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(Formerly ANSI/ISA-12.16.01-2002 (IEC 60079-7 Mod))
Supersedes ANSI/ISA-12.16.01-1998 (IEC 60079-7 Mod)



**Electrical Apparatus for Use in
Class I, Zone 1 Hazardous
(Classified) Locations
Type of Protection –
Increased Safety "e"**
Second Printing 15 July 2005

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This ANSI/UL Standard for Safety, which consists of the first edition is under continuous maintenance, whereby each revision is ANSI approved upon publication. Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Written comments are to be sent to the UL-RTP Standards Department, 12 Laboratory Drive, Research Triangle Park, NC 27709.

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**ISA — The Instrumentation, Systems,
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ANSI/ISA-60079-7
First Edition

Underwriters Laboratories Inc.
ANSI/UL 60079-7
First Edition



**ISA—The Instrumentation, Systems,
and Automation Society**



Electrical Apparatus for Use in Class I, Zone 1 Hazardous (Classified) Locations: Type of Protection — Increased Safety “e”

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General Notes

This is the common ISA and UL Standard for Electrical apparatus for explosive gas atmospheres – Part 7: Increased Safety "e". It is the first edition of ANSI/ISA-60079-7 [formerly ANSI/ISA-12.16.01-1998 (IEC 60079-7 Mod)] and the first edition of UL 60079-7. The suffix "Mod" indicates the document is a modification of the IEC document and includes U.S. deviations encompassing both additions and deletions of information.

ANSI/ISA-60079-7 and UL 60079-7 contain identical requirements, and identical publication dates. The presentation and format of the standards material may differ between the two published standards.

This common Standard was prepared by ISA — The Instrumentation, Systems, and Automation Society and Underwriters Laboratories Inc. (UL).

Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.

Level of harmonization

This standard adopts the IEC text with deviations.

The requirements are presented in different formats. The ISA version of the standard illustrates the national differences from the IEC text through the use of legislative text (strike-out and underline). The UL version of the standard illustrates national differences immediately following the IEC text. National differences between the UL version and the ISA version shall be word for word except for editorial changes.

Interpretations

The interpretation by the SDO of an identical or equivalent standard shall be based on the literal text to determine compliance with the standard in accordance with the procedural rules of the SDO. If more than one interpretation of the literal text has been identified, a revision shall be proposed as soon as possible to each of the SDOs to more accurately reflect the intent.

UL Effective Date

As of 2 December 2002 all products Listed or Recognized by UL must comply with the requirements in this Standard.



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Preface (ISA)

This ISA standard is based on IEC Publication 60079-7. It is the intention of the ISA SP12 Committee to develop an ANSI Standard that is harmonized with IEC 60079-7 to the fullest extent possible.

This preface is included for informational purposes and is not part of ANSI/ISA-60079-7. The document is a modification of the IEC document and includes U.S. deviations encompassing both additions and deletions of information.

The standards referenced within this document may contain provisions which, through reference in this text, constitute requirements of this document. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this document are encouraged to investigate the possibility of applying the most recent editions of the standards indicated within this document. Members of IEC and ISO maintain registers of currently valid International Standards. ANSI maintain registers of currently valid U.S. National Standards.

This document has been prepared as part of the service of ISA—The Instrumentation, Systems, and Automation Society, toward a goal of uniformity in the field of instrumentation. To be of real value, this document should not be static but should be subject to periodic review. Toward this end, the Society welcomes all comments and criticisms and asks that they be addressed to the Secretary, Standards and Practices Board; ISA; 67 Alexander Drive; P. O. Box 12277; Research Triangle Park, NC 27709; Telephone (919) 549-8411; Fax (919) 549-8288; E-mail: standards@isa.org.

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Foreword (UL)

A. This Standard contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Standard. These requirements are based upon sound engineering principles, research, records of tests and field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, inspection authorities, and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of the requirements of this Standard by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

C. A product which complies with the text of this Standard will not necessarily be judged to comply with the Standard if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and that involves a risk of fire or of electric shock or injury to persons shall be evaluated using appropriate additional component and end-product requirements to maintain the level of safety as originally anticipated by the intent of this standard. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this standard does not comply with this standard. Revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed. UL shall not be responsible to anyone for the use of or reliance upon this Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of, or reliance upon this Standard.

