

Translation

Supplementary requirements for the testing and certification of positively opening position switches

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Principles of testing
Positively opening
position switches
GS-ET -15 E

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GS-ET -15 E

These Principles of testing serve as verification that the requirements of the German Product Safety Act (ProdSG) and, as such, the 1st and 9th provisions of the ProdSG in particular, have been complied with in conjunction with DIN EN 60947-5-1.

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

These Principals of testing comprise the necessary requirements and tests found in DIN EN 60947-5-1 for positively opening position switches while supplementing these with additional requirements.

Changes with respect to Edition 2016-10:

1.3 Technical rules

- Update of the regulatory framework

5.2 Labels and markings

- Modification of the requirements related to legibility of inscriptions
- Clarification of inscriptions on switching elements and/or screwless clamping units

5.3 Operating instructions

- Additional information regarding the stripping length for conductor cables

5.7.3 Mechanical and electrical properties of connectors

- Integration of the testing stipulated for screwless clamping units in DIN EN 60947-5-1

5.19 Determination of B_{10D} value

- Modification of the testing used for determining B_{10D} values

5.20 Testing of resistance against exceptional heat and fire

- Integration of the testing stipulated in DIN EN 60947-5-1

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

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1 General

1.1 Scope

These Principles of testing apply to the testing of the safety function on positively opening position switches, henceforth referred to as position switches.

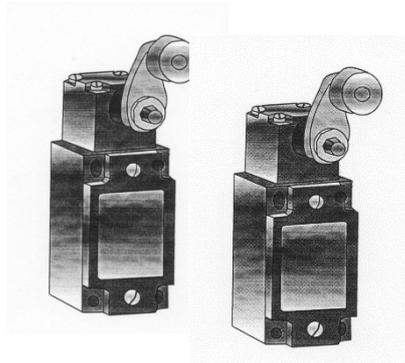
Nevertheless, the Principles of testing GS-ET 15:2015-05 will remain valid until 15 Dec. 2020

1.2 Design variants

Positively opening position switches can be classified into two design variants:

Design variant 1 (B1):

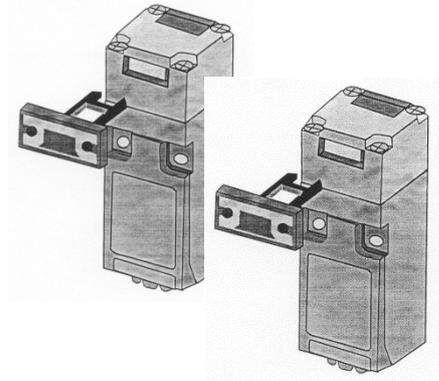
Switches, in which the contact element and actuator are structurally linked and functionally comprise a unit when switching.



Example of a position switch with safety functions, design variant 1

Design variant 2 (B2):

Switches, in which the contact element and actuator are not structurally linked, yet which functionally join or separate when switching.



Example of a position switch with safety functions, design variant 2

1.3 Technical rules

The basis for these Principles of testing comprises:

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

DIN EN ISO 14119	Safety of machinery; Interlocking devices associated with separating protective devices Principles for design and selection
DIN EN 60204-1 + A1 + Rev. 1 VDE 0113, Part 1	Safety of machinery; Electrical equipment of machines - General requirements -
DIN EN 60529 DIN VDE 0470, Part 1	Degrees of protection provided by enclosures (IP code)
DIN EN 60695-2-10 to DIN EN 60695-2-13 VDE 0471, Parts 2-10 to 2-13	Fire hazard testing; Part 2-10 to Part 2-13: Glowing/hot-wire based test methods
DIN EN 60947-1 VDE 0660, Part 100	Low-voltage switchgear and controlgear; Part 1: General rules
DIN EN 60947-5-1 VDE 0660, Part 200	Low-voltage switchgear and controlgear; Control circuit devices and switching elements, Electromechanical control circuit devices

