DGUV Test
Prüf- und Zertifizierungsstelle
Elektrotechnik
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Translation

Supplementary requirements for the testing and certification of Safety relays

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Principles of testing
Safety relays
GS-ET -20

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GS-ET -20

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 Electrical engineering testing and certification body.

GS-ET-20, Principles of testing, Edition 2020-02 is to be applied as of 16 Dec. 2020 and replaces Edition 2016-10.

These Principles of testing supplement the requirements and tests set forth in DIN EN 60947-5-1 with additional requirements for Safety relays.

Changes with respect to Edition 2016-10:

General	• Replacement of the term ‚Product information' and ‚User information' with the term ‚Operating instructions'
	• Dispensing with references to DIN EN 62061
	• Replacement of the term ‚Electrical relay' with the term ‚Safety relay'
	• Diverse editorial amendments (numbering, standards dating, etc.)
1.2	Supplement to the technical rules DIN EN 60947-5-1, DIN 61000-6-7 and to the standards series DIN EN 61810/VDE 0435
2.1.3	Use of the terminologies and definitions in accordance with DIN EN 61810-1, Section 3.6
4.2	• Supplement to the terms ‚Calibration instructions' and ‚Installation instructions'
	• Specification of I_e (if divergent from the requirements of the utilization category) and specification of B_{10D} for relays in accordance with DIN EN 61810-2-1
	• Deletion of Pt. u)
4.3.2	Adaptation of character/lettering sizes for marking and identification
4.4.2	Substantiation of contact monitoring methodology

Changes with respect to Edition 2016-10 (continued):

4.4.3 Substantiation of contact monitoring methodology

4.6
- Replacement of the conjunctive term ‚and 'through, with' in the Remarks
- Supplement to the information in the relevant Test specifications DIN EN 60664-3

4.14.1 Addition of testing and verification of functional safety parameters, PL, $MTTF_D$ (or B_{10D} for components affected by wear), DC and CCF in accordance with DIN EN ISO 13849-1

4.15 New: Section ‚Electrical and mechanical durability and B_{10D} value determination'

4.16 Supplement to the optional Test specifications DIN EN 61000-6-7

Annex A
- Provision of exemplary source information in Footnote 2)
- Addition of Variable n_{op} to the corresponding legends

Annex B
- Supplement to/modification of the list of ‚*Test reports provided for tests performed under special agreement according to, etc., for…*' to ‚*Test reports provided for tests performed (e.g. under special agreement according to), technical data sheets, etc., for…*'
- Deletion of the passage ‚Electrical/mechanical durability and B10D* value determination for relays 'under ‚*Test reports provided by externally accredited testing facilities for…*' and inserted under ‚*Test reports provided for tests performed* (e.g. under special agreement according to), technical data sheets, etc., for…'with the insertion of a footnote*

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1 General

1.1 Scope

These Principles of testing apply to Safety relays used in safety-related applications. These Safety relays may contain electromechanical and/or electronic and/or programmable electronic components for realizing the safety function.

1.2 Technical rules

DIN EN ISO 13849-1	Safety of machinery; Safety-related parts of control systems - Pt. 1: General principles for design
DIN EN ISO 13849-2	Safety of machinery; Safety-related parts of control systems - Pt. 2: Validation
DIN EN 60947-5-1	Low-voltage switchgear and controlgear - Part 5-1: Control circuit devices and switching elements - Electromechanical control circuit devices
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 −
DIN EN 61000-6-7: [optional]	Electromagnetic compatibility (EMC) – Part 6-7: Generic standards - Immunity requirements for equipment intended to perform functions in a safety-related system (functional safety) in industrial locations
Standards series DIN EN 61810/VDE 0435 Parts 1, 2, 2-1, 3 and 7 (where applicable)	Electromechanical elementary relays

2 Terms

2.1 General

2.1.1 Safety function

A switchgear function triggered by an input signal as a means of attaining a safe state.

