

Low-voltage switchgear and controlgear

Part 5. Control circuit devices and switching elements

Section 2. Proximity switches

The European Standard EN 60947-5-2 : 1997 has the status of a British Standard

ICS 29.120.60

National foreword

This British Standard is the English language version of EN 60947-5-2 : 1997. It was derived by CENELEC from IEC 60947-5-2 : 1992.

The CENELC common modifications have been implemented at the appropriate places in the text and are indicated by a sideline in the margin.

The UK participation in its preparation was entrusted by Technical Committee PEL/17, HV Switchgear, to Subcommittee PEL/17/2, Low-voltage switchgear, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

From 1 January 1997, all IEC publications have the number 60000 added to the old number. For instance, 27-1 has been renumbered as IEC 60027-1. For a period of time during the change over from one numbering system to the other, publications may contain identifiers from both systems.

A list of organizations represented on this committee can be obtained on request to its secretary.

Additional information

A new subclause 7.2.7 has been introduced by common modifications to IEC 947-5-2 : 1992 and its amendments 1 : 1994 and 2 : 1995 which includes table 6 on emission limits. In 8.3.3.4.2 there is already a table 6 on test voltages. This duplication has been reported to CENELEC in a proposal to amend the text.

Cross-references

Attention is drawn to the fact that CEN and CENELEC Standards normally include an annex which lists normative references to international publications with their corresponding European publications. The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled 'International Standards Correspondence Index', or by using the 'Find' facility of the BSI Standards Electronic Catalogue.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

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Partie 5: Appareils et éléments
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Teil 5: Steuergeräte und Schaltelemente
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European Committee for Electrotechnical Standardization
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Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of the International Standard IEC 947-5-2:1992 and its amendments 1:1994 and 2:1995, prepared by SC 17B, Low-voltage switchgear and controlgear, of IEC TC 17, Switchgear and controlgear, together with common modifications prepared by the Technical Committee CENELEC TC 17B, Low-voltage switchgear and controlgear including dimensional standardization, was submitted to the Unique Acceptance Procedure and was approved by CENELEC as EN 60947-5-2 on 1996-07-02.

The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
national standard or by endorsement (dop) 1997-10-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 1999-06-01

Annexes designated "normative" are part of the body of the standard.

In this standard all annexes are normative.

Annex ZA has been added by CENELEC.

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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 part 1 (IEC 947-1) are applicable to this standard, where specifically called for. General Rules clauses and subclauses thus applicable, as well as tables, figures and appendices, are identified by references to part 1, e.g. subclause 7.1.9.3 of part 1 or appendix C of part 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 International Standard 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 and photoelectric proximity switches that sense the presence of objects.

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 normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 50(441): 1984, *International Electrotechnical Vocabulary (IEV) – Chapter 441: Switchgear, controlgear and fuses*.

IEC 68-2-6: 1982, *Basic environmental testing procedures – Part 2: Tests – Test Fc and guidance: Vibration (sinusoidal)*.

Reprint includes Amendments 1 (1983) and 2 (1985).

IEC 68-2-14: 1984, *Environmental testing – Part 2: Tests – Test N: Change of temperature*

IEC 68-2-27: 1987, *Basic environmental testing procedures – Part 2: Tests – Test Ea and guidance: Shock.*

IEC 68-2-30: 1980, *Environmental testing – Part 2: Tests – Test Db and guidance: Damp heat, cyclic (12 + 12 hour cycle)*

IEC 255-5: 1977, *Electrical relays – Part 5: Insulation tests for electrical relays.*

IEC 364, *Electrical installation of buildings.*

IEC 446: 1989, *Identification of conductors by colours or numerals.*

IEC 536: 1976, *Classification of electrical and electronic equipment with regard to protection against electric shock.*

IEC 947-1: 1988, *Low-voltage switchgear and controlgear – Part 1: General rules.*

IEC 947-5-1: 1990, *Low-voltage switchgear and controlgear – Part 5: Control circuit devices and switching elements – Section One: Electromechanical control circuit devices.*

IEC 1000-3-2: 1995, *Electromagnetic compatibility (EMC) – Part 3: Limits – Section 2: Limits for harmonic current emissions (equipment input current up to and including 16 A per phase)*

IEC 1000-3-3: 1994, *Electromagnetic compatibility (EMC) – Part 3: Limits – Section 3: Limitation of voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current up to and including 16 A*

IEC 1000-4-2: 1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 2: Electrostatic discharge immunity test*

IEC 1000-4-3: 1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 3: Radiated, radio-frequency, electromagnetic field immunity test*

IEC 1000-4-4: 1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 4: Electrical fast transient/burst immunity test*

IEC 1020-5-1: 1991, *Electromechanical switches for use in electronic equipment – Part 5: Sectional specification for pushbutton switches – Section 1: Blank detail specification.*

