

Australian/New Zealand Standard™

Safety of machinery

Part 1602: Interlocking devices associated with guards—Principles for design and selection



AS/NZS 4024.1602:2014

This Joint Australian/New Zealand Standard was prepared by Joint Technical Committee SF-041, General Principles for the Guarding of Machinery. It was approved on behalf of the Council of Standards Australia on 5 July 2014 and on behalf of the Council of Standards New Zealand on 24 April 2014. This Standard was published on 30 June 2014.

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Australian Manufacturing Workers Union
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This Standard was issued in draft form for comment as DR AS/NZS 4024.1602.

Australian/New Zealand Standard™

Safety of machinery

Part 1602: Interlocking devices associated with guards—Principles for design and selection

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee SF-041, General Principles for the Guarding of Machinery, to supersede AS 4024.1602—2006.

It is emphasized that this Standard is part of the AS(/NZS) 4024.1 series and it is imperative that it is used in conjunction with other applicable parts of the series. A complete listing of all current parts of the AS(/NZS) 4024.1 series can be found at the Standards Australia website <www.standards.org.au> and in AS/NZS 4024.1100, *Safety of machinery*, Part 1100: *Application Guide*.

The objective of this Standard is to specify the principles for the design and selection, independent of the energy source, of interlocking devices associated with guards. It provides measures to minimize defeat of interlocking devices in a reasonably foreseeable manner and it covers the parts of guards which actuate interlocking devices. It does not necessarily provide all the specific requirements for trapped key systems.

This Standard is identical with, and has been reproduced from ISO 14119:2013, *Safety of machinery—Interlocking devices associated with guards—Principles for design and selection*.

As this Standard is reproduced from an International Standard, the following applies:

- (a) In the source text ‘this International Standard’ should read ‘this Australian/New Zealand Standard’.
- (b) A full point substitutes for a comma when referring to a decimal marker.

References to International Standards should be replaced by references to Australian or Australian/New Zealand Standards, as follows:

<i>Reference to International Standard</i>		<i>Australian/New Zealand Standard</i>	
ISO		AS/NZS	
		4024	Safety of machinery
12100	Safety of machinery—General principles for design—Risk assessment and risk reduction	4024.1201	Part 1201: General principles for design—Risk assessment and risk reduction
13849	Safety of machinery—Safety-related parts of control systems		
13849-1	Part 1: General principles for design	4024.1503	Part 1503: Safety-related parts of control system—General principles for design
13849-2	Part 2: Validation	AS 4024.1502	Part 1502: Design of safety related parts of control systems—Validation
IEC			
60204	Safety of machinery—Electrical equipment of machines	60204	Safety of machinery—Electrical equipment machines
60204-1	Part 1: General requirements	60204.1	Part 1: General requirements (IEC 60204-1, Ed. 5 (FDIS) MOD)
62061	Safety of machinery—Functional safety of safety-related electrical, electronic and programmable electronic control systems	62061	Safety of machinery—Functional safety of safety-related electrical, electronic and programmable electronic control systems

The term ‘informative’ has been used in this Standard to define the application of the annex to which it applies. An ‘informative’ annex is only for information and guidance.

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INTRODUCTION

The structure of safety standards in the field of machinery is as follows:

- a) Type-A standards (basic safety standards) giving basic concepts, principles for design, and general aspects that can be applied to all machinery;
- b) Type-B standards (generic safety standards) dealing with one safety aspect or one type of safeguard that can be used across a wide range of machinery:
 - Type-B1 standards on particular safety aspects (e.g. safety distances, surface temperature, noise);
 - Type-B2 standards on safeguards (e.g. two-hand controls, interlocking devices, pressure-sensitive devices, guards);
- c) Type-C standards (machine safety standards) dealing with detailed safety requirements for a particular machine or group of machines.

This document is a type-B2 standard as stated in ISO 12100.

The requirements of this document can be supplemented or modified by a type-C standard.

For machines which are covered by the scope of a type-C standard and which have been designed and built according to the requirements of that standard, the requirements of that type-C standard take precedence.

This International Standard has been prepared to give guidance to machinery designers and writers of product safety standards on how to design and select interlocking devices associated with guards.

Relevant clauses of this International Standard, used alone or in conjunction with provisions from other standards, may be used as a basis for verification procedures for the suitability of a device for interlocking duties.

The informative [Annexes A](#) to [F](#) describe the technology and the typical characteristics of the defined 4 types of interlocking devices. Other solutions may be adopted, provided that they comply with the principles of this standard. The informative [Annexes G](#) to [I](#) give information on particular aspects like interlocking devices used within safety functions, risk assessment considering the motivation to defeat and static action forces. ISO/TR 24119 is under preparation and will give information on the masking of faults in series connection of interlocking devices.

NOTES

AUSTRALIAN/NEW ZEALAND STANDARD

Safety of machinery**Part 1602:****Interlocking devices associated with guards—Principles for design and selection****1 Scope**

This International Standard specifies principles for the design and selection — independent of the nature of the energy source — of interlocking devices associated with guards.

This International Standard covers the parts of guards which actuate interlocking devices.

NOTE ISO 14120 specifies general requirements for the design and construction of guards provided primarily to protect persons from mechanical hazards. The processing of the signal from the interlocking device to stop and immobilize the machine is dealt with in ISO 13849-1 or IEC 62061.

This International Standard does not necessarily provide all the specific requirements for trapped key systems.