2.1.2 Safety relay

A device used to produce immediate, pre-determined changes in one or more electrical output circuits when certain conditions that control the device occur in the electrical input circuit.

2.1.3 Relays with mechanically connected/positively driven contacts [‚Relay 'in short]

Elementary relays with at least one break-contact and one make-contact using mechanical means to prevent the break-contact and make-contact from closing concurrently.

3 Documents and prototypes for submission

3.1 Technical documents

The information for connecting and commissioning the Safety relay must be provided in the form of drawings, circuit diagrams, tables, descriptions and operating instructions.

The following technical documents must be submitted **in the German language** for technical testing:

- Operating instructions
- Installation instructions (if separate from / not part of the Operating instructions)
- Calibration instructions (if separate from / not part of the Operating instructions)
- Sales literature (if available)
- Circuit diagrams
- Parts lists
- Circuit board layouts
- Component layout diagrams
- Software documentation according to the applicable standard
- Single fault analysis (e.g. FMEA)
- Fault combination analysis (e.g. FTA)

The testing facility can request further documentation if deemed necessary.

3.2 Product specifications

Form B as provided in the Annex shall be completed and submitted together with the Application form.

3.3 Prototype

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

4 Type testing

4.1 General test requirements

Safety relays must satisfy all of the requirements below. The testing sequence must be chosen in such a manner that preceding tests do not influence the results of subsequent tests. In case of doubt, a separate test specimen should be used.
Fulfilment of broader manufacturer specifications must be verified separately.

Testing shall be conducted on Safety relays according to the rating data prescribed by the manufacturer.

Unless otherwise specified in the individual test instructions, proper functioning of the Safety relay must be ascertained prior to initial testing and subsequent to each individual test.

4.2 Operating instructions

Operating instructions must be provided in an official language of the community that is acceptable in the country, in which the device is to be installed.
If the Operating instructions are not in German, a German translation must be provided. Testing will be conducted with reference to the German translation.

The devices should be accompanied by Operating instructions that facilitate proper connection and commissioning. In addition to the requirements set forth in the standards, the Operating instructions must contain at least:

a) Manufacturer's name and complete address

b) Product nomenclature

c) EC Declaration of Conformity according to Annex II 1.A

d) Information regarding the application of DIN EN ISO 13849-1
- Category
- PL
- Demand rate with a defined load (including load specification) for components subject to wear

e) Specification of voltage type and frequency (if differing from 50 Hz)

f) Specification of device power/current consumption

g) Information regarding the protection of the safety-relevant output contact current path

h) Operating ambient temperature range (at least -5 to +40 °C)

i) Separate IP-Protection class designations may be required according to the clamping terminal and enclosure, as well as a reference to the potential need for additional installation space

j) Manufacturer specifications for the conductor type (rigid, multi-strand or fine-strand), the smallest and largest conductor cross-sections for which the connections are suitable and, if necessary, the number of simultaneously connectible conductors

k) Information must be provided regarding response or release delays where time-delayed output contact current paths are present

l) Annotation that response times could lengthen, or release times could be curtailed where time-delayed safety-related contacts are used

m) Simplified depiction of the internal circuitry in order to illustrate the clamping terminal function (functional description)

n) Depiction of wiring examples corresponding to its intended proper usage

o) Information regarding fault characteristics

p) Annotation that Annex H.5 of DIN EN 60947-5-1 must be observed if semiconductor output switching elements are used

q) Reference to the differences between the electrical circuitry used for safety-related applications and the electrical circuitry used for reporting applications

r) Notice to the Safety relay user that the overall concept of the control system, into which the Safety relay is to be incorporated, must be validated.

s) Information regarding the conditions under which the prescribed PL has been determined

t) A graphic/tabular depiction ‚B_{10D}* vs. load current**‘ for at least the utilization categories AC15 and DC13 in accordance with DIN EN 60947-5-1 (if applicable)

** In accordance with DIN EN 61810-2-1*
*** Specification of I_e (if divergent from the requirements of the utilization category) and specification of B_{10D} for relays in accordance with DIN EN 61810-2-1*

Sales literature must not contradict the Operating instructions related to safety and health protection.

