

INTERNATIONAL STANDARD



**Low-voltage switchgear and controlgear –
Part 5-8: Control circuit devices and switching elements – Three-position
enabling switches**



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**Low-voltage switchgear and controlgear –
Part 5-8: Control circuit devices and switching elements – Three-position
enabling switches**

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CONTENTS

FOREWORD	3
1 General	5
1 Scope	5
2 Normative references	5
3 Terms and definitions	6
4 Classification	7
5 Characteristics	7
6 Product information	8
7 Normal service, mounting and transport conditions	10
8 Constructional and performance requirements	10
9 Tests	16
Annex A (informative) Example of an enabling devices incorporating a three-position enabling switch	23
Annex B (normative) Procedure to determine reliability data for three-position enabling switches used in functional safety applications	26
Bibliography	27
Figure 1 – Operation of three-position enabling switches	13
Figure 2 – Operating force, travel and enabling contact status	15
Figure A.1 – Grip type enabling device	23
Figure A.2 – One hand teaching pendant type enabling device	23
Figure A.3 – Two hand teaching pendant type enabling device	24
Figure A.4 – Manual pulse generator	24
Figure A.5 – Grip type enabling device for hand-held machine	24
Figure A.6 – Foot actuated enabling device	25
Figure A.7 – Hoist controller	25
Figure A.8 – Joystick type enabling device	25
Table 1 – Force values for F_2	15

INTERNATIONAL ELECTROTECHNICAL COMMISSION

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

**Part 5-8: Control circuit devices and switching elements –
Three-position enabling switches**

FOREWORD

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

International Standard IEC 60947-5-8 has been prepared by subcommittee 121A: Low-voltage switchgear and controlgear, of IEC technical committee 121: Switchgear and controlgear and their assemblies for low voltage.

This second edition cancels and replaces the first edition published in 2006. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) due to the increasing range of useful applications of three-position enabling switches, note of scope, operational characteristics and tests are reviewed;
- b) figures for example of devices incorporating enabling switch are added in Annex A;
- c) new Annex B for procedure to determine reliability data for the switch used in functional safety applications is added.

The text of this document is based on the following documents:

FDIS	Report on voting
121A/358/FDIS	121A/369/RVD

Full information on the voting for the approval of this document can be found in the report on voting indicated in the above table.

This document should be used in conjunction with IEC 60947-1:2020 and IEC 60947-5-1:2016.

The provisions of the general rules, IEC 60947-1, are applicable to this standard, where specifically called for. General rules clauses and subclauses thus applicable, as well as tables, figures and annexes are identified by a reference to IEC 60947-1, for example 1.2.3 or Annex A of IEC 60947-1:2020.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 60947 series, under the general title *Low-voltage switchgear and controlgear*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 5-8: Control circuit devices and switching elements – Three-position enabling switches

~~1~~ **General**

1 Scope

This part of IEC 60947 series specifies requirements for three-position enabling switches.

These switches are used as components of enabling devices ~~described in 10.9 of IEC 60204-1~~ to provide signals that,

- a) when activated, allow machine operation to be initiated by a separate start control, and
- b) when de-activated,
 - initiate a stop function, and
 - prevent initiation of machine operation.

NOTE 1 The enabling control function is described in ~~9.2.6.3~~ 9.2.3.9 of IEC 60204-1:2016 but the application of three-position enabling switches is not limited to a component of the enabling device described in IEC 60204-1.

NOTE 2 This document does not deal with enabling devices.

These switches are intended to be connected to circuits which rated voltage does not exceed 250 V AC 50 Hz/60 Hz or 300 V DC.

EXAMPLE Devices incorporating three-position enabling switches are:

- push-button enabling devices;
- grip actuated enabling devices;
- foot actuated enabling devices.

See Annex A for more typical examples.

This document does not apply to:

- three-position enabling switches for non-electrical control circuits, for example hydraulic, pneumatic;
- enabling switches without three-position mechanism;
- emergency stop devices (see IEC 60947-5-5).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60068-2-1:1990/2007, *Environmental testing – Part 2-1: Tests – Test A: Cold*
~~Amendment 1 (1993)~~
~~Amendment 2 (1994)~~

IEC 60068-2-2:~~1974~~2007, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*
~~Amendment 1 (1993)~~
~~Amendment 2 (1994)~~

IEC 60068-2-6:~~1995~~2007, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-27:~~1987~~2008, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

~~IEC 60204-1:2005, Safety of machinery – Electrical equipment of machines – Part 1: General requirements~~

IEC 60947-1:~~2004~~2020, *Low-voltage switchgear and controlgear – Part 1: General rules*

IEC 60947-5-1:~~2003~~2016, *Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices*

3 Terms and definitions

For the purposes of this document, ~~the relevant definitions given in Clause 2 of IEC 60947-1 and Clause 2 of IEC 60947-5-1 apply, with the following additional definitions~~ the terms and definitions given in Clause 3 of IEC 60947-1:2020 and Clause 2 of IEC 60947-5-1:2016, and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

Alphabetical index of definitions

.....	Reference
A	
Actuating system (of a three-position enabling switch)	3.3
Actuator (of a three-position enabling switch)	3.4
Auxiliary contact	3.5
E	
Enabling contact	3.6
Enabling device	3.1
T	
Three-position enabling switch	3.2

3.1

enabling device

manually operated control device used in conjunction with a start control and which, when continuously actuated, allows a machine operation

3.2

three-position enabling switch

~~switch having three sequential actuator positions, in which the contacts are closed when the actuator is in the mid position (partly depressed) and are open when the actuator is in the rest (not pressed) position and in the fully depressed position~~
three-position switch having enabling contact(s)

3.3

actuating system

<three-position enabling switch> all the mechanical parts which transmit the actuating force to the contact elements

[SOURCE: IEC 60050-441:2000, 441-15-21, modified – "all the operating means of a control switch" replaced by "all the mechanical parts", note to entry deleted.]

