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Translation

Principles of testing and certification for electromechanical enabling switches and enabling devices with and without start-up controllers

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Principles of testing
Electromechanical enabling switches and enabling devices with and without start-up controllers
GS-ET-22

GS-ET-22

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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 accordance with DIN EN 60947-5-8.

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 testing.

These Principles of testing supplement the requirements and tests set forth in DIN EN 60947-5-8 for enabling switches and devices with additional requirements.

Note: *Nevertheless, not every aspect of DIN EN 60947-5-8 will be addressed by the following Principles of testing.*

Changes with respect to Issue 2009-11:

- ***In general:*** ***- editorial changes, - actualization of standards***

Amendments to Edition 2009-11:

- ***Incorporation of special requirements related to foot-actuated enabling switches and enabling devices.***
- ***Amendment to Section 2.1, Definition of terms***
- ***Amendments to Section 5.2, Requirements for the Instruction manual***
- ***Amendment to Section 8.3.6, Supplement to Section 8.3.1 of DIN EN 60947-5-8, Test sequence VI***

Revision of Edition 2009-11:

- ***Section, Cable assembly***

New sections since Edition 2009-11

- ***Section 7.1.8 Latching function in position 3***
- ***Section 7.1.9 Additional requirements for foot-actuated enabling switches/ devices***

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1 General

1.1 Scope of application

These Principles are set forth as a basis for the testing of electromechanical enabling switches (two- and three-position configuration) and of stationary or non-stationary enabling devices, henceforth referred to as enabling switch(es)/ device(s).

Electromechanical enabling switches/ devices are used, for example, in industry robots and automated manufacturing systems to effect control functions under hazardous conditions via different command devices.

Note:
Unless otherwise mentioned, all requirements of the test principles refer to enabling switches/ devices in two- and three-position configuration.

1.1.1 Classification of directives

Electromechanical enabling switches/ devices with and without start-up controllers are included within the scope of Directive 2006/42/EC and, depending on the voltage level, the scope of Directive 2014/35/EU.
When active electronic components are used, it is possible that the equipment will fall within the scope of Directive 2014/30/EC.

1.2 Test specifications

These Principles of testing are based upon

2006/42/EC	Machinery Directive
2014/35/EU	Low-Voltage Directive
2014/30/EU	EMC Directive
DIN EN ISO 12100-1 2011-03	Safety of machinery; General principles for design − Risk assessment and risk reduction
DIN EN ISO 13849-1 2016-06	Safety of machinery; Safety-related parts of control systems; Part 1: General principles for design
DIN EN ISO 13849-2 2013-02	Safety of machinery; Safety-related parts of control systems; Part 2: Validation
DIN EN 60204-1	Safety of machinery;

(VDE 0113 Part 1) 2007-06	Electrical equipment of machines; Part 1: General requirements
DIN EN 60947-1 (VDE 0660 Part 100) 2015-09	Low-voltage switchgear and controlgear; Part 1: General requirements
DIN EN 60947-5-1 (VDE 0660 Part 200) 2010-04	Low-voltage switchgear and controlgear; Part 5-1: Control circuit devices and switching elements; Electromechanical control circuit devices
DIN EN 60947-5-8 (VDE 0660-215) 2007-08	Low-voltage switchgear and controlgear; Part 5-8: Control circuit devices and switching elements; Three-position enabling switch

2 Terms/Characteristic features

2.1 Definition of terms

DIN EN 60947-5-8:2007, Section 2 applies with the following supplements:

2.1.1 Enabling switch

A switching element that assumes the Off or Enable position via an actuator when exposed to a respective force.

Note:
- *The referenced enabling switch is identical to the enabling switch designated in DIN EN 60947-5-8.*
- *An enabling switch can also be an integral component in a hand-held control device.*

2.1.2 Two-position enabling switch

- Position 1: Off-function (control actuator not depressed)
- Position 2: Enable function (control actuator depressed)

2.1.3 Three-position enabling switch

Switches with three successive actuation positions, whereby the contacts in the middle (slightly) depressed actuator position are closed while the contacts in the fully depressed and in the neutral positions are open.

2.1.4 Enabling device

The definition of terms found in DIN EN 60947-5-8, Section 2.1 applies.

Note:
- *The enabling device designated in DIN EN ISO 12100-1 is identical to the enabling device designated in DIN EN 60947-5-8.*
- *Enabling devices are connected with a start-up controller, yet they do not necessarily form a physical unit. Together, they form an integral element of the safety-related control functions.*
- *Enabling devices are not restricted only to equipment intended to be actuated by hand (see DIN EN 60947-5-8, Section 4.2.1).*

2.1.5 Start-up controller

Within the context of these Principles of testing, the start-up controller is a signal processor that warrants the safety function of an enabling switch/ device in connection with monitoring measures, such as contact and performance monitoring (see DIN EN 60947-5-8, Section 2.1).

