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मानक

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“Step Out From the Old to the New”

IS/IEC 60947-5-2 (2007): Low-Voltage Switchgear and Control Gear, Part 5: Control Circuit Devices and Switching Elements, Section 2: Proximity Switches [ETD 7: Low Voltage Switchgear and Controlgear]



“ज्ञान से एक नये भारत का निर्माण”

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Bhartrhari—Nitiśatakam

“Knowledge is such a treasure which cannot be stolen”

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भारतीय मानक
निम्न-वोल्टता के स्विचगियर और नियंत्रणगियर
भाग 5 परिपथ नियंत्रण उपकरण और स्विचिंग घटक
अनुभाग 2 प्रोक्सिमिटी स्विच

Indian Standard
LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR
PART 5 CONTROL CIRCUIT DEVICES AND SWITCHING ELEMENTS
Section 2 Proximity Switches

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BUREAU OF INDIAN STANDARDS
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NEW DELHI 110002

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Low-Voltage Switchgear and Controlgear Sectional Committee, ETD 07

NATIONAL FOREWORD

This Indian Standard (Part 5/Sec 2) which is identical with IEC 60947-5-2 : 2007 (Edition 3.0) 'Low-voltage switchgear and controlgear — Part 5-2 : Control circuit devices and switching elements — Proximity switches' issued by the International Electrotechnical Commission (IEC) was adopted by the Bureau of Indian Standards on the recommendation of the Low-Voltage Switchgear and Controlgear Sectional Committee and approval of the Electrotechnical Division Council.

This standard was first published as IS 13947 (Part 5/Sec 2) : 2004 'Low-voltage switchgear and controlgear — Specification : Part 5 Control circuit devices and switching elements, Section 2 Proximity switches' based on IEC 60947-5-2 : 1999. The Committee has now decided to adopt the revised IEC Standard in a single number as IS/IEC 60947-5-2 : 2007 in order to harmonize it with the latest developments that have taken place at international level. The main changes in this standard with respect to the IS 13947 (Part 5/Sec 2) : 2004 are as follows:

- a) Addition for operation of a magnetic proximity switch **4.1.4**;
- b) Modification for operating range of a photoelectric proximity switch (**4.2.3.2, 7.2.1.3.4, 7.2.1.3.5**) and tests (**8.4.2**);
- c) IEC 60947-1 has been referred for clearances and creepage distances for all cases;
- d) Modification of Table 3;
- e) Additional requirements under Electromagnetic compatibility (EMC) (**7.2.6**) and immunity tests, Table 8 and corresponding tests; and
- f) Modification of status of Annex A, now informative.

This standard is part of a series of standards comprising the following parts under the title 'Low-voltage switchgear and controlgear':

- Part 1 General rules
- Part 2 Circuit-breakers
- Part 3 Switches, disconnectors, switch-disconnectors and fuse-combination units
- Part 4 Contactors and motor-starters

The text of IEC Standard has been approved as suitable for publication as an Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

- a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.
- b) Comma (,) has been used as a decimal marker, while in Indian Standards the current practice is to use a point (.) as the decimal marker.

In this adopted standard, reference appears to certain International/Other Standards for which Indian Standards also exist. The corresponding Indian Standards, which are to be substituted in their respective places are listed below along with their degree of equivalence for the editions indicated:

| <i>International/Other Standard</i> | <i>Corresponding Indian Standard</i> | <i>Degree of Equivalence</i> |
|--|--|------------------------------|
| IEC 60050 (441) : 1984 International Electrotechnical Vocabulary (IEV) — Chapter 441: Switchgear, controlgear and fuses Amendment 1(2000) | IS 1885 (Part 17) : 1979 Electrotechnical vocabulary: Part 17 Switchgear and controlgear (<i>first revision</i>) | Technically Equivalent |

| <i>International/Other Standard</i> | <i>Corresponding Indian Standard</i> | <i>Degree of Equivalence</i> |
|--|--|--------------------------------------|
| IEC 60068-2-6 : 1995 Environmental testing — Part 2: Tests — Test Fc: Vibration (sinusoidal) | IS 9000 (Part 8/Sec 1 and 2) : 1981 Basic environmental testing procedures for electronic and electrical items : Part 8 Vibration (sinusoidal) test | Technically Equivalent |
| IEC 60068-2-14 : 1984 Environmental testing — Part 2: Tests — Test N: Change of temperature Amendment 1(1986) | IS 9000 (Part 14/Sec 1 to 3) : 1988 Basic environmental testing procedures for electronic and electrical items: Part 14 Test N : Change of temperature | do |
| IEC 60068-2-27 : 1987 Environmental testing — Part 2: Tests — Test Ea and guidance: Shock | IS 9000 (Part 7/Sec 1) : 2006 Basic environmental testing procedures for electronic and electrical items: Part 7 Impact test, Section 1 Shock (Test Ea) | Identical |
| IEC 60068-2-30 : 2005 Environmental testing — Part 2-30: Tests — Test Db : Damp heat, cyclic (12 h + 12 h cycle) | IS 9000 (Part 5/Sec 2) : 1981 Basic environmental testing procedures for electronic and electrical items: Part 5 Damp heat (cyclic) test, Section 2 12 h + 12 h cycle | Technically Equivalent |
| IEC 60364 (All parts) Low-voltage electrical installations | SP 30 : 1985 National Electrical Code | do |
| IEC 60947-1 : 2007 Low-voltage switchgear and controlgear — Part 1: General rules | IS/IEC 60947-1 : 2007 Low-voltage switchgear and controlgear: Part 1 General rules | Identical |
| IEC 61000-3-2 : 2005 Electromagnetic compatibility (EMC) — Part 3-2: Limits — Limits for harmonic current emissions (equipment input current <16 A per phase) | IS 14700 (Part 3/Sec 2) : 2008 Electromagnetic compatibility (EMC): Part 3 Limits, Section 2 Limits for harmonic current emissions (equipment input current 16 A per phase) | do |
| IEC 61000-3-3 : 1994 Electromagnetic compatibility (EMC) — Part 3-3: Limitation of voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current <16 A Amendment 1 (2001) Amendment 2 (2005) | IS 14700 (Part 3/Sec 3) : 2008 Electromagnetic compatibility (EMC): Part 3 Limits, Section 3 Limitation of voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current <16 A | Identical to IEC 61000-3-3 : 2005 |
| IEC 61000-4-2 : 1995 Electromagnetic compatibility (EMC) — Part 4-2: Testing and measurement techniques — Electrostatic discharge immunity test Amendment 1 (1998) Amendment 2 (2000) | IS 14700 (Part 4/Sec 2) : 2008 Electromagnetic compatibility (EMC): Part 4 Testing and measurement techniques, Section 2 Electrostatic discharge immunity test | Identical to IEC 61000-4-2 : 2001 |
| IEC 61000-4-3 : 2006 Electromagnetic compatibility (EMC) — Part 4-3: Testing and measurement techniques — Radiated, radio-frequency, electromagnetic field immunity test | IS 14700 (Part 4/Sec 3) : 2008 Electromagnetic compatibility (EMC): Part 4 Testing and measurement techniques, Section 3 Radiated, radio-frequency, electromagnetic field immunity test | Identical |

| <i>International/Other Standard</i> | <i>Corresponding Indian Standard</i> | <i>Degree of Equivalence</i> |
|--|---|--------------------------------------|
| IEC 61000-4-4 : 2004 Electromagnetic compatibility (EMC) — Part 4-4: Testing and measurement techniques — Electrical fast transient/burst immunity test | IS 14700 (Part 4/Sec 4) : 2008 Electromagnetic compatibility (EMC): Part 4 Testing and measurement techniques, Section 4 Electrical fast transient/burst immunity test | Identical |
| IEC 61000-4-8 : 1993 Electromagnetic compatibility (EMC) — Part 4-8: Testing and measurement techniques — Power frequency magnetic field immunity test Amendment 1 (2000) | IS 14700 (Part 4/Sec 8) : 2008 Electromagnetic compatibility (EMC): Part 4 Testing and measurement techniques, Section 8 Power frequency magnetic field immunity test | Identical to IEC 61000-4-8 : 2001 |
| IEC 61000-4-11 : 2004 Electromagnetic compatibility (EMC) — Part 4-11: Testing and measurement techniques — Voltage dips, short interruptions and voltage variations immunity tests | IS 14700 (Part 4/Sec 11) : 2008 Electromagnetic compatibility (EMC): Part 4 Testing and measurement techniques, Section 11 Voltage dips, short interruptions and voltage variations immunity tests | Identical |
| CISPR 11 : 2003 Industrial, scientific and medical (ISM) radio-frequency equipment — Electromagnetic disturbance characteristics — Limits and methods of measurement Amendment 1 (2004) Amendment 2 (2006) | IS 6873 (Part 4) : 1999 Limits and methods of measurement of radio disturbance characteristics: Part 4 Industrial, scientific and medical (ISM) radio-frequency equipment | Identical to CISPR 11 : 1997 |

The technical committee has reviewed the provisions of the following International Standards referred in this adopted standard and has decided that they are acceptable for use in conjunction with this standard:

| <i>International Standard</i> | <i>Title</i> |
|--|--|
| IEC 60446 : 2007 | Basic and safety principles for man-machine interface, marking and identification — Identification of conductors by colours or numerals |
| IEC 61000-4-6 : 2003 Amendment 1 (2004) Amendment 2 (2006) | Electromagnetic compatibility (EMC) — Part 4-6: Testing and measurement techniques — Immunity to conducted disturbances, induced by radio-frequency fields |
| IEC 61000-4-13 : 2002 | Electromagnetic compatibility (EMC) — Part 4-13: Testing and measurement techniques — Harmonics and interharmonics including mains signalling at a.c. power port, low-frequency immunity tests |
| IEC 61140 : 2001 Amendment 1 (2004) | Protection against electric shock — Common aspects for installation and equipment |
| ISO 630 : 1995 | Structural steels — Plates, wide flats, bars, sections and profiles Amendment 1 (2003) |

Only the English language text has been retained while adopting it in this Indian Standard, and as such the page numbers given here are not the same as in the IEC Standard.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated expressing the result of a test, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

*Indian Standard***LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR****PART 5 CONTROL CIRCUIT DEVICES AND SWITCHING ELEMENTS****Section 2 Proximity Switches****1 General**

The provisions of the general rules in 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 references to IEC 60947-1, e.g. subclause 7.1.9.3 of IEC 60947-1 or Annex C of IEC 60947-1.

Clauses 1 to 8 contain the general requirements. Specific requirements for the various types of proximity switches are given in Annex A.

1.1 Scope and object

This part of IEC 60947 applies to inductive and capacitive proximity switches that sense the presence of metallic and/or non-metallic objects, ultrasonic proximity switches that sense the presence of sound reflecting objects, photoelectric proximity switches that sense the presence of objects and non-mechanical magnetic proximity switches that sense the presence of objects with a magnetic field.

These proximity switches are self-contained, have semiconductor switching elements(s) and are intended to be connected to circuits, the rated voltage of which does not exceed 250 V 50 Hz/60 Hz a.c. or 300 V d.c. This Standard is not intended to cover proximity switches with analogue outputs.

The object of this standard is to state for proximity switches:

- definitions;
- classification;
- characteristics;
- product information;
- normal service, mounting and transport conditions;
- constructional and performance requirements;
- tests to verify rated characteristics.

1.2 Normative references

The following referenced documents are indispensable for the application 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 60050(441):1984, *International Electrotechnical Vocabulary (IEV) – Chapter 441: Switchgear, controlgear and fuses*
Amendment 1 (2000)

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

IEC 60068-2-14:1984, *Environmental testing – Part 2: Tests – Test N: Change of temperature*

Amendment 1 (1986)

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

IEC 60068-2-30:2005, *Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60364 (all parts), *Low-voltage electrical installations*

IEC 60446:2007, *Basic and safety principles for man-machine interface, marking and identification – Identification of conductors by colours or numerals*

IEC 60947-1:2007, *Low-voltage switchgear and controlgear – Part 1: General rules*

IEC 61000-3-2:2005, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)*

IEC 61000-3-3:1994, *Electromagnetic compatibility (EMC) – Part 3-3: Limitation of voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current ≤ 16 A*
Amendment 1 (2001)
Amendment 2 (2005)

IEC 61000-4-2:1995, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*
Amendment 1 (1998)
Amendment 2 (2000)

IEC 61000-4-3:2006, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4:2004, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-6:2003, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*
Amendment 1 (2004)
Amendment 2 (2006)

IEC 61000-4-8:1993, *Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test*
Amendment 1 (2000)

IEC 61000-4-11:2004, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests*

IEC 61000-4-13:2002, *Electromagnetic compatibility (EMC) – Part 4-13: Testing and measurement techniques – Harmonics and interharmonics including mains signalling at a.c. power port, low-frequency immunity tests*

IEC 61140:2001, *Protection against electric shock – Common aspects for installation and equipment*
Amendment 1 (2004)

CISPR 11:2003, *Industrial, scientific and medical (ISM) radio-frequency equipment –*

Electromagnetic disturbance characteristics – Limits and methods of measurement
 Amendment 1 (2004)
 Amendment 2 (2006)

ISO 630:1995, *Structural steels – Plates, wide flats, bars, sections and profiles*
 Amendment 1 (2003)

2 Definitions

Clause 2 of IEC 60947-1 applies with the following additions:

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2.1 Basic definitions

2.1.1

proximity switch

a position switch which is operated without mechanical contact with the moving part

[IEV 441-14-51]¹

2.1.1.1

inductive proximity switch

a proximity switch producing an electromagnetic field within a sensing zone and having a semiconductor switching element

2.1.1.2

capacitive proximity switch

a proximity switch producing an electric field within a sensing zone and having a semiconductor switching element

2.1.1.3

ultrasonic proximity switch (see Figure 2)

a proximity switch transmitting and receiving ultrasound waves within a sensing zone and having a semiconductor switching element

2.1.1.4

photoelectric proximity switch (see Figure 1)

a proximity switch which senses objects that either reflect or interrupt visible or invisible light and having a semiconductor switching element

2.1.1.4.1

type D

diffuse reflective photoelectric proximity switch which is directly operated through lateral or axial approach to its reference axis by a defined object

2.1.1.4.2

type R

retroreflective photoelectric proximity switch which is indirectly operated through lateral approach to its reference axis between emitter-receiver and reflector by a defined object

2.1.1.4.3

type T

through beam photoelectric proximity switch which is indirectly operated through lateral approach of its reference axis between emitter and receiver by a defined object

2.1.1.5

non-mechanical magnetic proximity switch

proximity switch which senses the presence of a magnetic field and has a semiconductor switching element and no moving parts in the sensing element

2.1.1.6

direct operated proximity switch

proximity switch which detects its target without the use of an external means, e.g. a reflector

¹ See IEC 60050(441).

2.1.1.7

indirect operated proximity switch

proximity switch which detects its target with the use of an external means, e.g. a reflector

2.1.1.8

neutral density filters

filters which uniformly attenuate the intensity of light over a broad spectral range

NOTE Attenuation is accomplished by using either a light-absorbing glass or a thin-film metal coating that combines absorption and reflection.

2.2 Parts of a proximity switch

2.2.1

semiconductor switching element

an element designed to switch the current of an electric circuit by controlling conductivity of a semiconductor

2.2.2

Reference axis

2.2.2.1

reference axis for inductive, capacitive, non-mechanical magnetic and ultrasonic proximity switches

an axis perpendicular to the sensing face and passing through its centre

2.2.2.2

reference axis for types R and D photoelectric proximity switches

an axis located midway between the optical axis of the emitter and this of receiver elements or lenses (see Figure 1)

2.2.2.3

reference axis for type T photoelectric proximity switches

an axis perpendicular to the centre of the emitter

2.2.3

standard target

a specified object used for making comparative measurements of the operating distances and sensing distances

2.2.4

free zone

a volume around the proximity switch which is kept free from any material capable of affecting the characteristics of the proximity switch

2.2.5

damping material

a material which has an influence on the characteristics of a proximity switch

2.2.6

non-damping material

a material which has negligible influence on the characteristics of a proximity switch

2.2.7

sound-reflecting material

a material which reflects the ultrasound waves and gives detectable echoes

2.2.8

sound-absorbing material

a material with negligible reflecting characteristics for ultrasound waves which gives no detectable echo

2.2.9

embeddable proximity switch

a proximity switch is "embeddable" when any damping material can be placed around the sensing face plane without influencing its characteristics

2.2.10

non-embeddable proximity switch

a proximity switch is "non-embeddable" when a specified free zone around its sensing face is necessary in order to maintain its characteristics

2.2.11

Sensing face

2.2.11.1

sensing face of an inductive proximity switch

a surface of the proximity switch through which the electromagnetic field emerges

2.2.11.2

sensing face of a capacitive proximity switch

a surface of the proximity switch through which the electric field emerges

2.2.11.3

sensing face of an ultrasonic proximity switch

a surface of the proximity switch where ultrasound is transmitted and received

2.2.11.4

sensing face of a non-mechanical magnetic proximity switch

a surface of the proximity switch through which the change in a magnetic field is detected

2.2.12

emitter

the light source, lens and necessary circuitry which provide the light beam

2.2.13

receiver

the detector, lens and necessary circuitry to monitor the presence of the light beam from the emitter

2.2.14

reflector

a specified device used to reflect light back to the receiver for type R photoelectric proximity switches

2.2.15

Adjuster

2.2.15.1

adjuster of a capacitive proximity switch

a part of capacitive proximity switch used to set the operating distance. Its use compensates for influence due to target material, transmission medium and installation (mounting) conditions

2.2.15.2

adjuster of an ultrasonic or a photoelectric proximity switch

a part of an ultrasonic or a photoelectric proximity switch used to set the operating distance within the sensing range

2.3 Operation of a proximity switch

2.3.1

operating distances (s)

a distance at which the target approaching the sensing face along the reference axis causes the output signal to change

2.3.1.1

rated operating distance (s_n)

the rated operating distance is a conventional quantity used to designate the operating distances. It does not take into account either manufacturing tolerances or variations due to external conditions such as voltage and temperature

2.3.1.2

sensing range (s_d)

the range within which the operating distance may be adjusted

2.3.1.2.1

minimum operating distance

the lower limit of the specified sensing range of an ultrasonic or photoelectric proximity switch

2.3.1.2.2

maximum operating distance

the upper limit of the specified sensing range of an ultrasonic or photoelectric proximity switch

2.3.1.3

blind zone

the zone between the sensing face and the minimum operating distance, where no object can be detected

2.3.1.4

total beam angle

the solid angle around the reference axis of an ultrasonic proximity switch, where the sound level drops by 3 dB

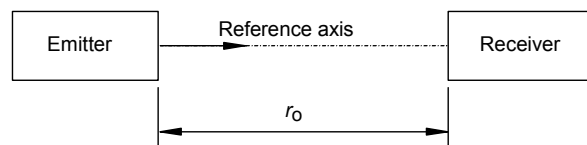


Figure 1a - Type T, emitter and receiver - Through beam photoelectric

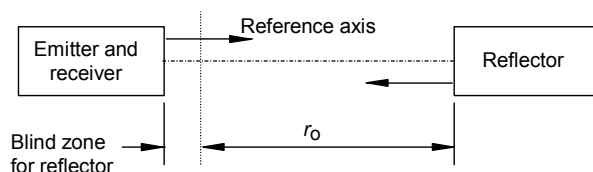


Figure 1b - Type R, emitter-receiver and reflector - Retroreflective photoelectric

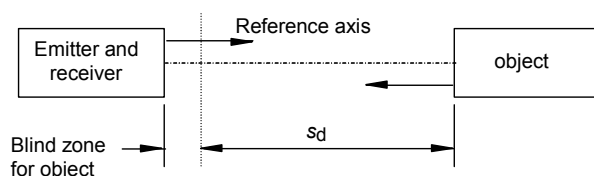


Figure 1c - Type D, emitter-receiver and object - Diffuse reflective photoelectric

Figure 1 – Sensing range and operating range of photoelectric proximity switches
(see 7.2.1.3 and 8.4)

2.3.1.5

effective operating distance (s_r)

the operating distance of an individual proximity switch, measured at stated temperature, voltage and mounting conditions

2.3.1.6

usable operating distance (s_u)

the operating distance of an individual proximity switch, measured under specified conditions

2.3.1.7

assured operating distance (s_a)

the distance from the sensing face within which the correct operation of the proximity switch under specified conditions is assured

2.3.1.8

operating range (r_o)

range within which a lateral approach of the target causes the output signal of a through beam or retroreflective proximity switch to change

2.3.2

lateral approach

the approach of the target perpendicular to the reference axis

2.3.3

axial approach

the approach of the target with its centre maintained on the reference axis

2.3.4

repeat accuracy (R)

the value of variation of the effective operating distance (s_r) under specified conditions

2.3.5

differential travel (H)

the distance between the operating point when the target approaches the proximity switch and the release point when the target moves away

2.4 Switching element characteristics

2.4.1

switching element function

2.4.1.1

make function

a make function causes load current to flow when a target is detected and load current not to flow when a target is not detected

2.4.1.2

break function

a break function causes load current not to flow when a target is detected and load current to flow when a target is not detected

2.4.1.3

make-break, or changeover function

a switching element combination which contains one make function and one break function

2.4.1.4

response time for a proximity switch

the time required for the device switching element to respond after the target enters or exits the sensing zone

2.4.1.5

turn on time for a photoelectric proximity switch

the time required for the switching element to respond after the target enters the sensing range with excess gain of 2 (see 2.4.6)

2.4.1.6

turn off time for a photoelectric proximity switch

the time required for the switching element to respond after the target exits the sensing range with excess gain of 0,5 (see 2.4.6)

2.4.2

independent (snap) action

a switching element function substantially independent from the velocity of the target

2.4.3

frequency of operating cycles (f)

number of operating cycles performed by a proximity switch during a specified period of time

2.4.4

time delay before availability (t_v)

the time delay before availability is the time between the switching on of the supply voltage and

the instant at which the proximity switch becomes ready to operate correctly

2.4.5

Currents (I)

2.4.5.1

off-state current (I_r)

the current which flows through the load circuit of the proximity switch in the OFF-state

2.4.5.2

minimum operational current (I_m)

the current which is necessary to maintain ON-state conduction of the switching element

2.4.5.3

no-load supply current (I_o)

the current drawn by a three or four-terminal proximity switch from its supply when not connected to a load

2.4.6

excess gain for a photoelectric proximity switch

the ratio of the light received by the photoelectric proximity switch to the light required to operate the photoelectric proximity switch

2.4.7

ambient light for a photoelectric proximity switch

for the purpose of this standard, ambient light is the light received by the receiver other than that originating from the emitter

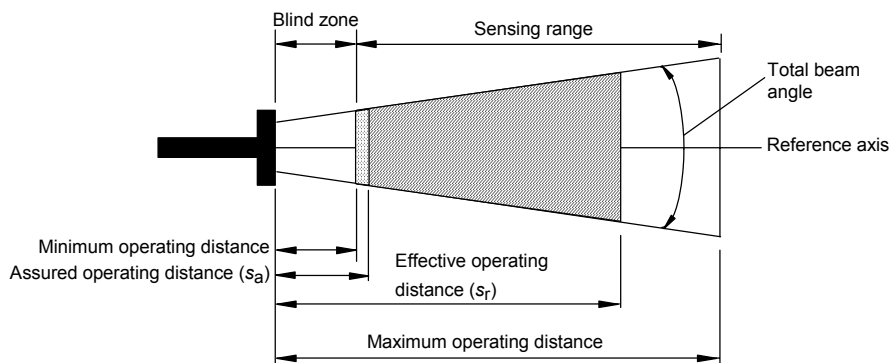


Figure 2 – Ultrasonic proximity switch operating distances

Table 1 – Classification of proximity switches

| 1 st pos./1 digit | 2 nd pos./1 digit | 3 rd pos./3 digits | 4 th pos./1 digit | 5 th pos./1 digit | 6 th pos./1 digit |
|---|--|--|---|---|---|
| SENSING MEANS 3.1 | MECHANICAL INSTALLATION 3.2 | CONSTRUCTION FORM AND SIZE 3.3 | SWITCHING ELEMENT FUNCTION (OUTPUT) 3.4 | TYPE OF OUTPUT 3.5 | METHOD OF CONNECTION 3.6 |
| I = inductive C = capacitive U = ultrasonic D = diffuse reflective photoelectric M = non-mechanical magnetic R = retroreflective photoelectric T = through beam photoelectric | 1 = embeddable 2 = non-embeddable 3 = either | FORM (1 capital letter) A = cylindrical threaded barrel B = cylindrical smooth barrel C = rectangular with square cross-section D = rectangular with rectangular cross-section DIMENSION (2 numbers) for diameter or side length | A = NO (make) B = NF (break) C = changeover (make-break) P = programmable by user S = other | P = PNP-output 3 or 4 terminal d.c. N = NPN-output 3 or 4 terminal d.c. D = 2 terminal d.c. F = 2 terminal a.c. U = 2 terminal a.c. or d.c. S = other | 1 = integral leads 2 = plug-in 3 = screw 9 = other |
| Ultrasonic proximity switch example: | | | | | |
| U Ultrasonic | 3 Either | A30 Cylindrical threaded Ø 30 mm | A NO (make) function | D 2 terminal d.c. | 2 Plug in |

3 Classification

Proximity switches shall be classified according to various characteristics as shown in Table 1. It is recommended that their dimensions are in accordance with those listed in Annex A.

3.1 Classification according to sensing means

In this standard the sensing means is designated by a capital letter in the first position.

3.2 Classification according to the mechanical installation

The mechanical installation is designated by one digit in the second position.

3.3 Classification according to the construction form and size

The construction form and the size are designated by three digits, one capital letter and two numbers. This three-digit designation is placed in the third position.

The capital letter designates the construction form, e.g. cylindrical or rectangular.

The two numbers designate the size, e.g. the diameter of cylindrical types or a length of one side for rectangular types.

3.4 Classification according to switching element function

The switching element function is designated by a capital letter placed in the fourth position.

3.5 Classification according to type of output

The type of output is designated by a capital letter and placed in the fifth position.

3.6 Classification according to method of connection

The method of connection is designated by a one-digit number placed in the sixth position.

4 Characteristics

4.1 Summary of characteristics

The characteristics of a proximity switch shall be stated in the following terms.

- Operating conditions (4.2)
- Rated and limiting values (4.3)
 - Rated voltages (4.3.1)
 - Currents (4.3.2)
 - Rated supply frequency (4.3.3)
 - Frequency of operating cycles (4.3.4)
 - Normal load and abnormal load characteristics (4.3.5)
 - Short-circuit characteristics (4.3.6)
- Utilization categories for the switching element (4.4).

4.1.1 Operation of an inductive or capacitive proximity switch

The output signal is determined by the presence or absence of a designated object in the electromagnetic or electric field which absorbs or alters energy radiated from the sensing face.

4.1.2 Operation of an ultrasonic proximity switch

The output signal is determined by the presence or absence of a designated object in the sensing zone which reflects ultrasound energy radiated from the sensing face.

4.1.3 Operation of a photoelectric proximity switch

The output signal is determined by the presence or absence of a designated object that either reflects or interrupts visible or invisible light radiated from the emitter.

