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BASIC SAFETY PUBLICATION

PUBLICATION FONDAMENTALE DE SÉCURITÉ

Electrical installations of buildings – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements, protective conductors and protective bonding conductors

Installations électriques des bâtiments – Partie 5-54: Choix et mise en oeuvre des matériels électriques – Mises à la terre, conducteurs de protection et conducteurs d'équipotentialité de protection

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ELECTRICAL INSTALLATIONS OF BUILDINGS –

Part 5-54: Selection and erection of electrical equipment – Earthing arrangements, protective conductors and protective bonding conductors

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FOREWORD

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IEC 60364-5-54 has been prepared by IEC technical committee 64, Electrical installations and protection against electric shock.

This second edition replaces the first edition, published in 1980, its amendment 1 (1982), as well as some clauses of IEC 60364-5-548, published in 1996, and its amendment (1998), and constitutes a technical revision.

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

FDIS	Report on voting
64/1231/FDIS	64/1249/RVD

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

It has the status of a basic safety publication in accordance with IEC Guide 104.

This publication has been drafted, as close as possible, in accordance with the ISO/IEC Directives, Part 3.

Annex A forms an integral part of this standard.

Annex B is for information only.

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The committee has decided that the contents of this publication will remain unchanged until 2007. At this date, the publication will be

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- withdrawn;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

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INTRODUCTION

Clause numbering is sequential, preceded by the number of this part (e.g. 541). Numbering of figures and tables takes the number of this part followed by a sequential number, i.e. Table 54.1, 54.2, etc. Numbering of figures and tables in annexes takes the letter of the annex, followed by the number of the part, followed by a sequential number, e.g. A.54.1, A.54.2, etc.

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ELECTRICAL INSTALLATIONS OF BUILDINGS –

Part 5-54: Selection and erection of electrical equipment – Earthing arrangements, protective conductors and protective bonding conductors

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541 General

541.1 Scope

This part of IEC 60364 addresses the earthing arrangements, protective conductors and protective bonding conductors in order to satisfy the safety of the electrical installation.

541.2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050(195), *International Electrotechnical Vocabulary (IEV) – Part 195: Earthing and protection against electric shock*

IEC 60287-1-1, *Electric cables – Calculation of the current rating – Part 1-1: Current rating equations (100 % load factor) and calculation of losses – General*

IEC 60364-4-41, *Electrical installations of buildings – Part 4-41: Protection for safety – Protection against electric shock*

IEC 60364-4-43, *Electrical installations of buildings – Part 4-43: Protection for safety – Protection against overcurrent*

IEC 60364-4-44, *Electrical installations of buildings – Part 4-44: Protection for safety – Protection against voltage disturbances and electromagnetic disturbances*

IEC 60364-5-52, *Electrical installations of buildings – Part 5-52: Selection and erection of electrical equipment – Wiring systems*

IEC 60724, *Short-circuit temperature limits of electric cables with rated voltages of 1 kV (U_m = 1,2 kV) and 3 kV (U_m = 3,6 kV)*

IEC 60853-2, *Calculation of the cyclic and emergency current rating of cables – Part 2: Cyclic rating of cables greater than 18/30 (36) kV and emergency ratings for cables of all voltages*

IEC 60909-0, *Short-circuit currents in three-phase a.c. systems – Part 0: Calculation of currents*

IEC 60949, *Calculation of thermally permissible short-circuit currents, taking into account non-adiabatic heating effects*

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IEC 61024-1, *Protection of structures against lightning – Part 1: General principles*

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

IEC Guide 104, *The preparation of safety publications and the use of basic safety publications and group safety publications*

541.3 Definitions

For the purposes of this part of IEC 60364, the definitions of IEC 61140, together with the following definitions taken from IEC 60050(195), apply.

Definitions used for earthing arrangements, protective conductors and protective bonding conductors are illustrated in annex B and listed here as follows:

541.3.1
exposed-conductive-part
conductive part of equipment which can be touched and which is not normally live, but which can become live when basic insulation fails

[IEV 195-06-10]

541.3.2
main earthing terminal
(main earthing busbar)
terminal or busbar which is part of the earthing arrangement of an installation enabling the electric connection of a number of conductors for earthing purposes

[IEV 195-02-33]

541.3.3
earth electrode
conductive part, which may be embedded in a specific conductive medium, e.g. concrete or coke, in electric contact with the earth

[IEV 195-02-01]

541.3.4
protective conductor
conductor provided for purposes of safety, for example protection against electric shock

[IEV 195-02-09]

541.3.5
protective bonding conductor
protective conductor provided for protective-equipotential-bonding

[IEV 195-02-10]

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541.3.6
earthing conductor
conductor which provides a conductive path, or part of the conductive path, between a given point in a system or in an installation or in equipment and an earth electrode

[IEV 195-02-03]

NOTE For the purposes of this part of IEC 60364, an earthing conductor is the conductor which connects the earth electrode to a point in the equipotential bonding system, usually the main earthing terminal.