Note:
- *If the start-up controller is required for the safety function of an enabling switch/ device, it should be considered as an integral part of that enabling switch/ device. If the start-up controller is not required for the safety function of an enabling switch/ device, then it will not be considered within the context of GS-ET-22.*
- *In addition, other functions, such as a start function, can be integrated into the start-up controller.*

2.1.6 Safety function

A machine function, whereby a loss of the function will lead to an immediate increase in the level of risk(s).

2.1.7 Bypass/ Defeat

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

2.1.8 Bypassing by simple and predictable means

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

Note:
Readily available objects for alternate actuation can be needles, sheet-metal blanks, weights, screw clamps and items for everyday use, as well as coins, adhesive tape, pack-twine and wire.

2.2 Characteristic features

Section 4 of DIN EN 60947-5-8 shall apply.

3 Test documentation to be submitted

3.1 Technical documents

The information for connection and commissioning of the electromechanical enabling switches/ devices must be provided in the form of drawings, circuit diagrams, tables and user information. The following test documents must be submitted for the technical test:

- Instruction manual
- Sales literature (if available)
- Block circuit diagram (if applicable)
- Electric circuit diagram
- Description of the functional process
- Parts list(s)
- Maintenance procedures and setting instructions (if applicable)
- Installation instructions
- Insofar as they are available, data sheets, test certificates, certificates for the enabling switch/enabling device and/or the parts it comprises;
- Printed circuit board layouts (if applicable)
- Layout diagrams (if applicable)
- Software documentation (if applicable)
- Insofar as a B_{10D} value is specified for the enabling switch, which is larger than the typical values listed in DIN EN ISO 13849-1, Table C.1, all test reports, test protocols and calculations used in its determination must be provided.
- FMEA and fault-combination analysis for enabling equipment

The testing facility can request further documents if needed.

3.2 Prototype

As a rule, three type prototype samples are to be provided for testing.

The testing facility can request additional prototypes if necessary.

4 General test conditions

Electromechanical enabling switches/ devices must satisfy all the requirements set forth in the following sections. These Principles of testing comprise minimum requirements. Insofar as the manufacturer may have specified more stringent requirements, those should be used as a basis for testing.
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 enabling switches/ devices must be ascertained prior to the initial test and subsequent to each individual test.

5 Product information

Section 5 of DIN EN 60947-5-8 is replaced by Sections 5.1 to 5.3 of the Principles of testing.

Note:
Sections 5.1 to 5.3 of the Principles of testing also comply with the requirements of DIN EN 60947-5-8, Section 5.

5.1 Labels and markings

5.1.1 Type plate

The following information must be provided on the outer casing:

- Manufacturer's/authorised representative's name and complete address
- Nomenclature of the safety component
- CE-marking
- Design series or type designation
- Serial number, as appropriate
- Year of manufacture
- IP-Protection class
- Symbol for Protection class II or III, if applicable

- „IEC 60947-5-8“, in the event the manufacturer claims conformity with this standard
- Type of design: two-stage or three-stage
  On three-stage models, the alternative symbol in accordance with Section 5.1 (d) of DIN EN 60947-5-8:
- Actuation forces/actuation strokes*
- Rated operational voltage*
- Rated operational current*
- Utilization category*
- Rated insulation voltage and rated surge voltage resistance*
- Degree of contamination (see IEC 60947-5-1, Section 6.1.3.2)*
- Type of and highest rated value of the short-circuit devices (see IEC 60947-5-1, Section 8.3.4.3)*
- Conditional short-circuit current if lower than 1,000 A*
- Marking of contact elements with the same polarity*
- Mechanical and/or electrical service life*

* The specifications can be provided on the type plate or in the Instruction manual.

Test: Visual inspection of the available prototype or the Instruction manual, as necessary.

5.1.2 Terminal connection designation and identification

Terminal connections and clamps must be identified in accordance with DIN EN 60947-1, Section 7.1.8.4.

Test: Visual inspection of the available prototype.

5.1.3 Functional identification

Either black, white or grey should be selected as the colour for the actuator. Other colours are permissible if there is not potential for mix-up with the emergency-stop device. The colour red is not permissible.

Test: Visual inspection.

5.1.4 Size of graphic symbols, characters and digits

The size of graphic symbols, characters and digits must be at least 2 mm.

Test: Visual inspection/measurement of inscriptions and/or those on the type plate (if present).