NOTE Many manufacturers of photoelectric proximity switches have traditionally used the terminology "light-operated" and "dark-operated". In this case, if the presence of light at the receiver causes the output element to be in ON state then the device is called "light-operated", and if the presence of light at the receiver causes the output to be in OFF state, then the device is called "dark-operated".

4.1.4 Operation of a magnetic proximity switch

The output signal is determined by the presence or absence of a designated object, which produces a change in a magnetic field within the sensing zone.

4.2 Operating conditions

4.2.1 Operating distance (s) of inductive and capacitive proximity switches

The relationship between the operating distances is shown in Figure 3.

4.2.1.1 Rated operating distance (s_n)

Rated operating distances are specified in the relevant annexes.

4.2.2 Operating distance (s) of an ultrasonic proximity switch

The relationship between the operating distances is shown in Figure 4.

4.2.2.1 Sensing range (s_d)

Sensing range values are given in the relevant annexes.

4.2.3 Operating distance(s) of a photoelectric proximity switch

4.2.3.1 Sensing range (s_d)

For photoelectric proximity switches type D, the operating distances are given as the sensing range (s_d).

4.2.3.2 Operating range (r_o)

For photoelectric proximity switches type T and R, the operating distances are given as the operating range (r_o).

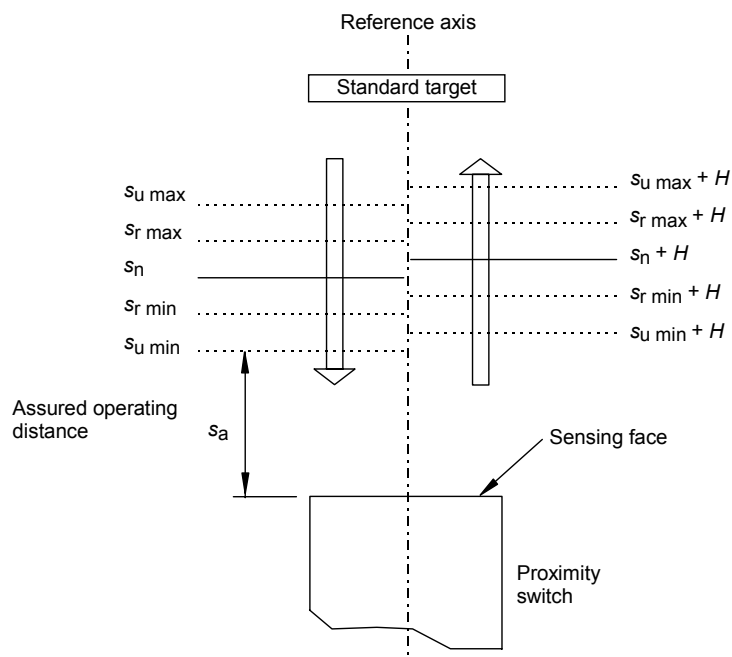


Figure 3 – Relationship between operating distances of inductive and capacitive proximity switches (see 4.2.1, 7.2.1.3 and 8.4.1)

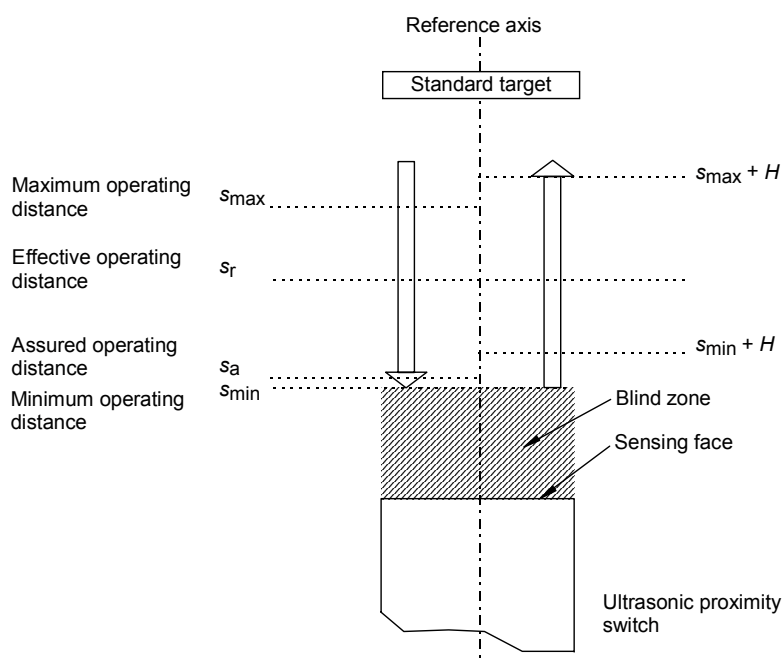


Figure 4 – Relationship between operating distances of ultrasonic proximity switches (see 4.2.2, 7.2.1.3 and 8.4.1)

4.3 Rated and limiting values for the proximity switch and switching element(s)

4.3.1 Voltages

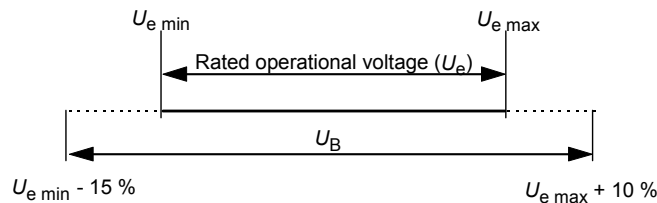
The proximity switch and its switching element(s) are defined by the following rated voltages:

4.3.1.1 Rated operational voltage (U_e)

The rated operational voltage (U_e) (or range) shall not exceed 250 V a.c. or 300 V d.c.

NOTE The manufacturer may state a range between the limiting values which include all the tolerances of U_e , this range shall be designated U_B .

The relationship between U_e and U_B is shown below:



4.3.1.2 Rated insulation voltage (U_i)

The rated insulation voltage of a proximity switch is the value of voltage to which the dielectric voltage tests and creepage distances are referred.

For proximity switches the highest rated operational voltage shall be considered to be the rated insulation voltage.

4.3.1.3 Rated impulse withstand voltage (U_{imp})

Subclause 4.3.1.3 of IEC 60947-1 applies.

4.3.1.4 Voltage drop (U_d)

The voltage drop is the voltage measured across the active output of the proximity switch when carrying the operational current flows under specified conditions. The values are specified in 7.2.1.15.

4.3.2 Currents

The proximity switch and its switching element are defined by the following currents.

4.3.2.1 Rated operational current (I_e)

See 7.2.1.11.

4.3.2.2 Minimum operational current (I_m)

See 7.2.1.12.

4.3.2.3 OFF-state current (I_r)

See 7.2.1.13.

4.3.2.4 No-load supply current (I_o)

The no-load supply current of a three- or four-terminal proximity switch shall be stated by the manufacturer.

4.3.3 Rated supply frequency

The rated supply frequency shall be 50 Hz and/or 60 Hz.

4.3.4 Frequency of operating cycles (f)

The frequency of operating cycles shall be in accordance with the relevant annexes or stated by the manufacturer.

4.3.5 Normal load and abnormal load characteristics**4.3.5.1 Rated making and breaking capacities and behaviour of switching element under normal conditions**

A switching element shall comply with the requirements given in Table 4.

NOTE For a switching element to which a utilization category is assigned, it is not necessary to specify separately a making and breaking capacity.

4.3.5.2 Making and breaking capacities under abnormal conditions

A switching element shall comply with the requirements given in Table 5.

NOTE For a switching element to which a utilization category is assigned, it is not necessary to specify separately a making and breaking capacity.

4.3.6 Short-circuit characteristics**4.3.6.1 Rated conditional short-circuit current**

The rated conditional short-circuit current of a proximity switch is 100 A prospective. The proximity switch shall withstand satisfactorily the test specified in 8.3.4.

4.4 Utilization categories for the switching element

The utilization categories as given in Table 2 are considered standard. Any other type of application shall be based on agreement, between manufacturer and user, but information given in manufacturer's catalogue or tender may constitute such an agreement.

Table 2 – Utilization categories for switching elements

| Kind of current | Category | Typical applications |
|---------------------|----------|---|
| Alternating current | AC-12 | Control of resistive loads and solid state loads with optical isolation |
| | AC-140 | Control of small electromagnetic loads with holding (closed) current $\leq 0,2$ A: e.g. contactor relays |
| Direct current | DC-12 | Control of resistive loads and solid state loads with optical isolation |
| | DC-13 | Control of electromagnets |

5 Product information

5.1 Nature of information – Identification

The following information shall be given by the manufacturer:

- The manufacturer's name or trade mark.
- A type designation or other marking which makes it possible to identify the proximity switch and get the relevant information from the manufacturer or his catalogue (see Table 1).
- Reference to this standard if the manufacturer claims compliance.

Basic rated values and utilization

- Rated operational voltage(s) (see 4.3.1.1).
- Utilization category and rated operational currents at the rated operational voltages and rated frequency/frequencies or at direct current, d.c.
- Rated insulation voltage (see 4.3.1.2).
- Rated impulse withstand voltage (see 4.3.1.3).
- IP code (see 7.1.10).
- Pollution degree (see 6.1.3.2).
- Type and maximum ratings of short-circuit protective device (see 7.2.5).
- Rated conditional short-circuit current (see 4.3.6.1).
- Electromagnetic compatibility (EMC) (see 7.2.6).
- Operating distances (see 7.2.1.3).
- Repeat accuracy (see 7.2.1.4).
- Differential travel (see 7.2.1.5).
- Frequency of operating cycles (see 7.2.1.6).
- Minimum operational current (see 7.2.1.12).
- OFF-state current (see 7.2.1.13).
- No-load supply current (see 4.3.2.4).
- Voltage drop (see 7.2.1.15).
- Switching element function (see 2.4.1).
- Mounting application, embeddable or non-embeddable (see 2.2.9 and 2.2.10).
- Physical dimensions (see 7.3).
- Excess gain (see 7.2.1.10).

5.2 Marking

5.2.1 General

Marking of data under a) and b) of 5.1 is mandatory on the nameplate or marked on the body of the proximity switch in order to permit the complete information to be obtained from the manufacturer.

Cylindrical proximity switches of 12 mm or smaller body diameter may provide this marking on the cord or on a tag permanently attached to the cord, located no further than 100 mm from the body of the device.

Marking shall be indelible and easily legible, and shall not be placed on parts normally removable in service.

Data under c) to y) when not included on the proximity switch, shall be included in the manufacturer's literature.

5.2.2 Terminal identification and marking

Subclause 7.1.7.4 applies.

5.2.3 Functional markings

The sensing face shall be marked where this is not apparent by the construction of the proximity switch.

5.3 Instruction for installation, operation and maintenance

The manufacturer shall specify in his documents or catalogues the conditions for installation, operation and maintenance of the proximity switch.

The above documents shall indicate the recommended extent and frequency of maintenance, if any.

6 Normal service, mounting and transport conditions

6.1 Normal service conditions

Proximity switches complying with this standard shall be capable of operating under the following standard conditions.

NOTE If the conditions for operation differ from those given in this standard, the user shall state the deviations from the standard conditions and consult the manufacturer on the suitability for use under such conditions.

6.1.1 Ambient air temperature

6.1.1.1 Inductive, capacitive, non-mechanical magnetic and ultrasonic proximity switches

These proximity switches shall operate between the ambient temperatures of $-25\text{ }^{\circ}\text{C}$ to $+70\text{ }^{\circ}\text{C}$. The operating characteristics shall be maintained over the permissible range of ambient temperature.

NOTE For ultrasonic proximity switches, due to the fact that the speed of sound is dependent upon air temperature, the operating distance may change by 0,17 % per kelvin.

6.1.1.2 Photoelectric proximity switch

Photoelectric proximity switches shall operate between the ambient temperatures of -5°C to $+55^{\circ}\text{C}$. The operating characteristics shall be maintained over the permissible range of ambient temperature.

6.1.2 Altitude

Subclause 6.1.2 of IEC 60947-1 applies.

6.1.3 Climatic conditions

6.1.3.1 Humidity

The relative humidity (RH) of the air shall not exceed 50 % at 70°C . Higher relative humidities are permitted at lower temperatures, e.g. 90 % at $+20^{\circ}\text{C}$.

NOTE Condensation on the sensing face and the change of humidity may influence the operating distances. Care should be taken of condensation which may occur due to variations in temperature. (50 % RH at 70°C equivalent to 100 % RH at 54°C).

6.1.3.2 Pollution degree

Unless otherwise stated by the manufacturer, a proximity switch is intended for installation under environmental conditions of pollution degree 3 as defined in 6.1.3.2 of IEC 60947-1. However, other pollution degrees may apply depending upon the micro-environment.

6.2 Conditions during transport and storage

A special agreement shall be made between the user and the manufacturer if the conditions during transport and storage, e.g. temperature and humidity conditions, differ from those defined in 6.1.

6.3 Mounting

Mounting dimensions and conditions shall be according to the relevant specification sheet of Annex A.

7 Constructional and performance requirements

7.1 Constructional requirements

7.1.1 Materials

Materials shall be suitable for the particular application and shall enable the equipment to comply with the relevant test requirements.

Special attention shall be called to flame and humidity resisting qualities, and to the necessity to protect certain insulating materials against humidity.

NOTE Requirements are under consideration.

7.1.2 Current-carrying parts and their connections

Current-carrying parts shall have the necessary mechanical strength and current-carrying capacity for their intended use.

For electrical connections, no contact pressure shall be transmitted through insulating material other than ceramic or other material with characteristics not less suitable, unless there is sufficient resiliency in the metallic parts to compensate for any possible shrinkage or yielding of the insulation material.

7.1.3 Clearances and creepage distances

Subclause 7.1.4 of IEC 60947-1 applies.

7.1.4 Actuation

Proximity switches are tested for operation by the presence or absence of the standard target, the characteristics of which are specified in 8.3.2.1.

7.1.5 Vacant

7.1.6 Vacant

7.1.7 Terminals

7.1.7.1 Constructional requirements

Subclause 7.1.8.1 of IEC 60947-1 applies.

7.1.7.2 Connecting capacity

Subclause 7.1.8.2 of IEC 60947-1 applies.

7.1.7.3 Connection means

Subclause 7.1.8.3 of IEC 60947-1 applies with the following additions.

Proximity switches may have integral connecting leads; in this case the outer sheath of the connecting leads shall be $2^{+0,1}_0$ m long.

7.1.7.4 Connection identification and marking

Subclause 7.1.8.4 of IEC 60947-1 applies with the following additions.

Proximity switches with integral connecting leads shall have wires identified with colours according to Table 3.

Proximity switches with terminal connections shall be identified according to Table 3.

Table 3 – Connection and wiring identification

| Type | Function | Wire | Wire colour | Terminal number ^{b, c, d} |
|--|--|--|---|---|
| 2 terminals a.c. and 2 terminals d.c. unpolarized | NO (make) | | Any colour ^a except Yellow, Green or Green and yellow | 3 4 |
| | NC (break) | | | 1 2 |
| | NO/NC programmable | | | 1 4 |
| 2 terminals d.c. polarized | NO (make) | + – | Brown Blue | 1 4 |
| | NC (break) | + – | Brown Blue | 1 2 |
| 3 terminals d.c. polarized | NO (make) | + – Output | Brown Blue Black | 1 3 4 |
| | NC (break) | + – Output | Brown Blue Black | 1 3 2 |
| 3 terminals a.c. and 3 terminals a.c./ d.c. polarized | NO (make) | L Output | Brown Blue Black | 1 3 4 |
| | NC (break) | L Output | Brown Blue Black | 1 3 2 |
| 4 terminals d.c. polarized | Change over (make/break) | + – NO output NC output | Brown Blue Black White | 1 3 4 2 |
| 8 poles M12 connector d.c. polarized ^g | NO, NC and other not defined functions | + – NO output NC output Not defined Not defined Not defined GND Screen | Brown Blue Black White Grey Pink Violet Orange ^e Screen ^f | 1 3 4 2 5 6 7 8 8 |

^a It is recommended that both wires are of the same colour.

^b Terminal numbers (except for a.c. proximity switches and proximity switches using three terminals 8 mm connector) shall be the same as integral connector pin numbers.

^c For proximity switches with four or eight terminals d.c. having special functions, terminals 2 or 4 may be used for functions other than outputs. In this case, the manufacturer shall give a clear indication of the wire colour and functionality.

^d For proximity switches with four terminals d.c., terminals 2 or 4 may be used for output combinations other than those shown in this table. In this case, the manufacturer shall give a clear indication of the function of each terminal.

^e For connectors without screen connection.

^f For connectors with screen connection.

^g Recommended colour coding. The manufacturer shall state the actual wire colours used in the information for use.

The bi-colour of green-and-yellow (green/yellow) shall be used only to identify the protective conductor (IEC 60446). To maintain historic integrity of earth security, the colour green shall not be used for any other purpose than to identify the protective earth conductor.

7.1.8 Vacant

7.1.9 Provisions for protective earthing

7.1.9.1 Constructional requirements

Subclause 7.1.10.1 of IEC 60947-1 applies with the following addition.

NOTE 1 For proximity switches having class II insulation, the outside metal enclosure is not required to be connected to the protective earth terminal (see IEC 61140).

NOTE 2 Proximity switches with maximum rated voltages not exceeding either 50 V a.c. or 120 V d.c. need no provision for protective earthing.

Consideration must be given to the safety insulation of the supply and its transformer (if any) in accordance with the installation rules (see IEC 60364).

7.1.9.2 Protective earth terminal

Subclause 7.1.10.2 of IEC 60947-1 applies.

7.1.9.3 Protective earth terminal marking and identification

Subclause 7.1.10.3 of IEC 60947-1 applies.

7.1.10 Degree of protection

Proximity switches, when installed in accordance with the manufacturer's instruction shall have minimum IP65 protection, except for photoelectric switches which shall have minimum IP54 protection and shall be verified according to 8.2.

NOTE During the test for the degree of protection the operation of the proximity switch is not required.

7.1.11 Requirements for proximity switches with integrally connected cables

See Annex C.

7.1.12 Class II proximity switches

These devices shall not be provided with means for protective earthing (see IEC 61140).

For class II proximity switches insulated by encapsulation, see Annex B.

7.2 Performance requirements

The following requirements apply to clean new equipment.

7.2.1 Operating conditions

7.2.1.1 General

The equipment shall be mounted in accordance with the instructions given in the relevant specification sheet (Annex A) or by the manufacturer.

For the tests of 7.2.1.3 through 7.2.1.6 the load shall be adjusted to provide $0,2 I_e$.

7.2.1.2 Operating limits

The proximity switch shall operate satisfactorily

- a) between 85 % and 110 % of U_e , or
- b) between 85 % $U_{e \min}$ and 110 % of $U_{e \max}$, or
- c) over the range U_B .

For d.c., the value of the ripple voltage (peak to peak) shall not exceed 0,1 U_e (see 4.3.1.1).

7.2.1.3 Operating distances

The operating distances are measured according to 8.4. The operating distances are stated when the target is moving towards the proximity switch in an axial approach.

For inductive and capacitive proximity switches, the relationship between the operating distances is shown in Figure 3.

For ultrasonic proximity switches, the relationship between the operating distances is shown in Figure 4.

For photoelectric proximity switches, the relationship between the operating distances is shown in Figure 1.

7.2.1.3.1 Effective operating distance (s_r)

The effective operating distance is measured at the rated voltage and at an ambient temperature of $23\text{ °C} \pm 5\text{ °C}$.

- For inductive and capacitive proximity switches it shall be between 90 % and 110 % of the rated operating distance (s_n):

$$0,9 s_n \leq s_r \leq 1,1 s_n$$

- For ultrasonic proximity switches it shall be any distance between the minimum and maximum operating distances:

$$s_{\min} \leq s_r \leq s_{\max}$$

7.2.1.3.2 Usable operating distance (s_u)

Usable operating distance is measured over the ambient temperature range and the supply voltage at 85 % and 110 % of their rated value.

- For inductive and ultrasonic proximity switches, it shall be between 90 % and 110 % of the effective operating distance (s_r):

$$0,9 s_r \leq s_u \leq 1,1 s_r$$

- For capacitive proximity switches, it shall be between 80 % and 120 % of the effective operating distance (s_r):

$$0,8 s_r \leq s_u \leq 1,2 s_r$$

7.2.1.3.3 Assured operating distance (s_a)

- For inductive proximity switches, the assured operating distance is between 0 % and 81 % of the rated operating distance s_n :

$$0 \leq s_a \leq 0,9 \times 0,9 s_n$$

- For capacitive proximity switches, the assured operating distance is between 0 % and 72 % of the rated operating distance s_n :

$$0 \leq s_a \leq 0,9 \times 0,8 s_n$$

7.2.1.3.4 Operating range (r_o) for photoelectric proximity switches of types T and R

The operating range is measured according to 8.4.

The operating range is shown

- in Figure 11a for type T: emitter and receiver,
- in Figure 11b for type R: emitter-receiver and reflector.

The operating range and the value of the excess gain shall be stated by the manufacturer for less than 300 lx and 5 000 lx of ambient light according to the test method specified in 8.4.2.

The excess gain is determined according to 8.4.2.1.

7.2.1.3.5 Sensing range (s_d) for photoelectric proximity switches of type D

The sensing range and/or the operating distance is measured according to 8.4.

The sensing range is shown in Figure 11c for type D: emitter-receiver and object.

The sensing range and the value of the excess gain shall be stated by the manufacturer for less than 300 lx and 5 000 lx of ambient light according to the test method specified in 8.4.2.

7.2.1.3.6 Sensitivity and operating distances of non-mechanical magnetic proximity switches

For non-mechanical magnetic proximity switches, the operating sensing characteristics and their tolerances shall be declared by the manufacturer.

7.2.1.4 Repeat accuracy (R)

The repeat accuracy of the effective operating distance (s_r) is measured over an eight hour period at an ambient temperature of between $23\text{ °C} \pm 5\text{ °C}$ at a relative humidity of any value in the range of 6.1.3.1 to a tolerance of $\pm 5\%$ and with a specified supply voltage.

The difference between any two measurements shall not exceed 10 % of the effective operating distance (s_r):

$$R \leq 0,1 s_r$$

7.2.1.5 Differential travel (H)

The differential travel is given as a percentage of the effective operating distance (s_r). The measurement is made in accordance with 8.4.1.3 at an ambient temperature of $23\text{ °C} \pm 5\text{ °C}$ and at the rated supply voltage. It shall be less than 20 % of the effective operating distance (s_r):

$$H \leq 0,2 s_r$$

7.2.1.6 Frequency of operating cycles (f)

7.2.1.6.1 Inductive, capacitive and ultrasonic proximity switches

The frequency of operating cycles shall be in accordance with the relevant annexes and shall be measured according to 8.5.1 and 8.5.2.

7.2.1.6.2 Photoelectric proximity switch

The frequency of operating cycles (f) is determined from the formula:

$$f = \frac{1}{t_{\text{on}} + t_{\text{off}}}$$

where

t_{on} is the turn on time;

t_{off} is the turn off time;

and shall be stated by the manufacturer;

t_{on} and t_{off} shall be measured according to 8.5.3.

7.2.1.7 Time delay before availability (t_v) (Start-up time)

The time delay before availability shall not exceed 300 ms.

During this time the switching element shall not give any false signal. A false signal is a signal other than zero which appears for longer than 2 ms (see 8.3.3.2.1).

NOTE Zero signal means that only OFF-state current flows through the load.

7.2.1.8 Turn on time (t_{on})

The turn on time and the measuring method shall be stated by the manufacturer.

7.2.1.9 Turn off time (t_{off})

The turn off time and the measuring method shall be stated by the manufacturer.

7.2.1.10 Excess gain, photoelectric proximity switch

The excess gain and the measuring method shall be stated by the manufacturer.

7.2.1.11 Rated operational current (I_e)

The rated operational current shall be:

50 mA d.c. or

200 mA a.c. r.m.s.

Greater values may be agreed upon between manufacturer and user.

7.2.1.12 Minimum operational current (I_m)

The minimum operational current shall be:

2 terminals $I_m \leq 5$ mA d.c. or a.c. r.m.s.

3 or 4 terminals $I_m \leq 1$ mA d.c.

and verified according to 8.3.3.2.2.

7.2.1.13 OFF-state current (I_r)

The maximum current (I_r) which flows through the load circuit of a proximity switch in the OFF-state shall be:

| | |
|------------------|--|
| 2 terminals | $I_r \leq 1,5 \text{ mA d.c. or}$ $I_r \leq 3 \text{ mA a.c. r.m.s.}$ |
| 3 or 4 terminals | $I_r \leq 0,5 \text{ mA d.c.}$ |

and verified according to 8.3.3.2.3.

7.2.1.14 Switching element operation

The switching element operation shall be independent action and shall be verified according to 8.3.3.2.4.

7.2.1.15 Voltage drop (U_d)

The voltage drop measured according to 8.3.3.2.5 shall be:

| | |
|------------------|---|
| 2 terminals | $U_d \leq 8 \text{ V d.c. or}$ $U_d \leq 10 \text{ V a.c. r.m.s.}$ |
| 3 or 4 terminals | $U_d \leq 3,5 \text{ V d.c.}$ |

7.2.2 Temperature rise

Subclause 7.2.2 of IEC 60947-1 applies with the following additions.

The temperature rise limit for proximity switches is 50 K. This temperature rise applies for the exterior of enclosure, metallic or non-metallic materials, and for terminals.

7.2.3 Dielectric properties

The proximity switch shall be capable of withstanding the dielectric tests specified in 8.3.3.4.

For class II proximity switches insulated by encapsulation, see Annex B.

7.2.3.1 Impulse voltage withstand

The minimum test voltage shall be 1 kV.

The characteristics of the impulse generator are: 1,2/50 μs impulse; source impedance: 500 Ω ; source energy: 0,5 J.

NOT For proximity devices with sizes below M12 it is permissible for the manufacturer to specify external protection components to achieve this requirement.

7.2.4 Ability to make and break under normal load and abnormal load conditions**7.2.4.1 Making and breaking capacities****a) Making and breaking capacities under normal conditions**

The switching elements shall be capable of making and breaking currents without failure under the conditions stated in Table 4, for the relevant utilization categories and the number of operations indicated, under the conditions specified in 8.3.3.5.

b) Making and breaking capacities under abnormal conditions

The switching elements shall be capable of making and breaking currents without failure under the conditions stated in Table 5, for the relevant utilization categories and the number of operations under the conditions specified in 8.3.3.5.

