

Electronic equipment for use in power installations

The European Standard EN 50178:1997 has the status of a
British Standard

ICS 29.240.01

NO COPYING WITHOUT BSI PERMISSION EXCEPT AS PERMITTED BY COPYRIGHT LAW

BSI
Documents



Document Sharing Hub

National foreword

This British Standard is the English language version of EN 50178:1997.
The UK participation in its preparation was entrusted to Technical Committee PEL/22, Static power convertor equipment, which has the responsibility to:

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

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

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled “International Standards Correspondence Index”, or by using the “Find” facility of the BSI Standards Electronic Catalogue.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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

Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 99 and a back cover.

The BSI copyright notice displayed throughout this document indicates when the document was last issued.

Sideline in this document indicates the most recent changes by amendment.

This British Standard, having been prepared under the direction of the Electrotechnical Sector Committee, was published under the authority of the Standards Committee and comes into effect on 15 December 1998

© BSI 08-1999

ISBN 0 580 30453 1

Amendments issued since publication

Amd. No.	Date	Comments
10604 Corrigendum	August 1999	Correction to Table 10

ICS 29.240.00

Descriptors: electrical installation, industrial electrical installation, electronic equipment, definitions, design, safety, protection against electric shocks, protection against live parts, climatic conditions, electrical properties, mechanical properties, tests, marking

English version

Electronic equipment for use in power installations

Équipement électronique utilisé dans les
installations de puissance

Ausrüstung von Starkstromanlagen mit
elektronischen Betriebsmitteln

This European Standard was approved by CENELEC on 1997-07-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 36, B-1050 Brussels

© 1997 CENELEC All rights of exploitation in any form and by any means reserved worldwide for CENELEC Members.

Foreword

This European Standard was prepared by the Task Force CENELEC BTTF 60-1, Assembly of electronic equipment.

A first draft was submitted to CENELEC enquiry (6MP) in August 1994 but failed to be accepted. A second draft was submitted to CENELEC enquiry (2MP) in September 1995 and was accepted. The text of the final draft was submitted to the Unique Acceptance Procedure and was approved by CENELEC as EN 50178 on 1997-07-01.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1998-06-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2003-06-01

Annexes designated “informative” are given for information only. In this standard annexes A and B are informative.

Annex A offers additional information e.g. as a basis for design purposes. It also indicated items where new standards are expected to be established. Functions or characteristics presented in the informative annex A may be used as options of the electronic equipment, provided that test methods are specified and test equipment is available. In any case, these points have to be discussed and clarified between customer and manufacturer.

Annex B is under consideration. It is intended to contain tables with all important figures and values. It shows a condensed overview on the conditions and requirements for convenience of the user of the standard.

The requirements of this European Standard are based on basic or generic standards issued by IEC or CLC where these standards exist. This is valid especially for safety and environmental requirements. Additional requirements are stipulated where necessary.

This European Standard is a harmonized standard for electronic equipment for use in power installations according to the Low Voltage Directive 73/23/EEC. No additional requirements are to be met for compliance with this directive.

Contents

	Page
Foreword	2
1 Scope	8
2 Normative references	8
3 Definitions	10
4 Requirements for entire system	16
4.1 Normal function	16
4.2 Damage to persons or material	16
4.3 EE connected to unearthed supply mains under condition of earth fault	17
4.4 Earthing requirements (grounding, earthing and screening)	17
4.5 Wires and cables for interconnection	17
4.6 Fuses in neutral and protective conductors	17
5 Safety requirements	18
5.1 General requirements	18
5.2 Requirements for EE with regard to protection against electric shock	20
5.2.1 Requirements for protection against electric shock	20
5.2.2 Protection against direct contact	21
5.2.3 Protection by means of insulation of live parts	21
5.2.4 Protection by means of enclosures and barriers	21
5.2.4.1 Distances	22
5.2.5 Discharge of capacitors	22
5.2.6 Built-in devices	22
5.2.7 EE for closed electrical operating areas	22
5.2.8 Protection in the case of direct contact	22
5.2.8.1 Protection by means of extra-low voltage with protective separation (SELV- and PELV-system)	22
5.2.8.2 Protection by means of limitation of the discharging energy	22
5.2.8.3 Protection by means of protective impedance	22
5.2.8.4 Protection by using limited voltages in control circuits	23
5.2.8.5 Connectors	23
5.2.9 Protection with regard to indirect contact	23

		Page			Page
5.2.9.1	Insulation between live parts and exposed conductive parts	23	5.2.18.6	Components and other electrical sub-assemblies	47
5.2.9.2	Protective bonding	23	5.3	Requirements for EEs in installations with regard to protection against electric shock	47
5.2.9.3	Rating of protective bonding	24			
5.2.9.4	Protection against corrosion	24	5.3.1	Protection with regard to direct contact	47
5.2.9.5	Protective bonding conductor with low cross-section	24	5.3.1.1	Cables and leads	47
5.2.9.6	EE with voltage above a.c. 1 400 V or d.c. 2 000 V	24	5.3.1.2	Connection of EE with protective separation	47
5.2.9.7	Interruption	24	5.3.1.3	Built-in devices in installations	47
5.2.9.8	Marking	24	5.3.1.4	EE in closed electrical operating areas	48
5.2.10	Means of connection for the protective conductor	24	5.3.2	Protection with regard to indirect contact	48
5.2.11	Leakage current and fault current	24	5.3.2.1	Leakage current through the protective conductor	48
5.2.11.1	High leakage current	24	5.3.2.2	Permissible touch voltage	48
5.2.11.2	Compatibility with residual-current-operated protective devices in case of low leakage current	25	5.3.2.3	Protection of EE by residual-current-operated protective device	48
5.2.12	Special features in EE for protective class II	26	6	Environmental requirements and conditions	48
5.2.13	Decisive voltage	27	6.1	Climatic conditions	48
5.2.14	Solid insulation, insulation of circuits	29	6.1.1	Temperature	49
5.2.14.1	Between circuits and exposed conductive parts or accessible surfaces of EE	29	6.1.1.1	Ambient air temperature	49
5.2.14.2	Between circuits	29	6.1.1.2	Cooling medium temperature	50
5.2.14.3	Bridging of the insulation via conductive parts	29	6.1.2	Humidity and air pressure	50
5.2.15	Clearances and creepage distances, pollution degree	29	6.1.3	Pollution	50
5.2.15.1	Clearances and creepage distances	29	6.2	Mechanical requirements (general)	50
5.2.15.2	Pollution degree	37	6.2.1	Mechanical shock	50
5.2.16	Clearances	37	6.2.2	Mechanical vibration	50
5.2.16.1	Clearances between mains-circuits and their environment	38	6.2.2.1	Immunity requirement to mechanical vibration	50
5.2.16.2	Clearances between non-mains-circuits and their environment	39	6.2.2.2	Mechanical vibration emission constraints	50
5.2.16.3	Clearances within a circuit	40	6.2.3	Sealing in case of liquid cooling	51
5.2.17	Creepage distances	40	6.2.4	Sealing against dust ingress to EE	51
5.2.18	Protective separation	44	6.3	Electrical and electromagnetic requirements	51
5.2.18.1	Constructive measures	45	6.3.1	Conditions in the system (immunity level for EE)	51
5.2.18.2	Protective separation by double or reinforced insulation	45	6.3.2	EE connected to a.c. supply mains (immunity)	51
5.2.18.3	Protective separation by protective screening	45	6.3.2.1	Supply voltage variation	51
5.2.18.4	Clearances and creepage distances in case of protective separation	46	6.3.2.2	Frequency	51
5.2.18.5	Partial discharge	46	6.3.3	EE connected to d.c. supply mains (immunity)	51
			6.3.4	Short-circuit withstand capability (immunity)	52

	Page		Page
6.3.5	Immunity from electromagnetic disturbance	8	Requirements for the assembly of EE(s) in power installations
	52		56
6.3.6	Effects of EE(s) on the system (emission)	8.1	General
	52		56
6.3.7	Rating of power electronic equipment	8.2	Fitting tolerances after assembly
	52		56
7	Requirements for electronic equipment	8.3	Supply mains
	52		56
7.1	Design and construction	8.3.1	Monitoring of insulation
	52		56
7.1.1	General	8.3.2	Functional earthing
	52		56
7.1.2	Quality and reliability	8.3.3	Design and protection of conductors to and in EE
	52		56
7.1.3	Working life	8.3.3.1	Power input conductors to EE
	52		56
7.1.4	Insulation	8.3.3.2	Conductors between separated parts of an EE
	52		57
7.1.5	Component selection and use	8.3.3.3	Conductors on the load side of EE
	53		57
7.1.5.1	Selection criteria for components	8.3.3.4	Protective conductors
	53		57
7.1.5.2	Hazards arising from components	9	Testing
	53		57
7.1.6	Power supply switching, fusing and usage	9.1	General
	53		57
7.1.6.1	Fire protection and fire risk	9.1.1	Tests and methods of testing
	53		57
7.1.6.2	Operation under fault conditions	9.1.1.1	Type test
	53		57
7.1.7	Construction	9.1.1.2	Routine test
	53		58
7.1.7.1	EE mounting practice — general	9.1.1.3	Sample test
	53		58
7.1.7.2	Cooling	9.1.1.4	Site test
	53		58
7.1.7.3	Mechanical protection of equipment and sub-units	9.1.2	General conditions for testing
	53		58
7.1.7.4	Layout of components and equipment	9.1.3	Verification procedure
	53		58
7.1.7.5	Temperature of accessible parts	9.2	Compliance with this European Standard
	54		59
7.1.7.6	Fixing (mechanical retention of components and sub-units)	9.3	Overview of tests
	54		59
7.1.8	Electrical connections	9.4	Performance of the tests
	54		61
7.1.9	Multiple connectors and plug-and-socket devices	9.4.1	Visual inspections
	54		61
7.1.10	Electrical conductors	9.4.2	Climatic environmental tests
	54		61
7.1.10.1	Wires and cables for interconnection	9.4.2.1	Dry heat test
	54		62
7.1.10.2	Conventional wiring within EE	9.4.2.2	Damp heat test
	54		62
7.1.11	Reference conductor, functional earthing	9.4.3	Mechanical tests
	54		63
7.2	Marking, identification, documentation	9.4.3.1	Topple test
	54		63
7.2.1	Marking	9.4.3.2	Vibration test
	54		63
7.2.2	Identification of equipment, sub-units, position and terminals	9.4.3.3	Seal test for liquid cooled EE
	55		63
7.2.3	Documentation	9.4.4	Safety related mechanical tests
	55		64
7.2.3.1	General	9.4.4.1	Clearances and creepage distances
	55		64
7.2.3.2	Operating documents	9.4.4.2	Non-accessibility test
	55		64
7.2.3.3	Instructions for transport, maintenance, fault finding, repair	9.4.4.3	Enclosure test
	56		64
7.2.3.4	Test records	9.4.4.4	Suitability test of varnish or coating
	56		64
7.2.4	Drawings and diagrams	9.4.5	Safety related electrical (dielectric) tests
	56		64
		9.4.5.1	Impulse voltage test
			65
		9.4.5.2	A.c. or d.c. voltage insulation test
			66

		Page			Page
9.4.5.2.1	Relation of a.c. or d.c. test voltage to rated insulation voltage	66	A.5.2.9.4	Protection against corrosion	77
9.4.5.2.2	Value and type of insulation test voltage	66	A.5.2.11.2	Compatibility with residual-current-operated protective devices	77
9.4.5.2.3	Performing the insulation voltage test	67	A.5.2.13	Decisive voltage	79
9.4.5.2.4	Duration and verification of the a.c. or d.c. voltage test	69	A.5.2.14.1	Between circuits and exposed conductive parts or accessible surfaces of EE	79
9.4.5.3	Partial discharge test	69	A.5.2.16	Clearances	82
9.4.5.4	Insulation resistance test in the power installation	69	A.5.2.18	Protective separation	83
9.4.5.5	Protective impedance, protective screening	70	A.5.2.18.1	Constructive measures	83
9.4.6	Electrical environmental tests	70	A.5.2.18.7	Coil devices	84
9.4.6.1	Emission of electromagnetic disturbance	70	A.5.2.18.8	Switchgear and electromechanical components	85
9.4.6.2	Immunity from electromagnetic disturbance	70	A.5.2.18.9	Semiconductor components and semiconductor configurations	85
9.4.6.3	Short-circuit withstand capability	70	A.5.2.18.10	Connectors and terminal blocks	85
9.4.7	Performance test	71	A.5.3	Requirements for EEs in installations with regard to protection against electric shock	85
Annex A (informative)	Additional information	72	A.5.3.2.4	Equipotential bonding between reference conductor and protective conductor	85
A.2	Bibliography	72	A.6	Environmental requirements and conditions	85
A.4	Requirements for entire system	72	A.6.1.2	Humidity and air pressure	86
A.4.4	Earthing requirements (grounding, earthing and screening)	72	A.6.1.3	Pollution (atmospheric)	86
A.4.4.1	Functional grounding/earthing	73	A.6.1.4	Special stress	86
A.4.4.1.1	Cable screens	73	A.6.2.2.1	Immunity requirement to mechanical vibration	86
A.4.4.1.2	Armoring, conduits and cable trays	73	A.6.3	Electrical and electromagnetic requirements	86
A.4.4.1.3	Reference conductors	73	A.6.3.2	EE connected to a.c. supply mains (immunity)	87
A.4.4.1.4	Transformer screens	74	A.6.3.2.3	Voltage dips and short supply interruptions	87
A.4.4.1.5	Filter returns	74	A.6.3.2.4	Harmonic and interharmonic voltages	87
A.4.4.1.6	Radio frequency (RF) screens	74	A.6.3.2.5	Voltage notches	87
A.4.7	Acoustic noise	74	A.6.3.2.6	Voltage unbalance	88
A.5	Safety requirements	74	A.6.3.3	EE connected to d.c. supply mains (immunity)	88
A.5.2.4	Protection by means of enclosures and barriers	74	A.6.3.5	Immunity from electromagnetic disturbance	88
A.5.2.4.2	Mechanical fault	74	A.6.3.5.1	Types of interference	88
A.5.2.4.3	Mechanical durability	74	A.6.3.5.2	Electrical isolation of process I/O and telecommunication ports	88
A.5.2.4.4	Screws	74	A.6.3.6	Effects of EE(s) on the system (emission)	89
A.5.2.4.5	Opening of enclosures	75	A.7	Requirements for electronic equipment	89
A.5.2.8	Protection in the case of direct contact	75			
A.5.2.8.2	Protection by means of limitation of discharging energy	77			
A.5.2.8.3	Protection by means of protective impedance	77			
A.5.2.9.2	Bonding connection arrangements	77			
A.5.2.9.3	Rating of protective bonding	77			