3.4

actuator

<three-position enabling switch> part of the actuating system which is actuated by a part of the human body

EXAMPLE A button.

3.5

auxiliary contact

contact of a three-position enabling switch that provides an auxiliary function

Note 1 to entry: Auxiliary contacts ~~may~~ can be normally open and/or normally closed.

3.6

enabling contact

contact of a three-position enabling switch, which is closed when the actuator is in the mid position (partly depressed, position 2 in Figure 1) and is open when the actuator is in the rest position (not pressed, position 1 in Figure 1) and in the fully depressed position (position 3 in Figure 1)

4 Classification

4.1 Contact elements

Subclause 3.1 of IEC 60947-5-1:2016 applies.

4.2 Three-position enabling switch

Three-position enabling switches may be classified according to the contact element and the nature of the actuating system, e.g. three-position enabling switches, form B.

5 Characteristics

5.1 Summary of characteristics

5.1.1 General

Subclause 4.1.1 of IEC 60947-5-1:2016 applies except for following type of equipment (see 5.2).

5.1.2 Operation of ~~a control~~ an enabling switch

Subclause ~~4.1.1~~ 4.1.2 of IEC 60947-5-1:2016 applies.

~~4.1.1.1 Normal conditions of use~~

~~Subclause 4.1.1.1 of IEC 60947-5-1 applies.~~

~~4.1.1.2 Abnormal conditions of use~~

~~Subclause 4.1.1.2 of IEC 60947-5-1 applies.~~

5.2 Type of three-position enabling switch

~~4.2.1 Examples of devices incorporating three-position enabling switches~~

- ~~— push-button enabling devices;~~
- ~~— grip-actuated enabling devices;~~
- ~~— foot-actuated enabling devices; etc.~~

5.2.1 Number of poles

The number of poles shall be stated by the manufacturer.

5.2.2 Kind of current

Alternating current or direct current.

5.3 Rated and limiting values for switching elements

Subclause 4.3 of IEC 60947-5-1:2016 applies.

5.4 Utilization categories for switching elements

Subclause 4.4 of IEC 60947-5-1:2016 applies.

5.5 Vacant

5.6 Vacant

5.7 Vacant

5.8 Vacant

5.9 ~~Switching overvoltages~~ Vacant

~~Subclause 4.9 of IEC 60947-1 applies.~~

5.10 Electrically separated contact elements

Subclause 4.10 of IEC 60947-5-1:2016 applies.

6 Product information

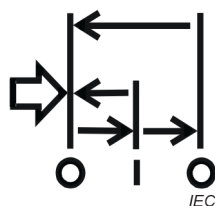
6.1 Nature of information

The following information shall be given by the manufacturer:

Identification

- a) The manufacturer's name or trade mark.
- b) A type designation or serial number that makes it possible to get the relevant information concerning the switching element (or the entire control switch) from the manufacturer.

- c) “IEC 60947-5-8” if the manufacturer claims compliance with this document.
- d) Three-position enabling switches shall be indelibly and legibly marked by the following symbol:



NOTE If it is not possible to affix the marking to the switch due to size constraints, then the symbol ~~may~~ can be put in the instructions for installation, operation and maintenance.

Basic rated values and utilization

- e) Actuating forces and ~~operational stroke~~ travel of the actuator.
- f) Rated operational voltage(s) (see ~~4.3.1.1~~ 4.3.2.2 of IEC 60947-5-1:2016).
- g) Utilization category and rated operational currents at the rated operational voltages of the switching element.
- h) Rated insulation voltage (see ~~4.3.1.2~~ 4.3.2.3 of IEC 60947-5-1:2016).
- i) Rated impulse withstand voltage U_{imp} in accordance with ~~4.3.1.3~~ 5.3.1.3 of IEC 60947-1:2020.
- j) IP code (see ~~5.1 and~~ Annex C of IEC 60947-1:2020).
- k) Pollution degree (see 6.1.3.2 of IEC 60947-5-1:2016).
- l) Type and maximum ratings of short-circuit protective device (see 8.3.4.3 of IEC 60947-5-1:2016).
- m) Conditional short-circuit current if less than 1 000 A.
- n) Indication of contact elements of same polarity.
- o) Mechanical and/or electrical durability.

6.2 Marking

6.2.1 General

Marking of data specified in items a), b), c) and d) of ~~5.1~~ 6.1 is mandatory on the nameplate of the three-position enabling switch in order to permit the complete information to be obtained from the manufacturer.

Marking shall be indelible and easily legible, and shall not be placed on screws and easily removable parts.

Whenever space permits, data under items e) to o) of ~~5.1~~ 6.1 shall be included on the nameplate, or on the three-position enabling switch or otherwise in the manufacturer's published literature.

6.2.2 Terminal identification and marking

Subclause ~~7.1.7.4~~ 5.2.2 of IEC 60947-5-1:2016 applies.

6.2.3 Functional markings

To avoid confusion with emergency stop devices, the actuator of an enabling switch shall not be coloured red (see ~~also~~ IEC 60204-1).