Table 4 – Verification of making and breaking capacities of switching elements under normal conditions corresponding to the utilization categories ^a

| Utilization category | Normal conditions of use | | | | | | | | |
|---|--------------------------|---------|---------------------------|--------------------|---------|---------------------------|--|-----------------------|------------|
| | Make ^b | | | Break ^b | | | Number and rate of operations for make and break | | |
| | I/I_e | U/U_e | $\cos \phi$ or $T_{0,95}$ | I/I_e | U/U_e | $\cos \phi$ or $T_{0,95}$ | Number of operations ^c | Operations per minute | ON-time ms |
| AC-12 | 1 | 1 | 0,9 | 1 | 1 | 0,9 | 6 050 | 6 | 50 |
| AC-140 | 6 | 1 | 0,3 | 1 | 1 | 0,3 | 6 050 | 6 | 20 |
| DC-12 | 1 | 1 | 1 ms | 1 | 1 | 1 ms | 6 050 | 6 | 1 |
| DC-13 | 1 | 1 | $6 P_{ms}^d$ | 1 | 1 | $6 P_{ms}^d$ | 6 050 | 6 | $T_{0,95}$ |
| I_e = rated operational current U_e = rated operational voltage I = current to be made or broken U = voltage before make $P = U_e I_e$ = steady-state power consumption $T_{0,95}$ = time to reach 95 % of the steady-state current, in milliseconds | | | | | | | | | |
| ^a See 8.3.3.5 ^b For tolerances on test quantities, see 8.3.2.2 ^c The first 50 operations shall be run at $U/U_e = 1,1$ with the loads set at U_e ^d The value " $6 \times P$ " results from an empirical relationship which is found to represent most d.c. magnetic loads up to and upper limit of $P = 50$ W. | | | | | | | | | |

Table 5 – Verification of making and breaking capacities of switching elements under abnormal conditions corresponding to the utilization categories ^a

| Utilization category | Abnormal conditions of use ^b | | | | | |
|--|---|---------|----------------|--|-----------------------|------------|
| | Make and break ^c | | | Number and rate of operations for make and break | | |
| | I/I_e | U/U_e | $\cos \varphi$ | Number of operations | Operations per minute | ON-time ms |
| AC-12 | Not applicable | | | | | |
| AC-140 ^d | 6 | 1,1 | 0,7 | 10 | 6 | 20 |
| DC-12 | Not applicable | | | | | |
| DC-13 | See footnote ^e | | | | | |
| <div><div>I_e = rated operational current</div><div>U_e = rated operational voltage</div><div>I = current to be made or broken</div><div>U = voltage before make</div></div> | | | | | | |
| <div><div>^a See 8.3.3.5.</div><div>^b The abnormal condition is to simulate a blocked open electromagnet.</div><div>^c For tolerances on test quantities, see 8.3.2.2.</div><div>^d An overload protection device specified by the manufacturer may be used to verify the abnormal conditions.</div><div>^e This test is covered by the test performed according to the footnote ^c of Table 4.</div></div> | | | | | | |

7.2.5 Conditional short-circuit current

The switching element shall withstand the stresses resulting from short-circuit currents under conditions specified in 8.3.4.

7.2.6 Electromagnetic compatibility (EMC)

7.2.6.1 General

The operating characteristics of the proximity switch shall be maintained at all levels of electromagnetic interferences (EMI) up to and including the maximum level stated by the manufacturer.

Due to the small physical size of proximity switches and their protected application environment, the immunity levels specified in this standard deviate, in some cases, from those specified in generic immunity standards.

The proximity device to be tested shall have all the essential design details of the type which it represents and shall be in a clean and new condition.

The EMC tests shall be made at U_e or $U_{e \max}$ if the rated operational voltage is given as a range.

Maintenance or replacement of parts during or after a testing cycle is not permitted.

Generally two environments A and B, as follows, are defined in EMC emission standards. The products covered by this standard are intended for use in environment A.

Environment A relates to low-voltage non-public or industrial networks/locations/installations including highly disturbing sources.

NOTE 1 Environment A corresponds to equipment class A in CISPR 11.

Environment B relates to low-voltage public networks such as domestic, commercial and light industrial locations/installations. Highly disturbing sources such as arc welders are not covered by this environment.

NOTE 2 Environment B corresponds to equipment class B in CISPR 11.

7.2.6.2 Immunity

7.2.6.2.1 Acceptance criteria

Table 7 gives acceptance criteria.

Table 7 – Acceptance criteria

| Item | Acceptance criteria (performance criteria during tests) | | |
|--|---|---|---|
| | A | B | C |
| Overall performance | No noticeable changes of the operating characteristic. Operating as intended ^a | During the tests, the state of the switching element shall not change for more than 1 ms for d.c. devices and one half cycle of supply frequency for a.c. devices | Temporary degradation or loss of performance which requires operator intervention or system reset |
| Operation of displays and signalling components | No changes to visible display information. Only slight light intensity fluctuation of LEDs, or slight movement of characters | Temporary visible changes or loss of information. Undesired LED illumination | Shut down, permanent loss of display or wrong information. Unpermitted operating mode. Not self-recoverable |
| Information processing and sensing functions | Undisturbed communication and data interchange to external devices remains within the specification | Temporarily disturbed communication, which is detected and is self-recoverable | Erroneous processing of information. Undetected loss of data and/or information. Errors in communication. Not self-recoverable |
| ^a The manufacturer shall state in his literature the operating frequency and bandwidth where conducted radio frequencies may cause malfunction. | | | |

7.2.6.2.2 Electrostatic discharges

In accordance with IEC 61000-4-2 and Table 8.

The test voltage shall be applied using the contact discharge method to proximity devices with metallic enclosures.

The test voltage shall be applied using the air discharge method to proximity devices with non metallic enclosures.

Table 8 – Immunity tests

| Type of test | Test level required | | Acceptance criteria |
|---|---|---|---------------------|
| Electrostatic discharge immunity test IEC 61000-4-2 | 8 kV / air discharge or 4 kV / contact discharge | | B |
| Radiated radio-frequency electromagnetic field immunity test (80 MHz to 1 GHz and 1,4 GHz to 2 GHz) IEC 61000-4-3 | 3 V/m ^f | | A |
| Electrical fast transient/burst immunity test IEC 61000-4-4 | 2 kV / 5 kHz using the capacitive coupling clamp | | B |
| Conducted disturbances induced by radio-frequency fields immunity test (150 kHz to 80 MHz) IEC 61000-4-6 | 3 V ^f | | A |
| Power frequency magnetic field immunity test ^a IEC 61000-4-8 | 30 A/m | | A |
| Voltage dips immunity test ^g IEC 61000-4-11 | Class 2 ^{b, c} 0 % during 0,5 cycle | Class 3 ^{b, c} 0 % during 0,5 cycle | B |
| | Class 2 ^{b, c, d} 0 % during 1 cycle 70 % during 25/30 cycles | Class 3 ^{b, c, d} 0 % during 1 cycle 40 % during 10/12 cycles 70 % during 25/30 cycles 80 % during 250/300 cycles | C |
| Voltage interruptions immunity test ^g IEC 61000-4-11 | Class 2 ^{b, c, d} 0 % during 250/300 cycles | Class 3 ^{b, c, d} 0 % during 250/300 cycles | C |
| Immunity to harmonics in the supply IEC 61000-4-13 | No requirements ^e | | |

^a Applicable only to proximity switches containing devices susceptible to power frequency magnetic fields.

^b Class 2 applies to points of common coupling and in-plant points of common coupling in the industrial environment in general.

Class 3 applies to in-plant couplings in industrial environment only. This class should be considered when a major part of the load is fed through converters; welding machines are present; large motors are frequently started or loads vary rapidly.

The manufacturer shall state the applicable class.

^c The given percentage means percentage of the rated operational voltage, e.g. 0 % means 0 V.

^d The value before the solidus (/) is for 50 Hz and the value after is for 60 Hz tests.

^e Test levels are under study for the future.

^f The level differs from IEC 60947-1 because the installation environment for proximity switches is primarily in automation machinery and experience of many years shows that the disturbance levels are so low that the immunity requirements in this standard are sufficient.

^g Applicable for a.c. switches only.

7.2.6.2.3 Radiated radio-frequency electromagnetic fields

In accordance with IEC 61000-4-3 and Table 8.

If the worst case direction is known, then the test need only be performed in that direction. Otherwise, the electromagnetic field shall be faced to the device under test in three mutually perpendicular directions.

7.2.6.2.4 Electrical fast transients/bursts

In accordance with IEC 61000-4-4 and Table 8.

7.2.6.2.5 Surges

For proximity devices it is not necessary to test for surge immunity. The operating environment of these devices is considered to be well protected against surge voltages caused by lightning strikes.

7.2.6.2.6 Conducted disturbances induced by radio-frequency fields

In accordance with IEC 61000-4-6 and Table 8.

7.2.6.2.7 Power-frequency magnetic fields

In accordance with IEC 61000-4-8 and Table 8.

NOTE See Annex E for strong magnetic fields.

7.2.6.2.8 Voltage dips and interruptions

In accordance with IEC 61000-4-11 and Table 8.

7.2.6.2.9 Harmonics in the supply

In accordance with IEC 61000-4-13 and Table 8.

7.2.6.3 Emission

7.2.6.3.1 Conditions during measurement

The measurement shall be made in the operating mode, including grounding conditions, producing the highest emission in the frequency range being investigated which is consistent with normal applications (see Clause 4).

Each measurement shall be performed in defined and reproducible conditions.

Descriptions of the tests, test methods and set-ups are given in CISPR 11. The contents of this standard is not reproduced here, however modifications or additional information needed for the practical application of the tests are given in this standard.

Proximity devices which are intended to be powered by public mains supply, therefore within the scope of IEC 61000-3-2 and IEC 61000-3-3, regarding low-frequency emission shall also comply with the requirements of these standards.

7.2.6.3.2 Limits for high-frequency emissions

Proximity devices can generate continuous electromagnetic disturbances.

Such emissions shall not exceed the limits given in CISPR 11 for environment A. These tests

are only required when the control and/or auxiliary circuits contain components with fundamental switching frequencies greater than 9 kHz.

7.2.6.3.3 Limits for low-frequency emissions

For proximity devices which generate low frequency harmonics, the requirements of IEC 61000-3-2 apply.

For proximity devices which generate low-frequency voltage fluctuations, the requirements of IEC 61000-3-3 apply.

NOTE These requirements are not required for devices that will not be connected to public mains.

7.3 Physical dimensions

Proximity switches with standardized physical dimensions are given in the relevant specification sheet (Annex A).

NOTE Proximity switches with other dimensions are also covered by this standard.

7.4 Shock and vibration

7.4.1 Shock

In accordance with IEC 60068-2-27 with the following conditions:

Six shocks applied in each direction along three mutually perpendicular axes (six separate tests):

| | |
|------------------------|-----------|
| Pulse shape: | half-sine |
| Peak acceleration: | 30 g_n |
| Duration of the pulse: | 11 ms |

7.4.2 Vibration

In accordance with IEC 60068-2-6 with the following conditions, along three mutually perpendicular axes:

| | |
|--|--|
| Frequency range: | 10 Hz to 55 Hz |
| Amplitude: | 1 mm for inductive, capacitive, non-mechanical magnetic and ultrasonic proximity switches 0,5 mm for photoelectric proximity switches |
| Sweep cycle duration: | 5 min |
| Duration of endurance at resonant frequency or at 55 Hz: | 30 min in each of the three axes (90 min in all). |

7.4.3 Results to be obtained

After the test, the operating characteristics shall remain as given in Clause 4.

8 Tests

Unless otherwise stated the tests shall be carried out at an ambient air temperature of

(23 ± 5) °C.

8.1 Kinds of tests

8.1.1 General

Subclause 8.1.1 of IEC 60947-1 applies.

8.1.2 Type tests

Type tests are intended to verify compliance with this standard.

This comprises the verification of:

- a) Temperature rise (8.3.3.3).
- b) Dielectric properties (8.3.3.4).
- c) Making and breaking capacities of switching elements under abnormal and normal conditions (8.3.3.5).
- d) Performance under conditional short-circuit current (8.3.4).
- e) Constructional requirements (8.2).
- f) Degree of protection (8.2).
- g) Operating distances (8.4).
- h) Operating frequency (8.5).
- i) Electromagnetic compatibility (8.6).
- j) Shock withstandability (7.4.1).
- k) Vibration withstandability (7.4.2).

8.1.3 Routine tests

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

The inspection may be supplemented by a dielectric test. When performed, the dielectric test is carried out according to 8.3.3.4, the test duration may be reduced to 1 s.

8.1.4 Sampling tests

Subclause 8.1.4 of IEC 60947-1 applies.

8.1.5 Special tests

These tests are subject to agreement between manufacturer and user.

8.2 Compliance with constructional requirements

Subclause 8.2 of IEC 60947-1 applies where applicable.

8.3 Performances

8.3.1 Test sequences

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

Sample No. 1

Test No. 1 – temperature rise (8.3.3.3).

Test No. 2 – mechanical properties of terminals (8.2.4 of IEC 60947-1).

Test No. 3 – dielectric properties (8.3.3.4).

Test No. 4 – visual inspection.

Sample No. 2

Test No. 1 – degree of protection (Annex C of IEC 60947-1).

Test No. 2 – vibration (7.4.2).

Test No. 3 – frequency of operating cycles (8.5).

Test No. 4 – operating distances (8.4).

Test No. 5 – dielectric properties (8.3.3.4).

Sample No. 3

Test No. 1 – degree of protection (Annex C of IEC 60947-1).

Test No. 2 – shock (7.4.1).

Test No. 3 – frequency of operating cycles (8.5).

Test No. 4 – operating distances (8.4).

Test No. 5 – dielectric properties (8.3.3.4).

Sample No. 4

Test No. 1 – making and breaking capacities (8.3.3.5).

Test No. 2 – dielectric properties (8.3.3.4).

Test No. 3 – operating distances (8.4).

Sample No. 5

Test No. 1 – electromagnetic compatibility (8.6).

Test No. 2 – performance under short-circuit conditions (8.3.4).

Test No. 3 – dielectric properties (8.3.3.4).

Test No. 4 – operating distances (8.4).

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

NOTE 1 More than one test sequence or all test sequences may be conducted on one sample at the request of the manufacturer. However, the test shall be conducted in the sequence given above for each sample.

NOTE 2 For class II proximity switches insulated by encapsulation, additional samples are required (see Annex B). For proximity switches with integrally connected cables, additional samples are required (see Annex C).

8.3.2 General test conditions

8.3.2.1 General requirements

Subclause 8.3.2.1 of IEC 60947-1 applies unless otherwise specified with the following addition.

8.3.2.1.1 Standard target for inductive and capacitive proximity switches

The target is square shape having a thickness of 1 mm and made of carbon steel e.g. type Fe 360 as defined in ISO 630 and it shall be of the rolled finish.

The length (a) of the side of the square is equal to

- the diameter of the circle inscribed on the active surface of the sensing face, or
- three times the rated operating distance s_n whichever is greater (Figure 5).

For a capacitive proximity switch, the target shall be connected to earth.

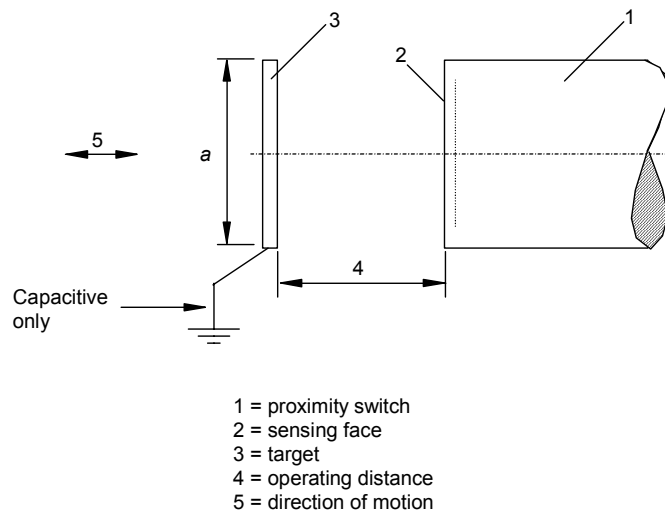


Figure 5 – Method of measuring the operating distance (8.3.2.1 and 8.4.1)

8.3.2.1.2 Standard target for ultrasonic proximity switch

The target is square shape, having the thickness of 1 mm and made from metal with rolled finish. For dimensions see relevant specification sheets in Annex A.

8.3.2.1.3 Standard target for photoelectric proximity switch

a) Type R

For the purpose of this test, the standard target is the reflector which is either supplied or specified by the manufacturer.

b) Type T

For the purpose of this test, the standard target is the emitter which is either supplied or specified by the manufacturer.

c) Type D

200 mm × 200 mm white paper with 90 % reflectivity.

NOTE The standardized target is chosen in accordance with the more general applications. For special products or applications, some additional information may be given.

8.3.2.1.4 Standard target for non-mechanical magnetic proximity switch

For non-mechanical magnetic proximity switches the target shall be specified by the manufacturer.

8.3.2.2 Test quantities

Subclause 8.3.2.2 of IEC 60947-1 applies except for 8.3.2.2.3.

8.3.2.3 Evaluation of test result

The condition of the proximity switch after each test shall be checked by the verification applicable to each test.

The proximity switch is deemed to have met the requirements of this standard if it meets the requirements of each test and/or test sequence as applicable.

8.3.2.4 Test reports

Subclause 8.3.2.4 of IEC 60947-1 applies.

8.3.3 Performance under no load, normal load and abnormal load condition

8.3.3.1 Operation

Subclause 8.3.3.1 of IEC 60947-1 applies.

8.3.3.2 Operating limits

Operational voltages are defined under 7.2.1.2.

8.3.3.2.1 Time delay before availability

The test is performed with the proximity switch connected to a test circuit shown in Figure 6. The target is placed in a position such that the switching element is in the ON-state. With rated operational voltage U_e , or with the minimum value of the rated operational voltage when it is given as a range, the load is adjusted to obtain the minimum operational current I_m .

The time delay before availability and the duration of any false signal are measured by recording the signal across the load with an oscilloscope as the bounce-free "Switch" is closed. Figure 7 shows typical oscillograms for a d.c. switching element. Figure 7a shows the oscillogram when the switching element is in ON-state and Figure 7b shows the oscillogram when the switching element is in OFF-state.

For inductive and capacitive proximity switches the target shall be positioned at either $1/3 s_n$ or $3 s_n$.

The measured time delay before availability, the time between t_3 and t_0 in Figure 7 shall be according to 7.2.1.7. The duration of the false signal, if any, the time between t_2 and t_1 on Figures 7a and 7b, shall be according to 7.2.1.7.

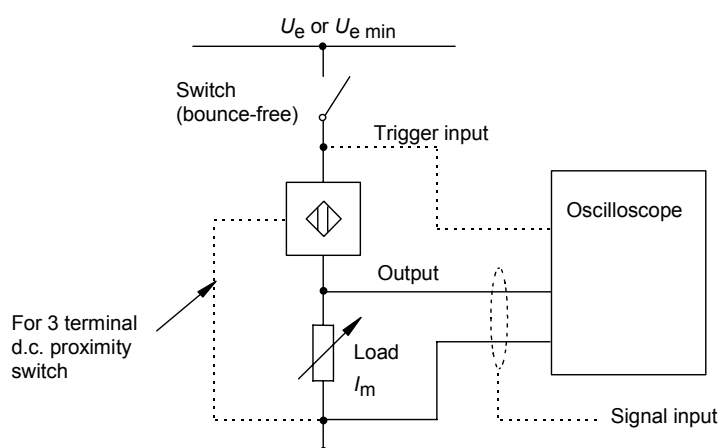


Figure 6 – Test circuit for the verification of time delay before availability
(see 7.2.1.7 and 8.3.3.2.1)

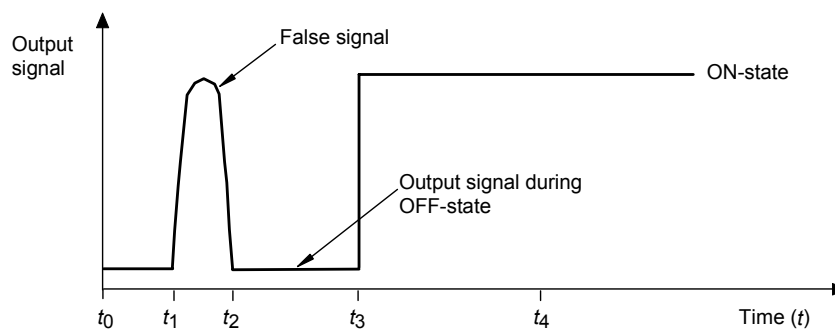


Figure 7a – Switching element is in ON-state

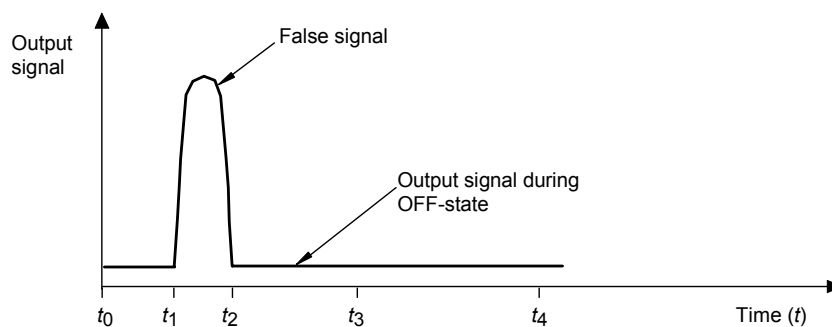


Figure 7b – Switching element is in OFF-state

- t_0 = supply is switched on
- t_1 = beginning of false signal (if any)
- t_2 = end of false signal (if any)
- t_3 = end of time delay
- t_4 = maximum time for delay (300 ms)

NOTE 1 The false signal (if any) may begin at t_0 , which means that t_0 and t_1 are the same time marks.

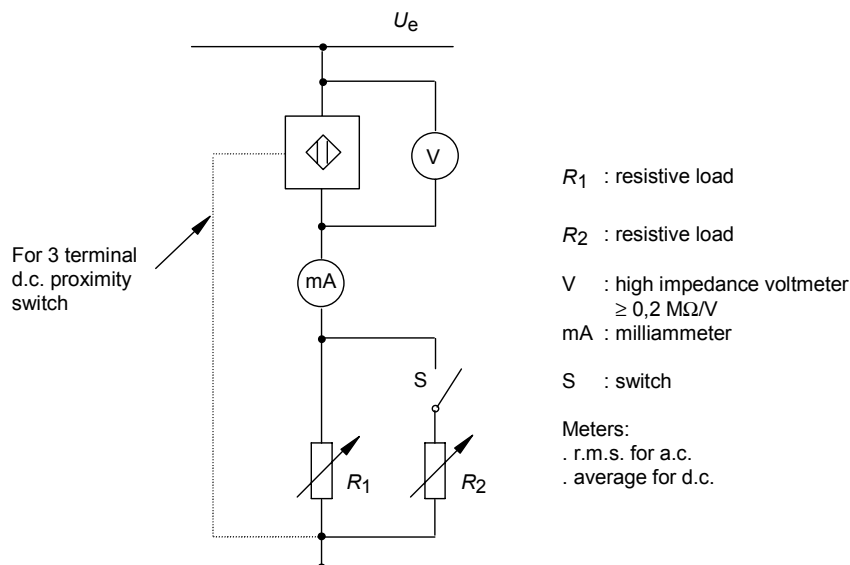
NOTE 2 In case of no false signal, the time mark t_3 can have any position between t_0 and t_4 .

NOTE 3 The waveform of the false signal (if any) is not defined.

Figure 7 – Signal output across load in Figure 6 (see 8.3.3.2.1)

8.3.3.2.2 Minimum operational current (I_m)

The test is performed with the proximity switch connected to a test circuit shown in Figure 8.



**Figure 8 – Test circuit for the verification of minimum operational current
OFF-state current, voltage drop and independent snap action**
(see 8.3.3.2.2, 8.3.3.2.3, 8.3.3.2.4 and 8.3.3.2.5)

The target is placed in a position such that the switching element is in the ON-state.

With supply voltage U_e and the switch S being open, the load R_1 is adjusted to obtain the current I_m . The measured value shall not exceed the value specified in 7.2.1.12.

The switching element shall not change state during the test.

8.3.3.2.3 OFF-state current (I_r)

With the circuit in Figure 8 and the switch S closed, the load R_2 is adjusted to obtain the rated operational current I_e when the supply voltage is the highest U_e . The target is then moved in a position such that the switching element is in the OFF-state.

The (I_r) current shall be measured with supply voltage $U_e + 10 \%$ or with the maximum value of the supply voltage U_B where it is specified as a range. The (I_r) current shall not exceed the value specified in 7.2.1.13.

8.3.3.2.4 Independent (snap) action

Independent (snap) action shall be checked at maximum and minimum operating load currents at both maximum and minimum rated operating voltages. Resistive loads of appropriate value shall be used for each of the four tests.

These tests shall be carried out by moving the target from a position where the switching element is in the OFF-state to a position where the switching element is in the ON-state and observing the output on an oscilloscope. The switching element function shall be substantially independent from the velocity of the target and the output shall switch between the ON and the OFF states without oscillating, or holding at any intermediate level.

8.3.3.2.5 Voltage drop (U_d)

The voltage drop is measured across the active outputs of the proximity switch when the switching element is in the ON-state and carrying the rated operational current (I_e) at $23^\circ\text{C} \pm 5^\circ\text{C}$ ambient temperature and at the lowest rated frequency. This measurement is performed with the circuit in Figure 8 and the switch S closed. The load R_2 is adjusted to

obtain the rated operational current (I_e) with the supply voltage U_e . The voltage drop U_d is measured:

- at $U_e + 10\%$ and $U_e - 15\%$,
- or $U_{e\max} + 10\%$ and $U_{e\min} - 15\%$,
- or $U_{B\max}$ and $U_{B\min}$

The measured voltage drop shall not exceed the values specified in 7.2.1.15.

8.3.3.3 Temperature rise

The proximity switch, installed in free air, is supplied with its rated operational voltage (U_e) (or the highest operational voltage of its voltage range), and connected to a load corresponding to its rated operational current (I_e) until the thermal equilibrium is reached.

The temperature rise, measured on the terminals when applicable, and on any point of the enclosure shall not exceed 50 K (see 7.2.2).

The length of conductor connected to each terminal shall be $2^{+0,1}_0$ m.

8.3.3.4 Dielectric properties

The test for verifying dielectric properties shall be made:

- in accordance with 8.3.3.4 of IEC 60947-1 for the rated impulse withstand voltage U_{imp} (see 4.3.1.3), and
- in accordance with 8.3.3.4.1 and 8.3.3.4.2 and 8.3.3.4.3 of this standard.

For class II proximity switches insulated by encapsulation, see Annex B.

8.3.3.4.1 Application of the test voltage

This test is to be carried out under circumstances approaching actual service conditions e.g. with conductors attached. The external surface of all insulating parts likely to be touched in service shall be made conducting by being closely covered by a metal foil.

The proximity switch shall be capable of withstanding the test voltage applied for 1 min for a type test, and 1 s for routine test with the following conditions:

- between live parts of the switching element and parts of the proximity switch intended to be earthed;
- between live parts of the switching element and surfaces of the proximity switch likely to be touched in service, conducting or made conducting by metal foil;
- between live parts belonging to electrically separated switching elements, if any.

8.3.3.4.2 Value of the test voltage

A sinusoidal voltage of power frequency is applied according to 8.3.3.4.1.

The test voltages are given in Table 6.

Table 6 – Test voltages

| Rated insulation voltage | | Dielectric test voltage |
|--------------------------|---------|-------------------------|
| DC V | AC V | AC (r.m.s.) V |
| 75 | 50 | 500 |
| 150 | 125 | 1 250 |
| 300 | 250 | 1 500 |

8.3.3.4.3 Results to be obtained

There shall be no unintentional disruptive discharge during the test.

NOTE 1 Exception is an intentional disruptive discharge designed for the purpose, e.g. transient overvoltage suppressing means.

NOTE 2 The term "disruptive discharge" relates to a phenomenon associated with the failure of insulation under electrical stress, in which the discharge completely bridges the insulation under test, reducing the voltage between the electrodes to zero or nearly to zero.

