

Australian Standard™

Low-voltage switchgear and controlgear

**Part 5.2: Control circuit devices and
switching elements—Proximity switches**



This Australian Standard was prepared by Committee EL-006, Industrial Switchgear and Controlgear. It was approved on behalf of the Council of Standards Australia on 22 July 2004.

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Australian Chamber of Commerce and Industry
Australian Electrical and Electronic Manufacturers Association
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Australian Standard™

Low-voltage switchgear and controlgear

Part 5.2: Control circuit devices and switching elements—Proximity switches

Originated as AS 3947.5.2—1995.
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PREFACE

This Standard was prepared by the Standards Australia Committee EL-006, Industrial Switchgear and Controlgear to supersede AS/NZS 3947.5.2:2000.

The objective of this Standard, apart from that stated in Clause 1.1, is to bring Australian requirements into line with Edition 2.2 of IEC 60947-5-2.

This Standard is Part 4.2 of a series which, when complete, will consist of the following:

AS 60947	Low-voltage switchgear and controlgear
AS 60947.1*	Part 1: General rules
AS 60947.2*	Part 2: Circuit-breakers
AS 60947.3	Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units
AS 60947.3 Suppl	Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units, Supplement 1: Fuse-switch-disconnectors and switch-disconnectors for use with low-voltage aerial bundled cables
AS 60947.4.1*	Part 4.1: Contactors and motor-starters—Electromechanical contactors and motor-starters
AS 60947.4.2*	Part 4.2: Contactors and motor-starters—A.C. semiconductor motor controllers and starters
AS 60947.4.3	Part 4.3: Contactors and motor-starters—A.C. semiconductor controllers and contactors for non-motor loads
AS 60947.5.1*	Part 5.1: Control circuit devices and switching elements—Electromechanical control circuit devices
AS 60947.5.2*	Part 5.2: Control circuit devices and switching elements—Proximity switches (this Standard)
AS 60947.5.3	Part 5.3: Control circuit devices and switching elements—Requirements for proximity devices with defined behaviour under fault conditions
AS 60947.5.4*	Part 5.4: Control circuit devices and switching elements—Methods of assessing the performance of low-energy contacts—Special tests
AS 60947.5.5	Part 5.5: Control circuit devices and switching elements—Electrical emergency stop devices with mechanical latching function
AS 60947.5.6	Part 5.6: Control circuit devices and switching elements—D.C. interface for proximity sensors and switching amplifiers (NAMUR)
AS 60947.5.7*	Part 5.7: Control circuit devices and switching elements—Requirements for proximity devices with analogue output
AS 60947.6.1	Part 6.1: Multiple function equipment—Automatic transfer switching equipment
AS 60947.6.2*	Part 6.2: Multiple function equipment—Control and protective switching devices (or equipment) (CPS)
AS 60947.7.1*	Part 7.1: Ancillary equipment—Terminal blocks for copper conductors
AS 60947.7.2*	Part 7.2: Ancillary equipment—Protective conductor terminal blocks for copper conductors

AS 60947.7.3*	Part 7.3:	Ancillary equipment—Safety requirements for terminal blocks for the reception of cartridge fuse-links
AS 60947.8*	Part 8:	Control units for built-in thermal protection for rotating machines

It is the intention of the Committee to align the numbering of this series of Standards with that of the corresponding IEC 60947 series of Standards.

Standards from the list above that are marked with an asterisk (*) are, at the time of publication of this document, available as a part of the AS 60947 series of Standards.

Standards that are not so marked remain as AS(/NZS) 3947 series Standards. Following the next amendment or revision of the corresponding IEC Standard, each of these Standards remaining in the AS(/NZS) 3947 series will be revised and renumbered as a part of the AS 60947 series.

This Standard is identical with, and has been reproduced from Consolidated Edition 2.2 (2004-01) of IEC 60947-5-2, Ed.2.2(2004), *Low-voltage switchgear and controlgear – Part 5-2: Control circuit devices and switching elements—Proximity switches* which includes its Amendment 1:1999 and Amendment 2:2003.