6.3 Instructions for installation, operation and maintenance

Subclause ~~5.3~~ 6.3 of IEC 60947-1:2020 applies with the following additions.

Manufacturers are encouraged to use graphical symbols as set out in international standards. Examples include ISO 7000 and IEC 60417.

EXAMPLE Following symbols can be used for “skilled person”.



IEC 60417-6182 (2013-09)

Installation, electrotechnical expertise



IEC 60417-6183 (2013-09)

Installation, mechanical expertise

6.4 Additional information

Subclause 5.4 of IEC 60947-5-1:2016 applies.

7 Normal service, mounting and transport conditions

7.1 General

Clause ~~6~~ 7 of IEC 60947-1:2020 applies with the following additions.

7.1.3.2 Pollution degree

~~Unless otherwise stated by the manufacturer, a three-position enabling switch is intended for installation under environmental conditions of pollution degree 3. However, other pollution degrees may apply, depending upon the micro-environment.~~

An enabling switch is intended for installation under environmental conditions of pollution degree 3. If it can be demonstrated that the micro-environment of a device to which the enabling switch (or part of) is exposed is different to pollution degree 3, then the pollution degree of the enabling switch can be adapted.

7.3 Mounting

Means shall be provided to allow the three-position enabling switch to be securely installed in its intended mounting position.

7.4 Special application

Environmental conditions (e.g. moisture, corrosive atmosphere, UV radiation) may cause additional requirements.

8 Constructional and performance requirements

8.1 Constructional requirements

8.1.1 General

Subclause ~~7.1~~ 8.1.1 of IEC 60947-1:2020 applies ~~except for 7.1.1, 7.1.2, 7.1.6, 7.1.8 and 7.1.12, and with the following additions.~~

~~7.1.1 Materials~~

~~Subclause 7.1.1 of IEC 60947-5-1 applies.~~

~~7.1.2 Current-carrying parts and their connections~~

~~Subclause 7.1.2 of IEC 60947-5-1 applies.~~

~~7.1.3 Clearances and creepage distances~~

~~Subclause 7.1.3 of IEC 60947-5-1 applies.~~

8.1.2 Materials

8.1.2.1 General material requirements

Subclause 7.1.2.1 of IEC 60947-5-1:2016 applies.

8.1.2.2 Glow-wire testing

Subclause 7.1.2.2 of IEC 60947-5-1:2016 applies.

8.1.2.3 Test based on flammability category

Subclause 7.1.2.3 of IEC 60947-5-1:2016 applies.

8.1.2.4 Biological and chemical effects

Under agreement between manufacturer and user, the manufacturer may provide a list of relevant materials in order to let the user verify that the product is suitable for the application.

NOTE 1 Additional requirements can be relevant in conjunction with special applications/branches e.g. for food and beverage, chemical industry, marine.

NOTE 2 Three-position enabling switches can be utilized in applications where a human operator can be in contact with the device for substantial periods, with bare hands. Due consideration can be given to the biological and chemical effects of skin contact with materials that emit substances when touched, for example, polycyclic aromatic hydrocarbons (PAH).

8.1.3 Current-carrying parts and their connections

Subclause 7.1.3 of IEC 60947-5-1:2016 applies.

8.1.4 Clearances and creepage distances

Subclause 8.1.4 of IEC 60947-1:2020 applies.

8.1.5 Actuator

8.1.5.1 Insulation

Subclause 8.1.5.1 of IEC 60947-1:2020 applies.

8.1.5.2 Direction of movement

Subclause 8.1.5.2 of IEC 60947-1:2020 applies.

8.1.5.3 Actuating force (or ~~moment~~ torque)

The force (or ~~moment~~ torque) required to operate the actuator shall be compatible with the intended application, taking into account the size of the actuator, the type of enclosure or panel, the environment of the installation and the use for which it is intended.

See 8.1.17 for the actuating force on each operation.

8.1.6 Indication of the contact position

Subclause 8.1.6 of IEC 60947-1:2020 applies.

8.1.7 Vacant

8.1.8 Terminals

Subclause 8.1.8 of IEC 60947-1:2020 applies.

8.1.9 Vacant

8.1.10 Provisions for protective earthing

Subclause 8.1.10 of IEC 60947-1:2020 applies.

8.1.11 Enclosures for equipment

Subclause 8.1.11 of IEC 60947-1:2020 applies.

8.1.12 Degrees of protection of enclosed equipment

Subclause 8.1.12 of IEC 60947-1:2020 applies.

8.1.13 Vacant

8.1.14 Class II three-position enabling switches

Subclause ~~7.1.7~~ 7.1.14 of IEC 60947-5-1:2016 applies.

8.1.15 Requirements for three-position enabling switches with integrally connected cables

Subclause ~~7.1.8~~ 7.1.15 of IEC 60947-5-1:2016 applies.