5.1.5 Durability

Inscriptions must be durable and clearly legible.

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. 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 60950-1, should be used as test fluid.

5.1.6 Position

The inscriptions should not be affixed to assembly parts (screws, washers, seals).

Test: Visual inspection.

5.2 Instruction manual

The enabling switch/ device should be accompanied by the information required for its proper connection and commissioning.

Safety-related information must be provided in a language acceptable in the country, in which the enabling switch/ device is to be installed.
If the Instruction manual is not in German, a German translation must be provided. The test will be conducted with reference to the German translation.
The Instruction manual supplied with the product must contain the following characteristic features of the enabling switch/ device:

- Annotation of „Original instruction manual“ or „Translation of the original instruction manual“ according to the Machinery Directive

- Manufacturer's/authorised representative's name and complete address

- Design series or type designation

- Designation of the safety component (enabling switch or enabling device)
- Rendering of the content found in the Declaration of Conformity (except for serial number and signature)

- General description of the enabling switch/ device

- Technical specifications
    - Overvoltage category

  - Degree of contamination
  - Rated insulation voltage
  - Rated surge voltage resistance
  - Information about short-circuit protection devices
  - Specification of the conductor type, as well as largest and smallest conductor cross-sections, for which the terminals are suitable.

- Terminal connection diagram/Circuit diagram

- Examples of usage applications (e.g. integration in the machine controller) for realization of the planned category or performance levels in accordance with DIN EN ISO 13849-1. If necessary, special components or parameters required may need to be addressed in more detail.

- Description of intended usage, in particular with respect to environmental influences

- If applicable, warning notices related to foreseeable faulty application

- Specification of the safety function

- Instructions for assembly, installation and connection of the enabling switch/ device, including drawings, circuit diagrams and attachments

- Annotated reference that the user of the enabling switch/ device must evaluate and document the remaining residual risk.

- If applicable, description of required maintenance measures

- If applicable „Additional information" according to DIN EN 60947-5-8, Section 5.4

- Specifications according to DIN EN ISO 13849-1:
  - Enabling device with start-up controller:
    - Category
    - PL
    - $MTTF_D$ or PFH_D
  - Enabling switch and enabling device without start-up controller:
    - B_{10D} value

- Ambient temperature range (min. -5 °C ≥ *t* ≥ 40 °C)

- If applicable, information regarding fault characteristics

- Notice to the user that the overall control concept into which the enabling switch/ device has been integrated must be validated in accordance with DIN EN ISO 13849-2.

- Note: Electromechanical enabling switches/ devices must be connected with the control unit in such a manner that the safety-related demands on the electrical circuit are fulfilled in accordance with DIN EN ISO 10218-1, DIN EN 60204-1, DIN EN ISO 13849-1 and DIN EN ISO 11161.

- Annotated reference that control signals introducing potentially hazardous conditions must not be initiated solely by the enabling switch/ device (see EN 60204-1, Section 9.2.6.3).

- Information regarding the use of two or more enabling switches/ devices in a hand-held unit, see Section 9.

- Annotated reference that the requirements of DIN EN 60204-1, Section 9.2.6.3 related to measures for inhibiting potential bypass must be taken into account.

- Additional information related to enabling switches/ devices with a latching function in the third stage: Annotated reference that the enabling switch/ device does not constitute an alternate Emergency-Stop device. Nevertheless, the third stage breaker contact can be integrated into an Emergency-Stop circuitry.

- Additionally for foot-actuated enabling switches/ devices:
  „Warning regarding the potential confusion and related hazard associated with using multiple foot switches or actuators.“

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

5.3 Sales literature

Sales literature, in which the enabling switch/ device is described, must not contradict the Instruction manual with respect to usage.
If performance characteristics are described in the sales literature, these must agree with the specifications in the Instruction manual.

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

6 Normal operating, installation and transport conditions

DIN EN 60947-5-8, Section 6 shall apply with the following supplements:

6.1 Supplement to DIN EN 60947-1, Section 6.1.1

Test: The enabling switch/ device should be stored at highest and lowest ambient temperature limits specified in Section 5.2 until a steady state condition is realized and must pass the functional test according to DIN EN 60947-5-8, Section 8.2.5.

7 Requirements for construction and characteristics

7.1 Construction requirements

DIN EN 60947-5-8, Section 7.1 shall apply with the following supplements:

7.1.1 Supplement to DIN EN 60947-5-8, Section 7.1.1

Insulating materials must be sufficiently resistant to heat and fire.

Test A: Ball pressure test of the switching element at 125°C and of the casing at 75°C.
The test is undertaken in a heating cabinet at a temperature of (125 ± 2)°C or (75 ± 2)°C respectively.
Testing is carried out according to DIN EN 60695-10-2.

