DGUV Test
Prüf- und Zertifizierungsstelle
Fachausschuss Elektrotechnik

Translation

Principles of testing and certification for Interlocking devices with key transfer systems

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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 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.

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

Table of contents Page

1 General

1.1 Scope

These Principles apply to the testing of interlocking devices with a key transfer system as a modular unit for safety-relevant applications **(henceforth referred to as key transfer system).**

1.2 System description

A key transfer system can be comprised of the following components:

- Switching element or switching element with a locking mechanism or an interlocking device
- Key
- Key change station
- Guard-locking mechanism

A key transfer system must be comprised of the following components:

- Switching element or switching element with a locking mechanism or an interlocking device
- Key
- Guard-locking mechanism.

2 Terms

2.1 Key transfer system

A key transfer system is an interlocking system based on a key transfer between the switching element interlock and the lock on a corresponding guard-locking mechanism.

2.2 Switching element

The switching element is comprised of a lock and switch, which form a positive locking unit.
The switching element serves to interrupt the supply of energy, which may create a threat (e.g. a hazardous motion).

2.3 Switching element with locking mechanism

The switching element is comprised of a lock and switch, which form a positive locking unit.
The switching element serves to interrupt the supply of energy to those drive elements related to a hazardous motion, whose run-down time is so great that a locking mechanism must be used to prevent removal of the key long enough for the hazardous motion to come to a standstill.

2.4 Key

The key is the element, through which the corresponding lock is actuated.

2.5 Key change station

The key change station serves to release one or more coded keys, through prior actuation of one or more locks with the help of one or more keys with different coding.

2.6 Guard-locking mechanism

A device whose purpose, for example, is to hold a separating safeguard in the closed position.
Integral components of the guard-locking mechanism are:

- Actuator
- Blocking mechanism
- Lock
- Optional: Additional lock / locks with removable keys to serve as protection for persons in the danger area.

2.7 Actuator

The actuator is the part of the guard-locking mechanism, which is connected to the moving part of the separating safeguard and which holds the safeguard in the safety position via the blocking mechanism.

2.8 Blocking mechanism

The blocking mechanism is the part of the guard-locking mechanism, which holds the actuator in the safety position and which can be released only by actuation of the lock.

2.9 Lock bolt (locking device)

The lock bolt is that part of the switching element with a locking mechanism, which prevents actuation of the lock and release of the key.

2.10 Control 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.

2.11 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).

2.12 Mechanical service life

The mechanical service life is an indication of a key transfer system's resistance to wear. It is determined by the number of switching cycles.

2.13 Interlocking device

A mechanical, electrical or other device, whose purpose is to prevent the operation of a machine element under certain conditions.

2.14 Delay mechanism

A component comprised of a switching element with a locking mechanism and delay element (e.g. time relay or spring).

3 Characteristic features

3.1 Control switch with positive opening operation

DIN EN 60947-5-1:2005, Section 4, including K4, shall apply.

3.2 Load break switch

DIN EN 60947-3:2006, Section 4 shall apply.

4 Test documentation to be submitted

4.1 Application documents

- Application form
- Form: Information regarding contract preparation
- System matrix

4.2 Technical documents

The following documents must be submitted for the technical test:

- All user information supplied with the key transfer system
  (Instruction manual, assembly instructions, maintenance procedures, etc.)
- Sales literature
- Block circuit diagram
- Electric circuit diagram (if necessary)
- Technical drawings

- Parts list(s)
- Strength calculations
- Technical documentation according to DIN EN ISO 13849-1, Sec. 10
- Data sheets for supplier parts used
- Description of the functional process (if necessary)
- Insofar as they are available, test reports from an accredited test laboratory

The testing facility can request further documents if necessary.

4.3 Prototype

The number of key transfer systems to be submitted will be determined by the testing body.

5 Tests

5.1 General test requirements

Key transfer systems must fulfil all of the following requirements, where applicable.
A test object must not fail any of the tests.

Manufacturer specifications that go beyond the following minimum requirements must be verified separately.

Tests shall be conducted on complete key transfer systems according to the rating data declared by the manufacturer. Test values for electrical components may deviate from the rating data as follows:

Refer to DIN EN 60947-1: 2008, Table 8, for test value variance limits.

Unless otherwise specified in the individual test instruction, the proper functioning of the key transfer system must be ascertained prior to the initial test and subsequent to each individual test.