NOTE 3 The term "sparkover" is used when a disruptive discharge occurs in a gaseous or liquid dielectric.

NOTE 4 The term "flashover" is used when a disruptive discharge occurs over the surface of a dielectric in a gaseous or liquid medium.

NOTE 5 The term "puncture" is used when a disruptive discharge occurs through a solid dielectric.

NOTE 6 A disruptive discharge in a solid dielectric produces permanent loss of dielectric strength; in a liquid or gaseous dielectric, the loss may be only temporary.

8.3.3.4.4 Impulse voltage withstand test

The test is performed according to 7.2.3 of IEC 60947-1 and 7.2.3.1 of this standard with the following additional requirement:

- the proximity device is not powered during the test;
- the impulse test shall be applied:
 - a) between all terminals connected together and earth;
 - b) between terminals intended to be connected to the power supply;
 - c) between each output terminal and each terminal intended to be connected to the power supply.
- three positive and three negative pulses shall be applied between each two points at intervals of not less than 5 s.

NOTE The impulse voltage withstand test is designed as a type test.

8.3.3.5 Making and breaking capacities

Tests for verification of making and breaking capacities shall be made according to the general test requirements stated in 8.3.2.1.

8.3.3.5.1 Test circuits

The load impedance shall be placed on the load side of the device as shown in Figure 9. The circuit voltage with the test current flowing shall not be less than U_e .

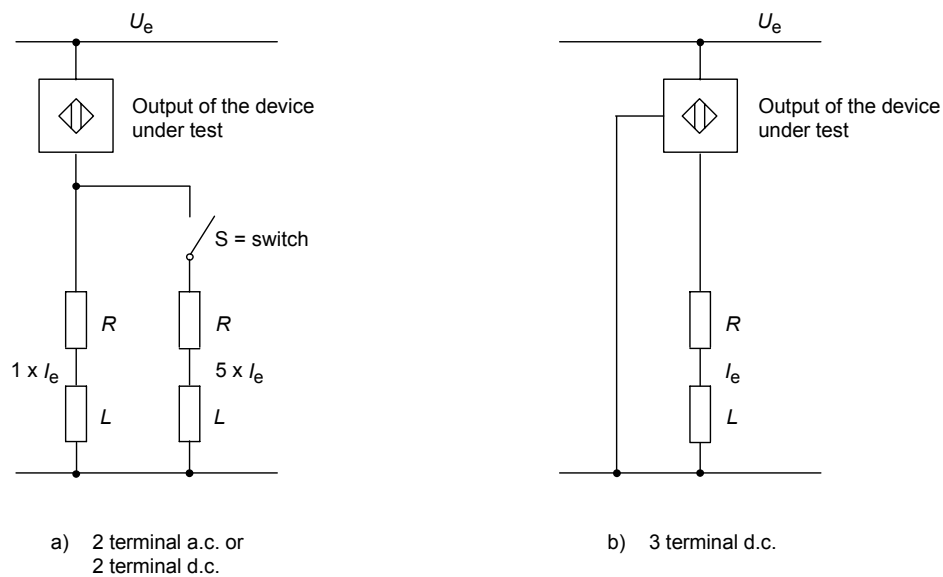


Figure 9 – Test circuit for the verification of making and breaking capability (see 8.3.3.5)

8.3.3.5.2 Making and breaking capacities under normal conditions

The load circuitry shall be adjusted to give the values shown in Table 4.

8.3.3.5.3 Making and breaking capacities under abnormal conditions

The load circuitry shall be adjusted to give the values shown in Table 5.

8.3.3.5.4 Results to be obtained

After the test, the effective operating distance of the proximity switch shall be measured and remain within the limits given in 7.2.1.3.1.

8.3.4 Performance under short-circuit current conditions

8.3.4.1 Test circuit and test procedure

The proximity switch "PS" in new condition shall be mounted as in service, in free air, and connected to the test circuit with the same size wire as used in service, see Figure 10.

The short-circuit protective device "SCPD" shall be of the type and rating stated by the manufacturer. This "SCPD" shall be omitted if the proximity switch is integrally protected against short circuits.

The target is placed in a position such that the switching element is in the ON-state, R_1 is selected so that the current flowing through the proximity switch is equal to its rated operational current. The supply S shall be adjusted to 100 A prospective short-circuit current. The "SC" switch, parallel with R_1 load, is intended to cause the short circuit. The open circuit voltage shall be 1,1 times the rated operational voltage or the maximum value of the voltage range.

The test shall be performed three times by randomly closing the "SC" switch. The test current is maintained until the SCPD or the internal short-circuit protection in the proximity switch has operated. The interval between each of the three tests shall be not less than 3 min. The actual time between tests shall be stated in the test report. After each test, the "SCPD" shall be replaced or reset.

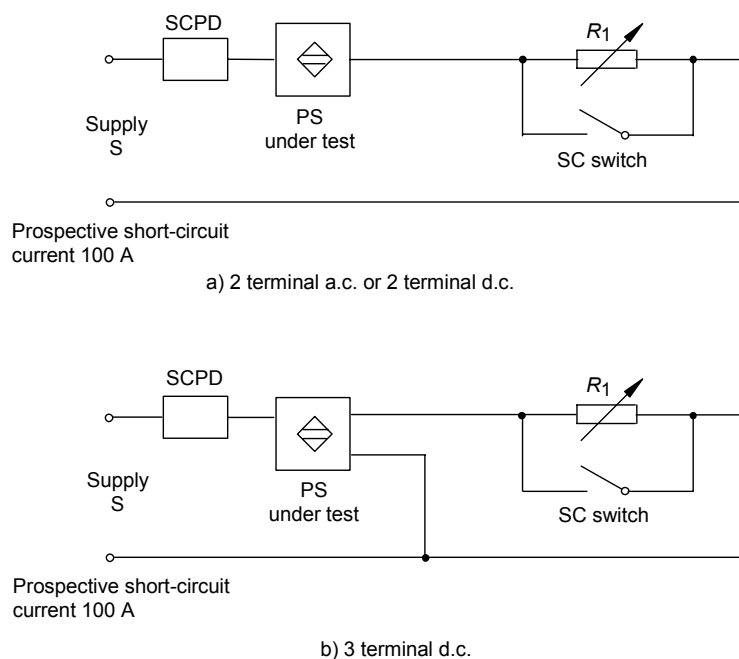


Figure 10 – Short-circuit testing (see 8.3.4.2)

8.3.4.2 Results to be obtained

After the test, the operating distance of the proximity switch shall be measured and remain within the limits given in 7.2.1.3.1.

8.4 Testing of operating distances

8.4.1 Inductive, capacitive, non-mechanical magnetic and ultrasonic proximity switches

8.4.1.1 Test conditions

A proximity switch in new condition is mounted according to the relevant annex and the target is moved, not faster than 1 mm/s, towards and away from the sensing face of the proximity switch in an axial direction. The operating distances are measured as shown in Figures 3 and 4.

8.4.1.2 Effective operating distance (s_r)

The effective operating distance is measured at the rated voltage or at any voltage within the voltage range and at $23\text{ °C} \pm 5\text{ °C}$ ambient air temperature. The measured value shall be within the limits given in 7.2.1.3.1.

8.4.1.3 Differential travel (H)

The differential travel is defined as a percentage of the effective operating distance (s_r). The measurement is made at the ambient temperature of $23\text{ °C} \pm 5\text{ °C}$ at rated supply voltage. The target shall be moved towards the proximity switch within the (s_r) range and then be moved away from the proximity switch. The measured value shall be according to 7.2.1.5.

8.4.1.4 Usable operating distance (s_u)

Usable operating distance is measured over the -25 °C to $+70\text{ °C}$ ambient temperature range with the supply voltage at 85 % and 110 % of its rated value. The target shall be moved towards the proximity switch. The measured value shall be within the limits given in 7.2.1.3.2.

8.4.1.5 Repeat accuracy (*R*)

The repeat accuracy of the effective operating distance (s_r) is measured over an 8 h period with an enclosure temperature within $23\text{ °C} \pm 5\text{ °C}$ and with supply voltage $U_e \pm 5\%$ or at any voltage $\pm 5\%$ within the rated operational voltage range. The target shall be moved towards the proximity switch. The measured value shall be within the limits given in 7.2.1.4.

8.4.2 Photoelectric proximity switches

8.4.2.1 Determination of the excess gain values

– Type D

The standard target is positioned at the stated sensing distance. The reduction of luminance which is necessary to deactivate the proximity switch is determined with neutral density filters. The excess gain is then calculated.

– Types R and T

The emitter or the reflector is positioned at the stated operating range. The reduction of luminance which is necessary to activate the proximity switch is determined with neutral density filters. The excess gain is then calculated.

EXAMPLE To determine the distance at which an excess gain of 2 is achieved, a 50 % neutral density filter may be used for type T, and a 70 % neutral density filter may be used for types R and D. The filter should be as close as possible to the sensing face.

The neutral density filter measurement technique is the preferred method. Other techniques leading to similar results may be used and shall then be stated by the manufacturer.

NOTE Care needs to be taken to avoid erroneous results due to reflections from the filter.

8.4.2.2 Testing of the operating / sensing range and/or operating distance

This test is performed at rated voltage or at any voltage within the voltage range with new photoelectric proximity switches, except when specified as verification after another test, in clean air conditions, at any ambient temperature between $23\text{ °C} \pm 5\text{ °C}$, both in darkness (less than 300 lx) and at an ambient light of 5 000 lx obtained as per 8.4.2.3.

The excess gain, as stated by the manufacturer in the documentation, shall be achieved.

8.4.2.3 Source for ambient light

A light source with a colour temperature between 3 000 K and 3 200 K shall be used. The light intensity is measured with a luxmeter and obtained by varying the distance between the light source and the luxmeter.

8.4.2.4 Type T

In the vicinity of the maximum and minimum operating distances, the emitter is moved, not faster than 1 mm/s in an axial direction, towards the receiver and the maximum and minimum operating distances are measured:

- a) without ambient light (300 lx);
- b) with ambient light (5 000 lx).

The light source is positioned at an angle of $5^\circ \pm 1^\circ$ to the reference axis and is aimed at the receiver (see Figure 11a, type T).

8.4.2.5 Type R

The reflector is installed on the reference axis at the maximum of the operating range r_o .

The light source is positioned at an angle of $5^\circ \pm 1^\circ$ to the reference axis and is aimed at the photoelectric proximity switch (see Figure 11b, type R).

8.4.2.6 Type D

a) For operating distances not exceeding 400 mm:

The light source is positioned at an angle of $15^\circ \pm 1^\circ$ to the reference axis and is aimed at the target (see Figure 11d, type D).

The device is moved, not faster than 1 mm/s in an axial direction, towards the target and the sensing distance is measured:

- 1) without ambient light (300 lx);
- 2) with ambient light (5 000 lx).

b) For operating distances above 400 mm:

The light source is positioned at an angle of $15^\circ \pm 1^\circ$ to the reference axis and is aimed at the device (see Figure 11c, type D).

In the vicinity of the sensing distance, the target is moved, not faster than 1 mm/s in an axial direction, towards the photoelectric proximity switch and the sensing distance is measured:

- 1) without ambient light (300 lx);
- 2) with ambient light (5 000 lx).

8.4.2.7 Results to be obtained

The sensing range shall be as stated by the manufacturer (see 7.2.1.3.4 and 7.2.1.3.5).

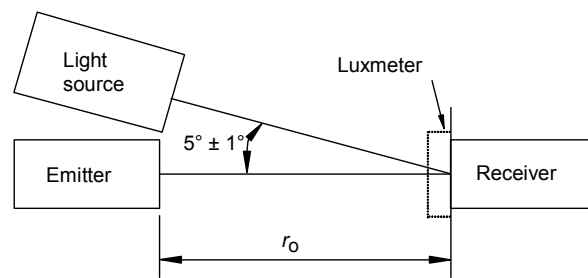


Figure 11a – Type T, emitter and receiver

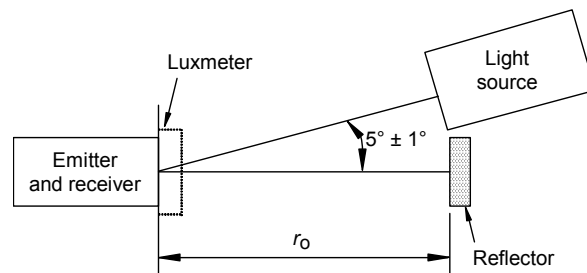


Figure 11b – Type R, emitter-receiver and reflector

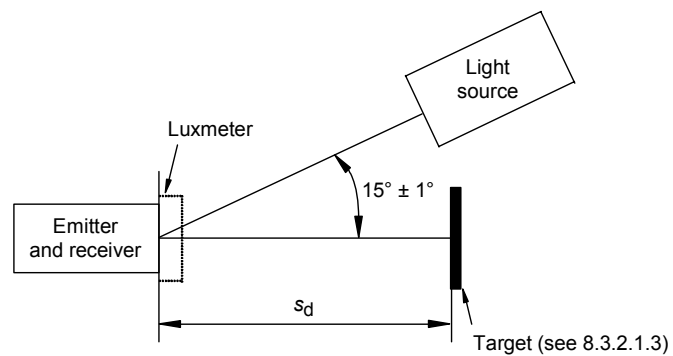


Figure 11c – Type D, emitter-receiver and object

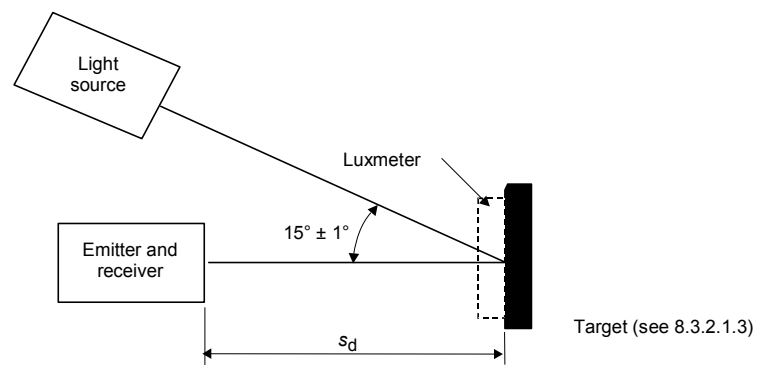
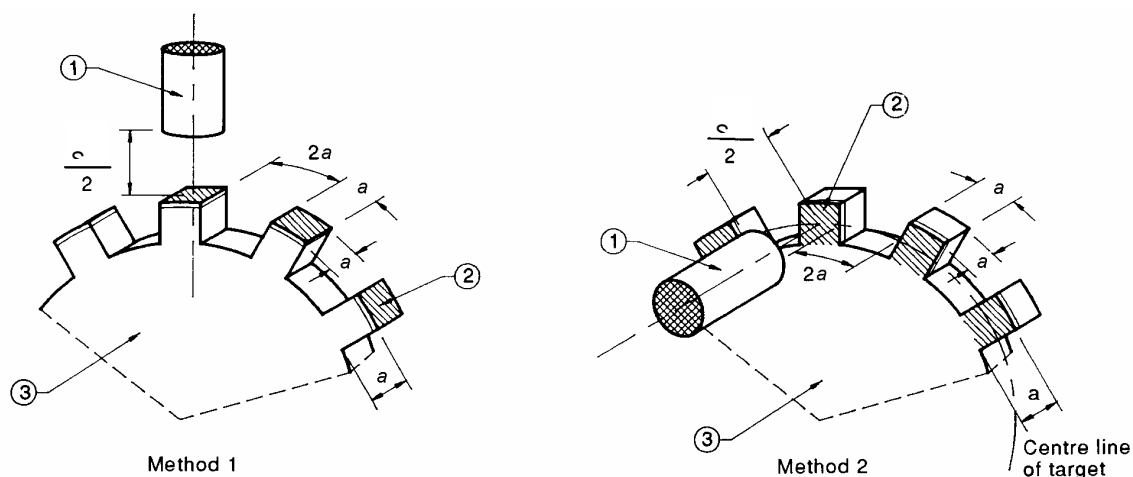


Figure 11d – Type D, emitter-receiver and target

Figure 11 – Testing of the sensing range (see 8.4)



1 = proximity switch

2 = target

3 = disc in non-magnetic and non-conducting material

NOTE To avoid angular influence from one target to another, the disc shall be constructed to include at least 10 targets, if the rated operating distance (s_n) is less than 10 mm, or 6 targets for higher operating distances.

Figure 12 – Methods for measuring the operating frequency of inductive, capacitive and non-mechanical magnetic proximity switches (if applicable)

8.5 Testing for the frequency of operating cycles

When the proximity switch frequency of operating cycles exceeds the limit of the measuring method described, the manufacturer shall state the method of measurement.

8.5.1 Method for measuring the frequency of operating cycles

a) Inductive, capacitive and non-mechanical magnetic proximity switches

As shown in Figure 12, the targets are fixed on the front (method 1) or sides (method 2) of teeth on a rotating disc, the spaces between the teeth being $2a$, in such a manner that they can pass in front of the sensing face of the proximity switch at a distance equal to half of the rated operating distance.

Each target shall have the same dimensions as those specified in 8.3.2.1. The output signal of the proximity switch is measured with the speed of rotation of the disc increasing from 0.

The targets of the rotating disc shall be connected to earth when capacitive proximity switches are tested.

An illustration of the output signal of proximity switches is given in Figure 14.

With the speed increasing, the durations t_1 and t_2 decrease.

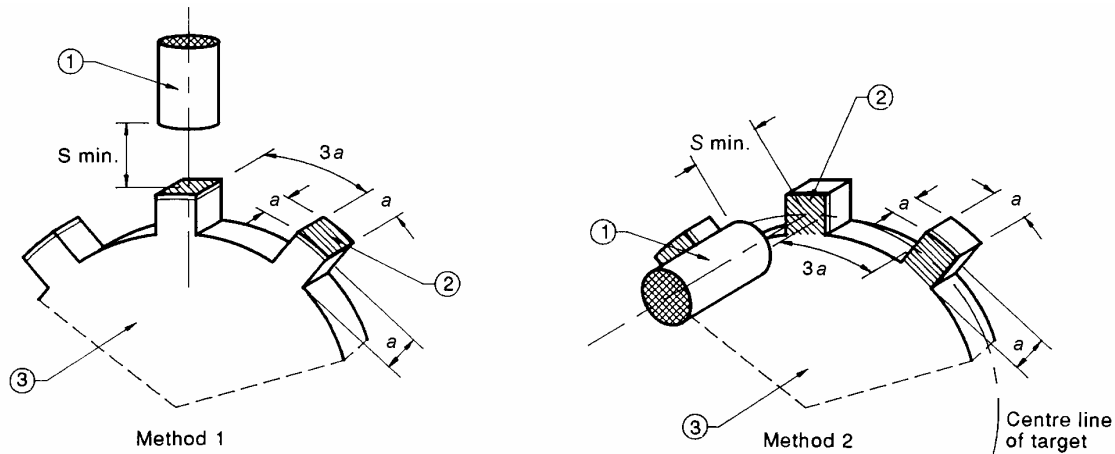
For direct current proximity switches, the rated value of the operating frequency is obtained when t_1 or t_2 correspond to $50 \mu\text{s}$, or when the characteristics of the output signal, in the "ON" or "OFF" states, reaches the values specified in the relevant annexes.

For alternating current proximity switches, the rated value of the operating frequency is obtained when either t_1 or t_2 corresponds to one-half period of the supply frequency (f_b).

b) Ultrasonic proximity switch

As shown in Figure 13 the targets are fixed on the front (method 1) or sides (method 2) of teeth on a rotating disc.

The spaces between the teeth being $3a$ in such a manner that they can pass in front of the sensing face at the minimum operating distance and the proximity switch shall be adjusted to this operating distance.



1 = proximity switch

2 = target

3 = disc in non-magnetic and non-conducting material

NOTE 1 To avoid angular influence from one target to another, the disc shall be constructed to include at least 10 targets.

NOTE 2 Method 2 is only applicable to narrow-beam angled proximity switches.

Figure 13 – Methods for measuring the operating frequency f , ultrasonic proximity switch

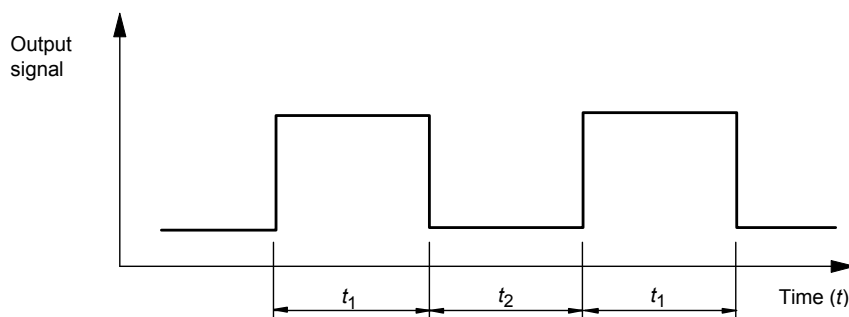


Figure 14 – Output signal of direct current proximity switch during the measurement of operating frequency f

The operating frequency f is determined from the following formula:

$$f = \frac{1}{t_1 + t_2}$$

8.5.2 Results to be obtained

The values obtained shall be not less than those given in the relevant annexes.

8.5.3 Photoelectric proximity switches

8.5.3.1 Measurement means

As shown in Figure 15, a rotating disc with one or more targets is fixed parallel to the sensing face of the proximity switch at a distance chosen by the manufacturer, and in such a way that the reference axis of the proximity switch passes through the centre of the target.

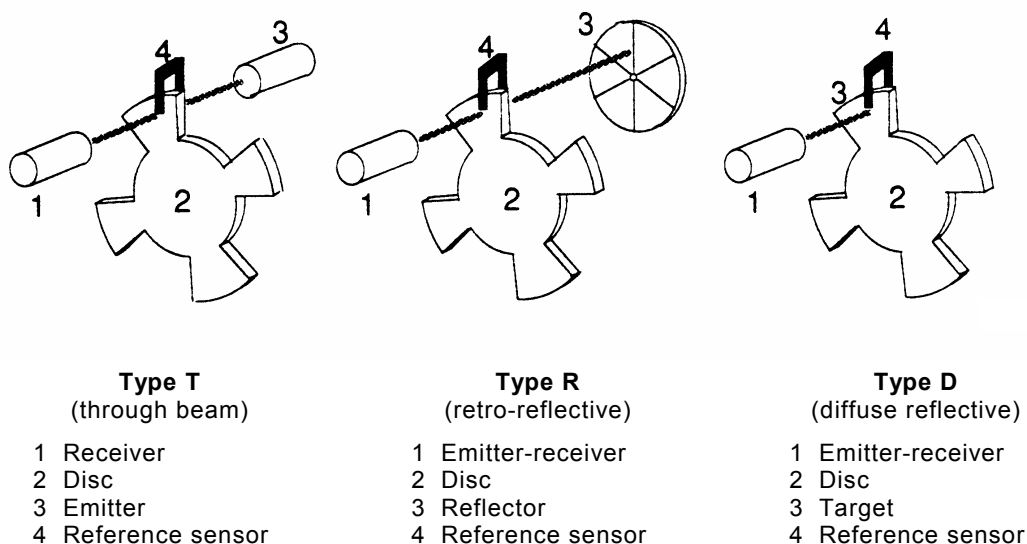


Figure 15 – Measurement means for turn-on time t_{on} and turn-off time t_{off}

For types T and R, the effective beam shall be fully broken by the rotating target.

For type D, the surface of the rotating target shall be made of the same material as the standard target.

If the operating distance affects the tests, then the manufacturer shall state the test distance.

A reference sensor having a switching frequency at least ten times higher than the equipment under test (EUT) is also put around the disc.

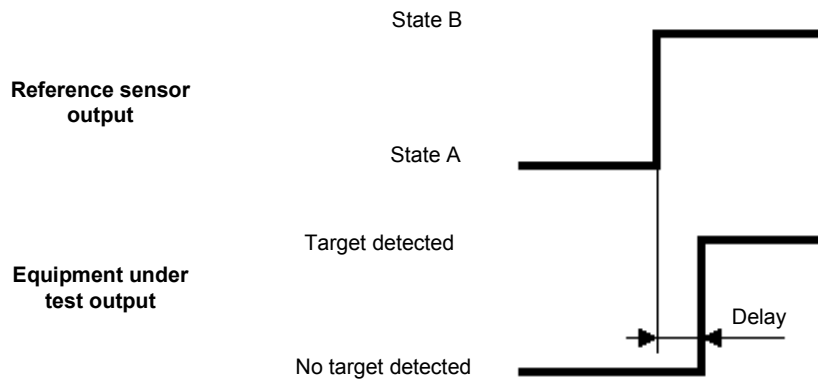
A recorder (for example, a memory oscilloscope) can draw simultaneously curves delivered by the proximity switch and by the reference sensor (see Figures 16 and 17).

8.5.3.2 Measurement of turn-on time (t_{on})

The positional relationship between the reference sensor and the EUT shall be adjusted while moving the disc slowly so that the output of the reference sensor changes its state simultaneously with the output of the EUT.

To measure t_{on} , the disc speed is adjusted so that the EUT is operated at approximately half of the maximum operating frequency stated by the manufacturer.

The turn-on time t_{on} is the maximum observed delay between the output of the reference sensor and the change of state of the EUT output (see Figure 16).



NOTE The diagram refers to logical states A and B. A and B will differ according to the type of proximity switch.

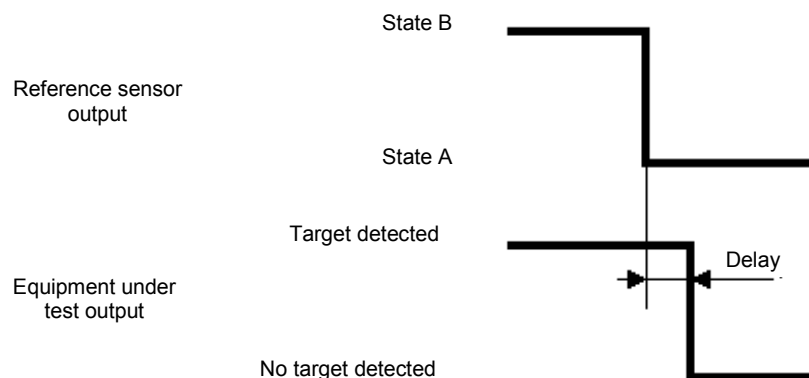
Figure 16 – Turn-on time t_{on} measurement

8.5.3.3 Measurement of turn-off time (t_{off})

The positional relationship between the reference sensor and the EUT shall be adjusted while moving the disc slowly so that the output of the reference sensor changes its state simultaneously with the output of the EUT.

To measure t_{off} , the disc speed is adjusted so that the EUT is operated at approximately half of the maximum operating frequency stated by the manufacturer.

The turn-off time t_{off} is the maximum observed delay between the noted output of the reference sensor and the change of state of the EUT output (see Figure 17).



NOTE The diagram refers to logical states A and B. A and B will differ according to the type of proximity switch.

Figure 17 – Turn-off time t_{off} measurement

8.5.3.4 Results to be obtained

The frequency of operating cycles f determined by the formula given in 7.2.1.6.2 shall be not less than that given by the manufacturer.

