



BSI Standards Publication

Safety of machinery — Interlocking devices associated with guards — Principles for design and selection

National foreword

This British Standard is the UK implementation of EN ISO 14119:2025. It is identical to ISO 14119:2024. It supersedes BS EN ISO 14119:2013, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee MCE/3, Safeguarding of machinery.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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UK Government is responsible for legislation. For information on legislation and policies relating to that legislation, consult the relevant pages of www.gov.uk.

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Amendments/corrigenda issued since publication

Date	Text affected

English Version

Safety of machinery - Interlocking devices associated with
guards - Principles for design and selection (ISO
14119:2024)

Sécurité des machines - Dispositifs de verrouillage
associés à des protecteurs - Principes de conception et
de choix (ISO 14119:2024)

Sicherheit von Maschinen -
Verriegelungseinrichtungen in Verbindung mit
trennenden Schutzeinrichtungen - Leitsätze für
Gestaltung und Auswahl (ISO 14119:2024)

This European Standard was approved by CEN on 21 July 2024.

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COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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European foreword

This document (EN ISO 14119:2025) has been prepared by Technical Committee ISO/TC 199 "Safety of machinery" in collaboration with Technical Committee CEN/TC 114 "Safety of machinery" the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2025, and conflicting national standards shall be withdrawn at the latest by September 2025.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN ISO 14119:2013.

This document has been prepared under a standardization request addressed to CEN by the European Commission. The Standing Committee of the EFTA States subsequently approves these requests for its Member States.

For the relationship with EU Legislation, see informative Annex ZA, which is an integral part of this document.

Any feedback and questions on this document should be directed to the users' national standards body/national committee. A complete listing of these bodies can be found on the CEN website.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and the United Kingdom.

Endorsement notice

The text of ISO 14119:2024 has been approved by CEN as EN ISO 14119:2025 without any modification.

Annex ZA
(informative)

Relationship between this European Standard and the essential requirements of 2006/42/EC aimed to be covered

This European Standard has been prepared under a Commission’s standardization request “M/396 Mandate to CEN and CENELEC for Standardisation in the field of machinery” to provide one voluntary means of conforming to essential requirements of Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC (recast).

Once this standard is cited in the Official Journal of the European Union under that Directive, compliance with the normative clauses of this standard given in Table ZA.1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding essential requirements of that Directive, and associated EFTA regulations.

Table ZA.1 — Correspondence between this European Standard and Annex I of Directive 2006/42/EC

The relevant Essential Requirements of Directive 2006/42/EC	Clause(s)/subclause(s) of this EN	Remarks/Notes
1.1.2	6, 7, 8, Annex K	
1.2.1	6, 9	
1.2.2	6, 7, Annex K	
1.2.3	9	
1.2.4	9	
1.4.2.2	5, 6, 7, 8	
1.5.4.	6	
1.5.14	6, 7, Annex K	
1.6.1	6, 8, 10	
1.7.3	10	
1.7.4.2	10	

Table ZA.2 — Applicable Standards to confer presumption of conformity as described in this Annex ZA

Reference in Clause 2	International Standard Edition	Title	Corresponding European Standard Edition
ISO 12100:2010	ISO 12100:2010	Safety of machinery — General principles for design — Risk assessment and risk reduction	EN ISO 12100:2010
ISO 13849-1:2023	ISO 13849-1:2023	Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design	EN ISO 13849-1:2023
ISO 13849-2:2012	ISO 13849-2:2012	Safety of machinery — Safety-related parts of control systems — Part 2: Validation	EN ISO 13849-2: 2012
ISO 13855:20—	ISO 13855:2023	Safety of machinery — Positioning of safeguards with respect to the approach speeds of parts of the human body	EN ISO 13855: 20—
ISO 14118:2017	ISO 14118:2017	Safety of machinery — Prevention of unexpected start-up	EN ISO 14118:2017
IEC 60204-1:2016 +AMD1:2021	IEC 60204-1:2016 +AMD1:2021	Safety of machinery — Electrical equipment of machines — Part 1: General requirements	EN 60204-1:2018
IEC 60947-1:2020	IEC 60947-1:2020	Low-voltage switchgear and controlgear — Part 1: General rules	EN IEC 60947-1: 2021
IEC 60947-3	IEC 60947-3	Low-voltage switchgear and controlgear — Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units	EN IEC 60947-3: 2021
IEC 60947-5-1:2016+ COR:2016	IEC 60947-5-1:2016+ COR:2016	Low voltage switchgear and controlgear — Part 5-1: Control circuit devices and switching elements — Electromechanical control circuit devices	EN 60947-5-1:2017

IEC 60947-5-3	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 (PDDB)	EN 60947-5-3:2013
IEC 62061:2021	IEC 62061:2021	Safety of machinery - Functional safety of safety-related control systems	EN IEC 62061:2021

The documents listed in the Column 1 of Table ZA.2, in whole or in part, are normatively referenced in this document, i.e. are indispensable for its application. The achievement of the presumption of conformity is subject to the application of the edition of Standards as listed in Column 4 or, if no European Standard Edition exists, the International Standard Edition given in Column 2 of Table ZA.2.

WARNING 1 — Presumption of conformity stays valid only as long as a reference to this European Standard is maintained in the list published in the Official Journal of the European Union. Users of this standard should consult frequently the latest list published in the Official Journal of the European Union.

WARNING 2 — Other Union legislation may be applicable to the product(s) falling within the scope of this standard.

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 199, *Safety of machinery*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 114, *Safety of machinery*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 14119:2013), which has been technically revised.

The main changes are as follows:

- ISO/TS 19837 has been integrated as new [Annex K](#) with specific requirements for Type 5 interlocking devices – “trapped key interlocking devices” (see definition [3.18.1](#));
- trapped key interlocking systems and Type 5 interlocking devices have been defined;
- [Table 5](#) has been improved and renamed;
- test procedures are described in new [Annex I](#);
- ISO/TR 24119 has been integrated into new [Annex J](#).

