

## ***Translation***

Principles of testing and certification for  
interlocking devices with solenoid guard-locking  
Status as of 2011-02

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 in connection with DIN EN 60947-5-1.

These principles will be revised and supplemented periodically in consideration of knowledge gained in the area of occupational health and safety, as well as technical progress. The most recent edition shall always be binding for tests conducted by the testing and certification body of the committee for "electrical engineering".

These Principals of testing comprise the necessary requirements and tests found in DIN EN 60947-5-1 for solenoid guard-locking devices and supplements these with additional requirements.

**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 solenoid guard-locking as a modular unit for safety-relevant applications (henceforth referred to as "interlocks").

### 1.2 Functional description

Guard-locking devices with position monitoring have the function of holding down moveable safeguards 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-locking devices with position monitoring should ensure that moveable safeguards employed in conjunction with a machine's control-related component cannot be opened until the hazard-producing condition (such as run-on motion) has ceased. Position monitoring of the protective door and/or position monitoring of the locking element can also take place by means of PDF in accordance with DIN EN 60947-5-3.

### 1.3 Technical rules

These principles of testing are based upon:

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

DIN EN 1088	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) Part 2-10 to Part 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) 2008-04	Low-voltage switchgear and controlgear; Part 1: General requirements
DIN EN 60947-5-1 (VDE 0660-200) 2010-04	Low-voltage switchgear and controlgear; Part 5-1; Control units and switching elements, Electromechanical control circuit devices
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 (PDF)
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; Test Ea and guidance: Shocks
DIN EN 60068-2-75	Environmental testing; Part 2: Tests; Test Eh: 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 <sup>1)</sup>	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

<sup>1)</sup> Note: *Besides DIN EN ISO 13849-1, the presumption of conformity according to RL 2006/42/EC still exists for DIN EN 954-1, which is time-limited to 31 Dec. 2011. Therefore, for contractual agreements with the applicant within the context of these principles of testing, DIN EN 954-1 may still be applied until 31 Dec. 2011.*

## **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**     **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 passed through the positive opening travel with the force specified by the manufacturer.

### **2.3**     **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).

### **2.4**     **Guard-locking**

A device with the purpose of holding a separating safeguard in the closed position and which is 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.

### **2.5**     **Faulty-closure protection**

A device on a guard-lock, which ensures that the guard-locking mechanism is able to assume its locked position (safeguard held closed) only after the safeguard is located in the safety position.

## **2.6 Manual release**

Provides a means of manually releasing a guard-locking device by means of a tool or key from the access side (outside the danger zone) in the event of its failure.

## **2.7 Escape release**

Provides a means of manually releasing a guard-locking device without auxiliary means from the escape side in order to evacuate the hazardous area (danger zone).

## **2.8 Emergency release**

Provides a means of manually releasing a guard-locking device without auxiliary means from the access side (outside the danger zone) in the event of danger. Release of the blockage and restoration of the operationally ready state must require the time and effort comparable to that expended on a repair.

## **2.9 Bypassing by simple and predictable means**

Bypassing by simple and predictable means is the rendering ineffective of a guard-locking device, either manually or through the use of a readily available object.

Readily available objects can be:

- Screws, needles, sheet-metal blanks,
- Items used everyday, such as keys, coins, adhesive tape, pack-twine and wire,
- Spare actuators,
- Tools that are required for the intended use of the machine or those that are readily available (e.g. screw driver, wrench, hexagonal spanner and pliers).

"Bypassing by simple and predictable means" encompasses the removal of guard-locks or their actuation by means of the tools list above with the intent of rendering an interlocking device ineffective.

## **2.10 Positive opening travel**

Minimum travel from the beginning of actuator actuation to the position, at which the positive opening of the contacts being opened has ended.

### **5.11 Mechanical service life**

The 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.

### **2.12 Logic unit**

An assembly intended for use in the safety-related parts of control systems and employed solely, or among other functions, for the implementation of safety functions.