8.6 Verification of the electromagnetic compatibility

8.6.1 General

The tests shall be performed under the following conditions:

- the proximity device mounted in free air shall be connected to a load corresponding to the rated operational current (I_e) and supplied with its rated operational voltage (or the maximum voltage of its voltage range) (U_e);
- the connecting leads shall be $2^{+0,1}_0$ m. For proximity devices not having integral cables, the type of cable used shall be specified by the manufacturer and recorded in the test report.
The test shall be performed:
 - a) with the target set at a position such that the switching element is in the OFF-state;
 - b) with the target set at a position such that the switching element is in the ON-state;
- for inductive and capacitive proximity devices, the target shall be positioned at $1/3 s_n$ or $3 s_n$;
- for photoelectric proximity devices, two tests shall be performed. The target shall firstly be positioned such that the excess gain is 2, then:
 - without the target for type D, or
 - without the reflector for type R, or
 - without the emitter for type T.

For the test according to 7.2.6.2.4, the following additional mounting conditions apply:

- cylindrical proximity devices shall be mounted in a non-embedded manner according to Figure A.2 (IA) b). A metal washer, clamped between the lock-nuts of the device, shall be connected to the reference ground plane;
- rectangular proximity devices shall be mounted in a non-embedded manner on a flat metal plate which shall be connected to the reference ground plane;
- the method of connection to the reference ground plane shall be in accordance with the manufacturer's instructions, if given, and shall be stated in the test report.

8.6.2 Immunity

8.6.2.1 Electrostatic discharges

The test shall be performed according to IEC 61000-4-2 and 7.2.6.2.2, and shall be repeated 10 times at each measuring point, with a minimum time interval of 1 s between pulses.

8.6.2.2 Radiated radio-frequency electromagnetic fields

The test shall be performed according to IEC 61000-4-3 and 7.2.6.2.3.

8.6.2.3 Electrical fast transients/bursts

The test shall be performed according to IEC 61000-4-4 and 7.2.6.2.4, with all the connecting leads placed in the capacitive coupling clamp.

8.6.2.4 Conducted disturbances induced by radio-frequency fields

The test shall be performed according to IEC 61000-4-6 and 7.2.6.2.6.

8.6.2.5 Power-frequency magnetic fields

The test shall be performed according to IEC 61000-4-8 and 7.2.6.2.7.

8.6.2.6 Voltage dips and interruptions

The test shall be performed according to IEC 61000-4-11 and 7.2.6.2.8.

8.6.2.7 Harmonics in the supply

Test levels are under study for the future.

8.6.3 Emission

The test shall be performed according to CISPR 11, group 1, class A, and 7.2.6.3.

These limits are given for proximity devices exclusively built for an industrial environment (environment A). When they may be used in a domestic environment (environment B), the following notice shall be included in the instructions for use:

NOTICE

This is a class A product. In a domestic environment this product may cause radio interference, in which case the user may be required to take adequate measures.

8.7 Test results and test report

The test results shall be documented in a comprehensive test report. The test report shall present the objective, the results and all relevant information of the tests. The test report shall define the proximity device under test, including the cable layout and the necessary auxiliary equipment. Any deviation from the test plan shall be mentioned.

Where a range of proximity devices are made according to the same principle and design, and using the same type of components, tests may be performed on representative samples. Furthermore based on first results, the testing laboratory may limit the tested frequency range for radiation or conduction tests and shall include in the report the frequency range used.

Annex A (informative)

Typical dimensions and operating distances of proximity switches

NOTE These dimensions and operating distances were normative for many years. The status of this annex is now changed to "informative", to avoid limiting technological progress.

MODEL IA

INDUCTIVE CYLINDRICAL PROXIMITY SWITCHES WITH THREADED BARREL

A.1 (IA) Dimensions

The dimensions and thread sizes shown in Figure A.1 (IA) shall be according to Table A.1 (IA). Within the dimensional limits of d_1 and l_2 all rigid parts of the connecting leads shall be included. The diameter of unthreaded portion d_2 shall not exceed the minor diameter of the thread. For type I1 embeddable, the thread can be omitted and the diameter reduced to d_2 on a length not exceeding $l_3 = 1$ mm. For type I2 the thread can be omitted and the diameter reduced to d_2 on a length not exceeding $l_3 = 2 s_n$.

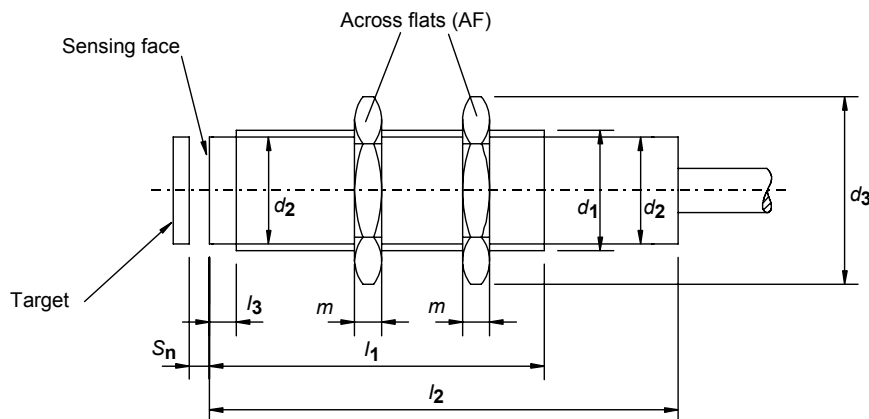


Figure A.1 (IA) – Dimensions

Table A.1 (IA) – Dimensions in millimetres

| Sensing means: inductive (I) | | Dimensions | | | | | |
|---------------------------------|-------------------------|----------------------|---------------|---------------|------|--------------|-----------------|
| 1 embeddable | 2 non- embeddable | Body | | | Nuts | | |
| Type | | d_1 Thread size | l_1 min. | l_2 max. | AF | m +0,15 | d_3^a max. |
| I1A08 | I2A08 | M8 × 1 | 40 | 60 | 13 | 4 | 15 |
| I1A12 | I2A12 | M12 × 1 | 40 | 80 | 17 | 4 | 20 |
| I1A18 | I2A18 | M18 × 1 | 50 | 100 | 24 | 4 | 28 |
| I1A30 | I2A30 | M30 × 1,5 | 50 | 100 | 36 | 5 | 42 |

^a d_3 min. = 1,13 AF.

A.2 (IA) Rated operating distances

The rated operating distance, for embeddable and non-embeddable proximity switches, shall be according to Table A.2 (IA). The rated operating distance is a conventional quantity, it does not take into account either manufacturing tolerances or variations due to external conditions such as voltage and temperature (see 2.3.1.1 and 7.2.1.3.1).

Table A.2 (IA) – Rated operating distances in millimetres

| Type I1 – Embeddable | | Type I2 – Non-embeddable | |
|----------------------|--------------------------|--------------------------|--------------------------|
| Form and size | Rated operating distance | Form and size | Rated operating distance |
| A08 | 1 | A08 | 2 |
| A12 | 2 | A12 | 4 |
| A18 | 5 | A18 | 8 |
| A30 | 10 | A30 | 15 |

A.3 (IA) Installation (mounting)

Embeddable proximity switches, when installed in damping material shall be according to Figure A.2 (IA) a.

Non-embeddable proximity switches when installed in damping material shall be according to Figure A.2 (IA) b.

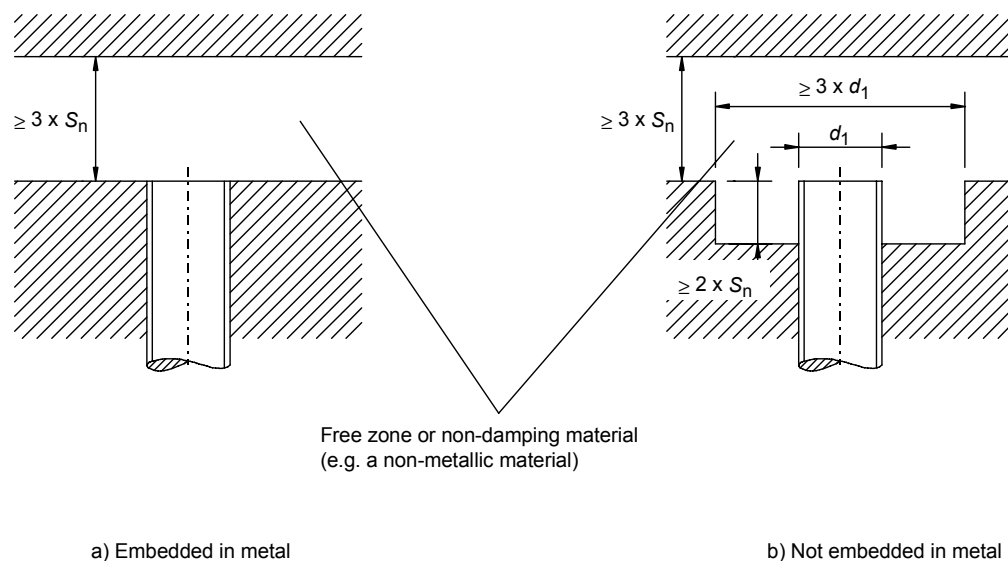


Figure A.2 (IA) – Installation (mounting)

A.4 (IA) Frequency of operating cycles (f) in operating cycles per second – Minimum requirements

| Form and size | Installation | Switching element function: A or B | | |
|--|--------------|------------------------------------|-----|---|
| | | Type of output | | |
| | | P or N | D | F |
| A08 | 1 | 500 | 300 | 5 |
| | 2 | 300 | 200 | |
| A12 | 1 | 400 | 200 | |
| | 2 | 200 | 100 | |
| A18 | 1 | 200 | 100 | |
| | 2 | 100 | 50 | |
| A30 | 1 | 70 | 50 | |
| | 2 | 50 | 30 | |
| NOTE The frequency of operating cycles are only stated for the most common types. For all other possible types (according to Table 1: Classification) the frequency of operating cycles shall be stated by the manufacturer. | | | | |

MODEL IB

INDUCTIVE CYLINDRICAL PROXIMITY SWITCH
WITH SMOOTH BARREL**A.1 (IB) Dimensions**

The dimensions shown in Figure A.1 (IB) shall be according to Table A.1 (IB). Within the dimensional limits of d_1 and l_2 , all rigid parts of the connecting leads shall be included.

No part of the proximity switch within the length l_2 shall exceed the diameter d_1 .

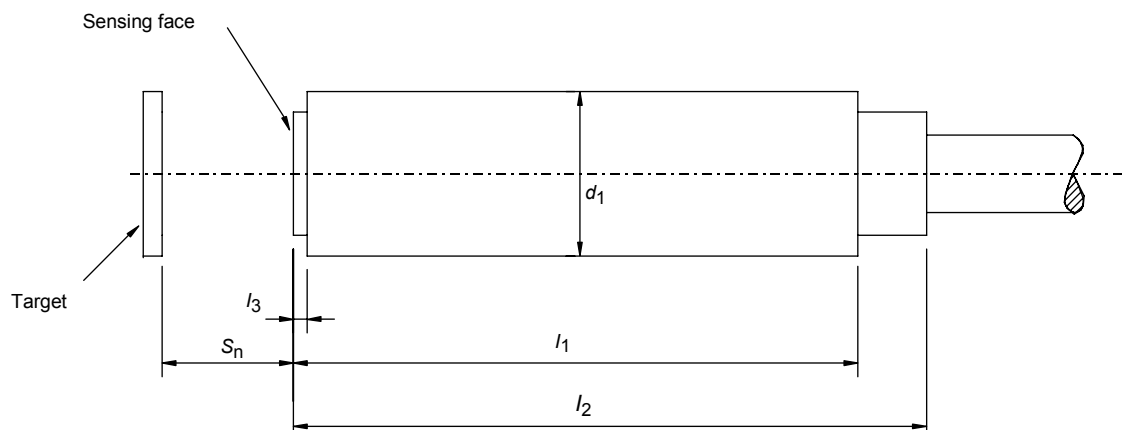


Figure A.1 (IB) – Dimensions

Table A.1 (IB) – Dimensions in millimetres

| Sensing means: inductive (I) | Dimensions | | | |
|---------------------------------|------------|---------------|---------------|---------------|
| 1 Embeddable type | d_1 | l_1 min. | l_2 max. | l_3 max. |
| I1B04 | 4 | 25 | 50 | 0,5 |
| I1B06 | 6,5 | 40 | 60 | 1 |

A.2 (IB) Rated operating distances

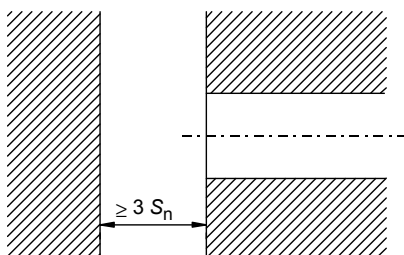
The rated operating distance shall be according to Table A.2 (IB). The rated operating distance is a conventional quantity. It does not take into account either manufacturing tolerances or variations due to external conditions such as voltage and temperature (see 2.3.1.1 and 7.2.1.3).

Table A.2 (IB) – Rated operating distance in millimetres

| Type I1 – Embeddable | |
|----------------------|--------------------------|
| Type | Rated operating distance |
| B04 | 0,8 |
| B06 | 1 |

A.3 (IB) Installation (mounting)

The proximity switch when installed in damping material shall be according to Figure A.2 (IB).

**Figure A.2 (IB) – Installation in damping material****A.4 (IB) Frequency of operating cycles (f) in operating cycles per second – Minimum requirements**

| Form and size | Mechanical installation | Switching element function: A or B | |
|------------------------|-------------------------|------------------------------------|-----|
| | | Type of output | |
| | | P or N | D |
| B04 | 1 | 600 | 300 |
| B06 | 1 | 500 | 250 |
| NOTE Same as A.4 (IA). | | | |

MODEL IC

INDUCTIVE RECTANGULAR PROXIMITY SWITCHES WITH SQUARE CROSS-SECTION

A.1 (IC) Dimensions

A.1.1 (IC) Type I1C26 inductive, embeddable, 26 mm x 26 mm. Overall and mounting dimensions shall be according to Figure A.1 (IC). The rigid part of the cable assembly is included in the overall dimensions. The cable entry shall allow the passage and ensure the anchorage as well as the tightness of a cable with an external diameter of 7 mm to 10 mm.

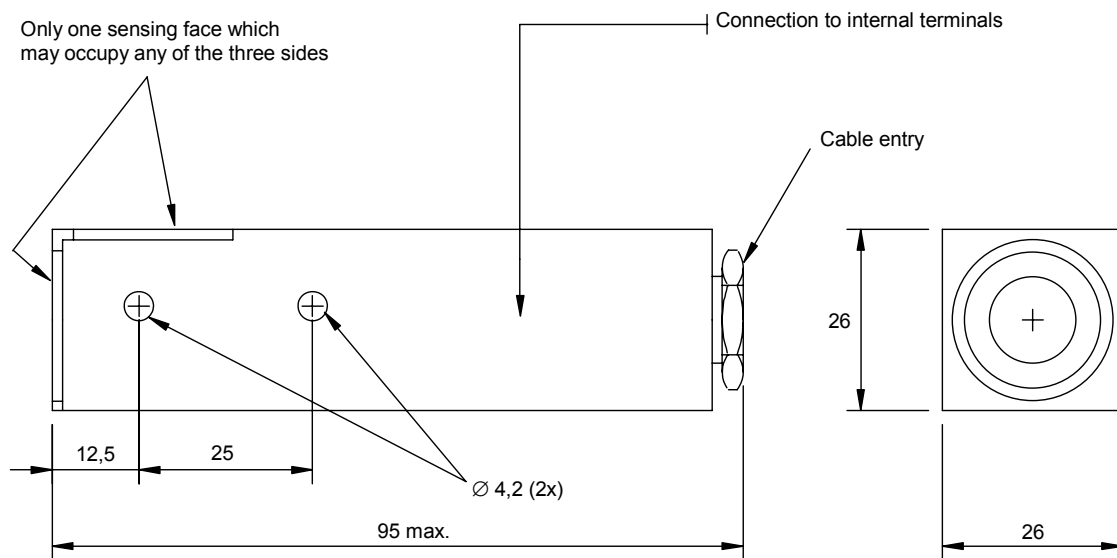


Figure A.1 (IC) – Dimensions in millimetres

A.1.2 (IC) Type I2C35 inductive, non-embeddable, 35 mm × 35 mm. Overall and mounting dimensions shall be according to Figure A.1.2 (IC). The rigid part of the cable assembly is included in the overall dimensions.

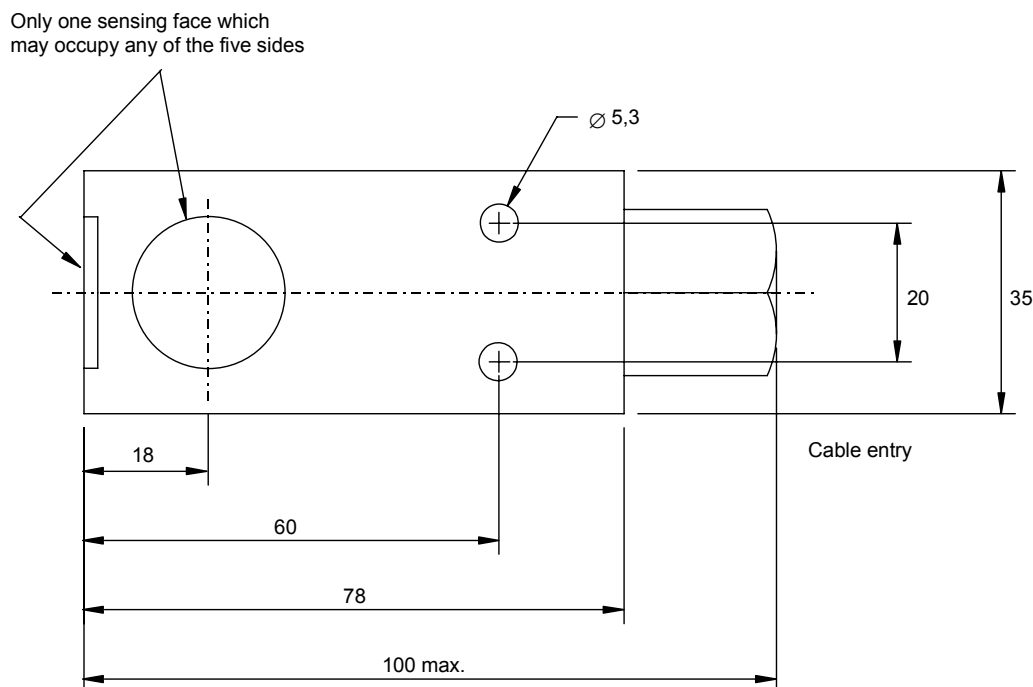


Figure A.1.2 (IC) – Dimensions in millimetres

A.1.3 (IC) Type I2C30 inductive, non-embeddable and type I1C30 inductive embeddable 30 mm × 30 mm. Overall and mounting dimensions shall be according to Figure A.1.3 (IC). The rigid part of the cable assembly is not included in the overall dimensions.

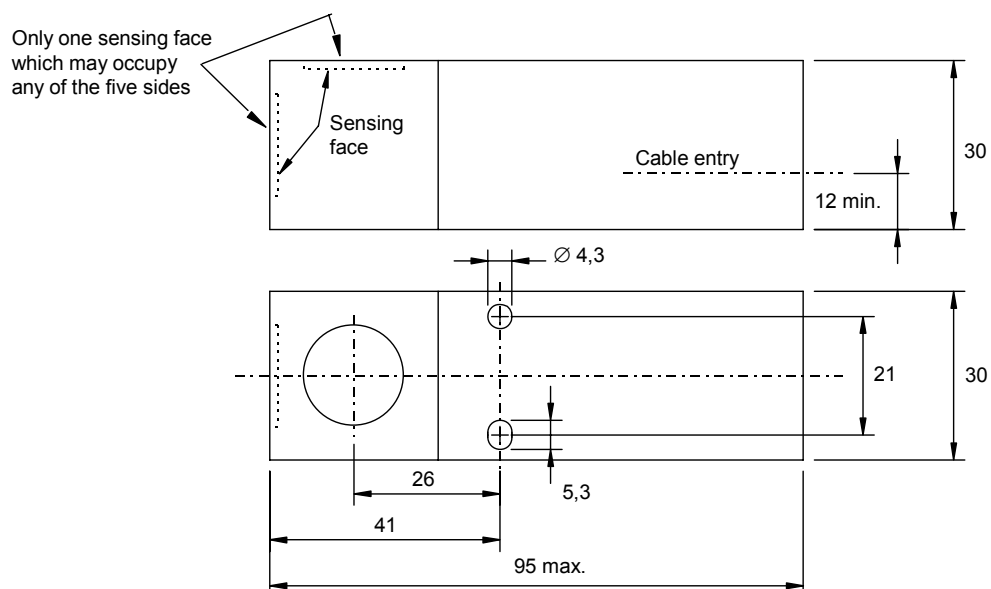


Figure A.1.3 (IC) – Dimensions in millimetres

A.1.4 (IC) Type I2C40 inductive, non-embeddable – Type I1C40 inductive embeddable 40 mm × 40 mm. Overall and mounting dimensions shall be according to Figure A.1.4 (IC). The rigid part of the cable assembly is not included in the overall dimensions.

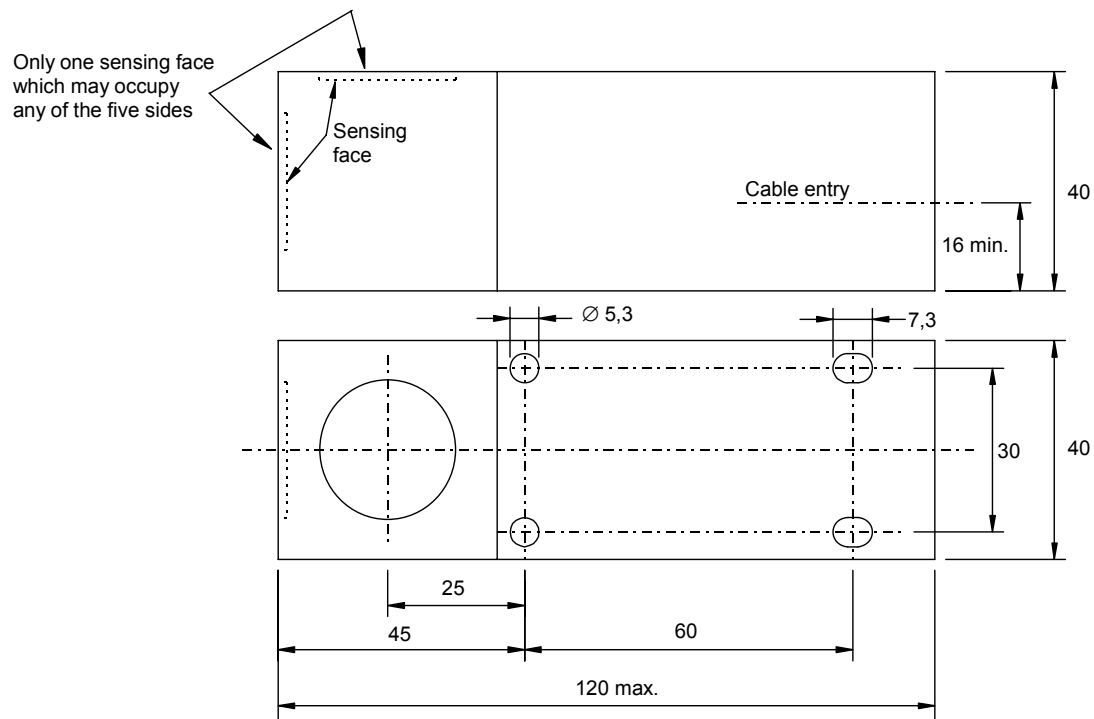


Figure A.1.4 (IC) – Dimensions in millimetres

A.2 (IC) Rated operating distance

The rated operating distance shall be according to Table A.2 (IC). The rated operating distance is a conventional quantity, it does not take into account either manufacturing tolerances or variations due to external conditions such as voltage and temperature (see 2.3.1.1 and 7.2.1.3).

Table A.2 (IC) – Rated operating distance in millimetres

| Type | Rated operating distance |
|----------------------|--------------------------|
| I1C26 embeddable | 10 |
| C35 non-embeddable | 15 |
| I1C40 embeddable | 15 |
| I2C40 non embeddable | 20 |
| I1C30 embeddable | 10 |
| I2C30 non-embeddable | 15 |

A.3 (IC) Installation (mounting)

A.3.1 (IC) Type I1C proximity switch installed in damping material is shown in Figure A.2 (IC). Figure A.2 (IC) a shows the proximity switch with front sensing face. Figure A.2 (IC) b shows the proximity switch with side sensing face installed.

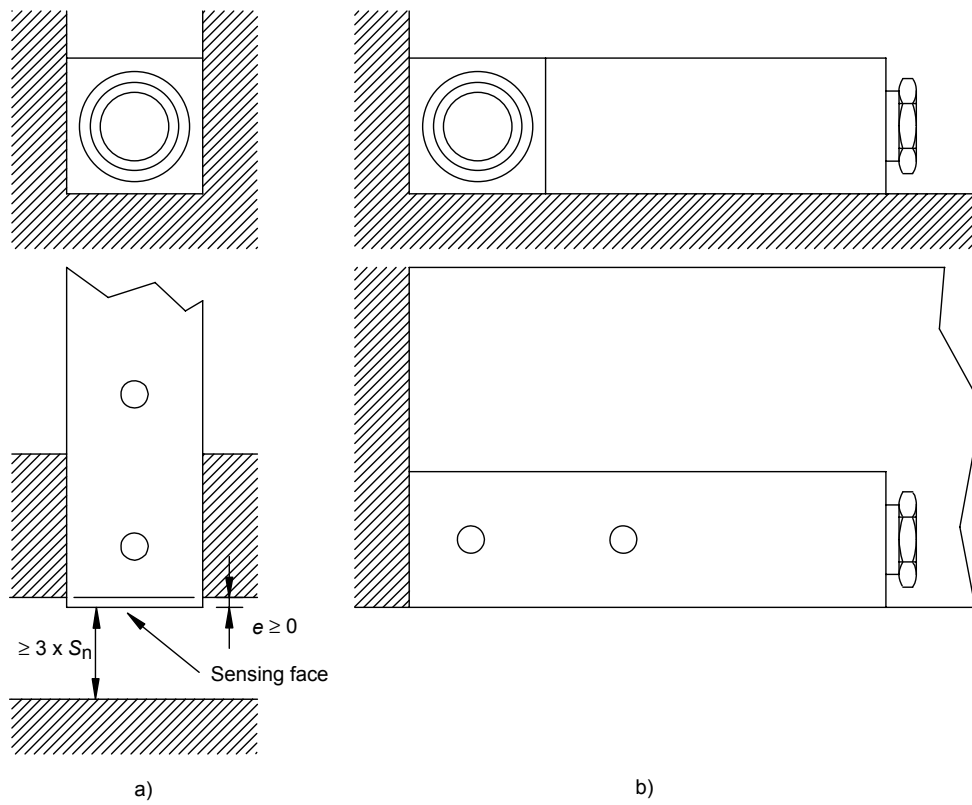


Figure A.2 (IC) – Installation of a I1C proximity switch in damping material

A.3.2 (IC) Type I2C proximity switch installed in damping material as shown in Figure A.3 (IC).

