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Interested committees:

Title: Draft BS EN 60079-7 Ed.6.0 Explosive atmospheres. Part 7: Equipment protection by increased safety "e".

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- i) has any issues related to 3rd party IPR, patent or copyright
- ii) affects other national standard(s)
- iii) requires additional national guidance or information

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Introduction

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

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

Submission of Comments

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Template for comments and secretariat observations

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

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



31/1519/CD

COMMITTEE DRAFT (CD)

PROJECT NUMBER:

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SUPERSEDES DOCUMENTS:

31/1516/RR

IEC TC 31 : EQUIPMENT FOR EXPLOSIVE ATMOSPHERES

SECRETARIAT:

United Kingdom

SECRETARY:

Mr Mick Maghar

OF INTEREST TO THE FOLLOWING COMMITTEES:

PROPOSED HORIZONTAL STANDARD:



Other TC/SCs are requested to indicate their interest, if any, in this CD to the secretary.

FUNCTIONS CONCERNED:

☐ EMC

☐ ENVIRONMENT

☐ QUALITY ASSURANCE

☐ SAFETY

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Recipients of this document are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

TITLE:

Explosive atmospheres - Part 7: Equipment protection by increased safety "e"

NOTE FROM TC/SC OFFICERS:

Note. This draft is being circulated with editing marks in accordance with clause 5.4 of the Good Working Practice document which states:

"All CDs that are revisions of documents should be circulated as complete texts including editing marks and not just as a list of major technical changes to be made to the existing text. This is for ease of understanding of what has been changed, added or removed thus saving time as in the past experts did not realize critical text had been deleted."

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

EXPLOSIVE ATMOSPHERES –

Part 7: Equipment protection by increased safety "e"

FOREWORD

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International Standard IEC 60079-7 has been prepared by IEC Technical Committee 31: Equipment for explosive atmospheres.

This [sixth](#) edition cancels and replaces the [fifth](#) edition published in [2015](#), and constitutes a technical revision.

305
306

307 **Table of Changes to be added at CDV stage.**

308 NOTE The technical changes referred to include the significance of technical changes in the revised IEC Standard,
309 but they do not form an exhaustive list of all modifications from the previous version.

310 **Explanations:**

311 **A) Definitions**

312 **Minor and editorial changes** clarification
313 decrease of technical requirements
314 minor technical change
315 editorial corrections

316 These are changes which modify requirements in an editorial or a minor technical way. They
317 include changes of the wording to clarify technical requirements without any technical change,
318 or a reduction in level of existing requirement.

319 **Extension** addition of technical options

320 These are changes which add new or modify existing technical requirements, in a way that new
321 options are given, but without increasing requirements for equipment that was fully compliant
322 with the previous standard. Therefore, these will not have to be considered for products in
323 conformity with the preceding edition.

324 **Major technical changes** addition of technical requirements
325 increase of technical requirements

326 These are changes to technical requirements (addition, increase of the level or removal) made
327 in a way that a product in conformity with the preceding edition will not always be able to fulfil
328 the requirements given in the later edition. These changes have to be considered for products
329 in conformity with the preceding edition. For these changes additional information is provided in
330 clause B) below.

331 NOTE These changes represent current technological knowledge. However, these changes should not normally
332 have an influence on equipment already placed on the market.

333 **B) Information about the background of 'Changes**

334 The text of this standard is based on the following documents:

FDIS	Report on voting
31/????/FDIS	31/????/RVD

335 Full information on the voting for the approval of this standard can be found in the report on
336 voting indicated in the above table.
337

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

339 A list of all parts of IEC 60079 series, under the general title *Explosive atmospheres*, can be
340 found on the IEC website.

341 The committee has decided that the contents of this publication will remain unchanged until the
342 stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to
343 the specific publication. At this date, the publication will be

- 344 • reconfirmed,
- 345 • withdrawn,
- 346 • replaced by a revised edition, or
- 347 • amended.

348 A bilingual version of this publication may be issued at a later date.

349

EXPLOSIVE ATMOSPHERES –

Part 7: Equipment protection by increased safety "e"

1 Scope

This part of IEC 60079 specifies the requirements for the design, construction, testing and marking of electrical **Ex Equipment** and Ex Components with **Type of Protection** increased safety "e" intended for use in explosive gas atmospheres.

Electrical **Ex Equipment** and Ex Components of **Type of Protection** increased safety "e" are either:

- a) Level of Protection "eb" (EPL "Mb" or "Gb"); or
- b) Level of Protection "ec" (EPL "Gc")

Level of Protection "eb" applies to **Ex Equipment** or Ex Components, including their connections, conductors, windings, lamps, and batteries; but not including semiconductor **devices** or electrolytic capacitors.

NOTE 1 The fundamental basis of "eb" is limitation of temperature, and reduced likelihood of insulation failure resulting in an arc or spark. Expected malfunctions of electronic components, such as semiconductor **devices** or electrolytic capacitors, can result in a failure producing excessive temperatures, or arcs and sparks.

Level of Protection "ec" applies to **Ex Equipment** or Ex Components, including their connections, conductors, windings, lamps, and batteries; and also including semiconductor **devices** and electrolytic capacitors.

NOTE 2 The use of electronic components, such as semiconductor **devices** or electrolytic capacitors, is permitted in Level of Protection "ec" as these are evaluated under both normal conditions and regular expected occurrences, and are not likely to result in excessive temperatures or arcs and sparks. As the requirements for separation distances are not applied to the internal construction, commercially available electronic components are generally suitable if the external separation distances comply.

The requirements of this standard apply to both Levels of Protection unless otherwise stated.

For Level of Protection "eb", this standard applies to electrical equipment where the rated voltage does not exceed 11 kV **AC_{RMS}** or **DC**.

For Level of Protection "ec", this standard applies to electrical equipment where the rated voltage does not exceed 15 kV **AC_{RMS}** or **DC**.

For voltages greater than 70.7 V_{RMS} with frequencies greater than 30 kHz, increased creepage and clearance may be required. For additional guidance, see IEC 60664-4. [WG32 is working to develop quantitative requirements]

NOTE 3 Short circuit currents flowing through increased safety connections of mains circuits are not considered to create a significant risk of ignition of an explosive gas atmosphere due to movement of connections as a result of mechanical stresses created by the short circuit current. Normal industrial standards require that the effects of short time high currents on the security of connections be considered. The presence of the explosive gas atmosphere does not adversely affect the **integrity** of the connection.

NOTE 4 Any short term thermal excursions that occur as a result of electrical current excursions above normal rated currents, such as those that occur during the starting of motors, are not considered to create a significant risk of ignition of an explosive gas atmosphere due to the relatively short duration of the event and the convection that occurs during the event.

395 NOTE 5 High-voltage connections and associated wiring (above 1 kV) can be susceptible to increased partial
396 discharge activity that could be a source of ignition. Increased spacings to earthed surfaces or other connections and
397 provision of suitable high-voltage stress relief for the terminations are typically provided.

398 This standard supplements and modifies the general requirements of IEC 60079-0. Where a
399 requirement of this standard conflicts with a requirement of IEC 60079-0, the requirement of this
400 standard takes precedence.

401 2 Normative references

402 The following documents, in whole or in part, are normatively referenced in this document and are
403 indispensable for its application. For dated references, only the edition cited applies. For undated
404 references, the latest edition of the referenced document (including any amendments) applies.

405 IEC 60034-1, *Rotating electrical machines – Part 1: Rating and performance*

406 IEC 60044-6, *Instrument transformers – Part 6: Requirements for protective current trans-*
407 *formers for transient performance*

408 IEC 60061-1, *Lamp caps and holders together with gauges for the control of interchangeability*
409 *and safety. Part 1: Lamp caps*

410 IEC 60061-2, *Lamp caps and holders together with gauges for the control of interchangeability*
411 *and safety – Part 2: Lampholders*

412 IEC 60064, *Tungsten filament lamps for domestic and similar general lighting purposes –*
413 *Performance requirements*

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

415 IEC 60068-2-27:2008, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

416 IEC 60068-2-42, *Environmental testing – Part 2-42: Tests – Test Kc: Sulphur dioxide test for*
417 *contacts and connections*

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

419 IEC 60079-1, *Explosive atmospheres – Part 1: Equipment protection by flameproof enclosures*
420 *"d"*

421 IEC 60079-11, *Explosive atmospheres – Part 11: Equipment protection by intrinsic safety "i"*

422 IEC 60079-30-1, *Explosive atmospheres – Part 30-1: Electrical resistance trace heating –*
423 *General and testing requirements*

