



BG-PRÜFZERT

Supplementary requirements for the testing and certification of safety switchgear

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Expert committee for electrical engineering
Test and certification body
at BG-PRÜFZERT
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GS-ET-20

The test principles serve to verify that in conjunction with DIN EN 60947-5-1, the requirements of the German Equipment and Product Safety Act (GPSG) and therefore also the 1st and 9th Regulations pursuant to it are observed.

The principles set out here will be periodically revised and extended in consideration of technical progress and the latest findings in the area of occupational health and safety. The most recent edition shall be binding for all tests conducted by the testing and certification department of the committee for electrical engineering.

Test principles GS-ET-20, issue date 2006-04, may be used until 29 December 2009.

The test principles supplement the requirements and tests set out in DIN EN 60947-5-1 for safety switchgear by the formulation of supplementary requirements.

Changes from the 2006-04 edition

- 1.2 Technical rules
 - Deletion of DIN EN 954-1
 - Inclusion of DIN EN ISO 13849-1

- 3.1 Technical documentation
 - New: detailed listing of documents

- 3.2 - New: product data

- 4.2 Product information
 - Addition of PL and SILCL to the data required in the user information
 - New: necessary reference to validation of the complete control system by the user
 - New: adaptation of the content to the Machinery Directive, 2006/42/EC

- 4.3 Labelling
 - New: 4.3.1 Minimum information on the safety switchgear

- 4.13 Delay time of safety-related contacts
 - Editorial changeover from Category to PL and SILCL

- 4.14 Fault-mode behaviour
 - Replacement of DIN EN 954-1 by DIN EN ISO 13849-1 and DIN EN 62061
 - Consideration of all uses in evaluation of the fault-mode behaviour, and statement of mean demand rate data

- 4.15 - New: EMC requirements

- Annex A New: definition of the value for the mean annual demand rate n_{op} where relevant manufacturer's data are not available

- Annex B New: contractual information for safety switchgear

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1 General

1.1 Scope

These test principles apply to safety switchgear in safety-related applications. The safety switchgear concerned may contain electromechanical and/or electronic and/or programmable electronic components for implementation of the safety function.

1.2 Technical rules

DIN EN ISO 13849-1: Safety of machinery;
Safety-related parts of control systems
Part 1: General principles for design

DIN EN ISO 13849-2: Safety of machinery;
Safety-related parts of control systems
Part 2: Validation

DIN EN 62061 Safety of machinery – Functional safety

VDE 0113-50: Safety-related electrical, electronic and
programmable electronic control systems

DIN EN 61326-3-1: Electrical equipment for measurement, control and
laboratory use
-EMC requirements-
Part 3-1: Immunity requirements for safety-related
systems and for equipment intended to perform
safety-related functions (functional safety)
- General industrial applications -

2 Terms and definitions

2.1 General

2.1.1 Safety function

Function of an item of switchgear triggered by an input signal, the purpose of the function being attainment of a safe state.

2.1.2 Electrical relay

Device with the function of effecting immediate, previously defined changes in one or more electrical output circuits when certain conditions which drive the device arise in the electrical input circuit.

2.1.3 All-or-nothing relay with mechanically linked contacts

All-or-nothing relay with at least 1 break contact and 1 make contact which assures by mechanical means that the break contact(s) and make contact(s) can never be closed at the same time.

3 **Documentation and type samples to be submitted**

3.1 **Technical documentation**

The information for placing in service and wiring up of the safety switchgear shall be supplied in the form of drawings, circuit diagrams, tables, descriptions and user information.

The following technical documentation shall be submitted **in German** for the technical test:

- Fitting instructions
- Adjustment instructions
- User information
- Sales brochure (if available)
- Circuit diagrams
- Parts lists
- Printed circuit board layouts
- Component mounting diagrams
- Software documentation in accordance with the applicable standard
- Single fault analysis (e.g. FMEA)
- Fault combination analysis (e.g. FTA)
- If applicable, test reports from accredited bodies

The test body may require the submission of further documentation if necessary.

3.2 Product data

The form in the annex must be completed in full and submitted together with the application form.

3.3 **Type samples**

The number of type samples to be submitted shall be specified by the test body. At least two type samples shall generally be supplied.

