

JAPANESE
INDUSTRIAL
STANDARD

Translated and Published by
Japanese Standards Association

JIS B 9710 : 2006

(ISO 14119 : 1998)

(JMF)

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

ICS 13.110

Reference number : JIS B 9710 : 2006 (E)

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B 9710 : 2006 (ISO 14119 : 1998)

Date of Establishment: 2006-11-25

Date of Public Notice in Official Gazette: 2006-11-27

Investigated by: Japanese Industrial Standards Committee
Standards Board

Technical Committee on Industrial Machinery

JIS B 9710 : 2006, First English edition published in 2008-01

Translated and published by: Japanese Standards Association
4-1-24, Akasaka, Minato-ku, Tokyo, 107-8440 JAPAN

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Printed in Japan

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Foreword

This translation has been made based on the original Japanese Industrial Standard established by the Minister of Health, Labour and Welfare and the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee according to the proposal of establishing a Japanese Industrial Standard from the Japan Machinery Federation (JMF) with a draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law.

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

Introduction

This Japanese Industrial Standard has been prepared based on the first edition of **ISO 14119** published in 1998 without modifying the technical contents.

1 Scope

This Standard specifies principles for the design and selection, independent of the nature of the energy source, of interlocking devices associated with guards (as defined in **3.26.1** of **JIS B 9700-1:2004** and **3.25.5** of **JIS B 9700-1:2004**).

It also provides requirements specifically intended for electrical interlocking devices.

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

- NOTE 1 Requirements for guards are given in **JIS B 9716**. The processing of the signal from the interlocking device to stop and immobilize the machine is dealt with in **JIS B 9705-1**.
- 2 The International Standard corresponding to this Standard is as follows.

ISO 14119:1998 *Safety of machinery — Interlocking devices associated with guards — Principles for design and selection* (IDT)

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according (not equivalent) according to **ISO/IEC Guide 21**.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute the provisions of this Standard.

If the indication of the year is given to the referred standard, the edition of indicated year applies but the revision (including amendments) made thereafter does not apply.

JIS B 9700-1:2004 *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology*

NOTE: Corresponding International Standard: ISO 12100-1:2003 *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology* (IDT)

JIS B 9700-2:2004 *Safety of machinery — Basic concepts, general principles for design — Part 2: Technical principles*

NOTE: Corresponding International Standard: ISO 12100-2:2003 *Safety of machinery — Basic concepts, general principles for design — Part 2: Technical principles* (IDT)

JIS B 9702:2000 *Safety of machinery — Principles of risk assessment*

NOTE: Corresponding International Standard: ISO 14121:1999 *Safety of machinery — Principles of risk assessment* (IDT)

JIS B 9705-1:2000 *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

NOTE: Corresponding International Standard: ISO 13849-1:1999 *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design* (IDT)

JIS B 9707:2002 *Safety of machinery — Safety distances to prevent danger zones being reached by the upper limbs*

NOTE: Corresponding International Standard: ISO 13852:1996 *Safety of machinery — Safety distances to prevent danger zones being reached by the upper limbs* (IDT)

JIS B 9714:2006 *Safety of machinery — Prevention of unexpected start-up*

NOTE: Corresponding International Standard: ISO 14118:2000 *Safety of machinery — Prevention of unexpected start-up* (IDT)

JIS B 9715:2006 *Safety of machinery — Positioning of protective equipment with respect to the approach speeds of parts of the human body*

NOTE: Corresponding International Standard: ISO 13855:2002 *Safety of machinery — Positioning of protective equipment with respect to the approach speeds of parts of the human body* (IDT)

JIS B 9716:2006 *Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards*

NOTE: Corresponding International Standard: ISO 14120:2002 *Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards* (IDT)

JIS B 9960-1:1999 *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

NOTE: Corresponding International Standard: IEC 60204-1:1997 *Safety of machinery — Electrical equipment of machines — Part 1: General requirements* (MOD)

JIS C 8201-5-1:1999 *Low-voltage switchgear and controlgear — Part 5-1: Control circuit devices and switching elements — Electromechanical control circuit devices*

NOTE: Corresponding International Standard: IEC 60947-5-1:1997 *Low-voltage switchgear and controlgear — Part 5-1: Control circuit devices and switching elements — Electromechanical control circuit devices* (MOD)

3 Terms and definitions

For the purpose of this Standard, the following definitions apply:

3.1 interlocking device; interlock

mechanical, electrical or other type of device, the purpose of which is to prevent the operation of machine elements under specified conditions (generally as long as a guard is not closed) (see **JIS B 9700-1:2004, 3.26.1**)

3.2 interlocking guard

guard associated with an interlocking device, so that:

- a) the hazardous machine functions “covered” by the guard cannot operate until the guard is closed;
- b) if the guard is opened while the hazardous machine functions are operating, a stop instruction is given;
- c) when the guard is closed, the hazardous machine functions “covered” by the guard can operate, but the closure of the guard does not by itself initiate their operation.