424 IEC 60081, *Double-Capped Fluorescent Lamps – Performance Specifications*

425 IEC 60085, *Electrical insulation – Thermal evaluation and designation*

426 IEC 60112, *Method for the determination of the proof and the comparative tracking indices of*
427 *solid insulating materials*

428 IEC 60216-1, *Electrical insulating materials – Thermal endurance properties – Part 1: Ageing*
429 *procedures and evaluation of test results*

- 430 IEC 60216-2, *Electrical insulating materials – Thermal endurance properties – Part 2:*
431 *Determination of thermal endurance properties of electrical insulating materials – Choice of test*
432 *criteria*
- 433 IEC 60228, *Conductors of insulated cables*
- 434 IEC 60238, *Edison screw lampholders*
- 435 IEC 60317-3:2004, *Specifications for particular types of winding wires – Part 3: Polyester*
436 *enamelled round copper wire, class 155*
437 IEC 60317-3:2004/AMD1:2010
- 438 IEC 60317-8, *Specifications for particular types of winding wires – Part 8: Polyesterimide*
439 *enamelled round copper wire, class 180*
- 440 IEC 60317-13, *Specifications for particular types of winding wires – Part 13: Polyester or*
441 *polyesterimide overcoated with polyamide-imide enamelled round copper wire, class 200*
- 442 IEC 60317-46, *Specifications for particular types of winding wires – Part 46: Aromatic polyimide*
443 *enamelled round copper wire, class 240*
- 444 IEC 60400, *Lampholders for tubular fluorescent lamps and starterholders*
- 445 IEC 60432-1, *Incandescent lamps – Safety specifications – Part 1: Tungsten filament lamps for*
446 *domestic and similar general lighting purposes*
- 447 IEC 60432-2, *Incandescent lamps – Safety specifications – Part 2: Tungsten halogen lamps for*
448 *domestic and similar general lighting purposes*
- 449 IEC 60432-3, *Incandescent lamps – Safety specifications – Part 3: Tungsten halogen lamps*
450 *(non-vehicle)*
- 451 IEC 60529, *Degrees of protection provided by enclosures (IP Code)*
- 452 IEC 60598-1, *Luminaires – Part 1: General requirements and tests*
- 453 IEC 60664-1, *Insulation coordination for equipment within low-voltage systems – Part 1:*
454 *Principles, requirements and tests*
- 455 IEC 60947-1, *Low-voltage switchgear and controlgear – Part 1: General rules*
- 456 IEC 60947-7-1, *Low-voltage switchgear and controlgear – Part 7-1: Ancillary equipment –*
457 *Terminal blocks for copper conductors*
- 458 IEC 60947-7-2, *Low-voltage switchgear and controlgear – Part 7-2: Ancillary equipment –*
459 *Protective conductor terminal blocks for copper conductors*
- 460 IEC 60947-7-4, *Low-voltage switchgear and controlgear – Part 7-4: Ancillary equipment – PCB*
461 *terminal blocks for copper conductors*
- 462 IEC 60998-2-4, *Connecting devices for low-voltage circuits for household and similar purposes*
463 *– Part 2-4: Particular requirements for twist-on connecting devices*
- 464 IEC 60999-1, *Connecting devices – Electrical copper conductors – Safety requirements for*
465 *screw-type and screwless-type clamping units – Part 1: General requirements and particular*
466 *requirements for clamping units for conductors from 0,2 mm² up to 35 mm² (included)*

- 467 IEC 60999-2, *Connecting devices – Electrical copper conductors – Safety requirements for*
 468 *screw-type and screwless-type clamping units – Part 2: Particular requirements for clamping*
 469 *units for conductors above 35 mm² up to 300 mm² (included)*
- 470 IEC 61184, *Bayonet lampholders*
- 471 IEC 61195, *Double-capped fluorescent lamps – Safety specifications*
- 472 IEC 61347-1, *Lamp controlgear – Part 1: General and safety requirements*
- 473 IEC 61347-2-3, *Lamp control gear – Part 2-3: Particular requirements for a.c. and/or d.c.*
 474 *supplied electronic control gear for fluorescent lamps*
- 475 IEC 62035, *Discharge lamps (excluding fluorescent lamps) – Safety specifications*
- 476 ISO 2859-1, *Sampling procedures for inspection by attributes – Part 1: Sampling schemes*
 477 *indexed by acceptance quality limit (AQL) for lot-by-lot inspection*
- 478 ISO 527-2, *Plastics – Determination of tensile properties – Part 2: Test conditions for moulding*
 479 *and extrusion plastics*
- 480 ISO 178, *Plastics – Determination of flexural properties*
- 481 ANSI/UL 746B, *Polymeric Materials – Long Term Property Evaluations*

482 **3 Terms and definitions**

483 For the purposes of this document, the terms and definitions given in IEC 60079-0 and the following
 484 apply.

485 ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- 486 • IEC Electropedia: available at <http://www.electropedia.org/>
- 487 • ISO Online browsing platform: available at <http://www.iso.org/obp>

488 **3.1**

489 **comparable converter**

490 a converter where the losses in the converter-supplied motor are not higher than the losses that would
 491 have occurred if the motor were used with the specific converter that was used during the type test

492 Note 1 to Entry: Additional information on determining comparability is given in Annex L.

493 **3.2**

494 **duty type (motor)**

495 continuous, short-time or periodic duty, comprising one or more loads remaining constant for the
 496 duration specified, or a non-periodic duty in which generally load and speed vary within the
 497 permissible operating range

498 Note 1 to entry: These include duty types S1 to S10, as defined in IEC 60034-1.

499 **3.3**

500 **ferrule**

501 metal tube crimped over fine-stranded wire to secure it within a terminal usually with electrical
 502 insulation protecting any exposed portion of the wire not completely inside the terminal post

503

504 **increased safety "e"**
 505 **Type of Protection** applied to **Ex Equipment** or **Ex Components** in which additional measures are
 506 applied so as to give increased security against the possibility of excessive temperatures and against
 507 the occurrence of arcs and sparks

508 **3.4**
 509 **initial starting current**
 510 **I_A**
 511 highest **RMS** value of current drawn by an **AC** motor when at rest or by an **AC** magnet with its armature
 512 clamped in the position of maximum air gap when supplied at rated voltage and rated frequency

513 Note 1 to entry: Transient phenomena are ignored.

514 **3.5**
 515 **Light Emitting Diode**
 516 **LED**
 517 solid state device embodying a p-n junction, emitting optical radiation when excited by an electric
 518 current

519 **3.6**
 520 **LED module**
 521 light source having no cap, incorporating one or more LED package(s) on a printed circuit board, and
 522 possibly including one or more of the following: electrical, optical, mechanical, and thermal
 523 components, interfaces, and controlgear

524 **3.7**
 525 **LED package**
 526 single electrical component encapsulating principally one or more LEDs, possibly with optical elements
 527 and thermal, mechanical, and electrical interfaces

528 Note 1 to entry: The component does not include the control unit of the controlgear, does not include a cap, and is not
 529 connected directly to the supply voltage.

530 Note 2 to entry: An LED package is a discrete component and part of the LED module or LED lamp.

531 **3.8**
 532 **normal service**
 533 <machines> continuous operation at the nameplate rating (or set of ratings) generally including
 534 starting conditions

535 Note 1 to entry: For motors of duty type S1, S2, S6 or S9, normal service for electrical machines for Level of Protection "ec"
 536 are assumed to be rated full-load steady conditions. For motors of duty types S3, S4, S5, S7, S8 or S10, normal service for
 537 Level of Protection "ec" includes starting.

538 **3.9**
 539 **rated dynamic current**
 540 **I_{dyn}**
 541 peak value of the current, the dynamic effect of which the electrical equipment can sustain without
 542 damage

543 **3.10**
 544 **rated short-time thermal current**
 545 **I_{th}**
 546 **RMS** value of the current required to heat up the conductor within 1 s from the temperature reached in
 547 rated service at the maximum ambient temperature to a temperature not exceeding the limiting
 548 temperature

3.11**resistance-heating applications****3.11.1****resistance-heating**

utilization of electric resistance-heating devices, units and any associated controls (other than electrical trace heating systems)

Note 1 to entry: Electric trace heating systems are addressed by IEC 60079-30-1.

3.11.2**resistance-heating device**

part of a resistance heating unit consisting of one or more heating resistors, typically composed of metallic conductors or an electrically conductive material suitably insulated and protected

Note 1 to entry: An example of a resistance heating device covered by this standard is an anti-condensation heater.

3.11.3**resistance-heating unit**

equipment consisting of an assembly of one or more resistance heating devices associated with any safety devices necessary to ensure that the limiting temperature is not exceeded

Note 1 to entry: It is not intended that the safety devices necessary to ensure that the limiting temperature is not exceeded should have Type of Protection "e" or any [Type of Protection](#) when they are located outside the hazardous area.