This Standard differs from AS/NZS 3947.5.2:2000 in the following areas:

- (a) Normative references have been updated.
- (b) New definitions/requirements and tests have been added for direct and indirect operated proximity switches, neutral density filters, operating range and types D, R and T photoelectric proximity switches.
- (c) The definition for non-mechanical magnetic proximity switch has been updated.
- (d) EMC requirements and tests have been updated.
- (e) Requirements for the carrying out of the test for verifying dielectric properties have been extended to all proximity switches except those class II switches insulated by encapsulation.
- (f) Figure D4 for 8 mm ϕ , 4-pin integral connectors for d.c. proximity switches has been updated.

As this Standard is reproduced from an International Standard, the following applies:

- (i) Its number does not appear on each page of text and its identity is shown only on the cover and title page.
- (ii) In the source text ‘this international standard’ should read ‘this Australian Standard’.
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STANDARDS AUSTRALIA

Australian Standard

Low-voltage switchgear and controlgear
Part 5.2: Control circuit devices and switching elements—Proximity switches

1 General

The provisions of the General Rules in Part 1 (~~IEC 60947-1~~ AS 60947.1) 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 annex 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 part of ~~IEC 60947-1~~ AS 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.

References to international standards that are struck through in this clause are replaced by references to Australian or Australian/New Zealand Standards that are listed immediately thereafter and identified by shading. Any Australian or Australian/New Zealand Standard that is identical to the International Standard it replaces is identified as such.

~~IEC 60050(441):1984, International Electrotechnical Vocabulary (IEV) — Chapter 441: Switchgear, controlgear and fuses — Amendment 1 (2000)~~

AS 1852.441, *International electrotechnical vocabulary—Switchgear, controlgear and fuses* (identical to IEC 60050(441))

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

AS 60068.2.6, *Environmental testing—Tests—Test Fc: Vibration (sinusoidal)* (identical to IEC 60068-2-6)

~~IEC 60068-2-14:1984, Environmental testing — Part 2: Tests — Test N: Change of temperature — Amendment 1 (1986)~~

AS 60068.2.14, *Environmental testing—Tests—Test N: Change of temperature* (identical to IEC 60068-14)

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

AS 60068.2.27, *Environmental testing—Tests—Test Ea and guidance: Shock* (identical to IEC 60068-27)

~~IEC 60068-2-30:1980, Environmental testing — Part 2: Tests — Test Db and guidance: Damp heat, cyclic (12 + 12 hour cycle) — Amendment 1 (1985)~~

AS 60068.2.30, *Environmental testing—Tests—Test Db and guidance: Damp heat, cyclic (12 + 12 hour cycle)* (identical to IEC 60068-2-30 including Amendment 1)

IEC 60364 (all parts), *Electrical installations of buildings*

IEC 60446:1999, *Basic and safety principles for man-machine interface, marking and identification – Identification of conductors by colours or numerals*

~~IEC 60947-1:1999, Low-voltage switchgear and controlgear — Part 1: General rules — Amendment 1 (2000) — Amendment 2 (2001)~~

AS 60947.1, *Low-voltage switchgear and controlgear—General rules*

~~IEC 60947-5-1:1997, Low-voltage switchgear and controlgear — Part 5-1: Control circuit devices and switching elements — Electromechanical control circuit devices — Amendment 1 (1999) — Amendment 2 (1999)~~

AS 60947.5.1, *Low-voltage switchgear and controlgear—Control circuit devices and switching elements—Electromechanical control circuit devices*

~~IEC 61000-3-2:2000, Electromagnetic compatibility (EMC) — Part 3-2: Limits — Limits for harmonic current emissions (equipment input current ≤ 16 A per phase) — Amendment 1 (2001)~~

AS/NZS 61000.3.2, *Electromagnetic compatibility (EMC, Part 3.2: Limits—Limits for harmonic current emissions (equipment input current less than or equal to 16 A per phase)*

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

AS/NZS 61000.3.3, *Electromagnetic compatibility (EMC), Part 3.2: Limits—Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current less than or equal to 16 A per phase and not subject to conditional connection* (identical to IEC 61000-3-3 including its Amendment)

~~IEC 61000-4-2:1995, Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 2: Electrostatic discharge immunity test — Basic EMC publication — Amendment 1 (1998) — Amendment 2 (2000)~~

AS/NZS 61000.4.2, *Electromagnetic compatibility (EMC), Part 4.2: Testing and measurement techniques—Electrostatic discharge immunity test* (identical to IEC 61000-4-2 including its Amendments)