		Page			Page
A.7.1.2	Quality and reliability	89	A.7.2.4.2	Diagrams	94
A.7.1.5	Component selection and use	89	A.7.3	Setting-up, calibration and maintenance	94
A.7.1.5.3	Rating	89	A.7.3.1	Objectives	94
A.7.1.5.4	Tolerance of components	89	A.7.3.2	Preset controls and adjustable components	94
A.7.1.5.5	Storage	89	A.7.3.3	Removal and replacement of sub-units	95
A.7.1.5.6	Failure mechanism	90	A.7.3.4	Test points and other maintenance aids	95
A.7.1.5.7	Semiconductor devices, including integrated circuits	90	A.7.3.5	Special tools	95
A.7.1.5.8	Indicating devices	90	A.7.3.6	Power sources for test equipment	95
A.7.1.5.9	Storage/transportation	90	A.7.3.7	Loose items	95
A.7.1.6	Power supply switching, fusing and usage	90	A.8	Requirements for the assembly of EE(s) in power installations	95
A.7.1.6.1	Fire protection and fire risk	90	A.8.3.3.1	Power input conductors to EE	95
A.7.1.6.3	Power supply units	90	A.9	Testing	95
A.7.1.6.4	Power supply unit usage	90	A.9.1.1.1	Type test	95
A.7.1.6.5	Batteries	91	A.9.1.1.5	Integration tests	96
A.7.1.7	Construction	91	A.9.4	Additional tests	96
A.7.1.7.2	Cooling	91	A.9.4.2.3	Low temperature test	96
A.7.1.7.7	Component mounting (avoidance of excessive mechanical stressing)	91	A.9.4.2.4	Salt corrosion test	96
A.7.1.8	Electrical connections	91	A.9.4.2.5	Humidity cycling test	96
A.7.1.8.1	Soldered connections	91	A.9.4.2.6	Mould growth test	96
A.7.1.8.2	Component soldering	91	A.9.4.2.7	Industrial atmosphere test	96
A.7.1.8.3	Solderless wrapped connections	91	A.9.4.3.4	Drop test	96
A.7.1.8.4	Screwtype connections	91	A.9.4.3.5	Seismic test	96
A.7.1.8.5	Current carrying parts and their connections	91	A.9.4.5.3	Partial discharge test	96
A.7.1.8.6	Crimped connections	91	A.9.4.6.4	High frequency disturbance test	96
A.7.1.8.7	Insulation displacement connections	91	A.9.4.6.5	Insulation tests for process I/O and telecommunication ports with electrical isolation	96
A.7.1.8.8	Terminal blocks	92	A.9.4.8	Soak test	99
A.7.1.9	Multiple connectors and plug-and-socket devices	92	Annex B (informative) Tables and figures		99
A.7.1.9.1	Printed circuit board connection	92	Figure 1 — Arrangement of fuses in sub-assemblies and in installations		18
A.7.1.10	Electrical conductors	92	Figure 2 — Functional summary of protective measures against electric shock		19
A.7.1.10.2	Conventional wiring within EE	92	Figure 3 — Examples for protection against direct contact		20
A.7.1.10.3	Materials and finishes	93	Figure 4 — Flow chart leading to requirements when using EE(s) behind an RCD		26
A.7.1.12	Programmable equipment	93	Figure 5 — Typical waveform for case a) a.c. voltage		27
A.7.1.12.1	Software and firmware	93	Figure 6 — Typical waveform for case b) d.c. voltage		27
A.7.1.12.2	Software/firmware support	93	Figure 7 — Typical waveform for case c) pulsating voltage		28
A.7.2	Marking, identification, documentation	93			
A.7.2.2	Component identification	93			
A.7.2.3.5	Documentation for software, firmware and programmable logic	94			
A.7.2.4	Drawings and diagrams	94			
A.7.2.4.1	Drawings	94			

	Page		Page
Figure 8 — Determination of insulation within a circuit	31	Table 7 — Climatic conditions	49
Figure 9 — Determination of insulation between live parts and accessible surfaces	32	Table 8 — Heating of accessible parts	54
Figure 10 — Determination of insulation between circuits and environment and of insulation between circuits	33	Table 9 — General test conditions	58
Figure 11 — Determination of functional insulation	34	Table 10 — Overview of tests	60
Figure 12 — Determination of basic insulation	35	Table 11 — Dry heat test	62
Figure 13 — Determination of double or reinforced insulation	36	Table 12 — Damp heat test	62
Figure 14 — Protective separation (with the respective subclauses in parentheses)	44	Table 13 — Topple test	63
Figure 15 — Clearances and creepage distances for protective separation	46	Table 14 — Vibration test	63
Figure 16 — Voltage test procedures	68	Table 15 — Non-accessibility test	64
Figure A.1 — Examples for protection in the case of direct contact	76	Table 16 — Impulse voltage test	65
Figure A.2 — Fault-current in connections with semiconductor devices.	78	Table 17 — Impulse test voltage	66
Figure A.3 — Planning example for application of RCD Type B	79	Table 18 — A.c. or d.c. insulation test voltage	67
Figure A.4 — Examples of subdivided insulation against accessible surfaces of EE	80	Table 19 — Partial discharge test	69
Figure A.5 — Examples for the insulation of control elements	81	Table 20 — Minimum value of insulation resistance	70
Figure A.6 — Examples for the design of clearances (continued)	82	Table 21 — Short-circuit withstand capability	71
Figure A.7 — Correlation between humidity and temperature of the air	86	Table A.1 — Values of accessible capacitance and charging voltage (threshold of pain)	77
Figure A.8 — Periodical momentary dips of a.c. mains voltage caused by convertors	88	Table A.2 — Maximum concentration of corrosive gases	86
Figure A.9 — Insulation displacement connection with flat cable	92		
Figure A.10 — Test set-up for EE grounded via a dedicated earthing connection	98		
Figure A.11 — Test set-up for EE grounded via the power cord	98		
Figure A.12 — Application of the test voltage to a single port and to grouping of ports	99		
Table 1 — Summary of the limits of the decisive voltage U_M	28		
Table 2 — Definitions of pollution degrees	37		
Table 3 — Clearances between mains-circuits and their environment	38		
Table 4 — Clearances between non-mains-circuits and their environment	39		
Table 5 — Clearances within a circuit	40		
Table 6 — Minimum creepage distances	42		

Introduction

As the title indicates this European Standard applies where electronic equipment is to be installed or is used in power installations. The term electronic equipment denotes equipment which may contain information technology equipment as well as power electronic equipment and non-electronic components. Electronic equipment may be designed and used as stand-alone-equipment or as sub-assemblies built as cubicles, plug-in-units or assembled printed circuit boards. However, the EMC requirements are always to be fulfilled on the apparatus or system level.

The term power installation as used in this European Standard denotes an installation with assembled electrical and electronic equipment in a given location and designed for coordinated operation and connected to an electricity supply system. Although the use of the installation is not specified it is expected that the main purpose will be controlling, regulating and converting electrical energy. In all cases within this European Standard a power installation is interacting with the electricity supply system, either directly e.g. by means of control, regulating and protection system, or indirectly e.g. by means of measurements leading to intervention by personnel. However, power installation as used in other standards may have other definitions.

As the title “Electronic equipment for use in power installations” implies the standard mainly applies where electronic equipment is integrated into or is used in power installations. As the standard is also concerned with the design and testing of electronic equipment, the appropriate clauses within it apply in cases where no other applicable specifications exist in individual product standards.

Beyond that the main intention of the standard is to stipulate minimum requirements for the design and manufacture of electronic equipment, for protection against electric shock, for testing and for the integration into systems for power installations. Right from the beginning and reflecting the experiences of the experts it seems necessary to use minimum requirements in order to achieve a certain technical level with respect to safety and reliability. This is especially true where electronic equipment is assembled into power installations.

In all cases where more severe requirements are defined in individual product standards or purchasing specifications they shall take precedence over the requirements of this European Standard. This may be true for special safety related applications of electronic equipment or applications under special environmental conditions.

In the other cases where a product standard does not meet the minimum requirements of this European Standard and therefore prevents the direct use of electronic equipment designed and manufactured fulfilling the requirements of those product standards additional means has to be considered in power installations. One possibility is to influence the

environmental conditions in which the electronic equipment is operating so that they are compatible with the requirements of this European Standard. This can be done by special casing or means of filtering for example. The other possibility is to improve the electronic equipment so that it meets the requirements of this European Standard.

1 Scope

This European Standard applies to the use of electronic equipment (EE) in power installations where a uniform technical level with respect to safety and reliability is necessary. This standard also applies to EE which are not covered by a specific product standard.

This European Standard defines the minimum requirements for the design and manufacture of EE, for protection against electric shock, for testing and its integration into systems for power installations.

This European Standard does not cover the following applications: electrical accessories and electrical appliances for household and similar purposes, medical equipment, electric railway equipment, data processing without control on systems and processes, public and private non-industrial telecommunication and radio communication equipment and networks, protection relays, residual-current-operated protective devices, uninterruptible power supplies, lighting equipment and public charging equipment for electrical vehicles.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

European Standards

EN 29000:1988, *Quality management and quality assurance — Guidelines for selection and use.*

EN 50081-1, *Electromagnetic compatibility — Generic emission standard — Part 1: Residential, commercial and light industry.*

EN 50081-2, *Electromagnetic compatibility — Generic emission standard — Part 2: Industrial environment.*

EN 50082-1, *Electromagnetic compatibility — Generic immunity standard — Part 1: Residential, commercial and light industry*

EN 50082-2, *Electromagnetic compatibility — Generic immunity standard — Part 2: Industrial environment.*

prEN 50093:1991, *Basic immunity standard for voltage dips, short interruptions and voltage variations.*

EN 60068-2-2 :1993, *Basic environmental testing procedures — Part 2: Tests — Tests B: Dry heat* (+A1:1993 +A2:1994).
(IEC 68-2-2:1974 +IEC 68-2-2/A1:1993 +IEC 68-2-2/A2:1994)

EN 60068-2-6:1995, *Basic environmental testing procedures — Part 2: Tests — Test Fc and guidance: Vibration (sinusoidal)*.
(IEC 68-2-6:1995)

EN 60068-2-31:1993, *Basic environmental testing procedures — Part 2: Tests — Test Ec: Drop and topple, primarily for equipment-type specimens*.
(IEC 68-2-31:1969 +A1:1982)

EN 60071-1:1995, *Insulation coordination — Part 1: Terms, definitions, principle and rules*
(IEC 71-1:1993)

EN 60146-1-1:1993, *Semiconductor convertors — General requirements and line commutated convertors — Part 1-1: Specifications of basic requirements*.
(IEC 146-1-1:1991)

EN 60269-1:1989, *Low-voltage fuses — Part 1: General requirements*.
(IEC 269-1:1986)

EN 60352-1:1994, *Solderless connections — Part 1: Solderless wrapped connections — General requirements, test methods and practical guidance*.
(IEC 352-1:1983)

EN 60352-2:1994, *Solderless connections — Part 2: Solderless crimped connections — General requirements, test methods and practical guidance*.
(IEC 352-2:1990)

EN 60529:1991, *Degrees of protection provided by enclosures (IP-Code)*.
(IEC 529:1989)

EN 60721-3-1:1993, *Classification of environmental conditions — Part 3: Classification of groups of environmental parameters and their severities — Storage*.
(IEC 721-3-1:1987 +A1:1991)

EN 60721-3-2:1993, *Classification of environmental conditions — Part 3: Classification of groups of environmental parameters and their severities — Transportation*.
(IEC 721-3-2:1985 +A1:1991)

EN 60721-3-3:1995, *Classification of environmental conditions — Part 3: Classification of groups of environmental parameters and their severities — Stationary use at weatherprotected locations*.
(IEC 721-3-3:1994)

EN 60721-3-4:1995, *Classification of environmental conditions — Part 3: Classification of groups of environmental parameters and their severities — Stationary use at non weatherprotected locations*.
(IEC 721-3-4:1995)

EN 61008-1:1994, *Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCB's) — Part 1: General rules*.
(IEC 1008-1:1990 +A1:1992)

EN 61136-1:1995, *Semiconductor power convertors — Adjustable speed electric drive systems — General requirements — Part 1: Rating specifications, particularly for d.c. motor drives*.
(IEC 1136-1:1992, modified)

EN 61180-1:1994, *High-voltage test technique for low-voltage equipment — Part 1: Definitions, test and procedure requirements*.
(IEC 1180-1:1992)

EN 61800-3:1996, *Adjustable speed electrical power drive systems — Part 3: EMC product standard including specific test methods*.
(IEC 1800-3:1996)

ENV 61000-2-2:1993, *Electromagnetic compatibility (EMC) — Part 2: Environment — Section 2: Compatibility levels for low-frequency conducted disturbances and signalling in public low-voltage power supply systems*.
(IEC 1000-2-2:1990, modified)

Harmonization Documents

HD 21.7 S1:1990, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V — Part 7: Single core non-sheathed cables for internal wiring for a conductor temperature of 90 °C*.

