**Draft for Public Comment**

Form 36

DPC: 20/30431965 DC

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Date: 18 December 2020
Origin: International

**Latest date for receipt of comments: 13 January 2021**

Project No. 2020/01112

Responsible committee: TCT/7 Telecommunications - Installation requirements

Interested committees:

Title: Draft BS ISO/IEC 11801-6 AMD1 - Information technology - Generic cabling for customer premises. Part 6: Distributed building services.

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**Introduction**

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

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| Date: xx/xx/20xx | Document: ISO/DIS xxxx |
|---|---|

| 1 | 2 | (3) | 4 | 5 | (6) | 7 |
|---|---|---|---|---|---|---|
| **MB** | Clause No./ Subclause No./Annex **(e.g. 3.1)** | Paragraph/Figure/ Table/Note | **Type of comment** | **Commend (justification for change) by the MB** | **Proposed change by the MB** | **Secretariat observations on each comment submitted** |
| | 3.1 | Definition 1 | ed | Definition is ambiguous and needs clarifying. | Amend to read '...so that the mains connector to which no connection...' | |
| | 6.4 | Paragraph 2 | te | The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK. | Delete reference to UV photometer. | |

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# 94/488/CD

COMMITTEE DRAFT (CD)

| | |
|---|---|
| PROJECT NUMBER: **IEC 62246-4 ED1** | |
| DATE OF CIRCULATION: **2020-12-18** | CLOSING DATE FOR COMMENTS: **2021-02-12** |
| SUPERSEDES DOCUMENTS: **94/477/CD, 94/486/CC** | |

| | |
|---|---|
| IEC TC 94 : ALL-OR-NOTHING ELECTRICAL RELAYS | |
| SECRETARIAT: Austria | SECRETARY: Mr Bernhard Spalt |
| OF INTEREST TO THE FOLLOWING COMMITTEES: TC 9,TC 13,TC 17,SC 17A,TC 18,TC 44,TC 61,TC 62,TC 65,TC 69,TC 80,SC 121A | PROPOSED HORIZONTAL STANDARD: ☐ Other TC/SCs are requested to indicate their interest, if any, in this CD to the secretary. |
| FUNCTIONS CONCERNED: ☐ EMC ☐ ENVIRONMENT ☐ QUALITY ASSURANCE ☐ SAFETY | |

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TITLE:

**Reed switches – Part 4: Application in conjunction with magnetic-actuator used for Magnetic Sensing Protective Equipment (MSPE)**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

# REED SWITCHES –

## Part 4: Application in conjunction with magnetic-actuator used for Magnetic-Sensing Protective Equipment (MSPE)

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

| CD | CC |
|---|---|
| 94/477/CD | 94/486/CC |

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

A list of all parts of IEC 62246 series, published under the general title *Reed switches* can be found on the IEC website.

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# INTRODUCTION

Most of the reed switches have been applied to magnetic-sensing protective equipment (MSPE) because of its simplicity, high reliability and zero power for operation. The MSPE is used for sensing devices or measurement/control/monitoring devices and/or output switching devices in variety of industrial applications (e.g. safety of machinery, alarm detectors, factory automation and robotics, cylinders, railways, automotive, utilities and smart grid, healthcare, consumer electronics and appliances, lifts, construction, iron, steel, cement making and petrochemical plants, aerospace and marine etc.). As new technologies emerge and diversify, standardization has been requested from various parties concerned.

Typical related standards (e.g. ISO 6432/ISO 15552 (Cylinders), ISO 8100/ISO 25745 (Lifts) and IEC 60355-2 series (Household and similar electric appliances)) specify the requirements for environmental service conditions, specific sensing distances, actuator speeds, and so on. Furthermore, the target categories and types of sensing devices and their E/E/PE systems are defined in accordance to functional safety standards (e.g. ISO 13849 series).

There are a few standards like IEC 62046 of "*Application of protective equipment to detect the presence of persons*" published in 2018. It specifies requirements for the selection, positioning, configuration and commissioning of protective equipment to detect the momentary or continued presence of persons in order to protect those persons from dangerous part(s) of machinery in industrial applications.