5.2 Labels and markings

Each key transfer system must be provided with at least the following durable and clearly legible markings (minimum font height = 2 mm):

5.2.1 On any system component, legible with the component in an assembled state:

- Manufacturer's/authorised representative's name and complete address
- Designation of the safety component (e.g. key transfer system)
- CE-marking
- System designation of the key transfer system
- Year of manufacture

5.2.2.1.1.1 On switching elements, legible with the component in an assembled state:

- Company name or mark of origin
- System identification (e.g. serial number)

5.2.2.1 Positively opening control switch, DIN EN 60947-5-1: 2005, Annex K:

- Marking according to DIN EN 60947-5-1: 2005

5.2.2.2.1.1.1 Load break switch:

- Marking according to DIN EN 60947-3: 2006

5.2.3 On switching elements with locking mechanisms, legible with the component in an assembled state:

- Company name or mark of origin
- System identification (e.g. serial number)
- Performance data with electromagnetic locking mechanisms (at any location)
- Terminal connection diagram with terminal assignments (at any location)

5.2.3.1 Positively opening control switch, DIN EN 60947-5-1: 2005, Annex K

- Marking according to DIN EN 60947-5-1: 2005

5.2.3.2 Load break switch

- Marking according to DIN EN 60947-3: 2006

5.2.4 Key

- Company name or mark of origin
- System identification (e.g. serial number)

5.2.5 On key change stations, legible with the component in an assembled state:

- Company name or mark of origin
- System identification (e.g. serial number)

5.2.6 On guard-locks, legible with the component in an assembled state:

- Company name or mark of origin
- System identification (e.g. serial number)
- Guard-locking force F_{Zh}

***Note**:*

The prescribed guard-locking force F_{Zh} must be ≤ the force $F1_{max}$ determined by testing! (also see Section 5.12)

Test: Visual inspection, measurement of font heights, rubbing test (gently rub using two cotton cloths, one soaked in water and the other in benzene, for 15 s each).

Evaluation: The markings must be complete with the minimum digit height retained. The markings must remain clearly legible following the test. It must not be possible to easily remove the marking labels by hand, nor should they be wrinkled or creased.

The benzene used for the test should be an aliphatic-soluble Hexan with a maximum aromatic volume share of 0.1%, a Kauri-butanol value of 29, a boiling service temperature of approx. 65 °C, a vaporizing temperature of approx. 69 °C and a specific mass of approx. 0.7 kg/l.

5.3 Instruction manual

The key transfer system 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 key transfer system 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 supplied with the product must contain the following characteristic features of the key transfer system, where applicable:

- Manufacturer's/authorised representative's name and complete address
- Designation of the safety component (e.g. key transfer system)
- Rendering of the content found in the Declaration of Conformity (except for serial number and signature)
- General description of the safety component
- Terminal connection diagram/Circuit diagram
- Application examples
- Guard-locking force F_{Zh}
- Description of intended usage
- Warning notices related to foreseeable faulty application thereof
- Warning notices related to coding allocations, if necessary (see 5.7.1)
- Specification of the safety function
- Instructions for assembly, installation and connection of the safety component, including drawings, circuit diagrams and attachments
- Instructions regarding integration of delay mechanisms related to time response
- Information regarding residual risks
- Description of required maintenance measures
- Technical specifications for electrical system components
- Overvoltage category
- Degree of contamination
- Rated insulation voltage
- Information about short-circuit equipment
- Minimum actuating radius, as well as maximum actuating radius where applicable, for curved or pre-stressed actuators
- Maximum actuation count/switching cycle count (mechanical/electrical) for the components used
- Information regarding the application of DIN EN ISO 13849-1:
  Category
  PL
  Average probability of hazardous failure per hour
  $MTTF_d$
  DC / DC_{avg}
  Mean operating duration in days/year (d_{op})
  Mean operating duration in hours/day (h_{op})
  Cycle time in seconds (t_{cycle})
- Operating temperature range
- IP-Protection class
- Specification of the conductor type, as well as largest and smallest cross-sections, for which the terminals are suitable

- Information regarding fault characteristics
- Notice to the user that the overall concept, into which the key transfer system has been integrated, must be validated in accordance with DIN EN ISO 13849-2
- Information regarding the conditions, under which the PL has been determined (incl. explanation of fault exclusions)
- Information regarding the ambient conditions, under which the key transfer system may be deployed
- Information regarding service positions
- Notice that the guard-lock must not be used as a mechanical stop
- Notice that, if, as a result of the risk assessment, it cannot be discounted that persons can be enclosed within a danger zone, then guard-locks with additional removable keys must be used or comparable measures must be taken.

  The additional information provided in DIN EN 60947-5-1:2005, Sections 5.1 and K.5.4 or DIN EN 60947-3:2006, Section 5.1 may also be included in the documentation accompanying the Instruction manual.

Test: Review of the technical documents submitted; check for completeness, correctness and consistency.

5.4 Sales literature

Sales literature, in which the safety component is described, must not contradict the Instruction manual with respect to its use.

The sales literature must contain all the information required for selection of the key transfer system, including specification of the safety-relevant function.

Additionally, it must contain the following notice:
If, as a result of the risk assessment, it cannot be discounted that persons can be enclosed within a danger zone, then guard-locks with additional removable keys must be used or comparable measures must be taken.

Test: Review of the technical documents submitted; check for completeness, correctness and consistency.

5.5 Requirements concerning switch construction and characteristics

Key transfer system switches may only be comprised of positively opening control switches or load break switches for integration into safety circuits.
Other switches may also be used for reporting purposes.

5.5.1 Positively opening control switches according to DIN EN 60947-5-1: 2005

Positively opening control switches must conform to the requirements of DIN EN 60947-5-1: 2005, Annex K.