4 Type examinations

4.1 General test requirements

Safety-related switchgear shall satisfy all the requirements set out below. Tests shall be performed in a sequence in which the results of tests do not influence the results of the following tests. Where uncertainty exists, a separate test specimen shall be employed.

The satisfaction of more far-reaching manufacturers' specifications must be demonstrated separately.

The tests shall be conducted on safety switchgear in accordance with the rating data stated by the manufacturer.

Unless stated to the contrary in the individual test instructions, proper functioning of the safety switchgear shall be ascertained prior to the first test and following each individual test.

4.2 Product information

4.2.1 The product information shall be in an official language of the Community which is accepted in the country in which the device is to be installed. Should this product information not be in German, a German translation shall be provided. Testing shall be conducted with reference to the German translation.

4.2.2 The devices shall be accompanied by user information which permits proper wiring up and placing in service. In addition to satisfying the requirements of the standards, the user information must also contain the following minimum information:

- a) Company name and full address of the manufacturer
- b) Product description
- c) EC declaration of conformity in accordance with Annex II 1.A
- d) Information concerning application of DIN EN ISO 13849-1

Category

PL

MTTF_d

DC/DC_{avg}

Mean operating time d_{op}

Mean operating time h_{op}

Cycle time t_{cycle}

d) Information on application of DIN EN 62061

SILCL
Hardware fault tolerance
DC/DC_{avg}
SFF
PFH_D

e) Indication of voltage type and frequency (if not 50 Hz)

f) Indication of power/current consumption of the device

g) Indication of protection of the safety-related output contact circuits

h) Operational temperature range, if other than -5 to +40 °C

i) If applicable, separate indication of the IP ingress protection according to terminal region and enclosure, and information concerning the additional installation space if required

j) The manufacturer must state the conductor type (solid, stranded or finely stranded), the smallest and the largest suitable terminal conductor cross-sections, and if applicable the number of conductors that may be connected at the same time

k) Information must be stated on the pick-up and drop-out delay of delayed output contact circuits

l) Where delayed safety-related contacts are used, the information must be included that they may extend the pick-up time or reduce the drop-out time

m) Simplified diagram of the internal circuit, in order to illustrate the function of the terminals (functional description)

n) Description of examples of wiring up for intended uses

o) Fault-mode behaviour

p) Where semiconductor output contact elements are used, Annex H.5 of DIN EN 60947-5-1 must be observed

q) Reference to differentiation between circuits for safety-related applications and circuits for signalling purposes

r) Information for the user of the safety switchgear that the overall concept of the control system into which the safety switchgear is incorporated must be validated

s) Indication of the boundary conditions under which the stated PL/SILCL was determined

Testing: Inspection of the submitted technical documents; review for completeness, correctness, and freedom from contradictions.

4.3 Labelling

4.3.1 Minimum information on the safety switchgear

- Company name and full address of the manufacturer
- Description of the safety switchgear
- Type designation
- Serial number, if applicable
- Year of manufacture, i.e. the year in which the manufacturing process was completed
- CE marking

4.3.2 Dimensions of symbols, letters and numbers

The symbols, letters and numbers must be at least 2 mm in height.

Testing: Visual inspection/measurement of the markings or type plate.

4.3.3 Durability

The markings must be indelible.

Testing: Light rubbing with a cloth soaked in water and a cloth soaked in petroleum, for 15 s in each case. The markings must then be clearly legible. Labels must not have come away from the device.

NOTE: *For the properties of the petroleum, refer to DIN EN 60950-1, Section 1.7.13.*

4.3.4 Position

The labelling of the terminals must remain clearly visible when the switchgear is wired up.

Testing: Visual inspection.

4.3.5 Completeness of the information

Besides fulfilment of the requirements of the standard, the following information must be included:

- a) Rated operational voltage and type; rated frequency, if not 50 Hz

- b) Protection of the operational voltage, if necessary
- c) Rated operational current values at the rated operational voltages of the output contacts
- d) Symbolic assignment of the terminals according to their function

Testing: Review for completeness, correctness, and freedom from contradictions.

4.4 Mechanical tests

Safety switchgear shall present adequate resistance to the mechanical loading, such as vibration, impact or shock, to which it is likely to be exposed in accordance with the specifications.