~~IEC 61000-4-3:2002, Electromagnetic compatibility (EMC) — Part 4-3: Testing and measurement techniques — Radiated, radio-frequency, electromagnetic field immunity test — Amendment 1 (2002)~~

AS/NZS 61000.4.3, *Electromagnetic compatibility (EMC), Part 4.3: Testing and measurement techniques—Radiated radio-frequency electromagnetic field immunity test* (identical to IEC 61000.4.3 including its Amendment)

IEC 61000-4-4:1995, *Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 4: Electrical fast transient/burst immunity test — Basic EMC publication* Amendment 1 (2000)
Amendment 2 (2001)

~~IEC 61000-4-5:1995, Electromagnetic compatibility (EMC) — Part 4-5: Testing and measurement techniques — Surge immunity test — Amendment 1 (2000)~~

AS/NZS 61000.4.5, *Electromagnetic compatibility (EMC), Part 4.5: Testing and measurement techniques—Surge immunity test* (identical to IEC 61000.4.5 including its Amendment)

~~IEC 61000-4-6:1996, Electromagnetic compatibility (EMC) — Part 4-6: Testing and measurement techniques — Immunity to conducted disturbances, induced by radio-frequency fields — Amendment 1 (2000)~~

AS/NZS 61000.4.6, *Electromagnetic compatibility (EMC), Part 4.6: Testing and measurement techniques—Immunity to conducted disturbances, induced by radio-frequency fields* (identical to IEC 61000-4-6 including its Amendment)

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

AS/NZS 61000.4.8, *Electromagnetic compatibility (EMC), Part 4.8: Testing and measurement techniques—Power frequency magnetic field immunity test* (identical to IEC 61000-4-8 including its Amendment)

IEC 61000-4-11:1994, *Electromagnetic compatibility (EMC) — Part 4-11: Testing and measurement techniques — Voltage dips, short interruptions and voltage variations immunity tests* Amendment 1 (2000)

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 61020-5-1:1991, *Electromechanical switches for use in electronic equipment – Part 5: Sectional specification for pushbutton switches – Section 1: Blank detail specification*

IEC 61140:2001, *Protection against electric shock – Common aspects for installation and equipment*

~~CISPR 11:1997, Industrial, scientific and medical (ISM) radio-frequency equipment—Electromagnetic disturbance characteristics—Limits and methods of measurement—Amendment 1 (1999)~~

AS/NZS CISPR 11, *Industrial, scientific and medical (ISM) radio-frequency equipment—Electromagnetic disturbance characteristics—Limits and methods of measurement*

ISO 630:1995, *Structural steels – Plates, wide flats, bars, sections and profiles*

2 Definitions

Clause 2 of Part 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

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

¹⁾ See IEC 60050(441).

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

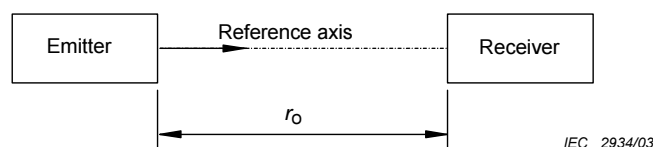


Figure 1a - Type T, emitter and receiver - Through beam photoelectric

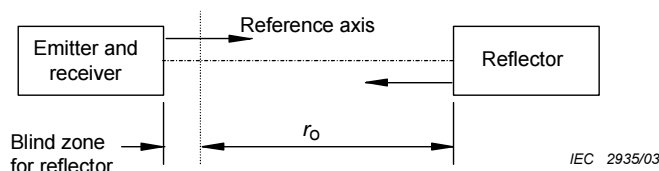


Figure 1b - Type R, emitter-receiver and reflector - Retroreflective photoelectric

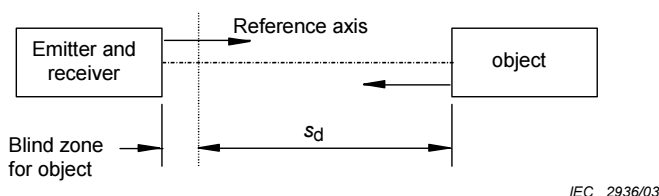


Figure 1c - Type D, emitter-receiver and object - Diffuse reflective photoelectric

