIN EN ISO 14119:2025), some changes and additions have been incorporated. For example, key transfer systems have been included in the standard as a new type 5 and ISO/TR 24119 "Evaluation of fault masking in series circuits of potential-free contacts" has been integrated as Annex J. After a transition period of 2 years, the new version of the standard will replace the previous version of DIN EN ISO 14119 in September 2026. As an ISO standard, it is also valid beyond the European Union.

This brochure's objective is to aid designers of machinery and plants with standard-compliant design of moveable guards taking into consideration the ISO 14119 and other relevant regulations.

In the centre of the brochure there is an accompanying poster, that gives a quick overview of the technically correct design of moveable safety guards and represents the whole process of their standard-compliant selection and design in the form of a flowchart.

This brochure outlines the enclosed poster and gives detailed information on the individual process steps of the flowchart. The page numbers noted on the poster refer to the relevant page in this brochure, where the process step is described.

The contents of this brochure reflect the interpretation of the Schmersal Group and is also based on the experience gained as a member of the Deutschen Institut für Normung e.V. (German institute for standardisation), Standards Committee NA 095 Safety principles and "Protective devices, safety measures and interlocks". Reading the brochure does not exempt you from your own study and interpretation of the standard.

A note on terminology first: The term "interlocking device" used in the standard as a synonym for safety switchgear often leads to confusion, because in general usage, an interlocking device is understood to be a component that actually holds, closes and/or locks the safety guard. From the standard's point of view this component is referred to as interlocking device with guard locking. The interlocking devices themselves, by definition of the standard, only monitor the position (open / closed) of the safety guard. This task can be fulfilled by electromechanical safety switches or non-contact safety sensors.

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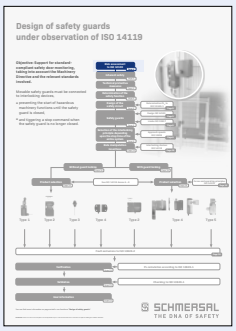
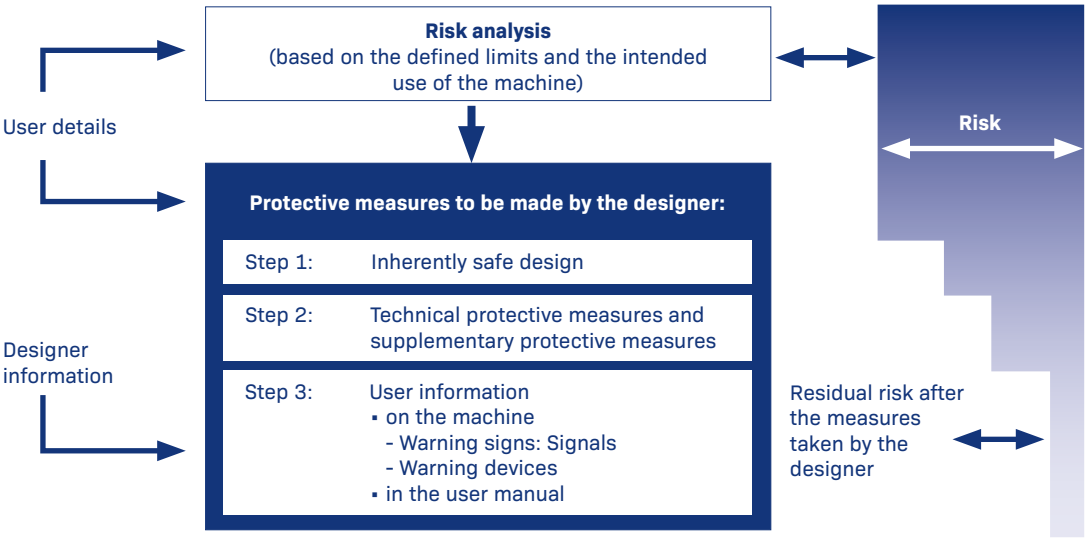


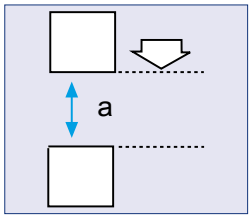
1. Risk assessment



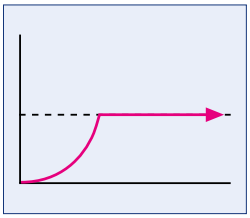
ISO 12100: Risk analysis

- The Machinery Directive (MRL) and therefore the law (in Germany the 9th Ordinance to the Product Safety Act), as well as the Machinery Regulation (MVO) from 2027, requires every machine manufacturer to carry out a risk assessment.
- The risk assessment consists of hazard identification, risk estimation and evaluation.
- The risk assessment takes into account the entire life cycle and all operating modes of the machine.
- Instructions for conducting a risk assessment can be found in the ISO 12100.
- Only after completing the risk assessment the manufacturer knows where there are possible risks of injury on the machine and whether anything needs to be done about them.

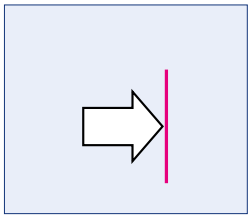
2. Inherent safety



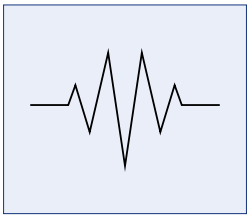
Minimum distances



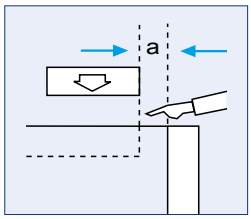
Limiting the effective energy



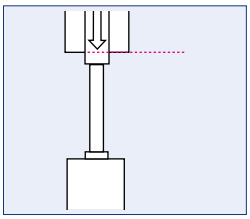
Interrupting the flow of power



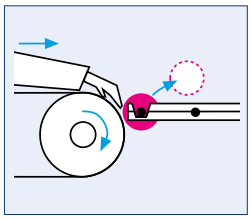
Elastic deformation



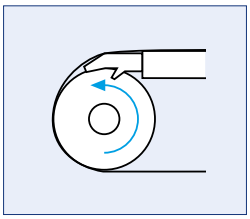
Dangerous movements stop at a distance that cannot deform limbs



Forces that occur at the hazard spot are to be deliberately limited so as not to have any bodily damaging effect

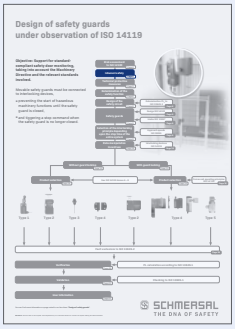


The buildup of forces that would lead to injuries is reliably interrupted before reaching the limits



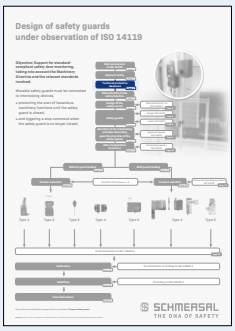
Deliberately resilient machine parts which deform and absorb most of the deforming energy

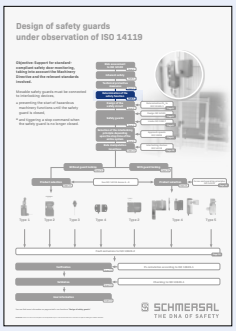
- In accordance with the "Risk assessment" diagram of the ISO 12100 on page 4 of the brochure, the risks must first be eliminated by design (= **inherently safe design;** see ISO 12100, section 3.20).
- Inherent safety is understood to mean the elimination of risks by constructive measures.