The intention of this document is:

1. To define the functions, types, characteristics, product information etc. for MSPE:
   - classes of enclosure, degrees of protection to (e.g., dust, cleaning methods using water, hazardous atmospheres) are determined (e.g., IEC 60529 or IEC 60079 series);
   - recommended operating distances are determined;
   - recommended response speed and frequency operating cycles are determined as rated values.
2. To specify the test and measurement procedures for MSPE:
   - functional tests and frequency operating cycles are determined in accordance with proximity switches (e.g. IEC 60947-5-2 or ISO 6859-1);
   - response speed and operating time of load are determined when used as trip function or presence sensing function according to the relevant standards.
3. To specify the additional requirements for magnetic switching devices used for safety-related control systems:
   - depending on the target PL/SIL level of the SRCS, give guidance on the calculation procedures of dangerous failure rates (e.g., $B_{10d}$ values and/or field data);
   - considers requirements to evaluate the safety of the magnetic switching devices and important influence factors in the system.
4. To support the user in performing the needed activities from the relevant standards.

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# REED SWITCHES –

## Part 4: Application in conjunction with magnetic-actuator used for Magnetic-Sensing Protective Equipment (MSPE)

## 1 Scope

This part of IEC 62246 provides guidance on the selection, positioning, configuration and commissioning, design concept to design validation and environmental conditions for reed switches used with magnetic-actuator for typical applications like Magnetic Sensing Protective Equipment (MSPE) when used in conjunction with functional safety standards (e.g. IEC 62061 or ISO 13849 series).

The following are examples of such applications:

- machinery safety;
- factory automation and robotics;
- fluid power systems;
- road vehicles;
- electrical power/energy transfer systems for EV;
- electrical equipment and systems for railways;
- auxiliary switches in low-voltage and high-voltage switchgears;
- electrical equipment in medical practice;
- household and similar electric appliances;
- electricity metering equipment;
- electrical equipment in lifts, escalators;
- industrial process measurement, control and automation;
- equipment for explosive atmospheres;
- transportation engineering in aircrafts and space vehicles;
- electrical installations of ships.

Magnetic proximity switches fall within the scope of the ISO 6859-1 – *Aircraft – Proximity switches – General requirements* – developed by Technical Committee ISO/TC 20 and are covered in the document.

Magnetic float liquid level switches fall within the scope of the IEC 61010-1 – *Safety requirements for electrical equipment for measurement, control, and laboratory use – General requirements* – developed by Technical Committee IEC/TC 66 and are covered in the document.

Magnetic safety switches fall within the scope of the ISO 14119 of standard – *Safety of machinery – Interlocking devices associated with guards – Principles for design and selection* – developed by Technical Committee ISO/TC 199 and are covered in the document.

Magnetic proximity switches and magnetic position switches do not fall within the scope of the IEC 60947-5 series of standards – *Low voltage switchgear and controlgear* – developed by Technical Subcommittee IEC/SC 121A and are covered in the document.

Information contained in this document is relevant to the application of MSPE on new installations as well as modifications to existing installations.

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## 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 (all parts), *Environmental testing*

IEC 60079-0: 2017, *Explosive atmospheres – Part 0: Equipment – General requirements*

IEC 60079-1:2014, *Explosive atmospheres – Part 1: Equipment protection by flameproof enclosure "d"*
IEC 60079-1:2014/COR1:2018

IEC 60079-10-1: 2015, *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmosphere*

IEC 60079-11: 2011, *Explosive atmospheres – Part 11: Equipment protection by intrinsic safety "i"*
IEC 60079:2011/ISH4:2019

IEC 60079-15: 2017 RLV, *Explosive atmospheres – Part 15: Equipment protection by type of "n"*

IEC 60079-18: 2014, *Explosive atmospheres – Part 18: Equipment protection by encapsulation "m"*

IEC 60417 (all parts), *Graphical symbols for use on equipment (available at http://www.grapical-symbols. Info/equipment)*

IEC 60445: 2017, *Basic and safety principles for man-machine interface, marking and identification – Identification of equipment terminals, conductor terminations and conductors*

IEC 60529:1989, *Degree of protection provided by enclosure (IP code)*
IEC 60529:1989/AMD2:2013
IEC 60529:1989/COR1:2019

IEC 60721-3-3: 1994, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Selection 3: Stationary use at weatherprotected locations*