HD 193 S2:1982, *Voltage bands for electrical installation of buildings*.
(IEC 449:1973 +A1:1979)

HD 214 S2:1980, *Method for determining the comparative and the proof tracking indices of solid insulation materials under moist conditions*.
(IEC 112:1979)

HD 243 S12:1995, *Graphical symbols for use on equipment*.
(IEC 417:1973 +IEC 417A:1974 to IEC 417M:1994)

HD 323.2.3 S2:1987, *Basic environmental testing procedures — Part 2: Tests — Test Ca: Damp heat, steady state*.
(IEC 68-2-3:1969 +A1:1984)

HD 323.2.28 S1:1988, *Basic environmental testing procedures — Part 2: Tests — Guidance for damp heat tests*.
(IEC 68-2-28:1980)

HD 366 S1:1977, *Classification of electrical and electronic equipment with regard to protection against electric shock*.
(IEC 536:1976)

HD 384.2 S1:1986, *International Electrotechnical Vocabulary (IEV) — Chapter 826: Electrical installations of buildings*.
(IEC 50(826):1982)

HD 384.3 S2:1995, *Electrical installation of buildings — Part 3: Assessment of general characteristics.*
(IEC 364-3:1993, modified)

HD 384.4.41 S2:1996, *Electrical installation of buildings — Part 4: Protection for safety — Chapter 41: Protection against electric shock.*
(IEC 364-4-41:1992, modified)

HD 384.4.43 S1:1980, *Electrical installation of buildings — Part 4: Protection for safety — Chapter 43: Protection against overcurrent.*
(IEC 364-4-43:1977, modified)

HD 384.4.47 S2:1995, *Electrical installation of buildings — Part 4: Protection for safety — Chapter 47: Application of protective measures for safety — Section 470: General — Section 471: Measures of protection against electric shock.*
(IEC 364-4-47:1981 +A1:1993, modified)

HD 384.4.473 S1:1980, *Electrical installation of buildings — Part 4: Protection for safety — Chapter 47: Application of protective measures for safety — Section 473: Measures of protection against overcurrent.*
(IEC 364-4-473:1977, modified)

HD 384.5.523 S1:1991, *Electrical installation of buildings — Part 5: Selection and erection of electrical equipment — Chapter 52: Wiring systems — Section 523: Current-carrying capacities.*
(IEC 364-5-523:1983, modified)

HD 384.5.54 S1:1988, *Electrical installation of buildings — Part 5: Selection and erection of electrical equipment — Chapter 54: Earthing arrangements and protective conductors.*
(IEC 364-5-54:1980, modified)

HD 384.6.61 S1:1992, *Electrical installation of buildings — Part 6: Verification — Chapter 61: Initial verification.*
(IEC 364-6-61:1986, modified)

HD 413.3 S1:1987, *Operating conditions for industrial-process measurement and control equipment — Part 3: Mechanical influences.*
(IEC 654-3:1983)

HD 472 S1:1989, *Nominal voltages for low voltage public electricity supply systems.*
(IEC 38:1983, modified)

HD 493.1 S1:1988, *Dimensions and mechanical structures of 482,6 mm (19 in) series — Part 1: Panels and racks.*
(IEC 297-1:1986)

HD 540.2 S1:1991, *Insulation co-ordination — Part 2: Application guide.*
(IEC 71-2:1976)

HD 540.3 S1:1991, *Insulation co-ordination — Part 3: Phase-to-phase insulation co-ordination — Principle, rules and application guide.*
(IEC 71-3:1982)

HD 588.1 S1:1991, *High voltage test techniques — Part 1: General definitions and test requirements.*
(IEC 60-1:1989)

HD 625.1 S1:1996, *Insulation coordination for equipment within low-voltage systems — Part 1: Principles, requirements and tests.*
(IEC 664-1:1992, modified)

IEC-Publications

IEC 50 (151):1978, *International Electrotechnical Vocabulary (IEV) — Chapter 151: Electrical and magnetic devices.*

IEC 50 (161):1990, *International Electrotechnical Vocabulary (IEV) — Chapter 161: Electromagnetic compatibility.*

IEC 364-6-61, *Electrical installation of buildings — Part 6: Verification — Chapter 61: Initial verification (+Amendment 1:1993).*

IEC 536-2:1992, *Classification of electrical and electronic equipment with regard to protection against electric shock — Part 2: Guidelines to requirements for protection against electric shock.*

IEC 664-3:1992, *Insulation coordination for equipment within low-voltage systems — Part 3: Use of coatings to achieve insulation coordination of printed board assemblies.*

IEC 747 series, *Semiconductor devices, discrete devices.*

IEC 748 series, *Semiconductor devices, integrated circuits.*

IEC 755:1983, *General requirements for residual-current-operated protective devices (+Amendment 1:1988, +Amendment 2:1992).*

IEC 990:1990, *Methods of measurement of touch current and protective conductor current.*

IEC 1000-2-1:1990, *Electromagnetic compatibility (EMC) — Part 2: Environment — Section 1: Description of the environment — Electromagnetic environment for low-frequency conducted disturbances and signalling in public power supply systems.*

IEC 1140:1992, *Protection against electric shock — Common aspects for installation and equipment.*

IEC 1201:1992, *Extra low voltage (ELV) — Limit values.*

IEC-Guide 106:1989, *Guide for specifying environmental conditions for equipment performance rating.*

3 Definitions

For the purposes of this European Standard, the following definitions apply.

3.1

adjacent circuits

electric circuits which are separated from the considered circuit by the necessary basic or double/reinforced insulation. Circuits which are separated by far more than double or reinforced insulation are not regarded to be adjacent



Documents

Document Sharing Hub
© BSI 08-1999

3.2

ambient air temperature

temperature measured at half the distance from any neighbouring equipment, but not more than 300 mm distance from the enclosure, at middle height of the equipment, protected from direct heat radiation from the equipment
[EN 60146-1-1]

3.3

apparatus

finished product with an intrinsic function intended for the final user and intended to be placed on the market or put into service as a single commercial unit

3.4

basic insulation

insulation applied to live parts to provide basic protection against electric shock
[HD 366 S1]

3.5

(electrical) circuit

current paths of components or assemblies, conductors, terminals and items of equipment located within the EE and connected to each other by electrically conducting connections. If electrical systems are conductively connected via earth only, then they are regarded as separate circuits

NOTE The clause "conductively connected" means the direct electrical connection and the connection via components such as resistors, capacitors, choke-coils, semiconductor-devices, switches and fuses, but not, however, coupling by means of transformers or opto-electronic devices or similar.

A protectively separated circuit of EE has protective separation from all adjacent circuits.

3.6

closed electrical operating area

rooms or locations which are exclusively used as enclosure for operation of electrical installations and are kept locked. The lock is only opened by authorized persons. Access is only allowed to skilled persons whilst energized

NOTE To these locations belong e.g. closed switchplants, distribution plants, switchgear cells, transformer cells, distribution systems in metal-sheet enclosures or in other closed installations.

3.7

(electromagnetic) compatibility

ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbance to anything in that environment
[IEV 161-01-07]

3.8

(electromagnetic) compatibility level

specified disturbance level at which an acceptable, high probability of electromagnetic compatibility should exist
[IEV 161-03-10/A]

3.9

component

any item used in the composition of a device or apparatus and without intrinsic function for the final user
[1(IEV 161)(Sec)1318]

3.10

considered circuit

electrical circuit which is in particular under consideration concerning its dielectric tests or its insulation to accessible surface or to adjacent circuits

3.11

control (action)

includes in this European Standard manual and automatic control of processes. It would apply to EE in which control action is incorporated within supervisory control and data acquisition systems and other process control systems

3.12

cooling medium

liquid (for example water) or gas (for example air) which removes the heat from the equipment

3.13

cooling medium temperature for air or gas cooling

average temperature measured outside the equipment at points 50 mm from the inlet to the equipment

3.14

cooling medium temperature for liquid cooling

temperature measured in the liquid pipe 100 mm upstream from the liquid inlet

3.15 decisive voltage

voltage, taking into account non-sinusoidal waveforms (see 5.2.13), defining the borderlines to be used between extra-low-voltage, low voltage and high voltage. These borderlines are used to determine the requirements of protective earthing when designing clearances and creepage distances for the arrangement of protective measures

3.16

device

combination of components having a given function, forming a part of a piece of equipment, apparatus or system

NOTE 1 For example, thermostat, relay, push buttons, switch or contactor.
[1(IEV 161)(Sec)1318]

NOTE 2 The terms "component" and "device" are used side by side in this European Standard.

3.17

direct contact

contact of persons or livestock with live parts
[HD 384.2 S103-05]

3.18

(electromagnetic) disturbance

any electromagnetic phenomenon which may degrade the performance of a device, equipment or system, or adversely affect living or inert matter

NOTE An electromagnetic disturbance may be noise, an unwanted signal or a change in the propagation medium itself.
[IEV 161-01-05]

3.19

double insulation

insulation comprising both basic insulation and supplementary insulation

NOTE Basic and supplementary insulation are separate, each designed for basic protection against electric shock.
[HD 366 S1]

3.20

electrical equipment

any items used for such purposes as generation, conversion, transmission, distribution or utilization of electrical energy, such as machines, transformers, apparatus, measuring instruments, protective devices, equipment for wiring systems, appliances

NOTE This includes sub-assemblies, equipment (such as assembled printed circuit boards, plug-in units, cubicles) and installations as defined in the contract.
[HD 384.2 S1-07-01 modified]

3.21

electricity supply system

distribution system through which various electricity users are fed from one or more electricity producers

NOTE The users may be independent of each other, their number and type are various and they may be connected or disconnected arbitrarily.

3.22

electronic equipment (EE)

electrical equipment, the main function of which is performed by the use of components using electron or ion conduction in semiconductors, in vacuum or in gases

NOTE 1 Electronic equipment contains data processing equipment and/or power electronic equipment according to its main function. It may contain non-electronic components or equipment.

NOTE 2 This includes sub-assemblies and equipment, such as assembled printed circuit boards, plug-in units, cubicles.

3.23

ELV (Extra Low Voltage)

any voltage not exceeding a limit which is generally accepted to be a.c. 50 V and d.c. 120 V (ripple free)

3.24

(electromagnetic) emission

phenomenon by which electromagnetic energy emanates from a source

[IEV 161-01-08]

3.25

(electromagnetic) emission level (of a disturbing source)

level of a given electromagnetic disturbance emitted from a particular device, equipment or system, measured in a specified way
[IEV 161-03-11]

3.26

equipotential bonding

electrical connection putting various exposed conductive parts and extraneous conductive parts at a substantially equal potential
[HD 384.2 S1-04-09]

3.27

exposed conductive parts

conductive part of electrical equipment, which can be touched and which is not normally live, but which may become live under fault conditions
[HD 384.2 S1-03-02]

3.28

extraneous conductive parts

conductive part not forming part of the electrical installation and liable to introduce a potential, generally the earth potential
[HD 384.2 S1-03-03]

3.29

FELV-system (Functional Extra Low Voltage)

electrical system

- in which the voltage cannot exceed ELV; and
- in which the safety requirements for SELV- or PELV-systems are not complied with

3.30

forced circulation of the cooling medium or the heat transfer agent (forced cooling)

method of circulating the cooling medium or heat transfer agent by means of blower(s), fan(s) or pump(s)

3.31

functional earthing

earthing of a point in an equipment or in a system which is necessary for a purpose other than safety

3.32

functional insulation

insulation between conductive parts which is necessary only for the proper functioning of the equipment
[HD 625.1 S1]

3.33

heat transfer agent

liquid (for example water) or gas (for example air) within the equipment to transfer the heat from its source to a heat exchanger from where the heat is removed by the cooling medium

3.34

(electromagnetic) immunity (to a disturbance)

ability of a device, equipment or system to perform without degradation in the presence of an electromagnetic disturbance
[IEV 161-01-20]

3.35

(electromagnetic) immunity level

maximum level of a given electromagnetic disturbance, incident in a specified way on a particular device, equipment or system, at which no degradation of operation occurs
[IEV 161 03 14/A]

3.36

(electromagnetic) immunity margin

ratio of the immunity limit to the electromagnetic compatibility level
[IEV 161-03-16/A]

3.37

indirect contact

contact of persons or livestock with exposed conductive parts which have become live under fault conditions
[HD 384.2 S1-03-06]

3.38

indirect cooling

method of cooling in which the heat transfer agent is used to transfer heat from the part to be cooled to the cooling medium

3.39

installation

several combined items of apparatus or systems put together at a given place to fulfil a specific objective but not intended to be placed on the market as a single functional unit

3.40

(electromagnetic) interference

degradation of the performance of the equipment, transmission channel or system caused by an electromagnetic disturbance
[IEV 161-01-06]

3.41

leakage current (in an installation)

current which, in the absence of a fault, flows to earth or to extraneous conductive parts in a circuit
[HD 384.2 S1-03-08]

NOTE This current may have a capacitive component including that resulting from the deliberate use of capacitors.