3. Technical protective measures

- If the identified risks cannot be eliminated by design measures, or at least minimised to an acceptable level, technical protective measures must be taken such as optoelectronic protective equipment, tactile protective devices, two-hand controls etc., refer to ISO 12100, section 3.21.
- Such a technical protective measure could for example be a movable safety guard. This brochure concentrates on such measures.





4. Determination of the safety function

- Table M.1 in Annex M of ISO 13849-1 defines safety functions that ensure that the identified risk is minimised, see also ISO 12100, section 3.30.
- When implementing safety functions, the entire safety circuit must be taken into consideration – starting with the sensors (input, in our case the interlocking device), the monitoring device (logic) and the actuator (output).

ISO 13849-1: Safety function

Every safety function or circuit includes the following components (Sub-systems):

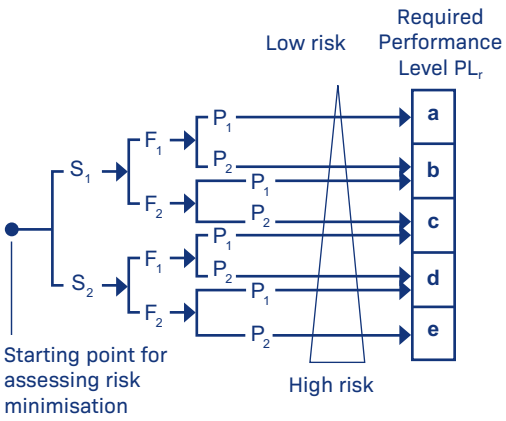
Input → **Logic** → **Output**

for example:

...or...

...or others

By using the risk graph of ISO 13849-1, Annex A, the required performance level (= PL_r) can be determined for this safety function.



S Severity of injury
- S_1 Slight (normally reversible injury)
- S_2 Serious (normally irreversible injury or death)

FF Frequency and / or exposure to hazard
- F1 may be selected if the total exposure duration does not exceed 1/20 of the total operating time and the frequency is not higher than once every 15 minutes
- F_2 Frequency greater than 1x every 15 min

P Possibility of preventing the hazard or limiting the damage
- P_1 Possible under certain conditions
- P_2 Barely possible

If there is a low probability of the occurrence of the hazardous event, the necessary PL_r can be reduced.

The probability of occurrence must be justified:

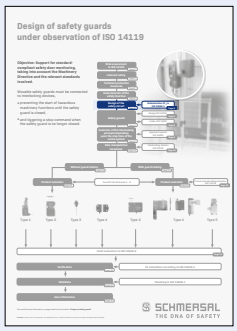
- Reliability data
- Accident history of comparable machinery

The relevant safety functions of movable safety guards are (see ISO 14119, section 3.2 and 3.4):

- Switching off the dangerous machine function when opening the safety guard
- Protection against unexpected start-up (see also ISO 14118:2017)
- If necessary, locking the safety door until the dangerous machine function is completed
- If necessary unlocking the guard locking device

For the safety function "Unlocking the guard locking device", the ISO 14119 standard assumes (see note 2 of section 9.3) that the PL of the guard locking function is lower than the PL of the interlocking function. Reason: "The probability of the locking function failing when a person enters at the same time is usually very low." Nevertheless, inadvertent unlocking of the locking device must be included in the safety classification.

ISO 14119 takes into account the characteristics and requirements on the sensor system (input) of the safety chain. Their sensor is part of the interlocking device of a safety guard described in the standard.



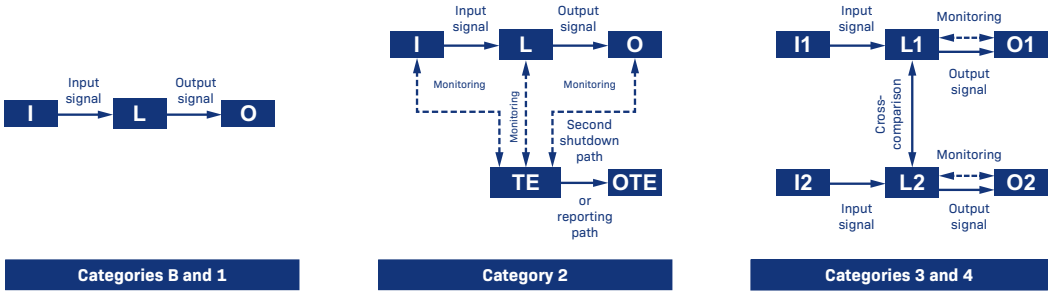
ISO 13849-1: Safety architecture

5. Design of the safety circuit

After the safety function has been determined, it is now necessary to design the appropriate safety circuit.

The design is to be in accordance with the requirements of the PL_r (see ISO 13849-1, section 6). This means it must meet the requirements of the:

- Structure of safety circuit



- expected service life of the components used until the first occurrence of a dangerous fault: $MTTF_D$ (or B_{10D})
- test quality, which means the quality of the dangerous fault detection: DC_{avg}
- measures against common cause failures: CCF

must be considered.

Note to DC_{avg}:

- In some applications the electromechanical interlocking devices are connected in series electrically. Because of the possibility that dangerous faults that occur may not be detected the DC_{avg} must be correspondingly reduced.
- The new Annex J of ISO 14119 provides corresponding information on the series connection of interlocking devices and their effect on the DC_{avg}.

