

ISO/FDIS 14119:~~2023~~2024(E)

~~2024-03~~

ISO/FDIS 14119.2:2024(E)

ISO/TC 199/SC 7/WG 7

Secretariat: DIN

~~Date: 2023-10-20~~

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

Sécurité des machines — Dispositifs de verrouillage associés à des protecteurs — Principes de conception et de choix

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Field Code Changed

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** — **Table 5** has been improved and renamed;
- test procedures are described in new **Annex I**;

— ISO/TR 24119 has been integrated into new [Annex I](#).

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.

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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.

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 organisations, 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~~ 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~~ 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~~ Annex I describes a locking force test and an impact resistance test for guard-locking devices.

~~Annex J~~ Annex J provides information on the masking of faults in series connection of interlocking devices with potential free contacts.

~~Annex K~~ Annex K provides requirements for trapped key interlocking systems and describes their technology.

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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 13855:20~~11~~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*

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

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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*

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>

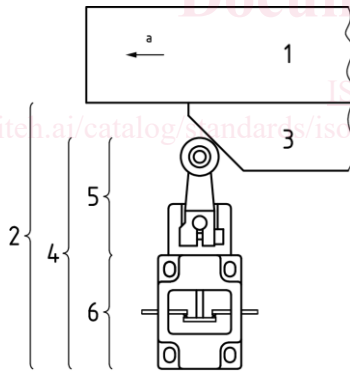
— IEC Electropedia: available at <https://www.electropedia.org/>

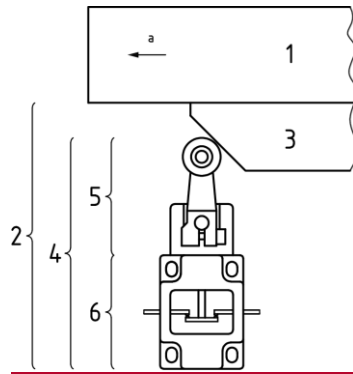
3.1 interlocking device

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 and;
- 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

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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 8.4.2) and spare actuators (for all types) are also considered as readily available objects.

3.6 automatic

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

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 EE](#) and [Annex K, Annex L](#).

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, 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, 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

EXAMPLE Access locks can also be used for locking in position objects other than guards, e.g. isolator, valves or barriers.

3.18.9

timed delay 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

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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 2 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 and/or protective devices are intended to protect persons

3.21
stop command

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

3.22