F. Many tests required by the Standards of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.



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National Differences

GENERAL

In the UL publication of this standard, National Differences from the text of International Electrotechnical Commission (IEC) Publication 60079-7 Electrical apparatus for explosive gas atmospheres — Part 7: Increased Safety "e", copyright 2001, are indicated by notations (differences) and are presented in bold text. The national difference type is included in the body.

In the ISA publication of this standard, National Differences are presented using legislative text (strike-out and underline). The national difference type is identified in an informative annex.

There are five types of National Differences as noted below. The standard may not include all types of these National Differences.

NOTE The UL printed standard includes the national difference types within the body of the text. The ISA printed standard includes the national difference types in an annex at the back of the standard.

DR – These are National Differences based on the National Electrical Code (NEC) and other U.S. Regulatory Requirements.

D1 – These are National Differences based on **basic safety principles and requirements**, elimination of which would compromise safety for U.S. consumers and users of products.

D2 – These are National Differences based on **safety practices**. These are differences for IEC requirements that may be acceptable, but adopting the IEC requirements would require considerable retesting or redesign on the manufacturer's part.

DC – These are National Differences based on the **component standards** and will not be deleted until a particular component standard is harmonized with the IEC component standard.

DE – These are National Differences based on **editorial comments or corrections**.



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Foreword (ISA)

All text of IEC 60079-7:2001 is included. U.S. National Deviations are shown by ~~strikeout~~ through text deleted and underline under text added. Tables, or portions of tables, that are to be deleted are shown as shaded; figures to be deleted are marked with the overlay "X." There are ten annexes in this standard. Annexes C, D, E, F, G, H, I, and J are informative and are not considered part of this standard. Annexes A and B are normative and are considered part of this standard.



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1 Scope

This part of ~~IEC 60079~~ ANSI/ISA-60079-7 specifies the requirements for the design, construction, testing and marking of electrical apparatus with type of protection increased safety "e" intended for use in Class I, Zone 1, Groups IIA, IIB, and IIC hazardous (classified) location explosive gas atmospheres. This standard applies to electrical apparatus with a rated value of supply voltage not exceeding 11 kV r.m.s. a.c. or d.c. Additional measures are applied to ensure that the apparatus does not produce arcs, sparks, or excessive temperatures in normal operation or under specified abnormal conditions.

These specific requirements are additional to the general requirements in ANSI/ISA-60079-0 ~~IEC 60079-0~~ that apply to type of protection increased safety "e" unless specifically excluded.

2 ~~Normative~~ References

The following ~~normative~~ documents may contain provisions which, through reference in this text, constitute provisions of this ~~part of IEC 60079 standard~~. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this ~~part of IEC 60079 standard~~ are encouraged to investigate the possibility of applying the most recent editions of the ~~normative~~ documents indicated below. For undated references, the latest edition of the ~~normative~~ document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards. ANSI maintains registers of currently valid U.S. National Standards.

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

IEC 60034-5, Rotating electrical machines, Part 5: Degrees of protection provided by internal design of rotating electrical machines (IP code) – Classification

IEC 60044-6, Instrument transformers – Part 6: Requirements for protective current transformers for transient performance

IEC 60050(426), International Electrotechnical Vocabulary (IEV) – Chapter 426: Electrical apparatus for explosive atmospheres

IEC 60050(486), International Electrotechnical Vocabulary (IEV) – Chapter 486: Secondary cells and batteries

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

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

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

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

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

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

~~IEC 60079-0: 1998, Electrical apparatus for explosive gas atmospheres – Part 0: General requirements~~

ANSI/ISA-60079-0 (12.00.01)-2002, Electrical Apparatus for Use in Class I, Zones 0, 1, & 2 Hazardous (Classified) Locations – General Requirements

~~IEC 60079-1, Electrical apparatus for explosive gas atmospheres – Part 1: Construction and verification test of flameproof enclosures of electrical apparatus~~

ANSI/ISA-60079-1 (12.22.01)-2002, Electrical Apparatus for Use in Class I, Zone 1 Hazardous (Classified) Locations – Type of Protection – Flameproof “d”

IEC 60079-4, Electrical apparatus for explosive gas atmospheres – Part 4: Method of test for ignition temperature