3.11.4**stabilized design**

design where the temperature of the resistance-heating device or resistance-heating unit will, by design and use, stabilize below the limiting temperature, under the most unfavourable conditions, without the need for a safety device to limit the temperature

3.11.5**temperature self-limiting characteristic**

characteristic whereby the thermal output of a resistance-heating device at its rated voltage decreases as the temperature of its surroundings increases until the device reaches a temperature at which its thermal output is reduced to a value at which there is no further rise in temperature

Note 1 to entry: The temperature of the surface of the element is then effectively that of its surroundings.

3.11.6**workpiece**

object to which a resistance-heating device or resistance-heating unit is applied

3.12**pulse frequency**

f_p

frequency, resulting from the average modulation cycle duration, which characterizes the lowest non-controllable frequency lobe of the phase-to-phase voltage spectrum

3.13**semiconductor device**

device, the essential electric characteristics of which are due to the flow of charge carriers within one or more semiconductor materials

[SOURCE: 151-13-63]

3.14**short-circuit current**

I_{sc}

maximum RMS value of the short-circuit current to which the equipment may be subjected in service

595 Note 1 to entry: This maximum value is recorded in the documentation prepared according to IEC 60079-0.

596 **3.15**

597 **starting current ratio**

598 I_A/I_N

599 ratio between initial starting current I_A and rated current I_N

600 **3.16**

601 **stator winding**

602 stationary winding in an electric machine, either for rotary or linear motion

603 **3.17**

604 **switching frequency**

605 f_{sw}

606 number of switching events of one semiconductor within one second

607 Note 1 to entry: It determines, together with the selected pulse pattern and the converter topology, the lowest frequency of
608 non-controllable harmonics or inter-harmonics at the IPC (in-plant point of coupling) or the motor.

609 Note 2 to entry: To turn on and turn off the semiconductor's switch are separate switching events. Thus, the switching
610 frequency of a two level converter is two times the pulse frequency (also called the carrier frequency) of the phase-to-phase
611 voltage for modulation that uses continuous switching and about 1,33 times the pulse frequency of the phase-to-phase
612 voltage for modulation that uses discontinuous switching.

613 **3.18**

614 **terminal**

615 conductive part of a device provided for electrical connection to external or internal circuits

616 Constructional requirements

617 **3.19**

618 **time**

619 t_E

620 time, in seconds, taken for an AC rotor or stator winding, when carrying the initial starting current I_A ,
621 to be heated up to the limiting temperature from the temperature reached in rated service at the
622 maximum ambient temperature (see Figure A.1)

623 **3.20**

624 **trace heater**

625 device designed for the purpose of producing heat on the principle of electrical resistance and typically
626 composed of one or more metallic conductors or an electrically conductive material suitably electrically
627 insulated and protected

628 Note 1 to entry: For additional information on trace heaters, see IEC 60079-30-1.

629 **4 Construction requirements**

630 **4.1 Level of Protection**

631 Electrical equipment with Type of Protection increased safety "e" shall be one of the following:

- 632 – Level of Protection "eb" (EPL "Mb" or "Gb"); or
- 633 – Level of Protection "ec" (EPL "Gc").

634 The requirements of this clause apply, unless otherwise stated in Clause 5, to all Ex Equipment and
635 Ex Components with Type of Protection "e".

636 Ex Equipment and Ex Components evaluated as Level of Protection "ec" may include manually
637 operated arcing or sparking components under the following conditions:

- located within an enclosure that cannot be opened without the use of a tool such as a key, screwdriver, or wrench; and
- cannot be accessed or operated without opening the enclosure

4.2 Electrical connections

4.2.1 General

Electrical connections intended to be terminated internal to the equipment enclosures are subdivided into those for field wiring connections, 4.2.2, and for factory connections, 4.2.3, and into permanent types and reconnectable / rewirable types for convenience in detailing the appropriate requirements.

External earthing and equipotential bonding connections shall comply with the requirements for field wiring connections, 4.2.2.

Each type shall, as applicable:

- a) be constructed in such a way that the conductors cannot slip out from their intended location during tightening of a screw or after insertion;
 - b) provide a means to avoid loosening of the connection in service;
 - c) be such that contact is assured without damage to the intended conductors such that would impair the ability of the conductors to fulfil their function;
 - d) provide a positive compression force to assure contact pressure in service;
 - e) be constructed in such a way that the contact they assure is not appreciably impaired by temperature changes occurring in normal service;
 - f) provide contact pressure that does not depend on the structural integrity of insulating materials except;
-as permitted by the earth continuity test of IEC 60079-0 or
-for printed circuit board material (See 4.6.2)
- NOTE Printed circuit boards are often inserted into card edge connectors where the contact pressure relies on the stability of the insulating material
- g) not be specified to accommodate more than one individual conductor in a clamping point unless specifically designed and assessed for doing so;
 - h) if intended for stranded conductors, employ a means to protect the conductors and distribute the contact pressure evenly. The method of applying contact pressure shall be capable, on installation, of reliably forming the stranded conductor into an effectively solid shape that does not subsequently change in service. Alternatively, the method of applying the contact pressure should be such that it is designed to accommodate any settlement of the strands in service;
 - i) for screw connections, have a torque value specified by the manufacturer;
 - j) for screwless connections intended for class 5 and/or class 6 fine-stranded conductors according to IEC 60228, the instructions shall specify that the fine-stranded conductor shall be equipped with a ferrule (See 9.3.2 c) or the termination shall have a method to open the clamping mechanism so that the conductors are not damaged during the installation of the conductor.

NOTE 1 The use of aluminium wire can cause difficulties by compromising critical creepage and clearance distances when anti-oxidant materials are applied. The connection of aluminium wire to terminals is typically by the use of suitable bi-metallic connection devices providing a copper connection to the terminal.

NOTE 2 Special precautions against vibration and mechanical shock are often applied to reduce the risk of loosening.

NOTE 3 Electrolytic corrosion where ferrous materials are used can occur. Guidance on limitation of corrosion based on the limitation of electrochemical potential between dissimilar metals can be found in IEC TR 60943.

NOTE 4 The limiting temperature of the insulation of terminal blocks and accessories will usually be based on the limiting temperature of the insulation in accordance with item a) of 4.7.2 but the limiting temperature allocated to the

terminal when used in equipment will also depend on the maximum cable insulation temperature rating of the cable which is to be connected.

4.2.2 Field wiring connections

4.2.2.1 General

Terminals for field wiring shall be dimensioned to allow the effective connection of conductors of cross-section equal to at least that required for the rated current of the electrical equipment.

Connections shall be located in a position so that when required to be inspected in service they are reasonably accessible.

The number, size, and type of conductors that can be safely connected shall be specified in the documentation prepared in accordance with IEC 60079-0.

NOTE 1 The "type of conductor" includes features such as conductor material and stranding.

NOTE 2 Some types of cables, such as those used to conform to EMC requirements, include multiple earthing conductors. Facilities are sometimes required for the termination of more earthing conductors than would normally be expected.

4.2.2.2 Connections made using terminal blocks

These requirements apply to terminal blocks of the types defined by IEC 60947-7-1, IEC 60947-7-2, IEC 60947-7-3, IEC 60947-7-4, IEC 60999-1, or IEC 60999-2.

Such terminals are intended for the connection of copper conductors with the insulation locally removed and without the addition of intermediate parts other than those replicating the form of a bare conductor, such as a ferrule.

Terminals in Level of Protection "eb" shall be subject to the terminal insulation material tests of 6.10.

Fused terminal blocks defined by IEC 60947-7-3 are only suitable for Level of Protection "ec" and shall also comply with requirements of 5.9.

Terminals shall be capable of being fixed in their mountings.

For Ex Component terminals in Level of Protection "eb", the temperature rise of the conductor bar shall not exceed 40 K at a reference current of 110 % of rated current according to the method of the temperature-rise test of IEC 60947-7-1.

NOTE 1 The 40 K rise referred to in 4.2.2.2 is only for the Ex Component evaluation of terminals and is not determined in the actual application of the terminal, where a rise of more or less than 40 K may be observed. The reference current is used for the comparison of terminals to allow the "worst case" to be determined. See 8.2g), 6.8 and Annex E.

NOTE 2 This test relates to the absolute maximum current rating of the terminal when tested without any enclosure. For practical purposes, when terminals are used in multiples within enclosures, it will be necessary to establish reduced current ratings according to the particular circumstances. See 5.7, 6.8 and Annex E.