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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.

This document is of relevance, in particular for the following stakeholder groups representing the market players with regard to machinery safety:

- machine manufacturers (small, medium and large enterprises);
- health and safety bodies (regulators, accident prevention organizations, market surveillance).

Others can be affected by the level of machinery safety achieved with the means of the document by the above-mentioned stakeholder groups:

- machine users/employers (small, medium and large enterprises);
- machine users/employees (e.g. trade unions, organizations for people with special needs);
- service providers, e.g. for maintenance (small, medium and large enterprises);
- consumers (in case of machinery intended for use by consumers).

The above-mentioned stakeholder groups have been given the possibility to participate in the drafting process of this document.

In addition, this document is intended for standardization bodies elaborating type-C standards.

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 document 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 document, 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.

[Annexes A](#) to [E](#) describe the technology and the typical characteristics of the defined interlocking devices types 1 to 4. Other solutions may be adopted, provided that they are in conformity with the principles of this document.

[Annexes F](#) to [H](#) give information on particular aspects such as interlocking devices used within safety functions, risk assessment considering the motivation to defeat and static action forces.

[Annex I](#) describes a locking force test and an impact resistance test for guard-locking devices.

ISO 14119:2024(en)

[Annex J](#) provides information on the masking of faults in series connection of interlocking devices with potential free contacts.

[Annex K](#) provides requirements for trapped key interlocking systems and describes their technology.

Safety of machinery — Interlocking devices associated with guards — Principles for design and selection

1 Scope

This document specifies principles for the design and selection (independent of the nature of the energy source) of interlocking devices associated with guards and provides guidance on measures to minimize the possibility of defeat of interlocking devices in a reasonably foreseeable manner.

This document covers principles for the design, selection and application of the following:

- parts of the guards which actuate interlocking devices;
- trapped key interlocking devices and systems for machinery applications.

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 the machine and prevent unexpected start up is covered in ISO 14118, ISO 13849-1 and IEC 62061.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. 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 13849-1:2023, *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*

ISO 13855:—¹⁾, *Safety of machinery — Positioning of safeguards with respect to the approach speeds of parts of the human body*

ISO 14118:2017, *Safety of machinery — Prevention of unexpected start-up*

IEC 60204-1:2016+AMD1:2021, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

IEC 60947-1:2020, *Low-voltage switchgear and controlgear — Part 1: General rules*

IEC 60947-3, *Low-voltage switchgear and controlgear — Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units*

IEC 60947-5-1:2016+COR:2016, *Low voltage switchgear and controlgear — Part 5-1: Control circuit devices and switching elements — Electromechanical control circuit devices*

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 (PDDB)*

IEC 62061:2021, *Safety of machinery — Functional safety of safety-related control systems*

1) Under preparation. Stage at the time of publication: ISO/FDIS 13855.

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12100:2010, ISO 13849-1 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1

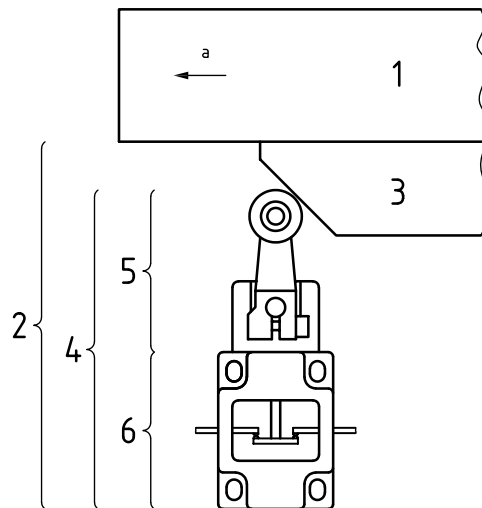
interlocking device

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 2](#).

[SOURCE: ISO 12100:2010, 3.28.1, modified — Note 1 to entry and [Figure 1](#) were added.]



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 such that, together with the control system of the machine, prevents the:

- operation of the hazardous machine functions associated with the guard until the guard is closed;
- if the guard is opened while hazardous machine functions are operating, a command to bring the machine to a safe state (a stop command) is given

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

Note 2 to entry: The generation of the (stop) command to bring the machine to a safe state when the guard is open does not apply to guards locked with a trapped key interlocking system.

3.3

guard-locking device

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

Note 1 to entry: A guard-locking device may be a separate device or integrated in an interlocking device.

Note 2 to entry: See [Annex E](#) for detailed examples.

3.4

interlocking guard with guard-locking function

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 associated with 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 associated with the guard has ceased; and
- when the guard is closed and locked, the hazardous machine functions associated with 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, modified — Note 1 to entry was deleted and in the first and second list item, "associated" replaces "covered", in the second list item "ceased" replaces "disappeared".]

3.5

defeat

defeat in a reasonably foreseeable manner

reasonably foreseeable action, either manually or by using readily available objects, 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 protective measures

Note 1 to entry: This definition includes the removal of position switches or actuators using tools that are needed for the intended use of the machine or that are readily available (screwdrivers, 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, e.g. keys, coins, adhesive tape, string and wire.

Note 3 to entry: Uncontrolled spare and master keys for Type 5 interlocking devices (see also 8.4.3) and spare actuators (for all types) are also considered as readily available objects.

3.6

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

3.7

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

3.8

direct opening action

direct opening action of a 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 60947-5-1:2016 + COR1:2016, K 2.2.]

3.9

position switch

part of interlocking device comprising the actuating system and the output system

3.10

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, shaped tongue, reflector, magnet, RFID tag.

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

Note 2 to entry: For type 1 and Type 3 interlocking devices the actuator can be a part of the guard itself.

Note 3 to entry: Examples of actuators are shown in [Figure 2](#).

Note 4 to entry: A key as used in a trapped key system is not covered by this definition.