541.3.7
extraneous-conductive-part
conductive part not forming part of the electrical installation and liable to introduce an electric potential, generally the electric potential of a local earth

[IEV 195-06-11]

542 Earthing arrangements

542.1 General requirements

542.1.1 The earthing arrangements may be used jointly or separately for protective and functional purposes according to the requirements of the electrical installation. The requirements for protective purposes shall always take precedence.

542.1.2 Where provided, earth electrodes within an installation shall be connected to the main earthing terminal using an earthing conductor.

542.1.3 Consideration shall be given to the earthing arrangements which are used in high-voltage and low-voltage systems (see IEC 60364-4-44, clause 442).

542.1.4 The requirements for earthing arrangements are intended to provide a connection to earth:

– which is reliable and suitable for the protective requirements of the installation;
– which can carry earth fault currents and protective conductor currents to earth without danger from thermal, thermo-mechanical and electromechanical stresses and from electric shock arising from these currents;
– which, if relevant, is also suitable for functional requirements.

542.2 Earth electrodes

542.2.1 Materials and dimensions of the earth electrodes shall be selected to withstand corrosion and to have adequate mechanical strength.

For commonly used materials, the common minimum sizes from the point of view of corrosion and mechanical strength for earth electrodes where embedded in the soil are given in table 54.1.

NOTE If a lightning protection system (LPS) is present, the IEC 61024-1 applies.

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Table 54.1 – Common minimum sizes for earth electrodes of commonly used material from the point of view of corrosion and mechanical strength where embedded in the soil

Material	Surface	Shape	Minimum size				
			Diameter mm	Cross-sectional area mm^2	Thickness mm	Thickness of coating/sheathing	
						Individual value µm	Average value µm
Steel	Hot-dip galvanized [a] or Stainless [a, b]	Strip [c]		90	3	63	70
		Sections		90	3	63	70
		Round rod for deep earth electrodes	16			63	70
		Round wire for surface electrode [g]	10				50 [e]
		Pipe	25		2	47	55
	Copper-sheathed	Round rod for deep earth electrode	15			2 000	
	With electro-deposited copper coating	Round rod for deep earth electrode	14			90	100
Copper	Bare [a]	Strip		50	2		
		Round wire for surface electrode [g]		25 [f]			
		Rope	1,8 for individual strands of wire	25			
		Pipe	20		2		
	Tin-coated	Rope	1,8 for individual strands of wire	25		1	5
	Zinc-coated	Strip [d]		50	2	20	40

[a] Can also be used for electrodes to be embedded in concrete.
[b] No coating applied.
[c] As rolled strip or slit strip with rounded edges.
[d] Strip with rounded edges.
[e] In the case of continuous bath-coating, only 50 µm thickness is technically feasible at present.
[f] Where experience shows that the risk of corrosion and mechanical damage is extremely low, 16 mm² can be used.
[g] An earth electrode is considered to be a surface electrode when installed at a depth not exceeding 0,5 m.

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542.2.2 The efficacy of any earth electrode depends upon local soil conditions. One or more earth electrodes suitable for the soil conditions and the value of resistance to earth required, shall be selected.

542.2.3 The following are examples of earth electrodes which may be used:

– underground structural networks embedded in foundations (foundation earthing);
– plates;
– metal reinforcement of concrete (except pre-stressed concrete) embedded in the earth;
– rods or pipes;
– tapes or wires;
– metal sheaths and other metal coverings of cables according to local conditions or requirements;
– other suitable underground metalwork according to local conditions or requirements.

NOTE 1 In Austria, Belgium, Finland, France, Germany, Sweden, Switzerland and the UK, water pipes are not permitted as earth electrodes.

NOTE 2 In Italy it is permitted to use a water pipe system, but only with the consent of the water distributor.

542.2.4 When selecting type and embedded depth of earth electrode, consideration shall be given to local conditions and regulations so that soil drying and freezing will be unlikely to increase the earth resistance of the earth electrode to such a value that would impair the protective measures against electric shock (see IEC 60364-4-41).

NOTE In Germany, there is an obligation to erect in every new building a foundation earth electrode according to National Standard DIN 18014.

542.2.5 Consideration shall be given to electrolytic corrosion when using different materials in an earthing arrangement.

542.2.6 A metallic pipe for flammable liquids or gases shall not be used as an earth electrode.

NOTE This requirement does not preclude the protective bonding of such pipes for compliance with IEC 60364-4-41.