Test B: DIN EN 60947-1, Section 7.1.2 applies.
Insulating materials, which are used to affix current-carrying components in place, must be tested at a heat-filament temperature of 750 °C, with all other
Testing is carried according to DIN EN 60947-1, Section 8.2.1.1.1 in conformity with DIN EN 60695-2-10 and DIN EN 60695-2-11.

7.1.2 Supplements to DIN EN 60947-5-8, Section 7.1.7

Either Protection class I, II or III conforming to DIN EN 61140 must be applied.

Test: Visual inspection of the available prototype, review of the technical documentation related to the rated operating voltage.

7.1.3 Supplements to DIN EN 60947-5-8, Section 7.1.8

7.1.3.1 Cable insertion points

Enabling switches/ devices must be designed with tension-/pressure-relief in order to relieve the cables from strain and pressure, as well as twisting.

The connection cable must be outfitted with a bend/kink protection sleeve or trumpet-shaped inlet opening at the location where the connection cable enters the enabling switch/ device enclosure.

Suitable tension relief and bend/kink protection must be provided for all existing plug connections in the circuit.

Test: Visual inspection of the available prototype to ensure the construction requirements above have been fulfilled.
Testing is carried according to DIN EN 60947-5-1, Annex G.

7.1.3.2 Cable assembly

Enabling switches/ devices must be designed in such a manner that the connection cables described in the Instruction manual can be connected.

Note:
Depending on the usage and the desired Performance level according to DIN EN ISO 13849-1, a fault exclusion may be necessary for short- and cross-circuits within the connection circuitry. This can be achieved through the use of isolated sheathed cables within the connection circuitry. A closure between different enabling circuits can be recognized by switching the individual circuits to different potentials.

Test: Review of the user information and appropriate visual inspection of the prototype.

7.1.3.3 Environmental influences

Connecting cables must be resistant to the environmental influences anticipated with proper usage (e.g. cooling lubricants, oils, swarf, temperatures, etc.). It must be taken into account that, especially with respect to non-stationary enabling switches/ devices, connecting cables will be pulled over the floor on a regular basis.

Test: Visual inspection of the connecting cables and review of the data sheets/ Instruction manual.

7.1.3.4 Conductor cross-sections

The minimum cross-section of an individual connecting cable must be at least 1 mm^2. Smaller cross-sections are permissible if the mechanical stability of the connecting cable can be otherwise guaranteed (e.g. protective tube covering).

Test: Measurement and calculation of the individual conductor cross-sections; evaluation of the connection circuitry.

7.1.4 Supplement to DIN EN 60947-5-8, Section 7.1.9

The spring for resetting stage 2 or stage 3 back to stage 1 must be designed as a reliable spring according to DIN EN ISO 13849-2, Table A5 or A2. Alternatively, and depending on the individual situation, a dual-channel assembly in the reset-system (without reliable spring) and contact monitoring can be implemented.

Test: Trial of the prototype on hand, visual inspection as to whether the specified requirements are fulfilled, measurement of the winding distance and comparison with the wire diameter, as necessary.

Three-stage enabling switches/ devices must have at least one positively opening break-contact for the third stage in accordance with DIN EN 60947-5-1, annex K. Alternatively, comparably safe techniques can be used (e.g. dual-channel signalling with corresponding control-related monitoring).

Additionally, the third stage may contain a make-contact circuit element that must be galvanically isolated from the break-contact circuit element. Further galvanically isolated circuit elements such as signalling contacts are permissible.

Overlapping contact signals for the third stage by make- and break-contact circuit elements are not permissible.

Test: Functional testing of the available prototype or disassembly of the prototype to determine if the above criteria has been fulfilled.

7.1.5 Supplement to DIN EN 60947-5-8, Section 7.1

Protection against bypassing:

Design features must exist which minimize the potential for bypassing by simple means. Possible examples could be a recessed actuator installation, protective collars, etc.

Protection against bypassing can also be achieved via the controller. For example,

- requiring re-actuation of the electromechanical enabling switch for each new alignment or test cycle,
- subjecting actuation to a time-limitation.

Note:
The measures taken against simple bypassing must always consider ergonomic actuation options. Consequently, some design measures will only be practicable to a limited extent. However, this does not negate the manufacturer's responsibility to provide adequate design features.

Test: Visual inspection of the prototype, check the switch operating function (if present) according to the criteria above.

7.1.6 Supplement to DIN EN 60947-5-8, Section 7.1

External materials and properties

No materials containing substances harmful to health may be used on any part of the enabling switch/ device that may regularly come into direct contact with the operator's skin during usage.

