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Translation

Principles of testing and certification for interlocking devices with guard-locking

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Principles of testing

Interlocking devices with guard-locking

GS-ET-19 E

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GS-ET-19 E

These Principles of testing serve as verification that the requirements of the German Equipment and Product Safety Act (GPSG) and, as such, the 1st and 9th provisions of the GPSG in particular, have been complied with.

These principles will be revised and supplemented periodically in consideration of knowledge gained in the area of occupational safety and the state of technological progress. The most recent edition shall always be binding for tests conducted by the Testing and certification body of the Energy, textile & electrical media products department.

These Principals of testing comprise the necessary requirements and tests for Interlocking devices with guard-locking, while supplementing these with additional requirements, such as those according to DIN EN 60947-5-1 or DIN EN 60947-5-3.

Changes with respect to Edition 2015-05:

1.3 Technical rules
- Update of the regulatory framework

2.16 Coding levels
- Newly introduced terminology

4.1 Technical documents
- Required documentation related to verification of the coding level

5.2 Labels and markings
- Modification of the requirements related to legibility of inscriptions
- Clarification of inscriptions on switching elements and/or screwless clamping units
- Definition of the requirements for labelling and inscriptions related to coding levels

5.3 Operating instructions
- Additional information regarding the stripping length for conductor cables

5.6.1.1 Spring-force actuated locking elements
- Editorial changes

5.7.1 Characteristics when using a non-integral actuator
- Introduction of new requirements

5.8.1 Heating
- Specification of temperature limits instead of temperature-rise limits

5.8.3 Mechanical and electrical properties of connectors
- Integration of the testing stipulated for screwless clamping units in DIN EN 60947-5-1

5.21 Determination of the B_{10D} value
- Adaptation of the testing requirements to DIN EN 60947-5-1, Section 8.1.5 and Annex N

5.22 Additional requirements for semiconductor switching elements in control units
- Integration of the testing stipulated in DIN EN 60947-5-1

5.23 Testing of resistance against exceptional heat and fire
- Integration of the testing stipulated in DIN EN 60947-5-1

This is the English translation of the German test principle. The German original version is obligatory.

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1 General

1.1 Scope

These test principles apply to the testing of interlocking devices with electromechanical or electromagnetic guard-locking (henceforth referred to as "guard-locks") as a modular unit for safety-relevant applications.

Nevertheless, the Principles of testing GS-ET 19:2015-05 will remain valid until 15 Dec. 2020

1.2 Functional description

Electromechanical guard-locks with position monitoring have the function of holding closed a moveable safeguard by means of positive locking elements such as latches, bolts or pins. These may be held in the locked position by spring force (spring-actuated) and released by electromagnetic actuation or held in the locked position by electromagnetic actuation and released by spring force (solenoid-actuated). Guard-locks with position monitoring should ensure that moveable safeguards employed in conjunction with a machine's control elements cannot be opened until hazard-producing conditions (such as run-on motion) have ceased.

An electromagnetic guard-lock is a guard-locking device, for which the force required to hold a corresponding separating safeguard closed is created by generating an electromagnetic field. An integrated sensor serves the position monitoring of the safeguard and is integral to the interlocking device.

Position monitoring of the protective door and/or the locking element can also be realized through PDDB in accordance with DIN EN 60947-5-3.

1.3 Technical rules

The basis for these Principles of testing comprises:

With regard to undated references, the last edition of the document being referenced applies (including all changes).

DIN EN ISO 14119	Safety of machinery Interlocking devices associated with separating safeguards - Principles for design and selection
DIN EN 60204-1 (VDE 0113-1)	Safety of machinery; Electrical equipment of machines - General requirements -
DIN EN 60529 (VDE 0470-1)	Degree of protection provided by enclosures (IP code)
DIN EN 60695-2-10 to DIN EN 60695-2-13 (VDE 0471) Parts 2-10 to 2-13	Fire hazard testing; Part 2-10 to Part 2-13: Glowing/hot-wire based test methods
DIN EN 60947-1 (VDE 0660-100)	Low-voltage switchgear and controlgear; Part 1: General rules
DIN EN 60947-5-1: (VDE 0660-200)	Low-voltage switchgear and controlgear; Part 5-1: Control units and switching elements, Electromechanical control circuit devices
and DIN EN 60947-5-3 (VDE 0660-214)	Low-voltage switchgear and controlgear; Part 5-3: Control units and switching elements, Proximity devices with defined behaviour under fault conditions
DIN EN 60068-2-6 (VDE 0468-2-6)	Environmental influences; Part 2-6: Test methods; Test Fc: Vibration (sinusoidal)

DIN EN 60068-2-27 (VDE 0468-2-27)	Environmental influences; Part 2-27: Test methods; Ea test and guidance: Shocks
DIN EN 60068-2-75	Environmental testing; Part 2: Tests; Eh test: Hammer tests
DIN EN 60068-2-78 (VDE 0468-2-78)	Environmental influences; Part 2-78: Tests; Test methods Cab: Damp heat, steady state
DIN EN ISO 13849-1	Safety of machinery; Safety-related parts of control systems; Part 1: General principles for design
DIN EN ISO 13849-2	Safety of machinery; Safety-related parts of control systems; Part 2: Validation
DIN EN 62061	Safety of machinery; Functional safety of safety-related electrical, electronic and programmable electronic control systems
AfPS-GS-2014:01 PAK or the current version, accordingly	Testing and evaluation of polycyclic aromatic hydrocarbon (PAH) for the issuance of the GS-mark
DIN EN 13906-1	Cylindrical helical springs made from round wire and bar - Calculation and design - Part 1: Compression springs
DIN EN 60999-1	Connecting devices - Electrical copper conductors; Safety requirements for screw-type and screwless-type clamping units − Part 1: General requirements and particular requirements for clamping units for conductors 0.2 mm² up to and including 35 mm²

2 Terms

DIN EN 60947-5-1, Section 2 shall apply with the following supplements:

2.1 Interlocking device (interlock)

A mechanical, electrical or other device used for the purpose of preventing operation of a machine element under certain conditions (usually as long as a separating safeguard is not closed).