This International Standard provides measures to minimize defeat of interlocking devices in a reasonably foreseeable manner.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 12100:2010, *Safety of machinery — General principles for design — Risk assessment and risk reduction*

ISO 13849-1:2006, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

ISO 13849-2:2012, *Safety of machinery — Safety-related parts of control systems — Part 2: Validation*

IEC 60204-1:2009, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

IEC 60947-5-3, *Low-voltage switchgear and controlgear — Part 5-3: Control circuit devices and switching elements — Requirements for proximity devices with defined behaviour under fault conditions (PDF)*

IEC 62061:2012, *Safety of machinery — Functional safety of safety-related electrical, electronic and programmable electronic control systems*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12100, ISO 13849-1 and the following apply.

3.1**interlocking device**

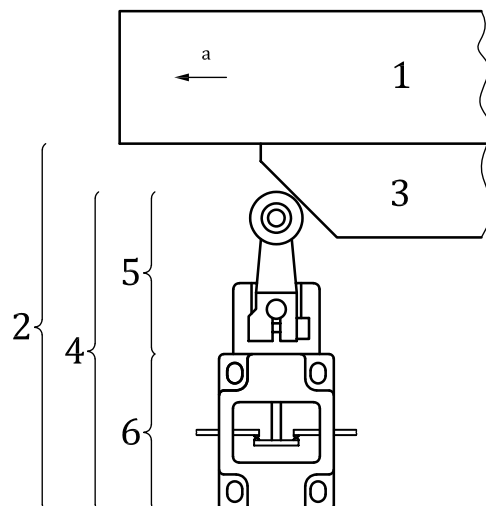
interlock

mechanical, electrical or other type of device, the purpose of which is to prevent the operation of hazardous machine functions under specified conditions (generally as long as a guard is not closed)

Note 1 to entry: See [Figure 1](#) and [Table 1](#).

[SOURCE: ISO 12100:2010, 3.28.1.]

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**Key**

- | | |
|-------------------------|--------------------|
| 1 guard | 4 position switch |
| 2 interlocking device | 5 actuating system |
| 3 actuator | 6 output system |
| a Direction of opening. | |

Figure 1 — Example of an interlocking device**3.2****interlocking guard**

guard associated with an interlocking device so that, together with the control system of the machine, the following functions are performed:

- the hazardous machine functions “covered” by the guard cannot operate until the guard is closed;
- if the guard is opened while hazardous machine functions are operating, a stop command is given;
- when the guard is closed, the hazardous machine functions “covered” by the guard can operate (the closure of the guard does not by itself start the hazardous machine functions)

Note 1 to entry: An interlocking guard can contain/be equipped of one or more interlocking devices. These interlocking devices can also be of different types.

[SOURCE: ISO 12100:2010, 3.27.4.]

3.3**interlocking guard with a start function**

control guard

special form of an interlocking guard which, once it has reached its closed position, gives a command to initiate the hazardous machine function(s) without the use of a separate start control

Note 1 to entry: ISO 12100:2010, 6.3.3.2.5 gives detailed provisions regarding the condition of use.

[SOURCE: ISO 12100:2010, 3.27.6.]

3.4**guard locking device**

device intended to lock a guard in the closed position and linked to the control system

3.5**interlocking guard with guard locking**

guard associated with an interlocking device and a guard locking device so that, together with the control system of the machine, the following functions are performed:

- the hazardous machine functions “covered” by the guard cannot operate until the guard is closed and locked;
- the guard remains closed and locked until the risk due to the hazardous machine functions “covered” by the guard has disappeared, and
- when the guard is closed and locked, the hazardous machine functions “covered” by the guard can operate (the closure and locking of the guard do not by themselves start the hazardous machine functions)

[SOURCE: ISO 12100:2010, 3.27.5.]

3.6**safety-related part of a control system****SRP/CS**

part of a control system that responds to safety-related input signals and generates safety-related output signals

Note 1 to entry: The combined safety-related parts of a control system start at the point where the safety-related input signals are initiated (including e.g. the actuating cam and the roller of the position switch) and end at the output of the power control elements (including, for example, the main contacts of a contactor).

Note 2 to entry: If monitoring systems are used for diagnostics, they are also considered as SRP/CS.

[SOURCE: ISO 13849-1:2006, 3.1.1.]

3.7**defeat**

action that makes interlocking devices inoperative or bypasses them with the result that a machine is used in a manner not intended by the designer or without the necessary safety measures

3.8**defeat in a reasonably foreseeable manner**

defeat of an interlocking device either manually or by using readily available objects

Note 1 to entry: This definition includes the removal of switches or actuators using tools that are needed for the intended use of the machine or that are readily available (screw drivers, wrenches, hexagon keys, pliers).

Note 2 to entry: Readily available objects for substitute actuation include screws, needles and sheet-metal pieces, objects in daily use such as keys, coins, adhesive tape, string and wire, spare keys for the trapped-key interlocking devices, and spare actuators.

3.9**automatic monitoring**

diagnostic function which initiates a fault reaction function if the ability of a component or an element to perform its function is diminished, or if the process conditions are changed in such a way that hazards are generated

3.10**direct mechanical action**

positive mechanical action

movement of a mechanical component which arises inevitably from the movement of another mechanical component either by direct contact or via rigid elements

3.11**direct opening action**

positive opening operation

<contact element>achievement of contact separation as a direct result of a specified movement of the switch actuator through non-resilient members (for example not dependent upon springs)

[SOURCE: IEC 60947-5-1:2003, K 2.2.]

3.12**actuator**

separate part of an interlocking device which transmits the state of the guard (closed or not closed) to the actuating system

EXAMPLE Guard-mounted cam, key, shaped tongue, reflector, magnet, RFID tag.

Note 1 to entry: See also [Annexes A](#) to [E](#).

Note 2 to entry: Examples of actuators are shown in [Figure 2](#).