ISO 630: 1980, *Structural steels.*

CISPR 11: 1990, *Limits and methods of measurement of radio disturbance characteristics of industrial, scientific and medical (ISM) radio-frequency equipment*

EN 50081-2: 1993, *Electromagnetic compatibility – Generic emission standard – Part 2: Industrial environment*

2 Definitions

Clause 2 of part 1 applies with the following additions:

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]*

2.1.1.1 Inductive proximity switch

A proximity switch producing an electro-magnetic 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, page 27)

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, page 19)

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

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 For inductive, capacitive and ultrasonic proximity switches

An axis perpendicular to the sensing face and passing through its centre.

2.2.2.2 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, page 19).

2.2.2.3 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.

* See IEC 50(441).

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 Of an inductive proximity switch

A surface of the proximity switch through which the electromagnetic field emerges.

2.2.11.2 Of a capacitive proximity switch

A surface of the proximity switch through which the electric field emerges.

2.2.11.3 Of an ultrasonic proximity switch

A surface of the proximity switch where ultrasound is transmitted and received.

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 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 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.

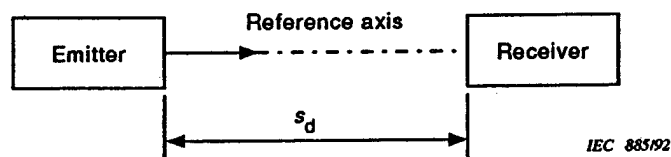


Figure 1a – Type T, emitter and receiver – Through beam photoelectric

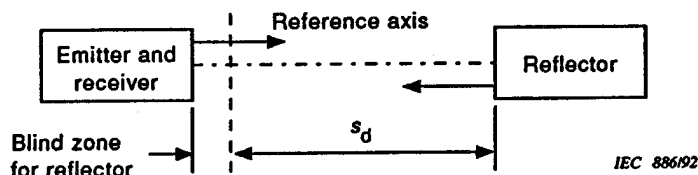


Figure 1b – Type R, emitter-receiver and reflector – Retroreflective photoelectric

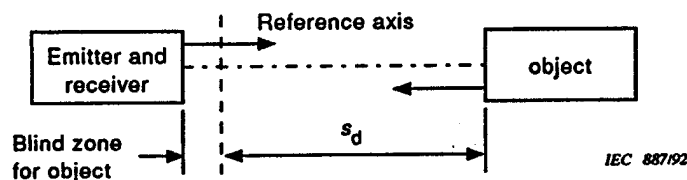


Figure 1c – Type D, emitter-receiver and object – Diffuse reflective photoelectric

Figure 1 – Sensing range (s_d) photoelectric proximity switches
(7.2.1.3 and 8.4)

2.3.1.5 *Effective operating distance (s_e)*

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.

2.3.2 *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, of 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_d)

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_0)

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.

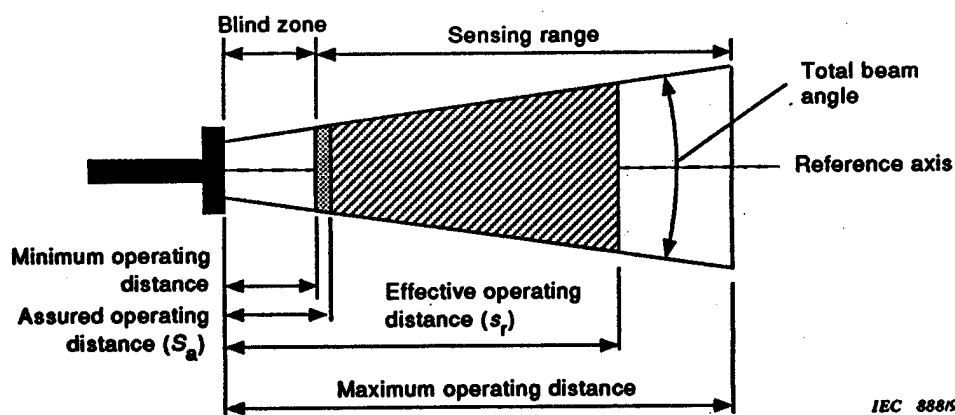
2.4.7 Ambient light for a photoelectric proximity switch

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

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IEC 888/92

Figure 2 – Ultrasonic proximity switch operating distances

Table 1 – Classification of proximity switches

1st pos./1 digit	2nd pos./1 digit	3rd pos./3 digits	4th pos./1 digit	5th pos./1 digit	6th 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 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	A = NO (make) B = NC (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	3	A30	A	D	2
Ultrasonic	Either	Cylindrical threaded Ø 30 mm	NO (make function	2 terminal d.c.	Plug in

3 Classification

Proximity switches are classified according to various general characteristics as shown in table 1.