2.2 Actuator

A separate part of an interlocking device, which conveys the state of the separating safeguard (closed or open) to the actuation system.

2.3 Position switch with positive opening operation

A control switch with one or more breaker contacts, which is connected to the switch actuator via non-spring-action parts in such a manner that the contact opening(s) of the breaker(s) is/are fully reached when the actuator has travelled through the positive opening path with the force specified by the manufacturer.

2.4 Positive opening operation (of a contact element)

Guarantee of contact separation resulting directly from a defined movement of the switch actuator via non-spring-action parts (e.g. not dependent upon a spring).

2.5 Positive opening path

Minimum travel path from when operating element actuation begins to the position, at which the positive opening of the contact has ended.

2.6 Guard-lock

A device that is designed to hold a separating safeguard in the closed position and connected with the control system in such a manner that:

- potentially hazardous movements are prevented if the safeguard is not closed and guard-locked
- the separating safeguard is held closed until the risk of injury no longer exists.

2.7 Faulty-closure protection

A mechanism on a guard-lock that ensures it is able to assume its locked position (safeguard held closed) only after the safeguard is located in its protective position.

2.8 Manual release

Provides the option for manually releasing the guard-lock from outside the protected area by means of a tool or a key in the event of a failure.

2.9 Escape release

Provides the option for manually releasing the guard-lock from inside the protected area without auxiliary means in order to vacate this area.

2.10 Emergency release

Provides the option for manually releasing the guard-lock from outside the protected area without auxiliary means in the event of an emergency.

2.11 Bypassing

An operation, through which an interlocking device is rendered inoperative or is circumvented in such a manner that a machine can no longer be used as intended by the designer or only without the required safety measures.

2.12 Bypassing by simple and predictable means

The bypassing of an interlocking device either manually or through the use of a readily available object.

Note 1 regarding the term:

This definition includes the removal of switches or actuators using tools required for the proper operation of a machine, or which are readily available (e.g. screwdriver, wrench, hexagonal spanner and pliers).

Note 2 regarding the term:

Objects readily available for alternative actuation include screws, needles and sheet-metal blanks, as well as everyday items, such as keys, coins, adhesive tape, packing twine and wire, spare keys for interlocking devices with key transfer systems and spare actuators.

2.13 Mechanical service life

Mechanical service life is an indication of a guard-lock's resistance to wear. It is determined by the number of switching cycles, performed without electrical load, for which the guard-lock is designed.

2.14 Electrical service life

Electrical service life of a device is expressed by the number of switching cycles which can be performed under load according to the operating conditions prescribed in DIN EN 60947-5-1, without repair or replacement of parts.

2.15 Logic unit

An assembly intended for use in the safety-related parts of control systems and employed exclusively, or in conjunction with other functions, for the realization of safety functions.

The logic unit

- receives and processes information from the sensors (e.g. PDDB) and generates signals for the Output Signal Switching Device (OSSD),
- monitors the sensors and OSSD.

2.16 PDDB (Proximity Device with Defined Behaviour)

Proximity switching device with defined fault-mode behaviour according to DIN EN 60947-5-3.

2.17 Coding levels

2.17.1 Coded actuators with a low coding level

Coded actuators, for which 1 to 9 coding options are available.

2.17.2 Coded actuators with a medium coding level

Coded actuators, for which 10 to 1,000 coding options are available.

2.17.3 Coded actuators with a high coding level

Coded actuators, for which more than 1,000 coding options are available.

3 Characteristic features

DIN EN 60947-5-1, Section 4, including K.4, shall apply.

4 Test documentation to be submitted

4.1 Technical documents

The information for the connection and commissioning of guard-locking devices must be provided in the form of drawings, circuit diagrams, tables and user information. The following documents must be submitted for technical testing:

- All user information supplied with the device (Operating instructions, assembly instructions, etc.),
- Sales literature (if available)
- Overview of the usable actuators for the guard-locking device
- Block circuit diagram (if applicable)
- Electric circuit diagram
- Technical drawings
- Parts list(s)
- Printed circuit board layouts (if applicable)
- Description of the functional process (if necessary)
- Maintenance procedures and setting instructions (if necessary)
- Insofar as they are available, data sheets, test certificates, certificates for the guard-locking device and/or the parts it comprises
- Test reports, test protocols and calculations, which were used in determining the B_{10D} value (see Section 5.21)
- Specification of type code
- Description of the coding process (including submission of the corresponding documentation) with specification of the various coding possibilities
- Description of the measures taken to achieve a sufficient statistical mix of the individual coded actuators
- For guard-locking devices with logic units (e.g. with the use of PDDB according to DIN EN 60947-5-3):

• Single fault analysis (e.g. FMEA)
• Fault combination analysis (e.g. FTA)
• Component failure rate, if available
• Calculation of the PFH or PFH_D
• Software documentation, if applicable.

The testing facility can request further documentation if deemed necessary.

4.2 Prototype

The number of test specimens to be submitted will be determined by the testing facility. As a rule, at least four prototypes should be made available.

If pre-assembled printed circuit boards are used, a set of bare circuit boards should also be submitted.

5 Inspections

5.1 General test requirements

Interlocking devices with guard-locking, henceforth referred to as "guard-lock(s)", must satisfy all of the requirements that follow. Performing the tests in the specified sequence will serve as verification that the prescribed requirements have been fulfilled.

Fulfilment of broader manufacturer specifications must be verified separately.

Tests shall be conducted on complete guard-locks according to the rating data declared by the manufacturer. Test values may deviate from the rating data as follows:

Refer to DIN EN 60947-1, Table 8 for test value variance limits.

Unless otherwise specified in the individual test instruction, proper functioning of the guard-lock must be ascertained prior to the initial test and subsequent to each individual test.

Guard-locking devices used in conjunction with PDDBs must be subjected to additional testing according to DIN EN 60947-5-3.

Guard-locking devices with logic units must be subjected to additional testing according to DIN EN ISO 13849-1 and must be validated according to DIN EN ISO 13849-2 or evaluated according to DIN EN 62061.

