

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

**Appareillage à basse tension –
Partie 5-2: Appareils et éléments de commutation pour circuits de commande –
DéTECTEURS de proximité**

Withdawn



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2007 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester.

If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de la CEI ou du Comité national de la CEI du pays du demandeur.

Si vous avez des questions sur le copyright de la CEI ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de la CEI de votre pays de résidence.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

- Catalogue of IEC publications: www.iec.ch/searchpub

The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: www.iec.ch/online_news/justpub

Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.

- Electropedia: www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.

- Customer Service Centre: www.iec.ch/webstore/custserv

If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:

Email: csc@iec.ch

Tel.: +41 22 919 02 11

Fax: +41 22 919 03 00

A propos de la CEI

La Commission Electrotechnique Internationale (CEI) est la première organisation mondiale qui élabore et publie des normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications CEI

Le contenu technique des publications de la CEI est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

- Catalogue des publications de la CEI: www.iec.ch/searchpub/cur_fut-f.htm

Le Catalogue en-ligne de la CEI vous permet d'effectuer des recherches en utilisant différents critères (numéro de référence, texte, comité d'études,...). Il donne aussi des informations sur les projets et les publications retirées ou remplacées.

- Just Published CEI: www.iec.ch/online_news/justpub

Restez informé sur les nouvelles publications de la CEI. Just Published détaille deux fois par mois les nouvelles publications parues. Disponible en-ligne et aussi par email.

- Electropedia: www.electropedia.org

Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 20 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International en ligne.

- Service Clients: www.iec.ch/webstore/custserv/custserv_entry-f.htm

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions, visitez le FAQ du Service clients ou contactez-nous:

Email: csc@iec.ch

Tél.: +41 22 919 02 11

Fax: +41 22 919 03 00

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

**Appareillage à basse tension –
Partie 5-2: Appareils et éléments de commutation pour circuits de commande –
DéTECTEURS de proximité**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX

XD

ICS 29.120.40; 29.130.20

ISBN 2-8318-9318-6

CONTENTS

FOREWORD	6
1 General	8
1.1 Scope and object	8
1.2 Normative references	8
2 Definitions	10
2.1 Basic definitions	12
2.2 Parts of a proximity switch	13
2.3 Operation of a proximity switch	15
2.4 Switching element characteristics	17
3 Classification	20
3.1 Classification according to sensing means	20
3.2 Classification according to the mechanical installation	20
3.3 Classification according to the construction form and size	20
3.4 Classification according to switching element function	20
3.5 Classification according to type of output	20
3.6 Classification according to method of connection	20
4 Characteristics	20
4.1 Summary of characteristics	20
4.2 Operating conditions	21
4.3 Rated and limiting values for the proximity switch and switching element(s)	23
4.4 Utilization categories for the switching element	24
5 Product information	25
5.1 Nature of information – Identification	25
5.2 Marking	26
5.3 Instruction for installation, operation and maintenance	26
6 Normal service, mounting and transport conditions	26
6.1 Normal service conditions	26
6.2 Conditions during transport and storage	27
6.3 Mounting	27
7 Constructional and performance requirements	27
7.1 Constructional requirements	27
7.2 Performance requirements	30
7.3 Physical dimensions	40
7.4 Shock and vibration	40
8 Tests	40
8.1 Kinds of tests	41
8.2 Compliance with constructional requirements	41
8.3 Performances	41
8.4 Testing of operating distances	50
8.5 Testing for the frequency of operating cycles	54
8.6 Verification of the electromagnetic compatibility	58
8.7 Test results and test report	59