The logic unit

- receives and processes information from the sensors (e.g. PDF) and generates signals for the output signal switching device (OSSD),
- monitors the sensors and OSSD.

### **2.13 PDF**

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

## **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 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 the technical test:

- All user information supplied with the device (instruction manual, assembly instructions, etc.),
- Sales literature (if available),
- Overview of the usable actuators for the guard-locking device,
- Block circuit diagram (if necessary),

- 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 devices and/or the parts it comprises,
- Insofar as a  $B_{10d}$ -value is specified, which is larger than the typical values listed in DIN EN ISO 13849 Table C.1, all test reports, test certificates and calculations, which were used in its determination, must be provided (also see Section 5.19).-
- For guard locking devices with logic units (e.g. with the use of PDF according to DIN EN 60947-5-3):
  - Single fault analysis (e.g. FMEA)
  - Fault combination analysis (e.g. FTA)
  - Component failure rate, if available
  - Software documentation, if applicable.

The testing facility can request further documents if necessary.

## 4.2 **Prototype**

The number of prototypes to be submitted will be determined by the testing body. As a rule, at least three prototypes should be made available.

In the event already assembled printed circuit boards are used, a set of bare circuit boards should be submitted.

## 5 **Tests**

### 5.1 **General test requirements**

Interlocking devices with guard-locking, henceforth referred to as "guard-lock(s)", must satisfy all of the following requirements. Execution of the tests in the specified sequence serves as confirmation that the specified requirements have been complied with. A test object must not fail any of the tests.

Fulfilment of farther reaching 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, the proper functioning of the guard-lock must be ascertained prior to the initial test, and subsequent to each individual test.

Where guard locking devices are used by PDF's, the tests according to DIN EN 60947-5-3 must also be carried out. Fault characteristic tests differ from those of DIN EN 60947-5-3 are a carried out in accordance with DIN EN ISO 13849-1, with validation in accordance with DIN EN ISO 13849-2 (also see the remarks in Section 1.3).

Guard-locking devices with logic units must additionally be tested in accordance with DIN EN ISO 13849-1 and must be validated in accordance with DIN EN ISO 13849-2 (also see the remarks in Section 1.3).

## 5.2 Labels and markings

Each guard-lock must be provided with at least the following durable and easily legible markings (minimum font height = 2 mm):

### 5.2.1 On the enclosure (externally):

- Manufacturer's/authorised representative's name and complete address,
- Nomenclature of the safety component,
- Design series or type designation,
- CE-marking,
- Year of manufacture,
- Symbol (positive opening),
- IEC 60947-5-1 or DIN EN 60947-5-1, in the event the manufacturer claims conformity with this standard,
- IP-Protection class,
- Guard-locking force  $F$  (preferred value:  $\geq 1000$  N),  
The prescribed guard-locking force  $F$  must be  $\leq$  the force  $F_{Zh}$  determined by testing (also see Point 5.17 in this context)!
- Change-over contact elements must be marked with the relevant symbols for the form  $Z_a$  or  $Z_b$  in accordance with DIN EN 60947-5-1, Fig. 4.

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 casing.

The markings must be readable without the removal of coverings from the product.

**Test:** See Point 5.2.2.

## 5.2.2 On the switch mechanism

Terminal marking

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

<sup>\*)</sup>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 60950-1, should be used as test fluid.

## 5.3 Instruction manual

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 Instruction manual is not in German, a German translation must be provided.

The test will be conducted with reference to the German translation.