Test: Visual inspection, review of the technical documents with respect to the prototype.
Test according to DIN EN 60947-5-1: 2005.

Evaluation: The components used must conform to the documents and pass the relevant tests according to DIN EN 60947-5-1: 2005.

5.5.1.2 Types of contact elements on control switches

The requirements of DIN EN 60947-5-1: 2005, Section K 7.1.4.6.1 are supplemented as follows:

If the switching element 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 notice to this effect.

Test: Visual inspection, review of the technical documents with respect to the prototype.
Test according to DIN EN 60947-5-1: 2005.

Evaluation: The components used must conform to the documents and pass the relevant tests according to DIN EN 60947-5-1: 2005.

5.5.2 Load break switches according to DIN EN 60947-3: 2006

Load break switches must conform to the requirements of DIN EN 60947-3: 2006.

Test: Visual inspection, review of the technical documents with respect to the prototype.
Test according to DIN EN 60947-3: 2006.

Evaluation: The components used must conform to the documents and pass the relevant tests according to DIN EN 60947-3: 2006.

5.6 Provisions for the design of key transfer systems

5.6.1.1 Types of control switch actuation with positive opening operation

Actuation of a control switch with positive opening operation must take place positively.

Non-positive actuation is permitted only in combination with a positively actuated control switch with positive opening operation.

Test: Visual inspection, functional check, review of the drawings, parts lists and circuit diagrams.

Evaluation: The components used must conform to the drawings, parts lists and circuit diagrams. The configuration must ensure that the requirements are fulfilled.

5.6.1.2 Switch configuration and mounting

5.6.1.3 Load break switch

- The load break switch casing must be flush mounted to the lock casing. The transmission of force between the lock and load break switch must be executed positively. The connection and transmission elements must absorb the force without damage when exposed to a torque of 5 Nm with the use of a rotary key and a tensile force of 250 N with the use of a linear key.

- The load break switch must be mounted in such a manner that the actuation shaft and its seating on the lock lie on a central axis and that the shaft will not be exposed to bending loads.

- All connections must be protected against accidental loosening.

  Test: Visual inspection, functional check, review of the drawings, parts lists and strength calculations, check torque or tensile force (load increase: 1 Nm/s or 50 N/s).

  Evaluation: The components used must conform to the drawings, parts lists and strength determinations. The configuration and design must ensure that the requirements are fulfilled.
  The torque or tensile force tests must not result in the permanent deformation of any component.

5.6.1.4 Control switch with positive opening operation

The control switch mounting elements must:

- be form-fitting
- have clearly defined positions
- require a tool in order to be loosened
- be protected against accidental loosening
- exhibit sufficient strength in order to warrant fault-free operation

Test: Visual inspection, functional check, review of the drawings and parts lists.

Evaluation: The components used must conform to the drawings and parts lists. The configuration and design must ensure that the requirements are fulfilled.

5.6.2 Control cam configuration and mounting

Control cams must be designed in such a manner that:

- they are flush mounted with mounting elements that require a tool in order to be loosened
- their accidental loosening is prevented
- they will neither damage nor impair the service life of the positively opening control switch or the locking device.

Test: Visual inspection, functional check, review of the drawings and parts lists.

Evaluation: The components used must conform to the drawings and parts lists. The configuration and design must ensure that the requirements are fulfilled.

5.6.3 Minimizing the probability of failures due to common causes

If the position monitoring for locking bolts on switching elements with locking mechanisms or control switches with positive opening operation is designed to be redundant, then it must work in combination with positive, as well as with non-positive types of actuation.

Test: Visual inspection, review of the data sheets, circuit diagrams and parts lists and, if necessary, failure simulation.

Evaluation: The components used must conform to the data sheets and parts lists. The configuration and design must ensure that only one control switch with positive opening operation can fail due to a common cause.

5.6.4 Guard-locking mechanism

The actuator must positively implement the guard-locking function through engagement of a rigid part.

The actuator and the blocking mechanism must be designed in such a manner that bypassing by simple means is not possible.

All parts of the guard-locking mechanism that are intended for blocking an actuator must act positively.

All parts of a rotary actuator that are intended for blocking the actuator must be able to withstand a torque of at least 5 Nm applied to the actuator.
Subsequently test in accordance with Section 5.12.
Furthermore, at torque values greater than 5 Nm, it must be ensured that the actuator does not sheer out of the lock but that the protective action is no longer afforded (e.g. through design features such as predetermined breaking points).

Note: *On linear actuators, the strength of the blocking mechanism will be verified solely in conjunction with Section 5.12.*

Test: Visual inspection, review of the drawings, parts lists and strength calculations and, if necessary, a torque check.

Evaluation: The components used must conform to the drawings and parts lists. The strength calculations must substantiate compliance with the limit force as well as component failure at higher force levels.
If strength calculations are not available, then this must be verified through the torque test.

5.6.5 Delay mechanism

Failure of the delay element on delay mechanisms must not fall short of the prescribed delay time.