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, 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_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)

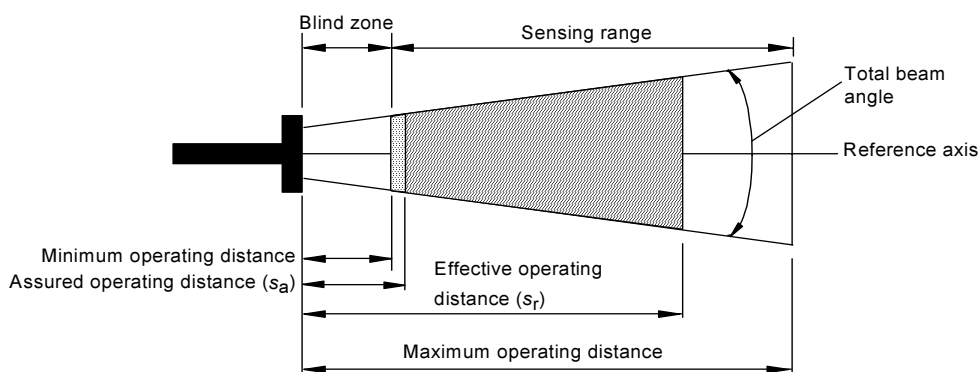
the current drawn by a three or four-terminal proximity switch from its supply when not connected to a load

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



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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 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 $\varnothing$ 30 mm	A NO (make) function	D 2 terminal d.c.	2 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.

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).

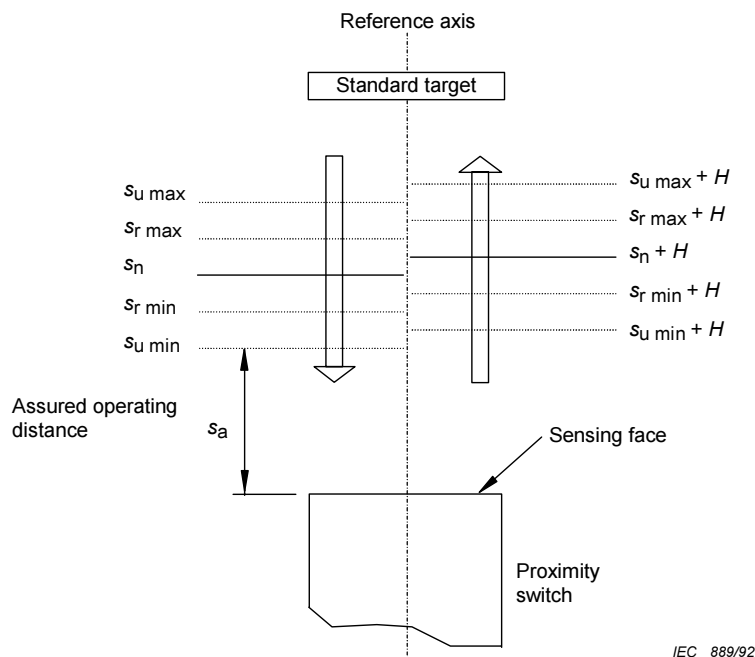


Figure 3 – Relationship between operating distances of inductive and capacitive proximity switches (see 4.2.1, 7.2.1.3 and 8.4.1)