(see **JIS B 9700-1:2004, 3.25.4**)

3.3 interlocking guard with guard locking

guard associated with an interlocking device and a guard locking device so that:

- a) the hazardous machine functions “covered” by the guard cannot operate until the guard is closed and locked;
- b) the guard remains closed and locked until the risk of injury from the hazardous machine functions has passed;
- c) when the guard is closed and locked, the hazardous machine functions “covered” by the guard can operate, but the closure and locking of the guard do not by themselves initiate their operation.

(see **JIS B 9700-1:2004, 3.25.5**)

3.4 guard locking device

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

- a) the machine cannot operate until the guard is closed and locked;
- b) the guard remains locked until the risk has passed.

3.5 automatic monitoring

a back-up safety function which ensures that a safety measure is initiated 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

NOTE : There are two categories of automatic monitoring:

- a) “continuous” automatic monitoring, whereby a safety measure is immediately initiated when a failure occurs;
- b) “discontinuous” automatic monitoring, whereby a safety measure is initiated during a following machine cycle, if a failure has occurred.

3.6 positive mode actuation

if a moving mechanical component inevitably moves another component along with it, either by direct contact or via rigid elements, the second component is said to be actuated in the positive mode (or positively) by the first one

(based on **JIS B 9700-2**)

3.7 positive opening operation of a contact element

the achievement of contact separation as the direct result of a specified movement of the switch actuator through non-resilient members (e.g. not dependent upon springs)

NOTE : For fluid power, the equivalent concept may be called “positive mode interruption”.

(based on **JIS C 8201-5-1**)

3.8 stopping time; time for hazard elimination

the period between the point at which the interlocking device initiates the stop command and the point at which the risk from hazardous machine functions has passed

3.9 access time; time for access to a danger zone

the time taken to access the hazardous machine parts after initiation of the stop command by the interlocking device, as calculated on the basis of an approach speed whose value may be chosen, for each particular case, taking into account the parameters given in **JIS B 9715**

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

NOTE : Reference is made to the relevant Annexes where it is considered useful for clearer understanding.