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.

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 the operating distances are given as the "sensing range" (s_d).

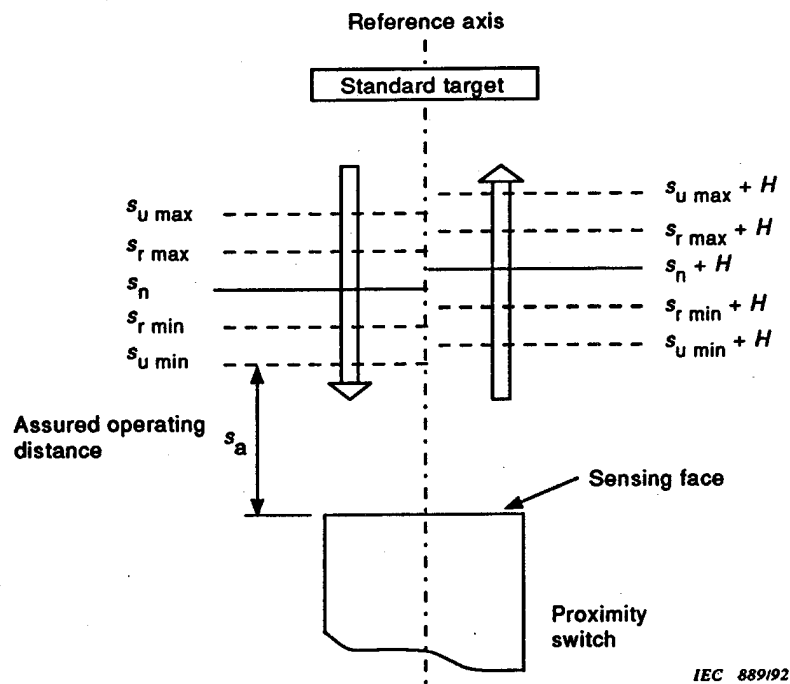


Figure 3 - Relationship between operating distances of inductive and capacitive proximity switches (4.2.1, 7.2.1.3 and 8.4.1)

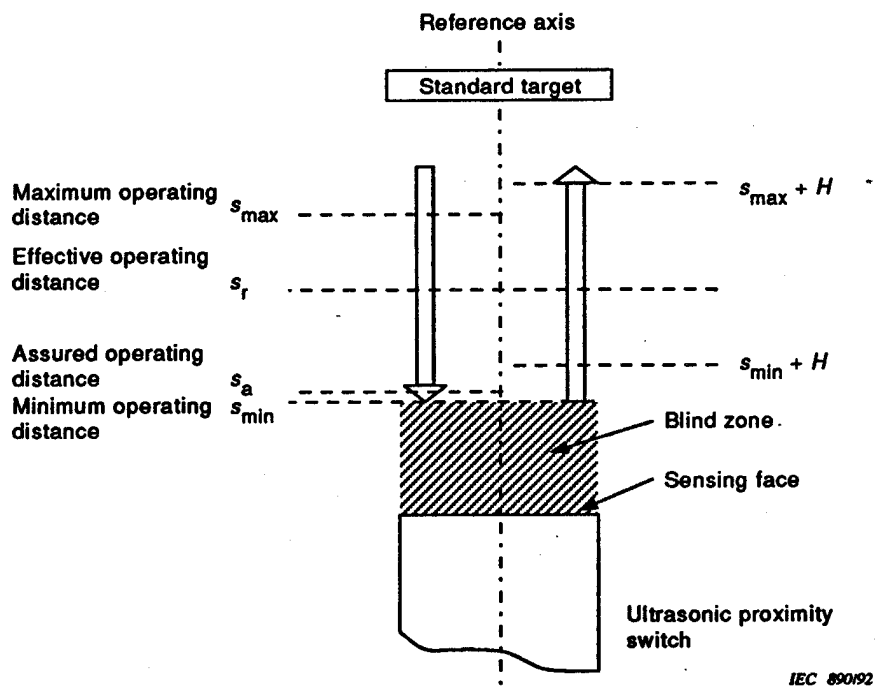


Figure 4 - Relationship between operating distances of ultrasonic proximity switches (4.2.2, 7.2.1.3 and 8.4.1)

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

4.3.1 Voltages

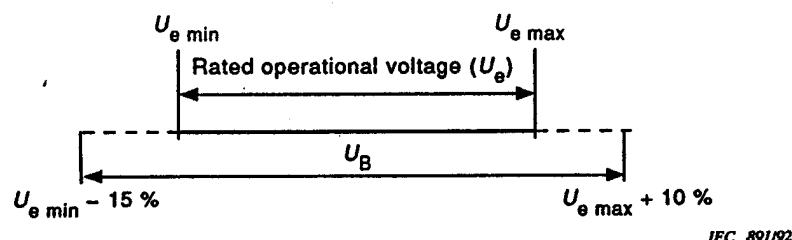
The proximity switch and its switching element(s) are defined by the following rated voltages:

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})

When the rated impulse withstand voltage is declared by the manufacturer, 4.3.1.3 of part 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_f)

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

The following information shall be given by the manufacturer.