5.2 Labels and markings

Each guard-lock must be labelled with the following discernible, clearly legible (e.g. with a minimum font height = 2 mm with good contrast) and durably marked inscriptions:

5.2.1 On the enclosure (externally):

a) Manufacturer's/authorised representative's company name and complete address

b) Nomenclature of the safety component

c) Design series or type designation

d) CE-marking

e) Year of manufacture

f) The symbol for positive opening  [IEC 60617-S00226(2001-07)], if applicable

g) The symbol  for monitoring of the guard-lock (marking of the positive opening contacts for monitoring the locking device)[1)]

NOTE: As an alternative, the symbol can be included in the user information (DIN EN ISO 14119:2014-03, Fig. 13)

h) The symbol for Protection Class II, if applicable

i) IEC 60947-5-1 or DIN EN 60947-5-1 if the manufacturer claims conformity with this standard

j) IP-Protection class

k) Guard-locking force F (preferred value: ≥ 1000 N)

The prescribed guard-locking force F must be ≤ the force F_{Zh} determined by testing! (refer also to Point 5.18)

m) Change-over contact elements must be marked with the relevant symbols for the form Za or Zb in accordance with DIN EN 60947-5-1, Fig. 4.

n) For guard-locks with emergency release: Annotated remark that the emergency release should be used only in the event of an emergency.

Note: As an alternative, this remark can be provided by the user (refer to Section 5.3).

If sufficient space is not available for the markings, a tag can be attached to a component on the guard-lock with the manufacturer's complete address and the product nomenclature. All other required markings must be applied to the enclosure.

The markings must be readable without removal of the product casing. Inscription labels must not be applied to bolts, screws or removable plates.

Test: See Point 5.2.2.

[1)] *Note: Contrary to 14119, only the electromechanical contacts are to be marked with Fig. 13 according to DIN EN ISO 14119.*

5.2.2 On the switch mechanism

a) Clamping unit designation

b) Identification of contact elements with the same polarity

c) Special screwless clamping units*):

- Clamping units for solid, single-strand conductors shall be marked with the character „s“ or „sol“;
- Clamping units for solid, single- or multi-strand conductors shall be marked with the character „r“;
- Clamping units for flexible conductors shall be marked with the character „f“.

*) If sufficient space is not available on the switch mechanism, then the marking should be applied to the smallest possible packing unit or specified in the technical information provided with the product.

Test: Visual inspection, check for completeness, correctness and consistency of information, measurement of font height, rubbing test (gently rub using two cotton cloths, one soaked in water and the other in a test fluid*), for 15 s each).

The markings must remain clearly legible following the test. It must not be possible to easily remove the marking labels, nor should they be wrinkled or creased.

*)The chemical product with the trade name "n-Hexan for analysis", which fulfils the requirements for the test fluid defined in DIN EN 60335-1 and DIN EN 62368-1, should be used as test fluid.

5.2.3 Type of label and marking

Labels and markings on coded guard-locks must not allow for inferences to be drawn as to the individual codes.

Test: Comparison of the coding codex to the label inscriptions and markings

5.2.4 Coding level

The coding process must be suitable for realizing the coding levels as prescribed in the Operating instructions.

The number of possible codes must agree with the prescribed coding level.

Test: Plausibility check based on the coding process as described and the four differently coded test specimens

5.2.4.1 When products are delivered, it must be ensured that a sufficient statistical mix of differing codes is available for each coding level.

Test: Plausibility check of the description of measures prescribed for achieving a sufficient statistical mix

5.3 Operating instructions

The guard-lock should be accompanied by the information required for proper connection and commissioning.

Safety-related information must be provided in a language acceptable in the country, in which the guard-lock is to be installed.

If the Operating instructions are not in German, a German translation must be provided. Testing will be conducted with reference to the German translation.

The Operating instructions provided with the device or, optionally, on the device must indicate the following characteristic features of the guard-lock:

a) Manufacturer's/authorised representative's company name and complete address
b) Design series or type designation
c) Designation of the safety component (e.g. guard-lock)
d) Rendering of the content found in the Declaration of Conformity (except for serial number and signature)
e) - General description of the guard-lock and its intended usage
f) Instructions for assembly, installation and connection of the guard-lock
g) Maintenance procedures and setting instructions (if necessary)
h) Description of fault characteristics (if necessary)
i) Rated operating voltage(s)
j) Usage category and rated operating current(s) at the rated operating voltage(s)
k) Rated insulation voltage

l) Rated surge voltage resistance

m) Type and highest rated values of the short-circuit protection device

n) Conditional short-circuit current

o) Specification of the conductor type, as well as the largest and smallest conductor cross-sections, for which the connecting clamps are suitable

p) Length of the insulation that must be removed prior to inserting the conductor into the clamping unit

q) Minimum actuating radius and, if applicable, the maximum actuating radius for curved or pre-stressed actuators

r) Locking force F (preferred value: ≥ 1000 N)

   i. The prescribed guard-locking force F must be ≤ the force F_{Zh} determined by testing! (refer also to Point 5.18)

   ii. If the manufacturer specifies additional forces, these must be annotated only in the Operating instructions, but not on the device itself. The additional forces prescribed must be defined in the Operating instructions and the difference to the locking force F must be clearly stated.

s) Maximum actuating speed

t) The highest actuation frequency

u) The code level (low, medium, high in accordance with DIN EN ISO 14119) for coded interlocking devices

v) Specification of the B_{10d} value

w) For guard-locking devices with logic units (e.g. when using PDDB's according to DIN EN 60947-5-3), the following additional information must be included instead of the B_{10d} value, if applicable, in accordance with DIN EN ISO 13849-1 or DIN EN 62061:

- Category
- PL
- $MTTF_D$ or PFH or PFH_D
- SIL CL

Furthermore, the Operating instructions must contain the following information, insofar as applicable:

aa) Functional description

ab) Annotated remark, clearly distinguished from other text passages, signifying that the installation and operation must take into account, in particular, the requirements of DIN EN 14119, Section 7 "Design for minimizing defeat possibilities".