Test: Review of the data sheets for components used; simulation test; review of the Instruction manual for the notice regarding the delay time.

Evaluation: The components used must conform to the data sheets. The simulation test must verify the requirements. The Information manual must contain an appropriate notice.

5.6.6 Environmental influences

Key transfer systems must fulfil their function throughout the manufacturer's prescribed scope of application.

The following requirements must be fulfilled as a minimum:

Indoor applications:

Temperature range:	+5 to +40 °C
Relative humidity:	50 % at +40 °C (even higher at lower temperatures)

Indoor and outdoor applications:

Temperature range:	-25 to +40 °C
Relative humidity:	50 % at +40 °C (even higher at lower temperatures)

Test: Review of the data sheets for components used and assessment of proper selection.

Based on DIN EN 6008-2-78, key transfer system components will be stored in a test chamber at the upper and lower limits of the temperature range and at a relative humidity of 50 % for 48 hours. In the event the manufacturer provides different values, the tests should be performed at those values.
A functional check is made subsequent to storage. The test must take place within 3 minutes of the removal from the test chamber.

Evaluation: It must be possible to actuate the components within the force limits set forth for their actuation while fulfilling their respective functions.

5.7 Protection against bypassing by simple and predictable means

Key transfer systems must be designed in such a manner that the safety function cannot be defeated by simple and predictable means.

Special consideration must be given to the following components:

- Key
- Lock
- Blocking mechanism
- Actuator

General requirements for carrying out the tests:

The tests are to be carried out by a person, manually or with the use of a readily available object, in accordance with DIN EN 1088: 2008, Sec. 5.7.1, Annotation 4, without in-depth understanding of the component's functioning principle.

5.7.1 Key

- The key must fit only into the corresponding lock (coding).
- It must be removable only from the position assigned to the defined safety function.

Test: a.) Analysis of the coding system.

b.) Testing of the design for minimizing the potential for bypassing will be carried out according to DIN EN 1088: 2008, Sec. 5.7.1 with consideration given to Annotation 4.

Evaluation: a.) The assignment of coding on key transfer systems must be made in such a manner that, on stationary systems at the same location (e.g. plant premises), there is no possibility of key transfer systems existing with identical coding.

If key transfer systems with recurring coding systems are used for a machine manufacturer / dealer, a notice in the Instruction manual must draw attention to the fact that these key transfer systems may not be deployed at one and the same location (e.g. plant premises).

b.)It must not be possible to remove the key during the test.

5.7.2 Lock

- It must be possible to actuate the lock only with the corresponding key.

Test: Testing of the design for minimizing the potential for bypassing will be carried out according to DIN EN 1088: 2008, Sec. 5.7.1 with consideration given to Annotation 4.

Evaluation: It must not be possible to actuate the lock during the test.

5.7.3 Blocking mechanism

- The key on the guard-locking mechanism must be removable only when the corresponding actuator is in the safety position.

- It must not be possible to loosen the mounting elements for the blocking mechanism casing by hand or with the use of any readily available objects.

Test: Testing of the design for minimizing the potential for bypassing will be carried out according to DIN EN 1088: 2008, Sec. 5.7.1 with consideration given to Annotation 4.

Evaluation: It must not be possible to remove the key or to loosen the mounting elements during the test.

5.7.4 Actuator

It must not be possible to loosen the mounting elements for actuators with safeguards by hand or with the use of any readily available objects.

Test: Testing of the design for minimizing the potential for bypassing will be carried out according to DIN EN 1088: 2008, Sec. 5.7.1 with consideration given to Annotation 4.

Evaluation: It must not be possible to remove the actuator during the test.

5.8 Switching element with locking mechanism

5.8.1 Requirements concerning locking mechanisms

5.8.1.1 Spring-operated locking mechanisms

The locking mechanism must act positively through the engagement of a rigid part.

The lock bolt (locking device) must be held in the locked position by spring force. The spring force must be generated by guided compression springs.

Springs used to hold the lock bolt in the locked position must be approved according to DIN EN ISO 13849-2: 2008, Annex A, Table A.2.

The lock bolt must be designed in such a manner that it will withstand the forces anticipated during normal operation of the switching element with locking mechanism.

The forces, which the lock bolt must be able to withstand without damage and without impairing further use, must conform to manufacturer data sheet specifications.

Test: Visual inspection, review of the data sheets, trial and, if necessary, simulation of spring breakage.

Evaluation: The lock bolt must be sufficiently dimensioned and remain in the locked position during the spring breakage simulation.

5.8.1.2 Electromagnetic actuated locking mechanism

Electromagnet actuation of the locking mechanism must function properly even with fluctuation of the rated operating voltage.

Test: Review the data sheets and operate the locking mechanism at 85 % and 110 % of the rated operating voltage.

Evaluation: Electromagnet actuation of the locking mechanism must function properly within the range of 85 % to 110 % of the rated operating voltage.

5.8.1.3 Heating

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 60947-1:2008, 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

Table 1: Excess temperature limit

Test: According to DIN EN 60947-5-1: 2005, Section 8.3.3.3 in conjunction with Table 1.