Terminals for connecting conductors of rated cross-section not exceeding 35 mm² (2 AWG) shall also be suitable for the effective connection of conductors at least two ISO wire sizes smaller, in accordance with Annex F, if not otherwise specified in the certificate.

4.2.2.3 Integral field wiring connection facilities

Integral field wiring connection facilities shall meet the requirements of 4.2.2.2, as applicable.

NOTE 1 The connection facilities for Ex Equipment or Ex Components employing other types of protection, such as flameproof enclosure "d", permit installation using increased safety "e" as the connection method.

NOTE 2 The 40 K rise referred to in 4.2.2.2 is only for the Ex Component evaluation of terminals and is not determined in the actual application of the terminal, where a rise of more or less than 40 K may be observed.

4.2.2.4 Connections designed to be used with cable lugs and similar devices

Such connections shall be fixed in their mountings.

Terminals shall meet the requirements of 4.2.2.1.

Terminals in Level of Protection “eb” shall be subject to the terminal insulation material tests of 6.10.

A means of securing the cable or conductors to prevent rotation or movement shall be provided to avoid either loosening or compromising creepage and clearance. Alternatively, the certificate number shall include the “X” suffix in accordance with the marking requirements of IEC 60079-0 and the Specific Conditions of Use listed on the certificate shall detail the provisions for securing the cable or conductors to avoid compromising creepage and clearance, and the provisions to avoid loosening of the connections. If the option to use marking instead of the “X” suffix is employed in accordance with IEC 60079-0, this marking may appear on either the exterior or the interior of the connection compartment.

NOTE Conductors with rated cross-section greater than 35 mm² can provide sufficient rigidity to avoid compromising creepage and clearance.

4.2.2.5 Connections using permanent arrangements

These connections are typically individual conductors (flying leads) that are intended to be terminated during installation using appropriate connection methods, see 4.2.1. Either a means of fixing the completed connections to a suitable location is to be provided or the completed connections are to be provided with means of reliably insulating them to the requirements of this standard.

If the method of connection is by soldering, a method of providing mechanical support of the completed connection, in addition to the solder, shall be provided. The mechanical support of the connection shall not be permitted to rely solely on the solder.

NOTE The intent of the mechanical support is to avoid mechanical stresses being transferred to the electrical connection.

4.2.3 Factory connections

4.2.3.1 General

Factory connections shall be either fixed in a specific location or be provided with means of meeting the creepage and clearance requirements of this standard.

Any of the connection methods suitable for use as field wiring connections may be used for a factory connection, except in this case, the terminal insulation material tests of 6.10 need not be conducted for either Level of Protection “eb” or “ec”.

NOTE The requirements for the thermal stability of the insulating material are given in 4.5.

4.2.3.2 Twist-on connectors for Level of Protection “ec”

In addition to the connection methods suitable for field wiring connections, twist-on connecting devices meeting the requirements of IEC 60998-2-4 may also be used for factory connections in Level of Protection “ec”.

4.2.3.3 Permanent connections

Permanent connections shall only be made by:

- a) crimping;
- b) brazing;
- c) welding;

d) soldering, with mechanical support of the completed connection, in addition to the solder, provided; or

e) In Level of Protection “ec”, **soldering of** printed circuit board mounted components, including surface-mount and through-hole mount components, **without** additional mechanical support

NOTE 1 The intent of the mechanical support is to avoid mechanical stresses being transferred to the electrical connection.

NOTE 2 The process commonly referred to as “silver soldering” is considered “brazing”.

4.2.3.4 Pluggable connections for Level of Protection “eb”

These connections are designed to be readily connected or disconnected during assembly, maintenance, or repair.

NOTE Typical examples are plug-in components, and card edge connectors

Pluggable connections in Level of Protection “eb” shall provide the following:

- a) each connection shall employ at least two areas of contact where the loss of one area of contact does not compromise the effectiveness of the other;
- b) the connection shall be provided with an interlock to prevent separation when energized or shall be marked in accordance with item a) of Table 19. For small items, adjacent marking can be provided; and
- c) Connection secureness **using either of the following:**

- each connection or group of connections shall be provided with a mechanical retaining device, which, excluding internal friction, provides a force resisting separation of at least 30 N with the force applied gradually near the centre of the component. Where a group of individual connections is mechanically linked and the separable component **has a mass of** more than 0,25 kg or carries more than 10 conductors, special consideration shall be given to the security of the connection; or

NOTE 3 It is the intent that the effectiveness of the mechanical retention for Level of Protection “eb” be evaluated by test due to the increased risk of ignition due to separation of contacts in equipment of EPL Gb.

- for a connecting component relying on friction to remain in place and not attached in any way outside of the connection points, **take the numerical value of 200 times the mass (in kg) of the component, and apply it (in Newtons) as a tensile force**, with the force applied gradually near the centre of the component. In this case, a mechanical retaining device is not required.

4.2.3.5 Pluggable connections for Level of Protection “ec”

These connections are designed to be readily connected or disconnected during assembly, maintenance, or repair.

NOTE Typical examples are connectors, plug-in components, and card edge connectors

Sockets of pluggable connection for Level of Protection “ec”, which in normal operation do not have a plug inserted and which are intended to be used only for maintenance and repairing, are evaluated without the mating part inserted.

Pluggable connections in Level of Protection “ec” shall provide connection secureness using either of the following:

- a) Each connection or group of connections shall be provided with a mechanical retaining device, excluding internal friction, or shall provide a force resisting separation of at least 15 N with the separating force applied gradually near the centre of the component. Where a group of individual connections is mechanically linked and the separable component **with a mass of** more than 0,25 kg or carries more than 10 conductors, special consideration shall be given to the security of the connection.

A means to evaluate the effectiveness of the mechanical retention is by the 15 N test described herein.

- b) For a connecting component relying on friction to remain in place and not attached in any way outside of the connection points, [take the numerical value of 100 times the mass \(in kg\) of the component, and apply it \(in Newtons\) as a tensile force, with the force applied gradually near the centre of the component](#). In this case, a mechanical retaining device is not required.

4.2.3.6 Pluggable terminal bridging connections

These connections are intended to be made one-time only and not connected or disconnected during maintenance or repair. For Level of Protection “eb”, a terminal bridging connector [shall have a separating force \(in Newtons\) that is calculated by taking the numerical value of 100 times the mass \(in kg\) of the component, and applying it \(in Newtons\) as a tensile force, with the force applied gradually near the centre of the terminal bridging connector](#).

For Level of Protection “ec”, a terminal bridging connector shall have a separating force in Newtons [that is calculated by taking the numerical value of 100 times the mass \(in kg\) of the component, and applying it \(in Newtons\) as a tensile force, with the force applied gradually near the centre of the terminal bridging connector](#).

4.2.4 External plug and socket connections for field wiring connection

Plug and socket connections, where the flange plug / socket forms part of the wall of the enclosure, and the mating plug / socket is intended to be inserted externally, shall comply with the supplementary requirements of this sub-clause. The connections of the mating portion, if provided un-terminated, are considered field wiring.

Plugs and sockets for field wiring connections either:

- Between one piece of electrical equipment and another piece of electrical equipment (by means of a cable assembly involving plugs / sockets on both ends; or a plug / socket on one end and un-terminated cable on the other), or
- Between the fixed installation and a piece of electrical equipment (by means of a cable assembly involving a socket on the equipment end and un-terminated cable on the fixed installation end),

shall comply with item a), b) or c) as follows:

- a) they shall be interlocked mechanically or electrically, or otherwise designed so that they cannot be separated when the contacts are energized and the contacts cannot be energized when [the plug and socket are separated](#);
- b) the equipment marked with the CONNECT / DISCONNECT marking as required by item a) of Table 19, and for:
 - Level of Protection “ec”:
 - [fixed together by means of a fastener in accordance with the general fastener requirements of IEC 60079-0](#);
 - [interconnected by means of two \(2\) or more engaged threads](#); or
 - [provided with a mechanical retaining device, other than friction, that ensures a minimum separation force of 30 N with the separating force applied gradually near the centre of the plug or socket](#).
 - Level of Protection “eb”, fixed together by means of [a special fastener according to IEC 60079-0](#).
- c) [where they cannot be de-energized before connection or disconnection according to b\) above because they are connected to a battery, the marking shall state the separation warning required by item j\) of Table 19](#).

Provision shall be made for the fixed part of a plug and socket connector to maintain the degree of protection (IP) of the enclosure on which it is mounted, even when the mating plug or socket has been removed. If the degree of protection (IP) is effectively reduced by accumulation of dust or water, provision shall also be made for maintaining an appropriate degree of protection (IP) for the plug or socket.