ac) Annotated reference to potential constraints on the service position, in particular with respect to anticipated functional disruptions when the device is used in a heavily contaminated environment.

ad) Annotated reference to potential constraints on the scope of application; in particular with respect to the influences due to contamination (e.g. by swarf, dust, fluids).

ae) Annotated reference to adequate mounting and definite fixation if the guard-lock attachment provides for adjustment.

af) Annotated remark that the guard-lock must not be used as a mechanical stop, if applicabl.

ag) If the guard-lock is suited for use as a mechanical stop according to manufacturer specifications: Specification of the degree of resistance to impact energy in J, or door mass and actuation speed, as well as specification of the maximum number of switching cycles (reduction of service life) dependent on the impact energy (e.g. as a derating curve).

ah) Notice that the point of access to the manual release must be tamper-proof sealed following assembly in order to prevent its use for normal operational purposes.

ai) For guard-locking devices with escape release: Annotated remark that the control actuator must be configured in such a manner that actuation is possible only from the escape side (danger zone).

aj) For guard-locks with emergency release: Annotated remark that the emergency release is to be installed and/or protected in such a manner that the inadvertent opening of the guard-lock is prevented.

ak) For guard-locks with an emergency release **and** in the event that application of the notice on the enclosure [see 5.2.1 n)] is not practicable:

Notice to the user when an emergency release is provided, it must be clearly marked to indicate that it be used only in the event of an emergency. This notice can be annotated on a separate placard and affixed in close proximity to the emergency release.

al) Scope of actuation system coverage (degree of mechanical freedom, such as angular offset).

am) Annotated remark that performance levels for series connected guard-locks/position switches may be reduced according to DIN EN 13849-1 due to decreased fault recognition.

an) Notice to the user that the overall control concept into which the guard-lock has been integrated must be validated in accordance with DIN EN ISO 13849-2 or evaluated in accordance with DIN EN 62061.

ao) Annotated remark that the availability of spare actuators and keys makes it possible to easily bypass the safety devices and, for this reason, the security of the spare actuators and keys must be effectively monitored. The same applies to keys used for resetting the emergency or escape release.

Test: Review of the technical documentation and comparison with the requirements; check for completeness, correctness and consistency of the information

5.4 Sales literature

Sales literature, in which the guard-lock is described, must not contradict the Operating instructions with respect to safety aspects.

If performance characteristics are described in the sales literature, these must agree with the specifications in the Operating instructions

Test: Review of the documents submitted; check for correctness and consistency

5.5 Requirements for construction and characteristics

DIN EN 60947-5-1, Section 7 shall apply (where applicable), including Section K.7, with the following amendments:

5.5.1 Regarding K.7.1.4.6.1, Types of contact elements:

The requirements of DIN EN 60947-5-1 are supplemented as follows:

Guard-locks using contact elements as output switching elements shall incorporate only positively opening contacts with additional make-contacts, e.g. for signalling purposes.

If the guard-lock is configured with C or Za-style change-over contacts and the break-contact is employed for a safety function, then the make-contact must not be occupied (not connected/clamped). The Operating instructions must contain an appropriate notice to this effect.

Test: Visual inspection of the prototype, review of the technical documentation; comparison with the requirements

5.5.2 In addition to DIN EN 60947-1, Section 7.1.10.1, guard-locks with metal enclosures must always be outfitted with a protective earth connection in the inner chamber. This also applies to guard-locks with metal enclosures supplied with low voltage. These must be outfitted with a protective earth connection in order to be able to detect a possible earth fault in the guard-lock when earthed auxiliary circuits are used.

Exception for guard-locks with Protection class III in metal enclosures:

Because guard-locks with Protection class III may not be configured with a protective conductor connection, design measures must be taken to prevent possible contact between the active components and the metal enclosure.

This can be achieved, for example, by fixing the connection cables and/or by the use of insulated lining in the electrical installation chamber.

Test: Visual inspection and measurement according to DIN EN 60204-1, Section 18.2.2

5.5.3 Fixing and alignment

It must be possible to clearly align and affix the guard-lock, or it must be pinned in place.

Test: Visual inspection

5.6 Requirements regarding the guard-locking function

5.6.1 Electromechanical guard-locks

5.6.1.1 Spring-force actuated locking elements

The locking element must be held in the locked position by spring force. The spring force may be substituted by the force of a permanent magnet, which cannot be reduced by simple means through external influence.

The spring force must be generated by guided helical compression springs.

Springs that hold the locking element in the locked position must be

- designed in such a manner that, in the event of spring fracture at the mid-point and complete intercoupling of the spring halves (worst-case assumption), a force is present to ensure that the locking system cannot assume the released state on its own.

  NOTE: *If springs are used that have a pitch between the spring coils in an unloaded state of less than the diameter of the wire, then the intercoupling of the spring halves following a spring fracture need not be taken into consideration.*

- designed to be fatigue resistant in accordance with DIN EN 13906-1.

  NOTE: „Fatigue resistant“ does not mean a fault exclusion for a „spring fracture“.

  Test: Trial testing and visual inspection; measurement of the spring coil pitch and comparison with the wire diameter, if applicable; simulation of a spring fracture, if necessary; check for verification of long-term reliability in accordance with DIN EN 13906-1

5.6.1.2 Solenoid actuated locking elements

The guard-locking device must operate as intended within the range from 85% to 110% of the rated operating voltage.

AC coils may be employed only if closure of the solenoid circuit is not impeded or an impermissible rise in temperature can be excluded.

Test: Visual inspection and operation of the guard-lock at 85% and 110% of the rated operating voltage

5.6.1.3 Guard-lock monitoring

Switch-On commands in response to a potentially hazardous situation must take effect only if the safeguard is in the safety position and the guard-locking device is in the locked position. This necessitates monitoring of the safeguard position and the locking element by means of safety-relevant sensors.