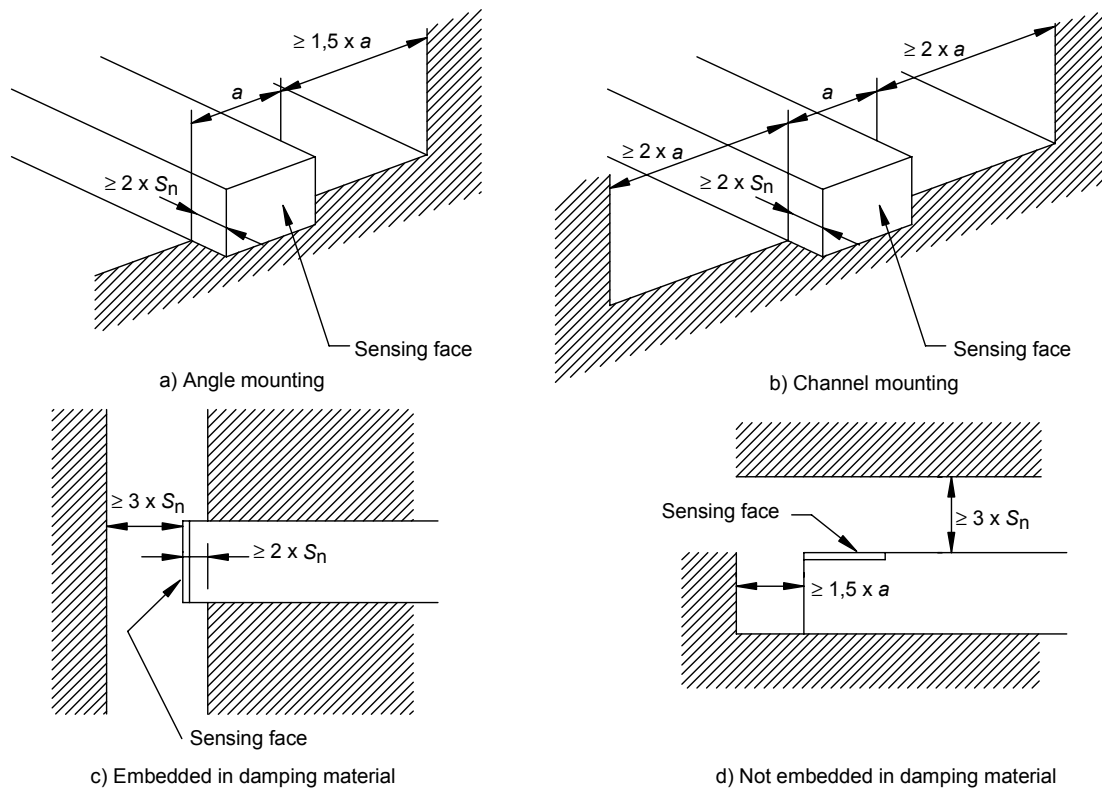


Figure A.3 (IC) – Installation of I2C35 in damping material

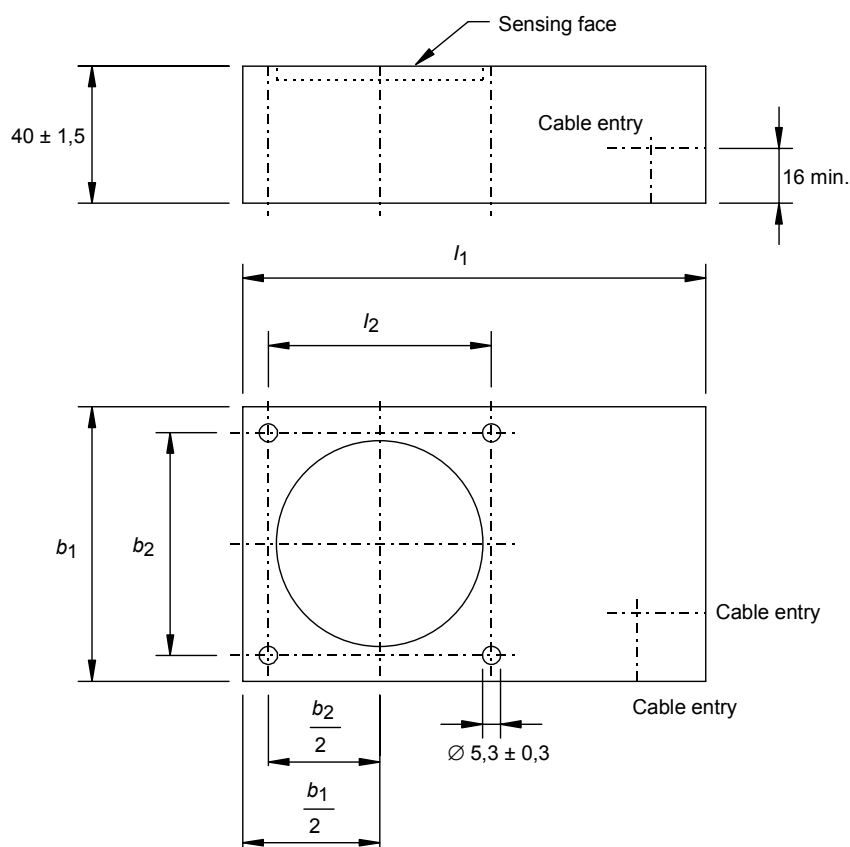
A.4 (IC) Frequency of operating cycles (f) in operating cycles per second – Minimum requirements

| Form and size | Installation | Switching element function: A or B | | |
|------------------------|--------------|------------------------------------|----|---|
| | | Type of output | | |
| | | P or N | D | F |
| C26 | 1 | 40 | 40 | 5 |
| C35 | 2 | 100 | 50 | |
| C30 | 1 | 70 | 50 | |
| and | | | | |
| C40 | 1 | 50 | 50 | |
| NOTE Same as A.4 (IA). | | | | |

MODEL ID

INDUCTIVE RECTANGULAR PROXIMITY SWITCHES
WITH RECTANGULAR CROSS-SECTION**A.1 (ID) Dimensions**

Type I2D non-embeddable proximity switches shall have overall and mounting dimensions according to Figure A.1 (ID) and Table A.1 (ID). Parts of the cable assembly are not included in the overall dimensions.

**Figure A.1 (ID) – Dimensions****Table A.1 (ID) – Dimensions in millimetres**

| Type | $l_1 \text{ max.}$ | $l_2 = b_2$ | $b_1 \text{ max.}$ |
|-------|--------------------|-------------|--------------------|
| I2D60 | 120 | 45 | 60 |
| I2D80 | 135 | 65 | 80 |

A.2 (ID) Rated operating distance

The rated operating distance for non-embeddable proximity switches shall be according to Table A.2 (ID). The rated operating distance is a conventional quantity, if does not take into account either manufacturing tolerances or variations due to external conditions such as voltage and temperature (see 2.3.1.1 and 7.2.1.3).

Table A.2 (ID) – Rated operating distances in millimetres

| Type | Rated operating distance |
|----------------------|--------------------------|
| I2D60 non-embeddable | 25 |
| I2D80 non-embeddable | 40 |

A.3 (ID) Installation (mounting)

The installation of the I2D60 and I2D80 proximity switches in damping material is shown in Figure A.2 (ID).

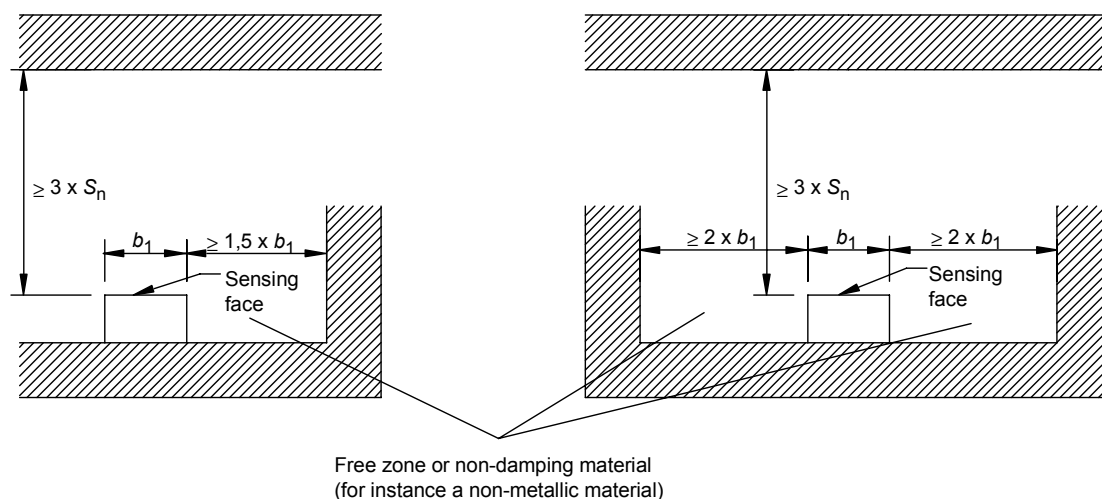


Figure A.2 (ID) – Installation of I2D in damping material

A.4 (ID) Frequency of operating cycles (*f*) in operating cycles per second – Minimum requirements

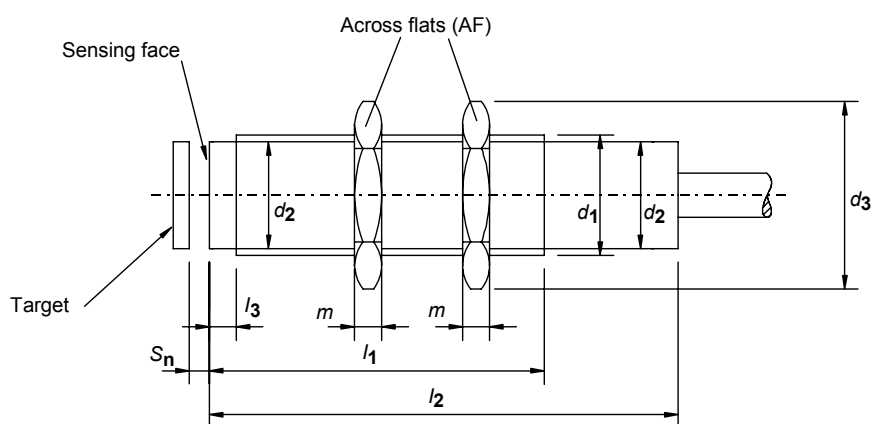
| Form and size | Installation | Switching element function: A or B | | |
|---------------|--------------|------------------------------------|----|---|
| | | Type of output | | |
| | | P or N | D | F |
| D60 | 2 | 25 | 15 | |
| D80 | 2 | 10 | 10 | 5 |

NOTE Same as A.4 (IA).

MODEL CA

CAPACITIVE CYLINDRICAL PROXIMITY SWITCHES
WITH THREADED BARREL**A.1 (CA) Dimensions**

The dimensions are thread sizes shown in Figure A.1 (CA) shall be according to Table A.1 (CA). Within the dimensional limits of d_1 and l_2 , all rigid parts of the connecting leads shall be included. The diameter of unthreaded portion d_2 shall not exceed the minor diameter of the thread. The thread can be omitted and the diameter reduced to d_2 on a length not exceeding $l_3 \leq 2 \times s_n$.

**Figure A.1 (CA) – Dimensions****Table A.1 (CA) – Dimensions in millimetres**

| Sensing means: capacitive (C) | Dimensions | | | | | |
|----------------------------------|----------------------|---------------|---------------|------|--------------|-----------------|
| Type | Body | | | Nuts | | |
| | d_1 Thread size | l_1 min. | l_2 max. | AF | m +0,15 | d_3^a max. |
| CA18 | M18 × 1 | 50 | 100 | 24 | 4 | 28 |
| CA30 | M30 × 1,5 | 50 | 100 | 36 | 5 | 42 |

^a d_3 min. = 1,13 AF.

A.2 (CA) Rated operating distance (s_n)

The rated operating distance is adjusted by the manufacturer under mounting conditions stated in Clause A.3 (CA).

The rated operating distance shall be set according to Table A.2 (CA). The rated operating distance is a conventional quantity, it does not take into account either manufacturing tolerances or variations due to external conditions such as voltage, temperature, humidity and mounting conditions.

Table A.2 (CA) – Rated operating distances in millimetres

| Type | Rated operating distance |
|------|--------------------------|
| CA18 | 5 |
| CA30 | 10 |

A.3 (CA) Installation (mounting)

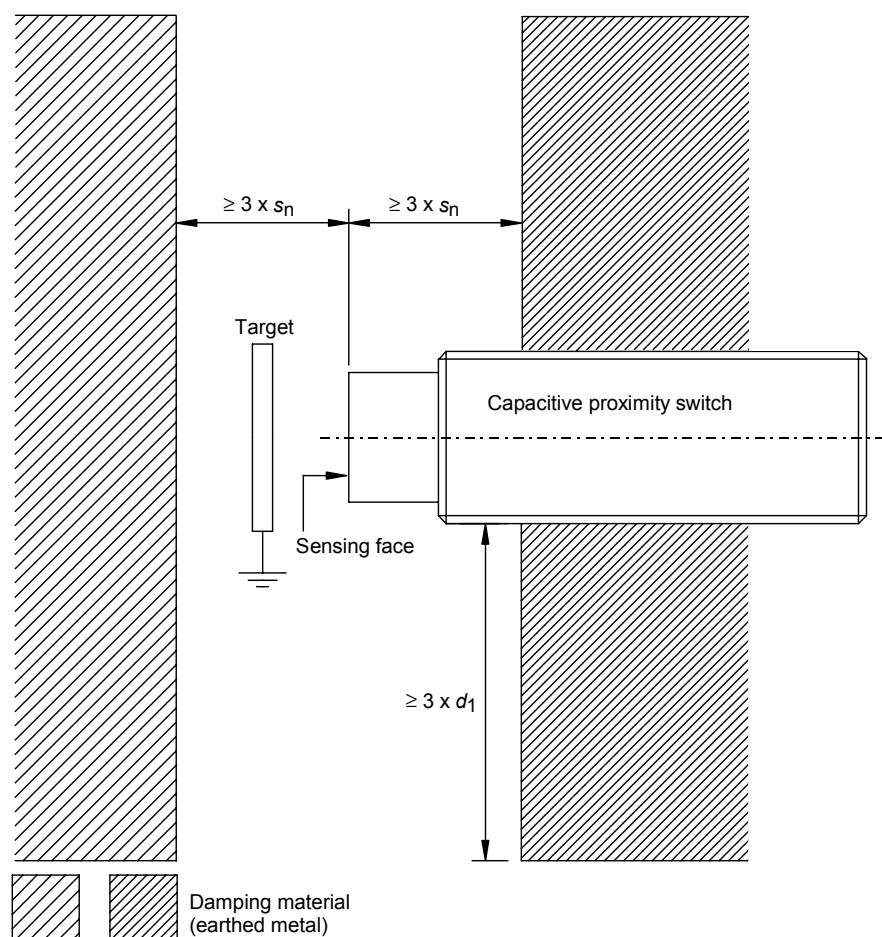


Figure A.2 (CA) – Installation (mounting)

A.4 (CA) Frequency of operating cycles (f)

Minimum requirements: 10 operating cycles per second for type A18 and type A30.

MODEL CB

CAPACITIVE PROXIMITY SWITCHES
WITH SMOOTH BARREL

(Under consideration.)

MODEL CC

CAPACITIVE RECTANGULAR PROXIMITY SWITCHES
WITH SQUARE CROSS-SECTION**A.1 (CC) Dimensions**

Overall and mounting dimensions of type C30 shall be according to Figure A.1 (CC) a and type C40 shall be according to Figure A.1 (CC) b. Apart from these dimensions, the design of the proximity switch is not restricted. The mounting dimensions are included within the dimensions of the housing, but the cable entry dimensions are not.

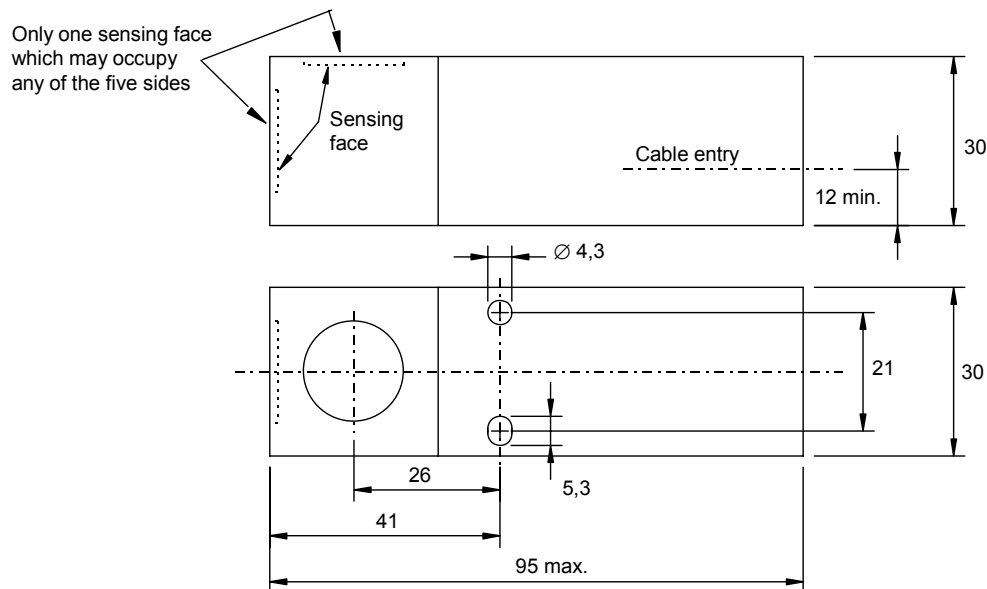


Figure A.1 (CC) a – Dimensions, type C30 in millimetres

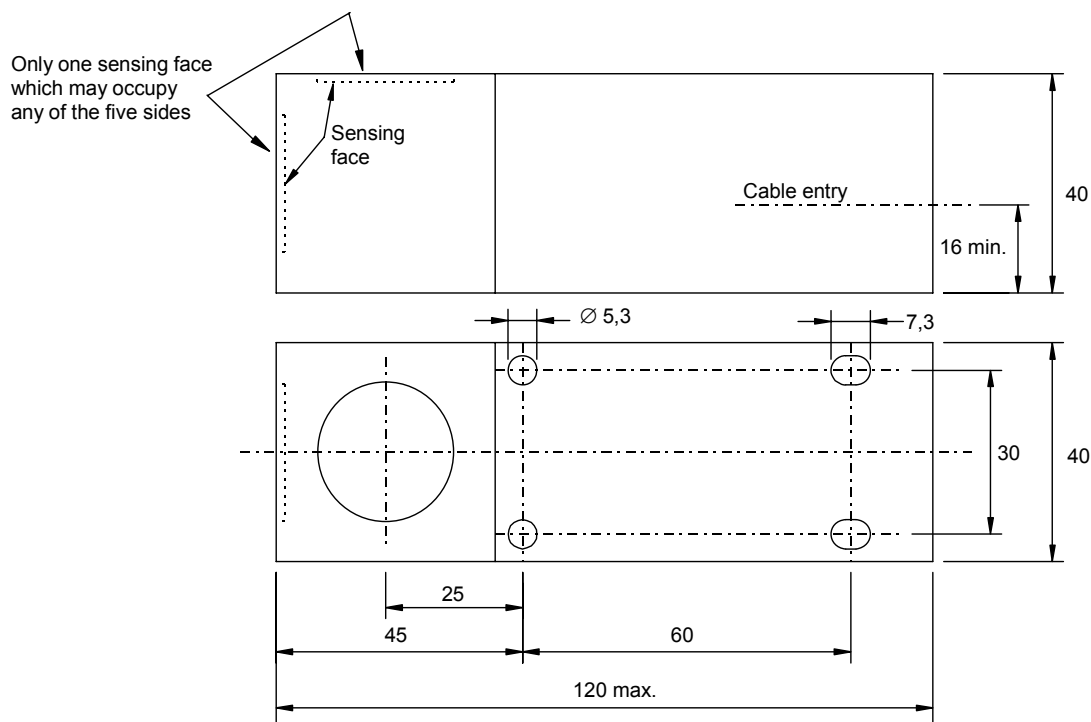


Figure A.1 (CC) b – Dimensions, type C40 in millimetres

A.2 (CC) Rated operating distances (s_n)

The rated operating distance is adjusted by the manufacturer under mounting conditions stated in Clause A.3 (CC).

The rated operating distance shall be according to Table A.2 (CC). The rated operating distance is a conventional quantity, it does not take into account either manufacturing tolerances or variations due to external conditions such as installation (mounting), voltage, humidity and temperature.

Table A.2 (CC) – Rated operational distance in millimetres

| Type | Rated operating distance |
|------|--------------------------|
| CC30 | 10 |
| CC40 | 15 |

A.3 (CC) Installation (mounting)

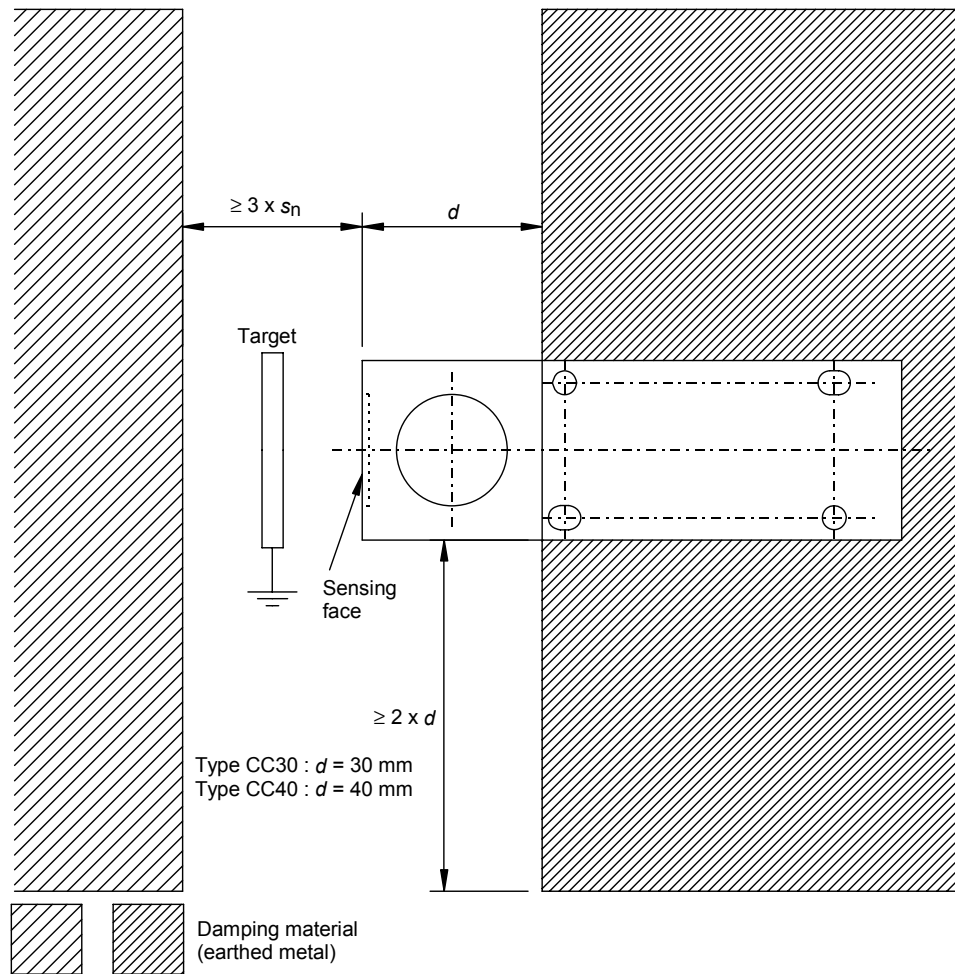


Figure A.2 (CC) – Installation (mounting)

A.4 (CC) Frequency of operating cycles (f)

Minimum requirements: 10 operating cycles per second for type C30 and type C40.

MODEL CD

CAPACITIVE RECTANGULAR PROXIMITY SWITCHES
WITH RECTANGULAR CROSS-SECTION**A.1 (CD) Dimensions**

Type D80 proximity switches shall have overall and mounting dimensions according to Figure A.1 (CD). Parts of the cable assembly are not included in the overall dimensions.

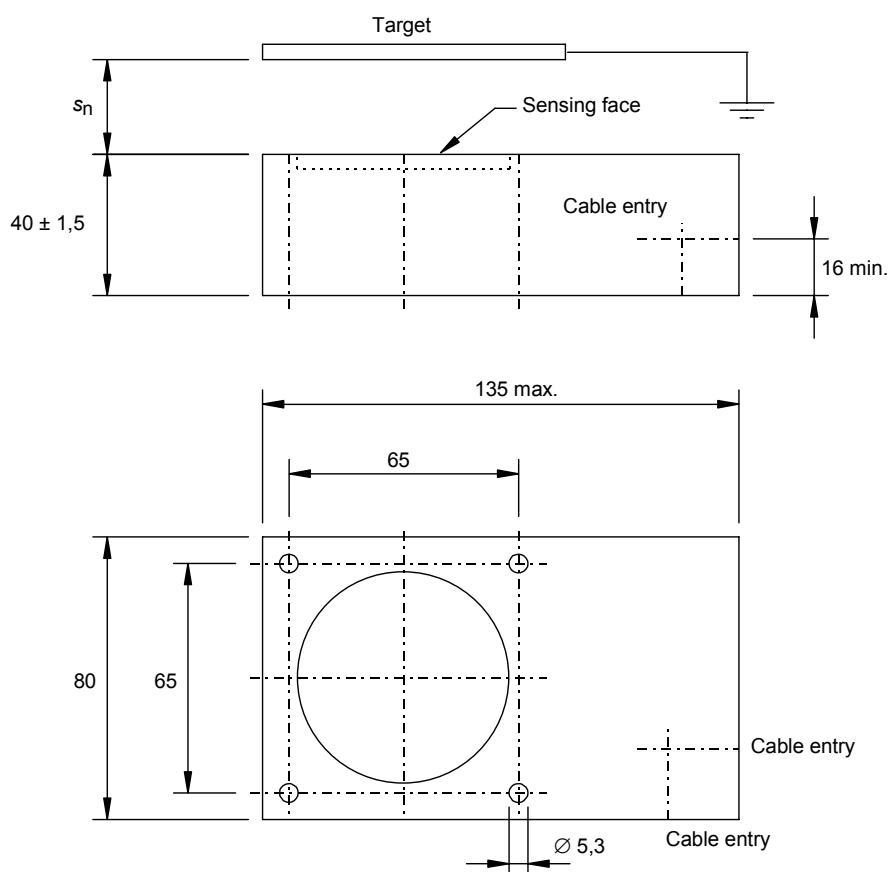


Figure A.1 (CD) – Dimensions in millimetres

A.2 (CD) Rated operating distance (s_n)

The rated operating distance is adjusted by the manufacturer under mounting conditions stated in Clause A.3 (CD).

The rated operating distance shall be: $s_n = 40 \text{ mm}$.

The rated operating distance is a conventional quantity, it does not take into account either manufacturing tolerances or variations due to external conditions such as installation (mounting), voltage, humidity and temperature.