Test: Review of the safety data sheets for the materials used, especially with regard to the proportion of polycyclic aromatic hydrocarbons (PAH).
Testing is carried out according to the German Product Safety Commission document, AfPS GS 2014:01 PAK.

Insofar as functionally practicable, any physically accessible piece of equipment must be free of sharp corners, edges or abrasive surfaces that can cause potential injury.

Test: Handling and visual inspection.

7.1.7 Latching function in position 3

If an enabling switch/ device is configured with a latching function in position 3, then the following requirements must be fulfilled:

- The latching function must remain engaged at least until the enabling switch/ device has been reset (unlocked).
- The latching function of the enabling switch/ device must not engage without an Off signal being generated.
- The enabling switch/ device must continue to function properly as intended in the event of a failure of the latching mechanism.

Test: The actuator for the enabling switch/ device should be placed in position for the latching function to engage. The break-contact must be open in this position.
For break-contacts conforming with DIN EN 60947-5-1, Annex K, a test surge voltage of 2500 V must be applied to the switching path in order to verify the open state of the circuit element.

- The latching mechanism must function properly any time the enabling switch/ device is used under the conditions set forth in Section 8.3.7 of the Principles of testing.

Test: Testing is carried out according to Section 8.3.7 by actuating the latching function with engagement and subsequent disengagement during each switching cycle.

7.1.8 Additional requirements for foot-actuated enabling switches/ devices

7.1.8.1 Coverings

Foot-actuated enabling switches/ devices must not be configured with a hood or similar covering.

Test: Visual inspection.

7.2 Characteristic requirements

DIN EN 60947-5-8:2007, Section 7.2 applies with the following supplements:

7.2.1 Fall times for safety-related contacts

The fall time for safety-related output contacts in the start-up controller must be maximum 200 ms.

Test: Measurement of the contact fall time at the tolerance specification limits zone for the operating voltage.

8 Tests

8.1 Type of tests

DIN EN 60947-5-8:2007, Section 8.1 shall apply with the following variance:

8.1.1 With the exception of insulation testing, DIN EN 60947-5-8, Section 8.1.3 is replaced as follows:

Note:
This section applies to component testing carried out at the responsibility of the manufacturer and is not relevant for purposes of type testing.

Functional test

The intended function of each enabling switch or enabling device must be checked with consideration given to the following design configurations:

a) two-stage design:
- Position 1: Off-function (control actuator not depressed)
- Position 2: Enable function (control actuator depressed)

b) three-stage design:
- Position 1: Off-function (control actuator not depressed)
- Position 2: Enable function (control actuator pressed to the middle position)
- Position 3: Off-function forced opening (control actuator pressed to the middle position)

The enabling function must not be activated when returning from position 3 to position 2.

c) With multiple enabling switches/ devices in one unit, the proper sequential interaction of the switches must be checked.

8.2 Conformance to construction requirements

DIN EN 60947-5-8:2007, Section 8.2 shall apply.

8.3 Operating characteristics

DIN EN 60947-5-8:2ßß7, Section 8.3 shall apply with the following supplements:

Note: *For enabling switches/ devices with Protection class II, the test voltage for doubled or reinforced insulation used during the „verification of insulation“ test must be selected in accordance with DIN EN 60947-5-1, Section F.7.3.*

8.3.1 Supplement to DIN EN 60947-5-8, Section 8.3.1, Test sequence I, Test 3

Mechanical properties of connectors

Testing 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 enabling switches/ devices with external terminal connections. If the terminal connections are located within an enclosed casing configured for the connection of sheathed wiring and providing tension relief, these tests can be dispensed with.

8.3.2 Supplement to DIN EN 60947-5-8, Section 8.3.1, Test sequence II, Test 1

Required utilization category

Contacts must at least conform to the utilization categories AC 15 and/or DC 13 if they interact, or are able to interact with the contact-based controllers used in contactor/relay technology. Contacts must at least conform to the utilization categories AC-12 and/or DC -12 if they switch only ohmic loads or semiconductor loads with isolation by means of optical couplers.

Note: Positively opening contacts must always conform to DIN EN 60947-5-1, K.4.4.

8.3.3 Supplement to DIN EN 60947-5-8, Section 8.3.1, Test sequence III, Test 1

Section 8.3.2 of these Principles of testing also applies.

8.3.4 Supplement to DIN EN 60947-5-8, Section 8.3.1, Test sequence IV, Test 1

Testing with positively opening contacts is to be carried out according to DIN EN 60947-5-1, Section K.8.3.4.

8.3.5 Supplement to DIN EN 60947-5-8, Section 8.3.1, Test sequence V, Test 1

Protection class

Note: Test sequence IX, Test 1 should be carried out for this test.