Test: • Review of the technical documents submitted
• Check for completeness, correctness and consistency

4.3 Markings

4.3.1 Minimum information on the Safety relay:

- Manufacturer's name and complete address
- Nomenclature of the Safety relay
- Type designation
- Serial number (if applicable)
- Year of manufacture, meaning the year in which the production process was completed
- CE-marking

Test: Visual inspection, check for completeness, correctness and consistency of information

4.3.2 Size of graphic symbols, lettering and numerics

The exemplary size of the graphic symbols, lettering and numerics must be at least 2 mm with good contrast so as to be clearly legible.

Test: Visual inspection with measurement of character size

4.3.3 Durability

Inscriptions must be durable.

Test: Gently rub the inscriptions using one cloth soaked in water and one cloth soaked in a test fluid* for 15 s each. The markings must remain clearly legible, while the marking label must remain firmly affixed to the device.

**The chemical product with the trade name "n-Hexan for analysis", which fulfils the requirements for the test fluid defined in DIN EN 60335-1 and DIN EN 60950-1, should be used as test fluid.*

4.3.4 Position

Markings on the terminal clamp must also remain legible when the switchgear is attached.

Test: Visual inspection.

4.3.5 Completeness of information

In addition to the requirements set forth in the standard applied, the following information must be included:

a) Rated operating voltages and type, as well as the rated frequency (if differing from 50 Hz)
b) Fused protection of the operating voltage, if necessary
c) Rated operating current values for the rated operating voltages at the output contact
d) Symbolic allocation of terminal clamps according to their function.

Test: Check for completeness, correctness and consistency

4.4 **Mechanical testing**

Safety relays must possess sufficient mechanical strength to withstand the anticipated operational demands corresponding to its intended proper usage, such as jolting, impact or shock.

4.4.1 Impact test

The device shall be stored for 2 h at the lowest operating ambient temperature prescribed by the manufacturer, after which Ehc "vertical hammer" testing is to be performed as follows (within 120 s) according to DIN EN 60068-2-75:

Three blows of 0.7 J shall be applied at what is considered to be the weakest point, whereby particular attention should be paid to the insulating materials used to shroud live components (contact terminals).

Subsequent to testing, no damage should be found on the test specimen. In particular:

1. the specified degree of protection (IP code) must still be warranted,
2. the effectiveness of insulated lining and separators must not be impaired.

Test: Visual inspection, Protection class testing as necessary

4.4.2 Vibration test

Vibration testing is to be carried out according to DIN EN 60068-2-6 with the following test parameters:

Frequency range / Amplitude	5 Hz ≤ f < 8.4 Hz / 3.5 mm
Frequency range / Acceleration	8.4 Hz ≤ f ≤ 150 Hz / 10 m/s^2
Exposure duration	10 frequency sweeps in each of the 3 perpendicularly positioned axes
Tuning speed	1 octave/min

Test: The test specimen functions in the active safety state, meaning its output(s) is/are opened. During testing, the output switching state must not change. This must be monitored by a measuring system capable of detecting switching state changes greater than 0.2 ms.
Optical monitoring by means of an oscilloscope is sufficient.

Subsequent to testing, the specified degree of protection (IP code) must still be warranted; air gaps and creepage distances must be maintained.
Component locations must remain unchanged. The device must continue to function properly, corresponding to its intended usage.

4.4.3 Shock test

Shock testing is to be carried out according to DIN EN 60068-2-27 with the following test parameters:

Type of shock	Half-sine wave
Shock amplitude	150 m/s^2
Shock duration	11 ms
Number of shocks	3*)

*) 3 successive shocks must be applied in both directions on each of the test specimen's 3 perpendicularly positioned axes: 18 shock exposures in total.