3.42

live parts

conductor or conductive part intended to be energized in normal use, including a neutral conductor, but, by convention, not a PEN conductor
[HD 384.2 S1-03-01]

3.43

mains-circuit

electrical circuit which is conductively connected to and energized directly from the supply mains

3.44

malfunction

operation of EE which is outside of the specification

3.45

natural circulation of the cooling medium or the heat transfer agent (convection)

method of circulating the cooling fluid (cooling medium or heat transfer agent) which uses the change of volumetric mass (density) with temperature

3.46

nominal value

suitable approximate quantity value used to designate or identify a component, device or equipment
[IEV 151-04-01]

3.47

non-mains-circuit

electrical circuit which is not energized directly from the supply mains but is e.g. isolated by a transformer for particular EE(s) or supplied by a battery

3.48

overvoltage category

numeral defining an impulse withstand level
[HD 625.1 S1]

NOTE Overvoltage categories I, II, III and IV are used, see 5.2.16.

3.49

PELV-system (protective extra low voltage)

electrical system

- in which the voltage cannot exceed ELV; and
- with protective separation from systems other than PELV; and
- with provisions for earthing of the PELV-system, or its exposed conductive parts, or both

3.50

PEN conductor

earthed conductor combining the functions of both protective conductor and neutral conductor

NOTE The acronym PEN results from the combination of both symbols PE for the protective conductor and N for the neutral conductor.

[HD 384.2 S1-04-06]

3.51

performance criteria

performance specification for the operation of the EE throughout the environmental conditions stated in this specification namely

- mechanical;
- climatic;
- electrical conditions

3.52

power electronic equipment

EE, the main function of which is conversion of energy

NOTE A static switch, where the main switching function is carried out by electronic components, converts the energy from input to output:

- without any transformation (except introduction of losses) in the ON state;
- to no energy available on the output in the OFF state.

This is a power electronic equipment.

NOTE 2 A switch gear, using electronics for triggering protection is not a power electronic equipment and is not an EE. (The main function is to establish or eliminate a contact performed by use of mechanical components.)

3.53

power installation

installation with assembled electrical equipment or electronic equipment or a combination of electric and electronic equipment in a given location and designed for coordinated operation and connected to an electricity supply system. The use of the installation is not specified, but it is interacting with the electricity supply system, either directly e.g. by means of control, regulating and protection equipment, or indirectly e.g. by means of measurements leading to intervention by personnel

NOTE Instead of "power installation" sometimes the wording "electrical installation" may be used.

3.54

protective bonding

electrical connection of exposed-conductive-parts or of protective screening to provide electrical continuity by means of connection to an external protective conductor which is securely returned to earth [IEC 536-2, modified]

3.55

protective class 0

equipment in which protection against electric shock relies upon basic insulation; this implies that there are no means for the connection of accessible conductive parts, if any, to the protective conductor in the fixed wiring of the installation, reliance in the event of a failure of the basic insulation being placed upon the environment [HD 366 S1]

3.56

protective class I

equipment in which protection against electric shock does not rely on basic insulation only, but which includes an additional safety precaution in such a way that means are provided for the connection of accessible conductive parts to the protective (earthing) conductor in the fixed wiring of the installation in such a way that accessible conductive parts cannot become live in the event of a failure of the basic insulation [HD 366 S1]

3.57

protective class II

equipment in which protection against electric shock does not rely on basic insulation only, but in which additional safety precautions such as double insulation or reinforced insulation are provided, there being no provision for protective earthing or reliance upon installation conditions [HD 366 S1]

3.58

protective class III

equipment in which protection against electric shock relies on supply at safety extra-low voltage (SELV) and in which voltages higher than those of SELV are not generated [HD 366 S1]

3.59

protective conductor

conductor required for protection against electric shock by electrically connecting any of the following parts:

- exposed conductive parts;
- extraneous conductive parts;
- main earthing terminal;
- earth electrode;
- earthed point of the source or artificial neutral

[HD 384.2 S1-04-05, modified]

3.60

protective earthing

earthing of a point in a system, installation or equipment for protection against electric shock in case of a fault

3.61

protective impedance device

component or assembly of components the impedance and construction of which are such that it reliably limits steady-state current and discharge to a non-hazardous level [IEC 1140]

3.62

protective screening

separation of circuits from hazardous live-parts by means of an interposed conductive screen, connected to the means of connection for an external protective conductor
[IEC 536-2]

3.63

protective separation

separation between circuits by means of basic and supplementary protection (basic insulation plus supplementary insulation or protective screening) or by an equivalent protective provision (e.g. reinforced insulation)
[IEC 536-2]

3.64

rated insulation voltage (RIV)

withstand voltage value assigned by the manufacturer to the equipment or to a part of it, characterizing the specified (long-term) withstand capability of its insulation

NOTE 1 The rated insulation voltage is higher or equal to the rated voltage of the equipment, or to the rated voltage of the concerned part of the equipment, which is primarily related to functional performance.

[HD 625.1 S1, modified]

NOTE 2 The rated insulation voltage refers to the insulation between electric circuits, between live parts and exposed conductive parts and within an electric circuit.

NOTE 3 For clearances and solid insulation the peak value of the voltage occurring across the insulation or clearance is the determining value for the rated insulation voltage. For creepage distances the r.m.s. value is the determining value.

3.65

rated value

quantity value assigned, generally by a manufacturer, for a specified operating condition of a component, device or equipment
[IEV 151-04-03]

3.66

rated voltage

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

NOTE Equipment may have more than one rated voltage value or may have a rated voltage range.

[HD 625.1 S1]

3.67

reference conductor

conductor to which the potential of other conductors is related

3.68

reinforced insulation

single insulation system applied to live-parts, which provides a degree of protection against electric shock equivalent to double insulation under the conditions specified in the relevant IEC standard

NOTE The term "insulation system" does not imply that the insulation must be one homogeneous piece. It may comprise several layers which cannot be tested singly as supplementary or basic insulation.

[HD 366 S1]

3.69

relative short-circuit power

ratio of the short-circuit power of the source to the fundamental apparent power on the line side of the convertor(s). It refers to a given point of the network, for specified operating conditions and specified network configuration
[EN 60146-1-1]

3.70

SELV-system (safety extra low voltage)

electrical system

- in which the voltage cannot exceed ELV; and
- with protective separation from systems other than SELV; and
- with no provisions for earthing the SELV-system, or its exposed conductive parts; and
- with simple separation from earth

3.71

shields/screens

fully or partly closed electrically or magnetically conductive coverings which prevents the reception or radiation of noise signals to some defined level

3.72

short supply interruption

disappearance of the supply voltage for a period of time not exceeding 1 min. Short supply interruptions can be considered as voltage dips with 100 % amplitude
[IEC 10002-1]

3.73

simultaneity factor

ratio of the sum of the fundamental apparent power of power convertors connected to a section of the supply mains which inevitably commutates during the same time, to the sum of the rated values of the fundamental apparent power of all power convertors connected to the same section of the supply mains

3.74 supplementary insulation

independent insulation applied in addition to basic insulation in order to provide protection against electric shock in the event of a failure of basic insulation

NOTE Basic and supplementary insulation are separate, each designed for basic protection against electric shock.
[HD 366 S1]

3.75 supply voltage variation

change of the supply voltage to a higher or lower value than the nominal voltage. The duration of the change can be short or long
[prEN 50093]

3.76 system

several items of apparatus combined to fulfil a specific objective and intended to be placed on the market as a single functional unit

3.77 used as intended

powered up, and in the operational state(s) stated in the relevant performance specifications of the EE concerned

3.78 voltage dip

sudden reduction of the voltage at a point in the electrical system, followed by voltage recovery after a short period of time, from half a cycle to a few seconds
[ENV 61000-2-2]

3.79 voltage notch

voltage change with a duration much shorter than the a.c. period, which may appear on an a.c. voltage e.g. due to the commutation process in a convertor
[IEV 161-08-12]

3.80 voltage unbalance

in a polyphase system, a condition in which the r.m.s values of the phase voltages or the phase angles between consecutive phases are not all equal
[IEV 161-08-09]

3.81 withstand

state of survival of the EE to the related imposed environmental or test condition (e.g. impulse withstand voltage)

3.82 working life

defined for EE by all the following factors:

- equipment maintenance has not yet reached the stage of being uneconomic;
- replacement parts are still available;
- failure rate is still in a specified level;
- the performance of the equipment has not degraded to a point where even with replacement of components and application of maintenance procedures, it no longer meets its specification requirements.

EE is considered to have come to the end of its working life when any of the above criteria is no longer true.

4 Requirements for entire system

The requirements of this European Standard are minimum requirements and apply to the design and manufacture of EE and for its erection in power installations.

To achieve a uniform technical level with respect to safety and reliability this European Standard defines the minimum requirements which are necessary when EE(s) are assembled into power installations.

- Where an EE has to meet more severe requirements as defined in its individual product standards, these requirements shall take precedence over the requirements of this European Standard.
- Where an EE does not meet sufficient safety requirements, that is to say the minimum requirements of this European Standard, and therefore prevents its direct use in a power installation,
 - a) either the environmental conditions for the EE shall be made compatible by additional means; or
 - b) the equipment shall be improved after agreement between the manufacturers of the EE and of the power installation, or selected to meet the requirements of this European Standard.

4.1 Normal function

Electronic equipment shall be designed and manufactured so that it fulfils its function and does not endanger persons and property in normal operation when set up as specified and used as intended. This also applies to the interaction of EE(s) with the entire installation.

For testing see 9.1.3 and 9.4.7.

4.2 Damage to persons or material

Damage to persons

The requirements for limiting the effects of fault conditions are the same for EE as for other equipment.

However, in the context of EE the breakdown/shorting of components (such as semiconductor junctions) shall be taken into account in a design. The application of safety techniques shall be considered such as

- within EE itself by safe practice, circuit arrangement and other measures, for example, fail-safe techniques, redundancy, diversity; and/or

- by additional independent EE or measures (e.g. by another EE which adopts the function of the failed EE); or
- by electrical or non-electrical protective arrangements (for example, interlocks in the power section, mechanical lock-out); or
- by measures that cover the entire system (e.g. automatic disconnection in case of fire); or
- by human action (where this is not the only measure).

When designing the entire installation, it shall be determined which safe practice measures should be applied assuming that no such safe practice measure has been applied within EE itself.

NOTE The use of measure “human action” assumes that the person assigned for this purpose can recognize a fault function which endangers persons and immediately can take measures to avoid danger.

Material damage

Depending on the requirements, measures shall be taken to avoid material damage in the event of failure of an EE.

4.3 EE connected to unearthed supply mains under condition of earth fault

According to 8.3.1 a monitoring device for the insulation resistance is required in an IT-network giving an alarm signal in case of an earth fault. This limits the risk that another earth fault occurs before the first earth fault is attended to.

NOTE It is assumed here that the EE is connected to a supply mains with normal earth capacitances not exceeding 5 μF per phase and that the overvoltages caused by the earth fault do not exceed the values referred to in A.6.3.5.1. Special agreements would be required in the case of extensively large supply mains with higher earth capacitances.

Earth fault in the supply mains

An earth fault in the supply mains to which the EE is connected with or without electrical isolation (transformer), shall neither cause any damage to the EE nor cause any protective device (e.g. fuse) of the EE to operate. The EE should be able to continue its operation trouble-free when an earth fault occurs, throughout the fault condition and when it is cleared.

Earth fault at the output

If required in the purchasing specification a single earth fault at the power output of an EE connected to unearthed supply mains shall neither cause any damage to the EE nor cause any protective device (e.g. fuse) of the EE to operate, regardless whether the power output is conductively coupled to the supply mains or not. The EE should be able to continue its operation when an earth fault occurs, during the earth fault and when it is cleared. However, the tolerance limits of the normal operation may be exceeded.

Tripping or fuse blowing in the EE caused e.g. by double earth fault in the installation shall be accepted in agreed cases.

4.4 Earthing requirements (grounding, earthing and screening)

Earthing in EE is required not only to reduce the effects of interference, but also, and more importantly, for reasons of personnel safety. Where there is any conflict between these two requirements, personnel safety shall always take precedence (see annex A).

4.5 Wires and cables for interconnection

Wires and cables specified in accordance with IEC standards for telecommunication systems and broadcasting systems may be used between components, sub-assemblies and equipment; etched printed wiring may also be used inside sub-assemblies.

The following shall apply for connections between components, sub-assemblies and equipment:

Conductors and their cross sections shall comply with the electrical, mechanical and climatic requirements of this European Standard. Furthermore, the structure of the conductors and their cross sections shall be matched to the connection method used (e.g. connection method without screws or soldering shall be according to the series of EN 60352-1 or EN 60352-2).