Annex A (informative) Typical dimensions and operating distances of proximity

switches	60
Annex B (normative) Class II proximity switches insulated by encapsulation – Requirements and tests	86
Annex C (normative) Additional requirements for proximity switches with integrally connected cables	90
Annex D (normative) Integral connectors for plug-in proximity switches.....	93
Annex E (normative) Additional requirements for proximity switches suitable for use in strong magnetic fields	97
Annex F (informative) Symbols for proximity switches.....	102
 Figure 1 – Sensing range and operating range of photoelectric proximity switches (see 7.2.1.3 and 8.4).....	16
Figure 2 – Ultrasonic proximity switch operating distances.....	18
Figure 3 – Relationship between operating distances of inductive and capacitive proximity switches (see 4.2.1, 7.2.1.3 and 8.4.1)	22
Figure 4 – Relationship between operating distances of ultrasonic proximity switches (see 4.2.2, 7.2.1.3 and 8.4.1)	22
Figure 5 – Method of measuring the operating distance (8.3.2.1 and 8.4.1).....	43
Figure 6 – Test circuit for the verification of time delay before availability (see 7.2.1.7 and 8.3.3.2.1).....	44
Figure 7 – Signal output across load in Figure 6 (see 8.3.3.2.1).....	45
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).....	46
Figure 9 – Test circuit for the verification of making and breaking capability (see 8.3.3.5)	49
Figure 10 – Short-circuit testing (see 8.3.4.2).....	50
Figure 11 – Testing of the sensing range (see 8.4)	53
Figure 12 – Methods for measuring the operating frequency of inductive, capacitive and non-mechanical magnetic proximity switches (if applicable)	54
Figure 13 – Methods for measuring the operating frequency f , ultrasonic proximity switch	55
Figure 14 – Output signal of direct current proximity switch during the measurement of operating frequency f	55
Figure 15 – Measurement means for turn-on time t_{on} and turn-off time t_{off}	56
Figure 16 – Turn-on time t_{on} measurement.....	57
Figure 17 – Turn-off time t_{off} measurement	57
Figure A.1 (IA) – Dimensions.....	60
Figure A.2 (IA) – Installation (mounting)	62
Figure A.1 (IB) – Dimensions.....	63
Figure A.2 (IB) – Installation in damping material.....	64
Figure A.1 (IC) – Dimensions in millimetres	65
Figure A.1.2 (IC) – Dimensions in millimetres	66
Figure A.1.3 (IC) – Dimensions in millimetres	66
Figure A.1.4 (IC) – Dimensions in millimetres	67
Figure A.2 (IC) – Installation of a I1C proximity switch in damping material	68
Figure A.3 (IC) – Installation of I2C35 in damping material.....	69
Figure A.1 (ID) – Dimensions	70

Figure A.2 (ID) – Installation of I2D in damping material	71
Figure A.1 (CA) – Dimensions	72
Figure A.2 (CA) – Installation (mounting)	73
Figure A.1 (CC) a – Dimensions, type C30 in millimetres	75
Figure A.1 (CC) b – Dimensions, type C40 in millimetres	76
Figure A.2 (CC) – Installation (mounting)	77
Figure A.1 (CD) – Dimensions in millimetres	78
Figure A.2 (CD) – Installation (mounting)	79
Figure A.1 (UA) – Dimensions	80
Figure A.1 (UC) – Dimensions of type U3C40	82
Figure A.1 (UD) – Dimensions of type U3D80 in millimetres	84
Figure B.1 – Encapsulated device	87
Figure B.2 – Test device	89
Figure D.1 – M12 Ø 3-pin integral connector for a.c. proximity switches	93
Figure D.2 – M12 Ø 5-pin integral connector for d.c. proximity switches	94
Figure D.3 – 8 mm Ø 3-pin integral connector for d.c. proximity switches	94
Figure D.4 – 8 mm Ø 4-pin integral connector for d.c. proximity switches	95
Figure D.5 – M12 Ø 4-pin integral connector for a.c. proximity switches	95
Figure D.6 – M12 Ø 5-pin integral connector for a.c. proximity switches	96
Figure D.7 – M12 Ø 6-pin integral connector for a.c. proximity switches	96
Figure E.1 – Examples of test configuration for verification of the immunity to an alternating field	100
Figure E.2 – Example of test configuration for verification of the immunity in a constant magnetic field	101
Figure F.1 – Examples of symbols for proximity switches	102
Table 1 – Classification of proximity switches	19
Table 2 – Utilization categories for switching elements	25
Table 3 – Connection and wiring identification	29
Table 4 – Verification of making and breaking capacities of switching elements under normal conditions corresponding to the utilization categories ^a	35
Table 5 – Verification of making and breaking capacities of switching elements under abnormal conditions corresponding to the utilization categories ^a	36
Table 7 – Acceptance criteria	37
Table 8 – Immunity tests	38
Table 6 – Test voltages	48
Table A.1 (IA) – Dimensions in millimetres	61
Table A.2 (IA) – Rated operating distances in millimetres	61
Table A.1 (IB) – Dimensions in millimetres	63
Table A.2 (IB) – Rated operating distance in millimetres	64
Table A.2 (IC) – Rated operating distance in millimetres	67
Table A.1 (ID) – Dimensions in millimetres	70
Table A.2 (ID) – Rated operating distances in millimetres	71
Table A.1 (CA) – Dimensions in millimetres	72