Evaluation: Compare the measured excess temperature with the limit values. The limit values from Table 1 must not be exceeded.

5.8.1.4 Position monitoring of the lock bolt

Switch-On commands introducing hazardous states may take effect only when the key is in the switching element lock with a blocking mechanism, the switch is in the ON-position and the lock bolt is in the locked position. This requires position monitoring of the lock bolt with at least one positively opening control switch according to DIN EN 60947-5-1: 2005, Annex K.

Test: Visual inspection, review of the data sheets, trial and, if necessary, simulation.

Evaluation: Switch-On commands may take effect only under the prescribed prerequisite conditions.

5.8.2 Mechanical properties of electrical connectors

5.8.2.1 Terminal connections within, or intended for enclosed casings

Terminal connections must be able to securely take up the cables prescribed by the manufacturer.

Test: According to DIN EN 60947-1: 2008, Sections 8.2.4.2 and 8.2.4.5.

Evaluation: It must be possible to route and connect the prescribed cables with little difficulty. During mechanical testing, the terminal points and connections must not loosen nor be damaged to the point that further use of the connection is impaired.

5.8.2.2 Space for cabling

The space provided for cabling must be sufficiently dimensioned. Proper connection of the cable must be possible beyond all doubt.

Test: Visual inspection.

Evaluation: The space provided for cabling must be dimensioned so that routing and connection of the cable is possible with little difficulty and so that proper positioning can be checked prior to closure.

5.8.3 Air gaps and creepage distances

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

Test: Measurement of air gaps and creepage distances according to DIN EN 60947-1: 2008, Sec. 7.1.4, comparison with minimum values.

Evaluation: The measured values must correspond to the normative limit values.

5.9 Protection class of switching elements

The protection class for switching elements prescribed by the manufacturer must correspond to the ambient conditions for the intended scope of application.

The switching elements must correspond to the prescribed protection class.

Test: Test the protection class in accordance with DIN EN 60529.

Note: *Testing of the protection class is made subsequent to the tests according to Sec. 5.10 and must be performed on the same test object.*

Evaluation: The protection class ascertained must correspond to the manufacturer's specifications and the scope of application.

5.10 Mechanical strength

Key transfer system components must possess sufficient mechanical strength with respect to the operational demands, such as jolting, shock or impact, which can be expected when used as intended.

Test: According to Sections 5.10.1 – 5.10.3

General evaluation criteria following each individual test:

1. It must not be possible to physically touch active components.
2. No components should have loosened or become detached.
3. No components should have been damaged.
4. The test object must still protect against the infiltration of dust, solid foreign objects and water conforming to the Protection class and corresponding to the Information manual.
5. The intended function must still be fulfilled in all aspects.

Component test	
I. Continuous vibration: Test standard Frequency range Amplitude Frequency cycle count Throughput speed	 DIN EN 60068-2-6 10 - 55 Hz 0.35 mm ± 15 % at the reference point 20 1 octave/min
II. Individual shock: 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 per axis (3 shocks each in both directions per axis)
III. Continuous shock: Test standard Type of shock Shock amplitude Shock duration Shock sequence Number of shocks	 DIN EN 60068-2-29 Half-sine wave 10 g 16 ms (1-3)/s 1000 ± 10 (in both directions per axis)

Table 2: Test parameters for vibration and shock loads

5.10.1 Test of resistance to vibration

All key transfer system components are subjected to constant oscillation amplitudes within a prescribed frequency range in their potential usage positions and on all three axes in accordance with Table 2. In so doing, the components in the following functional positions and monitoring measures must be checked:

Switching element:

Switching element in secure position(s) according to manufacturer's specifications; key removed

The monitoring equipment must be capable of detecting any switching element contact closure exceeding 0.2 ms in duration.

Evaluation: No contact engaging sequence should be initiated during the test.

Subsequent to the test, the evaluation criteria according to Sec. 5.10 must have been complied with.

Guard-locking mechanism:

Locked position; key removed

If electrical contacts are present, these must be monitored.
The monitoring equipment must be capable of detecting any switching element contact closure exceeding 0.2 ms in duration.

Evaluation: Subsequent to the test, the evaluation criteria according to Sec. 5.10 must have been complied with.

Key change station:

Release key removed; alternate key inserted

Evaluation: Subsequent to the test, the evaluation criteria according to Sec. 5.10 must have been complied with.

Switching element with locking mechanism:

Switching element in secure position(s) according to manufacturer's specifications; key removed; Lock bolt in unlocked position

The monitoring equipment must be capable of detecting any switching element contact closure exceeding 0.2 ms in duration.

Evaluation: No contact engaging sequence should be initiated during the tests.

5.10.2 Test of resistance to impact

5.10.2.1 Individual shock

System components are subjected to loading in their prescribed usage positions and on all three axes according to Table 1, Subtest II.

Evaluation: Subsequent to the test, the evaluation criteria according to Sec. 5.10 must have been complied with.

5.10.2.2 Continuous shock

System components are subjected to loading in their prescribed usage positions and on all three axes according to Table 1, Subtest II.