4.4.1 Impact test

The device shall be stored for 2 hours at -5 °C, after which the Ehc ("vertical hammer") test to DIN EN 60068-2-75 shall be performed as follows:

Three impacts of 0.7 J shall be executed at the point considered to be the weakest point; particular attention shall be paid to the insulating components shrouding live parts (terminals).

Damage to the test specimen following this test is not permissible. In particular:

1. Live parts shall not have become exposed to the touch.
2. The effectiveness of insulating shroudings and partitions shall not have been impaired.
3. The test specimen shall continue to present the degree of protection against the ingress of dust, solid foreign objects and water required by its classification.

Testing: Visual inspection.

4.4.2 Vibration test

The vibration test shall be conducted in accordance with DIN EN 60068-2-6. The test shall be conducted at a frequency of between 10 and 55 Hz and a vibration amplitude of 0.35 mm ± 15% at the control point over 10 cycles in all 3 axes. The sweep rate shall be 1 octave/minute.

Following this test, protection against electric shock must remain assured, i.e.: Shroudings shall not have become loose. Clearances and creepage distances must continue to be observed. The location of components shall have remained unchanged. The device must continue to work properly following the test.

Testing: Visual inspection, confirmation of serviceability.

4.4.3 Shock test

The discrete shock test shall be conducted with reference to DIN EN 60068-2-27. The loading shall be:

- 30 g
- 11 ms
- 3 shocks each in 6 directions *)
- Semisinusoidal shock

*) *Three successive shocks shall be applied in both directions on each of the three perpendicular axes of the test specimen, i.e. 18 shocks in total.*

Testing: Visual inspection, confirmation of serviceability following loading.

4.5 Thermal loading capacity of the insulating components

Insulating components (enclosure, mountings of live parts) shall exhibit sufficient thermal and flame resistance.

Testing: The insulating parts shall be subjected to a glow-wire test to DIN EN 60695-2-11 at a temperature of $850\text{ °C} \pm 15\text{ K}$. The glow wire shall be applied to the test specimen for $30 \pm 1\text{ s}$.

Any flame from or glowing of the test specimen shall have extinguished within 30 s of removal of the glow wire. Should any burning or molten droplets drop off the device, they shall not ignite a single layer of tissue paper spread out horizontally (200 ± 5) mm below the test specimen.

4.6 Clearances and creepage distances

As a minimum requirement, the clearances and creepage distances shall satisfy:

- Overvoltage category III
- Pollution degree 2

Between the main circuits, the control circuits and the contact circuits (safety-related contact circuits/signalling circuits), and between different contact circuits, the value for the basic insulation shall be selected as a minimum.

Interfaces intended for the connection of external data processing equipment (external displays, buses, modems, etc.) or communications equipment shall be reliably isolated from terminals and circuits which may carry dangerous contact voltages.

Exception for printed circuits:

Should the values for the clearances and creepage distances be lower than that specified above, the following test is specified:

For the basic insulation up to 300 V, clearances down to 1.5 mm are acceptable provided that it is assured by the use of suitable insulated coatings with appropriate insulating properties that the following withstand voltage test is passed, and the same level of safety thus assured.

Testing: Measurement of the clearances and creepage distances and if necessary performance of the following test.
The conductors concerned between which the clearances and creepage distances are not observed and the conductor paths which, owing to insufficient clearance, are protected by insulating coatings, shall be subjected to an impulse voltage test comprising three impulses of each polarity at an impulse voltage of 1.2/50 μ s and a pause of at least 1 s between pulses in accordance with the test voltage to DIN EN 60947-1, Table H.1 and Table 12. Flashover or dielectric breakdown shall not occur during the test.

For reasons of practicality, the test shall be performed on an unpopulated circuit board.

NOTE: When employed as circuit-board material, epoxy glass fibre is a Group IIIa insulating material and has a CTI value of $175 \leq CTI < 400$.

Should the design clearances between the conductor paths be less than 1.5 mm, acceptance of the reduced conductor path clearances shall in addition require demonstration that the coating employed complies with Type 2 of VDE 0110 Part 3.

4.7 **Demonstration of observance of the temperature-rise limits**

The upper ambient temperature of the safety switchgear during evaluation of the temperature rises is:

- a) That specified by the manufacturer in the user's information, or:
- b) Should no value be stated, at least 40 °C

Should the temperature-rise test be performed at room temperature, the measured temperature rise must be increased by the value of the temperature difference between the upper ambient temperature (manufacturer's figure) and the room temperature.