3.13**coded actuator**

actuator which is specially designed (e.g. by shape) to actuate a certain position switch

3.13.1**low level coded actuator**

coded actuator for which 1 to 9 variations in code are available

3.13.2**medium level coded actuator**

coded actuator for which 10 to 1 000 variations in code are available

3.13.3**high level coded actuator**

coded actuator for which more than 1 000 variations are available

3.14**actuating system**

part of the interlocking device which transmits the position of the actuator and changes the state of the output system

EXAMPLE Roller plunger, cam mechanism, optical, inductive or capacitive sensor.

Note 1 to entry: Examples of actuating systems are shown in [Figure 2](#).

3.15**output system**

part of the interlocking device that indicates the state of the guard to the control system

EXAMPLE Contact element (electromechanical), semiconductor output, valve.

3.16**Type 1 interlocking device**

interlocking device with mechanically actuated position switch with uncoded actuator

EXAMPLE Hinged interlocking devices.

Note 1 to entry: See [Annex A](#) for detailed examples.

3.17**Type 2 interlocking device**

interlocking device with mechanically actuated position switch with coded actuator

EXAMPLE Tongue-actuated position switches.

Note 1 to entry: See [Annex B](#) for detailed examples.

3.18

Type 3 interlocking device

interlocking device with non-contact actuated position switch with uncoded actuator

EXAMPLE Proximity switches.

Note 1 to entry: See [Annex C](#) for a detailed example.

3.19

Type 4 interlocking device

interlocking device with non-contact actuated position switch with coded actuator

EXAMPLE RFID tag actuated position switches.

Note 1 to entry: See [Annex D](#) for detailed examples.

3.20

stop command

signal generated by the interlocking device that causes the hazardous machine function to disappear

3.21

overall system stopping performance

time interval between the stop command given by opening the guard and the termination of the hazardous machine function

[SOURCE: ISO 13855:2010, 3.1.2, modified.]

3.22

access time

time taken by a person to reach the hazard zone after initiation of the stop command by the interlocking device, as calculated on the basis of an approach speed of the body or part of the body

Note 1 to entry: For the selection of the approach speed and the calculation, see ISO 13855.

3.23

holding force

force that a guard locking device can withstand without being damaged so that its further use will not be impaired and the guard will not leave the closed position

3.24

prevention of inadvertent locking position

feature of a guard locking device which ensures that the locking means (e.g. a locking bolt) cannot take the locking position when the guard is not closed

3.25

emergency release of guard locking

possibility to release manually without aids the guard locking from outside the safeguarded area in case of an emergency

Note 1 to entry: The guard locking with emergency release can be necessary for releasing trapped persons or fire-fighting, for example.

3.26

auxiliary release of guard locking

possibility to release manually by means of a tool or a key the guard locking from outside the safeguarded area in case of its failure

Note 1 to entry: The guard locking with auxiliary release is not suitable for emergency or escape release of guard locking.

3.27**escape release of guard locking**

possibility to release manually without aids the guard locking from inside the safeguarded area to leave the area

3.28**guard locking for protection of a person**

application of a guard locking device to protect a person against a hazard

3.29**guard locking for protection of the process**

application of a guard locking device to protect the working process from being interrupted

3.30**tool**

implement such as a key or wrench designed to operate a fastener

Note 1 to entry: An improvised implement such as a coin or a nail file cannot be considered as a tool.

[SOURCE: ISO 14120:2002, 3.9.]

3.31**power interlocking**

interlocking which directly interrupts the energy supply to the machine actuators or disconnects moving parts from the machine actuators

Note 1 to entry: Resumption of the energy supply is only possible with the guard in the closed and locked position. "Directly" means that, unlike control interlocking, the control system does not play any intermediate role in the interlocking function.

3.32**safety function**

function of a machine whose failure can result in an immediate increase of the risk(s)

[SOURCE: ISO 12100:2010, 3.30.]

4 Operating principles and typical forms of interlocking devices associated with guards

4.1 General

Interlocking techniques involve a broad spectrum of technological aspects. Interlocking devices can be classified using a great variety of criteria, e.g. the nature of the link between guard and output system, or the technological type (electromechanical, pneumatic, electronic, etc.) of the output system.

Interlocking devices have a guard position monitoring function that senses whether the guard is closed or not and produce a stop command when the guard is not in the closed position. An interlocking device can also be used in the control of other functions e.g. application of a brake to stop hazardous machine functions before access is possible. Some interlocking devices also have a guard locking function to keep the guard locked while hazardous machine function is present. A guard locking device status monitoring function monitors whether the guard locking device is engaged or released and produces an appropriate output signal (see 4.3.1 a) and b)).

NOTE 1 The guard locking device (see 3.4) can be an integral part of an interlocking device, or a separate unit.

NOTE 2 See also ISO 12100:2010, 6.3.3.1 for additional information on guards.