Test: The test specimen functions in the active safety state, meaning its output(s) is/are opened. During testing, the output switching state must not change. This must be monitored by a measuring system capable of detecting switching state changes greater than 0.2 ms.
Optical monitoring by means of an oscilloscope is sufficient.

Subsequent to testing, the specified degree of protection (IP code) must still be warranted; air gaps and creepage distances must be maintained.
Component locations must remain unchanged. The device must continue to function properly, corresponding to its intended usage.

4.5 Thermal load capacity of insulating materials

Insulating materials (enclosures, live part mountings) must be sufficiently resistant to heat and fire.

Test: Insulating materials used to affix current-carrying components in position must be tested at a heat-filament temperature of 750 °C, with all other insulating materials being tested at 650 °C, in accordance with DIN EN 60695-2-10 to DIN EN 60695-2-13.

4.6 Air gaps and creepage distances

Air gap and creepage distance dimensioning should be based on:

- Overvoltage category III
- Contamination level 2

as a minimum.

The minimum values according to DIN EN 60947-1, Tables 13 and 15 must be maintained between the mains circuits, the control circuits and the contact circuits (safety-relevant contact or signalling circuits), as well as between the various contact circuits themselves, with consideration given to DIN EN 60947-1 Table H.1.

Interfaces intended for connection to external data processing equipment (external displays, bus systems, modems, etc.) or communications equipment shall be reliably isolated from terminals and circuits whose voltage potential may prove hazardous with physical contact (refer to DIN EN 60947-1 Annex N).

Test: Measurement

Exception for printed circuits with basic insulation:

If the air gap and creepage distance values are lower than those stipulated above, the following test should be performed:

For the basic insulation up to 300 V, clearances down to 1.5 mm are acceptable if the use of suitable insulating shrouding with appropriate insulating properties is warranted and if the dielectric strength test below is passed, thus indicating that a corresponding level of safety has been achieved.

Test: Measurement of air gaps and creepage distances and, if necessary, execution of the testing below:

Affected conductors, between which the air gaps and creepage distances are not maintained, as well as the conductor paths protected by insulating shrouding due to insufficient clearance distances, are to be subjected to surge voltage testing. This test is comprised of three impulses for each polarity at a surge voltage of 1.2/50 µs with a pause of at least 1 s between pulses, corresponding to the test voltage according to DIN EN 60947-1, Table H.1 and Table 12.
Flashover or dielectric breakdown must not occur during testing.

For practical purposes, testing shall be performed on a bare printed circuit board.

Note: The epoxy glass fibre used for printed circuit boards is a Group IIIa insulating material and has a CTI value of 175 ≤ CTI < 400.

If a design clearance distance between conductor paths is less than 1.5 mm, the acceptability of the reduced clearance requires additional verification, indicating that the shroud coating used corresponds to Type 2 according to DIN EN 60664-3/VDE 0110 Part 3.

4.7 Verification of adherence to excess temperature limits

For analysis of temperature increase, the upper ambient temperature of the Safety relay must:

a) correspond to manufacturer specifications in the Operating instructions or
b) where no information is available, equate to 40 °C

as a minimum.

If temperature-rise testing is carried out at room temperature, the temperature rise ascertained must be increased by the temperature difference between the upper ambient temperature (manufacturer's specifications) and the room temperature.

4.8 Protection against electric shock

Measures must be taken to protect against direct as well as indirect physical contact.

The device must correspond to a minimum Protection class IP 2X.

This requirement does not apply to devices with open-type design, outfitted with operating or control elements. in such cases, the Operating instructions shall indicate that the device must be installed with particular consideration given to clearance distance requirements according to DIN EN 50274.

Plug connectors whose voltage potential may prove hazardous with physical contact, and which can be loosened without the use of tools, must correspond to IP 2X as a minimum, even in the loosened state.