4.3 Insulation coordination

4.3.1 Environmental conditions

The conditions of the micro-environment for the insulation shall be taken into account. They depend primarily on the conditions of the macro-environment in which the equipment is located and, in many cases, the environments are identical. However, the micro-environment can be better or worse than the macro-environment where, for example, enclosures, heating, ventilation or dust influence the micro-environment.

NOTE 1 Protection by enclosures provided according to the degrees of protection specified in IEC 60529 may increase the humidity of the micro-environment [as per IEC 60664-5].

NOTE 2 The main environmental parameters are as follows [as per IEC 60664-5]:

- for clearances
 - air pressure,
 - temperature, if it has a wide variation;
- for creepage distances
 - air pressure,
 - pollution,
 - relative humidity,
 - condensation;
- for solid insulation
 - temperature,
 - relative humidity

4.3.2 Clearances

4.3.2.1 General

Clearances shall be determined as a function of the working voltage. Where the equipment is intended for more than one rated voltage or for a range of rated voltages, the value of working voltage to be used shall be based on the highest value of rated voltage. In determining the clearances, Examples 1 to 11 (inclusive) in Figure 3 illustrate the features to be taken into account and the appropriate clearances.

Spacings at wiring terminals shall be evaluated with and without the conductor to determine the minimum clearance under worst case conditions. Conductor arrangement shall be as specified by the manufacturer.

NOTE 1 The conductor arrangement by the manufacturer includes conductor sizes, conductor stripping dimensions, conductor ferrule usage, maximum screw torque, etc.

NOTE 2 A wiring terminal supplied with the conductor clamping arrangement fully open can present the worst case condition for spacings.

4.3.2.2 Clearances for Level of Protection “eb”

Clearances between bare conductive parts at different potentials shall be as given in Table 2 with a minimum value for field wiring connections of 3 mm.

4.3.2.3 Clearances for Level of Protection “ec”

Clearances between bare conductive parts at different potentials shall be designed in accordance with Figure 2 with a minimum value for field wiring connections of 1,5 mm.

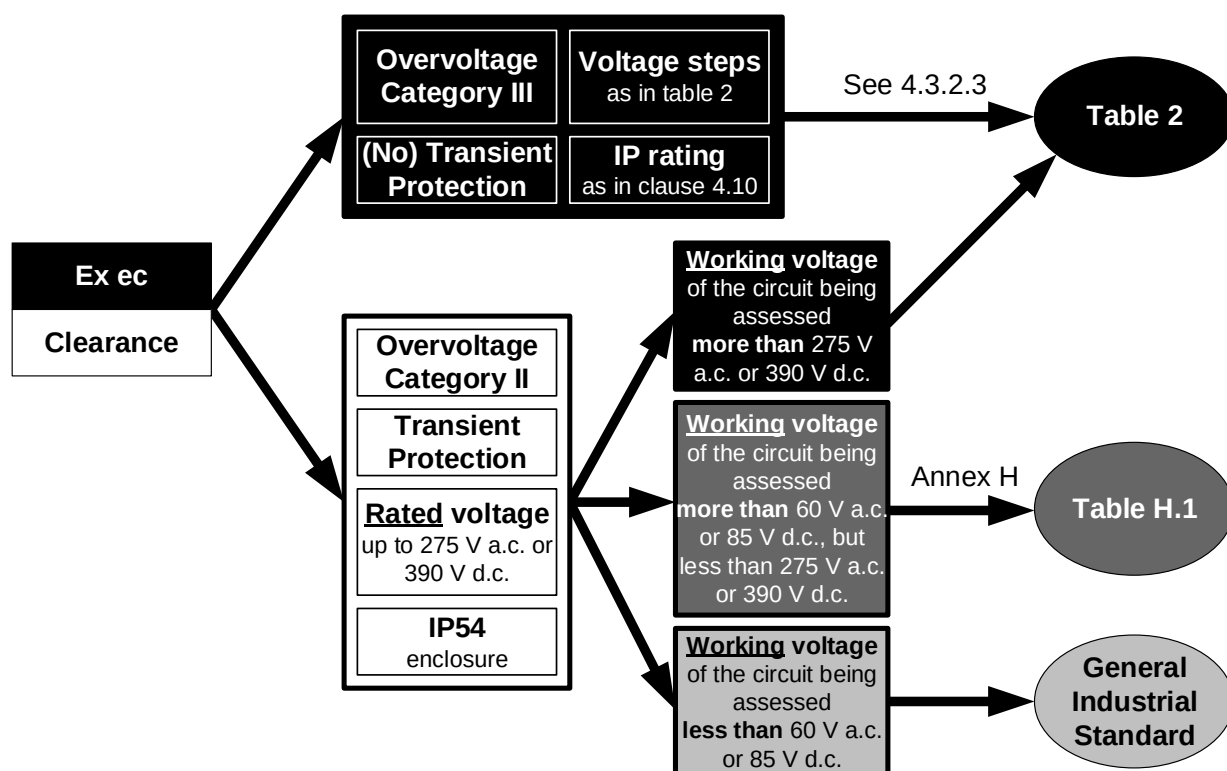


Figure 1 – Clearance for Level of Protection “ec”

4.3.3 Creepage distances

4.3.3.1 General

Spacings at wiring terminals shall be evaluated with and without the conductor to determine the minimum creepage distance.

Table 1 gives the grouping of electrical insulating materials according to the comparative tracking index (CTI) determined in accordance with IEC 60112. Inorganic insulating materials, for example glass and ceramics, do not track and need not therefore be subjected to the determination of the CTI. They are conventionally classified in material group I.

The grouping given in Table 1 is applied to insulating parts without ribs or grooves. If there are ribs or grooves in accordance with 0, the minimum permissible creepage distances for working voltages up to 1 100 V shall be based on the next higher material group, for example material group I instead of material group II.

NOTE 1 The material groups are identical with those given in IEC 60664-1.

Table 1 – Tracking resistance of insulating materials

Material group	Comparative tracking index (CTI)
I	$600 \leq \text{CTI}$
II	$400 \leq \text{CTI} < 600$
IIIa	$175 \leq \text{CTI} < 400$
IIIb	$100 \leq \text{CTI} < 175$

4.3.3.2 Creepage distances for Level of Protection “eb”

Creepage distances between bare conductive parts at different potentials shall be as given in Table 2, with a minimum value for field wiring connections of 3 mm and shall be determined based on the working voltage determined as a function of the rated voltage of the equipment. In determining the creepage distance, Figure 3 illustrates the features to be taken into account and the appropriate creepage distance. The value of dimension 'X' is 2,5 mm for Level of Protection “eb” and 1,5 mm for Level of Protection “ec”.

The effects of ribs and grooves may be taken into account provided that:

- ribs on the surface are at least 2,5 mm high and of a thickness appropriate to the mechanical strength of the material with a minimum value of 1,0 mm;
- grooves on the surface are at least 2,5 mm deep and at least 2,5 mm wide. If the associated clearance is less than 3 mm, the minimum groove width may be reduced to 1,5 mm.

Projections above or depressions below the surface are considered as being either ribs or grooves, irrespective of their geometric form.

Cement or compound used as part of the electrical insulation system is considered to be a solid electrical insulating material.

4.3.3.3 Creepage distances for Level of Protection “ec”

Creepage distances between bare conductive parts at different potentials shall be designed in accordance with Figure 2, with a minimum value for field wiring connections of 1,5 mm and shall be based on the working voltage determined as a function of the rated voltage of the equipment.