During testing, functional positioning and monitoring methods will be carried out according to Sec. 5.10.1.

Evaluation: During testing, the monitoring methods will evaluated according to Sec. 5.10.1 +

Subsequent to the test, the evaluation criteria according to Sec. 5.10 must have been complied with.

5.10.3 Test of resistance to shock

Using an impact test device according to DIN EN 60068-2-75:1998, Sec. 5, three blows are applied at 1 J (Nm) to an accessible location on each installed component of the key transfer system, which is considered to be the most critical point. Particular attention must be afforded the insulating materials covering or containing active electrical components.

Test: According to DIN EN 60068-2-75; Ehb test, with spring hammer. The spring hammer test is performed after 2 hours of component storage at the manufacturer's specified minimum application temperature.
The shock test must be carried out within 1 min. after removal from the climatic exposure test cabinet.

Evaluation: Subsequent to the test, the evaluation criteria according to Sec. 5.10 must have been complied with.

5.11 Resistance to damp heat and insulation properties

Switching elements must be designed in such a manner that they are sufficiently humidity-resistant and voltage-stable.

Test: Based on DIN EN 6008-2-78, the switching elements will be stored in a test chamber at a temperature of 40 (± 2) °C and at a relative humidity of 93 (+2/-3) % for 48 hours. In the event the manufacturer provides specifications that exceed the minimum specifications above, then those values should be used.

Following the storage period, an insulation test should be carried out in accordance with DIN EN 60947-1:2008, Section 8.3.3.4.1.

The test must take place within 3 minutes of the removal from the test chamber.

Switching elements in Protection class II will be tested at 1.5 times the test voltage set forth in the provision.

Evaluation: There must be no sparkover and/or flashover occurring during the test.

5.12 Guard-locking force

The guard-locking mechanism, when in the closed position, must be able to accept 1.3 times the guard-locking force (F_{Zh}) prescribed by the manufacturer.

Test: The guard-locking mechanism should be properly mounted to a base according to manufacturer's specifications using mounting elements prescribed or provided by the manufacturer. The guard-locking mechanism is then loaded to 1.3 times the guard-locking force (F_{Zh}) prescribed by the manufacturer by moving the actuator to the max. actuation angle with a constant speed in the loading direction of the guard-locking mechanism.

Requirements concerning testing equipment:

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

Requirements concerning force measurement equipment:

Sampling rate:	≥ 10 Hz
Measurement accuracy at maximum force:	± 2,5 %

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

Evaluation: The guard-locking mechanism must remain in the safety position without permanent deformation of the component.

5.13 Mechanical service life

The mechanical service life must be at least 200,000 switching cycles.
If the manufacturer provides greater switching cycle counts, then these must be verified separately.

5.14.1.1 Switching element and key

Test: Testing of mechanical service life will be carried out on the switching element through proper actuation.
Analysis of the wearing parts should be made, to include the components used to protect against bypassing by simple means.

Evaluation: Subsequent to the test, the switching element must function properly, including the protection against bypassing by simple means.
Wearing parts must not exhibit any abrasion, which could jeopardize the safety function.
Subsequent to the service life test, it must not be possible to remove the key from the lock until the test load is reached (see Sec. 5.19).

5.13.1 Switching element with locking mechanism

Test: Testing of mechanical service life will be carried out on the switching element with locking mechanism through proper actuation.

Analysis of the wearing parts should be made, to include the components used to protect against bypassing by simple means.

Subsequent to the test, the switching element with locking mechanism must function properly, including the protection against bypassing by simple means.
Wearing parts must not exhibit any abrasion, which could jeopardize the safety function.
Subsequent to the service life test, it must not be possible to remove the key from the lock until the test load is reached (see Sec. 5.19).

5.13.1.1 Key change station

Test: By means of analysis of the key change station on the basis of prototypes, parts lists, data sheets, drawings and, if necessary, by testing the mechanical service life of the presumed weakest component.

Evaluation: The design and selection of components must ensure that the safety function is retained.
If a test of the service life with consideration given to the weakest component is necessary, then, subsequent to the test, it must not be possible to remove the key from the lock until the test load is reached (see Sec. 5.19).

5.13.2 Guard-locking mechanism

Test: By means of analysis of the guard-locking mechanism on the basis of prototypes, parts lists, data sheets, drawings and, if necessary, by testing the mechanical service life of the presumed weakest component.

Evaluation: The design and selection of components must ensure that the safety function is retained.
If a test of the service life with consideration given to the weakest component is necessary, then, subsequent to the test, it must not be possible to remove the key or the actuator from the lock or guard-locking mechanism until the test load or prescribed guard-locking force is reached (see Sec. 5.19 or 5.12).

5.14 Insulating material resistance to heat and fire

Switching elements containing 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: Heat-filament test according to DIN EN 60695-2-11:2001.

Evaluation: Any flare-up or glowing of an insulated component must have gone out within 30 s after removal of the heat-filament. Any burning or molten droplets must not ignite a simple layer of tissue paper spread out horizontally, 200 (± 5) mm beneath the test object.