Table A.2 (CA) – Rated operating distances in millimetres	73
Table A.2 (CC) – Rated operational distance in millimetres	76
Table A.1 (UA) – Dimensions in millimetres	80
Table A.2 (UA) – Requirements for sensing range in millimetres	81
Table A.1 (UC) – Requirements for sensing range in millimetres	82
Table A.2 (UD) – Requirements for sensing range in millimetres	85

Withdrawn

INTERNATIONAL ELECTROTECHNICAL COMMISSION

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 5-2: Control circuit devices and switching elements – Proximity switches

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60947-5-2 has been prepared by subcommittee 17B: Low-voltage switchgear and controlgear, of IEC technical committee 17: Switchgear and controlgear.

This third edition cancels and replaces the second edition published in 1997, amendment 1 (1999) and amendment 2 (2003).

The document 17B/1570/FDIS, circulated to the National Committees as Amendment 3, led to the publication of the new edition.

The text of this standard is based on the second edition, its amendment 1, amendment 2 and on the following documents:

FDIS	Report on voting
17B/1570/FDIS	17B/1576/RVD

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

The main changes with respect to the previous edition are as follows:

- modification of Table 3;
- modifications of voltage dips and voltage interruptions immunity tests, in Table 8;
- modification of status of Annex A, now informative.

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

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

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under “<http://webstore.iec.ch>” in the data related to the specific publication. At this date, the publication will be

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

Withdrawn

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 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 element(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:

Alphabetical index of definitions

References

A		
Adjuster of a proximity switch		2.2.15
Adjuster of a capacitive proximity switch		2.2.15.1
Adjuster of an ultrasonic proximity switch		2.2.15.2
Ambient light for a photoelectric proximity switch		2.4.7
Assured operating distance (s_a)		2.3.1.7
Axial approach		2.3.3
B		
Blind zone		2.3.1.3
Break function		2.4.1.2
C		
Capacitive proximity switch		2.1.1.2
Currents (I)		2.4.5
D		
Damping material		2.2.5
Differential travel (H)		2.3.5
Direct operated proximity switch		2.1.1.6
E		
Effective operating distance (s_r)		2.3.1.5
Embeddable proximity switch		2.2.9
Emitter		2.2.12
Excess gain for a photoelectric proximity switch		2.4.6
F		
Free zone		2.2.4
Frequency of operating cycle (f)		2.4.3
I		
Independent (snap) action		2.4.2
Indirect operated proximity switch		2.1.1.7
Inductive proximity switch		2.1.1.1
L		
Lateral approach		2.3.2
M		
Make function		2.4.1.1
Make-break, or changeover function		2.4.1.3
Maximum operating distance		2.3.1.2.2
Minimum operating distance		2.3.1.2.1