5.1.1 Identification

- 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).

- r) Minimum operational current (see 7.2.1.12).
- s) OFF-state current (see 7.2.1.13).
- t) No-load supply current (see 4.3.2.4).
- u) Voltage drop (see 7.2.1.15).
- v) Switching element function (see 2.4.1).
- w) Mounting application, embeddable or non-embeddable (see 2.2.9 and 2.2.10).
- x) Physical dimensions (see 7.3).
- y) Excess gain (see 7.2.1.10).

5.2 Marking

5.2.1 General

Marking of data under a) and b) of 5.1.1 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

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 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 $-5\text{ }^{\circ}\text{C}$ to $+55\text{ }^{\circ}\text{C}$. The operating characteristics shall be maintained over the permissible range of ambient temperature.

6.1.2 Altitude

6.1.2 of part 1 applies.

6.1.3 Climatic conditions

6.1.3.1 Humidity

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

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 $70\text{ }^{\circ}\text{C}$ equivalent to 100 % RH at $54\text{ }^{\circ}\text{C}$).

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 part 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

7.1.1 of part 1 applies.

7.1.2 Current-carrying parts and their connections

7.1.2 of part 1 applies.

7.1.3 Clearances and creepage distances

When the manufacturer declares a rated impulse withstand voltage, U_{imp} , tables 13 and 15 of part 1 apply. If no value for U_{imp} has been declared, the requirements of 7.2.3 apply.

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 Indicating means

Proximity switches may incorporate one or more colour indicators.

The meaning of the colours shall be:

- a) continuous GREEN: power ON;
- b) continuous YELLOW: output ON;
- c) continuous RED: fault;
- d) any other continuous colour or any colour in flashing mode: other functions (e.g. short-circuit).

7.1.6 Vacant

7.1.7 Terminals

7.1.7.1 Constructional requirements

7.1.7.1 of part 1 applies.

7.1.7.2 Connecting capacity

7.1.7.2 of part 1 applies.

7.1.7.3 Connection means

7.1.7.3 of part 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 m long, -0, +0,1 m.

For plug-in type proximity switches, the built-in connector shall be in accordance with annex D (normative).

Table 3 – Connection and wiring identification

Type	Function	Wire colour	Terminal number
2 terminals a.c. and 2 terminals d.c. unpolarized	NO (make)	Any colour ¹⁾ except yellow, green or green-and-yellow	3 4
	NC (break)		1 2
2 terminals d.c. polarized	NO (make)	+ Brown – Blue	1 4
	NC (break)	+ Brown – Blue	1 2
3 terminals d.c. polarized	NO (make)	+ Brown – Blue Black	1 3
	Output		4
	NC (break)	+ Brown – Blue Black	1 3
	Output		2
4 terminals d.c. polarized	Change-over (make/break)	+ Brown – Blue Black White	1
	NO output		3
	NC output		4
			2

¹⁾ It is recommended that both wires are of same colour.

7.1.7.4 Connection identification and marking

7.1.7.4 of part 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.

The bi-colour of green-and-yellow (green/yellow) shall be used only to identify the protective conductor (IEC 446). 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

7.1.9.1 of part 1 applies with the following addition.

NOTES

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 536).

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 364).

7.1.9.2 *Protective earth terminal*

7.1.9.2 of part 1 applies.

7.1.9.3 *Protective earth terminal marking and identification*

7.1.9.3 of part 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 536).

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 Sensing range (s_d) for photoelectric proximity switches

The sensing range is measured according to 8.4

The sensing range is shown:

- in figure 11a for Type T: Emitter and Receiver,
- in figure 11b for Type R: Emitter, Receiver and Reflector,
- in figure 11c for Type D: Emitter, Receiver and Object.

The sensing range is stated by the manufacturer for 0 lx and 5 000 lx of ambient light according to the test method specified in 8.4.2.

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.

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} = turn on time

t_{off} = turn off time

and shall be stated by the manufacturer.

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_o)

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 $I_r \leq 1,5$ mA d.c. or

$I_r \leq 3$ mA a.c. r.m.s.

3 or 4 terminals $I_r \leq 0,5$ 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 $U_d \leq 8$ V d.c. or

$U_d \leq 10$ V a.c. r.m.s.

3 or 4 terminals $U_d \leq 3,5$ V d.c.