ANSI/ISA-60079-11 (12.02.01)-2002, Electrical Apparatus for Use in Class I, Zones 0, 1, & 2 Hazardous (Classified) Locations – Type of Protection “i”

~~IEC 60079-11, Electrical apparatus for explosive gas atmospheres – Part 11: Intrinsic safety “i”~~

IEC 60079-17, Electrical apparatus for explosive gas atmospheres – Part 17: Inspection and maintenance of electrical installations in hazardous areas (other than mines)

IEC 60085, Thermal evaluation and classification of electrical insulation

IEC 60112, Method for determining the comparative and the proof tracking indices of solid insulating materials under moist conditions

IEC 60238, Edison screw lampholders

IEC 60317-3, Specifications for particular types of winding wires – Part 3: Polyester enamelled round copper wires, class 155

IEC 60317-7, Specifications for particular types of winding wires – Part 7: Polyamide enamelled round copper wire, class 220

IEC 60317-8, Specifications for particular types of winding wires – Part 8: Polyesterimide enamelled round copper winding wire, class 180

IEC 60317-13, Specifications for particular types of winding wires – Part 13: Polyester or polyesterimide overcoated with polyamide-imide enamelled round copper wire, class 200

IEC 60364-3, Electrical installations of buildings – Part 3: Assessment of general characteristics

IEC 60400, Lampholders for tubular fluorescent lamps and starterholders

IEC 60432-1, Incandescent lamps – Safety specifications – Part 1: Tungsten filament lamps for domestic and similar general lighting purposes

IEC 60529, Degrees of protection provided by enclosures (IP Code)

IEC 60664-1, Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements, and tests

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

IEC 60947-7-1, Low-voltage switchgear and controlgear, Part 7 – Ancillary equipment- Section 1: Terminal blocks for copper conductors

IEC 60999-1, Connecting devices – Electrical copper conductors – Safety requirements for screw-type and screwless-type clamping units – Part 1: General requirements and particular requirements for clamping units for conductors from 0,2 mm² up to 35 mm²

IEC 60999-2, Connecting devices – Safety requirements for screw-type and screwless-type clamping units for electrical copper connectors – Part 2: Particular requirements for conductors from 35 mm² up to 300 mm²

IEC 61195, Double-capped fluorescent lamps - Safety specifications

IEC 62086-1, Electrical apparatus for explosive gas atmospheres – Electrical resistance trace heating – Part 1: General and testing requirements

ANSI C78.1, Fluorescent Lamps – RapidStart Types - Dimensional and Electrical Characteristics

ANSI C81.61, Electric Lamp Bases

ANSI C81.62, Lampholders for Electric Lamps

ANSI/IEEE 515, IEEE Recommended Practice for the Testing, Design, Installation, and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications

ANSI/NFPA 70:1999, *National Electrical Code*[®]

ANSI/NFPA 497, Classification of Flammable Liquids, Gases or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas.

ANSI/UL 94, Tests for Flammability of Plastics Materials

ANSI/UL 486E, Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors

ANSI/UL 508, Industrial Control Equipment

ANSI/UL 746A, Standard for Polymeric Materials - Short Term Property Evaluations

ANSI/UL 746C, Standard for Polymeric Materials - Use in Electrical Equipment Evaluations

ANSI/UL 840, Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment

ANSI/UL 1059, Terminal Blocks

3 Definitions

For the purpose of this ~~part of IEC 60079 standard~~, the definitions and certain terms used in ~~IEC 60079-0~~ ANSI/ISA-60079-0, together with the following terms and definitions apply.

For the definitions of any other terms, particularly those of a more general nature, reference should be made to IEC 60050(426) or other appropriate parts of the IEC (International Electrotechnical Vocabulary).

NOTE Where a word, for example "battery", is shown in parentheses in a term, it may be omitted when there is no risk of confusion or misunderstanding.

3.1 cells and batteries

3.1.1 cell:

assembly of electrodes and electrolytes which constitutes the smallest electrical unit of a battery.

NOTE A sketch illustrating the various parts of a cell is given in Figure 1. This sketch is included for descriptive purposes only and is not intended to imply any requirements or preference for a particular form of construction.

3.1.2 primary cell or battery:

electrochemical system capable of producing electrical energy by chemical reaction.