3.11

coded actuator

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

3.11.1

low-level coded actuator

coded actuator for which 1 to 9 variations in code are available and the different codes are evaluated by the interlocking device

3.11.2

medium-level coded actuator

coded actuator for which 10 to 1 000 variations in code are available and the different codes are evaluated by the interlocking device

3.11.3

high-level coded actuator

coded actuator for which more than 1 000 variations in code are available and the different codes are evaluated by the interlocking device

3.12

actuating system

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

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

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

3.13

output system

part of the interlocking device that signals the state of the actuator or the key to the control system

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

3.14

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.

3.15

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.

3.16

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.

3.17

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.

3.18

trapped key interlocking system

system fulfilling safety function(s) or part of safety function(s) and comprising at least two different Type 5 interlocking devices which work together through the transfer of a key

Note 1 to entry: See [Figure 2 d\)](#) and [Annex K](#) for detailed examples.

3.18.1

Type 5 interlocking device

trapped key interlocking device

device, which fulfils a function by trapping or releasing one or more keys in a given trapped key interlocking system

EXAMPLE Door locks, key-operated switches, key exchange units.

3.18.2

personnel key

key which is released from a trapped key interlocking device and retained by a person to prevent a hazardous situation (e.g. unexpected start-up)

3.18.3

key trapped

situation in which a key in a Type 5 interlocking device is locked and cannot be removed.

EXAMPLE A solenoid or the insertion of an actuator releases the trapped key.

3.18.4

key releasable

situation in which a key is not locked and so can be (turned and) removed causing a change of state of the device

EXAMPLE Change of state of the device releases or traps another key or changes contact state.

3.18.5

master key

key which can operate multiple locks of different coding

3.18.6

key transfer plan

drawing, scheme or diagram depicting the trapped key interlocking system with its individual Type 5 interlocking devices and the sequence(s) in which they are to be operated

3.18.7

bolt lock

trapped key interlocking device that extends a bolt to lock an object

EXAMPLE Bolt locks can be used to lock disconnecter switches, valves or sliding doors.

3.18.8

access lock

trapped key interlocking device intended to lock a guard in the closed position for trapped key interlocking systems, and linked to the control system via the key transfer

Note 1 to entry: Access locks can also be used for locking in position objects other than guards, e.g. isolators, valves or barriers.

3.18.9

time delayed key release

trapped key interlocking device that releases a key after a pre-determined period of time has elapsed

3.18.10

key exchange device

trapped key interlocking device in which the insertion of one or more keys releases one or more keys with a different coding, trapping the inserted key(s)

3.18.11

key-operated switch

key-operated switch as part of trapped key systems

trapped key interlocking device comprising a switch which can only be operated by means of a key

3.18.12

key-operated solenoid-controlled switch

key-operated solenoid-controlled switch as part of trapped key systems

trapped key interlocking device comprising a key-operated switch which can be mechanically locked by the operation of a solenoid

3.18.13

trapped key valve lock

trapped key interlocking device used to lock a valve in the open position [locked open (LO)], in the closed position [locked closed (LC)] or in both positions by different keys

3.18.14

energy control

sub-function of a trapped key interlocking system to achieve and maintain a safe state to prevent hazardous machine functions

3.18.15

intermediate transfer

sub function of a trapped key interlocking system that allows the transfer of keys between two Type 5 interlocking devices

3.18.16

access control

subfunction of a trapped key interlocking system that controls the access to safeguarded spaces or access to machine operating modes and functions

3.18.17

switch-disconnector

switch, which, in the open position, satisfies the isolating requirements specified for a disconnector

[SOURCE: IEC 60947-1:2020, 2.2.10]

3.19

whole body access

situation where a person can be completely inside a safeguarded space

Note 1 to entry: The term whole body access is used in other standards to specify the opening size for safe access.

3.20

safeguarded space

volume enclosing a hazard zone(s) where guards or protective devices, or both, are intended to protect persons

3.21

stop command

signal generated by the interlocking device that initiates the intended risk reduction

3.22

overall system response time

time interval between the stop command given by opening the guard and achieving the intended risk reduction

3.23

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.

3.24

locking 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

3.25

prevention of inadvertent locking position

feature of a guard-locking device, which ensures that the locking elements (e.g. a locking bolt) cannot achieve the locking position when the guard is not closed

3.26

emergency release of guard-locking

manual release without auxiliary means of the guard locking from outside the safeguarded space 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.

3.27

auxiliary release of guard locking

manual release by use of a tool or a key of the guard locking from outside the safeguarded space in case of its failure or absence of power supply

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

3.28

escape release of guard locking

manual release without auxiliary means of the guard locking from inside the safeguarded space to leave the area

3.29

tool

implement intended by the manufacturer for the purposes of tightening or loosening a fastener

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

3.30

power interlocking

function which directly interrupts the energy supply to the hazard sources

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

3.31

control interlocking

function which interrupts the energy supply to the hazard using indirect means

Note 1 to entry: Examples of indirect means can include a combination of relay modules, standstill monitoring devices, PLCs or other control devices/systems.

3.32

safety function

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

Note 1 to entry: See [Figures 3](#) and [4](#).

[SOURCE: ISO 12100:2010, 3.30, modified — Note 1 to entry added.]

3.33

fault masking

unintended resetting of faults or preventing the detection of faults in the safety-related parts in the control system (SRP/CS) by operation of parts of the SRP/CS which do not have faults

3.34

potential free contact

electrical switch contact in which electrical power is not directly provided by the device

Note 1 to entry: Potential free contact is also referred to as "dry contact" or "voltage free contact".