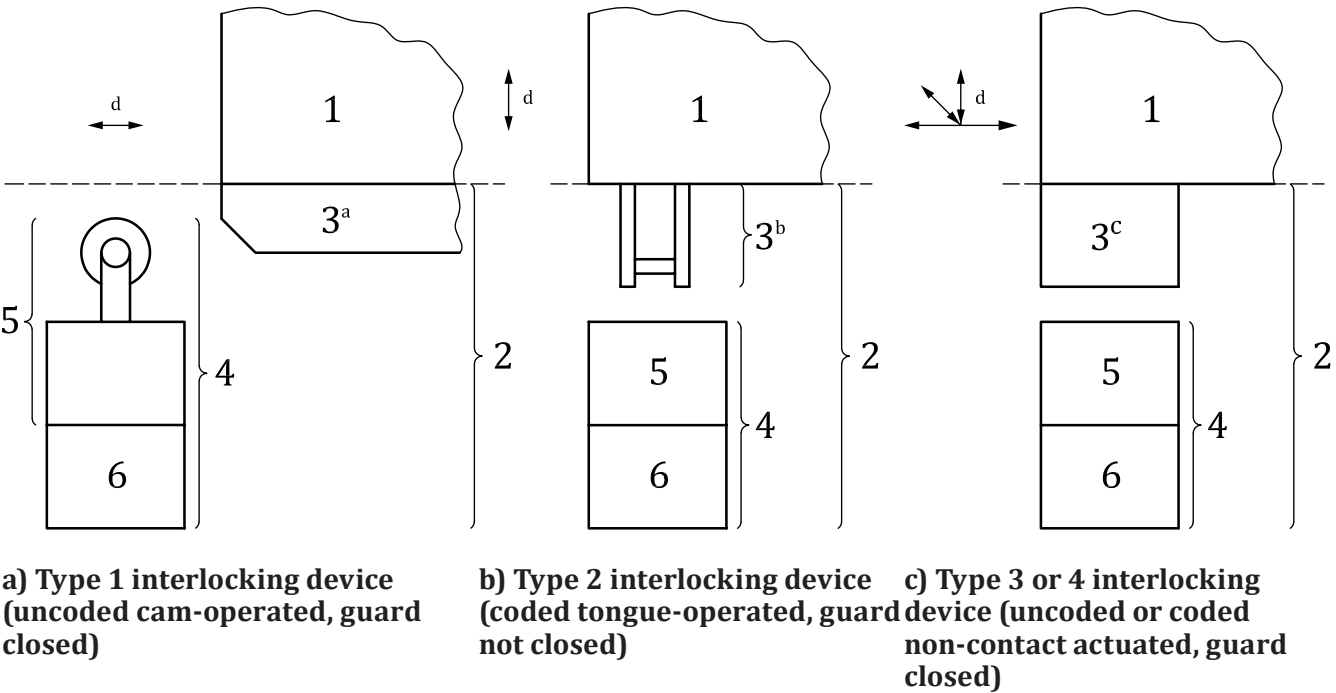
Table 1 shows the actuation principles and actuators for the defined interlocking device types.

NOTE 3 The four types of interlocking device are not presented in a hierarchical order. The correct application of each type of interlocking device will be dependent on the risk assessment that should be made for the specific machine.

Table 1 — Overview of interlocking devices

Actuation principle examples		Actuator examples		Type	Examples: see Annex ^a
Mechanical	Physical contact/ force	Uncoded	Rotary cam	Type 1	A.1
			Linear cam		A.2, A.4
			Hinge		A.3
		Coded	Tongue (-shaped actuator)	Type 2	B.1
			Trapped-key		B.2
Non- contact	Inductive	Uncoded	Suitable ferric metal	Type 3	C
	Magnetic		Magnet, solenoid		
	Capacitive		Any suitable object		
	Ultrasonic		Any suitable object		
	Optic	Coded	Any suitable object	Type 4	D.1
	Magnetic		Coded magnet		
	RFID		Coded RFID tag		D.2
	Optic		Optically coded tag		—

^a Examples of other interlocking devices are given in [Annex E](#).



Key

- | | | | |
|---|---------------------|---|---|
| 1 | movable guard | 4 | position switch |
| 2 | interlocking device | 5 | actuating system |
| 3 | actuator: | 6 | output system |
| a | Cam. | c | E.g. RFID, reflector, suitable surface. |
| b | Tongue. | d | Movement direction. |

NOTE In some exceptional cases, the position switch can be installed on the movable guard and the actuator on the stationary part of the machine. In these cases “1” is the stationary part of the machine.

Figure 2 — Principle of Types 1, 2, 3 and 4 interlocking devices

4.2 Principles of guard interlocking without guard locking

When guard interlocking function without guard locking is used, the guard can be opened at any time regardless of the function of the machine.

If the guard is not closed, the interlocking device shall generate a stop command.

The access time shall be longer than the overall system stopping performance.

NOTE 1 For interlocking with the machine control system see [Clause 8](#).

NOTE 2 Examples of interlocking devices without guard locking are shown in [Annexes A, B, C and D](#).

NOTE 3 A functional diagram of interlocking devices without guard locking is shown in [Figure 3](#).