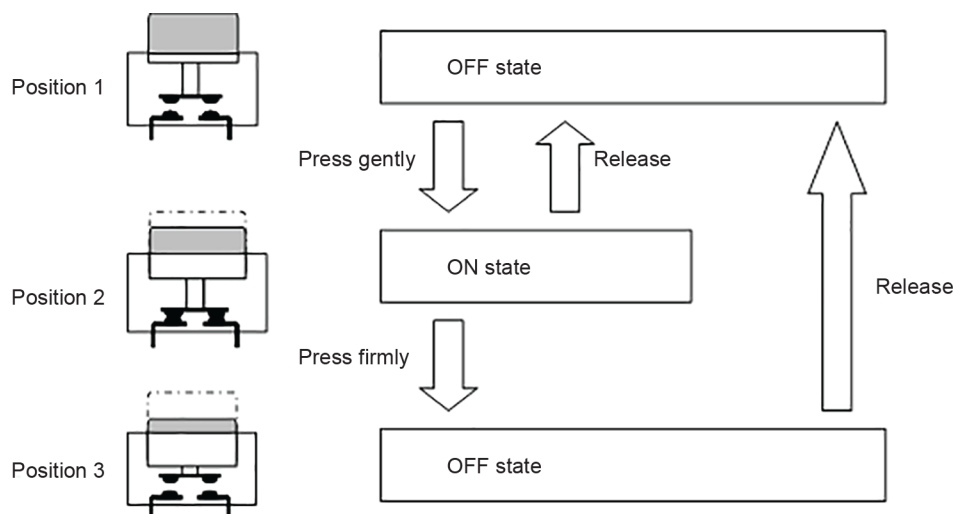
8.1.16 Three-position operation

The three positions are designated as follows (see Figure 2):

- position 1: OFF state of the contact (actuator is not pressed);
- position 2: ON state of the contact (actuator is pressed to the normal enabling position);
- position 3: OFF state of the contact (actuator is fully depressed).

The three-position enabling switch pressed to position 2 shall return to position 1 when released. The three-position enabling switch shall change from position 2 to position 3 when pressed further. When released from position 3 to position 1, the switching element shall not close when the actuator passes through position 2.

Figure 1 illustrates the three positions and the corresponding contact states.



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Figure 1 – Operation of three-position enabling switches

The operational stroke and force to actuate the three-position enabling switch from position 1 to position 2 and from position 2 to position 3 shall be stated by the manufacturer.

8.1.17 Operational characteristics

The three-position enabling switch shall be designed and manufactured to satisfy the following operational characteristics.

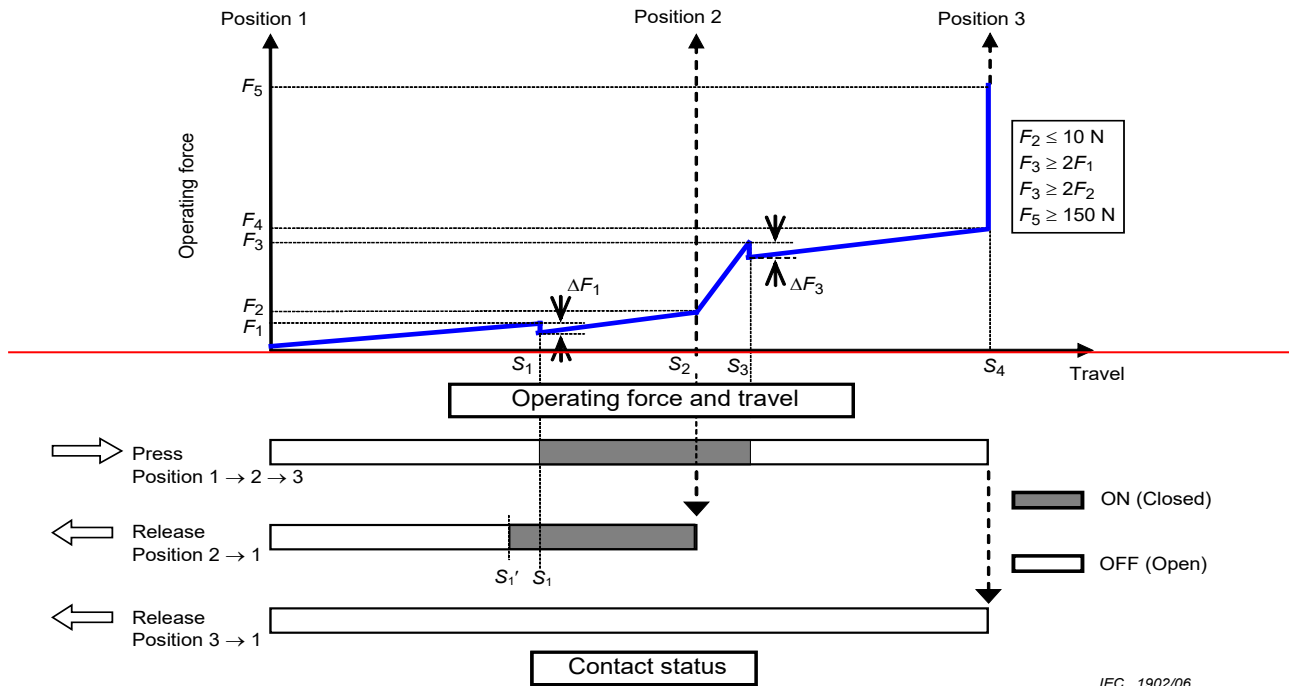
- To reduce physiological strain during actuation of three-position enabling switches, ~~F_2 shall be 10 N or smaller~~ the value of F_2 shall be as stated in Table 1 or lower. Manufacturer shall declare a maximum F_2 value.
- To reduce the possibility of inadvertent shifting of three-position enabling switches to position 3, F_3 shall be ~~$2 F_2$ or greater and F_3 shall be $2 F_1$ or greater~~ equal to or greater than 2 times the larger values of F_1 and F_2 .
- F_5 shall be 150 N or greater (see ~~8.2.6~~ 9.2.3).