3.35

series-connected devices

interlocking devices with potential free contacts that are connected in series to one logic unit which performs the diagnostics

3.36

interlock blocking device

mechanical means, capable of either being locked (e.g. by a padlock or other lockable device) or otherwise secured in a position, used to physically block or hold the actuator of an interlocking device to prevent actuating or engaging the interlocking device

3.37

direct guard monitoring

monitoring of the position of the guard, characterized by the detection of the position of the guard provided by a position switch directly

3.38**indirect guard monitoring**

indirect guard monitoring of the position of the guard

monitoring of the position of the guard, characterized by the signaling of the closed position of the guard provided by an actuated key-operated switch

Note 1 to entry: The key required for the operation of the switch is only available after the closing and locking of the guard. This can include intermediate steps (transfers).

3.39**category 3 behaviour**

behaviour of mechanical parts of trapped key interlocking systems where no single fault results in a loss of the safety function

Note 1 to entry: Category 3 behaviour is characterized by (see ISO 13849-1:2023, 6.1.3.2.5):

- continued performance of the safety function in the presence of a single fault;
- detection of some, but not all, faults;
- possible loss of the safety function due to accumulation of undetected faults.

3.40**category 4 behaviour**

behaviour of mechanical parts of trapped key interlocking systems where no accumulation of faults results in a loss of the safety function

Note 1 to entry: Category 4 behaviour is characterized by (see ISO 13849-1:2023, 6.1.3.2.6):

- continued performance of the safety function in the presence of a single fault;
- detection of faults in time to prevent the loss of the safety function;
- the accumulation of undetected faults is taken into account;
- the consideration of an accumulation of two faults may be sufficient.

4 Symbols**Table 1 — Symbols**

	Symbol	Function
1		key
2		key path
3		key trapped (see 3.19.3)
4		key releasable (see 3.19.4)
5		key inserted and removable
6		key removed
7		actuator locked

Table 1 (continued)

	Symbol	Function
8		actuator unlocked
9		actuator removed
10		time delayed function (see 3.18.9, see Figure K.21)

5 Operating principles and types of interlocking devices associated with guards

5.1 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 interlock device (types 1 to 5 interlocking devices, see Figure 2), or the technological type (electromechanical, pneumatic, electronic) of the interlock device's output system. For more information regarding trapped key interlocking systems see Annex K.

Interlocking devices have a guard position monitoring function that senses whether the guard is closed or not and produces 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 5.3.1 a) and b)].

NOTE 1 The guard-locking device 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 2 shows the actuation principles and actuators for the defined interlocking device types.

NOTE 3 The five 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 is made for the specific machine.

NOTE 4 A hybrid device consisting of two or more types of interlock technology can be used, depending on the application requirements.

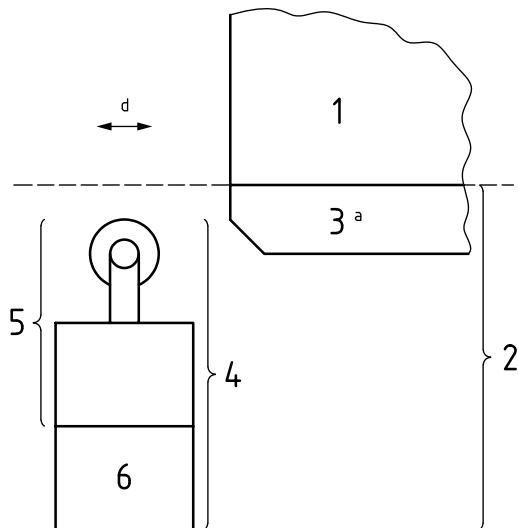
In addition, under specific conditions, an interlocking guard can be designed such that once it has reached its closed position, it gives a command to initiate the hazardous machine function(s) without the use of a separate start control (control guards).

NOTE 5 See ISO 12100:2010, 3.27.6 and 6.3.3.2.5, for additional information on control guards.

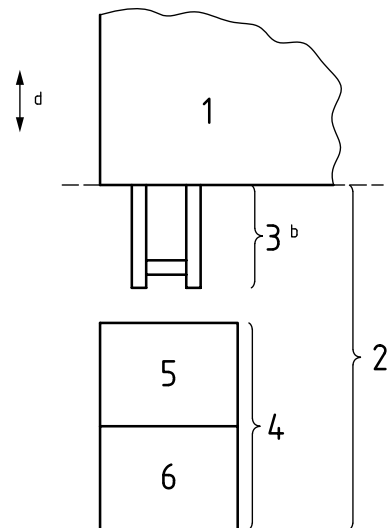
Table 2 — Overview of interlocking devices

Type	Actuation principles	Actuator	Guard monitoring	Example		
				Actuation principles	Actuator	Annex Clause
Type 1	Mechanical	Uncoded	direct	Physical contact / force	Rotary cam	A.1
					Linear cam	A.2, A.4
					Hinge	A.3
Type 2	Mechanical	Coded	direct	Physical contact / force	Tongue (shaped actuator)	B.1
Type 3	Non- contact	Uncoded	direct	Magnetic	Magnet, solenoid	C.1
				Inductive	Suitable ferric metal	
				Capacitive	Any suitable object	
				Ultrasonic	Any suitable object	
				Optic	Any suitable object	
Type 4	Non- contact	Coded	direct	Magnetic	Coded magnet	D.1
				RFID	Coded RFID tag	D.2
				Optic	Optically coded tag	—
Type 5	Mechanical (Trapped key)	Coded	indirect or direct		shaped	Annex K

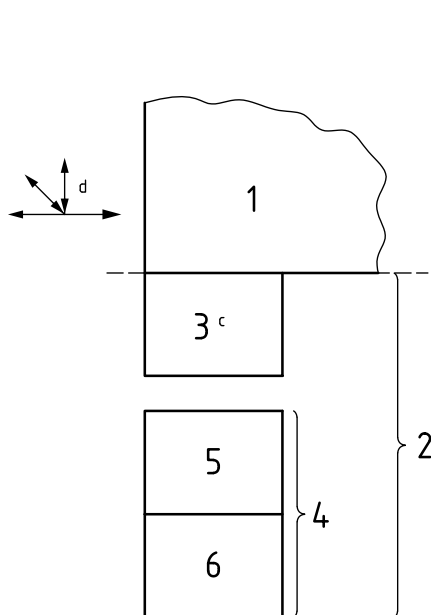
The interlocking function shall have precedence over the guard-locking function as selection criteria for the type of interlocking device (see [Table 2](#)) and actuation principle.