Monitoring of the safeguard position can be dispensed with if the locking element can only fall into the locked position when the moveable separating safeguard is in the closed state (fail-safe locking)

Test: Trial testing and visual inspection

5.6.2 Electromagnetic guard-locks

5.6.2.1 Guard-lock monitoring

The guard-locking force must be monitored in order to determine whether the specified locking force can be achieved and maintained.

Test: Trial testing and visual inspection

5.6.2.2 Measures for minimizing defeat possibilities

If the forced opening of a protective door can compromise the guard-locking function of an electromagnetic guard-lock, then it must be ensured that machine operation cannot be resumed immediately upon closure of the protective door.

Note: In contrast to mechanical guard-locks, electromagnetic guard-locks are not subject to damage through forced opening.

The forced opening of a guard-lock must result in the immediate interruption of the potentially hazardous machine function for a period of time correlating to a repair task comparable to that of a damaged electromechanical guard-lock.

This can be implemented by:

1) resetting only after a minimum of 10 minutes or
2) replacement or repair of the guard-lock

Test: Trial testing and visual inspection, time measurement

5.6.3 Auxiliary release of the guard-lock

5.6.3.1 Manual release

The manual release must be designed in such a manner that actuation is possible only by means of a tool or key, or that access to the manual release can be opened only by means of a tool. Release must be possible irrespective of the state of the solenoid.

Physical contact with live parts must not be possible during actuation of the manual release.

Resetting of the manual release must require deliberate action. The reset can be initiated either through the use of a tool or a key.

The point of access or actuation must be tamper-proof sealed after use.

Test: Trial testing and visual inspection, probing with a test finger, functional test (e.g. tool/key)

5.6.3.2 Emergency release

An emergency release must permit the deliberate opening of the safeguard without auxiliary means in the event of a hazardous situation.

If the guard-lock is outfitted with an emergency release, it must permit the deliberate opening of the safeguard without auxiliary means, irrespective of the operating state of the guard-locking device.

This mechanism must be manually operated and must positively act upon the locking element.

A guard-locking device outfitted with an emergency release must be designed in such a manner that actuation of the emergency release will result in blockage of the locking element in the released state.

Release of the blockage and restoration to the proper state must be possible only through tasks involving a substantial amount of time and/or material effort.

Examples of such material effort could be a deliberate resetting by an authorized person using special tools or a key, or requiring effort comparable to that of a repair.

Test: Visual inspection and functional test

5.6.3.3 Escape release

5.7 Requirements for minimizing defeat possibilities

Interlocking devices with guard-locking must be designed in such a manner that the safety function cannot be defeated by simple and predictable means.

The guard-lock must be designed in such a manner that closure of the safety-relevant contacts (break-contacts, OSSDs) by simply actuating the switch by hand or with readily available objects is not possible (e.g. through coding).

Examples of readily objects are:

- Screws, needles, sheet-metal blanks
- Everyday items, such as keys, coins, adhesive tape, packing twine and wire
- Tools (e.g. screwdriver, wrench, hexagonal spanner and pliers)
- Objects that can be easily assembled by hand without the use of other tools or appliances (e.g. wire formed by hand, manually formed sheet metal, folded paper).

Objects made especially for bypass-purposes that are fabricated only with tools or appliances requiring more than one work step are not considered to be readily available objects.

Note: *Spare actuators and other items are specified as readily available objects for bypassing in DIN EN 14119. This requirement is directed at the machine designer and/or operator. For type testing of a guard-lock, the actuator intended for use must not be used as an object for checking the capacity for bypassing.*

It must not be possible to loosen the guard-lock or actuator mounting elements by hand or with readily available objects.

If the manufacturer provides attachment screws for the guard-lock and/or actuator, these must be one-way screws.

Test: a) Attempt actuation by hand using readily available objects. The use of two identical objects is permissible if the design obviously allows for potential bypassing using two objects (e.g.: see Fig. 1).

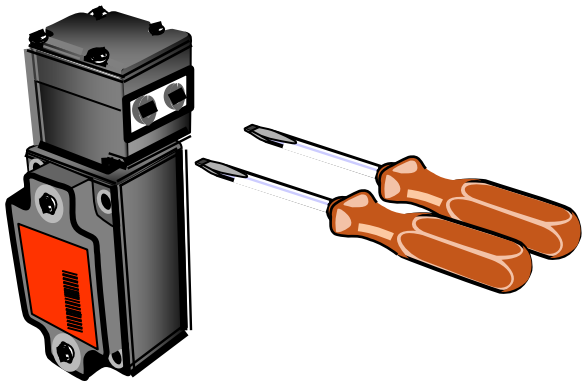

Fig. 1: Attempted actuation using two identical objects

It must not be possible to generate a release signal (e.g. closure of the break-contacts for position monitoring of the safeguard or locking element) during the test.

Note: A detailed knowledge of the design must not be a prerequisite for performing the test.

b) Visual inspection of the mounting elements provided.

5.7.1 Characteristics when using a non-integral actuator with individually coded guard-locks:

Actuation of the guard-lock (closure of the positively opening contact) must not be possible when a coded actuator is used, whose individual coding does not correspond exactly with the code on the guard-lock.

Test: One guard-lock from the four differently coded test specimens provided, as well as three actuators not corresponding to the selected guard-lock (different coding) are selected for testing. The actuators are introduced to the guard-lock at an axial orientation from all possible actuating directions at a maximum speed of 10 mm/min. The positively opening contact must not close and its proper function must remain warranted when subjected to a maximum force of 300 N.

5.8 Test sequence I according to DIN EN 60947-5-1, Section 8.3.1

5.8.1 Heating

Test: In accordance with DIN EN 60947-5-1, Section 8.3.3.3 with the following amendment:

The temperature of the electromagnetic actuating coil must not exceed the following limit values during testing under the conditions set forth in DIN EN 60947-1, Section 7.2.2:

Insulation class	Temperature limit
Y	90 °C
A	105 °C
E	120 °C
S	130 °C
F	155 °C
H	180 °C

5.8.2 Insulation properties

Guard-locks must be designed so that they are sufficiently voltage-stable even when exposed to the effects of moisture.