Minimum operational current (I_m)	2.4.5.2
N	
Neutral density filters	2.1.1.8
No-load supply current (I_o)	2.4.5.3
Non-damping material	2.2.6
Non-embeddable proximity switch	2.2.10
Non-mechanical magnetic proximity switch	2.1.1.5
O	
OFF-state current (I_f)	2.4.5.1
Operating distances (s)	2.3.1
Operating range (r_o)	2.3.1.8
Operation of a proximity switch	2.3
P	
Parts of proximity switches	2.2
Photoelectric proximity switch	2.1.1.4
Photoelectric proximity switch - type D	2.1.1.4.1
Photoelectric proximity switch - type R	2.1.1.4.2
Photoelectric proximity switch - type T	2.1.1.4.3
Proximity switch (IEV 441-14-51)	2.1.1
R	
Rated operating distance (s_n)	2.3.1.1
Receiver	2.2.13
Reference axis	2.2.2
Reflector	2.2.14
Repeat accuracy (R)	2.3.4
Response time proximity switch	2.4.1.4
S	
Semiconductor switching element	2.2.1
Sensing face	2.2.11
Sensing range (s_d)	2.3.1.2
Sound absorbing material	2.2.8
Sound reflecting material	2.2.7
Standard target	2.2.3
Switching element characteristics	2.4
Switching element function	2.4.1
T	
Time delay before availability (t_v)	2.4.4
Total beam angle	2.3.1.4
Turn off time for a photoelectric proximity switch	2.4.1.6
Turn on time for a photoelectric proximity switch	2.4.1.5
U	
Ultrasonic proximity switch	2.1.1.3
Usable operating distance (s_u)	2.3.1.6

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

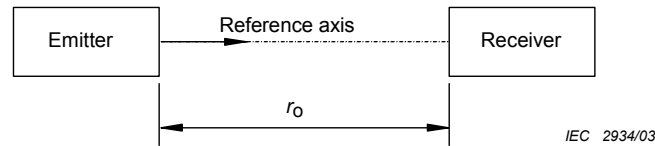


Figure 1a - Type T, emitter and receiver - Through beam photoelectric

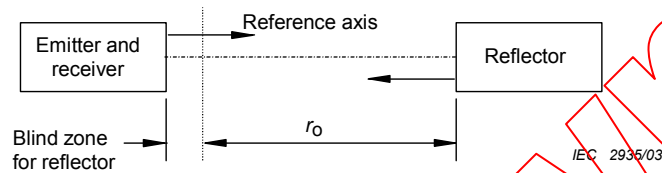


Figure 1b - Type R, emitter-receiver and reflector - Retroreflective photoelectric

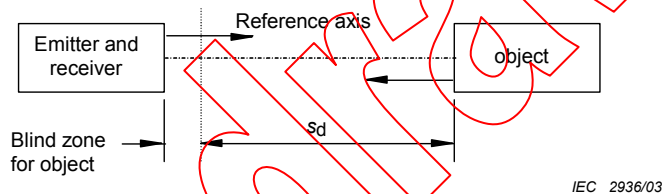


Figure 1c - Type D, emitter-receiver and object - Diffuse reflective photoelectric

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

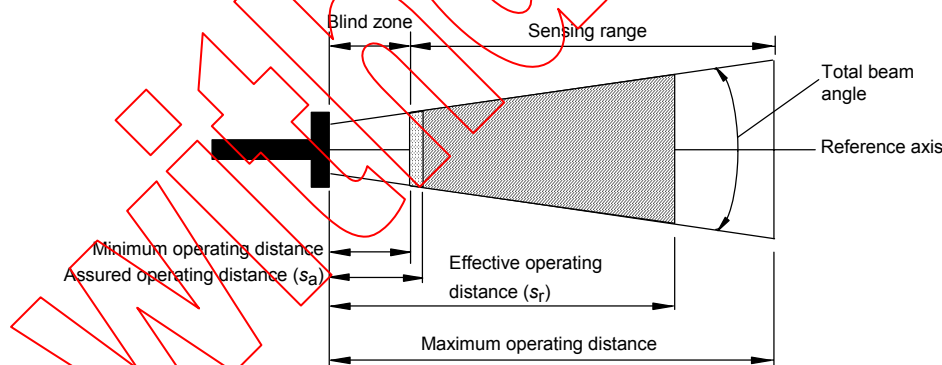
excess gain for a photoelectric proximity switch

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



IEC 888/92

Figure 2 – Ultrasonic proximity switch operating distances

Table 1 – Classification of proximity switches

1 st pos./1 digit SENSING MEANS 3.1	2 nd pos./1 digit MECHANICAL INSTALLATION 3.2	3 rd pos./3 digits CONSTRUCTION FORM AND SIZE 3.3	4 th pos./1 digit SWITCHING ELEMENT FUNCTION (OUTPUT) 3.4	5 th pos./1 digit TYPE OF OUTPUT 3.5	6 th pos./1 digit 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).