Enabling switches when installed or enabling devices in ready-for-use condition must at least conform to protection class IP 54.

Test: Protection class according to DIN EN 60529, Enclosure category 1.

8.3.6 Supplement to DIN EN 60947-5-8, Section 8.3.1, Test sequence VI, Test 1

Air gaps and creepage distances

With consideration given to Section 8.3.5, air gaps and creepage distances must be dimensioned for overvoltage category III, contamination level 2.

All circuit elements from the various stages must be configured with reliable isolation from each other corresponding to DIN EN 60947-1, Annex N.

Test: Visual inspection and measurement of air gaps and creepage distances.

Supplement to Test sequence VI, Test 2:

In variance to Test sequence IV, Test 2 in DIN EN 60947-5-8, forces F2 and F3 on the enabling switch/ device actuator must be oriented to the forces specified in DIN EN 894-3, Table 4.

Test: Measurement of the actuating forces on the test object actuator.

Evaluation of the actuation forces according to DIN EN 60947-5-8, Section 8.2.5 with consideration given to DIN EN 894-3, Table 4.

Supplement to Test Sequence VI, Test 2 for foot-actuated enabling switches/ devices:

In variance to Test sequence VI, Test 2 in DIN EN 60947-5-8, the forces measured at the enabling switch/ device actuator must fall within the following ranges:

- F2 ≤ 25 N
- F3 ≥ 2 x F2
- F5 ≥ 1000 N

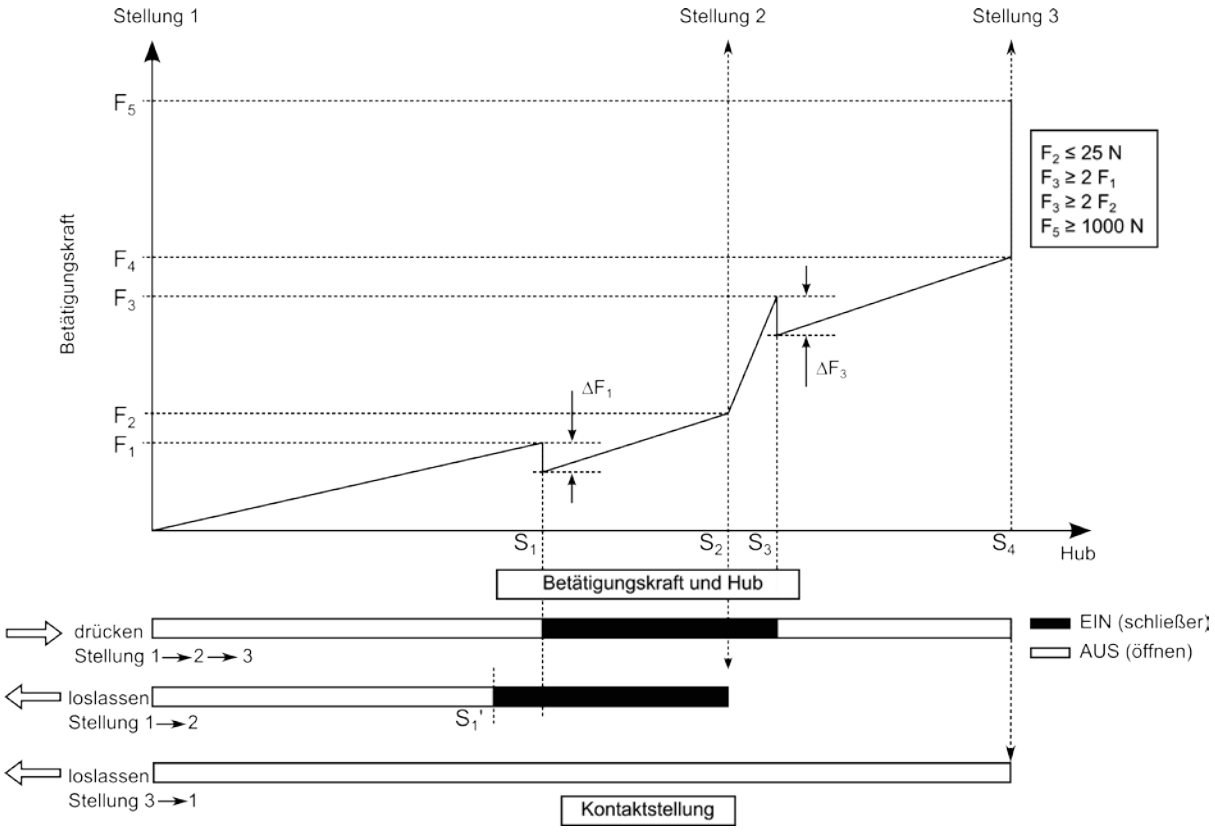

Figure 1: Representation of the operating characteristics of a three-position enabling switch/ device configured with a foot switch.