4.6 Fuses in neutral and protective conductors

Fuses in protective conductors are not permitted. Neutral and protective conductors shall not be connected together in any assembly or piece of equipment.

Generally it is not permitted to use a fuse in a neutral conductor. However, the following exceptions are permitted.

- a) A fuse may be used in the neutral conductor if the phase conductors are automatically disconnected at the same time as the neutral conductor.
- b) Fuses which function as overload protection in EE which is designed for connection to any type of mains-circuit, may be located in any live conductor. Short-circuit protection shall be ensured by other means (see Figure 1).

(see annex A for A.4.7 Acoustic noise)

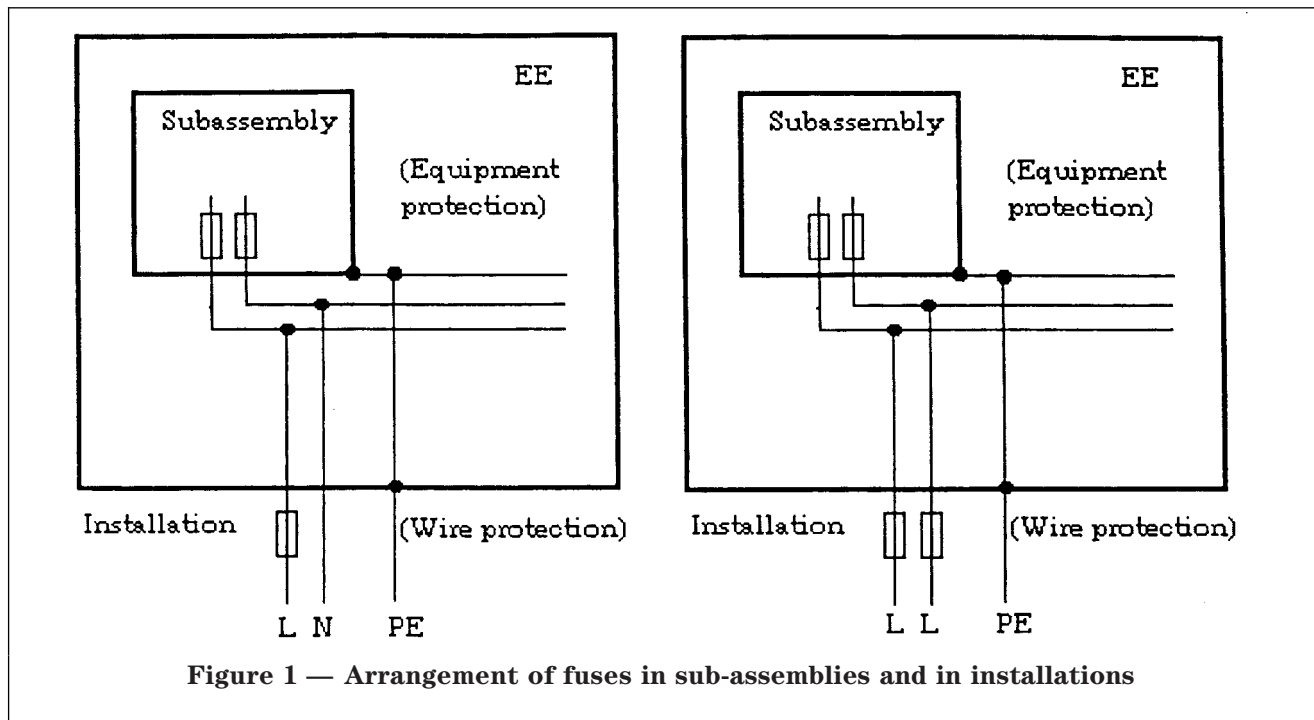


Figure 1 — Arrangement of fuses in sub-assemblies and in installations

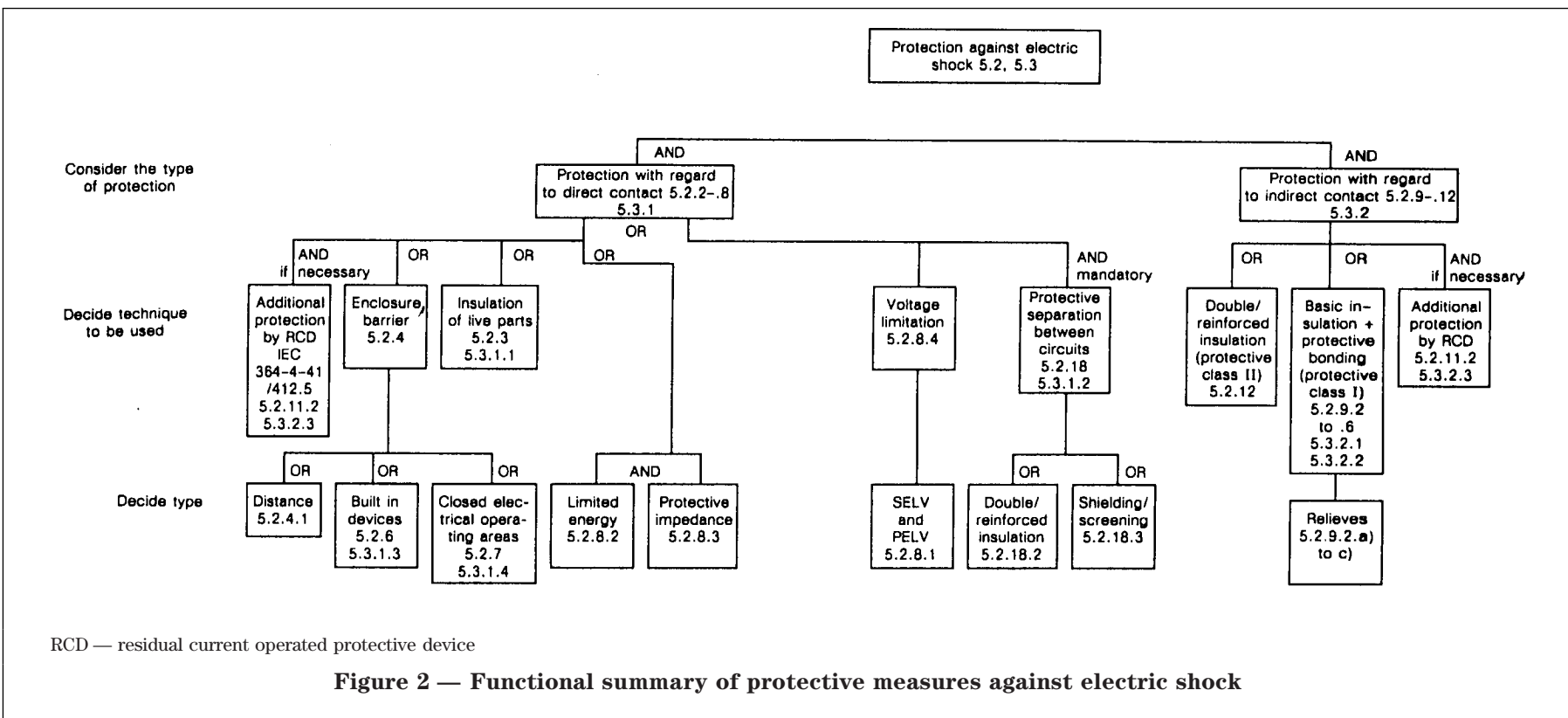
5 Safety requirements

5.1 General requirements

The protection of persons against electric shock shall be arranged so in the case of EE that a single fault does not cause a hazard. This is considered to be fulfilled if the requirements of 5.2 and 5.3 are complied with.

Figure 2 presents a summary for the design, construction and assembly of EE with regard to protection against electric shock arising from direct and indirect contact.

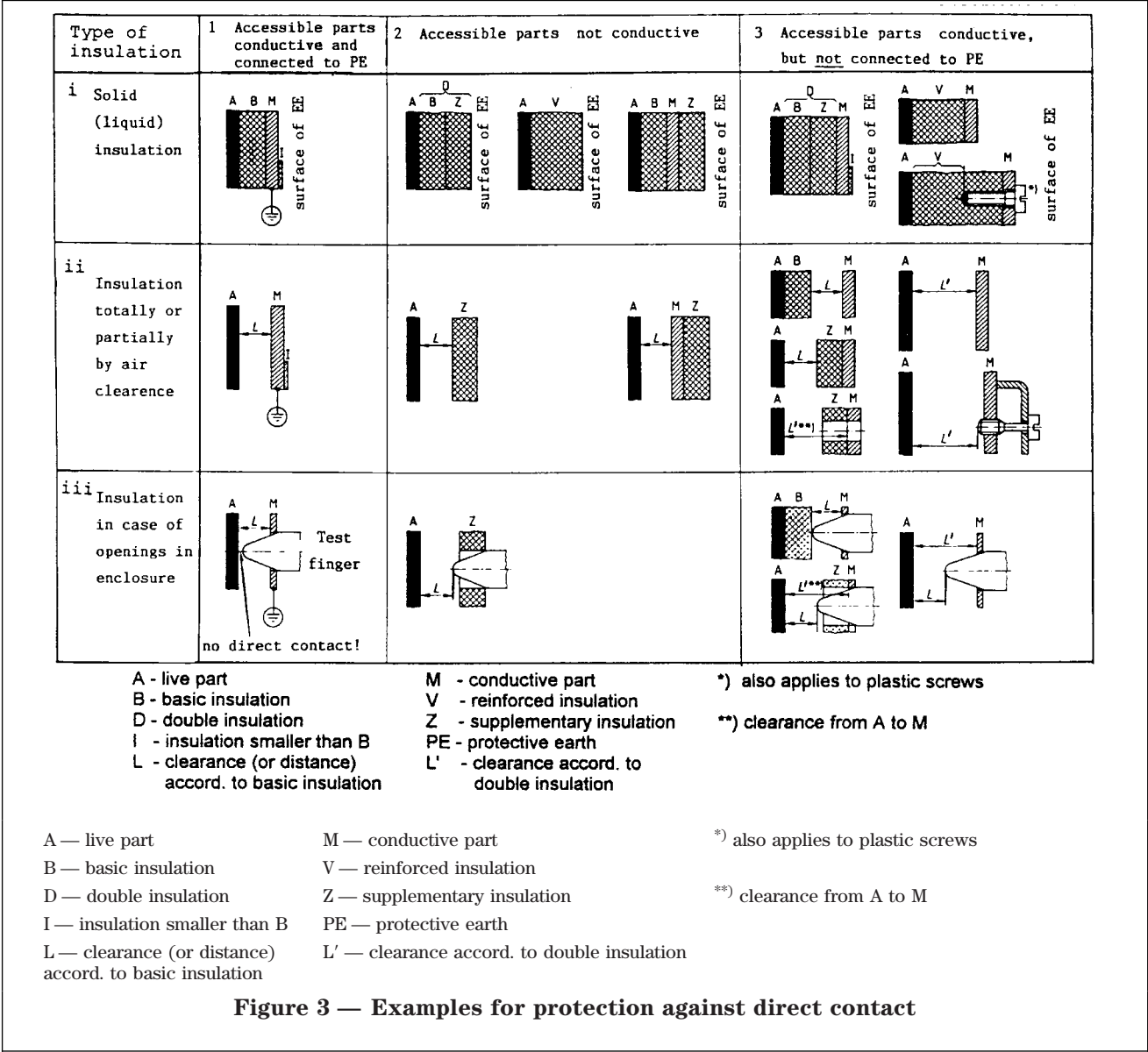
This figure is expanded upon, and complemented by Figures 8 to 13, (see 5.2.15.1) which lead to identification of the grade of insulation which together with Tables 3 to 6 (see 5.2.16 to 5.2.17) lead to the selection of the clearance, creepage distance and puncture strength of solid insulation which are required to satisfy this European Standard.



5.2 Requirements for EE with regard to protection against electric shock
5.2.1 Requirements for protection against electric shock

HD 384.4.41 S2 covers protection against electric shock within electrical installations of buildings and HD 366 S1 covers protection against electric shock from electrical equipment. The documents IEC 536-2 and IEC 1140 contain guidelines for the requirements for installation and equipment with regard to protection against electric shock. This European Standard provides additional requirements regarding special operational conditions for EE where the relevant information is not available within the above or other international standards.

The principle of the above mentioned standards is:
The protection of persons and livestock against electric shock shall be maintained in single fault conditions as well as under normal conditions. This protection shall be achieved by the application of 5.2 to the design and construction of EE.
The testing of components and equipment with regard to protection against electric shock shall be conducted as **type tests** and **routine tests** as defined in clause 9.



5.2.2 Protection against direct contact

Protection against direct contact is employed to prevent the live parts of EE being touched by persons. It shall be provided by one or more of the measures given in 5.2.2 to 5.2.7.

Any conductive part that is not separated from the live parts by at least basic insulation shall be considered to be a live part.

A metallic accessible part is considered to be conductive, if its surface is bare or is covered by an insulating layer which does not comply with the requirements of basic insulation.

With respect to testing of **components and equipment**, the measures taken in accordance with 5.2.2 to 5.2.7 shall be checked for compliance by visual inspection. These requirements shall also apply to devices constructed or installed during the implementation of the installation.

5.2.3 Protection by means of insulation of live parts

Live parts shall be completely surrounded with permanent (non removable) insulation. This insulation shall be designed for a rated insulation voltage (RIV) according to

- Table 3 in 5.2.16.1; (according to Tables 1 and 2
- Table 4 in 5.2.16.2; of HD 625.1 S1)
- 5.2.14.1.