Test: In accordance with DIN EN 60947-5-1, Section 8.3.3.4 with the following amendments:

Contrary to DIN EN 60947-5-1 and based on DIN IEC 60068-2-78, the guard-lock should be stored in a test chamber for 48 hours at a temperature of 40 (± 2) °C and a relative atmospheric humidity of 93 (+2/-3) %. Following the storage period, an insulation test should be carried out in accordance with DIN EN 60947-1, Section 8.3.3.4.1, Subsection 3). Testing must take place within 3 minutes after removal from the test chamber.

Verification of surge voltage resistance is carried out subsequently in accordance with DIN EN 60947-1, Section 8.3.3.4.1, Subsection 2).

For Guard-locks with Protection class II, the test voltage for doubled or reinforced insulation must be chosen in accordance with DIN EN 60947-5-1, Section F.7.3.

5.8.3 Mechanical and electrical properties of connectors

5.8.3.1 **Test:** In accordance with DIN EN 60947-5-1, Section 8.2.4 with the following amendments:

Testing should be carried out only on guard-locks with external connecting clamps in accordance with DIN EN 60947-1, Sections 8.2.4.3 (bending test) and 8.2.4.4 (extraction test) . This testing can be dispensed with if the connecting clamps are located inside an enclosed casing foreseen for the connection of sheathed wiring. In this case, the guard-lock must be outfitted with effective strain-relief for the connection wiring.

For screwless clamping units: A review of the clamping unit documentation is sufficient if the clamping units used have been tested in accordance with DIN EN 60999-1.

5.8.3.2 Guard-locks with integrated connection wiring will additionally be subject to the requirements of DIN EN 60947-5-1 Annex G.

Test: In accordance with DIN EN 60947-5-1, Annex G.8

5.8.3.3 The space provided for the supply lines and the protective earth lead must be dimensioned so that wire routing and connection is possible with little difficulty and so that proper positioning can be checked prior to closure.

Test: Visual inspection

5.9 Test sequence II according to DIN EN 60947-5-1, Section 8.3.1

5.9.1 Making and breaking capacity of switching elements under normal conditions

Test: In accordance with DIN EN 60947-5-1, Section 8.3.3.5.2

5.9.2 Verification of insulation

Test: In accordance with DIN EN 60947-5-1, Section 8.3.3.5.5.b.

For Guard-locks with Protection class II, the test voltage for doubled or reinforced insulation must be chosen in accordance with DIN EN 60947-5-1, Section F.7.3

5.10 Test sequence III according to DIN EN 60947-5-1, Section 8.3.1

5.10.1 Making and breaking capacity of switching elements under abnormal conditions

Test: In accordance with DIN EN 60947-5-1, Section 8.3.3.5.3

5.10.2 Verification of insulation

Test: In accordance with DIN EN 60947-5-1, Section 8.3.3.5.5.b.
For Guard-locks with Protection class II, the test voltage for doubled or reinforced insulation must be chosen in accordance with DIN EN 60947-5-1, Section F.7.3

5.11 Test sequence IV according to DIN EN 60947-5-1, Section 8.3.1

5.11.1 Characteristics with conditional short-circuit current

Test: In accordance with DIN EN 60947-5-1, Section 8.3.4.
Positively opening break-contacts should be tested in accordance with Section K.8.3.4

5.11.2 Functional capabilities and verification of insulation following testing

Test: In accordance with DIN EN 60947-5-1, Section 8.3.3.5.5.b for positively opening contacts in connection with K.8.3.4.4.1.

For Guard-locks with Protection class II, the test voltage for doubled or reinforced insulation must be chosen in accordance with DIN EN 60947-5-1, Section F.7.3

5.12 Test sequence V according to DIN EN 60947-5-1, Section 8.3.1

Note: These tests are carried out subsequent to the mechanical testing (see Section 5.16).

5.13 Test sequence VI according to DIN EN 60947-5-1, Section 8.3.1

5.13.1 Measurement of air gaps and creepage distances

DIN EN 60947-5-1, Section 7.1.4. applies.

The air gaps and creepage distances between adjacent contact elements must also be maintained during the switching operation.

Test: Measurement of air gaps and creepage distances, comparison with minimum values

5.14 Test sequence VII according to DIN EN 60947-5-1, Section 8.3.1

5.14.1 Mechanical function at temperature limits

Test: In accordance with DIN EN 60947-5-1, Section K.8.3.5

5.14.2 Verification of positive opening operation

5.14.2.1 Guard-locks must be designed so that the mechanical aspects of the positively opening break contacts will reliably open and remain open as long as the actuator remains outside the guard-lock.

Automatic actuation must take place via a positive-locking fit (without elastic means, such as springs) over the entire distance between the position where actuation force is applied to the actuator and the moveable, positively opening break contacts.

Test: In accordance with 5.14.2.6

5.14.2.2 The area in which the positively opening electrical contacts are located must be designed in such a manner that even in the event of mechanical failure of an element, such as due to a spring fracture or loosening of the contact bridge, the break contacts will still reliably open and remain in the open position. Bridging caused by individually detached or displaced components must not be possible. The minimum value for switching travel (verified by surge voltage testing) must also be maintained, even under fault conditions.

Test: In accordance with 5.14.2.6

5.14.2.3 Guard-locks must be designed in such a manner that their proper function is not impaired by actuation from the least favourable actuation angles.

If the manufacturer specifies the maximum actuation angle, this will be used for testing.

Test: In accordance with 5.14.2.6

5.14.2.4 Fail-locking protection must be designed in such a manner that its proper function is not impaired by presumed mechanical component faults.

Refer to DIN EN ISO 13849-2, Annex A.5 for presumed faults and fault exclusions.

Test: In accordance with 5.14.2.6

5.14.2.5 The spring force on safety-relevant springs used for actuation of guard-locks (e.g. radius actuators) must be generated by compression springs. Moreover, the springs must be designed for permanent reliability in accordance with DIN EN 13906-1.