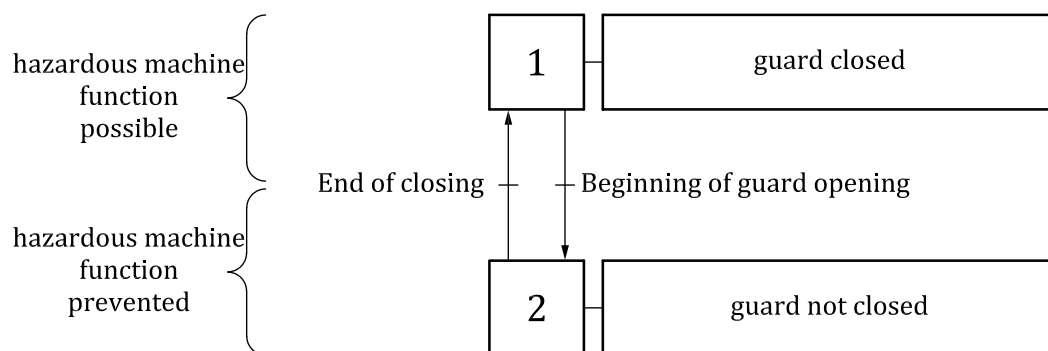


Figure 3 — Functional diagram of interlocking devices without guard locking

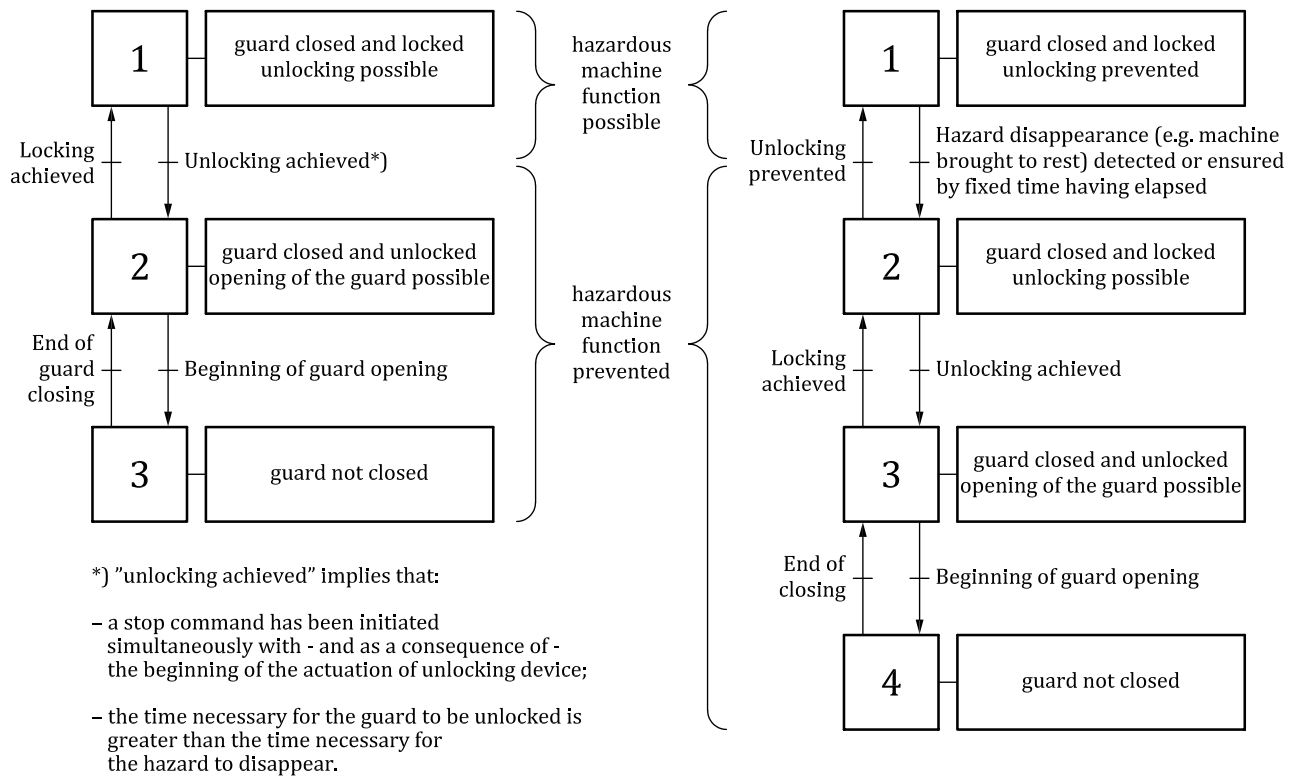
4.3 Principles of guard interlocking with guard locking

4.3.1 General

When interlocking with guard locking is applied, opening of the guard shall be prevented by a guard locking device (see [3.4](#)) unless all hazardous machine functions covered by this guard have disappeared.

There are two alternatives for the design of the guard locking function (see Figure 4).

- Unlocking of the guard can be initiated at any time by the operator. When unlocking is started, the guard locking device generates a stop command. This is called unconditional unlocking. The time necessary for the guard to be unlocked shall be greater than the time necessary for the hazardous machine function to disappear.
- Unlocking of the guard is possible only when the hazardous machine functions have disappeared. This is called conditional unlocking.



Unconditional unlocking

Conditional unlocking

NOTE In conditional locking, the change from state 2 to state 3 or from state 3 to state 2 can happen without time delay.

Figure 4 — Functional diagrams of interlocking devices with guard locking

Examples of guard locking devices are given in [Annex F](#).

4.3.2 Interlocking device with mechanically operated guard locking

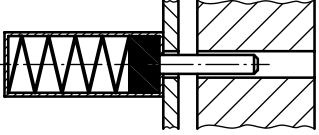
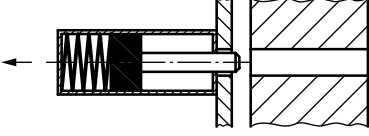
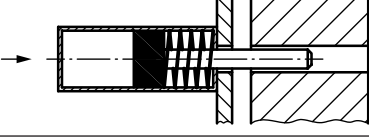
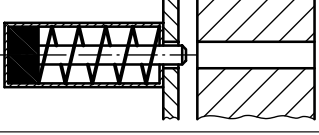
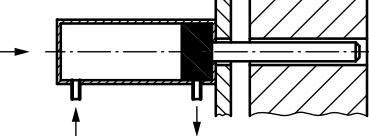
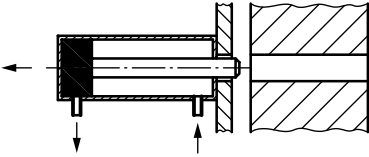
The mechanical part (e.g. bolt) which locks the interlocking guard can be

- manually applied and manually released (see [Figure E.5](#));
- spring (or similar) applied and power-ON released [see a) in [Figure 5](#)];
- power-ON applied and spring (or similar) released [see b) in [Figure 5](#)];
- power-ON applied and power-ON released [see c) in [Figure 5](#)].

Mechanically operated guard locking shall use the principle of direct mechanical blocking due to form. Friction and force alone shall not be relied upon.