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 27/02/0468)	Environmental influences; Part 2-27: Test methods; Test Ea and guidance: Shocks
DIN EN 60068-2-75	Environmental testing; Part 2: Tests; Eh test: Hammer testing
DIN EN 60068-2-78 (VDE 0468-2-78)	Environmental influences; Part 2-78: Test methods; Test Cab: Damp heat, steady state
AfPS-GS-2014:01 PAK or the current version, accordingly	Testing and evaluation of polycyclic aromatic hydrocarbon (PAH) for the issuance of the GS-mark
DIN EN 13906-1	Cylindrical helical springs made from round wire and bar - Calculation and design - Part 1: Compression springs
DIN EN 60999-1	Connecting devices - Electrical copper conductors; Safety requirements for screw-type and screwless-type clamping units – Part 1: General requirements and particular requirements for clamping units for conductors 0.2 mm ² up to and including 35 mm ²

2 Terms

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

2.1 Interlocking device (interlock)

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

2.2 Actuator

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

2.3 Position switch with positive opening operation

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

2.4 Positive opening operation (of a contact element)

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

2.5 Positive opening path

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

2.6 Bypassing

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

2.7 Bypassing by simple and predictable means

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

Note 1 regarding the term:

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

Note 2 regarding the term:

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

2.8 Mechanical service life

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

2.9 Electrical service life

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

2.10 Coding levels

2.10.1 Coded actuators with a low coding level

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

2.10.2 Coded actuators with a medium coding level

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

2.10.3 Coded actuators with a high coding level

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

3 Characteristic features

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

4 Test documentation to be submitted

4.1 Technical documents

Information for connection and commissioning of the position switch must be provided in the form of drawings, circuit diagrams, tables and user information.

The following documents must be submitted for technical testing:

- All user information supplied with the device (Operating instructions, installation instructions, etc.)
- Sales literature (if available)
- Overview of the actuators that can be used with the position switch
- Block circuit diagram (if applicable)

- Electric circuit diagram
- Technical drawings
- Parts list(s)
- Printed circuit board layouts (if applicable)
- Description of the functional process (if necessary)
- Maintenance procedures and setting instructions (if applicable)
- Insofar as they are available, data sheets, test certificates, certificates for the position switch and/or the parts it comprises
- Test reports, test protocols and calculations, which were used in determining the B_{10D} value (see Section 5.17)
- Specification of type code
- Description of the coding process (including submission of the corresponding documentation) with specification of the various coding possibilities
- Description of the measures taken to achieve a sufficient statistical mix of the individual coded actuators
- The testing facility can request further documentation if deemed necessary.

4.2 Prototype

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

The following is to be considered when selecting the test specimen:

Visual inspection of the design configuration and determination of „worst-case variants“ according to the following criteria:

- Strength, e.g.: material, material thickness, tolerances, geometries, direction of loading with actuation and,
- if applicable, electrical characteristics (e.g. electronic solutions).

Four additional test specimens with different codes shall be submitted for coding level testing.

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

5 Inspections

5.1 General test requirements

Positively opening position switches, hereafter referred to as "position switch (es)", must satisfy all of the requirements listed below. Performing the tests in the specified sequence will serve as verification that the prescribed requirements have been fulfilled.

Fulfilment of broader manufacturer specifications must be verified separately.

Tests shall be conducted on complete position switches 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 instructions, proper functioning of the position switch must be ascertained prior to the initial test, as well as subsequent to each individual test.

5.2 Labels and markings

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

5.2.1 On the enclosure (externally):

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

- - Symbol for Protection Class II, if applicable
- - Symbol for Protection Class III, if applicable

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

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

Test: See Point 5.2.2.

5.2.2 On the switch mechanism

- a) Clamping unit designation
- b) Identification of contact elements with the same polarity
- c) Special screwless clamping units*):
 - Clamping units for solid, single-strand conductors shall be marked with the character „s“ or „sol“;
 - Clamping units for solid, single- or multi-strand conductors shall be marked with the character „r“;
 - Clamping units for flexible conductors shall be marked with the character „f“.