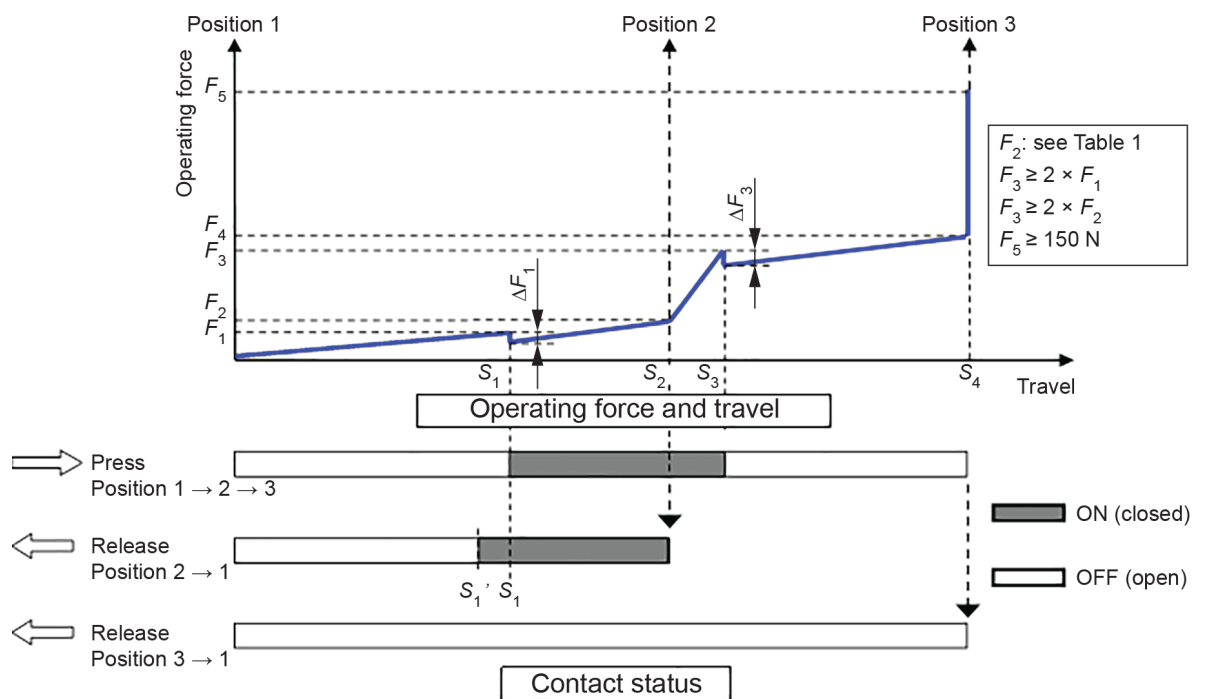
NOTE 1 To prevent inadvertent shifting of the three-position enabling switch to position 1, ~~it is recommended to set S_4 to smaller than S_4~~ S_1' can be set smaller than S_1 .

NOTE 2 To provide operator with tactile sensation of contact shifting, ~~it is recommended to provide~~ operating force dips ΔF_1 and ΔF_3 can be provided.

NOTE 3 The torque value is not specified in this document because there is no known enabling switch using torque for actuation.

Figure 2 shows the operational characteristics of the three-position enabling switch when the switch is pressed.





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Key

- F_1 Force to turn on the enabling contacts from position 1 to position 2
- F_2 Force to maintain the switch in position 2
- F_3 Force to turn off the enabling contacts from position 2 to position 3
- F_4 Full stroke force (position 3)
- F_5 Maximum rated operating force
- ΔF_1 Operating force dip across point S_1
- ΔF_3 Operating force dip across point S_3
- S_1 Point where the switch shifts from position 1 to position 2. Enabling contacts turn ON
- S_1' Point where the switch returns from position 2 to position 1. Enabling contacts turn OFF
- S_2 Point where the switch is maintained in position 2
- S_3 Point where the switch shifts from position 2 to position 3. Enabling contacts turn OFF
- S_4 Full stroke point

Figure 2 – Operating force, travel and enabling contact status

When released from position 3 to position 1, the enabling contacts shall not close.

Table 1 – Force values for F_2

Designated use of the three-position enabling switch	Maximum value of F_2 N
Actuation of the enabling device by finger	10
Actuation of the enabling device by hand	20
Actuation of the enabling device by foot	25

Manufacturer of foot-actuated enabling devices shall design their device to avoid mechanical stress to the switch greater than F_5 .

8.2 Performance requirements

8.2.1 General

~~Subclauses 7.2.1.1 and 7.2.2 of IEC 60947-1 apply with the following additions.~~

Subclause 8.2.1.1 of IEC 60947-1:2020 applies.

8.2.2 Temperature-rise

Subclause 8.2.2 of IEC 60947-1:2020 applies.

8.2.3 Dielectric properties

Subclause 7.2.3 of IEC 60947-5-1:2016 applies.

8.2.4 Ability to make and break under normal and abnormal conditions

8.2.4.1 General

Subclause 7.2.4 of IEC 60947-5-1:2016 applies with the following addition.

8.2.4.2 Durability

Three-position enabling switches shall be tested according to ~~8.3.3.6~~ 9.3.3.6.

8.2.5 Conditional short-circuit current

Subclause 7.2.5 of IEC 60947-5-1:2016 applies.

~~7.2.6 Switching overvoltage~~

~~Subclause 7.2.6 of IEC 60947-1 applies.~~

8.2.6 Additional requirements for control switches suitable for isolation

Subclause 7.2.7 of IEC 60947-5-1:2016 applies.