3.1.3 secondary cell or battery:

electrically rechargeable electrochemical system capable of storing electrical energy and delivering it by chemical reaction

3.1.4 open cell or battery:

secondary cell or battery having a cover provided with an opening through which gaseous products may escape (IEV 486-01-18 modified).

3.1.5 sealed valve regulated cell or battery:

cell or battery which is closed under normal conditions, but which has an arrangement which allows the escape of gas if the internal pressure exceeds a predetermined value. The cell cannot normally receive an addition to the electrolyte (IEV 486-01-20 modified).

NOTE This definition differs from the IEC definition 486-01-20 by virtue of the fact it applies to either a cell or battery.

3.1.6 sealed gas-tight cell or battery:

cell or battery which remains closed and does not release either gas or liquid when operated within the limits of charge or temperature specified by the manufacturer.

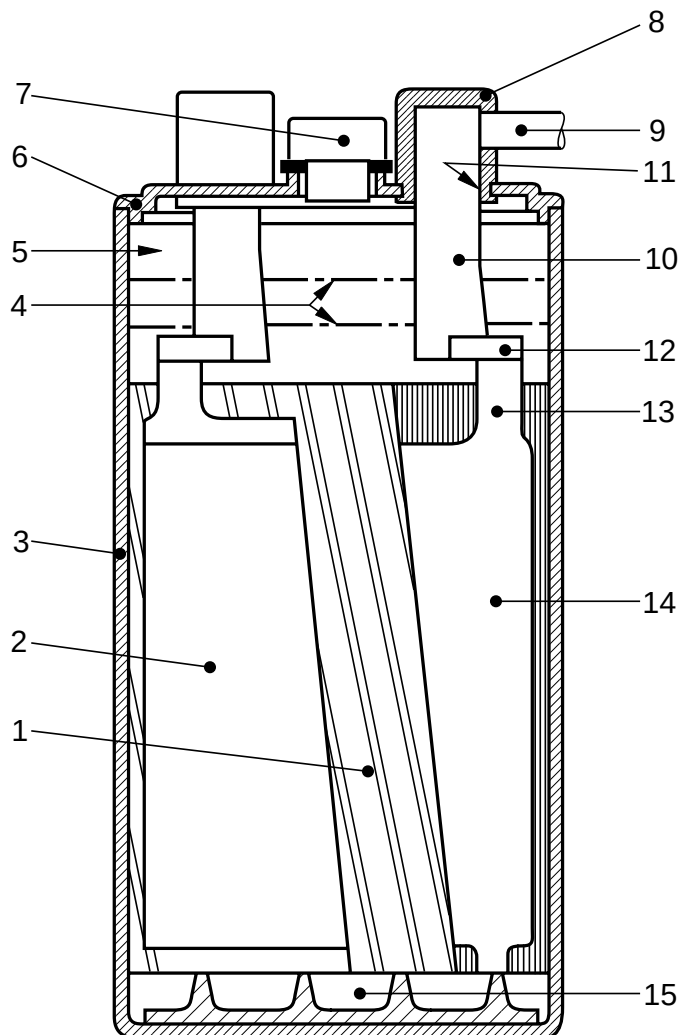
NOTE 1 Such cell and batteries may be equipped with a safety device to prevent dangerously high internal pressure. The cell or battery does not require addition to the electrolyte and is designed to operate during its life in its original sealed state.

NOTE 2 The above definition is taken from IEC 60079-11. It differs from the IEC definition 486-01-21 by virtue of the fact it applies to either a cell or battery.

3.1.7 battery:

assembly of two or more cells electrically connected to each other to increase the voltage or capacity

NOTE Where the terms "cell" or "cells" are used, the text refers to individual single cells. Where the terms "battery" or "batteries" are used, the text refers to both cells and batteries.



Key

- 1 Separator
- 2 Positive plate
- 3 Cell container
- 4 Electrolyte level (maximum/minimum)
- 5 Headspace
- 6 Electrolyte-tight lid seal
- 7 Filler and vent plug
- 8 Post encapsulation

- 9 Intercell connector
- 10 Terminal post
- 11 Electrolyte-tight terminal post seal
- 12 Group bar
- 13 Plate lug
- 14 Negative plate
- 15 Slurry space

Figure 1 – Parts of a cell

3.1.8 capacity:

quantity of electricity or electric charge, which a fully charged battery can deliver under specified conditions.