A.3 (CD) Installation (mounting)

The proximity switch shall be mounted on damping material. The dimensions of the damping material shall be at least three times the outside dimensions of the capacitive proximity switch.

Damping material in opposite of the sensing face shall not be closer than $3 \times s_n$.

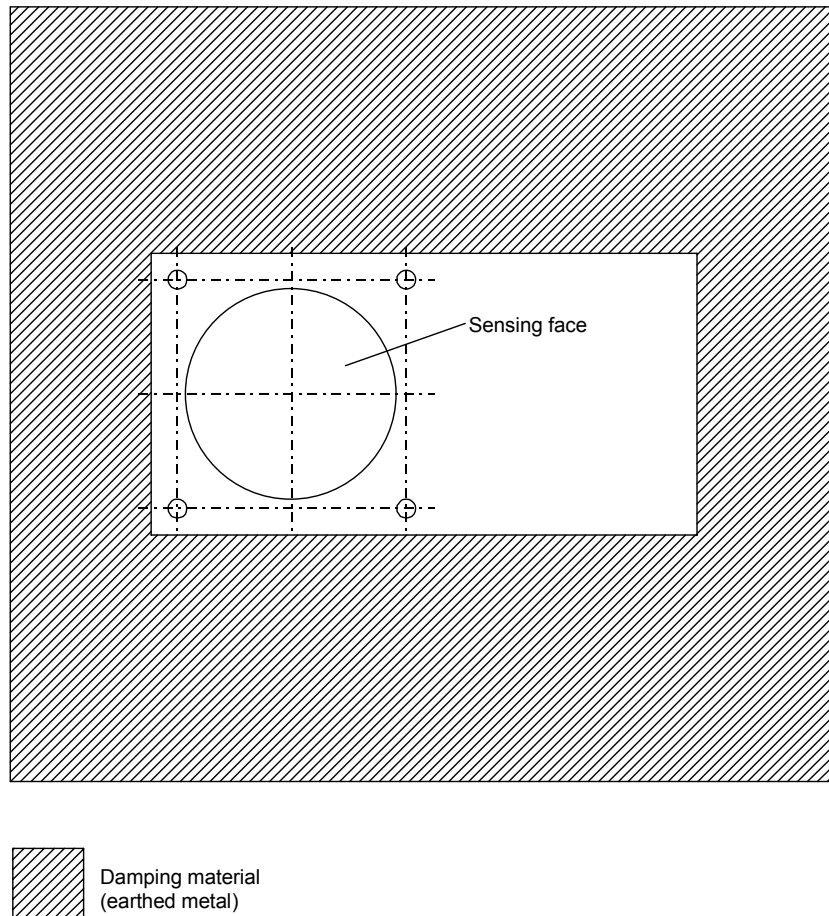


Figure A.2 (CD) – Installation (mounting)

A.4 (CD) Frequency of operating cycles (f)

Minimum requirement: 10 operating cycles per second.

MODEL UA

THREADED BARREL ULTRASONIC CYLINDRICAL
PROXIMITY SWITCHES

A.1 (UA) Dimensions

The dimensions and thread size shown in Figure A.1 (UA) shall be according to Table A.1 (UA). Within the dimensional limits of d_1 and l_2 , all rigid parts of the connecting leads shall be included. The diameter d_2 may exceed the diameter of the thread according to extended sensing ranges. The diameter d_4 of the unthreaded part shall not exceed the minor diameter of the thread.

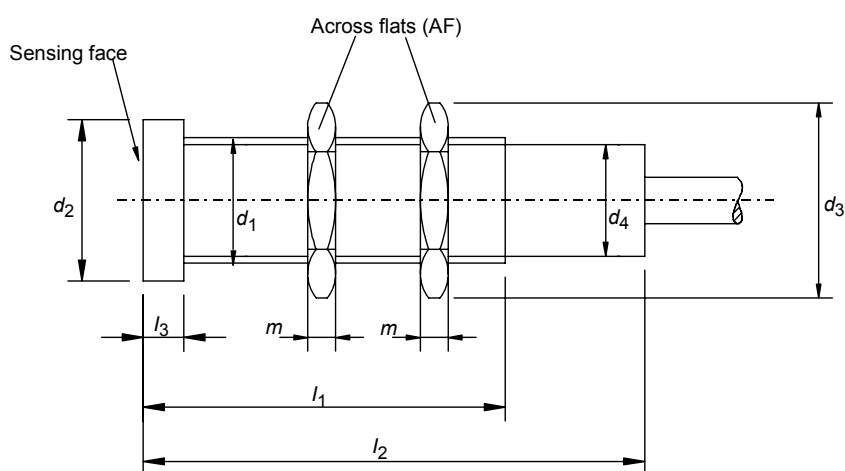


Figure A.1 (UA) – Dimensions

Table A.1 (UA) – Dimensions in millimetres

| Code | Dimensions | | | | | | | |
|----------|----------------------|---------|-------|-------|-------|------|--------------|----------------------------|
| | Body | | | | | Nuts | | |
| | d_1 thread size | d_2 | l_1 | l_2 | l_3 | AF | m +0,15 | d_3 ^a max. |
| U3A18..A | M18 × 1 | M18 | 30 | 100 | 0 | 24 | 4 | 28 |
| U3A30..A | M30 × 1,5 | M30 | 50 | 150 | 0 | 36 | 5 | 42 |
| U3A30..B | M30 × 1,5 | M30 | 50 | 150 | 0 | 36 | 5 | 42 |
| U3A30..E | M30 × 1,5 | 70 max. | 50 | 150 | 35 | 36 | 5 | 42 |
| U3A42..D | M42 × 1 | M42 | 35 | 150 | 0 | 50 | 6 | 57 |
| U3A42..E | M42 × 1 | 70 max. | 50 | 150 | 35 | 50 | 6 | 57 |

^a d_3 min. = 1,13 AF.

A.2 (UA) Sensing range

The operating distances max. and min. for ultrasonic proximity switches shall be according to Table A.2 (UA). These distances are conventional quantities, they do not take into account variations due to external conditions such as temperature, altitude and humidity.

Table A.2 (UA) – Requirements for sensing range in millimetres

| Sensing range | from | to | Target size mm |
|---------------|------|-------|-------------------|
| A | 60 | 300 | 10 × 10 |
| B | 300 | 800 | 20 × 20 |
| D | 500 | 2 000 | 100 × 100 |
| E | 800 | 6 000 | 100 × 100 |

A.3 (UA) Installation (mounting)

According to the instructions of the manufacturer.

A.4 (UA) Frequency of operating cycles (*f*)

Shall be stated by the manufacturer either in operating cycles per second or in operating cycles per minute.

MODEL UC

ULTRASONIC RECTANGULAR PROXIMITY SWITCHES
WITH SQUARE CROSS-SECTION**A.1 (UC) Dimensions**

Overall and mounting dimensions shall be according to Figure A.1 (UC). Apart from these dimensions, the design of the proximity switch is not restricted. Within the overall dimensions of the housing, the mounting dimensions are included but the cable entry dimensions are not included.

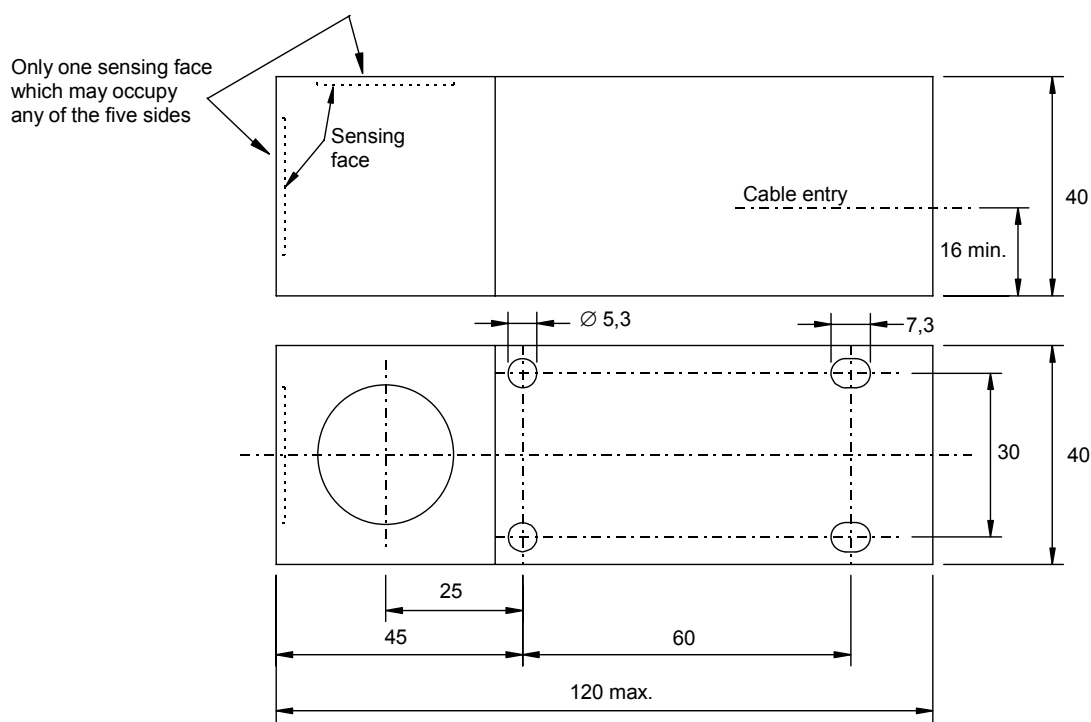


Figure A.1 (UC) – Dimensions of type U3C40

A.2 (UC) Sensing range

The maximum and minimum operating distances for ultrasonic proximity switches shall be according to Table A.1 (UC). These distances are conventional quantities, they do not take into account variations due to external conditions such as temperature, altitude and humidity.

Table A.1 (UC) – Requirements for sensing range in millimetres

| Sensing range | from | to | Target size mm |
|---------------|------|-------|-------------------|
| A | 60 | 300 | 10 × 10 |
| C | 300 | 1 000 | 20 × 20 |

A.3 (UC) Installation (mounting)

According to the instructions of the manufacturer.

A.4 (UC) Frequency of operating cycles (f)

Shall be stated by the manufacturer either in operating cycles per second or in operating cycles per minute.

MODEL UD

ULTRASONIC RECTANGULAR PROXIMITY SWITCHES
WITH RECTANGULAR CROSS-SECTION**A.1 (UD) Dimensions**

Type U3D80 ultrasonic proximity switches shall have overall and mounting dimensions according to Figure A.1 (UD). Parts of the cable assembly are not included in the overall dimensions.

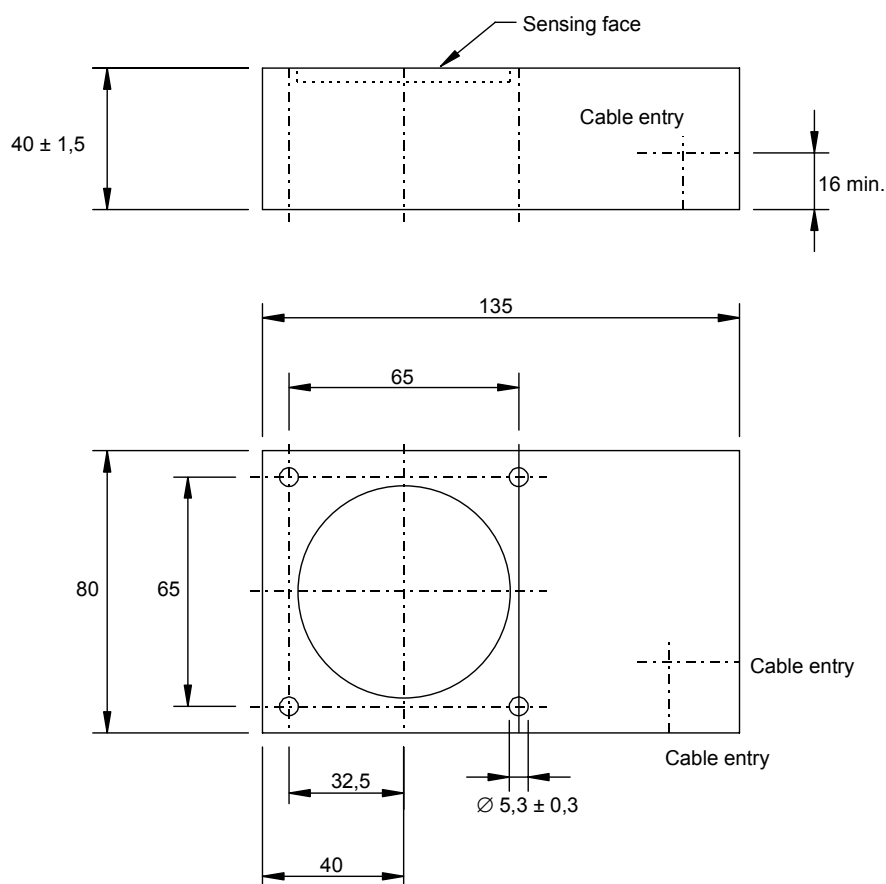


Figure A.1 (UD) – Dimensions of type U3D80 in millimetres

A.2 (UD) Sensing range

The operating distances shall be according to Table A.2 (UD). These distances are conventional quantities, they do not take into account variations due to external conditions such as temperature, altitude and humidity.

Table A.2 (UD) – Requirements for sensing range in millimetres

| Sensing range | from | to | Target size mm |
|----------------------|-------------|-----------|---------------------------|
| A | 60 | 300 | 10 × 10 |
| C | 300 | 1 000 | 20 × 20 |
| E | 800 | 6 000 | 100 × 100 |

A.3 (UD) Installation (mounting)

According to the instructions of the manufacturer.

A.4 (UD) Frequency of operating cycles (*f*)

Shall be stated by the manufacturer either in operating cycles per second or in operating cycles per minute.

Annex B (normative)

Class II proximity switches insulated by encapsulation – Requirements and tests

B.1 General

This annex specifies constructional requirements and tests for class II proximity switches or parts of devices in which insulation of class II, according to IEC 61140, is achieved by encapsulation.

All parts which are not encapsulated shall follow the requirements specified for double insulation concerning clearances and creepage distances.

B.2 Definitions

The following definitions apply to this annex.

B.2.1 encapsulation

process by which all components, conductors and ends of integral cables are encased in an insulating compound by suitable means such as embedding or potting

B.2.1.1 embedding

process of completely encasing electrical device(s) by pouring a compound over it (them) in a mould, and removing the encased device(s) from the mould after solidification of the compound

B.2.1.2 potting

embedding process in which the mould remains attached to the encased electrical device(s)

B.2.2 compound

thermosetting, thermoplastic, catalytically cured and elastomeric materials with or without fillers and/or additives, after solidification

B.2.3 temperature range of the compound

the ambient temperature range as stated in 6.1.1 of IEC 60947-1

B.5 Marking

Proximity switches according to this annex shall be marked with the following symbol



This symbol is 60417-2-IEC-5172.

B.7 Constructional and functional requirements

B.7.1 Choice of compound

The compound shall be chosen so that the encapsulated proximity switches comply with the tests in B.8.

B.7.2 Adhesion of the compound

The adhesion of the compound shall be sufficient to prevent the ingress of moisture between the compound and all encapsulated parts and to prevent movement of the encapsulated portion of the cable if any.

Compliance shall be verified by the tests of B.8.1.2.5 and B.8.1.2.2.

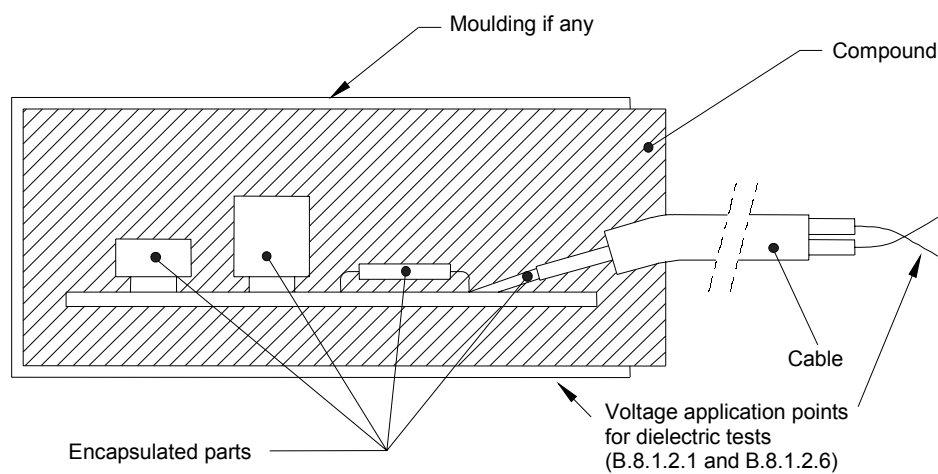


Figure B.1 – Encapsulated device

B.7.3 Dielectric properties

Subclause 7.2.3 applies with the following changes:

When U_{imp} is declared by the manufacturer, the test voltage shall be the next higher category of the maximum rated operational voltage in the first column of Table H.1 or H.2 of Annex H of IEC 60947-1 for the stated overvoltage category.

When U_{imp} is not declared by the manufacturer, the test voltage shall be the voltage stated in Table 6 of this standard plus 1 000 V.

B.8 Tests

B.8.1 Kind of tests

B.8.1.1 General

Subclause 8.1.1 of IEC 60947-1 applies.

B.8.1.2 Type tests

The following sequence of six tests shall be applied to each of three samples in the specified order.

B.8.1.2.1 Dielectric tests in new conditions

Subclause 8.3.3.4 of IEC 60947-1 applies with the exception that the values of voltage shall be applied between the stripped joined ends of the cable or the shorted terminals and any point of the surface (or metallic foil on the surface) of the encapsulated device (see Figure B1).

No breakdown of the insulation shall occur.

B.8.1.2.2 Cable tests (if applicable)

Proximity switches provided with integrally connected cables shall comply with requirements of Annex C.

B.8.1.2.3 Rapid change of temperature test

Test Na shall be performed in accordance with IEC 60068-2-14 with the following values:

- T_A and T_B are the minimum and the maximum temperatures stated in B.2.3;
- transition time t_2 : 2 min to 3 min;
- number of cycles: 5;
- exposure time t_1 : 3 h.

After the test, no visible damage shall be observed.²

B.8.1.2.4 Impact test

The test is performed as follows (see Figure B.2).

The sample is placed on a rigid support.

Three impacts of 0,5 J shall be applied near the centre of the largest surface or the longest axis (for cylindrical shape) of the encapsulated device.

The impacts are obtained by dropping a steel ball 0,25 kg from a height of 0,20 m.

² Small cracks of the moulding compounds, if any (see Figure B.1) are acceptable after tests B.8.1.2.3, B.8.1.2.4 and B.8.1.2.5. They shall not impair the results of the final test of B.8.1.2.6.

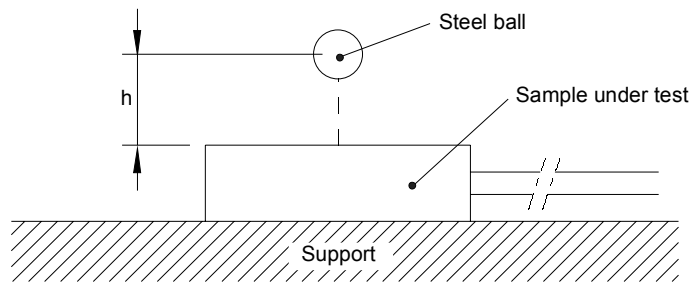


Figure B.2 – Test device

The support is considered sufficiently rigid if its displacement under the impact energy is less than 0,1 mm.

After the test, no visible damage shall be observed ³.

B.8.1.2.5 Damp heat, cyclic test

The test Db shall be performed in accordance with IEC 60068-2-30 with the following values:

- upper temperature: 55 °C;
- number of cycles: 6.

The test report shall state which variant is applied: variant 1 or variant 2.

After the test, no visible damage shall be observed.⁴⁾

B.8.1.2.6 Dielectric test after stresses

Following test B.8.1.2.5, the dielectric properties shall be checked by respecting tests specified in 8.3.3.4.1 and 8.3.3.4.2 with the test voltage being applied for 1 min.

The results to be obtained shall be as stated in 8.3.3.4.3 with the addition that the leakage current shall not exceed 2 mA at 1,1 U_i .

B.8.1.3 Routine tests

Subclause 8.1.3 applies but the dielectric test is mandatory.

³ Small cracks of the moulding compounds, if any (see Figure B.1) are acceptable after tests B.8.1.2.3, B.8.1.2.4 and B.8.1.2.5. They shall not impair the results of the final test of B.8.1.2.6.

Annex C (normative)

Additional requirements for proximity switches with integrally connected cables

C.1 General

This annex gives additional requirements applying proximity switches with integrally connected cables for electrical connection to other equipment and/or to the power source.

The cable integrally connected to such proximity switches is not considered replaceable by the user. This annex states the constructional and performance requirements for the cable, the cable anchorage and the cable entrance seal.

C.2 Definitions

The following definitions apply to this annex:

C.2.1

cable connected proximity switch

proximity switch having integrally connected leads for electrical connection to other equipment and/or to the power source

C.2.2

cable entrance sealing means

sealing means between cable and device enclosure providing the required protection from cable abrasion and which may provide required sealing of enclosure and cable anchorage

C.2.3

cable anchorage

means to relieve mechanical stress from the cable termination so as to prevent damage to the electrical connection between the device and the cable

C.7 Constructional and performance requirements

C.7.1 Constructional requirements

C.7.1.1 Cable material

The proximity switch shall be provided with flexible cable of appropriate voltage, current and temperature rating and environmental condition.

NOTE The length of cable provided may be specified in the relevant product standard.

C.7.1.2 Cable anchorage

The cable anchorage shall be such that a force being applied to the cable is not transmitted to electrical connections integral to the device.

Movement of the cable in to or out of the proximity switch shall not cause damage to the cable connection or internal parts of the device.

C.7.1.3 Cable entrance sealing means

A sealing means shall be provided at the cable entrance to the proximity switch suitable for the

degree of protection specified for the proximity switch (see Annex C of IEC 60947-1).

NOTE The sealing means may be inherent in the device encapsulation.

C.7.2 Performance requirements

The cable and the cable entrance sealing means shall be capable of withstanding the tests given in Clause C.8.

C.8 Tests

The purpose of these tests is to ensure integrity of the cable anchorage during transit handling and installation. Once installed, the proximity switch and cable should be fixed relative to each other.

C.8.1 Type tests

The following sequence of four tests shall be performed on a representative sample in the specified order.

C.8.1.1 Pull test

The cable shall be subjected to a steady pull along the axis of the cable entry, applied to the insulating jacket of the cable for a duration of 1 min.

The pull force shall be 160 N for the cable diameter greater than or equal to 8 mm. The pull force for cable diameters of less than 8 mm shall be of the value (in N) of 20 times the external cable diameter (in mm).

C.8.1.2 Torque test

The cable shall be subjected to a torque of 0,1 Nm or limited to the value giving an angle of torque of 360°. The torque shall be applied to the cable, clockwise for 1 min and then counter-clockwise for 1 min, at a distance of 100 mm from the proximity switch entrance.

C.8.1.3 Push test

The push force shall be applied along the axis of the cable as close as possible to the cable entrance.

The force is increased slowly to 20 N. The force shall be applied for 1 min for each time and with a 1 min pause between applications.

After the tests, no visible damage of the cable entrance sealing means and no displacement of the cable shall be observed.

C.8.1.4 Bend test

The cable shall be loaded and bent in the following manner:

- a) Suspend a 3 kg mass by attaching it to the cable 1 m from the cable entrance and with the axis of the cable entrance vertical.
- b) Tilt the proximity switch 90° to cause a 90° bend in the cable, maintaining that position for 1 min.
- c) Tilt the proximity switch 90° in the opposite direction relative to vertical so as to cause an opposite 90° bend in the cable, maintaining the position for a duration of 1 min.

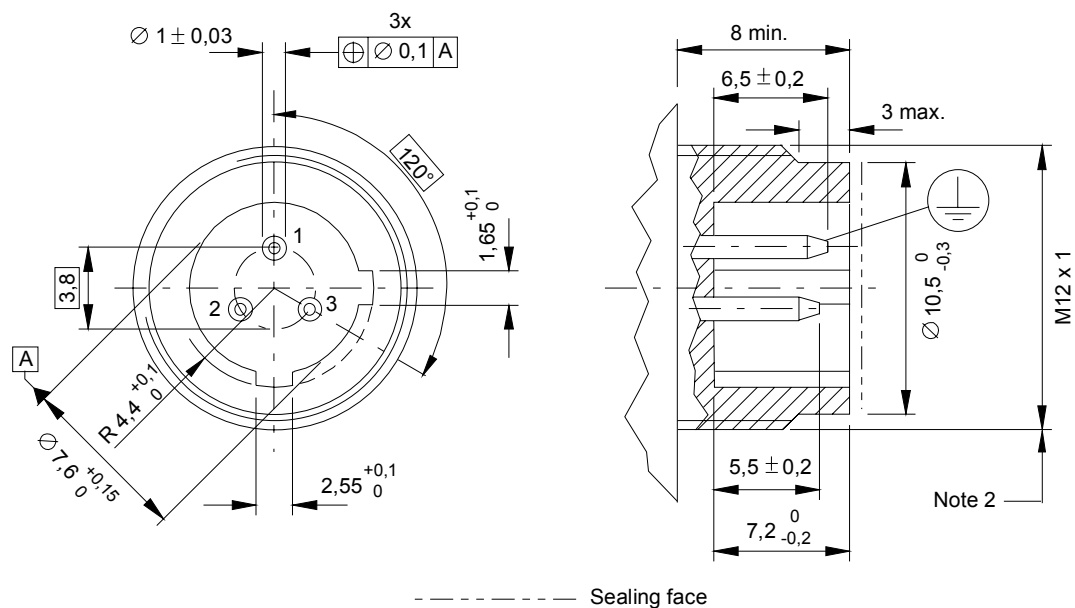
C.8.2 Results to be obtained

There shall be no damage to the cable, cable sealing means, cable entrance or electrical connecting means of the proximity switch. This will be verified by visual examination and verification of compliance with the stated IP designation.

Annex D (normative)

Integral connectors for plug-in proximity switches

The M12 or M8 integral connector used for plug-in proximity switches shall be in accordance with the following figures. They shall provide a minimum protection rating of IP65 when correctly coupled with their mating connector.