4.8 **Protection against electric shock**

Measures shall be taken to protect against direct and indirect contact.

A minimum ingress protection of IP 2X shall be assured for the device.

This requirement does not apply to open-type assemblies possessing operating or adjusting elements: in this case, the instruction handbook shall include the instruction that the device is to be fitted with particular observance of the clearances required by DIN EN 50274.

Connectors which may carry dangerous contact voltages and which are released without the use of tools shall continue to exhibit ingress protection of at least IP 2X in the released state.

Testing: Visual inspection of the switchgear.

4.9 **Withstand voltage**

In addition to the requirements of DIN EN 60947-5-1 Section 8.3.3.4, the safety switchgear shall be held for 96 hours at a temperature of (40 ± 2) °C and an atmospheric humidity of (90% to 95%) prior to demonstration of the power-frequency withstand voltage. Subsequent to the test, it shall be held for 1 hour at room temperature.

The test against the conductive mantle around the insulating enclosure/non-earthed exposed metal parts shall be performed at a test voltage of 1.5 times the value.

4.10 **Internal wiring**

4.10.1 Insulated conductors must be dimensioned at least for the rated insulation voltage and the anticipated current loading.

Testing: Visual inspection, measurement, comparison with DIN VDE 0891-1.

4.10.2 Insulated conductors must not come into contact with bare live parts at other potentials or with sharp edges; they must be fixed in a suitable manner.

Testing: Visual inspection.

4.10.3 Internal connections must be such that they are able to withstand the anticipated mechanical and electrical loads.

Testing: Visual inspection of the contact points.

4.10.4 Glass-fibre reinforced epoxy resin shall be employed as the PCB material. Suitable protection against corrosion must be assured.

Testing: Visual inspection of the PCBs.

4.11 **Suitability of the components employed**

All components employed must be used in accordance with their rating data and be suitable for their intended purpose.

Testing: Check of the accompanying data sheets; calculation if applicable.

4.12 **Assembly of components**

Removable plug-connectors for the connection of external lines shall be coded such that the risk of incorrect connection is reduced to a minimum.

Testing: Visual inspection and measurement.

4.13 **Delay time of safety-related contacts**

4.13.1 Safety-related contacts without delayed release

The drop-out time of safety-related contacts shall not exceed 200 ms.

Testing: Measurement of the drop-out time of the contacts at the limits of the stated tolerances for the operational voltage.

4.13.2 Safety-related contacts with delayed release

A delay of up to 30 s is acceptable for Category 3 and 4/Performance Level d and e safety-related contacts to DIN EN ISO 13849-1, and for SILCL 2 and SILCL 3 contacts to DIN EN 62061.

Should this specified maximum delay be exceeded, the following requirements must be met:

- a) The simultaneity of the two timing channels must be monitored.
- b) The simultaneity must be monitored within an interval of $\pm 5\%$ of the selected delay, and must prevent re-energization of the assembly in the event of this interval not being observed.

Testing: Measurement of the drop-out delay time; inspection of the circuit documentation.

4.14 Fault-mode behaviour

4.14.1 Safety switchgear

A check must be performed of whether the safety switchgear satisfies the safety-related parameters to DIN EN ISO 13849-1/DIN EN 62061 stated by the manufacturer. This check must consider all uses of the safety switchgear stated by the manufacturer. Should no data be available for the mean annual demand rate, the data stated in Annex A shall be applied.

Note:

In the sense of this provision, uses are the circuit and/or configuration variants indicated by the manufacturer (e.g. cross-short-circuit detection, single or multi-channel actuation, contact feedback, speed monitoring, adjustment of time delays).

Testing: Validation to DIN EN ISO 13849-2/DIN EN 62061.

4.14.2 Safety switchgear for extension of the contacts of existing devices in accordance with Section 4.14.1

These devices must be such that in the event of a single fault, breaking of the safety-related circuits is not prevented. The devices must feature a feedback circuit which can be inserted into the energization conditions (e.g. terminals X1, X2) of a higher-level device in accordance with Section 4.1.4.1.

Testing: Validation to DIN EN ISO 13849-2/DIN EN 62061.