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

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

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

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

5.2.3 Type of label and marking

Labels and markings on coded, positively opening position switches must not allow for inferences to be drawn as to the individual codes.

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

5.2.4 Coding level

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

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

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

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

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

5.3 Operating instructions

The position switch 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 position switch is to be installed.

If the Operating instructions are not in German, a German translation must be provided.

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

The Operating instructions provided with the device or, optionally, on the device must indicate the following characteristic features of the position switch:

- a) Manufacturer's/authorised representative's company name and complete address
- b) Design series or type designation
- c) Designation of the safety component (e.g. position switch)
- d) Rendering of the content found in the Declaration of Conformity (except for serial number and signature)
- e) General description of the position switch and its intended usage
- f) Instructions for mounting, installation and connection of the position switch
- g) Maintenance procedures and setting instructions (if applicable)
- h) Description of fault characteristics (if necessary)
- i) Usage category and rated operating current(s) at the rated operating voltage(s)
- j) Rated operating voltage
- k) Rated insulation voltage
- l) Rated surge voltage resistance
- m) Type and highest rated values of the short-circuit protection device
- n) Conditional short-circuit current
- o) Specification of the conductor type, as well as the largest and smallest conductor cross-sections, for which the connecting clamps are suitable
- p) Length of the insulation that must be removed prior to inserting the conductor into the clamping unit
- q) Minimum actuating radius and, if applicable, the maximum actuating radius for curved or pre-stressed actuators
- r) Positive opening path
- s) The minimum force required to achieve the positive opening of all breaker contacts
- t) The maximum value of the path travelled by the operating element, including the travel in excess of the minimum path (meaning to include the overrun)
- u) The maximum and minimum actuation speeds
- v) The highest actuation frequency
- w) The coding level (low, medium, high i.a.w. DIN EN ISO 14119) for coded interlocking devices
- x) Specification of the B_{10d} value.

Furthermore, the Operating instructions must contain the following information, where applicable:

- aa) Functional description
- ab) Annotated remark, clearly distinguished from other text passages, signifying that the installation and operation must take into account the requirements of DIN EN 14119; in particular Section 7 "Design for minimizing defeat possibilities".
- ac) Annotated reference to potential constraints on the service position, in particular with respect to anticipated functional disruptions when the device is used in a heavily contaminated environment.
- ad) Annotated reference to potential constraints on the scope of application; in particular with respect to the influences due to contamination (e.g. by swarf, dust, fluids).
- ae) Annotated reference to adequate mounting and definite fixation if the switch attachment allows it to be adjusted.
- af) If applicable, annotated remark that the position switch must not be used as a mechanical stop.
- ag) If the position switch is suited for use as a mechanical stop according to manufacturer specifications: Specification of the degree of resistance to impact energy in J, or door mass and actuation speed, as well as specification of the maximum number of switching cycles (reduction of service life) dependent on the impact energy (e.g. as a derating curve).
- ah) Annotated remark that performance levels according to DIN EN 13849-1 may be reduced with series connected position switches due to decreased fault recognition.
- ai) Provide notice to the user that the overall control concept, into which the position switch has been integrated, must be validated in accordance with DIN EN ISO 13849-2 or evaluated in accordance with DIN EN 62061.
- aj) Annotated remark that the availability of spare actuators and keys makes it possible to easily bypass the safety devices and, for this reason, the security of the spare actuators and keys must be effectively monitored.
 - a. ak) Information regarding the proper installation of actuators and switches (correct positional arrangement). Warning notice: Functionality should be tested following installation
 - b. al) Scope of actuation system coverage (degree of mechanical freedom, such as angular offset).

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 position switch is described, must not contradict the Operating instructions with respect to safety aspects.

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

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

5.5 Requirements related to construction and characteristics

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

5.5.1 Regarding K7.1.4.6.1, Types of contact elements

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

Position switches must possess only positively opening contacts with additional make-contacts, such as for signalling purposes.

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

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

5.5.2 In addition to DIN EN 60947-1, Section 7.1.10.1, position switches with metal **enclosures** must always be outfitted with a protective earth connection in the internal chamber. This applies to position switches with metal enclosures 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 switch when earthed auxiliary circuits are used.