5.15 Electromagnetic compatibility (EMC)

5.15.1 Immunity to interference

If electronic components are used in switching elements with locking mechanisms, then these must exhibit sufficient immunity to electromagnetic interference.

In addition to the requirements of DIN EN 60947-1:2008 regarding immunity to interference, key transfer systems with electronic components must also satisfy the requirements of DIN EN 61326-3-1: 2008 for safety-relevant electronics.

Test and evaluation: According to DIN EN 60947-1: 2008, Sections 8.4.1 and, if applicable, DIN EN 61326-3-1: 2008.

5.16 Electrical equipment

The electrical equipment used in switching elements with locking mechanisms must conform to the relevant requirements of DIN EN 60204-1:2007, with particular reference to:

- 5. “Network connections and equipment for isolating and disabling“
- 6. “Protection against electric shock“
- 9. “Control circuits and control functions“
- 10. “User interface and the machine-mounted control unit“
- 11. “Switchgear and control gear: configuration, assembly and enclosures“
- 12. “Conductors, cables and lines“
- 13. “Wiring technology“
- 17. “Technical documentation“

Test: Visual inspection, review of the data sheets and testing according to DIN EN 60204-1:2007, Sec. 18.

5.17 Validation according to DIN EN ISO 13849-2

The use of key transfer systems for safety functions on machines and systems requires validation according to DIN EN ISO 13849-2, as well as the through use of informative attachments.
The required Performance Level (PL_r) must be determined according to the actual application (see Product standard or DIN EN ISO 13849-1).

Key transfer systems must fulfil the requirements corresponding to the Performance Level (PL) for each prescribed safety function, to which they have been assigned.

The following information is required, where applicable, in order to determine the PL:

- Category
- regarding common cause failures (CCF)
- regarding mean operating duration (d_{op})
- regarding mean usage time (d_{op})
- regarding cycle time (t_{cycle})
- Average diagnostic coverage (DC_{avg})
- B_{10d} value for relevant key transfer system components.

If, by means of analysis (e.g. FMEA), it can be verified the faults cannot occur in the key transfer system that could lead to loss of the safety function (e.g. through fault exclusions), then a PL = d can be realized.

If a fault exclusion occurs for electromagnetic components, it is permissible only when:

- the force transmission takes place positively on the positively opening contact.

- measures are foreseen or are prescribed in the Instruction manual for over-current and short-circuit protection.

The following is applicable under the abovementioned conditions:

Because of fault exclusions, the Category 3 system behaviour is given and a diagnostic function (DC) is not necessary.
Because there is no occurrence of faults that could lead to loss of the safety function, a Performance Level (PL) = d and, for the average probability of a hazardous failure, 1×10^{-7} per hour can be assumed for the entire system.

In such cases, PL = d is the maximum attainable level.

If, in addition to system behaviour, the structure of Category 3 is also realized, then PL = e is also attainable.

Fault exclusions must be listed and explained in the Instruction manual. Fault exclusions, which are not tolerable because of a foreseeable faulty application of the key transfer system, must not be made.

In addition to the permissible fault exclusions according to DIN EN ISO 13849 - 2: 2009, Annex A, B, C, D, the presumption of breakage and deformation faults can be excluded for mechanical components, except for springs, if their strength is verified to Safety factor 2. In this case, the quality assurance measures applicable to the component manufacturing processes must be evaluated separately.

Test: Performance Level according to DIN EN ISO 13849-1.

The designated safety functions and categories listed for the safety-related parts of the controller should be validated by means of analysis (e.g. FMEA) or testing according to DIN EN ISO 13849-2.

Evaluation: The Performance Level attained must agree with the level prescribed.

5.18 Optional components for switching elements with locking mechanisms

If standstill monitors or safety relays with drop-out delay contacts are integral to the switching element with locking mechanism, then these must conform to the requirements of GS-ET-20.

Test and evaluation: According to GS-ET-20.

5.19 Removal force (key)

Measures must be taken to prevent the key from being removed from the lock in the actuated lock position.

Test: A lock is mounted to a base with mounting elements prescribed or provided by the manufacturer. The key is then used to set the lock to the actuated position.
The test load is applied lengthwise to the middle axis of the key handle up to a value of 250 N.

Requirements concerning testing equipment:

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

Requirements concerning force measurement equipment:

Sampling rate:	≥ 10 Hz
Measurement accuracy at maximum force:	± 2,5 %

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

Evaluation: It must not be possible to remove the key from the lock until the test load is reached.

5.20 Interlocking force

It must not be possible to remove the key in a locked state with an applied torque of 5 Nm or a tensile force of 250N (linear keys).

Test: Testing is to be carried out on the lock for the guard-locking mechanism and the switching element with locking mechanism, as well as on a changeover lock for the key change station. The respective component is to be mounted on the base. The key is then used to set the lock to the actuated position. The actuating element is not engaged or the locking mechanism is in the locked position. A torque load of 5 Nm is subsequently applied to the key handle in the unlocking direction using a torque wrench.