Test: In accordance with 5.14.2.6

5.14.2.6 Tests related to 5.14.2.1 to 5.14.2.5

Visual inspection and assessment of the entire actuating system with reference to the prototypes and technical documentation; if applicable, fault simulation followed by surge voltage testing in accordance with DIN EN 60947-5-1, Section K.8.3.6; comparison with the requirements.

5.15 Test sequence VIII according to DIN EN 60947-5-1, Section 8.3.1 − Verification of actuation system strength

Test: In accordance with DIN EN 60947-5-1, Section K.8.3.7 with the following amendment:

The test can also be performed by blockage of the contact element in the closed state and application of F2 ≥ 10 N to the plunger or actuating system.

5.16 Mechanical strength

Guard-locks must possess sufficient mechanical strength with respect to expected operational demands when used as intended, such as jolting, shock or impact.

Test: Individual testing in accordance with 5.16.1 to 5.16.3

General evaluation criteria following each individual test:

1. It must not have become possible to physically touch active electrical components.
2. Components must not have detached or loosened to the point that security of the position switch is impaired.
3. Damage must not have occurred that could influence the function, safety or proper mounting.
4. Proper function must remain completely warranted.

5.16.1 Vibration test

Guard-locks are subjected to constant oscillation amplitudes within a prescribed frequency range in their potential usage positions and on all three axes, in-turn, in accordance with Table 1, Component test I.

The devices are operated with voltage applied and the contacts in the open position while testing is being carried out. Contact making should not occur during testing.

The monitoring equipment must be capable of detecting any closure of the contacts exceeding 0.2 ms in duration. The evaluation criteria according to 5.16 must have been fulfilled subsequent to testing.

5.16.2 Shock test

5.16.2.1 Contacts remaining open

The guard-lock will be subjected to mechanical shocks at the permissible service positions, in-turn, whereby

a) according to Table 1, Component test II, the shocks are not continuously recurring

and

b) according to Table 1, Component test III, the shocks are continuously recurring.

The devices are operated with voltage applied and the contacts in the open position while testing is being carried out. Contact making should not occur during testing.

The monitoring equipment must be capable of detecting any opening or closing of the contacts exceeding 0.2 ms in duration.

The evaluation criteria according to 5.16 must have been fulfilled subsequent to testing.

5.16.2.2 Guard-locking of locking elements

The guard-lock will be subjected to mechanical shocks at the permissible service positions, in-turn, whereby, according to Table 1, Component test II, the shocks are not continuously recurring.

The devices will be operated in the locked position during testing. The guard-locked function must not be defeated by the test.

On guard-locking devices with separate actuators (design variant 2), the actuator will be pre-tensioned during testing at 5 N ± 20 %.

Component test	
I. Continuous vibration: Test standard Frequency range Amplitude Frequency cycle count Throughput speed	 DIN EN 60068-2-6 10 - 150 Hz (0.35 mm/5 g) ± 15 % at the reference point 20 1 octave/min
II. Shock 1: Test standard Type of shock Shock amplitude Shock duration Number of shocks	 DIN EN 60068-2-27 Half-sine wave 30 g 11 ms 3 ± 0 (in both directions per axis)
III. Shock 2: Test standard Type of shock Shock amplitude Shock duration Shock sequence Number of shocks	 DIN EN 60068-2-27 Half-sine wave 10 g 16 ms (1-3)/s 1000 ± 10 (in both directions per axis)

Table 1: Minimum requirements for vibration and shock loading

5.16.3 Impact test

Following exposure of the guard-lock to a temperature of -25 °C ± 2 K for three hours, the weak points on the enclosure and the accessible components of the actuation system must be subjected to a one-time impact loading of 1 Nm using an impact testing device according to DIN EN 60068-2-75. The test must be completed no later than 3 minutes following removal of the test object from the low-temperature cabinet.

The evaluation criteria according to 5.16 must have been fulfilled subsequent to testing.

5.17 Test of Protection class and actuating force

5.17.1 Protection class for enclosed guard-locking devices

Compliance with the Protection class prescribed by the manufacturer must be verified by testing. The tests are to be carried out on prototypes which have been subjected to testing according to 5.16.

Test: Testing of the Protection class is in accordance with DIN EN 60947-1, Annex C.

Protection class II guard-locks insulated by means of socketed encapsulation are additionally subject to the requirements and tests according to DIN EN 60947-5-1 Annex F. The tests specified should be carried out on a dedicated prototype according to Annex F.

5.17.2 Verification of actuating force or moment

Test: In accordance with DIN EN 60947-5-1, Section 8.2.5.

5.18 Guard-locking force

Interlocking devices with guard-locking must be designed in such a manner that the forces occurring (e.g. tensile or transverse forces, etc.) will not result in failure of the guard-locking function.

The examiner must be able to identify the forces occurring and/or the direction of effective exposure with proper usage, which could result in failure of the guard-locking function. A test of the locking force and its direction of effective exposure is to be carried out for each of these forces.

Note: *This means that in cases where the direction of safeguard (door) opening differs from the direction of actuator movement, for example, testing of the locking force should be carried out at least from these two directions.*

With respect to Point 5.2.1, the manufacturer must specify a locking force F on the enclosure, which must be ≤ the locking force F_{Zh} as determined by the following test:

Test: Contrary to the prescribed testing sequence, the test must be performed on an unused test object in as-new condition. The guard-lock must be properly attached to a base. The guard-lock is subsequently loaded by movement of the locking element at the maximum actuating angle and at a constant speed in the direction "Safeguard open" until failure of the locking function. The maximum force F_{max} will be measured along the deformation pattern during load application.

Evaluation: The guard-locking force F_{Zh} will be determined based upon the maximum force F_{max} measured during testing, with inclusion of the safety coefficient S according to the following formula:

$$F_{Zh} = \frac{F\,\max}{S}$$

Safety coefficient for electromechanical guard-locks: S = 1.3

Safety coefficient for electromagnetic guard-locks: S = 1.1

Requirements related to test equipment:

Tensile velocity: constant 10 mm/min. (± 2.5 %)

Requirements related to force measurement equipment:

Sampling rate: ≥ 10 Hz)

Measurement accuracy at maximum force: ± 2.5 %

5.19 Mechanical service life

The number of switching cycles to be tested will be determined by manufacturer specifications. This must equate to at least 10^6 switching cycles.