NOTE The SI unit for electrical charge is the coulomb (1 C = 1 As) but in practice, battery capacity is usually expressed in ampere-hours (Ah).

3.1.9 nominal voltage:

(of a cell or battery) voltage specified by the manufacturer.

3.1.10 maximum open circuit voltage:
(of a cell or battery) voltage which is the maximum attainable voltage under normal conditions, that is, from either a new primary cell, or a secondary cell just after a full charge.

NOTE The maximum open circuit voltage for acceptable cells is given in Tables 9 and 10.

3.1.11 charging:
act of forcing current through a secondary cell in the opposite direction to the normal flow to restore the energy stored originally.

3.1.12 reverse charging:
act of forcing current through either a primary cell or secondary cell in the same direction as the normal flow.

NOTE For example in an expired battery.

3.1.13 deep discharge:
event which reduces a cell voltage below that recommended by the cell or battery manufacturer.

3.1.14 container (of a cell):
container for the plate pack and electrolyte of a cell made of a material impervious to attack by the electrolyte (IEV 486-02-20).

3.1.15 (battery) container:
enclosure to contain the battery.

NOTE The cover is a part of the battery container.

3.1.16 plate pack:
assembly of the positive and negative plate groups with separators (IEV 486-02-15).

3.1.17 partition wall:
integral part of a battery container dividing it into individual sections and increasing its mechanical strength.

3.1.18 insulating barrier:
electrical insulating material between groups of cells subdividing the battery.

3.1.19 intercell connector:
conductor of electricity used for carrying current between cells.

3.2 clearance:
shortest distance in air between two conductive parts.

3.3 connections internal:
terminations intended for connection in the factory under controlled conditions.

3.4 connections external:
terminations intended for connection in the field.

3.5 creepage distance:
shortest distance along the surface of an electrically insulating material between two conductive parts.

3.6 increased safety "e":

type of protection applied to electrical apparatus in which additional measures are applied so as to give increased security against the possibility of excessive temperatures and of the occurrence of arcs and sparks in normal service or under specified abnormal conditions.

NOTE 1 This type of protection is denoted by "e". The "additional measures" are those required for compliance with this standard.

NOTE 2 Apparatus producing arcs or sparks in normal service is excluded by this definition of increased safety.

3.7 initial starting current I_A :

highest r.m.s. value of current absorbed by an a.c. motor when at rest or by an a.c. magnet with its armature clamped in the position of maximum air gap when supplied at rated voltage and rated frequency.

NOTE Transient phenomena are ignored.

3.8 limiting temperature:

maximum permissible temperature for apparatus or parts of apparatus equal to the lower of the two temperatures determined by:

- a) the danger of ignition of the explosive gas atmosphere; and
- b) the thermal stability of the materials used.

NOTE This temperature may be the maximum surface temperature (see both 3.8 and Clause 5 of IEC 60079-0) or a lower value (see 4.8 of this standard).

3.9 normal service, motors:

continuous operation at the nameplate rating (or set of ratings) including starting conditions.

3.10 rated dynamic current I_{dyn} :

peak value of the current, the dynamic effect of which the electrical apparatus can sustain without damage.

3.11 rated short-time thermal current I_{th} :

r.m.s. value of the current required to heat up the conductor within 1 s from the temperature reached in rated service at the maximum ambient temperature to a temperature not exceeding the limiting temperature.

3.12 rated voltage:

value of voltage assigned by the manufacturer to a component, device or equipment and to which operation and performance characteristics are referred.

3.13 resistance-heating devices and resistance-heating units

3.13.1 resistance-heating device:

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

3.13.2 resistance-heating unit:

apparatus comprising an assembly of one or more resistance heating devices associated with any devices necessary to ensure that the limiting temperature is not exceeded.

NOTE It is not intended that the 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.

3.13.3 workpiece:
object to which a resistance-heating device or unit is applied.

3.13.4 self-limiting property:
property such that 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 The temperature of the surface of the element is then effectively that of its surroundings.

3.13.5 stabilized design:
concept where the temperature of the resistance-heating device or unit will, by design and use, stabilize below the limiting temperature, under the most unfavourable conditions, without the need for a protective system to limit the temperature.