4.3.3 Interlocking device with electromagnetically operated guard locking

The guard is kept closed (locked) without any mechanical locking means by an electromagnetic force (see F.4). The electromagnetic guard locking operates on the principle of power-ON applied and power-OFF released [see d) in [Figure 5](#)].

a)		Spring applied	Engaged
		Power-ON released	Released
b)		Power-ON applied	Engaged
		Spring released	Released
c)		Power-ON applied	Engaged
		Power-ON released	Released

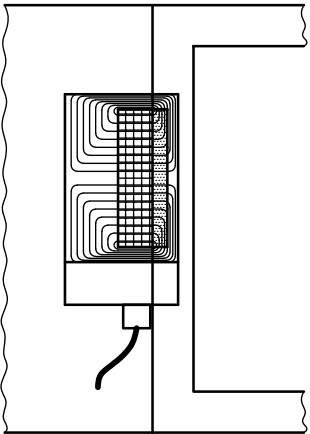
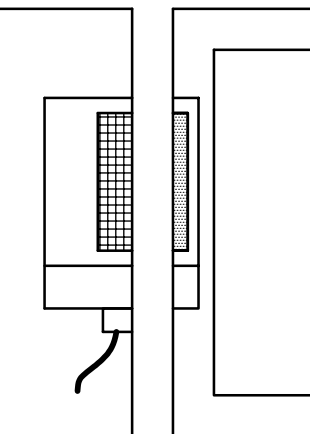
d)		Power-ON applied	Engaged
		Power-OFF released	Released

Figure 5 — Operating modes of guard locking device in power-actuated guard locking devices

5 Requirements for the design and the installation of interlocking devices with and without guard locking

5.1 General

Interlocking devices shall be installed in a suitable robust manner and in accordance with any instructions provided by the manufacturer (see [Clause 9](#)).

5.2 Arrangement and fastening of position switches

Position switches shall be arranged so that they are sufficiently protected against a change of their position. In order to achieve this, the following requirements shall be met:

- a) fasteners of the position switches shall be reliable and loosening them shall require a tool;
- b) Type 1 position switches shall have provisions for permanently fixing the location after adjustment (e.g. by means of pins or dowels);
- c) necessary means of access to position switches for maintenance and checking for correct operation shall be ensured. Prevention of defeat in a reasonably foreseeable manner shall also be considered when designing the access means;
- d) self-loosening shall be prevented;
- e) defeat of the position switch in a reasonably foreseeable manner shall be prevented (see [Clause 7](#));

- f) the position switch shall be located and, if necessary, protected so that damage from foreseeable external causes is avoided;
- g) the movement produced by mechanical actuation or the gap of the proximity device actuating system shall remain within the specified operating range of the position switch or actuating system specified by the switch manufacturer to ensure correct operation and/or prevent overtravel;
- h) a position switch shall not be used as a mechanical stop, unless this is the intended use of the position switch as declared by the manufacturer;
- i) misalignment of the guard that creates a gap before the position switch changes its state shall not be sufficient as to impair the protective effect of the guard (for access to hazard zones, see ISO 13855 and ISO 13857);
- j) the support and fastening for the position switches shall be sufficiently rigid to maintain correct operation of the position switch.

5.3 Arrangement and fastening of actuators

5.3.1 General

Actuators (see [Figure 2](#)) shall be so fastened to minimize the possibility that they come loose or change their intended position relative to the actuation system during the intended lifetime.

NOTE A regular check can be necessary (see [9.3.2](#)).

The following requirements shall be met:

- a) fasteners of the actuators shall be reliable and loosening them shall require a tool;
- b) self-loosening shall be prevented;
- c) the actuator shall be located and, if necessary, protected so that damage from foreseeable external causes is avoided;
- d) an actuator shall not be used as a mechanical stop, unless this is the intended use of the actuator as declared by the manufacturer;
- e) the support and fastening for the actuators shall be sufficiently rigid to maintain correct operation of the actuator.

5.3.2 Cams

Rotary and linear cams for Type 1 interlocking devices shall meet the following requirements:

- a) they are fixed by fasteners requiring a tool for loosening them;
- b) final fixing is achieved by form (e.g. spline or pin) or other methods that provide equivalent integrity of fixing;
- c) they do not damage the position switch or impair its durability.

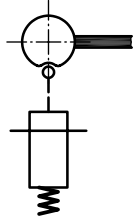
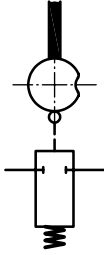
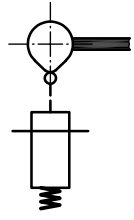
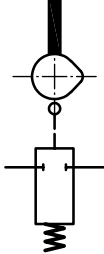
5.4 Actuation modes of interlocking devices

When a single Type 1 or Type 2 interlocking device is used to generate a stop command, it shall be actuated by direct mechanical action between guard, actuator and actuating system and the contact element shall have direct opening action (see [3.10](#), [3.11](#) and [Table 2](#)).

Non-direct mechanical action for a Type 1 interlocking device shall be used only in conjunction with a Type 1 or Type 2 interlocking device with direct mechanical action between guard, actuator and output

system. Combining one interlocking device with direct mechanical action with a second interlocking device with non-direct mechanical action avoids common cause failures (see 8.3).

Table 2 — Direct and non-direct mechanical action of Type 1 interlocking devices

Mechanical action	Guard closed	Guard not closed	Working mode	Example of behaviour in case of failure (see 8.3.2)
Direct			Plunger held depressed by cam as long as guard is not closed When guard closed, output system changes its state as result of action of return spring	Output system remains in safe state when guard is not closed even if spring breaks
Non-direct			The plunger is held depressed by a cam as long as the guard is closed. When guard not closed, output system changes state as result of action of return spring.	If spring breaks, output system can go to unsafe state even if guard not closed.

