

## ***Translation***

Principles of testing and certification for  
positively opening position switches  
Status as of 2011-02

Expert committee for electrical engineering  
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**GS-ET-15**

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 Principles of testing comprise the necessary requirements and tests found in DIN EN 60947-5-1 for position switches with safety functions and supplements these with additional requirements.

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

**Changes with respect to Issue 2009-10:**

**1.3** - Adaptation of technical rules to the current state

**5.6 Requirements for minimizing defeat possibilities**

- More specific description of „readily available objects“
- Revision of the requirements for carrying out tests;  
Fig. 1 inserted (among other items)

**5.15 Mechanical strength**

Establishment of evaluation criteria

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## 1 General

### 1.1 **Scope**

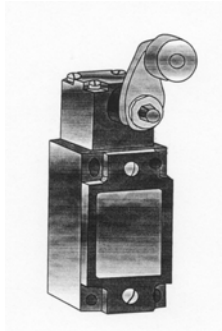
These test principles apply to the testing of the safety function on positively opening position switches, henceforth referred to as position switches.

### 1.2 **Design variants**

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

#### Design variant 1 (B1):

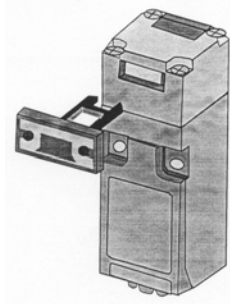
Switches, in which the contact element and actuator are structurally linked and functionally comprise a unit when switching.



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 join or separate functionally when switching.



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

### 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<br>Interlocking devices associated with guards<br>Principles for design and selection                      |
| DIN EN 60204-1<br>VDE 0113 Part 1  | Safety of machinery;<br>Electrical equipment of machines<br>- General requirements -   |
| DIN EN 60529<br>DIN VDE 0470 Part 1                                      | Degree of protection provided by enclosures<br>(IP code)   |
| DIN EN 60695-2-10 to<br>DIN EN 60695-2-13<br>VDE 0471 Parts 2-10 to 2-13 | Fire hazard testing;<br>Part 2-10 to Part 2-13: Glowing/hot-wire based<br>test methods   |
| DIN EN 60947-1<br>VDE 0660 Part 100<br>2008-04                           | Low-voltage switchgear and controlgear;<br>Part 1: General rules (IEC 60947-1:2004)  |
| DIN EN 60947-5-1<br>VDE 0660 Part 200<br>2010-04                         | Low-voltage switchgear and controlgear;<br>Control circuit devices and switching elements -<br>Electromechanical control units |
| DIN EN 60068-2-6<br>(VDE 0468-2-6)                                       | Environmental influences;<br>Part 2-6: Test methods;<br>Test Fc: Vibration (sinusoidal)  |
| DIN EN 60068-2-27<br>(VDE 0468-2-27)                                     | Environmental influences;<br>Part 2-27: Test methods;<br>Test Ea and guidance: Shocks  |
| DIN EN 60068-2-75  | Environmental testing<br>Part 2: Tests;<br>Test Eh: Hammer tests   |
| DIN EN 60068-2-78<br>(VDE 0468-2-78)                                     | Environmental influences;<br>Part 2-78: Test methods;<br>Test Cab: Damp heat, steady state                                     |

## **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 with the purpose of preventing operation of a machine element under certain conditions (usually as long as a guard 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**    **Bypassing by simple and predictable means**

Bypassing by simple and predictable means is the rendering ineffective of position switches, 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 switches or their actuation by means of the tools list above with the intent of rendering an interlocking device ineffective.

## 2.5 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.

## 2.6 Mechanical service life

The 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.

## 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 the position switch 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 position switch,
- 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 position switch 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 138491 Table C.1, all test reports, test certificates and calculations, which were used in its determination, must be provided (see Section 5.17).

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

Positively opening position switches for safety functions, henceforth referred to as "position switch(es)", 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 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 instruction, the proper functioning of the position switch must be ascertained prior to the initial test, and subsequent to each individual test.

### 5.2 Labels and markings

Each position switch 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,
- 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.

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 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 609501, should be used as test fluid.*

### 5.3 Instruction manual

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 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 position switch:

- Manufacturer's/authorised representative's name and complete address,
- Designation of the safety component (e.g. position switch)
- Rendering of the content found in the Declaration of Conformity (except for serial number and signature),

- General description of the position switch and its intended usage,
- Instructions for assembly, installation and connection of the position switch,
- Maintenance procedures and setting instructions (if necessary),
- Description of fault characteristics (if necessary),
- Usage category and rated operating current(s) at the rated operating voltage(s),
- Rated voltage,
- 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,
- Actuating travel through completion of positive opening,
- Maximum actuating speed,
- Maximum actuation frequency,
- Specification of the  $B_{10d}$  value.