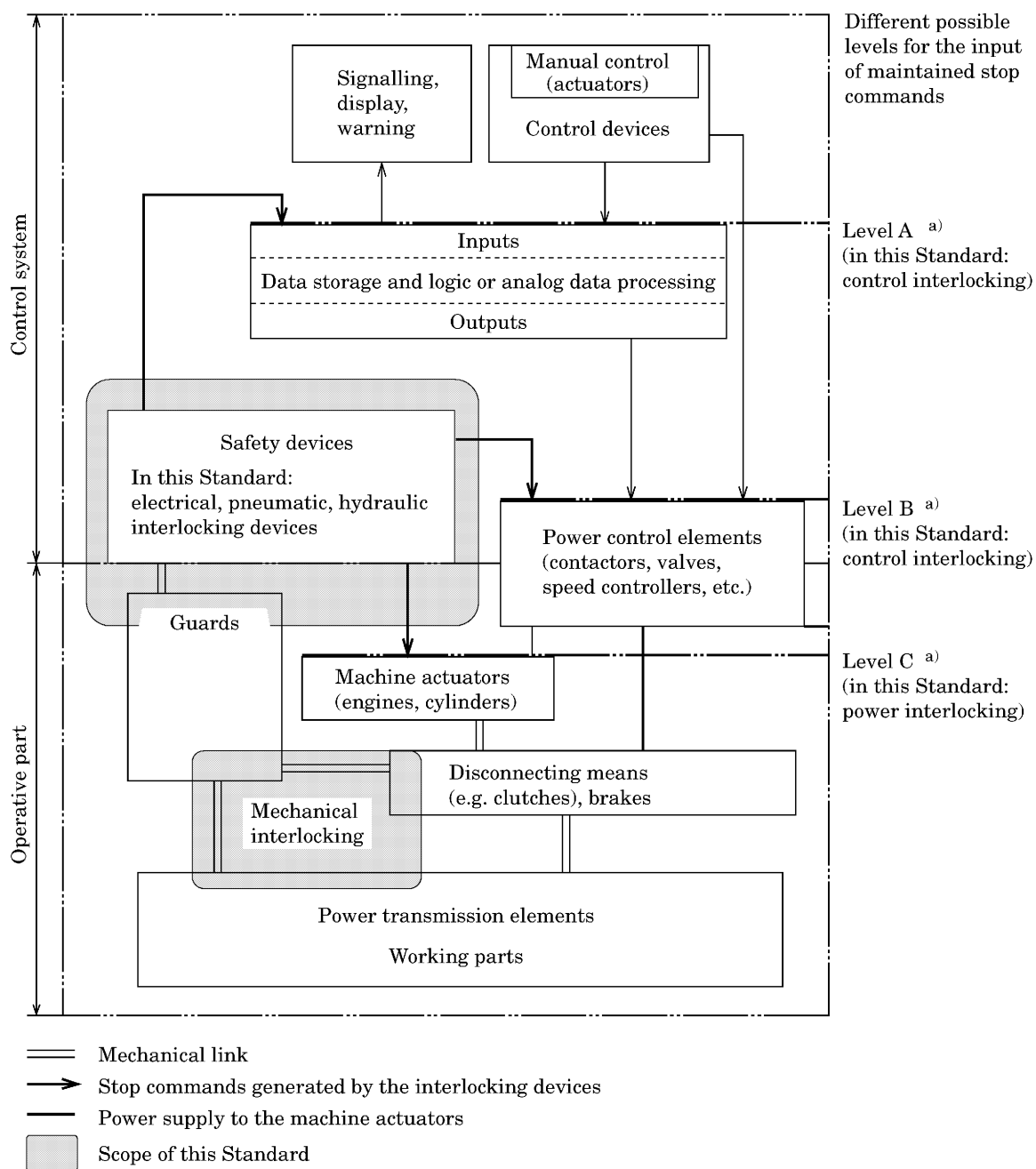
4.1 Interlocking principles

4.1.1 Control interlocking

The stop command from the interlocking device is introduced into the control system so that interruption of the energy supply to the machine actuators — or mechanical disconnection of moving parts from the machine actuators — is triggered by the control system (indirect interruption: levels A and B in figure 1).

4.1.2 Power interlocking

The stop command from the interlocking device directly interrupts the energy supply to the machine actuators or disconnects moving parts from the machine actuators (level C in figure 1). “Directly” means that, unlike control interlocking (see 4.1.1), the control system does not play any intermediate role in the interlocking function.



Note ^{a)} In accordance with **JIS B 9714 : 2006**

Figure 1 Location of interlocking devices in machinery

4.2 Typical forms of interlocking devices

4.2.1 Interlocking device (without guard locking) [see table 1 and figure 3 a)]

It is always possible to open the guard. As soon as the guard is not longer closed, the interlocking device generates a stop command. As it is possible to start opening the guard during operation of the machine (or of the hazardous machine elements), the function is that of an interlocking device, as defined in **3.25.4** of **JIS B 9700-1:2004**.

Examples of interlocking devices without guard locking are shown in Annexes A, B, F, G, J, K and L.

4.2.2 Interlocking device with guard locking [see table 1 to figure 3 b)]

The guard is held closed by a guard locking device (see 3.4). There are two types of device:

- those where unlocking the guard can be initiated at any time by the operator [unconditional unlocking: see table 1 and figure 3 b1)];
- those where unlocking the guard is possible only if a condition is fulfilled, thus ensuring that the hazard has disappeared [conditional unlocking: see table 1 and figure 3 b2)].

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

In a guard locking device, the part which is intended to lock/unlock the guard can be

- manually applied, manually released (see figure N.1 in Annex N)
- spring-applied, power-released [see figure 2 a)];
- power-applied, spring-released [see figure 2 b)];
- power-applied, power-released [see figure 2 c)].

Examples of interlocking devices with guard locking are given in Annexes C, D, E, H, M and N.