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

IEC 60947-5-2: 2019, *Low voltage switchgear and controlgear – Part 5-2: Control circuit devices and switching elements – Proximity switches*

IEC 610101-1:2010, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements*
IEC 61010-1:2010/AMD1:2016 CSV

IEC 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety-related systems*

IEC 61076-2 (all parts), *Connectors for electronic equipment – Product requirements – Part 2: Circular connector*

IEC 61810-1:2015+AMD1:2019, *Electromechanical elementary relays – Part 1: General and safety requirements*

IEC 61810-2:2017, *Electromechanical elementary relays – Part 2: Reliability*

IEC 61810-2-1:2017, *Electromechanical elementary relays – Part 2-1: Reliability – Procedure for the verification of $B_{10}$ values*

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IEC 61810-7:2006, *Electromechanical elementary relays – Part 7: Test and measurement procedures*

IEC 62061:2005, *Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems*
IEC 62061:2005/AMD1:2012
IEC 62061:2005/AMD2:2015

IEC 62246-1:2015, *Reed switches – Part 1: Generic specification*

IEC 62246-1-1:2018, *Reed switches – Part 1-1: Generic specification – Blank detail specification*

IEC TR 62246-3:2018, *Reed switches – Part 3: Reliability data* for reed switch-devices in typical safety applications

ISO/IEC 80079-20-1: 2017, *Explosive atmospheres – Part 20-1: Material characteristics for gas and vapour classification – Test method and data*

ISO 6859-1:1982, *Aircraft – Proximity switches – Part 1: General requirements*

ISO 13849-1:2015, *Machine Safety – Safety-related parts of control systems – Part 1: General principles for design*

ISO 13849-2:2012, *Machine Safety – Safety-related parts of control systems – Part 2: Validation*

ISO 14119:2013, *Safety of machinery – Interlocking devices associated with guards – Principles for design and selection*

# 3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62246 (all) , 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

## 3.1 Definitions of a Magnetic-Sensing Protective Equipment (MSPE)

**3.1.1**
**Magnetic-Sensing Protective Equipment**
**MSPE**
assembly of devices and/or components working together for protective tripping or presence sensing purposes and comprising as a minimum of

– a magnetic switching device (reed contact);

– a magnetic-actuator;

– an output signal switching device;

– a safety related monitoring and control sub-system, performing appropriate PL/SIL level according to IEC 62061 or ISO 13849-1.

Note 1 to entry: Output switching device may be reed switch.

Note 2 to entry: A description of the functions is given in sub-clause 3.2, the one of the elements in sub-clause 3.3, the one of the external connections in sub-clause 3.4 and the one of the operation in sub-clause 3.5.

Note 3 to entry: Explanations regarding magnetic proximity switch are given in Annex A.

Note 4 to entry: Explanations regarding operation of magnetic switching device are given in Annex B.

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[SOURCE: IEC 62046: 2018, 3.1.7, modified – “electro” and “ESPE” have been replaced with “magnetic” and “MSPE” in the term. “sensing device” and “control/monitoring devices” have been replaced with “magnetic switching device” and “magnetic-actuator” in the definition and Notes 1 to 4 have been added.]

## 3.2 Definitions of magnetic switching devices

### 3.2.1
**magnetic safety switch**
guard interlocking devices that are designed to protect both people and machines, consisting of reed switches, overcurrent protection, non-coded or coded magnetic-actuator in a separate housing which could be of plastic or metal

Note 1 to entry: A magnetic safety switch consists of one or more reed contact elements with a specific magnetic-actuator.

Note 2 to entry: The operating principles are described in Annex C.2.

Note 3 to entry: see IEC 60947-5-3:2013 and ISO 14119:2013.

### 3.2.2
**magnetic proximity switch, <separate type>**
electromechanical control circuit devices without external power supply, consisting of reed switches and magnetic-actuator, separated housing which could be plastic or metal

Note 1 to entry: A magnetic proximity switch consists of one or more reed contact elements with a specific magnetic-actuator.

Note 2 to entry: The operating principles are described in Annexes C.2 and C.3.

Note 3 to entry: they can detect the presence of magnetic objects without contact (see IEC 60947-5-2:2019).

### 3.2.3
**magnetic proximity switch, <vane type>**
electromechanical control circuit devices without external power supply, consisting of reed switches and magnetic-actuator in the same housing which could be plastic or metal

Note 1 to entry: The operating principles are described in Annex C.4.