Evaluation: In the process, the lock must not permanently deform, it must unlock and the key must be released.

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

5.21 Lock actuation force

The actuation force must be oriented to the values prescribed according to DIN EN 894-3: 2010, Table 4, dependent on the form and handling characteristics of the key.

Test: Measure the actuation force on each component. Evaluate the actuation forces.

5.22 External materials and properties

No materials containing substances harmful to health may be used on any part of the key transfer system that comes in regular contact with the operator's skin (as a rule, this would be the key or the actuator).

Test: Review of the safety data sheets for the materials used.
Use the procedure according to ZEK 01.2-08 to check the amount of polycyclic aromatic hydrocarbon (PAH).

Evaluation: 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. The PAH value determined must not exceed the limit value dependent on contact duration.

Unit components accessible by hand must have no sharp corners or edges, or abrasive surfaces that can cause injuries.

Test: Handling and visual inspection.

Evaluation: Corners and edges must be deburred and surfaces must be smooth to the touch.

Annex 1 Technical rules

1.0 Applicable standards

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 1088:	Safety of machinery; Interlocking devices associated with guards; Principles for design and selection
DIN EN 60204-1: VDE 0113 Part 1	Safety of machinery; Electrical equipment of machines; Part 1: General requirements
DIN EN 60529: VDE 0470 Part 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 Part 100	Low-voltage switchgear and controlgear; Part 1: General requirements
DIN EN 60947-3: VDE 0660 Part 107	Low-voltage switchgear and controlgear; Part 3; Load switches, isolating switches, switch disconnectors and switch safeguard devices
DIN EN 60947-5-1 VDE 0660 Part 200	Low-voltage switchgear and controlgear; Part 5-1; Control units and switching elements, Electromechanical control circuit devices
DIN EN 60068-2-6 VDE 0468-2-6	Environmental influences; Part 2: Test methods; Test Fc: Vibration (sinusoidal)
DIN EN 60068-2-27	Environmental testing; Part 2: Test methods; Ea test and guidance: Shocks

DIN EN 60068-2-29	Environmental testing; Part 2: Test methods; Eb tests and guidance: Continuous shock
DIN EN 60068-2-75	Environmental testing; Part 2: Tests; Eh test: Hammer tests
DIN EN 60068-2-78	Environmental testing; Part 2-78: Tests; Test Cab: Damp heat, steady state

Annex 2

Determination of the value for the mean annual demand rate n_{op} with missing relevant manufacturer specifications

If the applicant does not provide information regarding the mean annual demand rate n_{op} according to DIN EN ISO 13849-1:2008-12, Section C.4.2, Form C.2, the following values listed for n_{op} will be applied, dependent on the system application(s) identified in the Information manual:

Application	**d_{op} in [days/a]**	**h_{op} in [h/day]**	**t_{cycle} in [s/cycle]** [1)]	**h_{op} in [cycles/a]**
For maintenance and repair work	365	24	4.32×10^5	73
For cleaning work	365	24	2.88×10^4	1095

1) The values for t_{cycle} represent assumed average values:
For maintenance and repair work: 1 time per week
For cleaning work: 1 time per shift

Legend:
d_{op} mean operating time in days per year
h_{op} mean operating time in hours per day
t_{cycle} mean time between the start of two consecutive cycles in seconds

Annex 3

DGUV Test Prüf- und Zertifizierungsstelle Fachausschuss Elektrotechnik	**Information regarding contract preparation** **- Key transfer system -**	Company:

Product identification information

Product nomenclature	
Type	
Product variants available?	yes ☐ / no ☐
Variant matrix attached?	yes ☐ / no ☐

Information regarding test specifications and parameters

Testing in accordance with DIN EN ISO 13849-1	yes ☐ / no ☐
Category	
PL	
$MTTF_d$	in [a]
DC / DC_{avg}	in [%]
CCF	in [points]
Service life	in [years]
Mean operating duration d_{op} [days/years]	in
Mean operating duration h_{op} [hours/days]	in
Cycle time t_{cycle}	in [s^{-1}]

EMC-Tests

Testing in accordance with DIN EN 61326-3-1	yes ☐ / no ☐

DGUV Test
Prüf- und Zertifizierungsstelle
Fachausschuss Elektrotechnik

Information regarding contract preparation

- Key transfer system -

Documentation to be submitted	*attached*	*will be submitted*
User information	☐	by
Sales literature	☐	by
Drawings	☐	by
Circuit diagram(s)	☐	by
Parts list(s)	☐	by
Strength calculations	☐	by
Single fault analysis (e.g. FMEA)	☐	by

Test reports provided by external accredited test bodies for…	*attached*	*will be submitted*
Electromagnetic compatibility	☐	by
Load break switch	☐	by
Control switch with positive opening operation	☐	by

Test reports provided for tests performed under special agreement for…	*attached*	*will be submitted*
	☐	by
	☐	by

Note: In the interest of prompt order processing, it is essential that the information above be provided in its entirety!

_____ _____ _____
Date Name Signature