Test: Visual inspection of the Safety relay

4.9 Dielectric strength

In addition to the requirements of DIN EN 60947-5-1: 2018-03, Section 8.3.3.4, Safety relays shall be stored for 96 hours at a temperature of 40 (± 2) °C and an atmospheric humidity of (93 +2/-3) % prior to verification of operating frequency dielectric strength. A post-treatment period of 1 hour at room temperature shall be observed.

Test: According to DIN EN 60947-1: 2015-09, Section 8.3.3.4
The testing voltage for Safety relays in Protection class II must be chosen in accordance with DIN EN 60947-5-1, Section F.7.3.

4.10 Internal wiring

Insulated conductors must be dimensioned for the rated insulation voltage and the anticipated current loading as a minimum.

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

Insulated conductors must not come in contact with bare live parts of differing potential or with sharp edges; they must be fixed in a suitable manner.

Test: Visual inspection.

Internal connections must be configured in such a manner that they are capable of withstanding anticipated electrical and mechanical loads.

Test: Visual inspection of the contact points.

As a rule, glass-fibre reinforced epoxy resin material should be used for printed circuit boards. Suitable protection against corrosion must be warranted.

Test: Visual inspection of the printed circuit board.

4.11 Suitability of components used

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

Test: Check the corresponding data sheets or calculate, as necessary.

4.12 Component assembly

Removable plug connectors used to connect external lines must be coded in such a manner that the risk of inadvertent swapping is reduced to a minimum.

Test: Visual inspection and measurement.

4.13 Delay time for safety-related contacts

4.13.1 Safety-related contacts without release time-delay

Dropout times for safety-related contacts shall not exceed 200 ms.

Test: Measurement of the contact dropout time at the tolerance limit specified for the operating voltage.

4.13.2 Safety-related contacts with release time-delay

A time-delay of up to 30 s is acceptable for safety-related contacts rated as Category 3 and 4, or Performance Level d and e, in accordance with DIN EN ISO 13849-1.

If the specified maximum delay-time is to be exceeded, the following requirements must be met:

a) Simultaneous monitoring of the two timing channels shall be adhered to.

b) This simultaneous monitoring must take place within an interval of ± 5% of the selected time-delay and must prevent the re-energizing of a component in the event the interval is not maintained.

Test: Measurement of the release time-delay and review of the circuit documentation.

4.14 Fault characteristics

4.14.1 Safety relays

A check shall be made to determine whether the Safety relay satisfies the safety-relevant parameters as prescribed by the manufacturer in accordance with DIN EN ISO 13849-1. In so doing, all Safety relay usage variants prescribed by the manufacturer must be considered.

If no information is available regarding the mean annual demand rate, then the specifications prescribed in Annex A should be applied.

Note: *Usage variants in the sense of this provision refer to the circuit and/or configuration variants as specified by the manufacturer (e.g. cross-wire detection, single- or multi-channel actuation, contact feedback, turn-speed monitoring, time-delay settings).*

Test:
- Verification of functional safety parameters PL, $MTTF_D$ (or B_{10D} for structural components affected by wear), DC and CCF in accordance with DIN EN ISO 13849-1
- Validation in accordance with DIN EN ISO 13849-2

4.14.2 Safety relays providing contact expansion on existing devices in accordance with Section 4.14.1

These devices must function in such a manner that a single fault event will not prevent the breaking of a safety-relevant circuit. The devices must feature a feedback circuit that can be incorporated into the switching conditions (e.g. terminals clamps X1, X2) of a higher-level safety relay in accordance with Section 4.1.4.1.

Test: Validation in accordance with DIN EN ISO 13849-2

4.15 Electrical and mechanical durability and B_{10D} value determination for relays

The requirements for electrical and mechanical durability in accordance with DIN EN 61810-3 or the B_{10D} value determination in accordance with DIN EN 61810-2-1 are to be determined by type testing.
As an alternative, a relevant B_{10D} value can be used in accordance with DIN EN ISO 13849-1, Annex C.1.