3.14 short-circuit current I_{sc} :
maximum r.m.s. value of the short-circuit current to which the apparatus may be subjected in service.

NOTE This maximum value is recorded in the documentation according to 23.2 of IEC 60079-0.

3.15 starting current ratio I_A / I_N :
ratio between initial starting current I_A and rated current I_N .

3.16 time t_E :
time taken for an a.c. rotor or stator winding, when carrying the initial starting current I_A , to be heated up to the limiting temperature from the temperature reached in rated service at the maximum ambient temperature (see Figure A.1).

3.17 trace heating:
utilization of electric trace heater cables, pads, panels and support components, externally applied and used to raise or maintain the temperature of contents in piping, tanks and associated equipment.

3.18 working voltage (identical with 1.3.5 of IEC 60664-1):
highest r.m.s. value of the a.c. or d.c. voltage across any particular insulation which can occur when the equipment is supplied at rated voltage.

NOTE 1 Transients are disregarded.

NOTE 2 Both open-circuit conditions and normal operating conditions are taken into account.

4 Constructional requirements for all electrical apparatus

4.1 General

The requirements of this clause apply, unless otherwise stated in Clause 5, to all electrical apparatus with type of protection "e". They are additional to the general requirements of ~~IEC 60079-0~~ ANSI/ISA-60079-0 and are themselves supplemented for certain electrical apparatus by the supplementary requirements in Clause 5.

4.2 Terminals for external connections

Terminals for connections to external circuits shall be generously dimensioned to permit the effective connection of copper conductors of cross-section equal to at least that corresponding to the rated current of the electrical apparatus.

The number and sizes of copper conductors that can be safely connected to terminals shall be specified in the descriptive documents according to 23.2 of ~~IEC 60079-0~~ ANSI/ISA-60079-0.

~~NOTE~~ ANSI/UL 1059 and ANSI/UL 486E require terminals to be identified with the permitted wire sizes in AWG or kcmil.

~~NOTE 1 Attention is drawn to the use of aluminium wire because of the difficulties associated with controlling critical creepage and clearance distances with the application of anti-oxidant materials. The connection of aluminium wire to external terminals may be accomplished by the use of suitable bi-metallic ferrule connections providing a copper connection to the terminal.~~

Terminals shall be subjected to the terminal insulating material tests of 6.9.

Terminals with a rated voltage greater than 1500 V shall be subjected to the applicable examination and tests of ANSI/UL 1059 and ANSI/UL 486E except for the dielectric tests which shall be conducted in accordance with 6.10.

These terminals shall

- c) be fixed to their mountings without possibility of self-loosening;
- d) be constructed in such a way that the conductors cannot slip out from their intended location during tightening of the terminal; and
- e) be such that proper contact is assured without damage to the conductors that would impair the ability of the conductors to fulfil their function, even if multi-stranded conductors are used in terminals intended for direct clamping of a conductor.

~~NOTE 2~~ NOTE The use of crimped cable terminations is allowed provided that the requirements in a), b) and c) are fulfilled.

In particular, terminals shall: ~~not~~

- not have sharp edges which would damage the conductors;
- not be able to turn, twist or be permanently deformed during normal tightening which shall be defined by the manufacturer of the apparatus and which shall not be less than that specified in IEC 60947-7-1, IEC 60999-1 or IEC 60999-2, where applicable;
- not be constructed of aluminum.

Terminals shall be such that the contact they assure is not appreciably impaired by temperature changes occurring in normal service. The contact pressure shall not be transmitted through insulating material.

Terminals intended for clamping stranded conductors shall include a resilient intermediate part. Terminals for connecting conductors of rated cross-sections not exceeding 4 mm² (12 AWG) shall also be suitable for the effective connection of conductors at least two ISO wire-sizes smaller.

~~NOTE 3~~ NOTE 1 Special precautions against vibration and mechanical shock may be required.

~~NOTE 4~~ NOTE 2 Special precautions against electrolytic corrosion should be considered.

~~NOTE 5~~ NOTE 3 Special precautions against corrosion should be considered where ferrous material is used.

4.3 Internal connections

Connections within electrical apparatus and forming an integral part of that apparatus shall not be subject to undue mechanical stress. Only the following means for the connection of conductors are permitted:

- a) Screwed fasteners with means of locking
- b) Crimping
- c) Soldering, provided that the conductors are not supported by the soldered connection alone
- d) Brazing
- e) Welding
- f) Any means of connection complying with the requirements of 4.2

NOTE Special precautions against electrolytic corrosion should be considered.