Note 2 to entry: they can detect the presence of magnetic objects without contact (see IEC 60947-5-2:2019).

### 3.2.4
**magnetic position switch, <reed switch type>**
electromechanical control circuit device without external power supply, consisting reed switches and magnetic-actuator used the actuating system of which is operated by a moving part of machine, when this part reaches a predetermined position

Note 1 to entry: A magnetic position switch consists of one or more reed contact elements with a specific magnetic-actuator.

Note 2 to entry: The operating principles are described in Annex C.5.

### 3.2.5
**magnetic float liquid level switch, <reed switch type>**
electromechanical control circuit device which is consist of reed switch(s) and float(s) without external power supply for sensing the height of liquid

Note 1 to entry: A magnetic float liquid level switch consists of one or more reed contact elements with a specific magnetic-actuator.

Note 2 to entry: The operating principles are described in Annex C.6.

## 3.3 Elements of an MSPE

### 3.3.1
**switching element, <for reed switch type>**
reed switch that drives magnetically and switches the current of electric circuit

### 3.3.2
**magnetic-actuator**
polarized permanent magnet used to operate the MSPE switches (e.g. magnetic safety switches, magnetic proximity switches and magnetic position switches)

Note 1 to entry: Standard magnetic-actuator for comparative measurement of operating distance and releasing distance.

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**3.3.3**
**float, <magnetic float liquid level switch>**
spherical, cylindrical, oblong or similarly shaped object with a polarized permanent magnet built to float on water and other liquids

**3.3.4**
**sensing face**
surface of the separate type magnetic proximity switch which the magnetic field emerges

**3.3.5**
**sensing ferromagnetic plate**
plate for the vane type magnetic proximity switch to cut off the magnetic field of in-side magnetic-actuator

## 3.4 Connections

### 3.4.1 External connections
output signals from the element of MSPE

Note 1 to entry: The design is such as the external connections may be extracted directly from the lead wire, terminal, connector and/or leaded connector.

## 3.5 Operation of an MSPE

**3.5.1**
**rated operating distance ($S_n$)**
conventional value used to designate the operating distances.

Note 1 to entry: It does not consider either manufacturing tolerances or variations due to external conditions such as temperature.

**3.5.2**
**operating distance ($S_{on}$)**
distance at which the target approaching the sensing face along the reference axis causes the output signal to turn on for NO contacts, turn off for NC contacts

**3.5.3**
**releasing distance ($S_{off}$)**
distance at which the target leaving the sensing face along the reference axis causes the output signal to turn off for NO contacts, turn on for NC contacts

**3.5.4**
**sensing distance**
operating distance or releasing distance

**3.5.5**
**differential travel ($H$)**
absolute value of the difference between the operating distance and releasing distance

**3.5.6**
**sensing area**
area of operating or releasing as obtained using a predetermined object

**3.5.7**
**magnetic interference**
state in which the performance or characteristics of MSPEs are affected when 2 or more MSPEs is placed near to each other

**3.5.8**
**response time, <for output of MSPE>**
length of the delay from the instant when an object enters or leaves the sensing area until a change is completed in the output of a MSPE.

Note 1 to entry: The term ‘operating response time’ is used to refer to response delays during times of operation and the term ‘releasing response time’ is used to refer to response delays at times of release.

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**3.5.9**
**response speed**
speed at which the magnetic-actuator or sensing ferromagnetic plate enters the sensing area that the MSPE can output the pulse signal of predetermined time

**3.5.10**
**turn-on time**
time interval between the application of the specified magnetic-actuator or sensing ferromagnetic plate enters the sensing distance to a reed switch in the release condition and the change of state of the last output circuit (not including time)

**3.5.11**
**turn-off time**
time interval between the removal of the specified magnetic-actuator or sensing ferromagnetic plate exits the sensing distance to a reed switch in the operate condition and the change of state of the last output circuit (not including time)