8.2.7 Shock and vibration

Shock or vibration shall not cause opening of closed contacts or closing of open contacts. The tests shall be conducted according to ~~8.3.5.2 and 8.3.5.3~~ 9.3.5.2 and 9.3.5.3.

9 Tests

9.1 Kinds of test

9.1.1 General

Subclause ~~8.1.4~~ 9.1.1 of IEC 60947-1:2020 applies.

9.1.2 Type tests

Type tests are intended to verify compliance of the design of the three-position enabling switches with this document.

They comprise the verification of:

- a) temperature-rise (~~8.3.3.3~~ 9.3.3.3);
- b) dielectric properties (~~8.3.3.4~~ 9.3.3.4);
- c) making and breaking capacities of switching elements under normal conditions (~~8.3.3.5~~ 9.3.3.5);
- d) making and breaking capacities of switching elements under abnormal conditions (~~8.3.3.5~~ 9.3.3.5);
- e) performance under conditional short-circuit current (~~8.3.4~~ 9.3.4);
- f) constructional requirements (~~8.2~~ 9.2);
- g) degree of protection of three-position enabling switches, if applicable (~~8.3.1~~ 9.3.1);
- h) durability (~~8.3.3.6~~ 9.3.3.6);
- i) shock and vibration (~~8.3.5~~ 9.3.5).

9.1.3 Routine tests

Routine tests are the responsibility of the manufacturer and are usually limited to a mechanical inspection and a verification of the electromechanical operation.

The inspection shall be supplemented by a dielectric test which is carried out according to ~~8.3.3.4~~ 9.3.3.4 with the following amendments: the required minimum duration of voltage application is reduced to 1 s and the metal foil and external terminal connections are unnecessary.

Additional routine tests for the three-position enabling switch may be specified as appropriate. A sampling plan may be accepted.

9.1.4 Sampling tests

Subclause ~~8.1.4~~ 9.1.4 of IEC 60947-1:2020 applies.

9.1.5 Special tests

These tests are subject to agreement between manufacturer and user.

The manufacturer of the three-position-enabling device (user of the enabling switch) shall verify all necessary requirements of the application with the three-position-enabling device.

In cases where it is necessary to verify environmental conditions of damp heat, salt mist, vibration and shock, the tests shall be conducted according to Annex Q of IEC 60947-1:2020.

During the damp heat test and salt mist test, the enabling switch is assembled to an enabling device, or to a representative enclosure.

Reliability data for three-position enabling switches intended for use in functional safety applications shall be made available in accordance with Annex B.

9.2 Compliance with constructional requirements

~~Subclause 8.2 of IEC 60947-1 applies except for 8.2.5 and 8.2.6.~~

9.2.1 General

Subclause 9.2 of IEC 60947-1:2020 applies except 9.2.6 and 9.2.7 and with the following additions.

9.2.2 Verification of operation of three-position enabling switches

The requirements of ~~7.1.9~~ 8.1.16 are verified by operating the actuator while monitoring the state of the enabling contacts. The monitoring means shall be capable of detecting a contact closure longer than 0,2 ms.

Three-position operation shall be verified during test sequence VII of ~~8.3.1~~ 9.3.1.

9.2.3 Verification of operation of actuator

The actuator shall withstand the maximum rated operating force specified by the manufacturer (see F_5 as defined in Figure 2) in the direction of normal operation.

This shall be verified during test sequence VII of 9.3.1.

9.3 Performance

9.3.1 Test sequences

The type and sequence of tests to be performed on representative samples are as follows.

- **Test sequence I** (sample No. 1)
 - Test No. 1 – Temperature rise (~~8.3.3.3~~ 9.3.3.3)
 - Test No. 2 – Dielectric properties (~~8.3.3.4~~ 9.3.3.4)
 - Test No. 3 – Mechanical properties of terminals (~~8.2.4~~ 9.2.5 of IEC 60947-1:2020)
- **Test sequence II** (sample No. 2)
 - Test No. 1 – Making and breaking capacities of switching elements under normal conditions (~~8.3.3.5.2~~ 8.3.3.5.3 of IEC 60947-5-1:2016)
 - Test No. 2 – Dielectric verification (~~8.3.3.5.5~~ 8.3.3.5.6 item b) of IEC 60947-5-1:2016)
- **Test sequence III** (sample No. 3)
 - Test No. 1 – Making and breaking capacities of switching elements under abnormal conditions (~~8.3.3.5.3~~ 8.3.3.5.4 of IEC 60947-5-1:2016)
 - Test No. 2 – Dielectric verification (~~8.3.3.5.5~~ 8.3.3.5.6 item b) of IEC 60947-5-1:2016)
- **Test sequence IV** (sample No. 4)
 - Test No. 1 – Performance under conditional short-circuit current (~~8.3.4~~ 9.3.4)
 - Test No. 2 – Dielectric verification (~~8.3.3.5.5~~ 8.3.3.5.6 item b) of IEC 60947-5-1:2016)
- **Test sequence V** (sample No. 5)
 - Test No. 1 – Degree of protection of three-position enabling switches (Annex C of IEC 60947-1:2020)
 - Test No. 2 – Dielectric verification (~~8.3.3.5.5~~ 8.3.3.5.6 item b) of IEC 60947-5-1:2016)
- **Test sequence VI** (sample No. 6)
 - Test No. 1 – Verification of clearances and creepage distances, if applicable (~~7.1.3~~ 8.1.4)
 - Test No. 2 – Measurement of actuation force ~~or moment~~ (~~7.1.10~~) (~~8.2.5~~) (or torque) (8.1.17, 9.2.2)
 - Test No. 3 – Verification of robustness of actuator (~~8.3.3.7~~ 9.3.3.7)
- **Test sequence VII** (sample No. 7)
 - Test No. 1 – Verification of operation of three-position enabling switches (9.2.2)
 - Test No. ~~42~~ – Mechanical durability (~~8.3.3.6.1~~ 9.3.3.6.2, 9.2.3)
 - Test No. ~~23~~ – Dielectric verification (~~8.3.3.5.5~~ 8.3.3.5.6 item b) of IEC 60947-5-1:2016)