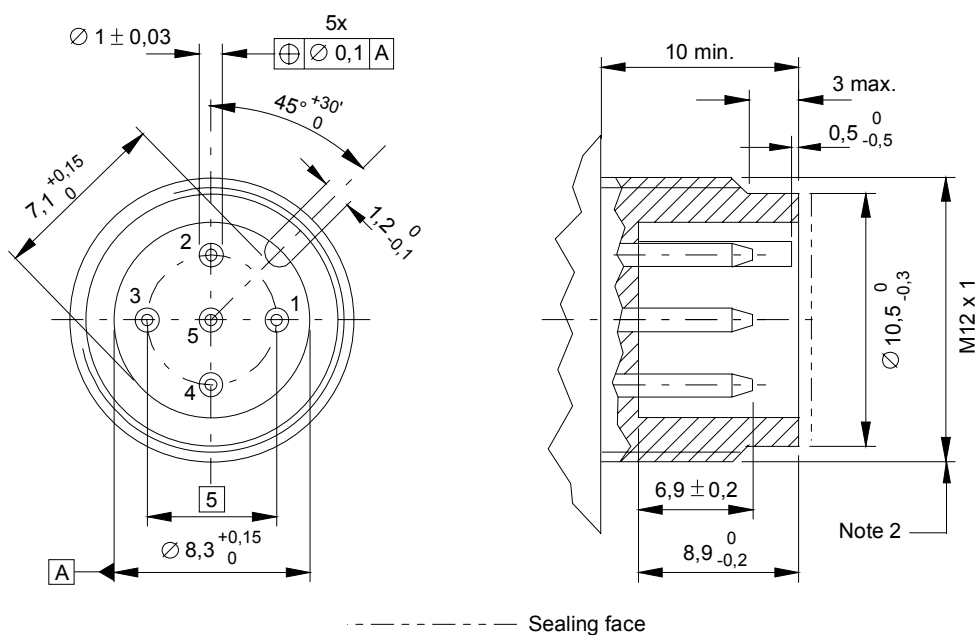


NOTE 1 Pin identification numbering is not necessary.

NOTE 2 For a provisional period the use of 1/2" UNF is permissible as an alternative to M12 on a.c. proximity switches.

NOTE 3 Protective earth pin shall be omitted for class II proximity switches.

Figure D.1 – M12 Ø 3-pin integral connector for a.c. proximity switches



NOTE The central pin may be omitted when not necessary.

Figure D.2 – M12 Ø 5-pin integral connector for d.c. proximity switches

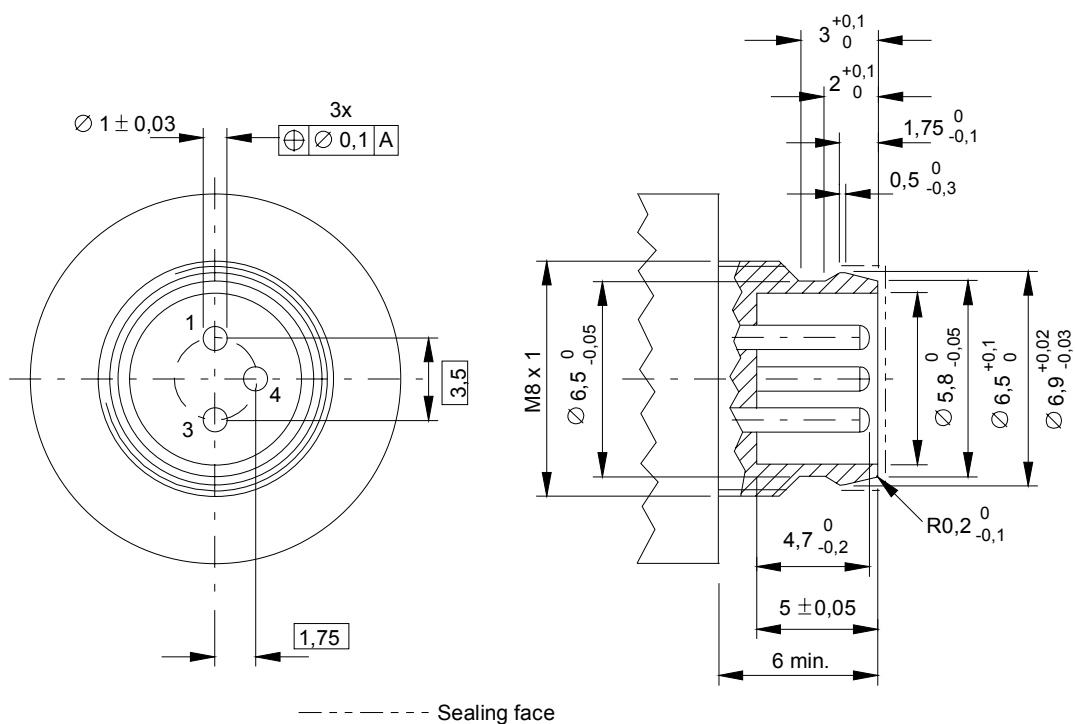


Figure D.3 – 8 mm Ø 3-pin integral connector for d.c. proximity switches

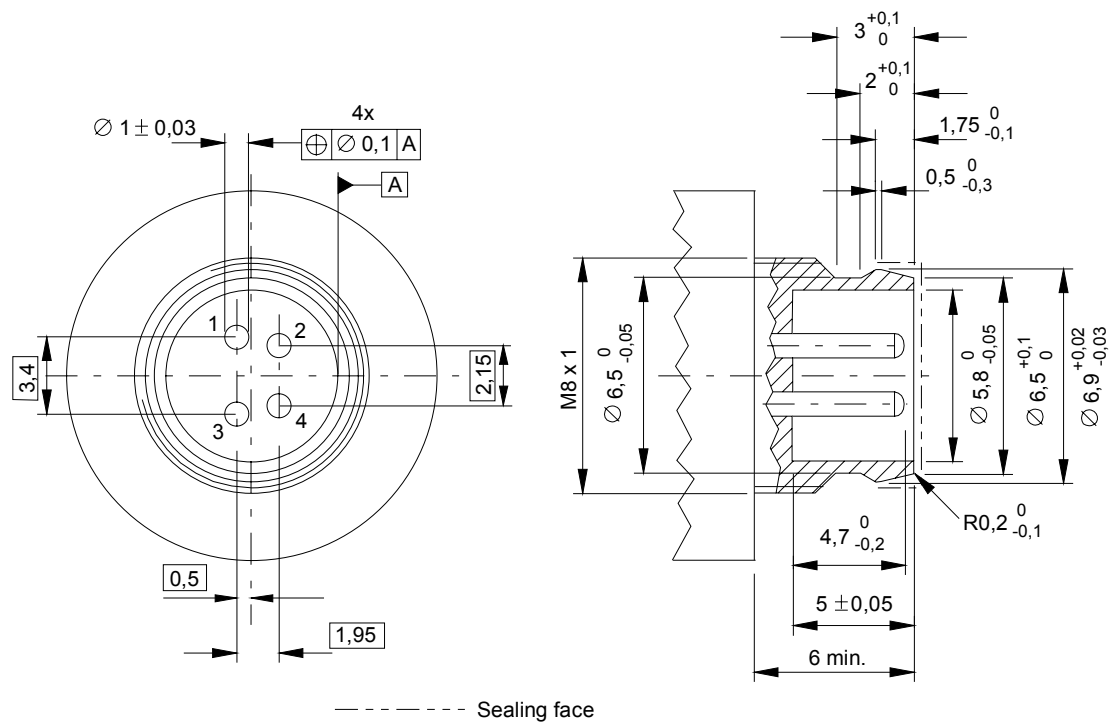
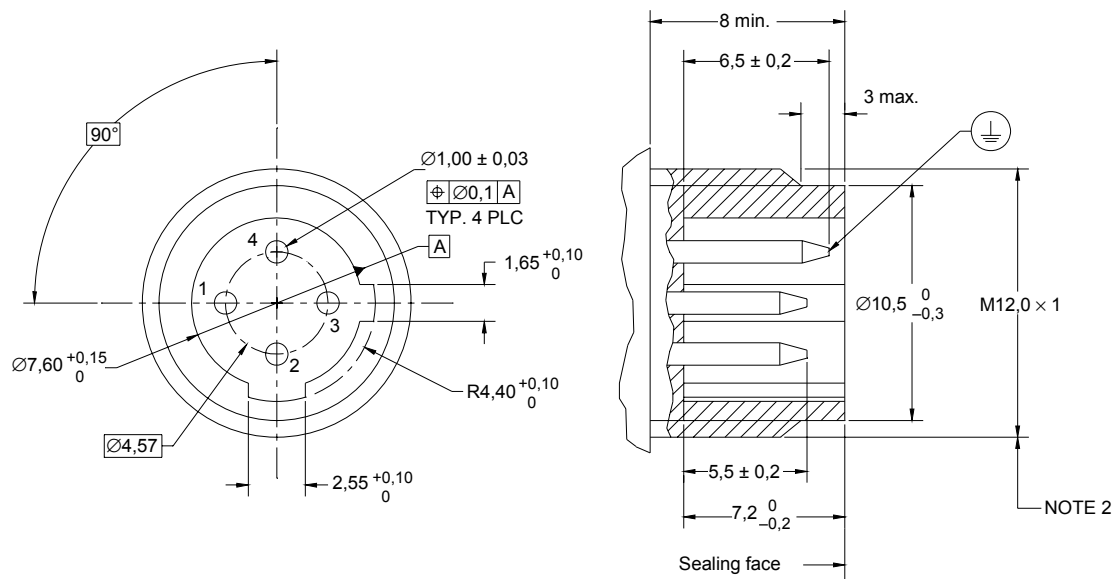


Figure D.4 – 8 mm Ø 4-pin integral connector for d.c. proximity switches

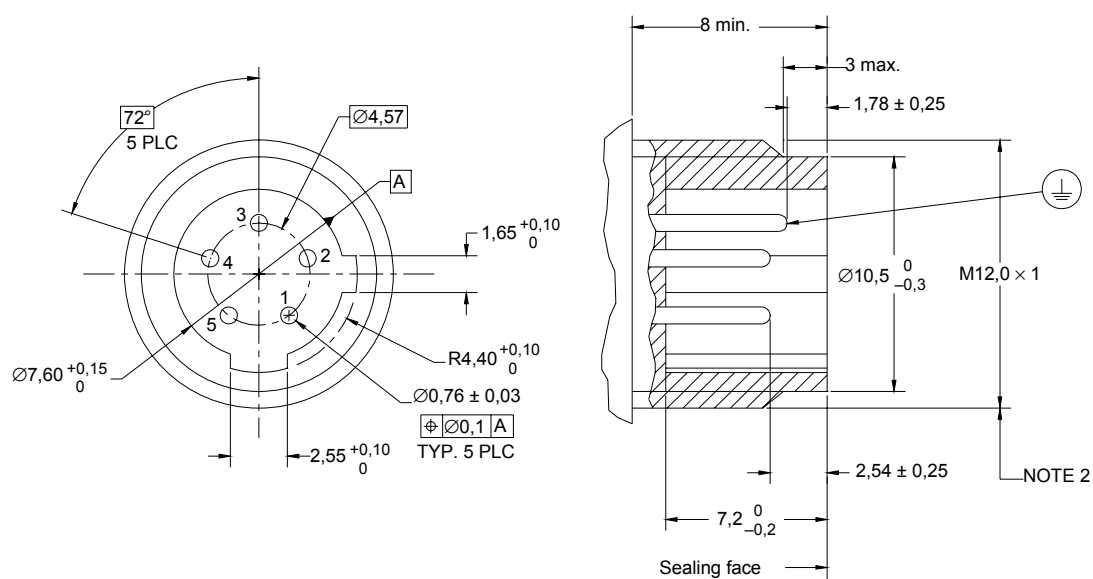


NOTE 1 Pin identification numbering is not necessary.

NOTE 2 For a provisional period, the use of 1/2"-20UNF-2A is permissible as an alternative to M12 on a.c. proximity switches.

NOTE 3 The protective earth pin shall be omitted for class II proximity switches.

Figure D.5 – M12 Ø 4-pin integral connector for a.c. proximity switches

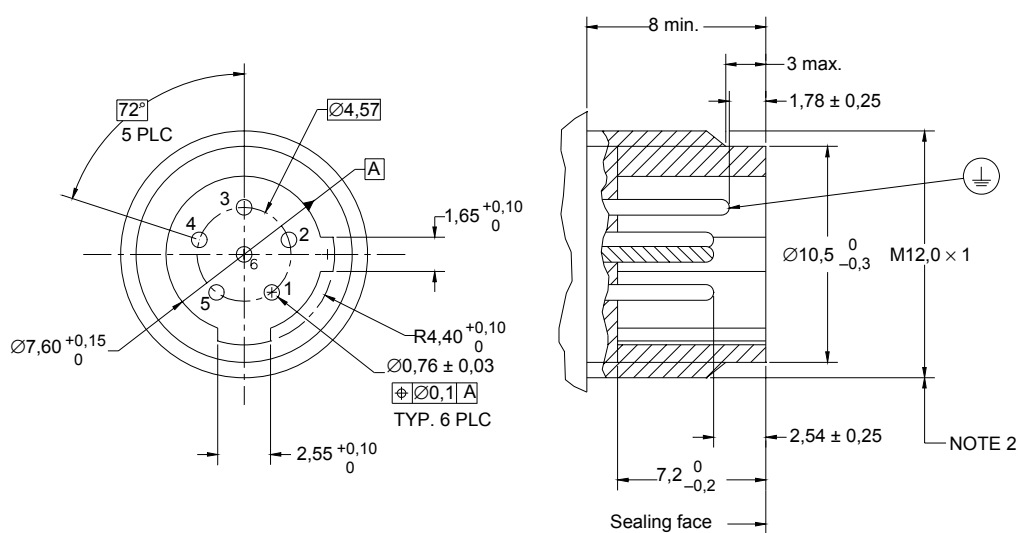


NOTE 1 Pin identification numbering is not necessary.

NOTE 2 For a provisional period, the use of 1/2"-20UNF-2A is permissible as an alternative to M12 on a.c. proximity switches.

NOTE 3 The protective earth pin shall be omitted for class II proximity switches.

Figure D.6 – M12 Ø 5-pin integral connector for a.c. proximity switches



NOTE 1 Pin identification numbering is not necessary.

NOTE 2 For a provisional period, the use of 1/2"-20UNF-2A is permissible as an alternative to M12 on a.c. proximity switches.

NOTE 3 The protective earth pin shall be omitted for class II proximity switches.

Figure D.7 – M12 Ø 6-pin integral connector for a.c. proximity switches

Annex E (normative)

Additional requirements for proximity switches suitable for use in strong magnetic fields

E.1 General

The provisions of this standard apply, unless specified otherwise in this annex.

E.1.2 Scope and object

This annex is applicable for proximity switches which operate within strong magnetic fields, for example electric weld fields (normally alternating) or electrolytic fields (normally constant).

The object of this annex is to state the performance and the test conditions for proximity switches which operate in strong magnetic fields.

E.2 Definitions

E.2.5

magnetic field

the magnetic field in the meaning of this standard is defined by the value of the magnetic induction (flux density). The value is stated in teslas [V.s/m²]

E.2.5.1

alternating magnetic field

a magnetic field with alternating direction of the magnetic induction with a fundamental frequency f of 45 Hz to 65 Hz where the reference value is the peak value of the magnetic induction

E.2.5.2

constant magnetic field

a magnetic field with a temporal constant value of the magnetic induction, where the reference value is the mean value of the magnetic induction. A total ripple content of $\pm 5\%$ is allowed

E.2.5.3 Immunity

E.2.5.3.1

immunity to an alternating magnetic field

a proximity switch is immune to an alternating magnetic field when the state of the output is not changed by the influence of the alternating magnetic field under specified conditions

E.2.5.3.2

immunity to a constant magnetic field

a proximity switch is immune to a constant magnetic field if the change – due to the influence of the constant magnetic field – of the effective operating distance (s_r) is not higher than the value specified

E.3 Classification

According to Table 1 with the following addition:

E.3.7 Classification according to the type of the influencing magnetic field

E.3.7.1 Immunity to an alternating magnetic field

The immunity to an alternating magnetic field is designed by a capital letter X, placed in the seventh position.

E.3.7.2 Immunity to a constant magnetic field

The immunity to a constant magnetic field is designated by a capital letter Y, placed in the seventh position.

E.3.7.3 Immunity to an alternating field and to a constant magnetic field

The immunity to both types of magnetic field is designated by a capital letter Z, placed in the seventh position.

E.7 Construction and performance requirements

E.7.2.1.6 Frequency of operating cycles

E.7.2.1.6.1 Inductive and capacitive proximity switches

The frequency of operating cycles shall be stated by the manufacturer, and measured according to 8.5.

E.7.5 Immunity to a magnetic field

The following values shall be applied:

- a) alternating magnetic field maximum
Magnetic induction: 0 to 0,1 T, peak value;
- b) constant magnetic field
Magnetic induction: 0 to 0,1 T, mean value.

E.7.5.1 Performance

E.7.5.1.1 In an alternating magnetic field

The state of the output shall not change when proximity switch tested in accordance with E.8.9.1.

E.7.5.1.2 In a constant magnetic field

Subclause 7.2.1.3.1 applies, with the following addition for inductive and capacitive proximity switches.

The effective operating distance (s_r) shall not deviate more than ± 30 % over the state range of the magnetic field.

Test is made according to E.8.9.2.

E.8 Tests

E.8.9 Verification of immunity

E.8.9.1 Immunity to an alternating magnetic field

E.8.9.1.1 Inspection and test sequence (see Figure E.1)

NOTE Other test configurations may be set up.

The test shall be performed as follows:

- a) The sensor (1) for measuring the magnetic field shall be arranged in the centre of the interior of the air-core inductor (4).
- b) The air-core inductor (4) shall be energized with alternating current (A), until the oscilloscope (3) shows a peak value of the magnetic induction of 0,1 T. This value I_{ref} of the current shall be noted.

NOTE To adjust the value I_{ref} , it is allowed to use a phase control up to 30°.

- c) The sensor (1) is removed and the proximity switch (I) shall be arranged in the air-core inductor, so that the reference axis of the proximity switch is identical with the axis of the air-core inductor (4) and the sensing face of the proximity switch is at the mid point (L/2) of the air-core inductor.

Tests should be performed with the orientations of the proximity switches in line and perpendicular to the magnetic field.

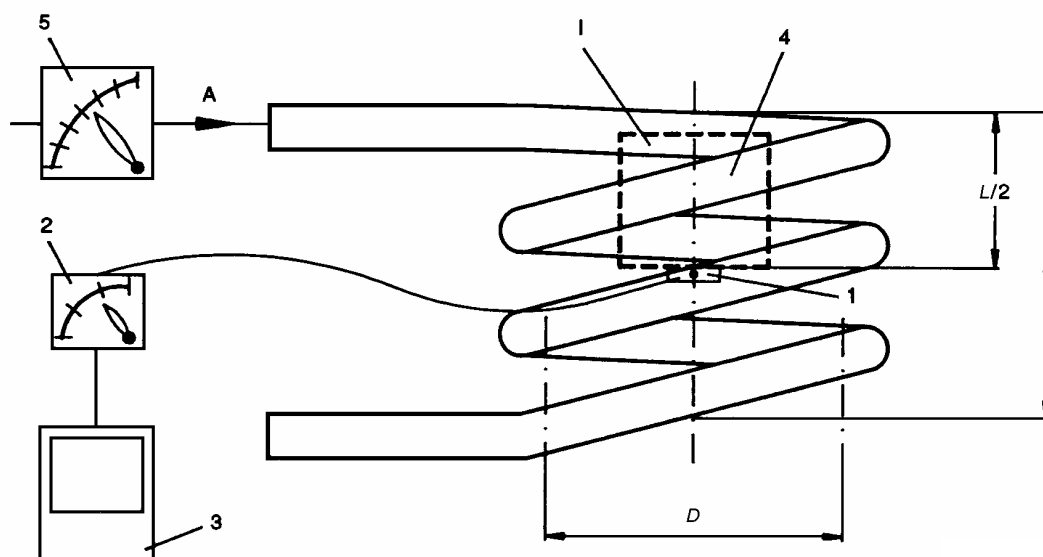
- d) The air-core inductor (4) shall be energized with the value I_{ref} for an approximate time t (s) = $3/f$, but not less than 0,1 s.
- e) The test according to d) shall be performed;
 - with the target located at $3 \times s_n$ from the sensing face;
 - with the target located at $1/3 \times s_n$ from the sensing face.

E.8.9.1.2 Results to be obtained

The state of the output shall not change by switching on and switching off I_{ref} or during the time I_{ref} current flows in the air-core inductor.

After the test, the effective operating distance (s_r) shall remain in accordance with 7.2.1.3.1.

NOTE For sensing face diameters larger than 18 mm, the target in the off condition may be removed.



- 1 Sensor
- 2 Measuring instrument for the magnetic induction
- 3 Oscilloscope (to indicate the peak value)
- 4 Air-core inductor (the number of windings is not stated)
- 5 AC ammeter
- A Alternating current
- I Proximity switch
- D Interior diameter of the air-core inductor ≥ 100 mm
- L Length of the air-core inductor ≥ 100 mm

Figure E.1 – Examples of test configuration for verification of the immunity to an alternating field

E.8.9.2 Immunity to a constant magnetic field

E.8.9.2.1 Inspection and test sequence (see Figure E.2)

NOTE Other test configurations may be set up.

The test shall be performed as follows.

- a) The sensor (1) for measuring the magnetic induction shall be arranged in the centre of the air gap between the iron cores (3).
- b) The inductance coils (4) shall be energized with direct current (A) until the measuring instrument for the magnetic induction (2) shows the magnetic induction of 0,1 T. The value I_{ref} of the current shall be noted.
- c) The sensor (1) is removed and the proximity switch (I) shall be arranged in the middle of the air gap between the iron cores (3) and so that the sensing face is in line with the outsides of the iron cores (3).
- d) The effective operating distance s_r shall be measured by axis approach of the target with the direct current A being adjusted to each of the following values:

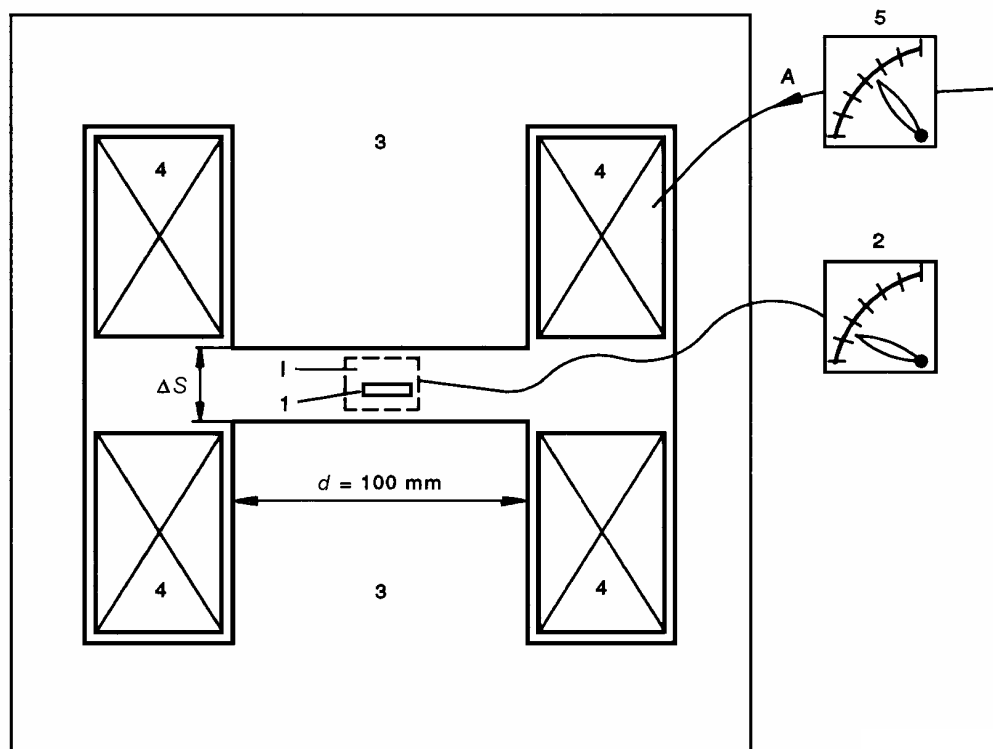
- 0 I_{ref}
- 0,2 I_{ref}
- 0,4 I_{ref}
- 0,6 I_{ref}

$0,8 I_{\text{ref}}$

$1,0 I_{\text{ref}}$

E.8.9.2.2 Results to be obtained

In the whole range of the direct current A , the deviation of the effective operating distance s_r shall be within $\pm 30\%$ of the value measured at $0 I_{\text{ref}}$.



- 1 Sensor
- 2 Measuring instrument for the magnetic induction
- 3 Iron core of the magnetic inductor
(inner diameter of iron core = 100 mm)
- 4 Inductance coils
- 5 DC ammeter
- A Direct current
- 1 Proximity switch
- ΔS Air gap between core (3) $> 2 \times$ proximity switch diameter
with a minimum of 40 mm.

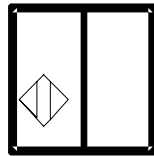
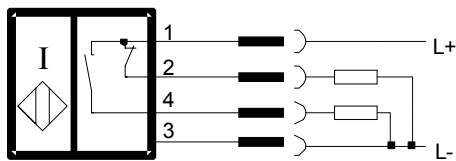
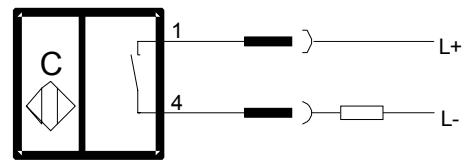
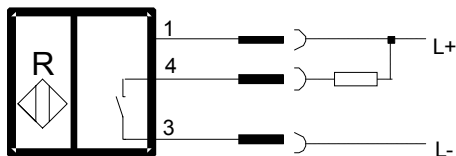
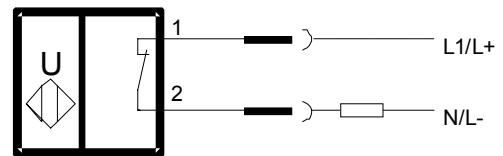
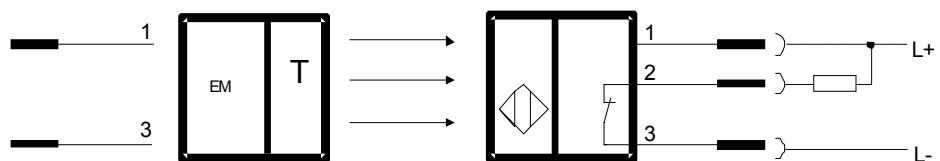
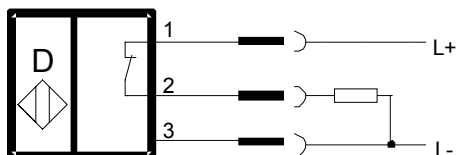
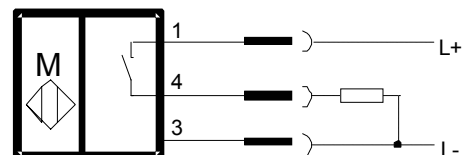
NOTE For test purposes, the parts of the proximity switch affected by the magnetic field may be separated from the rest of the switch.

Figure E.2 – Example of test configuration for verification of the immunity in a constant magnetic field

Annex F (informative)

Symbols for proximity switches

General symbol

Inductive proximity switch
4-terminal d.c. PNP output, NO NCCapacitive proximity switch
2-terminal d.c. NORetroflective photoelectric proximity switch
3-terminal d.c. NPN output, NOUltrasonic proximity switch
2-terminal d.c. NCThrough beam photoelectric proximity switch
3-terminal d.c. NPN output, NCDiffuse reflective photoelectric proximity switch
3-terminal d.c. NPN output, NCNon-mechanical magnetic proximity switch
3-terminal d.c. PNP output, NO

NOTE It is permitted to have different orientations of the symbols provided that all information required is retained.

Figure F.1 – Examples of symbols for proximity switches

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