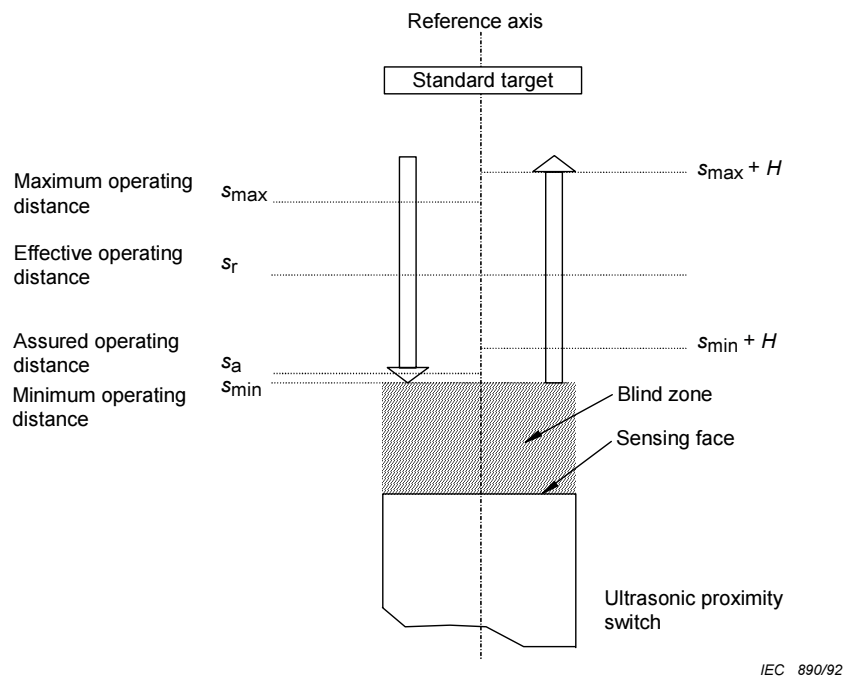


Figure 4 – Relationship between operating distances of ultrasonic proximity switches (see 4.2.2, 7.2.1.3 and 8.4.1)

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

4.3.1 Voltages

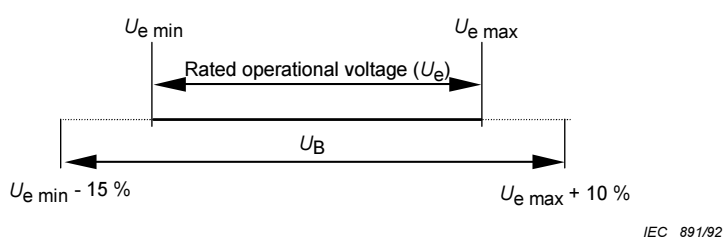
The proximity switch and its switching element(s) are defined by the following rated voltages:

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 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_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

The following information shall be given by the manufacturer.

5.1.1 Identification

- a) The manufacturer's name or trade mark.
- b) 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).
- c) Reference to this standard if the manufacturer claims compliance.

Basic rated values and utilization

- d) Rated operational voltage(s) (see 4.3.1.1).
- e) Utilization category and rated operational currents at the rated operational voltages and rated frequency/frequencies or at direct current, d.c.
- f) Rated insulation voltage (see 4.3.1.2).
- g) Rated impulse withstand voltage (see 4.3.1.3).
- h) IP code (see 7.1.10).
- i) Pollution degree (see 6.1.3.2).
- j) Type and maximum ratings of short-circuit protective device (see 7.2.5).
- k) Rated conditional short-circuit current (see 4.3.6.1).
- l) Electromagnetic compatibility (EMC) (see 7.2.6).
- m) Operating distances (see 7.2.1.3).
- n) Repeat accuracy (see 7.2.1.4).
- o) Differential travel (see 7.2.1.5).
- p) 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

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°C to $+70^{\circ}\text{C}$. 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 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°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 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

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 7.1.3 of Part 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 7.1.7.1 of Part 1 applies.

7.1.7.2 Connecting capacity

Subclause 7.1.7.2 of Part 1 applies.

7.1.7.3 Connection means

Subclause 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 $2^{+0,1}_0$ m long.

7.1.7.4 Connection identification and marking

Subclause 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.

Table 3 – Connection and wiring identification

Type	Function	Wire	Wire colour	Terminal number ²⁾
2 terminals a.c. and 2 terminals d.c. unpolarized	NO (make)		Any colour ¹⁾ except Yellow, Green or Green and yellow	3
	NC (break)			4
	NO/NC programmable			1 2 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	NO (make)	L Output	Brown Blue Black	1 3 4
3 terminals a.c./d.c. polarized	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
¹⁾ It is recommended that both wires are of the same colour. ²⁾ Terminal numbers (except for a.c. proximity switches and proximity switches using 3 terminals 8 mm connector) shall be the same as integral connector pin numbers.				

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 7.1.9.1 of Part 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~~ AS/NZS 3000).

7.1.9.2 Protective earth terminal

Subclause 7.1.9.2 of Part 1 applies.

7.1.9.3 Protective earth terminal marking and identification

Subclause 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 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 °C $\pm$ 5 °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 °C $\pm$ 5 °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.