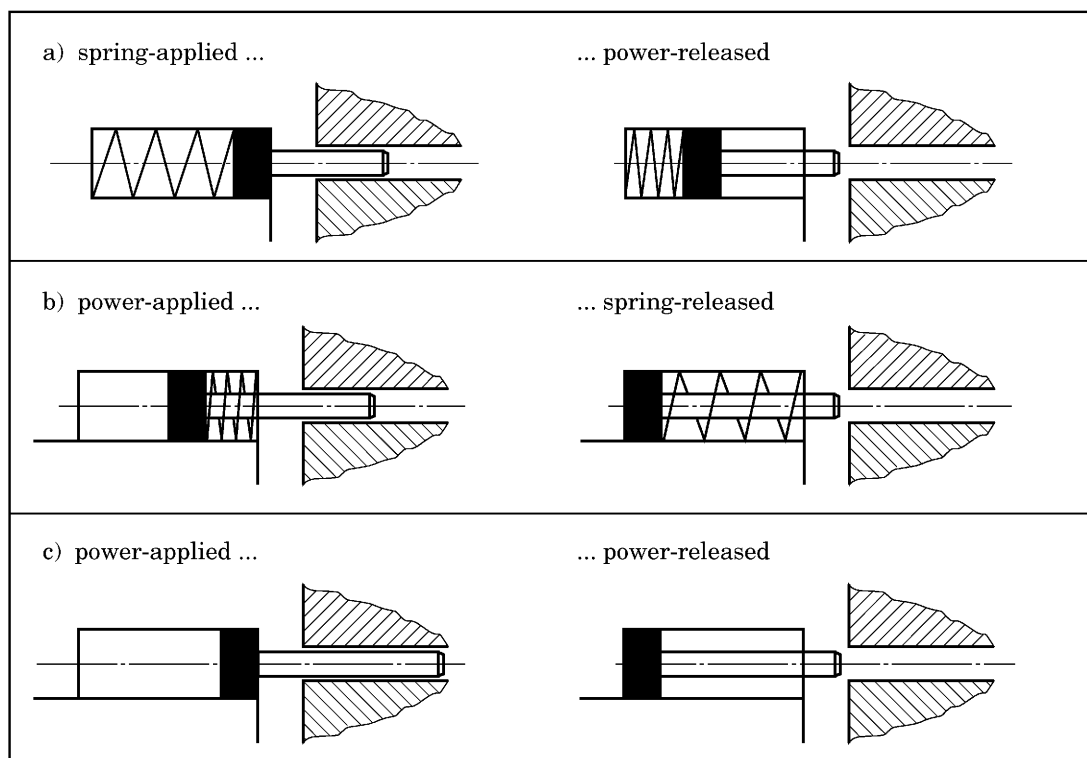
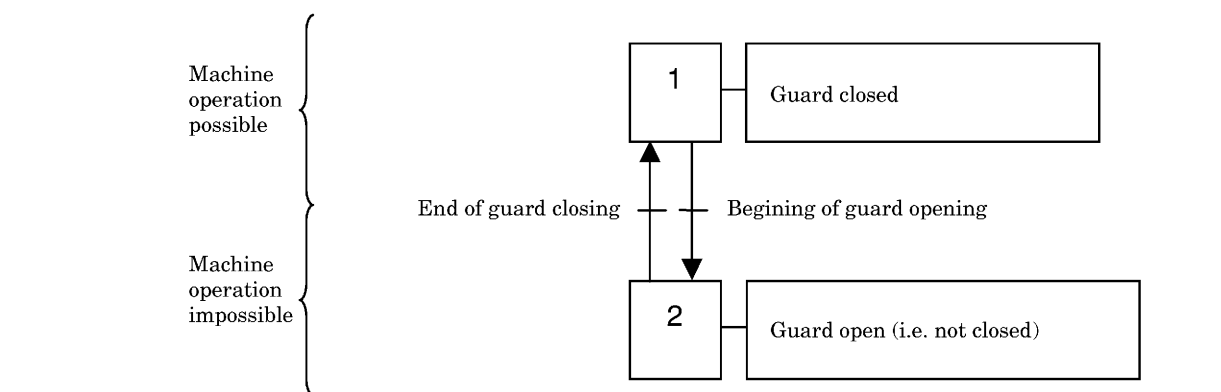