Test: • Review of the documents submitted
• Check for completeness, correctness and consistency

4.16 EMC requirements

In addition to the requirements in accordance with DIN EN 60947-5-1 concerning immunity to interference, Safety relays must also fulfil the requirements of DIN EN 61326-3-1 or DIN EN 61000-6-7.

Test: In accordance with DIN EN 61326-3-1 or DIN EN 61000-6-7

4.17 External materials and properties

Where function allows, device components subject to physical contact should have no sharp corners, 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.

Annex A

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

If the applicant does not provide information regarding the mean annual demand rate n_{op} in accordance with DIN EN ISO 13849-1:2016-06, Section C.4.2, Form C.2, the following list of values will be applied for n_{op} dependent on the Safety relay application(s) identified in the Operating instructions:

Application as	**d_{op} in [days/a]**	**h_{op} in [h/day]**	**t_{cycle} in [s/cycle]** [1)]	**n_{op} in [cycles/a]**
Emergency-Stop device	365[2)]	24[2)]	$2.6 \cdot 10^6$ [2)]	12
Safety door monitoring	220	12	30	$317 \cdot 10^3$
Contact-free protective equipment	220	12	30	$317 \cdot 10^3$
Two-hand device	220	12	5	$2 \cdot 10^6$

1) The values for t_{cycle} represent ‚*worst case*' values.
2) In this context, it is assumed that the function of a permanently available emergency-stop device will be tested at regular intervals (e.g. § 3 Section 6 of the German Ordinance on Industrial Safety and Health [BetrSichV])

Legend:

d_{op}	Mean operating time in days per year
h_{op}	Mean operating time in hours per day
n_{op}	Mean annual demand rate in cycles per year
t_{cycle}	Mean time between the start of two consecutive cycles in seconds

Annex B

Information related to contract preparation - Safety Relays

Company:	Information related to contract preparation - Safety Relays -	Name: Tel.:

Product identification information	
Product nomenclature	
Type	
Product variants available?	Yes ☐ / No ☐
Variant matrix attached?	Yes ☐ / No ☐

Test specification(s) and parameters according to test specification(s) to be used		
Testing in accordance with DIN EN ISO 13849-1		Yes ☐ / No ☐
Category		
PL		
$MTTF_D$	in[a]	
DC/DC_{AVG}	in [%]	
CCF	in [points]	
Service life	in [years]	
Mean operating duration d_{op}	in [days/years]	
Mean operating duration h_{op}	in [hours/days]	
Cycle time t_{cycle}	in [s^{-1}]	

Documentation to be submitted	*attached*	*will be submitted*
Operating instructions	☐	by
Sales literature	☐	by
Circuit diagram(s)	☐	by
Printed circuit board-layout(s)	☐	by

Company:	Information related to contract preparation - Safety Relays -	Name: Tel.:

Documentation to be submitted	*attached*	*will be submitted*
Parts list(s)	☐	by
Component failure rate (if available)	☐	by
Single fault analysis (e.g. FMEA)	☐	by
Fault combination analysis (e.g. FTA)	☐	by
Documentation of software according by Principles of Testing	☐ ☐ Not applicable	by

Test reports provided by externally accredited test bodies for…	*attached*	*will be submitted*
Electromagnetic compatibility	☐	by
Making/Breaking capacity for safety-related shutdown devices	☐	by
Conditional short-circuit current for safety-related shutdown devices	☐	by

Test reports provided for tests performed (e.g. under special agreement according to ...), technical data sheets, etc., for...	*attached*	*will be submitted*
Electrical/mechanical durability and B_{10D}* value determination for relays	☐	by
	☐	by
	☐	by

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

_____ _____ _____

Date Name Signature

* see Section 4.15 of these Principles of testing