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

- Manufacturer's/authorised representative's name and complete address,
- Designation of the safety component (e.g. guard-lock)
- Rendering of the content found in the Declaration of Conformity (except for serial number and signature),
- General description of the guard-lock and its intended usage,
- Instructions for assembly, installation and connection of the guard-lock,
- Maintenance procedures and setting instructions (if necessary),
- Description of fault characteristics (if necessary),
- Rated operating voltages,
- Usage category and rated operating current(s) at the rated operating voltage(s),
- Rated insulation voltage,
- Rated surge voltage resistance,
- Type and highest rated values of the short-circuit protection device,
- Specification of the conductor type, as well as largest and smallest conductor cross-sections, for which the terminals are suitable,

- Minimum actuating radius and, if applicable, the maximum actuating radius for curved or pre-stressed actuators,
- Guard-locking force  $F$  (preferred value:  $\geq 1000$  N);  
The prescribed guard-locking force  $F$  must be  $\leq$  the force  $F_{Zh}$  determined by testing (also see Point 5.17 in this context)!  
If the manufacturer provides additional force values, these must be prescribed only in the Instruction manual and not on the device. The additional forces prescribed in addition must be defined in the Instruction manual and the difference to the guard-locking force  $F$  must be clearly stated.
- Maximum actuating speed,
- Maximum actuation frequency,
- Specification of the  $B_{10d}$  value,
- For guard-locking devices with logic units (e.g. when used by PDF's according to DIN EN 60947-5-3), the following additional information must be included instead place of the  $B_{10d}$  value in accordance with DIN EN ISO 13849-1 (also see the remarks in Section 1.3):
  - Category
  - PL
  - $MTTF_d$  or PFH
  - Response time (corresponding to Section 5.20.1)

Furthermore, the Instruction manual must contain the following information, where applicable:

- Functional description and terminal connection diagram,
- Annotated reference, clearly distinguished from other text passages, signifying that the installation and operation must take into account the requirements of DIN EN 1088; in particular Section 5.7 „Design for minimizing defeat possibilities“.
- 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.
- 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).
- Annotated reference to adequate mounting and definite fixation if the guard-lock attachment provides for adjustment.
- Notice that the guard-lock must not be used as a mechanical stop.
- Notice that the point of access to the manual release must be sealed following assembly in order to prevent its use for operational purposes.

- For guard locking devices with escape release: Notice that the control actuator must be configured in such a manner that actuation is possible only from the escape side (danger zone).
- Annotated notice that the installation of actuator mounting elements must protect against potential dismantling, such as through welding, rivets, one-way screws, adhesive bonding and bored screw heads.
- Notice that performance levels according to DIN EN 13849-1 may be reduced with series connected guard-locks/position switches due to decreased fault recognition.
- 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.

The additional information provided in DIN EN 60947-5-1, Sections 5.1 and K.5.4 may also be included in other manufacturer documentation not supplied with the device.

**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 Instruction manual with respect to safety aspects.

If performance characteristics are described in the sales literature, these must agree with the specifications in the Instruction manual.

**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 supplements:

### **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 output switching elements must contain only positively opening contacts with additional make-contacts, such as 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 Instruction manual must contain an appropriate reference to this effect.

**Test:** Inspection of the prototype and technical documentation; comparison with the requirements.

**5.5.2** In addition to DIN EN 60947, Section 7.1.9.1, guard-locks with metal enclosures must always be outfitted with a protective earth connection in the inner chamber. This applies to guard-locks with metal enclosures, which are supplied with low voltage, as well. They 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.

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

### **5.5.3 Fixing and alignment**

Guard-locks must be able to be positively aligned and fixed or pinned.

**Test:** Visual inspection.

## **5.6 Requirements related to the guard-locking function**

### **5.6.1 Spring-operated guard locking device**

Spring-operated guard locking devices 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 external influence by simple means. The spring force must be generated by guided compression springs.

Springs, which hold the locking element in the locked position, must be designed in such a manner that, in the event of spring breakage 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 accord.

Tried-and-tested springs must be designed in accordance with the principles of DIN EN ISO 13849-2, Annex A.3 (Table A.5 in conjunction with Tables A.1 and A.2).

Furthermore, the spring must be of durable design according to DIN EN 13906-1.

**Test:** Actual trial and visual inspection; measurement of the coil distance and comparison with the wire diameter, accordingly; simulation of spring breakage, as necessary.