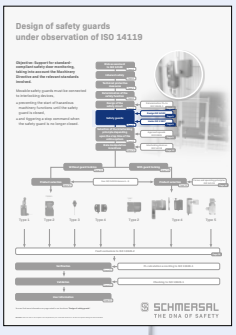
We recommend the following procedure for series connection of interlocking devices:

- The first choice for series connection is the use of self-monitoring electronic interlocking devices. Here, a DC_{avg} of "high" is also given in the series connection, which enables a maximum performance level of PL e.
- For series connection of interlocking devices with positive break contacts or series connection of magnetic interlocking devices, a comprehensive analysis in accordance with Annex J of ISO 14119 is required.
  In any case, the DC_{avg} is reduced to "medium" or "low", which reduces the maximum performance level to PL d or even PL c.

6. Safety guards

The mechanical design of the safety guard is also described by requirements in the following standards:

- ISO 14120: Safety guards
  There is a reference in section 6.4.4.1 on the access or frequency of access with a movable safety guard indicating when they are to be used. At a frequency of more than once a week a movable guard should be used with an interlocking device to ISO 14119.
- ISO 13857: Safety distances to prevent hazard areas being reached by the upper and lower limbs. This standard describes the sizes of limbs and consequently the necessary safety distances to hazardous areas. It states in section 4.4, among other things, that guard doors should not exceed a ground clearance of 180 mm, because then the whole body has access to the danger zone.

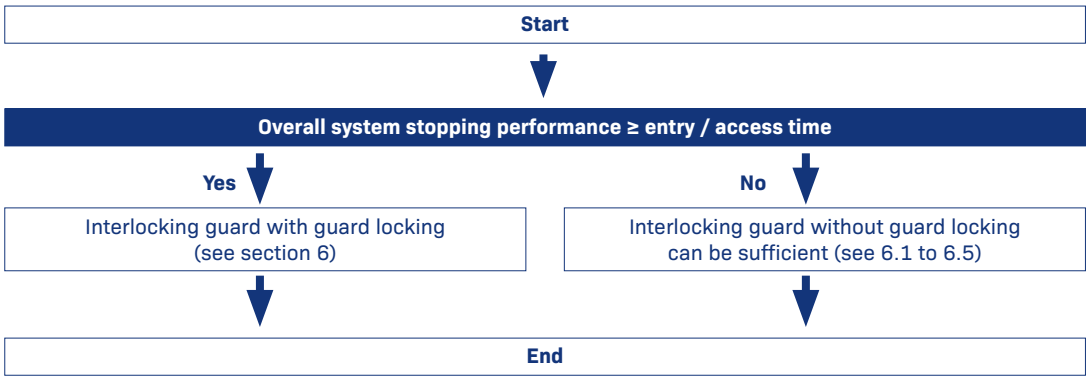


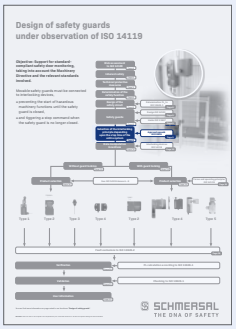
ISO 14120: Safety guards

ISO 13857: Safety distances

7. Choosing the locking principle

The type of interlocking device, i.e. with or without guard locking, can be determined using the flow chart in Figure 6 / Chapter 7.2.1 of ISO 14119.



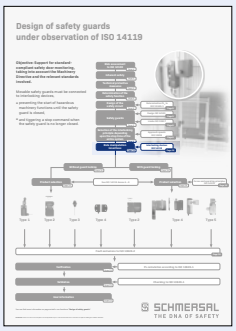


ISO 14119: Interlocking principle

ISO 13855: Entry and access speed

Information to answer the question whether the stop time of the whole system is ≥ entry / access time is given in the standard ISO 13855 section 12.

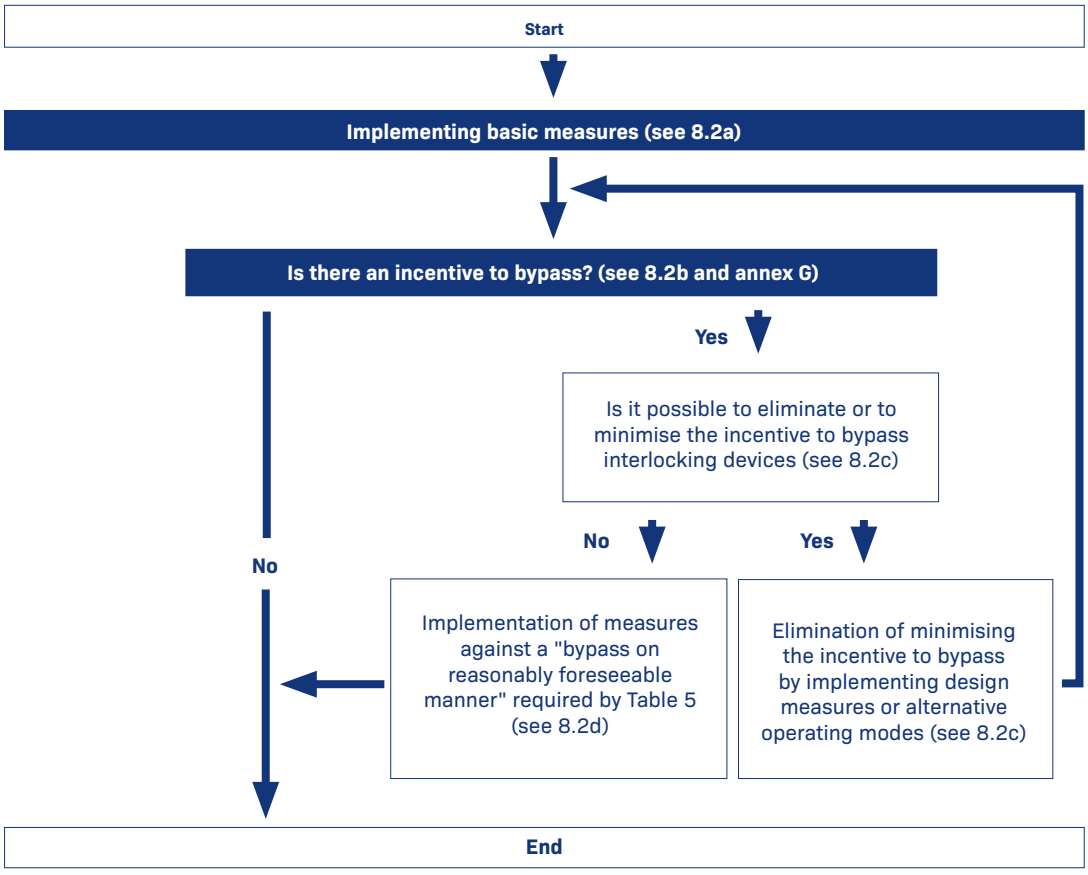
- This given standard calculates the safety distance from behind the safety guard to the danger zone with an entry speed of 1600 mm/s or an access speed of 2000 mm/s.
- The safety distance is also dependent on the size of the body parts that obtain access to the danger zone when the safety guard is opened. Therefore, the standard ISO 13857 is also to be considered when calculating the stopping time.