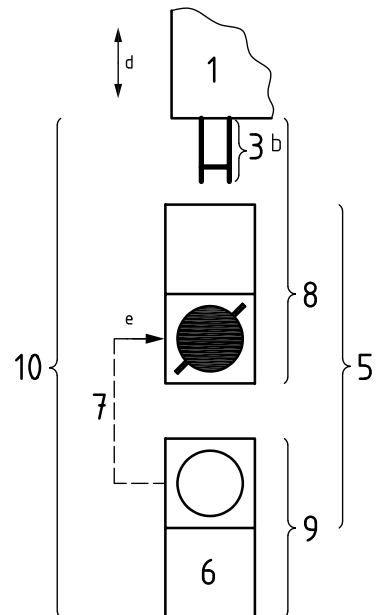
**a) Type 1 interlocking device
(uncoded cam-operated, guard closed)**



**b) Type 2 interlocking device
(coded tongue-operated, guard not closed)**



**c) Type 3 or 4 interlocking device
(uncoded or coded non-contact actuated,
guard closed)**



**d) Trapped key interlocking system
comprising two trapped key interlocking
devices respectively. Type 5 interlocking
devices (guard not closed)**

Key

- 1 movable guard
- 2 interlocking device
- 3 actuator
- 4 position switch
- 5 actuating system

- 6 output system
- 7 intermediate key transfer
- 8 Type 5 interlocking device (access lock)
- 9 Type 5 interlocking device (key operated switch)
- 10 trapped key interlocking system

- | | | | |
|---|---------|---|---|
| a | Cam. | c | E.g. RFID, reflector, suitable surface. |
| b | Tongue. | d | Movement direction. |
| | | e | Key trapped. |

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, 4 and 5 interlocking devices

5.2 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 initiate a stop command.

The access time shall be longer than the overall system response time (see ISO 13855:—, 5.4).

NOTE 1 For interlocking with the machine control system, see [Clause 9](#).

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](#).

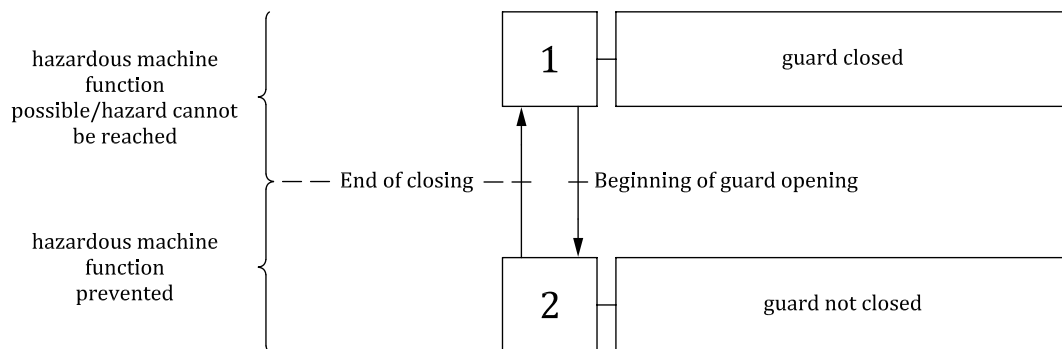


Figure 3 — Functional diagram of interlocking devices without guard locking

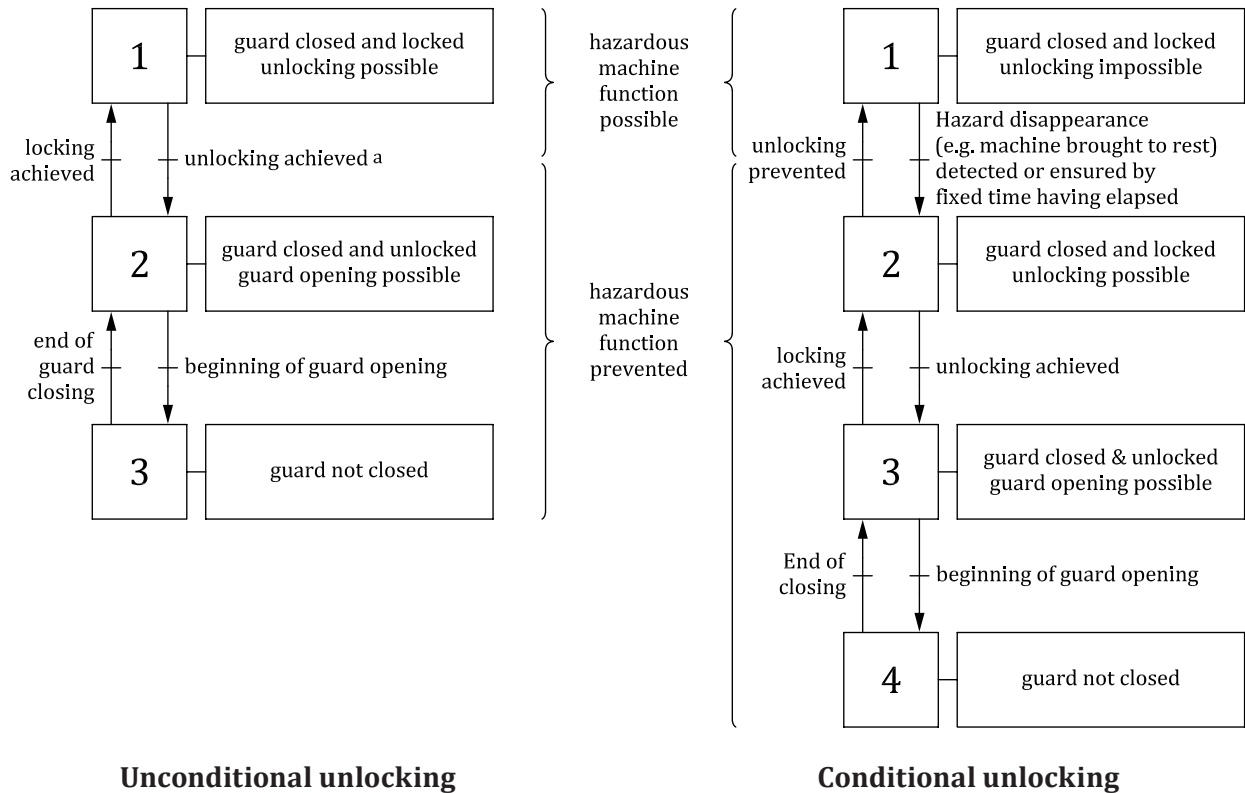
5.3 Principles of guard interlocking with guard locking