4.15 EMC requirements

4.15.1 Immunity to interference

With effect from 1 June 2011 **at the latest**, safety switchgear shall satisfy the requirements of DIN EN 61326-3-1 in addition to the requirements to DIN EN 60947-5-1 concerning immunity to interference.

Testing: see DIN EN 61326-3-1

Annex A

Definition of the value for the mean annual demand rate n_{op} where relevant manufacturer's data is not available

Should the applicant fail to state a mean annual demand rate n_{op} in accordance with DIN EN ISO 13849-1:2008-12 Section C.4.2 Formula C.2, the values for n_{op} listed below shall be employed in consideration of the application(s) of the safety switchgear stated in the user information:


Application as	d_{op} in [days per annum]	h_{op} in [hours per day]	t_{cycle} in [seconds per cycle] ¹⁾	n_{op} [in cycles per annum]
Emergency stop device	365 ²⁾	24 ²⁾	2.6×10^6 ²⁾	12
Protective door monitoring	220	12	30	317×10^3
Electro-sensitive protective equipment	220	12	30	317×10^3
Two-hand device	220	12	5	2×10^6

- 1) The values for t_{cycle} constitute "worst-case" values
- 2) It is assumed in this context that the function of a permanently available emergency-stop facility is tested at regular intervals (cf. Section 3 (3) of the German Plant Safety Regulation (BetrSichV)).

Key:

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 successive cycles, in seconds

Annex B


 <p>Fachausschuss Elektrotechnik Prüf- und Zertifizierungsstelle BG-PRÜFZERT</p>	<p>Contractual information</p> <p>- Safety switchgear -</p>	<p>Company:</p>
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Product identification information

Product description	
Type	
Do variants of the product exist?	Yes <input type="checkbox"/> / No <input type="checkbox"/>
Is a variant matrix attached?	Yes <input type="checkbox"/> / No <input type="checkbox"/>

Test principles to be applied and parameters in accordance with the test principles

Testing in accordance with DIN EN ISO 13849-1		Yes <input type="checkbox"/> / No <input type="checkbox"/>
Category		
PL		
MTTF _d in [a]		
DC / DCavg in [%]		
CCF in [points]		
Service life in [years]		
Mean operating time dop in [days/year]		
Mean operating time hop in [hours/day]		
Cycle time tcycle in [s-1]		
Testing in accordance with DIN EN 62061		Yes <input type="checkbox"/> / No <input type="checkbox"/>
SILCL		
Service life in [years]		
Hardware fault tolerance		
DC / DCavg in [%]		
SFF in [%]		
PFHd in [h-1]		
EMC tests		
Tests to DIN EN 61326-3-1		Yes <input type="checkbox"/> / No <input type="checkbox"/>

 <p>Expert committee for electrical engineering, testing and certification department at BG-PRÜFZERT</p>	<p>Contractual information</p> <p>- Safety switchgear -</p>	
Documentation to be submitted	<i>Attached</i>	<i>Will be sent</i>
User information	<input type="checkbox"/>	until
Sales brochure	<input type="checkbox"/>	until
Circuit diagram(s)	<input type="checkbox"/>	until
PCB layout(s)	<input type="checkbox"/>	until

Documentation to be submitted	<i>Attached</i>	<i>Will be sent</i>
Parts list(s)	<input type="checkbox"/>	until
Component failure rates (if available)	<input type="checkbox"/>	until
Single fault analysis/analyses, e.g. FMEA	<input type="checkbox"/>	until
Fault combination analysis/analyses, e.g. FTA	<input type="checkbox"/>	until
Documentation of software in accordance with the test principles	<input type="checkbox"/>	until
	<input type="checkbox"/> Not relevant	

Supplied test reports from external accredited test bodies, for ...	<i>Attached</i>	<i>Will be sent</i>
Electromagnetic compatibility	<input type="checkbox"/>	until
Making and breaking capacity of the safety-related breaking devices	<input type="checkbox"/>	until
Conditional short-circuit current of the safety-related breaking devices	<input type="checkbox"/>	until

Supplied reports of tests in accordance with special agreements, for ...	<i>Attached</i>	<i>Will be sent</i>
	<input type="checkbox"/>	until
	<input type="checkbox"/>	until

Note: In the interests of prompt processing, please ensure that all information is complete.

Date

Name

Signature