Interlocking devices shall be actuated appropriate to the actuation principle of the applied position switch.

If a Type 3 or Type 4 interlocking device is the only interlocking device it shall meet the requirements of IEC 60947-5-3.

5.5 Interface to control systems

The output system of interlocking devices shall be suitable for inclusion in a control system designed in accordance with ISO 13849-1 or IEC 62061.

5.6 Mechanical stop

If an interlocking device is declared by the manufacturer of the device to be suitable for use as a mechanical stop the maximum impact energy withstand value shall be given (see also 9.2.2 r)).

5.7 Additional requirements on guard locking devices

5.7.1 General

If the application of the guard locking function creates hazards additional measures shall be considered (see 5.7.5 and ISO 12100:2010, 6.3.5.3).

The locking element (e.g. bolt) intended to lock the guard shall be “spring applied – power-ON released” (see Figure 5 a)) or “power-ON applied – power-ON released” (see Figure 5 c)) unless the outcome of the risk assessment shows that this is not appropriate. If in a specific application other systems (e.g. Figure 5 b)) are used, they shall provide an equivalent level of safety.

NOTE When the loss of power results in the release of the locking element, the stopping time of the machine is often lengthened considerably and it can be possible to access to the hazard before the movements have been stopped (or other hazard disappeared).

The requirements of [5.7](#) apply when guard locking function is used for the protection of persons. The requirements do not apply when guard locking function is used solely for the protection of a process. Nevertheless if guard locking function and guard interlocking function are part of the same device the safety level of the guard interlocking function shall not be negatively affected by a non safety related guard locking function (i. e. guard locking function used solely for the protection of the process).

The requirements of [5.7](#) apply to both guard locking devices composed of separate components as well as to guard locking devices which form an integral part of an interlocking device with guard locking. They apply to all technologies.

The guard locking device shall allow the engaged position to be monitored by providing an output system compatible with a control system designed in accordance with ISO 13849-1 or IEC 62061.

The guard locking device shall only allow hazardous functions of the machine when the guard is closed and locked.

5.7.2 Mechanical guard locking device

5.7.2.1 General

Mechanically operating guard locking shall result from the engagement of two rigid parts (form closure, see [Figure 5 a](#)) to c)).

If it is foreseeable that access is necessary in case of emergency, for “spring applied – power-ON released” or “power-ON applied – power-ON released” systems (see [Figure 5 a](#)) and c)), a guard locking device with emergency release (see [5.7.5.3](#)) shall be provided.

[Figure 6](#) shows the functionality of such a device.

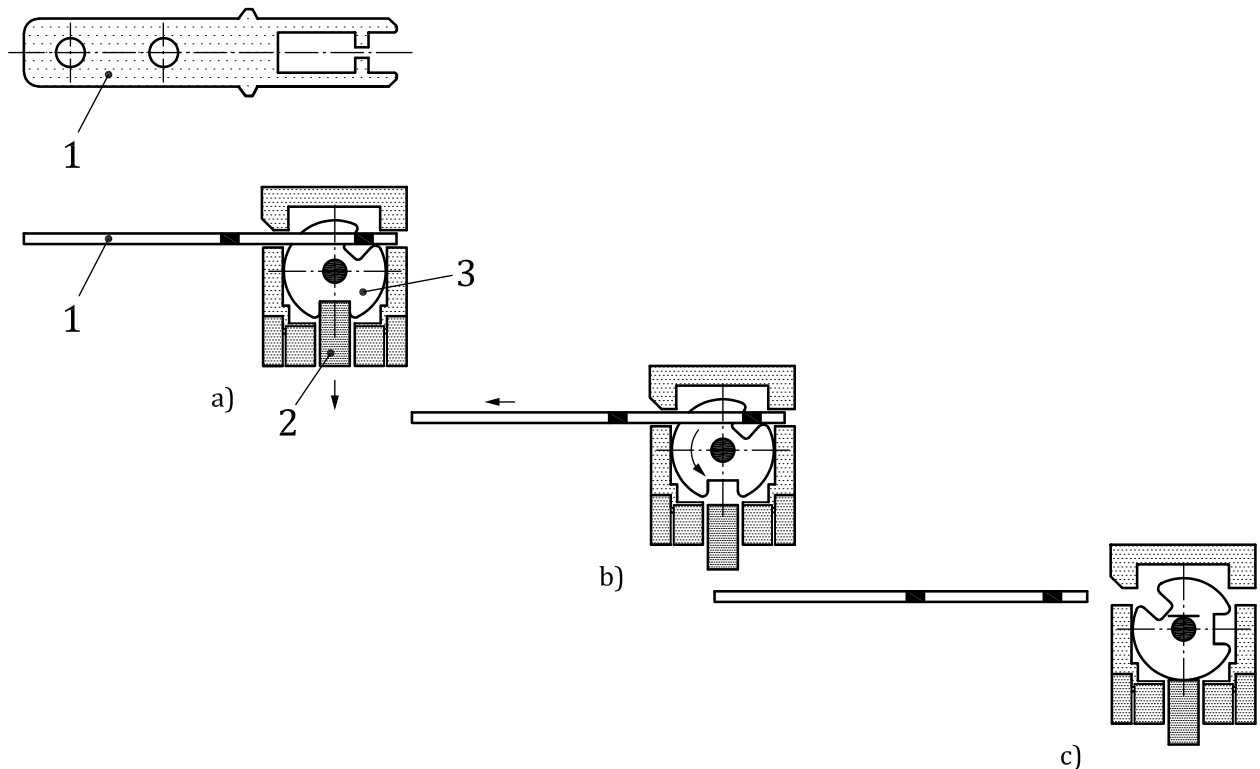
5.7.2.2 Locking monitoring

The engaged position of the locking element shall be monitored in accordance with the requirements of [5.5](#).