5.3.1 General

When interlocking with guard locking is applied, opening of the guard shall be prevented by a guard-locking device unless all hazardous machine functions associated with this guard have reached a safe state.

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 cease.
- Unlocking of the guard is possible only when the hazardous machine functions have ceased or hazardous situation has ceased. This is called conditional unlocking.



Key

- ^a "unlocking achieved" implies that:
- a stop command has been initiated simultaneously, with and as a consequence of, the beginning of the actuation of unlocking device;
 - the time necessary for the guard to be unlocked is greater than the time necessary for the hazard to cease.

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

Figure 4 — Functional diagrams of interlocking devices with guard locking

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

5.3.2 Interlocking device with guard locking

5.3.2.1 Interlocking device with guard locking by form

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

- manually applied and manually released (see [E.5](#));
- spring (or similar) applied and power-ON released [see a) in [Table 3](#)];
- power-ON applied and spring (or similar) released [see b) in [Table 3](#)];
- power-ON applied and power-ON released [see c) in [Table 3](#)].

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

5.3.2.2 Interlocking device with power-operated guard locking by electromagnetic force

The guard is kept closed (locked) without any mechanical locking elements by an electromagnetic force [see d) in Table 3]. The electromagnetic guard locking operates on the principle of power-ON applied and power-OFF released.

Table 3 — Operating modes of guard-locking device in power-operated guard-locking devices

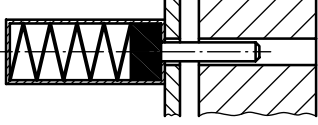
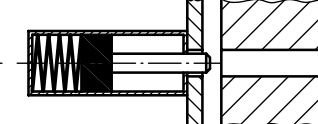
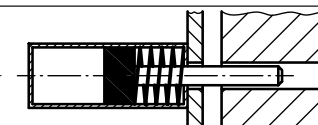
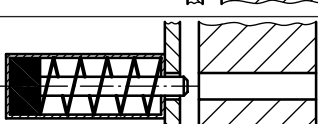
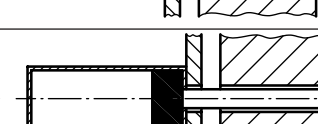
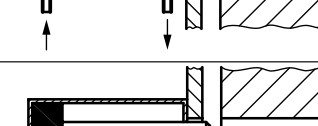
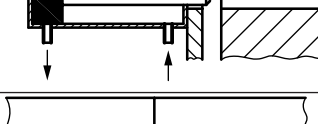
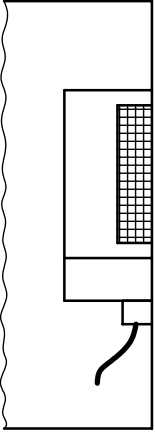
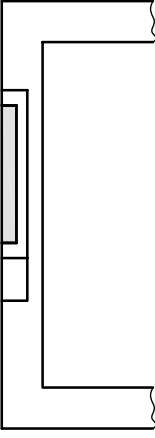
a)		Spring applied	Engaged
		Power-ON released	Released
b)		Power-ON applied	Engaged
		Spring released	Released
c)		Power-ON applied	Engaged
		Power-ON released	Released
d)		Power-ON applied	Engaged

Table 3 (continued)

			Power-OFF released	Released
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6 Requirements for the design and the arrangements of interlocking devices with and without guard locking

6.1 General

Interlocking devices shall be installed in accordance with the instructions provided by the manufacturer (see [Clause 10](#)).

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

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

- fasteners of the position switches, bolt locks and access locks shall be reliable and loosening them shall require a tool;
- position switches of Type 1 interlocking devices and bolt locks shall have provisions for permanently fixing the location after adjustment (e.g. by means of drill holes in combination with non-removable fasteners, pins or dowels);
- for bolt locks and access locks, oblong holes shall not be used as the sole means of fastening;
- necessary means of access to position switches, bolt locks and access locks 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;
- self-loosening shall be prevented;
- the position switch, bolt lock or access lock shall be located and, if necessary, protected so that a failure due to foreseeable external causes is avoided;
- 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 manufacturer of the interlocking device to ensure correct operation and/or prevent overtravel resulting in damage;
- a position switch, bolt lock or access lock shall not be used as a mechanical stop, unless this is the intended use of the position switch, bolt lock or access lock as declared by the device manufacturer;
- misalignment of the guard that creates a gap before the position switch, bolt lock or access lock changes its state, shall not 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, bolt locks and access locks shall be sufficiently rigid to maintain correct operation of the position switch, bolt lock or access lock.

6.3 Arrangement and fastening of actuators

6.3.1 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 [10.2.2](#)).

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 failure due to 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.