ISO 14119:
Defeat incentives

8. Rate defeat incentives

An investigation* has shown that accidents are often the result of protective equipment being defeated. ISO 14119 therefore focuses primarily on preventing the manipulation of interlocking devices.
To prevent this, the standard suggests a certain method in the form of a flowchart.



The aim of this approach is to recognise the defeat incentive and to reduce or eliminate it. If there are no defeat incentives, it is not necessary to take any further measures.

The ISO 14119 also supports the designer with determining the defeat incentive. It suggests a matrix that shows the task to be carried out on the machine and the consideration of easing the task through corresponding defeat.

*Source: www.dguv.de/ifa/publikationen/reports-download/bgia-reports-2005-bis-2006/report-manipulation-von-schutzeinrichtungen/index.jsp

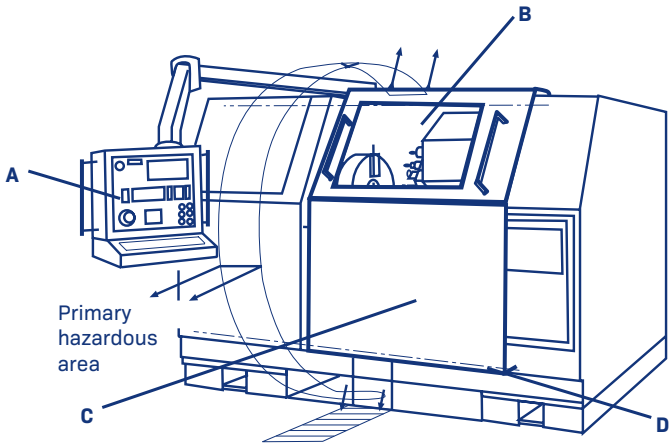
Thus, it is readily apparent, at what point and in which task or operating mode of the machine there is a risk of defeat:

Tab. 2 Example of an assessment of incentives to bypass interlocking devices
(Source: ISO/DIS 14119, Table G.1).

Task	Operating mode 1[a]	Operating mode 2[a]	Operating mode 3[a]	Operating mode 4[a]	Operating mode 5[a]	Allowable tasks for this operation mode?	Tasks possible without bypassing?	Easier / more convenient [b]	Quicker / high productivity[b]	Flexibility, such as with larger work pieces	Higher level of precision[b]	Improved visibility [b]	Improved audibility [b]	Less physical effort [b]	Less travel [b]	Larger freedom of movement [b]	Better flow of movement [b]	Prevention of interruptions [b]	...
Commissioning																			
Program test / Test run																			
Installation / adjustment / modifcation / equipping																			
Proccessing																			
Manual intervention for removal of debris																			
Manual changing of work-pieces																			
Manual intervention with troubleshooting																			
Check / random sampling																			
Manual intervention with measurement / fine adjustment																			
Manual tool change																			
Maintenance / Repair																			
Fault rectification on machine																			
Cleaning, e.g. removing debris																			

Legend:
a Operating modes
b Advantages without guard system: 0 = none; + = few; ++ = many

Of course, this table is to be adapted to the respective application or machine.
Further information on this topic can also be found at:
www.dguv.de/ifa/praxishilfen/practical-solutions-machine-safety/index.jsp



If it is determined that defeat incentives exist, then these must first be eliminated by design, see ISO 14119, section 8.2 c. Examples of purely constructive measures are:

A) Ergonomics:
- Height adjustment of the control panel
- Arrangement and design of the display and operating elements
- Position of the emergency stop switch
- Observability of the working zone
- Dimensions and location of the handles
- Manual forces for displacing

B) Viewing window:
Window construction: Polycarbonate – window must be protected against chemical and abrasive influences from inside with a safety glass pane and from the outside should be protected with a non-splintering plastic pane or splintering prevention foil.
Window mounting: The mounting should be able to withstand high impact reaction forces, allow considerable deforming and at the same time the ends of the polycarbonate window should be hermitically sealed against chemical reaction.

C) Protective cover:
Cover structure: With sandwich construction, the inner skin must be extremely deformable, and the outer skin designed to be extremely resistant and stiff.
Main closing edge: With power-operated safety doors the kinetic energy and speed when closing must be limited so that no dangerous pinching point is created at the main closing edge. The effective closing force must not exceed 150 N.
Cover mounting: Guidance on rollers in form-fitting custom runners. Clamps prevent ejection of the cover if damaged. The lower area of the cover should be designed that neither debris nor cooling lubricant can escape outwards.

D) Controllers:
Functional safety: Reliable fulfilling of safety functions within a defined period of time with the safety relevant part of the controller.
Manipulation protection: Interlocking device non-accessibly mounted with non-detachable fixings. Assess manipulation incentives for the intended use of the machine during all phases of its lifecycle.

Measures for tamper protection

Principles and measures	Type 1: without hinge	Type 1: with hinge	Type 2: low/medium coding	Type 2: high coding	Type 3	Type 4: low/medium coding	Type 4: high coding	Type 5: low/medium coding	Type 5: high coding
Additional interlocking device and plausibility checks, see 8.3 d) 2)	R		R		R	R		X	
Mounting out the reach, see 8.2 a) 1)	X		X		X	X			
Physical obstacle/shielding, see 8.3 a) 2)								X	
Mounting in hidden location, see 8.3 a) 3)									
Condition monitoring or cyclical testing, see 8.3 d) 1)								X	
Non-releasable attachment of the actuating element, see 8.3 c)			M	M		M	M	M	M
Non-releasable attachment of the interlocking device, see 8.3 c)			R	R		R	R	R	R
Non-releasable attachment of the interlocking device and the actuating element, see 8.3 c)	X	M							

X At least one of these measures is mandatory.
M Mandatory measure
R Recommended / additional measures based on the assessment of the manipulation incentive (see Appendix G)

ISO 14119: Schedule 5

In ISO 14119 section 6 very general requirements for the installation and mounting of interlocking devices are described which must be observed regardless of the measures described in Table 5 above:

Section 6.2, Arrangement and fastening of position switches, bolt locks and access locks

Position switches, bolt locks and access locks must be arranged in such a way that they are secured against changing their position. To achieve this, the following requirements must be met:

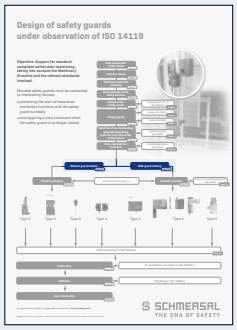
- The fastening elements of the position switches, bolt locks and access locks must be reliable and a tool must be required to release them.
- Type 1 position switches and bolt locks must have provisions for permanently securing the position after adjustment (e.g. using bolts or dowel pins).
- For bolt locks and access locks, slotted holes must not be used as the sole means of fastening.
- The necessary access options to the position switches, bolt locks and access locks for maintenance and checking correct operation must be ensured. The prevention of circumvention in a reasonably foreseeable manner must also be taken into account when designing the access options.
- Gradual loosening must be prevented.
- The position switch, the bolt lock or the access lock must be arranged and, if necessary, protected in such a way that failure due to foreseeable external influences is prevented.
- The movement caused by the mechanical operation or the distance to the actuating system of a non-contact position switch must remain within the actuating area of the position switch specified by the switch manufacturer or the actuating system, this is to ensure proper operation and/or to prevent an overrun.
- A position switch, a bolt lock or an access lock must not be used as a mechanical stop unless this is the intended use according to the manufacturer's specifications.
- Misalignment of the guard, caused by an opening before the position switch state changes should not affect the protective effect of the safety device (regarding access to hazardous areas, see ISO 13855 and ISO 13857).
- The receptacle and the mounting of the position switches, the bolt locks and the access locks must be sufficiently stable to maintain proper operation.

Section 6.3: Arrangement and mounting of actuators

Actuators must be secured so that the possibility of becoming loose or the possibility of modifying its intended position relative to the actuating system is reduced to a minimum over the intended service life.

- The fasteners of the actuators must be reliable and to move them, a tool is required.
- Gradual loosening must be prevented.
- The actuators must be arranged and, if necessary, be protected in such a way to prevent damage by unforeseen external causes.
- An actuator should not serve as a mechanical stop, unless this is the intended use of the actuator according to the manufacturer.
- The receptacle and the mounting of the actuator must be sufficiently stable to maintain proper operation of the actuator.

In the new version of ISO 14119, the topic of “Defeat in a reasonably foreseeable manner” is defined more precisely in point 3.5 and in chapter 8. It should not be possible to bypass, i.e. manipulate, the interlocking device with readily available tools or with tools that are required for the intended use of the machine. As a consequence, this means that the evaluation of manipulation incentives must be carried out very accurately and standard screws should only be used after careful analysis.



9. Interlocking devices with and without guard locking

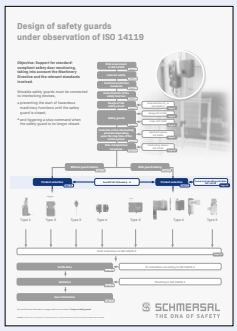
The standard distinguishes five different types of interlocking systems:

The coding level is not important. When considering the designs, the first consideration is whether the interlocking device is coded or not.

The following coding levels are defined in the standard (see section 3.11.1 to 3.11.3):

low: Coding options: 1 - 9
medium: Coding options: 10 - 1,000
high: Coding options: > 1,000

This definition is independent of the locking function of the interlocking device.



10. Product selection

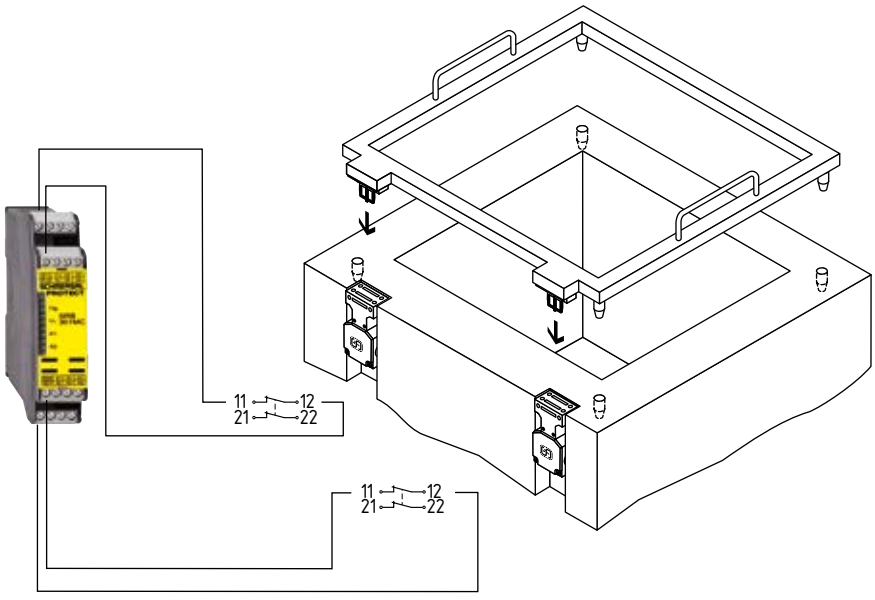
The selection of the appropriate product always depends of course on the real application, i.e. operating conditions, such as:

- Temperature
- Humidity
- Dirt
- Shock/vibration
- Explosive atmosphere
- Necessary holding force

Further details and application instructions for the different types described above are given in annexes A - G of the standard.

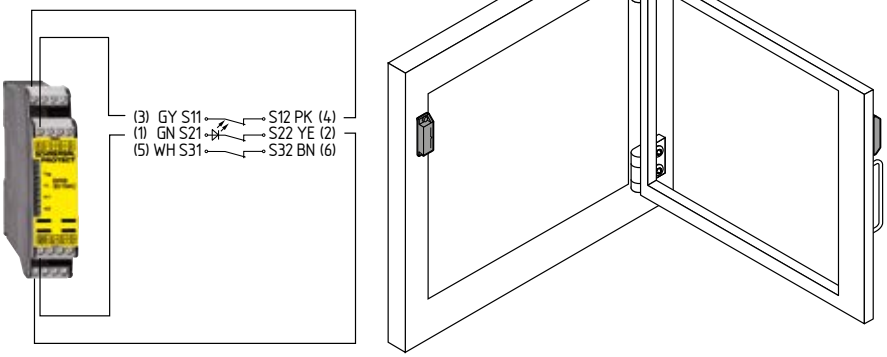
ISO 14119 / ISO 13849-2: Redundancy

The selection of a product also depends on the PLr to be achieved (see above on page 7). ISO 14119 and ISO 13849-2 prescribe redundancy of Type 1 or Type 2 switches when the PL_r = PL e is to be reached (see ISO 14119 section 9.1 and ISO 13849-2, table D.8).