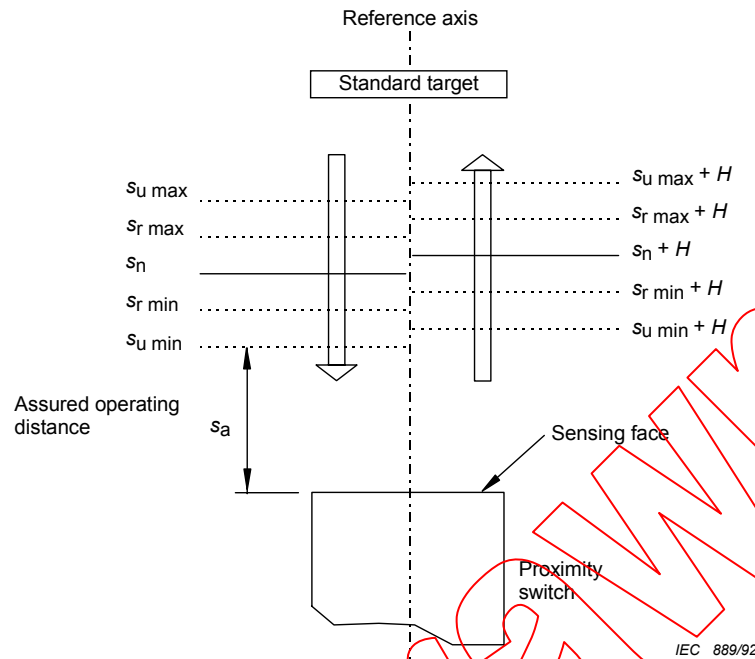


Figure 3 – Relationship between operating distances of inductive and capacitive proximity switches (see 4.2.1, 7.2.1.3 and 8.4.1)

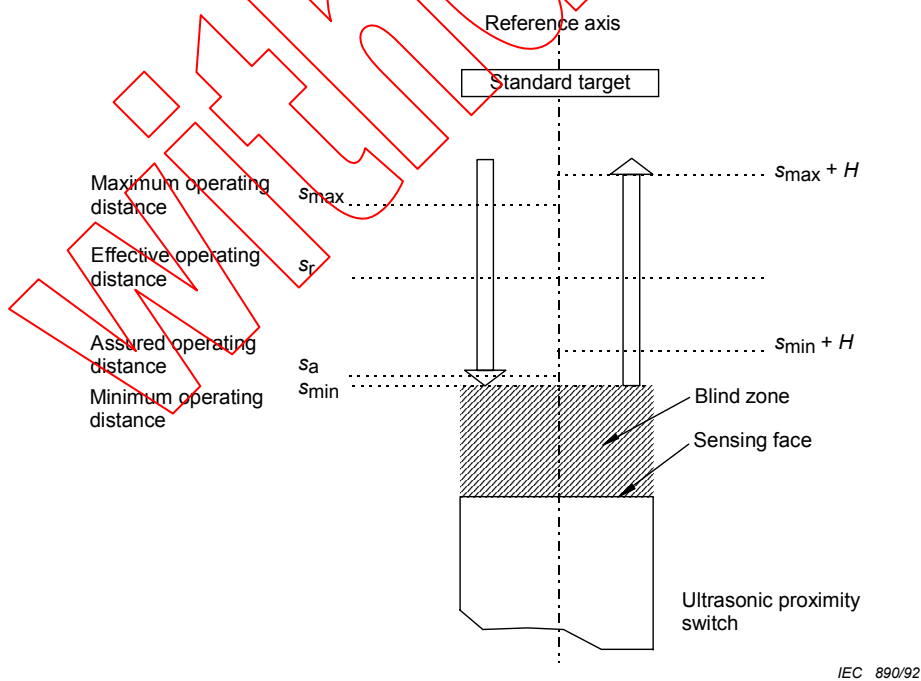


Figure 4 – Relationship between operating distances of ultrasonic proximity switches (see 4.2.2, 7.2.1.3 and 8.4.1)