**3.5.12**
**lateral approach**
approach of the magnetic-actuator perpendicular to the reference axis

**3.5.13**
**axial approach**
approach of the magnetic-actuator with its centre maintained on the reference axis

### 3.6 MSPE

**3.6.1**
**contact arrangement, <for output of contact>**
actual arrangement of output contacts

**3.6.2**
**contact rating**
rated level at which a MSPE may be directly opened or closed

**3.6.3**
**operational rating**
magnetic characteristics of a MSPE magnetic drive contact may be caused to operate or be reset is calculated as the product the current flowing in a standard coil and the number of coils or energy in the magnetic field formed by a permanent magnet

**3.6.4**
**bias magnet**
magnet which is using to maintain the operation of switch with a magnetic energy level somewhere near the intermediate point between the point of sensitivity and that of release

## 4 Influence quantities

The specified performance of a MSPE shall be given with respect to the reference conditions, i.e. the set of reference values of all influence quantities.

Unless otherwise explicitly stated by the manufacturer, the tests shall be carried out at the reference values and tolerance ranges listed in Table 1 apply.

**Table 1 – Reference values of influence quantities**

| Influence quantity | Reference value | Tolerance range and conditions for testing[a] |
|---|---|---|
| Ambient temperature | 23 °C | ±5 K |
| Atmosphere pressure | 96 kPa | 86 kPa to 106 kPa |
| Relative humidity | 50 % | 25 % to 75 % |
| External magnetic induction | 0 | $0 \pm 5 \times 10^{-4}$ T in any direction |

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| | | |
|---|---|---|
| Mounting position | As indicated by the manufacturer | According to Annex C |
| Voltage/current (load) | As indicated by the manufacturer | ±5 % for steady-state conditions |
| Frequency | | Same as reference value with tolerance ±2 % |
| Waveform | Sinusoidal | Sinusoidal; maximum distortion factor 5 % [a] |
| AC component in DC (ripple) | 0 | Maximum 6 % [b] |
| DC component in AC | 0 | Maximum 2 % of peak value |
| Shock and vibration | 0 | Maximum 1 m/s$^2$ |
| Industrial and other atmosphere | Clean air | Clean air (pollution not exceeding class 3C2 of IEC 60721-3-3) |

[a] Distortion factor: The ratio of the harmonic effective value obtained by dividing the effective value of all non-sinusoidal harmonics by the effective value of the fundamental wave. It is usually expressed as a percentage.

[b] AC component including ripple of DC power supply is defined as follows and expressed in percent:

$$\frac{\text{maximum value} - \text{minimum value}}{\text{d.c. component}} \times 100$$

# 5 Rated values

## 5.1 General

The recommended values listed below do not comprise all technical possibilities and other values may be adopted according to the conditions of operation and use.

## 5.2 Rated insulation voltage ($U_i$)

Recommended rated insulation voltage values are listed in Table 2.

**Table 2 – Rated insulation voltage**

| AC or DC | Rated Insulation voltage (V) | | | |
|---|---|---|---|---|
| AC/DC | 30 | 60 | 125 | 250 |

## 5.3 Rated operating voltage ($U_e$)

Recommended rated operating voltage values are listed in Table 3.

**Table 3 – Rated operating voltage**

| AC or DC | Rated operating voltage (V) |
|---|---|
| AC | 100; 200; 220; 230; 240 |
| DC | 3; 5; 6; 12; 14; 24; 28; 42; 100; 115 |

## 5.4 Rated operating current ($I_e$)

The operating current values are recommended based on 4.5 of IEC 62246-1: 2015.

## 5.5 Contact ratings

The contact rating values are recommended based on 4.6 of IEC 62246-1: 2015.

## 5.6 Number of operations

The number of operation values are recommended based on 4.7 of IEC 62246-1: 2015.

## 5.7 Rated operating distance ($S_n$)

Recommended operating distance values referred to specified direction are listed in Table 4.

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**Table 4 – Rated operating distance**

| Rated operating distance (mm) |
|---|
| 1; 2; 3; 4; 5; 8; 10; 12; 15; 20; 25; 30; 40; 50; 70; 100 |

### 5.8 Climatic category

The climatic category is recommended based on 4.8 of IEC 62246-1: 2015.

### 5.9 Environmental severities

a) Vibration (IEC 60068-2-6: 2007, Test Fc)

The vibration values and ranges are recommended based on 4.9 a) of IEC 62246-1: 2015.

b) Shock (IEC 60068-2-27: 2008, Test Ea)

The shock values are recommended based on 4.9 b) of IEC 62246-1: 2015.

c) Low pressure (IEC 60068-2-13: 2008, Test M)

The low-pressure values are recommended based on 4.9 d) of IEC 62246-1: 2015.

d) High pressure (IEC 60068-2-18:2017, Test R)

The recommended values for the rated maximum working pressure are listed in Table 5.