IEC 60947-5-3: Product standard Safety sensors

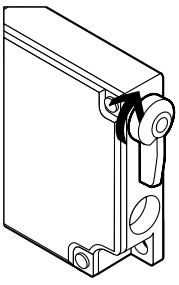
If a safety sensor (type 3 or type 4) is selected, with which a PL e can be achieved with just one sensor instead of two – as described above – then it must be ensured that it fulfils the requirements of product standard IEC 60947-5-3 (see ISO 14119 section 6.4).



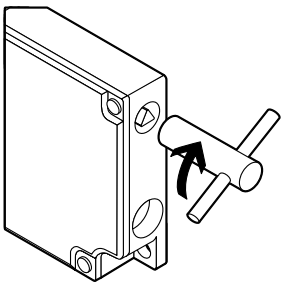
If, because of the stopping time described above, an **interlocking device with guard locking** is required, then Annex I of ISO 14119 is to be observed. It informs about the maximum possible static action forces that may be posed on interlocking devices with guard locking feature. As an informative annex and as an exemplary enumeration it is to be understood as a guideline of possible maximum force levels (ie: orders of magnitude) are represented. The locking forces actually required in a real application cannot and will of course not be prescribed by the standard. This is a matter for the machine manufacturer and the requirements from section 7.2.2 of ISO 14119 must be taken into account.

If an interlocking device with guard locking is used, a manual (deliberate) deactivation of the guard locking device should be considered for installation, maintenance or repair work purposes on the machine.

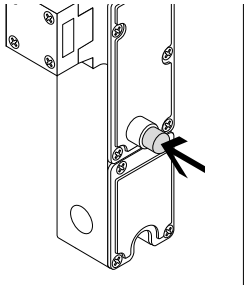
Such types of release are defined in the standard ISO 14119 section 3.26 to section 3.28:



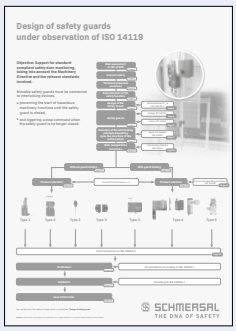
- Emergency release: mounted outside the hazardous area, for emergency use



- Auxiliary release: for unlocking during setup, no emergency



- Emergency exit: mounted within hazardous area to be able to exit the area independently in the event of danger.

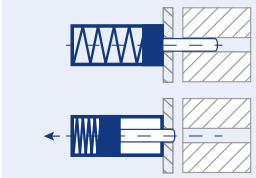
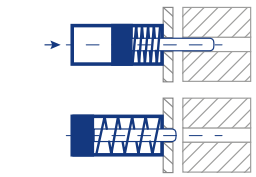
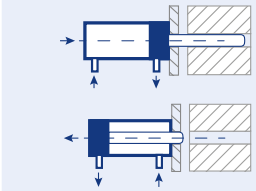
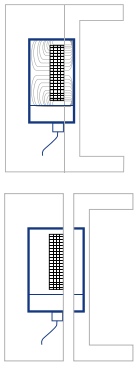


11. “Power to lock” or “Power to unlock” working principle

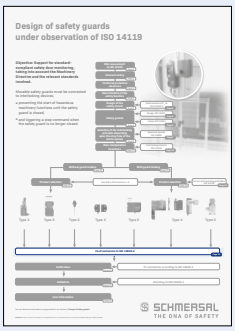
Depending on whether energy is needed to lock or unlock the safety door, one distinguishes between

- Power to unlock: mechanically locked, unlocked by applying energy (see A)
- Power to lock: energy required to keep locked, release by removing the energy (see B and D)
- Bi-stabile principle of operation: power serves to interlock, power also serves to release (see C)

For safety reasons, the power to unlock principle (unlocked by Energy ON) is preferable. After a proper risk assessment the power to lock principle (unlocked by Energy OFF) may also be applied. However, measures must then be taken to minimise the risks caused by power supply failure (see ISO 14119 section 6.6.1).
For this reason, guard locking devices based on the power to unlock principle are the first choice for personal protection.

A)		Power to unlock Energy ON unlocked	Locked Unlocked
B)		Energy ON locked Power to lock	Locked Unlocked
C)		Energy ON locked Energy ON unlocked	Locked Unlocked
D)		Energy ON locked Energy OFF unlocked	Locked Unlocked

12. Fault exclusions



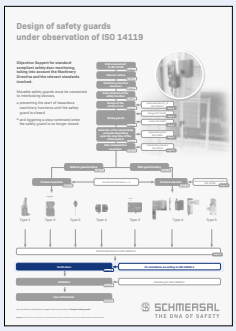
ISO 13849-2:
Fault exclusions

Machine safety requires the correct functioning of the safety circuit. It is therefore of utmost importance that any errors that could occur leading to a loss of safety are excluded.

The central standard that deals with possible errors in the components of a safety circuit, is the ISO 13849-2.

In the annexes, possible errors and possible exclusions due to the application of certain techniques are described in tabular form. For example: The non-opening of an electro-mechanical contact can be excluded by using a switch with positive break contacts.

It is important to study the applicable tables of the standard (especially Annex D: Validation tools for electrical systems) and document possible fault exclusions.



ISO 13849-1: Verification

13. Verification

The verification is used to provide evidence that the selected components and their inter-connections are sufficiently resistant to systematic and random errors that would result in the loss of the safety function. This is accomplished using a PL-calculation that must also include the corresponding monitoring device and the actuator. This calculation process is described in ISO 13849-1.

Calculation of the safety function

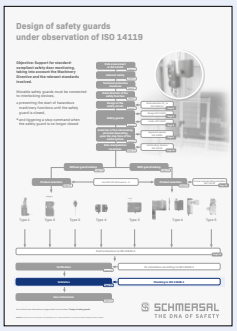
Input	Logic	Output
		
Structure = Category 3 B_{10D} = 2,000,000 (ISO 13849-1) F = 1/h $MTTF_D$ = 2,283 a $MTTF_D$ > 100 a = High DC = 90 % = Low CCF = 80 points > 65	DC = 99 % CCF = 80 points PFH_D = 5.0 × 10^9/h	Structure = Category 4 B_{10D} = 2,000,000 (ISO 13849-1 norm. load) F = 1/h $MTTF_D$ = 2,283 a $MTTF_D$ > 100 a = High DC = 60 % = Low CCF = 80 points > 65
PL d	+ PL e	+ PL e

Assessment in accordance with Table 9 of ISO 13849-1
$PL_{achieved}$ = PL d = PL_r