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 switch attachment provides for adjustment,
- ▶ Notice that the position switch must not be used as a mechanical stop.
- ▶ For design variant 2 position switches: Annotated notice that the installation of actuator mounting elements must protect against potential dismantling, such as through welding, rivets, one-way screws, adhesive bonding, bored screw heads.
- ▶ Notice that performance levels according to DIN EN 13849-1 may be reduced with series connected position switches due to decreased fault recognition.

- ▶ 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.

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 position switch 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 concerning 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:

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

If the position switch 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 609471**, Section 7.1.9.1, position switches with metal enclosures must always be outfitted with a protective earth connection in the inner chamber. This applies to position switches 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 switch 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

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

On design variant 1 position switches, measures can be taken during installation to protect against bypassing.

Design variant 2 position switches 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 position switch, the actuator intended for use must not be used as an object for checking bypassing capacity.*

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

If the manufacturer provides attachment screws for the position switch 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).

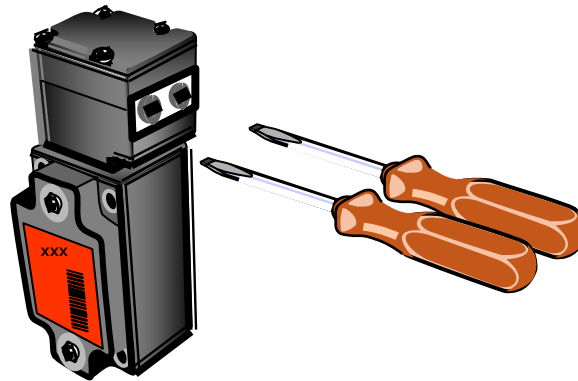


Fig. 1: Trial actuation with two identical objects

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

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

b) Visual inspection of the mounting elements provided.

## 5.7 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 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 position switch 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 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 60947-1, 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 position switches 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 position switch must be outfitted with effective strain-relief for the connection wiring.

#### **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**

#### **5.8.1 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 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 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

### 5.11.1 Position switch protection class inside enclosures

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 position switches 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.

### 5.11.2 Verification of actuating force or moment

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

## 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 7.1.3 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.

## 5.12 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 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 5.13.2.5.

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

**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 according to DIN EN 13906-1.

**Test:** In accordance with 5.12.2.5.

#### **5.13.2.5 Tests for 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 supplements:  
The test can also be performed by immobilization of the contact element in the closed state and application of  $F_2 \geq 10 \text{ N}$  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 test 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. Damage must not have occurred, which could influence the function, safety or proper mounting.
3. Components must not have detached or loosened to the point that impairment of position switch safety results.
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.

### 5.15.1 Shock test

The position switch will be subjected in-turn to mechanical shocks in 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. 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 5.15.

| <b>Component test</b>        |  |
|------------------------------|--|
| <b>I. Shock:</b>             |  |
| 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 per axis (3 shocks each in all 6 directions) |
| <b>II. Continuous shock:</b> |  |
| Test standard                | DIN EN 60068-2-29                              |
| 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.

Subsequent to the test, the evaluation criteria must have been fulfilled according to 5.15.

### 5.16 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 position switches 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 design variant 2 position switches, the actuator must be inserted at the at the least favourable actuation angle. Actuation must be carried out from the least favourable approach direction.

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

### 5.17 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).

### 5.18 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.

### 5.19 External materials and properties

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

**Test:** Handling and visual inspection.

### 5.20 Electromagnetic compatibility (EMC)

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

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

## **GS-ET-15, Annex A (Status as of: May 2001)**

### **Additional requirements for design variant 2 position switches for use in applications with increased demands on the safety function**

#### **A.1 Instruction manual**

##### **5.3 applies with the following supplements:**

- Instructions regarding protection against the accumulation of dust, etc. in the switch head,
- Instructions that, in the event of an increased risk of contamination, such as due to dust exposure, the device must be installed with the switch head mounted in a downwards direction,
- Instructions regarding mounting and cable routing,
- Instructions regarding integration of the switch into a control system with increased safety functions,
- Instructions regarding cross-circuit detection, as necessary,
- Annotated reference that this switch does not replace two switches, in cases where a Type C standard explicitly requires two-channel control by means of two separate position switches,
- Annotated reference that, in applications where stricter requirements are imposed upon the safety function, the switch may be loaded to max. half the rated current.

#### **A.2 Actuation system/Positive opening system**

##### 5.13.2 applies with the following supplements:

##### **A.2.1 Switch head**

Switches used for applications where stricter requirements are imposed upon the safety function, and whose heads are not a fixed part of the enclosure (e.g. single-piece enclosure), must be designed in such a manner that the head cannot be detached by means of simple tools and the mounting elements are secured against accidental loosening.

**Test:** Visual inspection; safety assessment of the monitoring facility

##### **A.2.2 Switch strength**

Switches used for applications where stricter requirements are imposed upon the safety function must be designed in such a manner that, when the break contact element is closed, no damage can occur to a blocked actuation system when exposed to an opening force of at least 1000 N.