- Test No. 4 – Verification of operation of three-position enabling switches (9.2.2)
- **Test sequence VIII** (sample No. 8)
 - Test No. 1 – Electrical durability (~~8.3.3.6.2~~ 9.3.3.6.3)
 - Test No. 2 – Dielectric verification (~~8.3.3.5.5~~ 8.3.3.5.6 item b) of IEC 60947-5-1:2016)
- **Test sequence IX** (sample No. 9)
 - Test No. 1 – Shock and vibration (~~8.3.5~~ 9.3.5)
 - Test No. 2 – Dielectric verification (~~8.3.3.5.5~~ 8.3.3.5.6 item b) of IEC 60947-5-1:2016)

There shall be no failure in any of the above tests.

More than one test sequence or all test sequences may be conducted on one sample at the request of the manufacturer. However, the tests shall be conducted in the sequence given for each sample above.

NOTE 1 For class II three-position enabling switches insulated by encapsulation, additional samples are ~~required~~ used (see Annex F of IEC 60947-5-1:2016).

NOTE 2 For three-position enabling switches with integrally connected cables, see Annex G of IEC 60947-5-1:2016.

For shock and vibration tests, the test shall be conducted on three samples, see ~~8.3.5~~ 9.3.5.

9.3.2 General test conditions

9.3.2.1 General requirements

Subclause ~~8.3.2.1~~ 9.3.2.1 of IEC 60947-1:2020 applies with the following addition.

The tests shall be performed with the actuator operated by a machine complying with the following:

- the operating machine shall apply the actuating force to the actuator in the direction of its motion;
- the maximum force exerted on the actuator shall not exceed F_4 (see Figure 2);
- at the moment when the switching operation occurs, the velocity of the part of the operating machine that contacts the actuator shall be between 0,05 m/s and 0,15 m/s;
- the mechanical connection between the operating machine and the actuator shall not impede the free motion of the actuator away from it.

9.3.2.2 Test quantities

Subclause ~~8.3.2.2~~ 9.3.2.2 of IEC 60947-1:2020 applies except for ~~8.3.2.2.3~~ 9.3.2.2.3.

9.3.2.3 Evaluation of test results

The condition of the three-position enabling switch after each test shall be checked by the verifications applicable to each test.

A three-position enabling switch is deemed to have met the requirements of this document if it meets the requirements of each test and/or test sequence as applicable.

9.3.2.4 Test report

Subclause ~~8.3.2.4~~ 9.3.2.4 of IEC 60947-1:2020 applies.

9.3.3 Performance under no-load, normal load and abnormal load conditions

9.3.3.1 Operation

Subclause ~~8.3.3.1~~ 9.3.3.1 of IEC 60947-1:2020 applies.

9.3.3.2 Vacant

9.3.3.3 Temperature rise

Subclause 8.3.3.3 of IEC 60947-5-1:2016 applies.

9.3.3.4 Dielectric properties

Subclause 8.3.3.4 of IEC 60947-5-1:2016 applies.

9.3.3.5 Making and breaking capacities

Subclause 8.3.3.5 of IEC 60947-5-1:2016 applies.

9.3.3.6 Durability

9.3.3.6.1 General

The three-position enabling switch shall successfully pass the mechanical and electrical durability tests described in ~~8.3.3.6.1 and 8.3.3.6.2~~ 9.3.3.6.2 and 9.3.3.6.3.

Minimum test operations: 100 000 cycles

Recommended test operations: 0,1 – 0,3 – 1 – 3 – 10 – 30 – 100 million operations

9.3.3.6.2 Mechanical durability

The three samples (see ~~8.4~~ 9.1) shall be subjected to the following test.

The test shall be performed for minimum 50 000 cycles of position 1 → 2 → 1 operation and minimum 50 000 cycles of position 1 → 2 → 3 → 1 operation. The actuator of a three-position enabling switch shall be subjected to the forces necessary to achieve the required positions.

The maximum rated operating force specified by the manufacturer (see F_5 as defined in Figure 2) is applied at position 3.

The movement and actuating forces of the three-position enabling switch shall be consistent throughout the test. This shall be verified by measurement before and after the tests.

The mechanical durability of the three-position enabling switch is defined as the number of no-load operating cycles which will be attained by all samples tested without repair or replacement of any part.

Tests shall be carried out according to C.1.2 of IEC 60947-5-1:2016.

During the test, the enabling contacts shall be checked at each change of state by the manufacturer at the conditions described below, and there shall be no failure.

Test voltage and current: 24 V DC, 10 mA maximum.

Test method: The agreement of switch position and enabling contact status shall be checked at every position before shifting to the next position.

The **enabling** contact status shall be checked at each position. The three-position enabling switch shall be shifted to the next position only when the agreement of switch position and contact status has been confirmed. When any disagreement of position and contact status is found, tests shall be stopped.