The grade of insulation — basic, double or reinforced — depends upon:

- the decisive voltage U_M (see 5.2.13) of the circuit under consideration;
- the limits for extra-low voltage a.c. 50 V or d.c. 120 V;
- the use of extra-low voltage systems (SELV or PELV);

in accordance with 411.1.1, 411.1.4, 411.1.5 of HD 384.4.41 S2, HD 193 S2 and IEC 1201.

The choice of insulation shall be determined from list a) or b)1), b)2), b)3) and b)4) below (referring also to Figure 3).

- a) **Basic Insulation** with the rated insulation voltage (RIV) of the circuit (case i 1)
 - when it is positioned between live parts and accessible conductive parts of EE that are connected to the protective conductor via protective bonding.
- b)1) **Double or reinforced insulation** with the rated insulation voltage of the circuit (cases i 2 or i 3)
 - when it is located between live parts and the surface of accessible parts of EE that are non-conductive or conductive, but are not connected to the protective conductor; **and**
 - when live parts have a decisive voltage U_M a.c. 50 V or d.c. 120 V.
- b)2) **Basic insulation** for the rated insulation voltage (RIV) corresponding to the highest RIV of adjacent circuits

— when it is positioned between live parts and the surface of accessible parts of EE that are non-conductive or conductive, but are not connected to the protective conductor; **and**

— when live parts have a decisive voltage $U_M \leq$ a.c. 50 V or d.c. 120 V and are separated by basic insulation from adjacent circuits which have a $U_M >$ a.c. 50 V or d.c. 120 V.

b)3) **Basic insulation** for the rated insulation voltage of the circuit corresponding to a.c. 25 V or d.c. 60 V $< U_M \leq$ a.c. 50 V or d.c. 120 V

— when it is positioned between live parts and the surface of accessible parts of EE that are non-conductive or conductive, but are not connected to the protective conductor; **and**

— with live parts of the circuits at a.c. 25 V or d.c. 60 V $< U_M \leq$ a.c. 50 V or d.c. 120 V that have protective separation (see 5.2.18) from adjacent circuits with decisive voltage U_M a.c. 50 V or d.c. 120 V.

b)4) **No insulation required** for live parts designed according to 5.2.8 with a decisive voltage of $U_M \leq$ a.c. 25 V or d.c. 60 V that have protective separation from adjacent circuits.

A flow chart for determination of insulation between live parts and accessible surface is given in Figure 9 of 5.2.15.1.

NOTE Examples for insulation between live and accessible parts are shown in Figure 3 and for insulation between separate electrical circuits and accessible parts are shown in Figures A.4 and A.5 of A.5.2.14.1.

Basic insulation and double or reinforced insulation shall be subjected to voltage tests as given in Table 17 of 9.4.5.1 and/or Table 18 of 9.4.5.2.2.

5.2.4 Protection by means of enclosures and barriers

EE shall comply with the relevant requirements of HD 384.4.41 S2 and IEC 536-2.

Live parts shall be arranged in enclosures or located behind barriers that meet at least the requirements of the Protective Type IP2X according to 5.1 of EN 60529. The top surfaces of enclosures or barriers that are easily accessible shall meet at least the requirements of the Protective Type IP4X.

The minimum protection provided shall take account of the particular circumstances of the installation and in addition, such protection shall be provided in accordance with the expected environmental conditions as given in clause 6 (see annex A).

Testing shall be by visual inspection. In case of doubt, re-measurement of the enclosure openings and testing with a probe according to clause 12 of EN 60529 shall be conducted. In this context, the test procedure laid down in 12.2 of EN 60529 (i.e., with test lamp and voltage at least 40 V) can be used when it is ensured that contact of the probe with a live part of the circuit in the EE to be tested will in fact result in a test indication. If this is not the case, then non-contact of the probe with live parts shall be determined in another manner.

5.2.4.1 Distances

As an alternative to insulation according to 5.2.3, a clearance according to 5.2.15.1 and 5.2.16 or a distance corresponding to a clearance as shown by L and L' in Figure 3 of 5.2.3, cases ii, may be totally or partially provided (see Figure 3, case ii 1 or cases ii 2 and ii 3).

Testing shall be by visual inspection and/or if necessary by applying the probe test according to clause 12 of EN 60529.

5.2.5 Discharge of capacitors

After switching-off the EE, capacitors shall be discharged down within 5 s to a residual charge of 50 μC (see A.5.2.8.2) or to a voltage of 60 V. If such a measure interferes with the operation of the EE, a warning sign shall be placed where it is easily observable, indicating that the discharging time is greater than 5 s. In the case of installed EE, where the voltage at the plug-and-socket devices of EE can be touched and these devices may be pulled out when live without the use of tools, the capacitors shall be discharged within 1 s to a charge of 50 μC , or to a voltage of 60 V (see 5.1.2 of IEC 536-2).

With respect to the above two discharge cases, testing shall be by re-calculation of the energy or measurement of the voltage 5 s or 1 s after switching off of the EE. Where several capacitors are interconnected throughout the circuit, this shall be allowed for in such calculations.

5.2.6 Built-in devices

Sub-assemblies and devices that are intended for inclusion within a larger device or enclosure which offers the required protection do not need themselves a protective measure against direct contact. However, where there are components requiring manual operation on or closer to them, 5.1.1 of IEC 536-2 shall be taken into consideration.

5.2.7 EE for closed electrical operating areas

EE which is intended for installation in closed electrical operating areas need not have a protective measure itself against direct contact (however, see note 2 in A.5.2.8). Where EE requires manual intervention (e.g. for repair, replacements of bulbs, fuses, batteries etc.), 412.2.1 of HD 384.4.41 S2 shall be consulted.

5.2.8 Protection in the case of direct contact

Protection in the case of direct contact is required to ensure that contact with live parts of EE does not produce any dangerous shock current.

The protection against direct contact according to 5.2.2 through 5.2.7 may be waived if the contact with the live parts does not produce any dangerous shock current. This applies to circuits according to one of the measures given in 5.2.8.1 to 5.2.8.5 provided that protective separation according to 5.2.18 from all other circuits is ensured.

Any external terminals which belong to EE circuits dealt with in 5.2.8 shall be identified in the operating manuals.

These clauses apply to the entire circuit including power supplies and if necessary associated peripheral devices (see annex A).

Testing for protective separation shall be according to 9.4.5.1, 9.4.5.2.2, 9.4.5.2.3, 9.4.5.3 and 9.4.5.5 if applicable.

5.2.8.1 Protection by means of extra-low voltage with protective separation (SELV- and PELV-system)

Where SELV- or PELV-systems are applied in EE or in parts of EE, the respective requirements shall be fulfilled.

When the decisive voltage according to 5.2.13 is not higher than a.c. 25 V or d.c. 60 V [see Figure A.1a) in A.5.2.8], and equipment is used within a zone of equipotential bonding, then protection against direct contact is not necessary.

In an area of limited space where the live parts are protected against direct contact according to 5.2.2 the decisive a.c. voltage may vary between 25 V and 50 V to produce a supply voltage of up to d.c. 60 V.

For testing protection using extra-low voltage with protective separation, the decisive voltage (as determined by 5.2.13) shall, in case of doubt be re-measured. If applicable, the area of limited space as defined in paragraph 3 above shall be tested for protection against direct contact in accordance with 5.2.2 to 5.2.5.

5.2.8.2 Protection by means of limitation of the discharging energy

The stored charge available between simultaneously accessible parts protected by protective impedance shall not exceed 50 μC (see 4.4.3.2 of IEC 536-2). According to 6.5 of IEC 1201 the charging voltage and capacitance should be limited as given in Table A.1 of A.5.2.8.2 (see annex A).

When testing protection which uses limitation of the discharging energy, calculations and/or measurements shall be performed to determine the charge or the voltage and capacitance.

5.2.8.3 Protection by means of protective impedance

The connection of accessible live parts to a circuit having a higher decisive voltage (5.2.13) than a.c. 25 V or d.c. 60 V as mentioned in 5.2.8.1 shall only be made through a protective impedance (411.1.2.4 of HD 384.4.41 S2, 4.4.1 of IEC 5362).

The same constructional provisions as those for protective separation (see 5.2.18) shall be applied for the construction and arrangement of protective impedance. The current value stated below shall not be exceeded in the event of failure of a single part. When capacitors are connected to the protective impedance, the residual charge shall be in accordance with 5.2.5.

The protective impedance shall be designed so that the current through the protective impedance does not exceed a value of a.c. 3,5 mA or d.c. 10 mA. It shall be noted that the decisive voltage (see 5.2.13) of the circuit having the higher voltage appears across the protective impedance (see 4.4.3.1 of IEC 5362).

The voltage endurance for the protective impedance shall be designed in such a manner that the protective impedance withstands the impulse withstand voltage $1,2/50 \mu\text{s}$ in accordance with column 8 in Table 3 of **5.2.16.1** respectively column 8 in Table 4 of **5.2.16.2** (see annex A).

This protection method shall be verified by visual inspection and by fault simulation. During fault simulation, calculations shall be performed to determine whether the current remains below the limits laid down in paragraph 2 and 3 above.

For details of testing see **9.4.5.1** and **9.4.5.5**.

5.2.8.4 Protection by using limited voltages in control circuits

This type of protection is applicable only in control circuits for the purpose of forming reference and actual values [see Figure A.1d) of **A.5.2.8**]. This type of protection shall not be used in EE of protective class II as given in **3.3** of HD 366 S1, because of the provision of earthing (PE) at the basepoint of the voltage divider.

This part of control circuit shall be designed reliably in such a way that, even if a fault occurs in the EE, the voltage across its output terminals as well as the voltage to earth will not become higher than the decisive voltage of a.c. 25 V or d.c. 60 V according to **5.2.8.1**. The same constructive measures as in protective separation (see **5.2.18**) shall be employed in this case.

When providing disconnection points for a circuit with protective separation, **A.5.2.8.3** should apply, where relevant.

When testing protection by means of voltage limitation, it shall be verified by visual inspection and by fault simulation. During fault simulation, calculations shall be performed to determine whether the voltage remains below the limits laid down in paragraph 2 above.

5.2.8.5 Connectors

In addition to the measures as given in **5.2.8.1** to **5.2.8.4**, — SELV, PELV, limited discharging energy, protective impedance, limited voltage — it shall be ensured that in the event of error or polarity reversal of connectors no voltages that exceed a.c. 25 V or d.c. 60 V can be connected into a circuit with protective separation. This applies e.g. to plug-in-sub-assemblies or other plug-in devices which can be plugged-in without the use of a tool (key) or which are accessible without the use of a tool. This does not apply to EE which is intended for assembly in closed electrical operating areas (see **5.2.7**). See also **7.1.9**.

If required, testing of non-interchangeability and protection against polarity reversal of connectors, plugs and socket outlets shall be confirmed by visual inspection and trial insertion.

5.2.9 Protection with regard to indirect contact

Protection against indirect contact is required to prevent shock currents which can result from exposed conductive parts of EE during an insulation failure.

This protection shall be designed according to the following requirements:

For EE constructed to protective class I (see **3.2** of HD 366 S1) the requirements as given in **5.2.9.1** to **5.2.11** apply.

The content of **5.2.12** deals with particular aspects of protective class II.

Protective class III is rarely applicable for EE.

Protective class 0 is not acceptable for EE.

At a decisive voltage higher than a.c. 1 400 V or d.c. 2 000 V only protective class I is acceptable.

All conductive parts which are not separated from live parts by at least basic insulation (see HD 366 S1) shall be treated as live parts.

With respect to testing of **components and equipment**, the measures taken according to **5.2.9** to **5.2.12** shall be checked for compliance by means of visual inspection. These requirements shall also apply to devices constructed or installed during the implementation of the installation.

5.2.9.1 Insulation between live parts and exposed conductive parts

Exposed conductive parts of EE shall be separated from live parts at least by basic insulation or by clearances in accordance with Table 3 or 4 of **5.2.16.1** to **5.2.16.2** respectively.

Testing shall be by visual inspection. In cases of doubt re-measurement of clearances, creepage distances and solid insulation, shall be made.

5.2.9.2 Protective bonding

Protective bonding shall always be provided between exposed conductive parts of EE and the means of connection for the protective conductor; it is not however essential when the following apply:

- when exposed conductive parts are exclusively related to electrical circuits with protection in case of direct contact according to **5.2.8**, with the limiting value of the decisive voltage increased to a.c. 50 V or d.c. 120 V (**413.1.1.1** of HD 384.4.41 S2) for SELV- or PELV-systems (see **5.2.8.1**), alternatively where protection is provided by means of voltage limitation (see **5.2.8.4**); or
- when magnet cores are used, for example, transformers, chokes and contactors; or
- when exposed conductive parts of small dimensions (about 50 mm × 50 mm) cannot be touched or grasped when the EE is used as intended and which have a low probability of contact. Such exposed conductive parts are, for example, screws, rivets, nameplates and cable clamps (see **471.2.2** of HD 384.4.47 S2).

NOTE Conductive parts which are separated from live parts using double or reinforced insulation (see **5.2.18.2**) they are no longer considered to be exposed conductive parts and therefore, require no protective bonding.

Testing shall be by visual inspection. When claiming one of the exceptions from the requirements of providing protective bonding in accordance with a), b) or c), it shall be confirmed by documentation that these requirements are met.