The actuator must remain in the locked position.

**Test:** This test should be carried out immediately following the test of the mechanical service life. The switch should be properly secured to a base and the actuator inserted into the actuation system so that the break contact element is closed. With the actuation system blocked, the actuator is subsequently subjected to a steadily increasing force in the opening direction of at least  $F_{\max} = 20 \times$  minimum opening force or  $F_{\max} = 1000 \text{ N}$ , whichever is the higher (holding time at  $F_{\max}$ : 3 s). Blockage should be effected at the interface to the electrical installation space.

Following blockage release, the switch should exhibit no damage that might degrade safety and its proper function must be warranted.

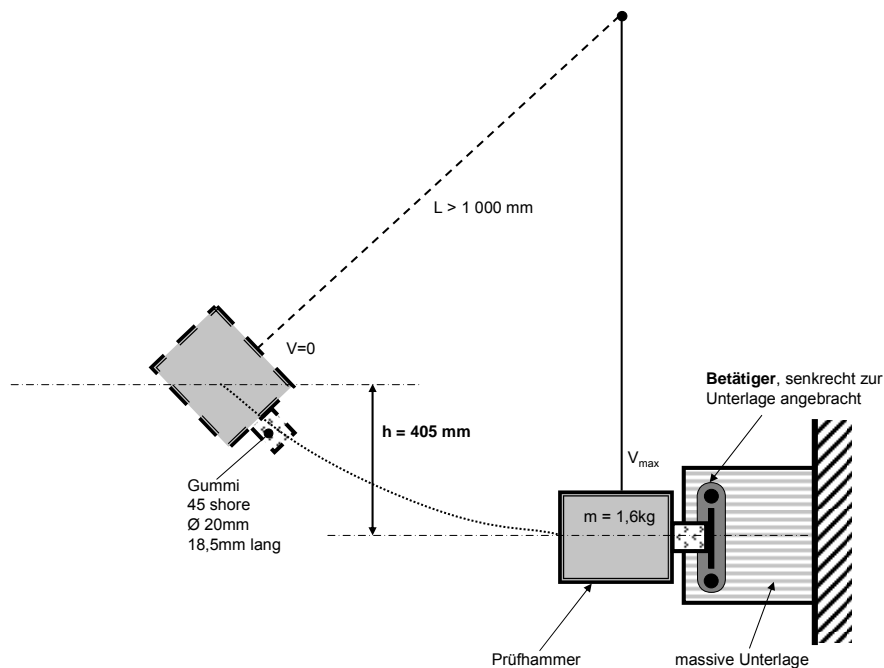
### A.2.3 Actuator strength

Position switch actuators used for applications where stricter requirements are imposed upon the safety function must be made of metal and designed in such a manner, with regard to its strength, that impact forces acting from either side and perpendicular to the direction of actuation do not result in breakage of or visible material failure on the actuator.

**Test:** The actuator should be properly secured to a solid (non-resilient) base in front of a test hammer as shown in Fig. 1, and in such a manner that the hammer is able to impact the free end of the actuator. The test hammer is then raised to a height of  $h = 405 \text{ mm} \pm 2 \text{ mm}$  with  $V = 0$  and released.

Following the impact, there should be no breakage of or visible material failure on the actuator. If deformation to the actuator results from the impact, it must be realigned so as to restore its original form. When restoring the actuator to its original form, there should be no breakage of or visible material failure on the actuator.

The test should be carried out 3 times on each side of the actuator.



**Fig. 1:**

### A.3 Contact elements

5.5.1 applies with the following supplements:

Switches used for applications where stricter requirements are imposed upon the safety function must comprise at least two positively opening contacts with each in a separate chamber.

**Test:** Visual inspection.

### A.4 Protection class based on the enclosure

The electrical installation space for switches used for applications where stricter requirements are imposed upon the safety function must conform to Protection class IP 65/IP 67 as a minimum.

**Test:** Testing is carried out according to 5.11.1.

## **A.5 Mechanical strength**

5.15 applies with the following supplements:

The impact test described in Section 5.14.2 should be performed with an impact energy of 2 Nm.

**Test:** Visual inspection; assessment of the type of mounting; impact test

## **A.6 Terminal connections and terminal compartment**

**5.7.3 applies with the following supplements:**

Switches used for applications where stricter requirements are imposed upon the safety function must be designed in such a manner that

a) Cross-circuits are prevented, for example by means of

- Installation of insulation points between the terminal pairs,
- Introduction of two separate light plastic-sheathed cables,
- Separate cable routing,

or

b) Cross-circuits are identified by means cross-circuit monitoring or cross-circuit detection with additional control-related measures.

**Test:** Visual inspection; assessment of the measures, review of the Instruction manual.

## **A.7 Mechanical service life**

The mechanical service life must be at least  $1.5 \times 10^6$  switching cycles.

**Test:** Testing is carried out according to 5.16.