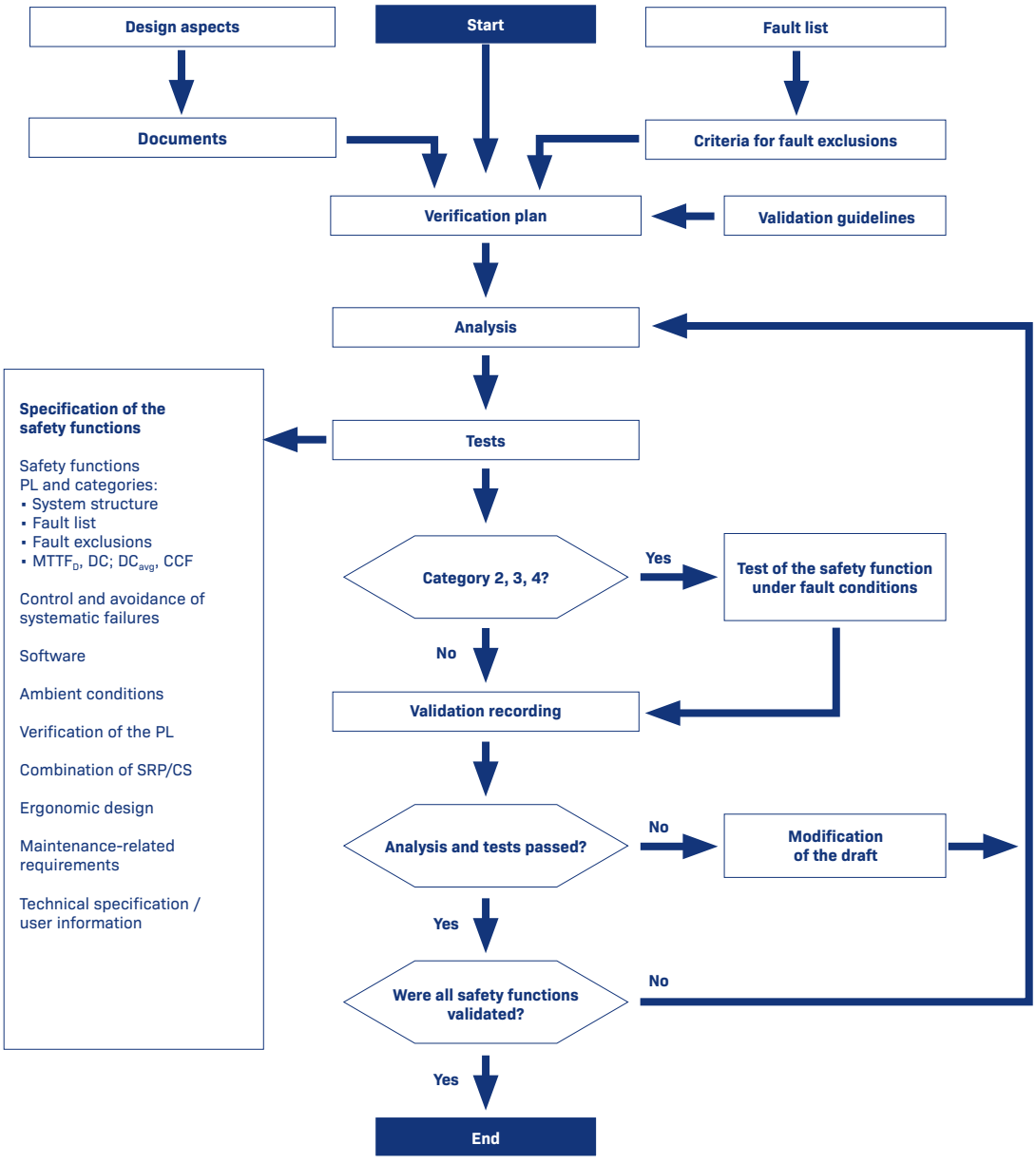
Such calculations can be performed on the computer with the SISTEMA software tool provided free of charge by the IFA
Download: **https://www.dguv.de/ifa/praxishilfen/practical-solutions-machine-safety/software-sistema/**

Many manufacturers of safety components make the data of their components available in so-called SISTEMA libraries.
The Schmersal library is available in "Further products/software“ at: **products.schmersal.com**

14. Validation



Despite all care, a final check of all conditions and parameters is mandatory, see ISO 13849-1, image 4. How to proceed with the validation, is described in section 10 of ISO 13849-1.
The procedure is shown in Figure 17 as follows:

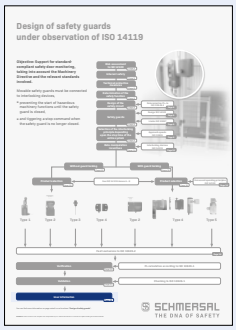


ISO 13849-1: Validation

Hence it does not only depend on the theoretical analysis, but depending on the complexity of the machine, also on the practical check of the safety function.

For a practical check of a two-channel machine it can be useful to deliberately disconnect one channel and then test the reaction of the system.

Here it is again important to record the results (validation report).



15. User information

If, in spite of all protection measures there are still remaining risks at the safety guard (such as with certain operating modes, e.g. maintenance operations, setting up) it is essential that the user is informed.

This is done in two different ways: on the guard door itself and in the machine's operating instructions.

However, at this point it must be made clear that this is the last possibility for risk reduction that may be used after the inherent construction (see page 5 of this brochure) and also the technical protection measures (ie: locking the safety guard) have been exploited.

Information on creating standardised operating instructions can be found in ISO 12100 section 6.4 and also in ISO 20607.

ISO 12100
ISO 20607:
Operating instructions

16. List of Standards

ISO 12100:2010	General principles for design - Risk assessment and risk reduction
ISO 13849-1:2023	Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design
ISO 13849-2:2012 (in revision)	Safety of machinery – Safety-related parts of control systems – Part 2: Validation
ISO 13855:FDIS (in revision)	Safety of machinery – Positioning of protective devices with regard to the approach of the human body
ISO 13857:2019	Safety of machinery – Safety distances to prevent hazard zones being reached by upper and lower limbs
ISO 14118:2017	Machine safety – preventing unexpected start-up
ISO 14119:2024	Safety of machinery – Interlocking devices associated with guards – Principles for design and selection
ISO 14120:2015	Safety of machinery – Guards – General requirements for the design and construction of fixed and movable guards
ISO/TR 24119:2015	Evaluation of fault masking in series circuits of potential-free contacts Not applicable, incorporated as Annex J in ISO 14119
IEC 60947-5-1:2022 (in revision)	Low-voltage switchgear and control gear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices
IEC 60947-5-3:2016 (in revision)	Low-voltage switchgear and control gear – Part 5-3: Control circuit devices and switching devices – Requirements for proximity devices with defined behaviour under fault conditions (PDDB)
ISO 20607:2019	Safety of machinery - Operating instructions - General Principles for Design

Finally with this brochure we hope to have given you helpful tips with the standard-compliant construction of protective devices. We have created the content of this brochure and the poster to the best of our knowledge and belief, but assume no responsibility for their content. We also wish to point out the standardisation in European and international level are in constant change in order to keep in line with the technical progress and to adapt the standards and regulations to this new technology.