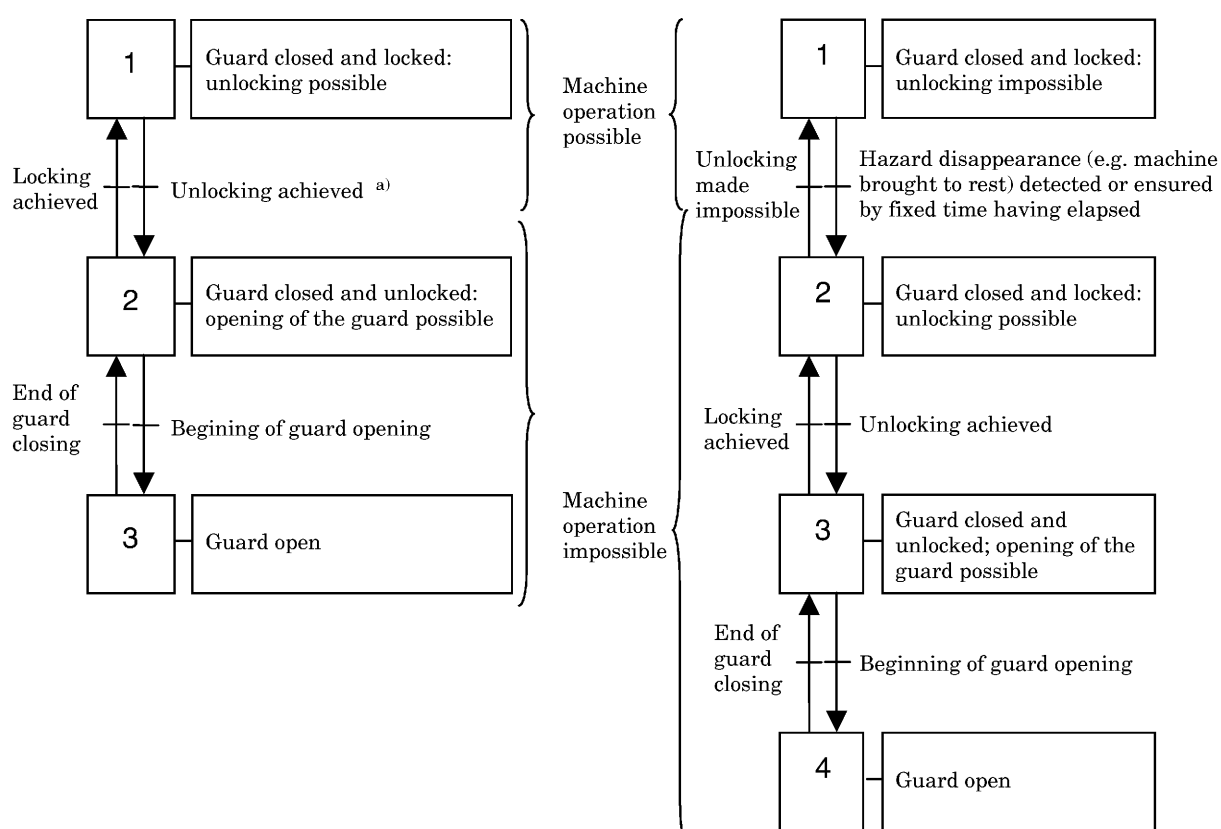