**Table 5 – Rated maximum working pressure**

| Rated maximum working pressure (MPa) |
|---|
| 0,1; 0,5; 1; 2; 3; 4; 5; 6 |

e) Degree of enclosure (IEC 60529:1989/AMD2:2013/COR1:2019)

The recommended degrees of enclosure shall have minimum IP54 protection.

### 5.10 Response speed

The recommended response speed is less than 10 000 mm/s.

### 5.11 Frequency operating cycles

The recommended frequency cycles are less than 1 000 Hz.

## 6 Types

The types of MSPE are classified according to output format are given in Table 6.

**Table 6 – Output function of MSPE**

| Output function | Definition |
|---|---|
| Make contact (NO) | contact which is closed (turn-on) when the MSPE is in its operate condition and which is open (turn-off) when the MSPE is in its release condition, there is no applied magnetic field,<br>or<br>contact which is closed when the MSPE is in its operate condition and which is keep closed if there is no applied magnetic field. |
| Break contact (NC) | contact which is open (turn-on) when the MSPE is in its operate condition and which is closed (turn-off) when the MSPE is in its release condition, there is no applied magnetic field. |
| Change-over contact (CO) | contact set which contains a make contact and a break contact within a single envelope, one contact blade being common; such that when one of these contact circuits is open, the other is closed when the MSPE is in its operate condition. |

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# 7 General provisions for testing

## 7.1 General

In the subsequent clauses, the requirements to be checked as well as the related tests are specified.

The tests according to this standard are type tests and routine tests.

HAZARDS considered in this standard are hazards from electrical shock, rough handling shocks, fluid contamination, dust, different cleaning methods using water, pressurized water, explosive gasses and vapour, heating, ignition and foreseeable misuse before the end of life.

HAZARDS shall not exceed a tolerable level. For the component, the compliance to the tests specified in Table 7 are considered to represent a tolerable level. For the application of the MSPE, a risk assessment shall be carried out according to Annex E.

## 7.2 Type tests

Unless otherwise prescribed in the detail specification, the specimens shall be grouped in 11 inspection lots, and the related tests shall be taken from Table 7.

For each inspection lot, the tests shall be carried out in the given order. Sample size should be specified by the manufacturer.

If one or more specimen(s) of an inspection lot do(es) not pass a test, this test as well as every other one that may have influenced the result of this test shall be repeated once with an additional set of specimens of the same design. In case the manufacturer modifies the MSPE(s), all tests technically influenced by the modification shall also be repeated.

**Table 7 – Type testing**

| Inspection lot | Tests | Clause | Additional references |
|---|---|---|---|
| 1 | Marking and documentation | 8 | IEC 60417 |
| | Functional tests | 9.3 | |
| 2 | Insulation resistance | 9.4 | |
| | Dielectric strength | 9.5 | |
| 3 | Endurance tests | 9.6 | |
| | Electrical endurance | 9.6.2 | IEC 62246-1<br>IEC 61810-2 |
| | Mechanical endurance (if applicable) | 9.6.3 | |
| 4 | External connections | 9.7 | |
| | Robustness of terminal with lead wire (if applicable) | 9.7.2 | |
| | Robustness of terminal (if applicable) | 9.7.3 | IEC 60068-2-21 |
| | Solder terminals (if applicable) | 9.7.4 | IEC 61810-1:2019, 14.4 |
| | Connector (if applicable) | 9.7.5 | IEC 61076-2 |
| 5 | Mechanical stresses | 9.8 | |
| | Mounting | 9.8.2 | |
| | Vibration | 9.8.3 | IEC 60068-2-6 |
| | Shock | 9.8.4 | IEC 60068-2-27 |
| | Rough handling shocks (if applicable) | 9.8.5 | IEC 60068-2-31:2008 |
| 6 | Environmental tests | 9.9 | |
| | Cold | 9.9.2 | IEC 60068-2-1 |
| | Dry heat | 9.9.3 | IEC 60068-2-2 |

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