### 5.6.2 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 solenoid state.

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

The manual release must reset automatically when the tool or key is removed, or the manual release must remain in the safe position.

The access and/or actuating point must permit sealing following mounting/adjustment.

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

### 5.6.3 Emergency release

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

If the guard-locking device 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 device must be manually operated and must positively act upon the locking element.

The 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 from 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 means of special tools or resetting by means of a key by an authorized person, or by effort comparable to that expended on a repair.

**Test:** Visual inspection and functional test.

#### **5.6.4 Escape release**

An escape release must permit the deliberate opening of the safeguard without auxiliary means irrespective of the operating state.

The escape release must be manually operated and must act positively upon the locking element.

The guard-locking device outfitted with an escape release must be designed in such a manner that actuation of the escape release will result in blockage of the locking element from the released state. The control actuator of the escape release must be configured in such a manner that actuation is possible from the escape side.

**Test:** Visual inspection and functional test.

#### **5.6.5 Electromagnetic actuation of the guard-lock**

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, such as due to obstruction of the locking element during safeguard movement.

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

#### **5.6.6 Switch-On commands related to hazardous states may take effect only if the safeguard is in the safety position and the guard-locking device is in the locked position. This necessitates position monitoring of the safeguard and the locking element by means of safety-relevant sensors.**

The sensor for monitoring the safeguard position (e.g. position switch) can be dispensed of if the guard-locking device is outfitted with faulty closure protection.

## 5.7 Requirements for minimizing defeat possibilities

Guard-locks intended for safety functions must be designed in such a manner that the safety function cannot be defeated by simple and predictable means.

Where safeguard position monitoring is carried out by a design variant 2 position switch, the guard-lock must be designed in such a manner that the closure of a break-contact by simple mechanical switch actuation, by hand or with readily available objects, is not possible (e.g. through coding).

Readily available objects are, for example:

- Screws, needles, sheet-metal blanks,
- Items used everyday, such as keys, coins, adhesive tape, pack-twine and wire,
- Tools (e.g. screw driver, 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, among other items, are listed as readily available objects for bypassing in DIN EN 1088:2008-10, Section 5.7.1. This requirement is directed at the machine designer or operator. For the type test of a guard-lock, the actuator intended for use must not be used as an object for checking bypassing capacity.*

It must not be possible to loosen 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 with two objects (e.g.: see Fig. 1).

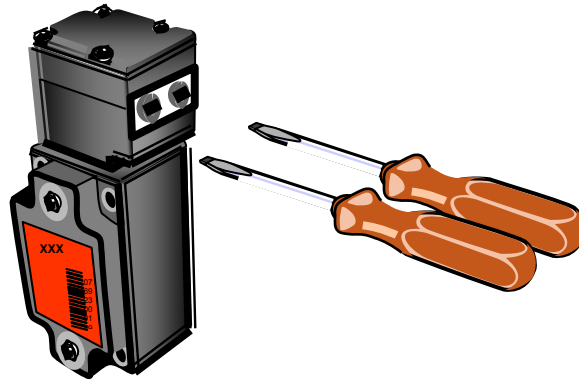


Fig. 1: Trial actuation with two identical objects

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

*Note: Detailed knowledge of the design must not be assumed during the test.*

- b) Visual inspection of the mounting elements provided.

## 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 supplements:

The excess 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	Excess temperature limit
Y	50 K
A	65 K
E	80 K
B	90 K
F	115 K
H	140 K

### 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 changes:

Differing from DIN EN 60947-5-1 and based upon DIN IEC 60068-2-78, the guard-lock should be stored in a test chamber for 48 hours at a temperature of 40 ( $\pm 2$ ) °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). The test must take place within 3 minutes of the removal from the test chamber.