Supplement to Test sequence VI, Test 3:

In variance to Test sequence VI, Test 3 in DIN EN 60947-5-8, the actuator must be able to withstand 150 % of F5 ≥ 1000 N, which replicates 3 times the stress commonly applied in the actuating direction through human action.

Test: Measurement of the actuating forces on the test object actuator.

Load testing of the test object actuator. The point of force application should be determined depending on the design and with consideration given to the least favourable actuating direction.

Evaluation of the actuation forces according to DIN EN 60947-5-8, Section 8.2.5 with consideration given to the preceding aspects.

8.3.7 Supplement to DIN EN 60947-5-8, Section 8.3.1, Test sequence VII, Test 1

The test for mechanical service life can be dispensed with, as this test is already comprised in Test sequence VIII, Test 1.

Note:
The fault-criteria from section. 8.3.3.6.1, mechanical service life, must be considered during the test for electrical service life.

8.3.8 Mechanical strength

Replace DIN EN 60947-5-8, Section 8.3.1, Test sequence IX, Test 1 with the following tests:

Note: Testing of the Protection class (Test sequence V, Test 1) should be carried out subsequent to this test using the same test object.

Enabling switches/ devices must possess sufficient mechanical strength with respect to anticipated operational stresses, e.g. due to jolting, shock or impact, when used as intended.

Note: The requirements according to GS-ET-20, Section 4.4 shall apply for start-up controllers as separate structural units, which are part of an enabling switches/ device.

Test: According to Sections 8.3.8.1 to 8.3.8.4.

Prior to testing carried out in accordance with Sections 8.3.8.1 to 8.3.8.4, the test object must be stored in an indoor climate for at least 24 h.

Note:
Contact monitoring during testing according to Sections 8.3.8.1 and 8.3.8.2 is not necessary because contact signalling for position 2 and contact opening in position 3, by themselves, must not trigger any hazardous movement when the enabling switch/ device is used in compliance with standards.

8.3.8.1 Vibration test

Enabling switches/ devices must be subjected to mechanical vibrations in their potential mounting or usage positions in accordance with Table 1, I. The enabling switch/ device is set in position 1 during the test.

8.3.8.2 Shock test

Enabling switches/ devices will be subjected in-turn to mechanical shocks in their potential mounting or usage positions in accordance with Table 1, II, III. The enabling switch/ device is set in position 1 during the test.

8.3.8.3 Impact test

Weak points on enabling switch/ device enclosures and the accessible actuation system components must be subjected to a one-time impact load of 1 Nm using an impact testing device according to DIN EN 60068-2-75, Section 5.

Test: Ehb: undertaken using a spring hammer at room temperature (T= 20°C + 5°C). The enabling switch/ device is set in position 1 during the test.

8.3.8.4 Drop test

The test shall be carried out on ready-for-use mobile enabling switch/ device according to the provisions of DIN EN 60068-2-31, Procedure 1 – Free-falling, from a drop height of 1000 mm.
Two drop tests are to be carried out from each transport/usable position.

Execution of the test in accordance with DIN EN 60068-2-31 is expedient only on mobile switches.

Testing can also be carried out on equipment without connection circuitry.

The enabling switch/ device is set in position 1 during the test.

Following the test according to Sections 8.3.8.1 to 8.3.8.4, the functionality of the test object must still be warranted in accordance with DIN EN 60947-5-8 , Section 8.2.5 and it must remain undamaged. This means:

1. It must not be possible to physically touch active components.

2. The effectivity of the insulation material lining and isolating partitions must not be impaired.

3. The test object must still offer the protection against the infiltration of dust, solid foreign objects and water, conforming with the Protection class and corresponding to the Instruction manual.

Test: Visual inspection

Component test		**Remarks**
I. Continuous vibration: Test standard Frequency range Amplitude/Acceleration Frequency cycle count Tuning speed	 DIN EN 60068-2-6 10 - 150 Hz ± 1 Hz 0.35 mm/5g ± 15 % at the control point 20 1 octave/min	The prescribed frequency range applies only to enabling switches/ devices, which are directly exposed to machine vibration. A separate start-up controller, which is commonly installed in a separate control cabinet, is exempted from this provision (see note, Section 8.3.8).
II. Shock: Test standard Type of shock Shock amplitude Shock duration Number of shocks	 DIN EN 60068-2-27 Half-sine wave 30 g 11 ms 3 per axis and per direction	
III. Continuous shock: Test standard Type of shock Shock amplitude Shock duration Shock sequence Number of shocks	 DIN EN 60068-2-27 Half-sine wave 10 g 16 ms (1 - 3)/s 1000 ± 10 per axis and per direction	

Table 1: Minimum requirements for vibration and shock loading

9 Additional requirements for units with two separate enabling switches/ devices

For equipment with two separate enabling switches/ devices that can be arranged either on the left or right side of the casing, switch interaction should be realized as „Exclusive-OR“.