542.3 Earthing conductors

542.3.1 Earthing conductors shall comply with 543.1 and where buried in the soil, their cross-sectional areas shall be in accordance with table 54.2.

In TN systems, where no noticeable fault current is expected to pass in the earth electrode, the earthing conductor may be dimensioned according to 544.1.1

Table 54.2 – Minimum cross-sectional areas of earthing conductors buried in the soil

	Mechanically protected	Mechanically unprotected
Protected against corrosion	2,5 mm² Cu 10 mm² Fe	16 mm² Cu 16 mm² Fe
Not protected against corrosion	25 mm² Cu 50 mm² Fe	

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542.3.2 The connection of an earthing conductor to an earth electrode shall be soundly made and electrically satisfactory. The connection shall be by exothermic welding, pressure connectors, clamps or other mechanical connectors. Mechanical connectors shall be installed in accordance with the manufacturer's instructions. Where a clamp is used, it shall not damage the electrode or the earthing conductor.

NOTE Connection devices or fittings that depend solely on solder, do not reliably provide adequate mechanical strength.

542.4 Main earthing terminal

542.4.1 In every installation where protective bonding is used, a main earthing terminal shall be provided and the following shall be connected to it:

– protective bonding conductors;
– earthing conductors;
– protective conductors;
– functional earthing conductors, if relevant.

NOTE 1 It is not intended to connect every individual protective conductor directly to the main earthing terminal when they are connected to this terminal by other protective conductors.

NOTE 2 The main earthing terminal of the building can generally be used for functional earthing purposes. For information technology purposes, it is then regarded as the connection point to the earth electrode network.

542.4.2 Each conductor connected to the main earthing terminal shall be able to be disconnected individually. This connection shall be reliable and disconnectable only by means of a tool.

NOTE Disconnection means may conveniently be combined with the main earthing terminal, to permit measurement of the resistance of the earthing arrangements.

543 Protective conductors

543.1 Minimum cross-sectional areas

543.1.1 The cross-sectional area of every protective conductor shall satisfy the conditions for automatic disconnection of supply required in clause 413.1 of IEC 60364-4-41 and be capable of withstanding the prospective fault current.

The cross-sectional area of the protective conductor shall either be calculated in accordance with 543.1.2, or selected in accordance with table 54.3. In either case, the requirements of 543.1.3 shall be taken into account.

Terminals for protective conductors shall be capable of accepting conductors of dimensions required by this subclause.

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Table 54.3 – Minimum cross-sectional area of protective conductors

Cross-sectional area of line conductor S mm²	Minimum cross-sectional area of the corresponding protective conductor mm²	
	If the protective conductor is of the same material as the line conductor	If the protective conductor is not of the same material as the line conductor
$S \leq 16$	S	$\frac{k_1}{k_2} \times S$
$16 < S \leq 35$	16 [a]	$\frac{k_1}{k_2} \times 16$
$S > 35$	$\frac{S}{2}$ [a]	$\frac{k_1}{k_2} \times \frac{S}{2}$

where

k_1 is the value of k for the line conductor, selected from table A.54.1 or from the tables in IEC 60364-4-43, according to the materials of the conductor and insulation;

k_2 is the value of k for the protective conductor, selected from tables A.54.2 to A.54.6 as applicable.

[a] For a PEN conductor, the reduction of the cross-sectional area is permitted only in accordance with the rules for sizing of the neutral conductor (see IEC 60364-5-52).

543.1.2 The cross-sectional areas of protective conductors shall not be less than the value determined either:

– in accordance with IEC 60949;

– or by the following formula applicable only for disconnection times not exceeding 5 s:

$$S = \frac{\sqrt{I^2 t}}{k}$$

where

S is the cross-sectional area, in mm²;

I is the value (r.m.s) in A of prospective fault current for a fault of negligible impedance, which can flow through the protective device (see IEC 60909-0);

t is the operating time of the protective device for automatic disconnection in s;

NOTE 1 Account should be taken of the current-limiting effect of the circuit impedances and the limitation of I^2t of the protective device.

k is the factor dependent on the material of the protective conductor, the insulation and other parts and the initial and the final temperatures (for calculation of k, see annex A).

If application of the formula produces non-standard sizes, conductors of a higher standard cross-sectional area shall be used.

NOTE 2 For limitations of temperatures for installations in potentially explosive atmospheres, see IEC 60079-0.

NOTE 3 As the metallic sheaths of mineral insulated cables according to IEC 60702-1 have an earth fault capacity greater than that of the line conductors, it is not necessary to calculate the cross-sectional area of the metallic sheaths when used as protective conductors.

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