The hazardous function of the machine shall only be possible when the monitoring detects the closed position of the guard and the engaged position of the locking element (see [Annex F](#)).

For an effective monitoring of the guard locking device one of the following methods shall be ensured

- the locking element can only go in the engaged position if the movable guard is in the closed position (see [Figure 6](#)), in that case the closed position and the locking of the guard can be checked by the monitoring of the locking element;
- in the other case the monitoring of the locking element and additionally the monitoring of the guard position shall be used for interlocking.



Key

- | | |
|------------------------------------|--|
| a) guard closed and locked | 1 actuator (tongue) |
| b) guard closed and not locked | 2 locking element (bolt) |
| c) guard not closed and not locked | 3 actuating system (internal rotating cam) |

NOTE In this kind of position switch the actuator has two functions: to operate the contacts (not shown in the figure) and together with the internal rotating cam and the bolt to provide the guard locking function. The bolt can be operated by external means e.g. a solenoid or pneumatic cylinder.

Figure 6 — Example of Type 2 interlocking device with guard locking

5.7.3 Electromagnetic guard locking device

5.7.3.1 General

The force required for the locking of the guard is applied by the generation of an electromagnetic field (see [Figure 5 d](#)).

5.7.3.2 Locking monitoring

The holding force shall be monitored to determine if the specified holding force has been achieved and maintained (see [6.2.2](#) and [Annex I](#)).

The hazardous function of the machine shall only be possible when the monitoring detects the closed position of the guard and the achievement of the specified holding force.

5.7.3.3 Basic measures for minimizing defeat possibilities

If an electromagnetic guard locking device is opened by force, it shall be ensured that the process cannot be immediately continued.

NOTE In contrast to a mechanical guard locking, an electromagnetic guard locking shows no damage after an opening by force.

The objective of the measure is that an opening by force results in a time expenditure which is similar to that of repair works (time delay) and comparable with the repair of a damage of an electromechanical guard locking.

This can be implemented by

- a) means of measures within the guard locking, such as e.g.
 - 1) a reset after an interruption of the hazardous machine function is only possible after a minimum of 10 min, or
 - 2) the generation of a malfunction of the guard locking, which requires replacement or repair,
 or
- b) means of equivalent time-consuming measures in the machine control system, such as, e.g. the following sequence:
 - 1) warning message at the machine, and
 - 2) cycle stop, and
 - 3) switching-off the production mode, and
 - 4) testing of the guard locking function, and
 - 5) switching-on the production mode, and
 - 6) restarting the next machine cycle (after a fixed time period of a minimum of 10 min).

5.7.4 Holding force

The manufacturer of the guard locking device shall ensure that in the engaged position, the guard locking device withstands at least the specified holding force F . The manufacturer shall specify a holding force which shall be less or equal than the holding force F_{Zh} , which is determined via the following test:

Test

The guard locking device is fastened onto a base as intended by the manufacturer. The guard locking device is then loaded up to the point of failure of the guard locking function, in that the locking means at its maximum operating angle is moved at a constant speed in the "open guard" direction. During this loading, the maximum force F_{1max} is measured during the course of deformation. The test shall be carried out on an unused as-new sample.

Evaluation

Based on the maximum force F_{1max} measured during the test taking into consideration the safety factor S the holding force F_{Zh} is ascertained using the following formula:

$$F_{Zh} = \frac{F_{1max}}{S}$$

with

$$S = 1,3$$

Requirements on the test device

Traction speed: constant $(10 \pm 0,25)$ mm/min

Requirements on the force measurement device

Sampling rate: ≥ 10 Hz

Measurement accuracy of maximum force: $\pm 2,5$ %

NOTE For test details, see Reference [19].

5.7.5 Supplementary release of guard locking

5.7.5.1 General

Depending on the application supplementary methods of release of guard locking can be necessary (see ISO 12100:2010, 6.3.5.3). For the selection see 6.2.3. Escape and emergency releases of guard locking shall fulfil at least the requirements of Category B according to ISO 13849-1.

NOTE When one of the described release methods is used, a considerable longer stopping time than normal could be the effect which should be considered in the risk assessment.

5.7.5.2 Escape release of guard locking

When the guard locking device is provided with an escape release the following requirements shall be met:

- deliberate unlocking of the guard locking from inside of the safeguarded area shall be easily possible without auxiliary means and regardless of the operating condition;
- the unlocking means shall be manually operated and act directly on the principle of the locking mechanism;
- the unlocking shall generate a stop command;
- the unlocking means for the escape release shall only be accessible from inside the safeguarded area.

5.7.5.3 Emergency release of guard locking

When the guard locking device is provided with an emergency release the following requirements shall be met:

- deliberate unlocking of the guard locking from outside the safeguarded area shall be possible and be easily actuated without auxiliary means, regardless of the operating condition;
- the unlocking means shall be manually operated and act directly on the principle of the locking mechanism;
- the unlocking shall generate a stop command;
- the unlocking results in a blocking of the locking means in the released condition;
- the emergency guard locking release shall be clearly marked to be used only in emergency situations and shall be positioned and/or shielded to prevent accidental opening of the lock;
- the resetting of the emergency release shall be possible only by means of a tool or by other methods (e.g. change of component). This requirement can be fulfilled on a control system level. If the requirements are intended to be fulfilled on a safety control system level (not in the guard locking device), clear instructions that this needs to be achieved shall be provided in the instructions for use of the guard locking device (see 9.2.2 m)).

NOTE Provided that the emergency release meets the conditions of an escape release, the emergency release can become an escape release when it is mounted inside of the safeguarded area.