6.3.2 Cams

Rotary and linear cams (actuator, see [Annex A](#)) for Type 1 interlocking devices shall meet the following requirements:

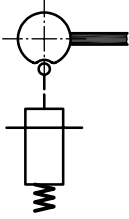
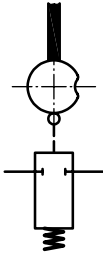
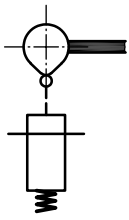
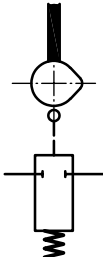
- a) they shall be fixed by fasteners requiring a tool for loosening them;
- b) final fixing shall be achieved by form (e.g. spline or pin) or other methods that provide equivalent integrity of fixing;
- c) they shall not damage the position switch or impair its durability.

6.4 Actuation modes of interlocking devices

When a single Type 1 or Type 2 interlocking device is used to initiate 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 [3.7](#), [3.8](#) and [Table 4](#)).

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 (CCFs) (see [9.2](#)).

Table 4 — 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 9.2.4)
Direct			The plunger is held depressed by a cam as long as the guard is not closed. When the guard is closed, the output system changes its state as the result of action of the return spring.	The output system remains in a safe state when the guard is not closed even if the spring breaks.
Non-direct			The plunger is held depressed by a cam as long as the guard is closed. When the guard is not closed, the output system changes state as the result of action of the return spring.	If the spring breaks, the output system can go to an unsafe state even if the guard is not closed.

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

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

6.5 Mechanical stop

Where an interlocking device or guard-locking device is used as a mechanical stop of the interlocking guard, it shall be ensured that the device is not subjected to impact (s) in excess of the maximum impact energy withstand value stated by the manufacturer.

NOTE Additional mechanical stops can be installed to ensure the device is not subjected to such impact(s).

If an interlocking device is declared by its manufacturer to be suitable for use as a mechanical stop, the maximum impact energy withstand value shall be evaluated according to [1.2](#) and its value shall be stated in the instructions for use [see [10.2.2 q](#)].

6.6 Additional requirements on guard-locking devices

6.6.1 General

In addition to the requirements stated in [6.1](#) to [6.5](#), the following requirements apply to guard-locking devices.

If the application of the guard-locking function creates hazards, e.g. a person exposed to a hazard whilst trapped within a safeguarded space, additional measures shall be taken (according to [7.2.3](#) 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 [Table 3 a](#)] or "power-ON applied – power-ON released" [see [Table 3 c](#)] unless this is not appropriate based on the risk assessment. If, in a specific application, operating modes of the guard-locking device according to [Table 3 b](#)) or [Table 3 d](#)) are used, measures shall be taken to reduce risks generated by power failures. For a selection see, e.g. [7.2.3](#).

Electromagnetic coils used for the locking and unlocking function shall meet the construction and performance requirements of IEC 60947-1:2020, 8.2.2.7.

The requirements of 6.6 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 functional safety performance of the guard interlocking shall not be negatively affected by the guard-locking function (i.e. where the guard-locking function is used solely for the protection of the process).

The requirements of 6.6 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.

6.6.2 Locking force

The manufacturer of the guard-locking device shall specify the maximum locking force F_{ZH} the guard-locking device withstands in the engaged position. This force, F_{ZH} , shall be determined according to [Annex I](#).

When applied, a guard-locking device shall be selected such that the maximum expected force exerted on the guard F_{MAX} in the application (see [Annex H](#)) does not exceed the maximum locking force, F_{ZH} .

6.6.3 Electromechanical guard-locking device

6.6.3.1 General

Electromechanically operating guard locking shall result from the engagement of two rigid parts [form closure, see [Table 3](#) a) to [Table 3](#) c)].

[Figure 5](#) shows the functionality of such a device.