The guard-lock must not be used as a mechanical stop during testing.

Test: Testing of mechanical service life must be verified on complete guard-locks in as-new condition at the approach speeds prescribed by the manufacturer. The test method is based upon DIN EN 60947-5-1, Annexes C.1.2 and C.1.3.

One switching cycle comprises the following steps:

1. The actuator is introduced to the guard-locking device
2. The locking element automatically locks or is appropriately triggered
3. The locking element is released
4. The actuator is withdrawn.

The actuator must be introduced at the maximum possible actuation angle for this test. Actuation must be carried out from the least favourable approach direction.

Following load application, proper functioning of the guard-lock must be warranted and it must be able to withstand at least the locking force as prescribed by the manufacturer (≤ F_{Zh} from Point 5.18) in the locked position.

Test: The guard-lock must be properly attached to a base. The guard-lock is subsequently loaded by movement of the locking element at the maximum actuating angle and at a constant speed in the direction "Safeguard open" until failure of the locking function. During loading, the maximum force (F_{max}) will be measured along the deformation pattern. This force must be ≥ F_{Zh}.

Requirements regarding testing equipment and the force measuring device: see Point 5.18.

5.20 Impact energy

Note: This test must be performed only if the guard-lock is suitable for use as a mechanical stop according to manufacturer specifications.

The number of switching cycles to be tested will be determined by manufacturer specifications.

If the switching cycle count specified by the manufacturer for use as a mechanical stop is identical to the switching cycle count specified for the mechanical service life, then it is permissible to verify both requirements with one combined test.

Test: Testing must be performed on complete guard-locks in as-new condition with a mass and speed corresponding to the max. impact energy.

If the manufacturer specifies a max. mass and max. speed, then testing is to be performed using these values. The test method is based upon DIN EN 60947-5-1, Annexes C.1.2 and C.1.3.

One switching cycle comprises the following steps:

1. Actuator approaches the guard-lock up to the stop
2. Actuator withdrawn from the guard-lock.

The actuator must be introduced at the maximum possible actuation angle for this purpose. Actuation must be carried out from the least favourable approach direction.

Following load application, proper functioning of the guard-lock must be warranted and it must be able to withstand at least the locking force as prescribed by the manufacturer (≤ FZh from Point 5.18) in the locked position.

Test: The guard-lock must be properly attached to a base. The guard-lock is subsequently loaded by movement of the locking element at the maximum actuating angle and at a constant speed in the direction "Safeguard open" until failure of the locking function. During loading, the maximum force (F_{max}) will be measured along the deformation pattern. This force must be ≥ F_{Zh}.

Requirements regarding testing equipment and the force measuring device:
see Point 5.18.

5.21 Determination of the B_{10D} value

5.21.1 DIN EN 60947-5-1, Section 8.1.5., as well as Annex N apply.

Testing is to be carried out on at least 10 test specimens.

The utilization categories AC15 and/or DC13 must be taken into consideration when verifying the electrical service life of positively opening contacts used in a functional safety capacity. The manufacturer may specify a current (I_{e2}) which diverges from I_e.

In this case, the rated current I_{e2} diverging from I_e for the purpose of functional safety must also be specified in the Operating instructions. The requirements of utilization categories AC15 and/or DC13 shall remain unaffected.

Test: Review of the documents submitted; check for plausibility and consistency.

5.22 Guard-locking devices with logic units

5.22.1 Fault characteristics

On guard-locking devices with logic units, testing must be carried out to determine whether the safety-related parameters as prescribed by the manufacturer have been fulfilled in accordance with DIN EN ISO 13849-1 or DIN EN 62061. In so doing, the various guard-lock circuit options as prescribed by the manufacturer must be considered.

Test: Validation according to DIN EN ISO 13849-1 and DIN EN ISO 13849-2 or evaluation according to DIN EN 62061.

Validation must confirm the performance level or SIL CL as prescribed by the manufacturer.

NOTE: When applying DIN EN 62061 and when complex structural elements are used, the requirements found in DIN EN 61508 shall apply (refer also to -DIN EN 62061, Section 6.7).

5.22.2 Additional requirements for semiconductor switching elements used in control units

Test: In accordance with DIN EN 60947-5-1, Annex H.

5.23 Testing of resistance against exceptional heat and fire

DIN EN 60947-5-1, Sections 7.1.2.1 and 8.2.1.1 apply, whereby the “heat-filament testing“ process according to DIN EN 60947-5-1, Sections 7.1.2.2 and 8.2.1.1.1, as well as Table 6 are utilized.

Note: Footnote „b“ in Table 6 is not taken into consideration.

Test: In accordance with DIN EN 60947-5-1, Section 8.2.1.1.1 in agreement with DIN EN 60695-2-10 to DIN EN 60695-2-13.

5.24 External materials and properties

5.24.1 No materials containing substances harmful to health may be used on any part of the guard-lock that comes in regular contact with the operator's skin (e.g. door handles, knobs, actuators for escape release).

Test: Review of the safety data sheets for the materials used.

Use the procedure comparable to the German Product Safety Commission GS specification, AfPS-GS-2014:01 PAK (or the valid version at the time of testing) to check the amount of polycyclic aromatic hydrocarbon (PAH). The PAH value determined must not exceed the limit value as a function of contact duration.

5.24.2 Unit components accessible by hand must have no sharp corners or edges, or abrasive surfaces that can cause injury. Corners and edges must be deburred with surfaces smooth to the touch.

Test: Handling and visual inspection.

5.25 Electromagnetic compatibility (EMC)

DIN EN 60947-5-1, Section 7.3 applies.

Test: In accordance with DIN EN 60947-5-1, Section 8.4.

Contrary to these requirements, guard-locking devices with logic units used in safety-relevant applications must fulfil the requirements related to Immunity to interference found in DIN EN 60947-5-3, Section 7.3.3.

Test: see DIN EN 60947-5-3, Section 7.3.3