Position 1: **enabling** contacts open



Position 2: **enabling** contacts closed



Position 3: **enabling** contacts open



Position 3 – Position 1: **enabling** contacts open

Failure criteria:

During the tests, there shall be no electrical and/or mechanical failures. Following the tests, the switching element shall pass the dielectric test of 8.3.3.4 of IEC 60947-5-1:2016 with a test voltage equal to $2 U_e$ with a minimum of 1 000 V.

9.3.3.6.3 Electrical durability

The test conditions are those of ~~8.3.3.6.1~~ 9.3.3.6.2 except that the circuit of the switch is energized according to the manufacturer's specified ratings in accordance with ~~5.1~~ 6.1, item g).

9.3.3.7 Robustness

The actuator shall withstand a force of 150 % of the maximum rated operating force specified by the manufacturer (see F_5 as defined in Figure 2), applied three times in the direction of normal operation in a manner simulating human action.

9.3.4 Performance under conditional short-circuit current

Subclause 8.3.4 of IEC 60947-5-1:2016 applies.

9.3.5 Shock and vibration tests

9.3.5.1 Conditioning procedures

The purpose of the following procedures is to expose the three-position enabling switches to various environmental conditions in order to verify their functioning after such exposure.

The three three-position enabling switches shall be subjected to the following exposures:

- 96 h at +40 °C in dry atmosphere according to test ~~Ba~~ Bb of IEC 60068-2-2;
- 96 h at +5 °C according to test ~~Aa~~ Ab of IEC 60068-2-1.

Following the environmental exposures and after the samples have been restored to room temperature, the sequence of tests in ~~8.3.5.2 and 8.3.5.3~~ 9.3.5.2 and 9.3.5.3 shall be conducted.

9.3.5.2 Shock

The three three-position enabling switches that have been conditioned in accordance with ~~8.3.5.1~~ 9.3.5.1 shall be tested in each of the three mutually perpendicular axes.

Each three-position enabling switch is tested in position 1 and shall withstand 15 g shock in both directions of each axis according to IEC 60068-2-27: 11 ms – 15 g.

During the test, no closed contacts shall open and no open contacts shall close.

The monitoring means shall be able to detect any opening or closing of contacts longer than 0,2 ms.

9.3.5.3 Vibration

The three samples used for ~~8.3.5.2~~ 9.3.5.2 shall be tested, in accordance with IEC 60068-2-6, with the following conditions, in each of the three mutually perpendicular axes:

- frequency range: 10 Hz to 55 Hz;
- amplitude: 0,5 mm;
- sweep cycle duration: 5 min;
- duration at resonant frequency or at 55 Hz: 30 min in each of the three axes (90 min in total).

During the test, no closed contacts shall open and no open contacts shall close.

The monitoring means shall be able to detect any opening or closing of contacts longer than 0,2 ms.

Annex A (informative)

Example of ~~an~~ enabling devices incorporating a three-position enabling switch

~~Figure A.1 shows an enabling device incorporating a three position enabling switch. The enabling device is used as a control circuit device to initiate the enabling function described in IEC 60204-1.~~

Figure A.1 to Figure A.8 show enabling devices incorporating three-position enabling switches.

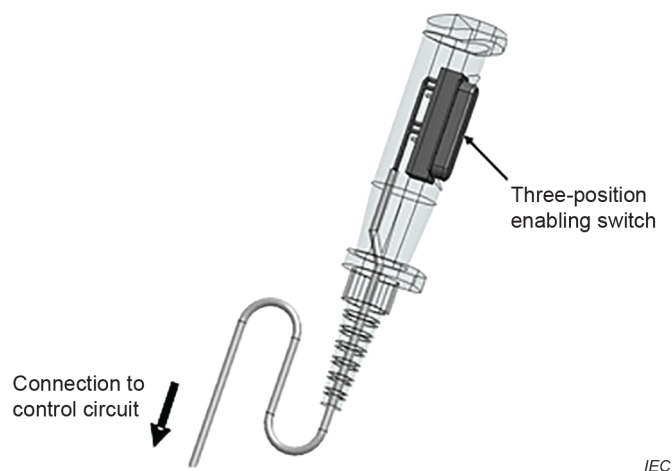


Figure A.1 – Grip type enabling device

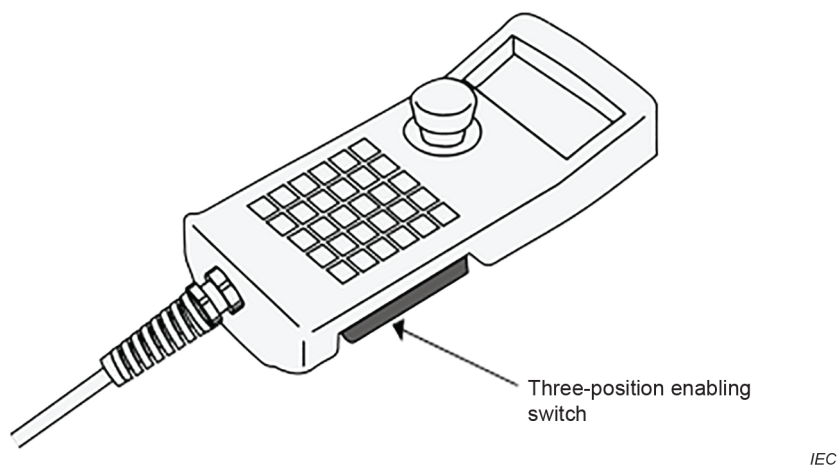


Figure A.2 – One hand teaching pendant type enabling device