(For bonding connection arrangements see **5.2.11**.)

5.2.9.3 Rating of protective bonding

Protective bonding shall withstand the highest thermal and dynamic stresses that can occur to the EE item(s) concerned when they are subjected to a fault connecting to exposed conductive parts (according to 4.1.2 of IEC 536-2).

In order to avoid thermal overload, the requirements of 8.3.3.4 shall be applied to the design of the protective bonding (4.1.4 of IEC 536-2) (see annex A). For testing, the resistance of protective bonding shall in case of doubt be measured in accordance with paragraph 3 of A.5.2.9.3, the voltage drop in case of short-circuit with respect to an exposed conductive part shall then be determined from this measurement.

5.2.9.4 Protection against corrosion

Protective connections shall be protected against corrosion under the specified ambient conditions (4.1.4 of IEC 536-2) (see annex A).

5.2.9.5 Protective bonding conductor with low cross-section

Where the exposed conductive parts of EE are connected to the protective conductor of EE using a protective bonding conductor with small cross-section, care shall be taken that a fault between these exposed conductive parts and live parts with larger cross-section is prevented. This can be achieved by a suitable construction or by double or reinforced insulation.

NOTE This applies for example for data processing equipment within power electronic equipment.

5.2.9.6 EE with voltage above a.c. 1 400 V or d.c. 2 000 V

In EE with a decisive voltage (5.2.13) of more than a.c. 1 400 V or d.c. 2 000 V, accessible and non-accessible conductive parts which are not live parts shall be included within the protective bonding. Excepted are conductive parts with small dimensions or those assigned to circuits with protective separation and extra-low voltage or magnet cores according to 5.2.9.2a) to c).

5.2.9.7 Interruption

The protective bonding of EE shall be permanently connected and not be interrupted by a switch or an electronic device (4.1.8 of IEC 536-2).

Where the protective connection to a sub-assembly of EE is made by a plug-and-socket device when it is live or conducting, the protective connection shall not be broken before the live conductors. On re-connection the protective conductor shall re-connect before the live connection, or at the latest, together with the live conductors (4.1.7 of IEC 536-2).

5.2.9.8 Marking

Protective bonding conductors shall be easily recognizable from their shape, location (e.g. short visible pieces of conductors) or colour coding; exceptions are the protective bonding conductors on printed circuit boards and such protective bonding conductors in wire-wrap and similar back wiring of electronic sub-assemblies which cannot be unfastened

without destruction. When marking by colours, the colour combination green-yellow shall be used. Insulated single-core protective bonding conductors shall be green-yellow along their entire length. The colour coding green-yellow shall be used only for the protective bonding conductors and for the protective conductors (4.1.9 of IEC 536-2).

5.2.10 Means of connection for the protective conductor

EE with internal protective bonding shall have means of connection for the external protective conductor near the terminals for the respective live conductors. They shall be corrosion-resistant and shall be suitable for the connection of the protective conductor cross-section which is determined from the dimension of the live conductors according to Table 54F of HD 384.5.54 S1, unless a larger cross-section is required according to 8.3.3.4. The means of connection for the protective conductor shall not be used as a part of the mechanical assembly of the EE.

The means of connection for the protective conductor should be marked in a well recognizable way with

- the symbol No. 5019 ⊕ according to HD 243 S10; or
- the letters “PE”; or
- the colour coding green-yellow.

Marking should not be done on easily changeable fixtures such as screws. This marking is not necessary for connectors (5.2.2.4 of IEC 536-2). The content of 7.1.9 applies to the external connectors.

5.2.11 Leakage current and fault current

5.2.11.1 High leakage current

Where an EE has a continuous leakage current of more than a.c. 3,5 mA or d.c. 10 mA in normal use, a fixed connection is required for protection; this shall be stated in the operating manuals.

The combination of a residual-current-operated protective device (RCD) with in particular several EEs may be incompatible if the resulting leakage current drawn by their radio frequency filters is so high that the RCD is triggered.

When several items of EE are connected to a source of supply, the total leakage current of a.c. 3,5 mA or d.c. 10 mA in the protective conductor may be exceeded. In these cases and where the protective conductor is interrupted, it is possible for a person to become exposed to a leakage current higher than the limit a.c. 3,5 mA or d.c. 10 mA. Under such conditions, and as long as no international standard exists on the measures to be taken to prevent this, the following shall be provided:

- duplication of the protective conductor; or
- automatic disconnection of the supply in case of discontinuity of the protective conductor; or
- incorporation of a double-wound transformer (or equivalent) in the supply with the circuit protective conductor connected to the exposed conductive parts of the EE and to the secondary winding of the transformer.

Measurement of leakage current is required on EE which is not intended for permanent connection:

The EE shall be set up in an insulated state without connection of the protective earth conductor and shall be operated at rated voltage. Under these conditions, the current shall be measured at the following points:

- a) for an EE which is intended for connection to a TT- or TN-system, between the protective terminal conductor and the protective earth conductor itself;
- b) for an EE which is intended for connection to an IT-system, between the protective terminal conductor and each outer conductor.

The current measuring circuit shall be performed according to Figure 3 in 5.1 of IEC 990.

NOTE New limits for the leakage current are expected in 7.5 of IEC 1140.

5.2.11.2 Compatibility with residual-current-operated protective devices in case of low leakage current

A residual-current-operated protective device (RCD) may be used to provide protection in case of indirect contact or/and with rated fault current $I_{fn} \leq 30$ mA according to 412.5 of HD 384.4.41 S2 supplementary protection in case of direct contact. It is presupposed that the leakage current of the EE(s) according to 5.2.11.1 is low enough not to trigger unintentionally the RCD connected in series.

Before connecting an EE to a supply protected by an RCD, the compatibility of the EE with the RCD shall be verified, by reference to Figure 4 and the paragraphs below. Depending on the supply side circuitry of the EE and the type of RCD (type A or AC according to amendment 2 of IEC 755), EE and RCD may be compatible or incompatible. Figure 4 indicates:

- 1) when an EE is required to be compatible with the RCD;
- 2) when a design notice as given below shall be fitted to the EE requiring the use of an RCD Type B or of another protection (Type B according to amendment 2 of IEC 755).

Design notice: Where residual-current-operated protective device (RCD) is used for protection in case of direct or indirect contact, **only RCD of Type B** is allowed on the supply side of this Electronic Equipment (EE). Otherwise another protective measure shall be applied such as separation of the EE from the environment by double or reinforced insulation or isolation of EE and supply system by a transformer.

- a) Movable EE with rated input ≤ 4 kVA shall be designed to be compatible with RCD of type A — protection in case of indirect or/and direct contact.
- b) Movable EE with rated input < 4 kVA, shall have the design notice (see above) fitted to the equipment and written in the operating manual.

- c) Permanently connected EE shall have the design notice (see above) fitted to the equipment and written in the operating manual.

In particular, operation of an RCD connected in series with EE shall not be prevented by a d.c. component in the fault current.

Circuits 2, 3, 6 and 7 in Figure A.2 of A.5.2.11.2, may contain a high d.c. component in the residual current and reduce the sensitivity of the RCDs of type A and AC, therefore these combinations are unacceptable. Suitable and acceptable are combinations of the circuits mentioned with RCDs of type B, which are triggered by all waveforms of residual current occurring (see Figure A.2 of A.5.2.11.2)

NOTE RCDs suitable to be triggered by differing waveforms of residual current should be marked with symbols as defined in amendment 2 of IEC 755 as follows:



: Type A

— a.c. current sensitive and pulse current sensitive (suitable for circuits 1, 4, 5, 8, 9 according to Figure A.2 of A.5.2.11.2)

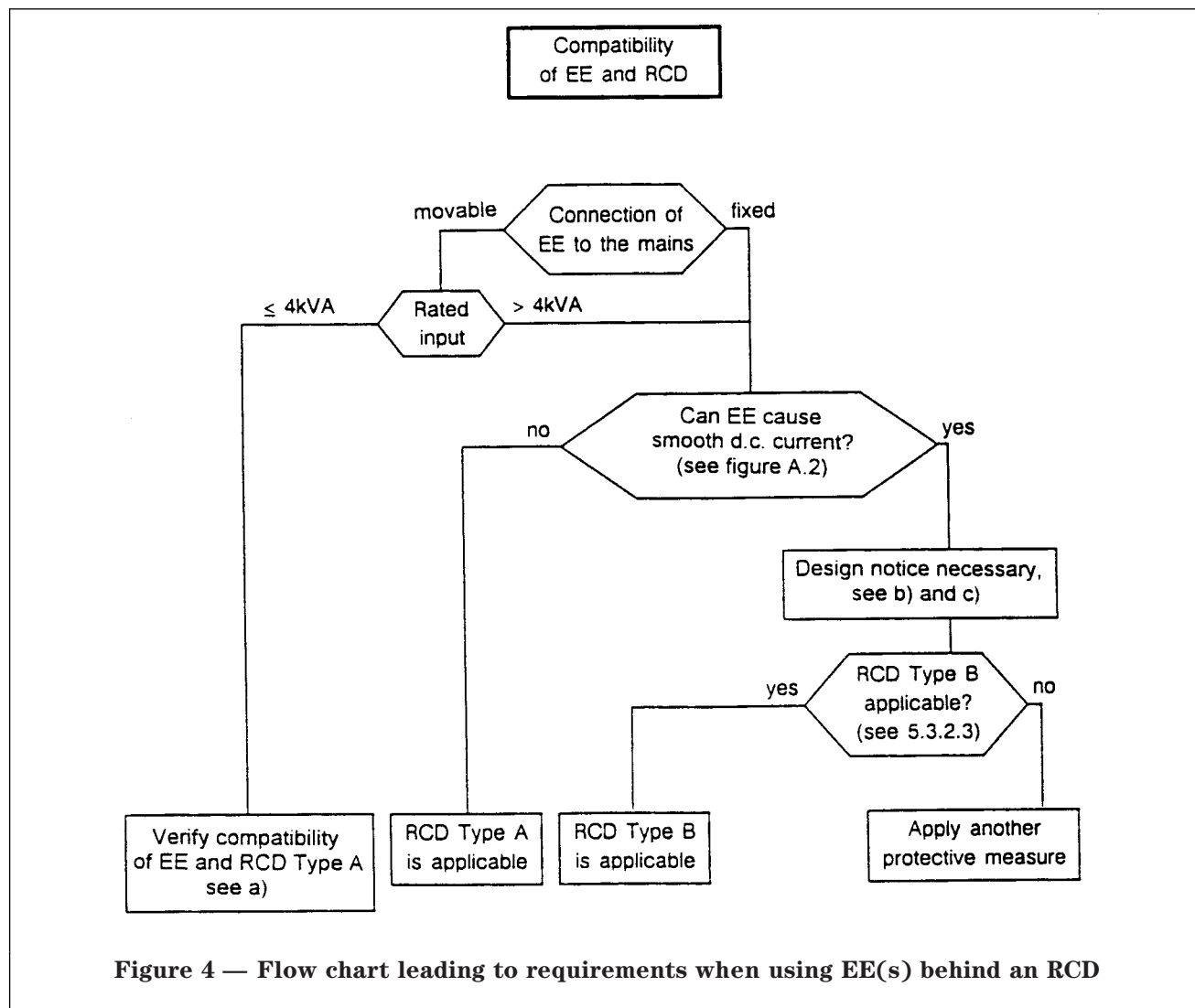


: Type B

— universal current sensitive (suitable for all circuits according to Figure A.2 of A.5.2.11.2)

For design and construction of electrical installations care shall be taken with RCDs of type B, see 5.3.2.3 and design example in Figure A.3 of A.5.2.11.2.

If necessary, re-checking should be carried out to confirm the compatibility of the RCD (according to EN 610081 respectively to amendment 2 of IEC 755) with the circuitry employed in the EE (see Figure A.2 of A.5.2.11.2).



5.2.12 Special features in EE for protective class II

If EE is designed to use double or reinforced insulation between live parts and accessible surfaces of an EE in accordance with 5.2.3b)1) or 5.2.4, then the design is considered equivalent to protective class II if the following also apply (5.2.3.1.1 of IEC 536-2).

— EE designed to protective class II shall not have means of connection for the protective conductor (PE or PEN). However this does not apply if the protective conductor is passed through the EE to equipment series-connected beyond it. In the latter event, the protective conductor and its means for connection shall be insulated with basic insulation against the accessible surface of the EE and against circuits, which employ protective separation, extra-low voltage, protective impedance and limited discharging energy, according to 5.2.8. This basic insulation shall correspond to the rated insulation voltage of the series-connected equipment.

— Metal-encased EE of protective class II may have provision on its enclosure for the connection of an equipotential bonding conductor (413.4 of HD 384.4.41 S2 and Note 4 in 3.3 of HD 366 S1).

— EE of protective class II may have provision for the connection of a functional earthing conductor or for the damping of overvoltages; it shall, however, be insulated as though it is a live part.

— EE of protective class II shall be classified on the name plate with the symbol No. 5172 ☐ according to HD 243 S10.

5.2.13 Decisive voltage

The decisive voltage of a circuit in respect of the protective measures to be employed against electric shock is the highest voltage which occurs continuously between any two arbitrary live parts of the EE during rated worst operating conditions when used as intended. If continuous direct earthing of the circuit of EE is provided through conductors of sufficiently low impedance, then the decisive voltage is the highest voltage which occurs continuously between any arbitrary live part of this circuit and earth (e.g. circuits connected to an earthed three-phase supply).