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

4.3.1 Voltages

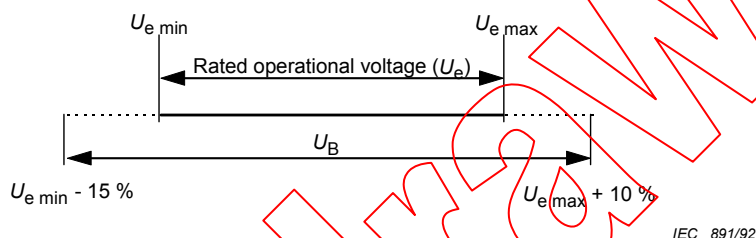
The proximity switch and its switching element(s) are defined by the following rated voltages:

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°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 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	$\cos \varphi$ or $T_{0,95}$	I/I_e	U/U_e	$\cos \varphi$ 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 $P = 50 \text{ W}$.									

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					
I_e = rated operational current U_e = rated operational voltage I = current to be made or broken U = voltage before make						
^a See 8.3.3.5. ^b The abnormal condition is to simulate a blocked open electromagnet. ^c For tolerances on test quantities, see 8.3.2.2. ^d An overload protection device specified by the manufacturer may be used to verify the abnormal conditions. ^e This test is covered by the test performed according to the footnote ^c of Table 4.						

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.

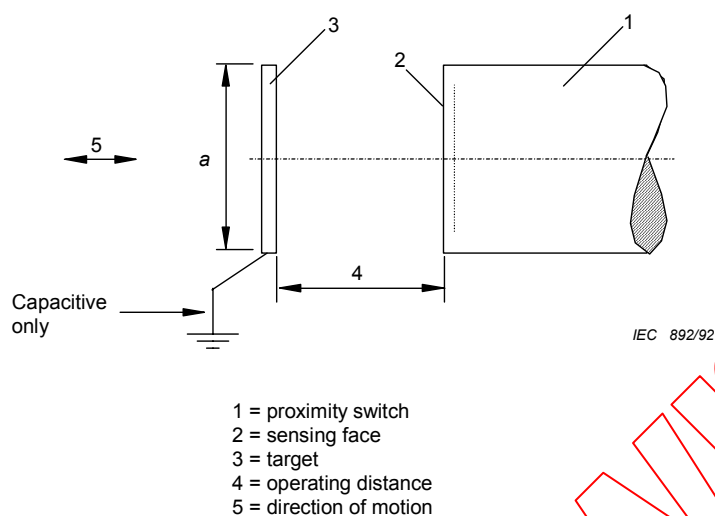


Figure 5 – Method of measuring the operating distance (8.3.2.1 and 8.4.1)

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.

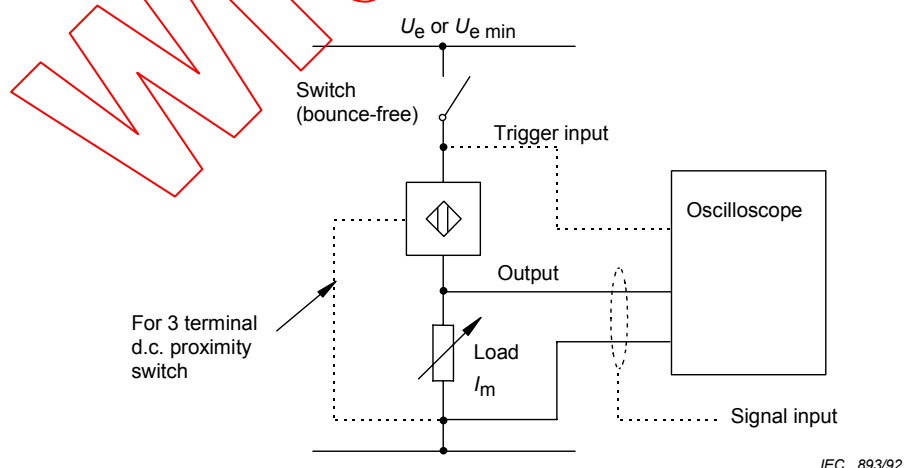


Figure 6 – Test circuit for the verification of time delay before availability
(see 7.2.1.7 and 8.3.3.2.1)