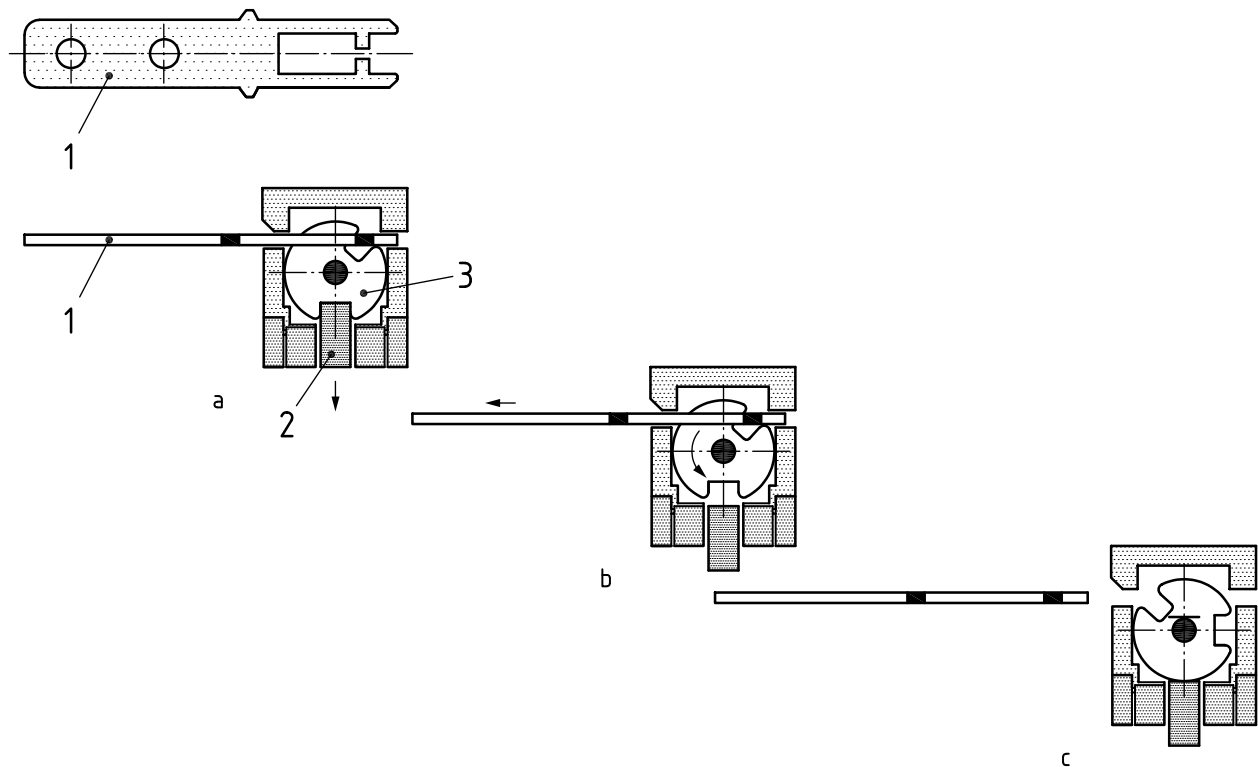
6.6.3.2 Guard-locking monitoring

The engaged position of the locking element shall be monitored in accordance with the requirements of [Clause 9](#).

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 E](#)).

Monitoring of the guard-locking device requires one of the following methods to be applied:

- a) if the locking element can only be engaged when the movable guard is in the closed position (see [Figure 5](#)), by monitoring of the locking element (prevention of inadvertent locking position);
- b) monitoring of the locking element and additionally monitoring the guard position.

**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 5 — Example of locking element that can only be engaged when the movable guard is in the closed position

6.6.4 Electromagnetic guard-locking device

6.6.4.1 General

The force required for the locking of the guard is applied by the generation of an electromagnetic field [see [Table 3 d](#)].

6.6.4.2 Guard-locking monitoring

When an electromagnetic guard-locking device is used for safeguarding, its effective locking force shall be monitored to determine that it is equal or exceeds the specified locking force F_{ZH} .

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 locking force F_{ZH} .

NOTE Depending on the design of the electromagnetic guard-locking device, this function can be achieved by different means, e.g. measuring the solenoid current, by measuring the electromagnetic field strength.

When the lock force monitoring function is not provided by the electromagnetic guard-locking device itself, it shall be provided by external safety-related parts of the control system of the machine.

6.6.4.3 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.

This can be implemented by:

- a) means of measures within the guard-locking device, such as, for example:
 - 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, for example, the following sequence:
 - 1) warning message at the machine;
 - 2) cycle stop;
 - 3) switching-off the production mode;
 - 4) testing of the guard-locking function;
 - 5) switching-on the production mode;
 - 6) restarting the next machine cycle (after a fixed time period of a minimum of 10 min).

NOTE 1 In contrast to an electromechanical guard-locking device, an electromagnetic guard-locking device shows no damage after an opening by force.

NOTE 2 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 to an electromechanical guard-locking device.

6.7 Additional requirements on access locks

6.7.1 General

In addition to the requirements stated in [6.1](#), [6.2](#), [6.3.1](#) and [6.5](#), the following requirements apply to access locks.

If the application of the guard-locking function creates hazards, e.g. a person exposed to a hazard whilst trapped within a safeguarded space, additional measures shall be taken (according to [7.2.3](#) and ISO 12100:2010, 6.3.5.3).

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

Parts designed with intentionally weak points may also be used to create safe failures in order that other critical parts are not exposed to high loading and, therefore, cannot fail dangerously, e.g. a key designed to break at a low force (safe failure) prevents damage to the lock if an attempt is made to force the key to override the locking mechanism.

6.7.2 Locking force

The manufacturer of the access lock shall specify the maximum locking force F_{ZH} the access lock withstands in the engaged position. This force, F_{ZH} , shall be determined according to [Annex I](#).

When applied, an access lock device shall be selected such that the maximum expected force exerted on the guard F_{MAX} in the application (see [Annex H](#)) does not exceed the specified locking force, F_{ZH} .

6.8 Whole body access

For applications where there is a risk that person(s) can be trapped inside a safeguarded space, measures to reduce or eliminate risks arising from the situation shall be implemented.

These measures can include:

- application of personnel keys according to [K.4.3](#);
- escape release according to [6.9.1](#);
- use of interlock blocking devices according to [6.10](#).

If there is a risk of unexpected startup of a machine when a person is inside a safeguarded area of the machine, means in accordance with ISO 14118 shall be applied. These measures can include:

- a manual reset function according to ISO 13849-1:2023, 5.2.2.3;
- presence sensing devices according to IEC 62046.

Depending on the application, supplementary methods of release of guard locking can be necessary (see ISO 12100:2010, 6.3.5.3). For their selection, see [7.2.3](#).

NOTE Escape and emergency releases can be separate devices or provided with the guard-locking device.

Where applied, separate devices for escape or emergency release and guard-locking devices, with provided escape or emergency releases, shall withstand the following:

- expected operating stresses, e.g. force and frequency of operation;
- environmental influence, e.g. influence of abrasive materials, e.g. cement dust in a cement production line;
- other relevant external influences, e.g. mechanical vibration.

6.9 Supplementary releases

6.9.1 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 space 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 which is maintained;
- the unlocking means for the escape release shall only be accessible from inside the safeguarded space.

6.9.2 Auxiliary release of guard locking

When the guard-locking device is provided with an auxiliary release the following requirements shall be met.

- Deliberate unlocking of the guard locking from outside the safeguarded space shall be possible only by the use of a tool or key(s) and regardless of the operating condition. The instructions for use shall state that the restoring of the function of the guard-locking device is necessary before normal operation is resumed.
- The unlocking of the auxiliary release shall generate a stop command which is maintained.
- The resetting of the auxiliary release shall be possible only by means of a tool, key(s) or similar objects or by other equivalent methods (e.g. change of a component). This requirement can be fulfilled on a