If, due to ergonomic reasons for machine operation, an OR-operation is used instead of an Exclusive-OR-operation, reference should be made in the equipment Instruction manual as to the absence of the Exclusive-OR-operation so the user can take this into account for the risk assessment.

Short- or cross-circuits in the enabling circuitry must be sufficiently excluded or readily identifiable with consideration given to DIN EN ISO 13849-1 + 2.

Test: Functional test, review of the circuit diagram.

10 Fault characteristics

The following requirements are to be tested only within the scope permitted by the enabling switch/ device based on its technical design, or in connection with the manufacturer's requirements with regard to subsequent signal processing.
Control-related measures which do not directly take over the enabling switch/ device must be realized via the machine controller. The measures must be described in the enabling switch/ device Instruction manual.

10.1 Safety function

The safety function of enabling switches/ devices with a start-up controller must open the enabling circuit when the enabling switch/ device position 1 (or 3) is actuated and hold it open until the next actuation of the enabling function (position 2). Additionally, the enabling function must not be activated when returning from position 3 to position 2 or position 1.
This also applies to hand-held control units with two or more separate enabling switches/ devices.

10.2 Determination of the B_{10D} value

The B_{10D} value for electronic components should be determined and specified by the manufacturer.

If the characteristics have been fulfilled according to DIN EN ISO 13849-1, Section C.2 („Procedures for good engineering practices“), the B_{10D} value can be specified according to DIN EN ISO 13849-1, Table C.1.

If the B_{10D} value specified varies from the typical values according to DIN EN ISO 13849-1, Table C.1, then it must be determined under the following conditions:

1. Test the mechanical service life (based on DIN EN 60947-5-8, Section 8.3.3.6.1) with 10 test objects. Determine the B_{10} value by means of "Weibull approximation".
2. If a hazard-producing failure rate of 50% is assumed, the B_{10D} value is determined

by doubling the B_{10} value: $B_{10D} = 2 \times B_{10}$.

3. Alternatively to Point 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.

Test: Plausibility check of the specifications and documents submitted by the manufacturer.

The following amendment applies when the enabling switch/ device is configured with a latching function:

- When an enabling switch/ device is configured with a latching function in position 3, determination of the B_{10D} value must be accompanied by the engagement and subsequent disengagement of the latching function during each switching cycle.

10.3 Determination of performance levels (PL)

For enabling switches/ devices with start-up controllers, the manufacturer must determine and specify:

- Category
- Performance Level (PL)
- $MTTF_D$ or PFH_D

in accordance with DIN EN ISO 13849-1.

Test: Validation of the specifications and documents (FMEA, fault-combination analysis, component failure rate, calculations, etc.) submitted by the manufacturer in accordance with DIN EN ISO 13849-1 + 2.

11 Electromagnetic compatibility

Immunity to interference

Enabling switches/ devices must fulfil the requirements regarding immunity to interference according to DIN EN 60947-5-1. Enabling switches/ devices with start-up controllers must also fulfil the requirements according to DIN EN 61326-3-1.

Test: see DIN EN 60947-5-1 and DIN EN 61326-3-1

Annex 1: Information related to contract preparation

	Information related to contract preparation − Enabling switches/ devices with and without start-up controllers −	Company:

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

Test specification(s) and parameters to be used according to test specification(s)	
Testing in accordance with DIN EN ISO 13849-1	Yes ☐ / No ☐
Category	
PL	
PFH_d	
$MTTF_d$ 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}]	
EMC Tests	
Testing in accordance with DIN EN 61326-3-1	Yes ☐ / No ☐

	Information related to contract preparation − Enabling switches/ devices with and without start-up controllers −	

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

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 to Principles of Testing	☐	by
	☐ not applicable	

Test reports provided by external accredited test bodies for…	*attached*	*will be submitted*
Electromagnetic compatibility	☐	by
Switch-ON/switch-OFF capacity of the safety-related shutdown devices	☐	by
Contingent short-circuit current from safety-related shutdown devices	☐	by
Electrical service life	☐	by

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

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

_____ _____ _____

Date Name Signature