If you have any questions or suggestions, we would be happy that you contact us. If you require more information please refer to our current event and training program, which can be viewed under **www.tecnicum.com/en/academy**. Additionally our staff are available with further information.

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excellence in safety

tec.nicum is the Schmersal Group's business unit for solutions and services related to machine, plant and occupational safety.

Schmersal restructured its service business in 2024. The range of safety services offered by tec.nicum has been significantly expanded – particularly with regard to digitalisation and complete solutions for machine safety – and the global activities and expertise have been more closely integrated.

In April 2024, Schmersal founded tec.nicum – Solutions & Services GmbH as a new subsidiary, which also incorporated omnicon engineering GmbH, which Schmersal had already acquired in 2019. The headquarters of the new subsidiary is located in Kirkel-Limbach, Germany.

The four pillars on which tec.nicum's offering has been built to date – academy, consulting, engineering and integration – have been supplemented by two more: digitalisation and outsourcing.

digitalisation: tec.nicum is increasingly offering newly developed software solutions, such as a new tool for carrying out risk assessments, as well as new digital technologies such as cloud solutions, IIoT applications, digitalised lockout-tagout procedures and energy management tools.

outsourcing: tec.nicum offers companies the opportunity to completely outsource all tasks related to machine safety, from the planning and installation of control cabinets to the design of holistic safety solutions. tec.nicum provides the user with ready-to-connect plug & play solutions.

Thanks to its worldwide consultancy network, tec.nicum services are available around the globe. tec.nicum provides customers with competent, product- and manufacturer-neutral advice and supports them in the safety-related design of their machines and production lines.

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academy

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- Training courses
- Customer-specific trainings
- In-house seminars
- Certified courses (mce.expert and FSE)

consulting

Analysis and documentation

- Technical support
- Risk assessment
- CE conformity assessment
- Evaluation of machines and production lines
- Reports

engineering

Planning and design

- Technical project planning
- Conceptual project development
- Electrical and mechanical design
- Executive project management

integration

Practical application

- Turnkey approach
- Installation
- Retrofit

digitalisation

Software integration

- tec.**ps** (Product Service System)
- tec.**ssm** (Schmersal Smart Machine)
- tec.**cvs** (AI and Computational Vision Solutions)
- tec.**dloto** (Digital Lockout Tagout)
- tec.**ems** (Energy Monitoring System)

outsourcing

Serial solutions

- Plug & Play products
- Engineer to Order projects
- Systems and cabinets

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The range of services offered by tec.nicum comprises six segments: academy (knowledge transfer), consulting (advisory services), engineering (technical planning), integration (execution and implementation), digitalisation (software solutions and new digital technologies) as well as outsourcing (complete solutions).

Design of safety guards under observation of ISO 14119

Objective: Support for standard-compliant safety door monitoring, taking into account the Machinery Directive and the relevant standards involved.

Movable safety guards must be connected to interlocking devices,

- preventing the start of hazardous machinery functions until the safety guard is closed,
- and tiggering a stop command when the safety guard is no longer closed.

Risk assessment to ISO 12100 — Page 4

Inherent safety — Page 5

Technical protective measures — Page 5

Determination of the safety function — Page 6

Design of the safety circuit — Page 8
- Determination PL_r to ISO 13849-1 — Page 8

Safety guards — Page 9
- Design ISO 14120 — Page 9
- Limbs ISO 13857 — Page 9

Selection of the interlocking principle depending upon the stop time of the entire system — Page 9
- Approach speeds ISO 13855 — Page 9

Rate manipulation incentives — Page 10
- Interlocking devices ISO 14119 — Page 10

Without guard locking — Page 15

With guard locking — Page 15

Product selection — Page 16

See ISO 14119 Annex A - G

Product selection — Page 16
- Forces and operating principles ISO 14119 — Page 16

Type 1 | Type 2 | Type 3 | Type 4 | Type 2 | Type 4 | Type 5

Fault exclusions to ISO 13849-2 — Page 19

Verification — Page 20
- PL calculation according to ISO 13849-1

Validation — Page 21
- Checking to ISO 13849-1

User information — Page 22

You can find more information on page noted in our brochure "**Design of safety guards**".

SCHMERSAL
THE DNA OF SAFETY

THE SCHMERSAL GROUP
PROTECTION FOR MAN AND MACHINE

In the demanding field of machine safety, the owner-managed Schmersal Group is one of the international market leaders. The company, which was founded in 1945, has a workforce of about 2,000 people and seven manufacturing sites on three continents along with its own companies and sales partners in more than 60 nations.

Customers of the Schmersal Group include “Global Players” in mechanical engineering and plant manufacturing and operators of machinery. They benefit from the company’s extensive expertise as a provider of systems and solutions for machine safety. In addition, Schmersal specialises in various areas including intralogistics, foodstuff production, the packaging industry, machine tool industry, lift switchgear, heavy industry and the automotive industry.

A major contribution to the systems and solutions offered by the Schmersal Group is made by tec.nicum with its comprehensive range of services: Certified Functional Safety Engineers advise machinery manufacturers and machinery operators in all aspects relating to machinery and occupational safety – and do so with product and manufacturer neutrality. Furthermore, they design and realise complex solutions for safety around the world in close collaboration with the clients.

SAFETY PRODUCTS

- Safety switches and sensors, solenoid interlocks
- Safety controllers and safety relay modules, safety bus systems
- Optoelectronic and tactile safety devices
- Automation technology: position switches, proximity switches

SAFETY SYSTEMS

- Complete solutions for safeguarding hazard areas
- Individual parametrisation and programming of safety controllers
- Tailor-made safety technology – be it for individual machines or a complex production line
- Industry-specific safety solutions

SAFETY SERVICES

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- tec.nicum engineering – Design and technical planning
- tec.nicum integration – Execution and installation
- tec.nicum digitalisation – Software solutions and new digital technologies
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