Figure 2 Operating modes of the guard locking device
in power-actuated guard locking devices



a) Interlocking devices without guard locking ("two-state interlocking")



Note ^{a)} "Unlocking achieved" implies that:

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

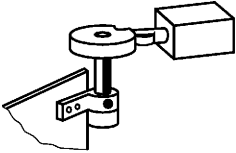
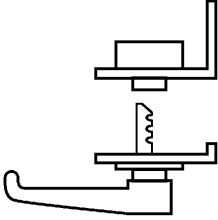
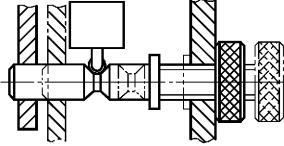
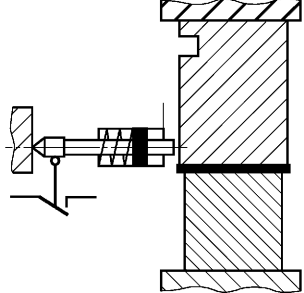
b1) Unconditional unlocking ("three-state interlocking")

b2) Conditional unlocking ("four-state interlocking")

b) Interlocking devices with guard locking

Figure 3 Functional diagrams of the different types of interlocking devices

Table 1 Various aspects of the interlocking devices with and without guard locking

Interlocking devices without guard locking [see 4.2.1 and figure 3 a)]		Interlocking devices with guard locking [see 4.2.2 and figure 3 b)]	
		Unconditional unlocking [see figure 3b1)] – Unlocking the guard can be started at any time by the operator, but the time necessary for the guard to be unlocked is longer than the time necessary for the hazard to disappear	Conditional unlocking [see figure 3b2)] Unlocking the guard is made possible only if (or is triggered when) one of the following conditions is fulfilled:
		– a fixed time ^{b)} has elapsed after the stop command has been given:	– disappearance of the hazard has been detected (e.g. zero-speed detection).
Stop command given: – at the beginning of the guard opening stroke (the interlocking device is actuated by the guard itself):	– simultaneously with the beginning of the actuation of the lock ^{a)} and as a consequence of it:	– shortly after the beginning of the actuation of the guard locking device and as a consequence of it:	– by the operation, or automatically by the control system, then memorized by the interlocking device.
 (see Annexes A and G)	 (see Annex D)	 (see Annex N)	 (see Annex M)
Typical examples			
Notes ^{a)} Strictly speaking, the guard is unlocked after the beginning of the stop command. Where the hazard disappears “as soon as the stop command is given” (in any case before the guard is unlocked), the function ensured is equivalent to that of an interlocking guard with guard locking. ^{b)} Longer than the time necessary for the hazard to disappear.			

4.3 Technological forms of interlocking device

Interlocking techniques involve a broad spectrum of technological aspects. As such, interlocking devices can be classified using a great variety of criteria, e.g. the nature of the link between guard and circuit-opening elements, or the technological type (electromechanical, pneumatic, electronic, etc.) of the circuit-opening elements.

Table 2 establishes the link between the main technological forms of interlocking device and the elements of this Standard which deal with them.

Table 2 Technological forms of interlocking device

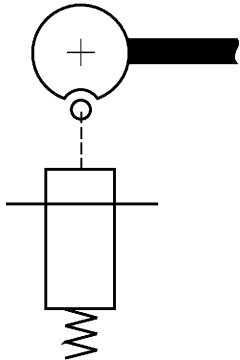
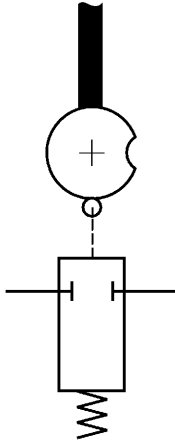
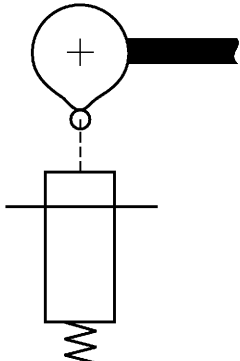
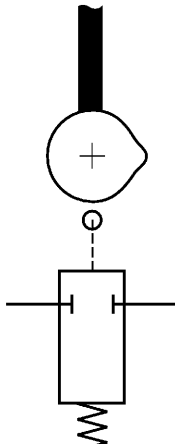
Technological forms	Provisions in subclauses	Examples in annexes
Interlocking devices with mechanically actuated detectors : – with cam-operated detectors – with tongue-operated detectors	5.1 to 5.4, 5.7.2, 6.2 5.7.2.1 5.7.2.2	A, G, L, M B
Interlocking devices with non-mechanically actuated detectors : – with magnetically actuated switches – with electronic proximity switches	 5.7.3 to 6.3 5.7.3 to 6.3	 J K
Systems incorporating keys : – captive-key systems; – trapped-key systems.		D E
Plug and socket systems	5.7.4	F
Mechanical interlocking between guard and movable parts		H

5 Provisions for the design of interlocking devices (independent of the nature of the energy source)

5.1 Actuation modes of mechanically actuated position detectors

When a single detector is used to generate a stop command, it shall be actuated in the positive mode (see table 3 and **3.6**). Non-positive mode actuation is only allowed in conjunction with a detector with positive mode actuation, notably to avoid common-cause failures (see **5.4.1**). The design of the actuator should be as simple as possible, since this may reduce the probability of failure.

Table 3 Actuation of position detectors in the positive mode and in the non-positive mode

Mode of actuation	Guard closed	Guard open	Working mode
Positive			The detector stem (actuator) is held depressed by a cam as long as the guard is open . When the guard is closed , the detector changes its state as the result of the action of a return spring.
Non-positive mode			The detector stem (actuator) is held depressed by a cam as long as the guard is closed . When the guard is opened , the detector changes its state as the result of the action of a return spring.

5.2 Arrangement and fastening of position detectors

5.2.1 Position detectors shall be arranged so that they are sufficiently protected against a change of their position. In order to meet this requirement:

- the fasteners of the position detectors shall be reliable and loosening them shall required a tool;
- the use of slots shall be limited to initial adjustment;
- provisions shall be made for positive location after adjustment (e.g. by means of pins or dowels).

Replacement of the detectors shall be possible without any readjusting need.