Verification of surge voltage resistance takes place 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 properties of connectors**

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

The tests according to DIN EN 60947-1, Sections 8.2.4.3 (bending test) and 8.2.4.4 (extraction test) should be carried out only on guard-locks with external terminal connections. If the terminal connections are located within an enclosed casing foreseen for the connection of light plastic-sheathed wiring, these tests can be dispensed with. In this case, the guard-lock must be outfitted with effective strain-relief for the connection wiring.

#### **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 the test

**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

### 5.12.1 Protection class for enclosed guard-locking devices

Compliance with the protection class prescribed by the manufacturer must be verified by testing.

**Test:** Test the protection class 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.

### 5.12.2 Verification of actuating force or moment

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

## 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 7.1.2.2 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

**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 breakage of a spring or loosening of the contact bridge, the break contacts will still reliably open and remain in the open position. Bridging caused by individual detached or displaced components must not be possible. The minimum value for switching travel (verified by the surge voltage test) 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 at the least favourable actuation angles.

**Test:** In accordance with 5.14.2.6.

**5.14.2.4** Faulty closure protection must be designed in such a manner that its proper function is not impaired by assumed mechanical component faults.

For assumed faults and fault exclusions, refer to DIN EN ISO 13849-2, Annex A.5.

**Test:** In accordance with 5.14.2.6.

**5.14.2.5** The spring force of safety-relevant springs used for actuation of guard-locks (e.g. radius actuators) must be generated by compression springs. Furthermore, they must be designed for permanent reliability according to 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 test according to 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 supplements:

The test can also be performed by blockage of the contact element in the closed state and application of  $F_2 \geq 10 \text{ N}$  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 test 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 impairment of position switch safety results.
3. Damage must not have occurred, which could influence the function, safety or proper mounting.

4. The test object must still fulfil the requirements of the protection class prescribed in the Instruction manual with regard to the infiltration of dust, solid objects and water.
5. The intended function must still be maintained in all aspects.

### **5.16.1 Vibration test**

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

The devices are operated under voltage with the contacts in the open position while the test is being carried out. No contact should be made during the tests.

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

Subsequent to the test, the evaluation criteria must have been fulfilled according to 5.16.

### **5.16.2 Shock test**

#### **5.16.2.1 Contacts remaining open**

The guard-locks will be subjected in-turn to mechanical shocks in the permissible service positions, 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 under voltage with the contacts in the open position while the test is being carried out. No contact should be made during the tests.

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

Subsequent to the test, the evaluation criteria must have been fulfilled according to 5.16.

### 5.16.2.2 Holding locking elements closed

Guard-locks will be subjected to mechanical shocks in-turn in each of the permissible service positions; whereby according to Table 1, Component test II, the shocks are not continuously recurring.

During execution of the test, the devices will be operated in the guard-locked position. 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  $5 \text{ N} \pm 20 \%$ .

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 $\pm$ 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 $\pm$ 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 $\pm$ 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  $-25\text{ °C} \pm 2\text{ K}$  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.

Subsequent to the test, the evaluation criteria must have been fulfilled according to 5.16.

### 5.17 Guard-locking force

The guard locking device must withstand at least the locking force  $F$  as prescribed by the manufacturer while in the locked position.

In accordance with Point 5.2.1, the manufacturer must state a locking force on the enclosure, which must be  $\leq$  the locking force  $F_{Zh}$  as determined by the following test.

**Test:** The guard locking device must be properly attached to a base. The guard-locking device will be subsequently loaded by movement of the locking element at the maximum actuating angle at a constant speed in the direction "open safeguard" until failure of the locking function. During loading, the maximum force  $F_{1\max}$  will be measured along the deformation pattern.