Exception for position switches with Protection class III in metal enclosures:

Because position switches with Protection class III must not possess a protective earth connection, suitable design measures must be taken to prevent possible contact between any active components and the metal enclosure. This can be achieved by fixing the connection cables, for example, and/or by the use of insulated lining in the electrical installation chamber.

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

5.5.3 Fixing and alignment

Position switches must be able to be positively aligned and fixed or pinned.

Test: Visual inspection.

5.6 Requirements for minimizing defeat possibilities

Position switches must be designed in such a manner that the safety function cannot be defeated by simple and predictable means.

Design variant 1 position switches allow for measures to be taken during installation to protect against bypassing.

Design variant 2 position switches must be configured 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).

Examples of readily available objects are:

- Screws, needles, sheet-metal blanks
- Everyday items, such as keys, coins, adhesive tape, packing 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 or sheet metal formed by hand, folded paper).

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

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

It must not be possible to loosen position switch mounting elements by hand or with readily available objects.

If the manufacturer provides mounting screws for the position switch and/or actuator, these must be one-way screws.

Test: a) Attempt to manually actuate 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).

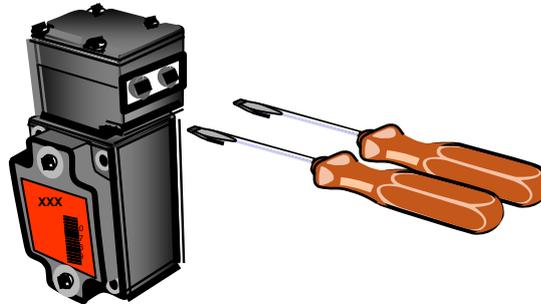


Fig. 1: Attempted actuation using two identical objects

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

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

b) Visual inspection of the mounting elements provided.

5.6.1 Characteristics when using a non-integral actuator with individually coded switches:

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

Test: A switch is selected for testing from the four differently coded test specimens provided, as well as three actuators not corresponding to the selected switch (different coding).

The actuators are introduced to the switch at an axial orientation from all possible actuating directions at a maximum speed of 10 mm/min. With a maximum force of 300 N, the positively opening contact must not close and its proper function must remain warranted.

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

5.7.1 Heating

Test: In accordance with DIN EN 60947-5-1, Section 8.3.3.3.

5.7.2 Insulation properties

Position switches must be designed so that they are sufficiently voltage-stable, especially 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:
In deviation from DIN EN 60947-5-1 and based upon DIN IEC 60068-2-78, the position switch should be stored in a test chamber for 48 hours at a temperature of $40 (\pm 2) ^\circ\text{C}$ 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 after removal from the test chamber.

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

For position switches 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.

5.7.3 Mechanical properties of connectors

5.7.3.1 Test: In accordance with DIN EN 60947-5-1, Section 8.2.4 with the following changes:

Testing should be carried out only on position switches with externally mounted connecting clamps in accordance with DIN EN 60947-5-1, Sections 8.2.4.3 (bending test) and 8.2.4.4 (extraction test).

This testing can be dispensed with if the connecting clamps are located inside an enclosed casing foreseen for the connection of sheathed wiring. In this case, the position switch must be outfitted with effective strain-relief for the connection wiring.

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

5.7.3.2 Position switches 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.

5.7.3.3 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.

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

5.8.1 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.

5.8.2 Verification of insulation

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

For position switches 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.

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

5.9.1 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.

5.9.2 Verification of insulation

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

For position switches 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 IV according to DIN EN 60947-5-1, Section 8.3.1

5.10.1 Characteristics with conditional short-circuit current

Test: In accordance with DIN EN 60947-5-1, Section 8.3.4.

Positively opening contacts should be tested in accordance with Section K.8.3.4.