The decisive voltage applies to all parts of circuits of the EE under consideration.

No agreed procedure is available for the calculation of the decisive voltage at the present time. Therefore the method of calculation which follows shall be used to determine the measures to be taken to provide adequate protection. These measures fall into categories described by the limit levels according to the classifications in column 1 of Table 1.

The actual classification of a circuit of EE with regard to protection against electric shock is dependent upon the decisive voltage U_M which relates to the a.c. and d.c. voltage of the circuit. U_M is also affected by the nature of the voltage waveforms and these shall be taken into consideration when calculations are performed (i.e. the ripple voltage, chopped voltage, and recurring overshoots that may occur).

It should be understood that the method of calculation in the procedure to be adopted below does not lead to a definite solution for a value for decisive voltage U_M . It does however allow a decision to be made as to which classification of Table 1 the value of U_M fits.

Three cases a), b) and c) of waveforms are given for deciding which classification of a circuit shall be chosen from Table 1.

Case a) for a.c. voltage (see Figure 5) where

U_{AC} = an a.c. voltage (r.m.s.) in volts with;

U_{ACP} = a repetitive peak value in volts, and a value of;

U_{ACL} = the limit of the a.c. voltage (r.m.s.) chosen from column a) of Table 1.

$$\text{If } \frac{U_{AC}}{U_{ACL}} \leq 1 \text{ and } \frac{U_{ACP}}{\sqrt{2}U_{ACL}} \leq 1 \text{ then } U_M \leq U_{ACL}$$

But if one or both conditions are not true, then repeat the calculation with the next higher value of U_{ACL} in Table 1.

The value for U_{ACL} for which both conditions are true shall be used to decide which range applies in Table 1 to the circuit considered. If one of the conditions is not true even with U_{ACL} = a.c. 1 400 V, then the higher voltage range applies (Table 1, last row).

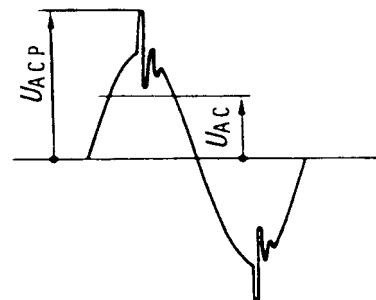


Figure 5 — Typical waveform for case a) a.c. voltage

Case b) for d.c. voltage (see Figure 6) where

U_{DC} = a d.c. voltage of mean value in which the ripple content giving rise to U_{DCP} is not more than 10 % (10 % r.m.s. ripple content resulting from the ratio of the r.m.s. values of the superimposed a.c. voltage and of the smooth d.c. voltage);

U_{DCP} = the repetitive peak value of the d.c. voltage in volts;

U_{DCL} = the limit of the d.c. voltage mean value in volts, chosen from column b) of Table 1.

$$\text{If } \frac{U_{DC}}{U_{DCL}} \geq 1 \text{ and } \frac{U_{DCP}}{1,17U_{DCL}} \geq 1 \text{ then } U_M \leq U_{DCL}$$

But if one or both conditions are not true, then repeat the calculation with the next higher value of U_{DCL} in Table 1.

The value for U_{DCL} for which both conditions are true shall be used to decide which range applies in Table 1 to the circuit considered. If one of the conditions is not true even with U_{DCL} = d.c. 2 000 V, then the higher voltage range applies (Table 1, last row).

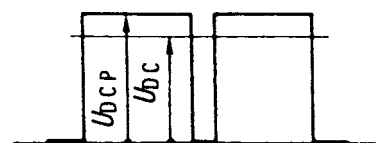


Figure 6 — Typical waveform for case b) d.c. voltage

Case c) for pulsating voltage (see Figure 7)

For a pulsating voltage (d.c. voltage where the ripple content is more than 10 %) the evaluation of both components is made separately according to the formula below where:

U_{AC} = a.c. voltage component (r.m.s. value), in volts;

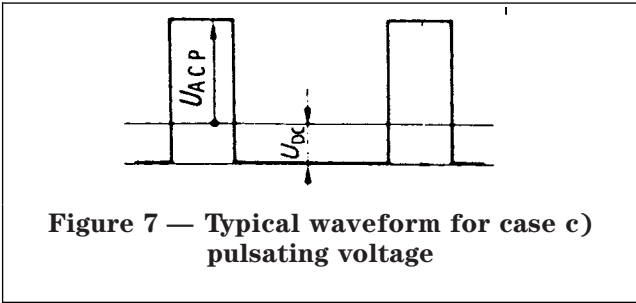
U_{DC} = d.c. voltage component (mean value), in volts;

U_{ACP} = repetitive peak value of the a.c. voltage component, in volts.

$$\text{If } \frac{U_{AC}}{U_{ACL}} + \frac{U_{DC}}{U_{DCL}} \leq 1 \text{ and } \frac{U_{ACP}}{\sqrt{2}U_{ACL}} + \frac{U_{DC}}{1,17U_{DCL}} \leq 1 \text{ then } U_M \leq U_{DCL} \text{ and } U_{ACL}$$

But if one or both conditions are not true, then repeat the calculation with the next higher values of U_{ACL} and U_{DCL} in Table 1.

The values for U_{ACL} and U_{DCL} for which both conditions are true shall be used to decide which range applies in Table 1 to the circuit considered. If one of the conditions is not true even with $U_{ACL} =$ a.c. 1 400 V or $U_{DCL} =$ d.c. 2 000 V, then the higher voltage range applies (Table 1, last row).



The following give additional information relating to the limit voltages of cases a), b) and c) of Table 1:

U_{ACL} — limit of a.c. voltage (see Table 1):

$U_{ACL} = 25$ V as upper limit of protective extra-low voltage (SELV or PELV) according to 5.2.8.1 and 5.2.8.4.

$U_{ACL} = 50$ V as upper limit for circuits with exposed conductive parts without protective bonding according to 5.2.9.2a).

$U_{ACL} = 1\,400$ V as limit of the a.c. voltage according to 5.2.9, 5.2.9.6 and 5.2.14.2.

U_{DCL} — limit of d.c. voltage (see Table 1):

$U_{DCL} = 60$ V as upper limit of protective extra-low voltage (SELV or PELV) according to 5.2.8.1

and 5.2.8.4.

$U_{DCL} = 120$ V as upper limit for circuits with exposed conductive parts without protective bonding according to 5.2.9.2a).

$U_{DCL} = 2\,000$ V as limit of the d.c. voltage according to 5.2.9, 5.2.9.6 and 5.2.14.2.

These voltages are mean values allowing for a ripple content of not more than 10 % r.m.s.

Table 1 gives a summary of the limits of the decisive voltage. According to the three limit levels for the decisive voltage in Table 1 four voltage ranges exist:

- 1) $U_M \leq$ a.c. 25 V or d.c. 60 V
applies to circuits without protection against direct contact, but with protective separation to adjacent circuits with U_M a.c. 50 V or d.c. 60 V;
- 2) a.c. 25 V or d.c. 60 V < $U_M \leq$ a.c. 50 V or d.c. 120 V
applies to circuits with protection against direct contact and protective separation to adjacent circuits with U_M a.c. 50 V or d.c. 120 V, but without protective bonding of the exposed conductive parts;
- 3) a.c. 50 V or d.c. 120 V < $U_M \leq$ a.c. 1 400 V or d.c. 2 000 V
applies to circuits with protection against direct contact and protective separation to adjacent circuits with U_M a.c. 1 400 V or d.c. 2 000 V and with protective bonding or double or reinforced insulation of exposed conductive parts. Basic insulation is required from adjacent circuits with a.c. 50 V or d.c. 120 V < $U_M \leq$ a.c. 1 400 V or d.c. 2 000 V;
- 4) U_M a.c. 1 400 V or d.c. 2 000 V
applies to circuits with protection against direct contact, with protective bonding of exposed conductive parts and with basic insulation to adjacent circuits with U_M a.c. 1 400 V or d.c. 2 000 V.

For the design of the insulation depending on these

Table 1 — Summary of the limits of the decisive voltage U_M

Classification of a circuit in EE	Limit of decisive voltage U_M			Subclause
	a) a.c. voltage (r.m.s. value) U_{ACL} V	b) d.c. voltage (mean value) U_{DCL} V	c) a.c. voltage (peak value) $U_{ACL} \cdot \sqrt{2}$ V	
Electric circuits with protective separation and without protection against direct contact	25	60	35	5.2.8.1, 5.2.8.4
Exposed conductive parts of circuits with protective separation and without protective bonding	50	120	71	5.2.9.2a)
Circuits with higher voltage	1 400	2 000	2 000	5.2.9, 5.2.9.6, 5.2.14.2

NOTE The extra-low-voltage limits of decisive voltage are those from 411.1.4.3 and 411.1.5.2 of HD 384.4.41 S2.

voltage ranges see Figures 9 and 10 (see annex A).

5.2.14 Solid insulation, insulation of circuits

Solid insulation shall be designed to resist the stresses occurring, especially mechanical, electrical, thermal and climatic stresses that are to be expected in normal use and, it shall have a sufficient resistance to ageing during the life time of EE. This applies also to liquid insulation. Thin, easily damageable materials such as coating with lacquer or oxides and anode coatings are considered insufficient to satisfy these requirements (412.1 of HD 384.4.41 S2).

The design of solid insulation as for clearances and creepage distances results from Figures 11 to 13 in relation to Figures 8 to 10. Additional requirements are given in 5.2.14.1 to 5.2.14.3.

Testing shall be by visual inspection. In case of doubt measurement of the thickness of the insulation and re-calculation of its dielectric strength shall be made.

5.2.14.1 Between circuits and exposed conductive parts or accessible surfaces of EE

Basic, supplementary, double or reinforced insulation shall be applied for the protection against electric shock.

This insulation shall be designed according to the rated insulation voltage (RIV) for an impulse withstand voltage, determined from Table 3 or 4, column 6 or 8, according to 5.2.16.1 or 5.2.16.2.

Where the appropriate clearances are **not** designed to meet overvoltage category III (see Table 1 of HD 625.1 S1) as set out in column 6 of Table 3 according to 5.2.16.1, and it is decided to choose alternative clearances according to paragraph 3 or 4 of 5.2.16.1, **then** the impulse withstand voltage appropriate to these clearances determines the RIV. The following shall apply for the insulation between live parts and the surface of accessible parts of EE according to 5.2.3b)1) to b)4).

When a design involves subdivided basic and supplementary insulation or subdivided double insulation with an electrical circuit in between, then the **highest** of the RIVs shall be employed for design purposes, and **not** the voltage of the particular circuit. Figure A.4 in A.5.2.14.1 shows an example.

The foregoing paragraph does not apply to parts with small dimension (approximately 50 mm × 50 mm) which — when the EE is used as intended — are not required to be touched or cannot be grasped or where the danger of touch is not significant (471.2.2 of HD 384.4.47 S2).

Figure A.5 in A.5.2.14.1, shows examples for the insulation required for control elements.

For voltage tests see 9.4.5.1 and 9.4.5.2.

5.2.14.2 Between circuits

Basic insulation shall be applied between separate circuits of an EE.

Exceptions are:

- between circuits designed according to 5.2.8 and other circuits **not** designed according to 5.2.8;

- between circuits designed for a decisive voltage of more than a.c. 1 400 V or d.c. 2 000 V and other circuits designed for a lower decisive voltage.

These circuits shall be insulated to the requirements of protective separation (see 5.2.18; double or reinforced insulation or protective screening).

NOTE In this case earthing of transformer secondary is not necessary.

The insulation shall be designed for an impulse withstand voltage which corresponds to the respective rated insulation voltage, determined from columns 6 or 8 in Tables 3 or 4 of 5.2.16.1 or 5.2.16.2.

For voltage tests see 9.4.5.

5.2.14.3 Bridging of the insulation via conductive parts

Conductive parts, for example resistors and capacitors, which bridge over an insulation according to 5.2.14.1 or 5.2.14.2 shall withstand the same electric stress as that defined for the insulation concerned. If these components bridge over a double or reinforced insulation, then they shall correspond additionally to the requirements of protective impedance according to 5.2.8.3 (4.4.1 of IEC 536-2).

For voltage tests see 9.4.5.

5.2.15 Clearances and creepage distances, pollution degree

5.2.15.1 Clearances and creepage distances

Clearances and creepage distances shall be selected according to the principles of HD 625.1 S1.

The determined clearances and creepage distances are minimum values. Manufacturing tolerances shall be taken into account, when installing or connecting EE on site. Greater clearances and creepage distances shall be provided particularly, when they may be newly created or changed by the kind of mounting or method of wiring during installation or connection of the EE on site (see 8.2). The defined minimum values shall not diminish during the working life of the EE.

The design of clearances and creepage distances shall make allowance for the total degradation to be expected during the working life in the expected environment.

In addition, where there is a requirement for enhanced reliability, it is appropriate to increase the distances considerably.

The determination of clearances and creepage distances does not apply to the interior of enclosures which provide a sealed environment which has been proven to be impervious to pollution, or precipitation of moisture.

Also the determination of clearances and creepage distances does not apply to active or passive components when pollution, or precipitation of moisture is avoided by suitable construction methods. Examples are semiconductors, capacitors, and printed circuit boards which have been covered with varnish or protective coating of adequate and proven quality for protection of the item against pollution and moisture to the requirements of 5.2.8.3.