**Evaluation:** Based upon the maximum force  $F_{1\max}$  measured during the test, the locking force  $F_{Zh}$  will be measured with inclusion of the safety coefficient  $S$  according to the following formula:

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

Safety coefficient:  $S = 1.3$

Requirements regarding testing equipment:

Tensile velocity: Constant 10 mm/min. ( $\pm 2.5\%$ )

Requirements regarding force measurement equipment:

Sampling rate:  $\geq 10\text{ Hz}$ )

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

*Note: the test must be carried out on a prototype in as-new condition.*

## 5.18 Mechanical service life

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

**Test:** Testing of mechanical service life must be verified on complete guard-locks 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 inserted into the guard-locking device,
2. The locking element locks automatically or is triggered accordingly,
3. The locking element is released,
4. The actuator is withdrawn.

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

Following loading, proper functioning of the guard-locking device must be warranted and, in the locked position, it must be able to withstand at least the locking force ( $\leq F_{Zh}$  from Point 5.17) as prescribed by the manufacturer.

**Test:** The guard locking device must be properly attached to a base. The guard-locking device will be subsequently loaded by movement of the locking element at the maximum actuating angle at a constant speed in the direction "open safeguard" until failure of the locking function. During loading, the maximum force  $F_{2max}$  will be measured along the deformation pattern. This force must be  $\geq F_{Zh}$ .

Requirements regarding testing equipment and force measurement apparatus: see Point 5.17).

## 5.19 Determination of the $B_{10d}$ value

On the condition that all requirements of these principles of testing have been fulfilled and that all type tests performed have been passed successfully, the  $B_{10d}$  value can be specified according to DIN EN ISO 13849-1, Table C.1.

**Alternatively, the  $B_{10d}$  value can also be determined as follows:**

1. Test the mechanical service life using  $\geq 10$  test objects based on DIN EN 60947-5-1, Section C.2. Determine the  $B_{10}$  value by means of "Weibull approximation".
2. If a 50 % hazard-producing failure rate is assumed, the  $B_{10d}$  value is determined by doubling the  $B_{10}$  value:  $B_{10d} = 2 \times B_{10}$ .
3. Alternatively to 2., the  $B_{10d}$  value can also be determined through analysis of the failed test objects and by determining the percentage of potentially hazardous failures (non-opening of the positively opening break contacts upon actuation).

## **5.20 Guard-locking devices with logic units**

### **5.20.1 Guard locking device response time**

If the maximum time between tripping of the sensor function (position monitoring of the door and/or position monitoring of the locking element) and the point, at which the guard-lock output signal has switched to the OFF state is determined by a logic unit, then this response time must be specified in the Instruction manual.

**Test:** Measurement of the response time at the tolerance specification limits zone for the operating voltage.

### **5.20.2 Fault characteristics**

On guard locking devices with logic units, a check 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 (also see the remarks in Section 1.3). In so doing, all guard-lock circuit variants as specified by the manufacturer must be taken into account.

**Test:** Validation according to DIN EN ISO 13849-1 and DIN EN 13849-2. Validation must confirm the performance level as prescribed by the manufacturer.

## **5.21 Heat-filament test**

DIN EN 60947-1, Section 7.1.2.2 applies.

Insulating materials, which are used to affix current-carrying components in place, must be tested at a heat-filament temperature of 850 °C, with all other insulating materials being tested at 650 °C.

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

## 5.22 External materials and properties

**5.22.1** 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. Review of the information provided by the manufacturer regarding component materials that come in regular contact with the operator's skin, which must not contain any substances harmful to health.  
Use the procedure according to ZEK 01.2-08 to check the amount of polycyclic aromatic hydrocarbon (PAH). The PAH value determined must not exceed the limit value dependent on contact duration.

**5.22.2** Unit components accessible by hand must have no sharp corners or edges, or abrasive surfaces that can lead to injuries. Corners and edges must be deburred and surfaces must be smooth to the touch.

**Test:** Handling and visual inspection.

## 5.23 Electromagnetic compatibility (EMC)

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

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

In addition to the requirements of DIN EN 60947-5-1 regarding immunity to interference, guard locking devices with logic units must also satisfy the requirements of DIN EN 61326-3-1 as of 1 June 2011 **at the latest**.

**Test:** See DIN EN 61326-3-1.