5.10.2 Verification of insulation and functional capacity following testing

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

For position switches 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 V according to DIN EN 60947-5-1, Section 8.3.1

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

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

5.12.1 Measurement of air gaps and creepage distances

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

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

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

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

5.13.1 Mechanical function at temperature limits

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

5.13.2 Verification of positive opening operation

5.13.2.1 Position switches 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 in the position corresponding to its open position.

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 5.13.2.5

5.13.2.2 The area in which the positively opening electrical contacts are located must be designed in such a manner that even in the event of the 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 individually detached or displaced components must not be possible. The minimum value for switching travel (verified by surge voltage testing) must also be maintained, even under fault conditions.

Test: In accordance with 5.13.2.5

5.13.2.3 Position switches must be designed in such a manner that their proper function is not impaired by actuation from the least favourable actuation angles.

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

Test: In accordance with 5.13.2.5

5.13.2.4 The spring force of safety-relevant springs used for actuation of design variant 2 position switches (e.g. radius actuators) must be generated by compression springs. Furthermore, they must be designed for permanent reliability in accordance with DIN EN 13906-1.

Test: In accordance with 5.13.2.5

5.13.2.5 Tests related to 5.13.2.1 to 5.13.2.4

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.

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

– Verification of actuation system strength

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

The test can also be carried out by immobilization of the contact element in the closed state and with force $F_2 \geq 10$ N applied to the plunger or actuating system.

5.15 Mechanical strength

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

Test: Individual testing in accordance with 5.15.1 to 5.15.2.

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 that could influence the function, safety or proper mounting.
4. Intended function must still be completely warranted in all aspects.

5.15.1 Shock test

The position switch will be subjected to successive mechanical shocks at the permissible service positions, whereby

- a. according to Table 1, Component test I, the shocks are not continuously recurring and
- b. according to Table 1, Component test II, 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. Contact closure should not be made during testing.

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

The evaluation criteria must have been fulfilled subsequent to testing according to 5.15.

Component test	
I. Shock:	
Test standard	DIN EN 60068-2-27
Type of shock	Half-sine wave
Shock amplitude	30 g
Shock duration	11 ms
Number of shocks	3 ± 0 (in both directions per axis)
II. Continuous shock:	
Test standard	DIN EN 60068-2-27
Type of shock	Half-sine wave
Shock amplitude	10 g
Shock duration	16 ms
Shock sequence	(1-3)/s
Number of shocks	1000 ± 10 (in both directions per axis)

Table 1: Minimum requirements for the shock loading

5.15.2 Impact test

Following exposure of the position switch 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.

The evaluation criteria must have been fulfilled subsequent to testing according to 5.15.

5.16 Test of Protection class and actuating force

5.16.1 Protection class of enclosed position switches

Compliance with the Protection class prescribed by the manufacturer must be verified by testing. The tests are to be carried out on prototypes which have been subjected to testing according to 5.15.

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

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

5.16.2 Verification of actuating force or moment

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

***NOTE:** The actuation force for position switches of design variant 2 correlates to the extracting force.*

5.17 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.

During testing, the position switch must not be used as a mechanical stop.

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

On position switches of design variant 2, the actuator must be introduced from the maximum possible actuation angle. Actuation must be carried out from the least favourable approach direction.

Proper function of the position switch must still be warranted subsequent to loading.

5.18 Impact energy

***Note:** The test must be performed only when the position switch is suitable for use as a mechanical stop according to manufacturer specifications.*

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

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

Test: Testing is carried out on complete position switches in as-new condition with a mass and speed corresponding to the max. impact energy.

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

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

Proper functioning of the position switch must still be warranted subsequent to loading.

5.19 Determination of the B_{10D} value

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

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

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

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

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

5.20 Testing of resistance against exceptional heat and fire

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

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

Insulating materials used to fix current-carrying components in place must be tested at a heat-filament temperature of 750 °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.

5.21 Electromagnetic compatibility (EMC)

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

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

5.22 External materials and properties

5.22.1 No materials containing substances harmful to health may be used on any part of the position switch that comes in regular contact with the operator's skin (e.g. door handles, knobs).

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

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

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

Test: Handling and visual inspection.