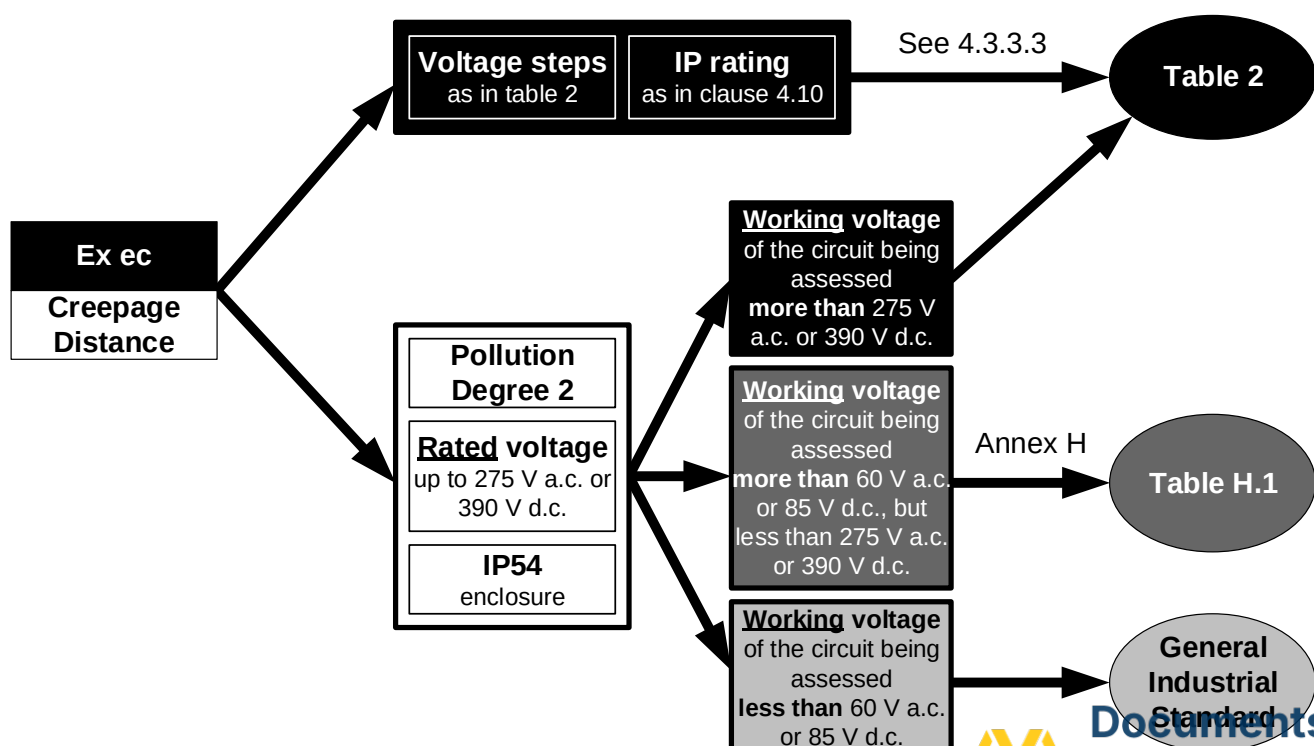


Figure 2 – Creepage distance for Level of Protection “ec”

In determining the creepage distance, Figure 3 illustrates the features to be taken into account and the appropriate creepage distance. The value of dimension 'X' is 1,5 mm.

The effects of ribs and grooves may be taken into account provided that:

- ribs on the surface are at least 1,5 mm high and of a thickness appropriate to the mechanical strength of the material with a minimum value of 0,4 mm;
- grooves on the surface are at least 1,5 mm deep and at least 1,5 mm wide.

Projections above or depressions below the surface are considered as being either ribs or grooves, irrespective of their geometric form.

Cement or compound used as part of the electrical insulation system is considered to be a solid electrical insulating material.

4.3.4 Separation distances

Table 2 – Minimum Creepage distances, clearances and separations

Voltage (see a and b) <i>U</i> <i>AC_{RMS}</i> or <i>DC</i> V	Minimum creepage distance								Clearance mm		Distance		
	mm										mm		
	Material group										under		
	I		II		IIIa		IIIb				Coating ^e	Type 1 Coating ^e	Type 2 Coating ^e
"eb"	"ec"	"eb"	"ec"	"eb"	"ec"	"eb"	"ec"	"ec"	"ec"	"ec"			
≤10 (see °)	1,6	<i>-_d</i>	1,6	<i>-_d</i>	1,6	<i>-_d</i>	-	<i>-_d</i>	1,6	<i>-_d</i>	<i>-_d</i>	<i>-_d</i>	<i>-_d</i>
≤ 12,5	1,6	<i>-_d</i>	1,6	<i>-_d</i>	1,6	<i>-_d</i>	-	<i>-_d</i>	1,6	<i>-_d</i>	<i>-_d</i>	<i>-_d</i>	<i>-_d</i>
≤ 16	1,6	1,1	1,6	1,1	1,6	1,1	-	1,1	1,6	0,8	<i>0,3</i>	<i>0,1</i>	<i>0,1</i>
≤ 20	1,6	1,2	1,6	1,2	1,6	1,2	-	1,2	1,6	0,8	<i>0,3</i>	<i>0,11</i>	<i>0,1</i>
≤ 25	1,7	1,25	1,7	1,25	1,7	1,25	-	1,25	1,7	0,8	<i>0,3</i>	<i>0,125</i>	<i>0,1</i>
≤ 32	1,8	1,3	1,8	1,3	1,8	1,3	-	1,3	1,8	0,8	<i>0,3</i>	<i>0,14</i>	<i>0,1</i>
≤ 40	1,9	1,4	2,4	1,6	3,0	1,8	-	1,8	1,9	0,8	<i>0,6</i>	<i>0,16</i>	<i>0,1</i>
≤ 50	2,1	1,5	2,6	1,7	3,4	1,9	-	1,9	2,1	0,8	<i>0,6</i>	<i>0,18</i>	<i>0,1</i>
≤ 63	2,1	1,6	2,6	1,8	3,4	2	-	2	2,1	0,8	<i>0,6</i>	<i>0,25</i>	<i>0,2</i>
≤ 80	2,2	1,7	2,8	1,9	3,6	2,1	-	2,1	2,2	0,8	<i>0,8</i>	<i>0,25</i>	<i>0,2</i>
≤ 100	2,4	1,8	3,0	2	3,8	2,2	-	2,2	2,4	0,8	<i>0,8</i>	<i>0,25</i>	<i>0,2</i>
≤ 125	2,5	1,9	3,2	2,1	4,0	2,4	-	2,4	2,5	1	<i>0,8</i>	<i>0,75</i>	<i>0,45</i>
≤ 160	3,2	2	4,0	2,2	5,0	2,5	-	2,5	3,2	1,5	<i>1,1</i>	<i>0,75</i>	<i>0,45</i>
≤ 200	4,0	2,5	5,0	2,8	6,3	3,2	-	3,2	4,0	2	<i>1,7</i>	<i>1,5</i>	<i>1,2</i>
≤ 250	5,0	3,2	6,3	3,6	8,0	4	-	4	5,0	2,5	<i>1,7</i>	<i>1,5</i>	<i>1,2</i>
≤ 320	6,3	4	8,0	4,5	10,0	5	-	5	6,0	3	<i>2,4</i>	<i>1,5</i>	<i>1,2</i>
≤ 400	8,0	5	10,0	5,6	12,5	6,3	-	6,3	6,0	4	<i>2,4</i>	<i>1,92</i>	<i>1,5</i>
≤ 500	10	6,3	12,5	7,1	16	8	-	8	8,0	5	<i>2,4</i>	<i>2,33</i>	<i>1,5</i>
≤ 630	12	8	16	9	20	10	-	10	10	5,5	<i>2,9</i>	<i>2,75</i>	<i>1,5</i>
≤ 800	16	10	20	11	25	12,5	-	-	12	7	<i>4</i>	<i>4,0</i>	<i>3</i>
≤ 1 000	20	11	25	11	32	13	-	-	14	8	<i>5,8</i>	<i>4,0</i>	<i>3</i>
≤ 1 250	22	12	26	12	32	15	-	-	18	10	-	-	-
≤ 1600	23	13	27	13	32	17	-	-	20	12	-	-	-
≤ 2 000	25	14	28	14	32	20	-	-	23	14	-	-	-
≤ 2 500	32	18	36	18	40	25	-	-	29	18	-	-	-
≤ 3 200	40	22	45	22	50	32	-	-	36	22	-	-	-
≤ 4 000	50	28	56	28	63	40	-	-	44	28	-	-	-
≤ 5 000	63	36	71	36	80	50	-	-	50	36	-	-	-
≤ 6 300	80	45	90	45	100	63	-	-	60	45	-	-	-
≤ 8 000	100	56	110	56	125	80	-	-	80	56	-	-	-
≤ 10 000	125	71	140	71	160	100	-	-	100	70	-	-	-
≤ 12 500	-	90	-	90	-	125	-	-	-	89	-	-	-
≤ 13 640	-	98	-	98	-	138	-	-	-	97	-	-	-

^a When determining the required values for creepage and clearance, the working voltage may be higher than the voltage in Table 2 by a factor of 1,1.

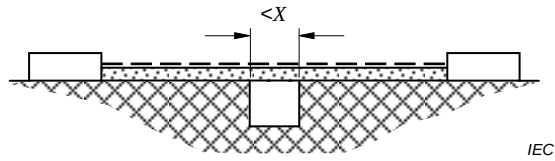
NOTE The factor of 1,1 recognizes that at many places in a circuit, the working voltage equals the rated voltage and that there are a number of rated voltages in common use that can be accommodated by the 1,1 factor.

^b The creepage distance and clearance values shown already take into account a maximum supply voltage tolerance of ±10 %. Therefore it is not necessary to further consider supply voltage fluctuations when determining which voltage value from Table 2 to use.