Connections which are terminals shall be subjected to the terminal insulating material tests of 6.9.

Terminals with a rated voltage greater than 1500 V shall be subjected to the applicable examination and tests of ANSI/UL 1059 and ANSI/UL 486E except for the dielectric tests which shall be conducted in accordance with 6.10.

4.4 Clearances

Clearances between bare conductive parts at different potentials shall be as given in Table 1 with a minimum value for external connections of 3 mm.

Spacings at wiring terminals shall be evaluated with the conductor size that produces the minimum clearance.

NOTE For requirements for lamps with screw caps see 5.3.3.1.4.

Clearances shall be determined as a function of the working voltage. Where the apparatus is intended for more than one rated voltage or for a range of rated voltage, 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 2 illustrate the features to be taken into account and the appropriate clearances.

Table 1 — Creepage distances and clearances

Voltage (see note 1) <i>U</i> _{r.m.s.} a.c. or d.c. V	Minimum creepage distance mm			Minimum clearance mm
	Material group			
	I	II	IIIa	
10 (see note 3)	1.6	1.6	1.6	1.6
12.5	1.6	1.6	1.6	1.6
16	1.6	1.6	1.6	1.6
20	1.6	1.6	1.6	1.6
25	1.7	1.7	1.7	1.7
32	1.8	1.8	1.8	1.8
40	1.9	2.4	3.0	1.9
50	2.1	2.6	3.4	2.1
63	2.1	2.6	3.4	2.1
80	2.2	2.8	3.6	2.2
100	2.4	3.0	3.8	2.4
125	2.5	3.2	4	2.5
160	3.2	4	5	3.2
200	4.0	5.0	6.3	4.0
250	5	6.3	8	5
320	6.3	8.0	10.0	6.0
400	8	10	12.5	6
500	10.0	12.5	16.0	8.0
630	12.0	16.0	20.0	10
800	16.0	20.0	25.0	12
1000	20	25	32	14
1250	22	26	32	18
1600	23	27	32	20
2000	25	28	32	23
2500	32	36	40	29
3200	40	45	50	36
4000	50	56	63	44
5000	63	71	80	50
6300	80	90	100	60
8000	100	110	125	80
10000	125	140	160	100

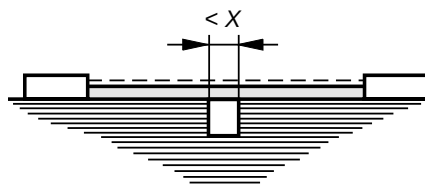
NOTE 1 Voltages shown are derived from IEC 60664-1. The working voltage may exceed by 10 % the voltage level given in the table. This is based on the rationalization of supply voltages given in Table 3b of IEC 60664-1.

NOTE 2 The creepage distance and clearance values shown are based on a maximum supply voltage tolerance of ± 10 %.

NOTE 3 At 10 V and below, the value of CTI is not relevant and materials not meeting the requirement for material group IIIa may be acceptable.

NOTE These examples are identical with those given in IEC 60664-1.

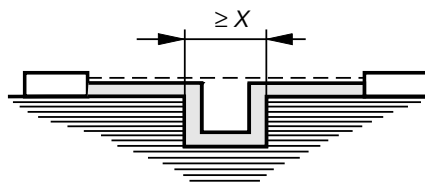
Example 1



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.

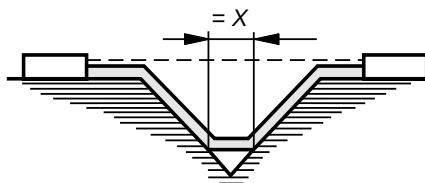
Example 2



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

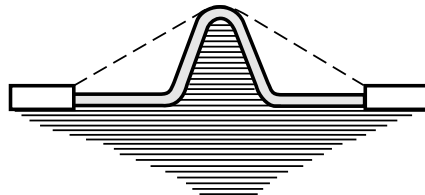
Example 3



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.

Example 4



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
1 clearance

— 2
2 creepage distance

Figure 2 — Determination of creepage distances and clearances