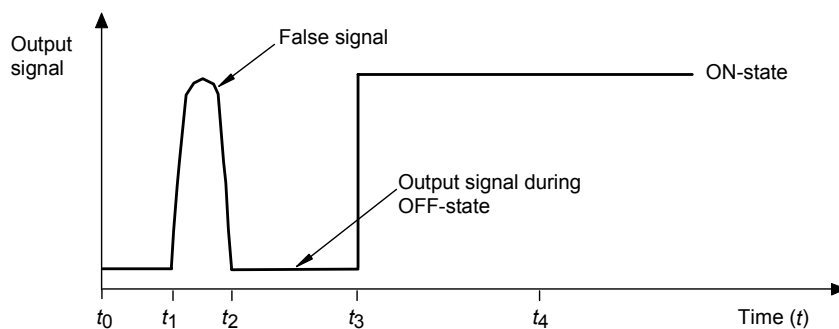


Figure 7a – Switching element is in ON-state

IEC 894/92

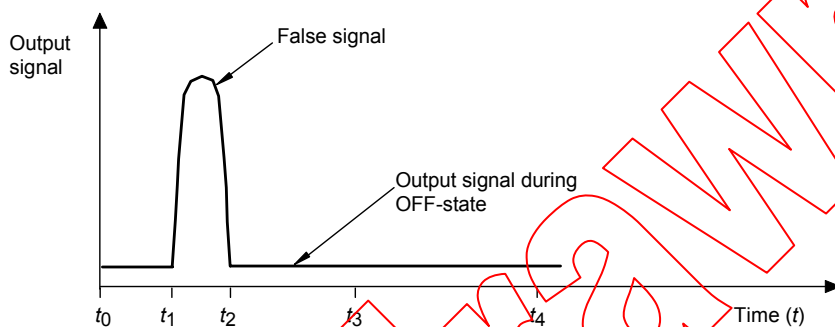


Figure 7b – Switching element is in OFF-state

IEC 895/92

- 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.

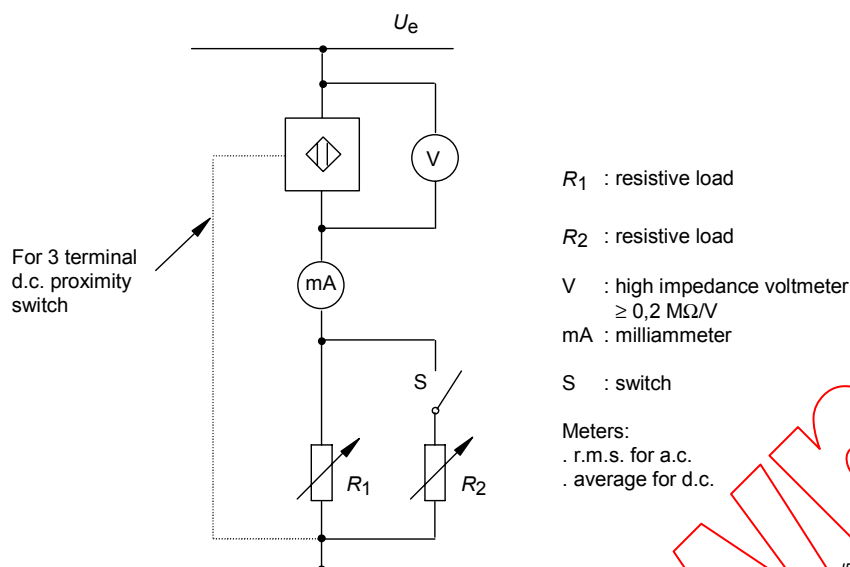


**Figure 8 – Test circuit for the verification of minimum operational current
 OFF-state current, voltage drop and independent snap action**
 (see 8.3.3.2.2, 8.3.3.2.3, 8.3.3.2.4 and 8.3.3.2.5)

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 $23 \text{ }^\circ\text{C} \pm 5 \text{ }^\circ\text{C}$ 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 .