^c At 10 V and below, the value of CTI is not relevant and materials not meeting the requirement for material group IIIb may be acceptable.

d	For Level of Protection "ec" general industrial spacings apply for 10 V and 12.5 V.
e	The distances under coating shown are permitted for printed circuit boards in Level of Protection "ec" as described in 4.4.

Example 1



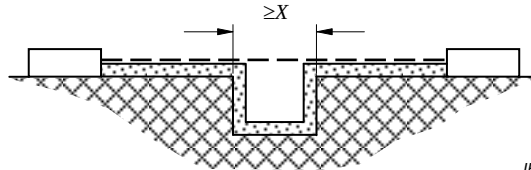
IEC

Condition: Path under consideration includes a parallel- or converging-sided groove of any depth with a width less than X mm.

Rule: Creepage distance and clearance are measured directly across the groove as shown.

— — — — 1 clearance 2 creepage distance

Example 2



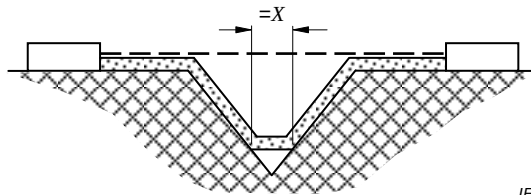
IEC

Condition: Path under consideration includes a parallel-sided groove of any depth d equal to or more than X mm.

Rule: Clearance is the 'line of sight' distance. Creepage path follows the contour of the groove.

— — — — 1 clearance 2 creepage distance

Example 3



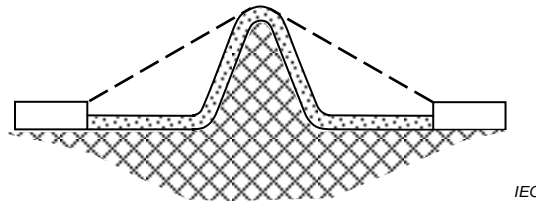
IEC

Condition: Path under consideration includes a V-shaped groove with a width greater than X mm.

Rule: Clearance is the 'line of sight' distance. Creepage path follows the contour of the groove but 'short circuits' the bottom of the groove by X mm link.

— — — — 1 clearance 2 creepage distance

Example 4



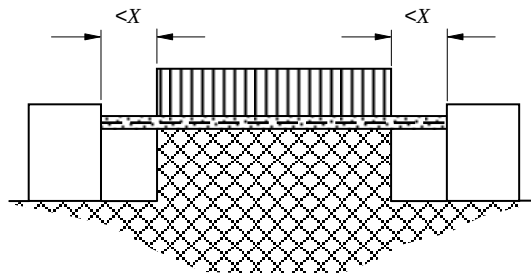
IEC

Condition: Path under consideration includes a rib.

Rule: Clearance is the shortest direct air path over the top of the rib. Creepage path follows the contour of the rib.

----- 1 clearance 2 creepage distance

Example 5



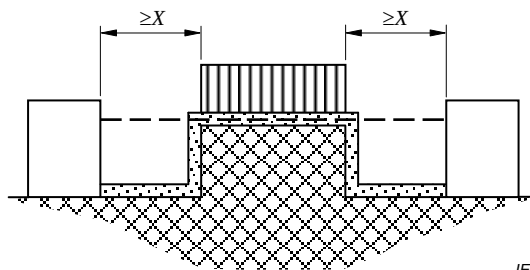
IEC

Condition: Path under consideration includes an uncemented joint with groove less than X mm wide on each side.

Rule: Creepage and clearance path is the 'line of sight' distance shown.

----- 1 clearance 2 creepage distance

Example 6



IEC

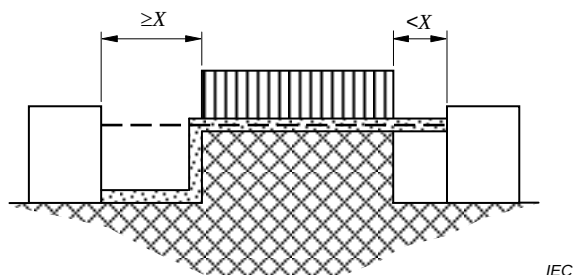
Condition: Path under consideration includes an uncemented joint with grooves equal to or more than X mm wide on each side.

Rule: Clearance is the 'line of sight' distance. Creepage path follows the contour of the grooves.

----- 1 clearance 2 creepage distance

973

Example 7



974

975

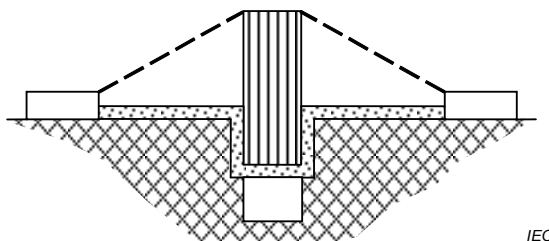
Condition: Path under consideration includes an uncemented joint with a groove on one side less than X mm wide and the groove on the other side equal to or more than X mm wide.

Rule: Clearance and creepage paths are as shown.

— — — — 1 clearance  2 creepage distance

976

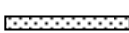
Example 8



977

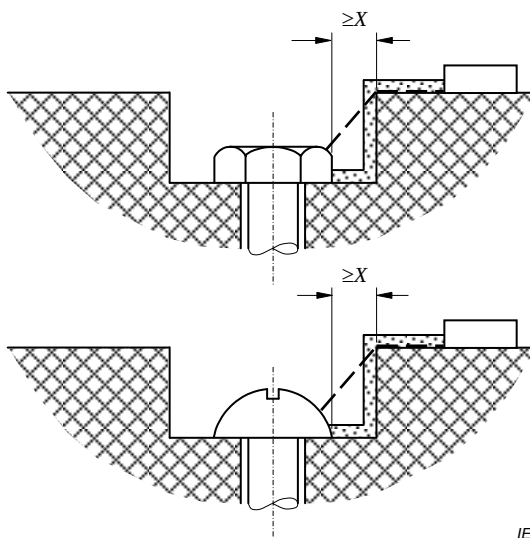
Condition: Creepage distance through uncemented joint is less than creepage distance over barrier.

Rule: Clearance is the shortest direct air path over the top of the barrier.

— — — — 1 clearance  2 creepage distance

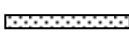
978

Example 9

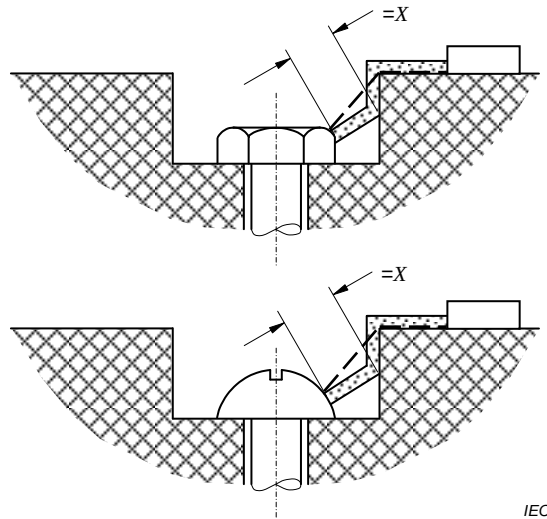


979

Gap between head of screw and wall of recess wide enough to be taken into account.

— — — — 1 clearance  2 creepage distance

Example 10



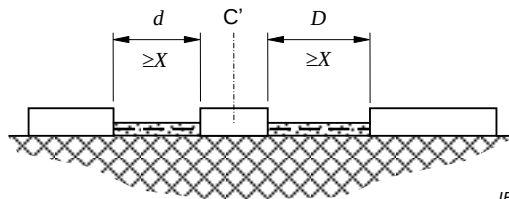
IEC

Gap between head of screw and wall of recess too narrow to be taken into account.

Measurement of creepage distance is from screw to wall when the distance is equal to X mm.

— — — — 1 clearance  2 creepage distance

Example 11



IEC

Clearance is the distance $d + D$

Creepage distance is also $d + D$

C' conductive part interposed in the insulating path between the conductors

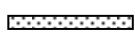
— — — — 1 clearance  2 creepage distance

Figure 3 – Determination of creepage distances and clearances

NOTE The examples in Figure 3 are identical with those given in IEC 60664-1.

4.4 Printed circuit boards with coating, Level of Protection "ec"

Table 2 and Table H.1 both provide for a reduced separation distance where the tracks and components on a printed circuit board are sealed from the atmosphere with a coating.

In both Table 2 and Table H.1, the column headed "coating" applies to any coating which may be applied to the circuit board.

The coating shall adhere to the conductive parts and the insulating material. Coating may be applied by spraying, dip coating, brushing, vacuum impregnating, or other methods which achieve an effective, lasting, unbroken seal. A solder mask alone is not considered as a coating, but may be accepted as

one of the two coats when an additional coat is applied, provided the solder mask is not damaged during soldering.

If the coating is of a type that meets the requirements of a Type 1 or a Type 2 coating, in accordance with the requirements of IEC 60664-3, it will provide a higher level of protection against moisture contamination, than an unspecified coating may do, and advantage may be taken in the further reduction in separation distances. Additionally, both Type 1 and Type 2 coating are considered to provide full environmental protection against the effects of condensation, so would negate the requirement in Annex H, for pollution degree 2, or equivalent, for those parts of the circuit board covered with the Type 1 or Type 2 coating.

NOTE It is not the intent of 4.4 to increase the requirements for coatings beyond those of general industrial equipment. Requirements for coatings can be found in IEC 60664-3 and UL 746E. Coatings in accordance with UL 746E are considered equivalent to Type 1 coatings. [the reference to UL 746E is included for alignment with the current draft text for IEC 60079-11, Ed 7 and may be revised to align with the final agreed text of IEC 60079-11]

4.5 Solid electrical insulating materials

There are no specified distances through solid insulation in this standard, as the specified distances for normal industrial equipment, the requirements for the thermal stability of the insulating material, and dielectric tests are considered to provide the required level of safety for the applicable EPL.

4.5.1 Specification

The specification for insulating material applies to materials supporting current-carrying parts in position or defining separation distances, but does not apply to interconnecting wiring or printed circuit board mounted components. The specification shall include the following:

- a) the name or registered trademark of the material manufacturer;
- b) the identification of the material;
- c) the possible surface treatments, such as varnishes, etc.;
- d) long-term thermal stability of the material (such as the TI per IEC 60216-1, RTI per ANSI/UL 746B, or other rating systems establishing long term continuous operating temperature, e.g. 20 000 hour, ratings of the material),
- e) when applicable, the comparative tracking index (CTI) determined in accordance with IEC 60112;
- f) when the insulating material is part of the external enclosure, the temperature index TI, corresponding to the 20 000 h point on the thermal endurance graph without loss of flexural strength exceeding 50 %, determined in accordance with IEC 60216-1 and IEC 60216-2 and based on the flexing property in accordance with ISO 178. If the material does not break in this test before exposure to the heat, the index shall be based on the tensile strength in accordance with ISO 527-2 with test bars of Type 1A or 1B. As an alternative to the TI, the relative thermal index (either RTI - mechanical strength or RTI - mechanical impact) may be determined in accordance with ANSI/UL 746B.

NOTE It is not a requirement of this standard that conformity to the manufacturer's specification of the insulating material needs to be verified.

4.5.2 Long-term thermal stability

The long-term thermal stability rating of materials supporting current-carrying parts in position or defining separation distances, other than interconnecting wiring and printed circuit board mounted components, shall be:

- a) for Level of Protection "eb", at least 20 K above the maximum service temperature, and at least 80 °C,
- b) for Level of Protection "ec", at least equal to the maximum service temperature, or for insulated windings, see 4.7.3 and Table 4.

Insulating parts made of plastics or laminates, where the original surface is removed during manufacture, shall be coated with an insulating varnish having at least the same grading according to CTI as the original surface. This requirement does not apply to materials where these actions have not

1046 affected the grading according to CTI or where the specified creepage distance is provided by other
1047 parts not subjected to these actions.

1048 **4.6 Windings**

1049 **4.6.1 General**

1050 The requirements of 4.6.2 to 4.7.5 apply to Level of Protection “eb” only, and not to Level of Protection
1051 “ec”.

1052 **4.6.2 Insulated conductors**

1053 Insulated conductors shall conform to either one of the following requirements:

- 1054 a) The conductors shall be covered with at least two layers of insulation, only one layer of which may
1055 be enamel; or
- 1056 b) Enamelled round winding wires shall be in accordance with either:
- 1057 – grade 1 of IEC 60317-3, IEC 60317-8, IEC 60317-13, or IEC 60317-46 provided that:
 - 1058 • when tested in accordance with Clause 13 of IEC 60317-3, IEC 60317-8, IEC 60317-13, or
1059 IEC 60317-46 there shall be no failure with the minimum values of breakdown voltage listed
1060 for grade 2; and that
 - 1061 • when tested in accordance with Clause 14 of IEC 60317-3, IEC 60317-8, IEC 60317-13, or
1062 IEC 60317-46 there shall be not more than six faults per 30 m of wire irrespective of
1063 diameter; or
 - 1064 – grade 2 of IEC 60317-3, IEC 60317-8, IEC 60317-13, or IEC 60317-46; or
 - 1065 – grade 3 of IEC 60317-8.

1066 **NOTE** It is not a requirement of this standard that conformity to the specification of the enamel grade be verified.

1067 **4.6.3 Winding impregnation**

1068 Windings, after having been fastened or wrapped, shall be dried to remove moisture before
1069 impregnation with a suitable substance. Except as limited herein, dipping, trickling or vacuum pressure
1070 impregnation (VPI) is acceptable. Coating by painting or spraying is not recognized as impregnation.

1071 **NOTE** The VPI process is considered to adequately remove moisture prior to impregnation.

1072 The impregnation shall be carried out in accordance with the specific instructions of the manufacturer
1073 of the impregnating substance used and in such a way that the spaces between the conductors are
1074 filled as completely as possible and that good cohesion between the conductors is achieved.

1075 This does not apply to fully insulated coils and conductors of windings if, prior to their fitting into the
1076 electrical equipment, the slot portions and end windings of these coils and conductors have been
1077 impregnated, provided with filling material, or otherwise insulated in an equivalent manner, and if, after
1078 assembly, they are no longer accessible for the stated insulating procedures.

1079 If impregnating substances containing evaporating solvents are used for dipping or trickling, the
1080 dipping or trickling and drying processes shall be carried out at least twice.

1081 **4.6.4 Conductor dimensions**

1082 The minimum nominal conductor dimension of wires used for windings shall be 0,25 mm.

1083 **NOTE:** The minimum dimension is the diameter of a round conductor or the smallest dimension of a rectangular conductor.

4.6.5 Sensing elements

Sensing elements of **embedded** temperature detectors (**ETDs**) are not considered to be windings, but when applied to the windings of electric machines, they shall be impregnated or sealed with the windings by the manufacturer.

When **ETDs** are applied in electric machines with a rated voltage exceeding 1 kV, the **ETD** and its connecting leads shall be located in or adjacent to an earthed area. A means of satisfying this requirement is to locate the **ETD** between two winding layers, each of which is bound by a conductive covering prior to insertion in the slots. The **ETD** connecting leads could be routed adjacent to the core end immediately upon leaving the slot and routed to the terminal box avoiding any winding connections.

Other sensing elements, including those that incorporate make/break constructions, shall employ a Type of Protection suitable for the application.

Note Motors of duty type S1, S2, S6, or S9 can be subjected to conditions during normal service that result in the activation of the protection circuit based on input from the sensing element.

4.7 Limiting temperature

4.7.1 General

4.7.1.1 Thermal stability of insulating materials

No solid electrical insulating material shall attain a temperature in excess of that defined by 4.5.2 when tested under rated conditions. Determination shall be in accordance with the procedure for the determination of **service** temperature in IEC 60079-0.

4.7.1.2 Maximum surface temperature

Furthermore, no surface of any part of electrical equipment, including the surface of internal parts to which the explosive gas atmosphere might have access, shall attain a temperature in excess of the maximum surface temperature prescribed in IEC 60079-0 except for lamps in luminaires for which the requirement is given in 5.3.7.2. The determination of the maximum surface temperature specified in IEC 60079-0 shall consider the additional overload or malfunction conditions defined in Table 3 of this standard and considering the test configuration described by the applicable industrial standard.

Table 3 – Conditions for the determination of maximum surface temperature

Type of electrical equipment	Overload or malfunction conditions in addition to the conditions of IEC 60079-0	
	Level of Protection "eb"	Level of Protection "ec"
Luminaires	Per 5.3	Per 5.3
Electric machines	Per 5.2.8	None
Resistors	None	None
Terminals	None	None
Electromagnets	Worst-case air-gap	Worst-case air-gap
Other equipment	As specified by the applicable standard for industrial equipment	As specified by the applicable standard for industrial equipment as normal operating conditions

4.7.2 Conductors

In determining the temperature of the conductors, both the self-heating of the conductors and the effect of heating by neighbouring parts shall be taken into account.