REPUBLIC OF SLOVENIA
MINISTRY FOR THE ENVIRONMENT AND SPACE

TECHNICAL GUIDELINES TSG-N-002: 2026

Pursuant to Article 36(1) of the Construction Act (Uradni list RS (UL RS; Official Gazette of the Republic of Slovenia) Nos 199/21, 105/22 – ZZNŠPP, 133/23, 85/24 – ZAID-A, 47/25 – odl. US and 75/25) issue a technical guideline

INDUSTRIAL ELECTRIC INSTALLATIONS

Minister for the Environment and Spatial Planning

mag. POLONA RIFELJ

Number: 007-52/2026-2560
Done at Ljubljana, 21 July 2026.

This Guideline is issued taking into account the information procedure under Directive (EU) 2015/1535 of the European Parliament and of the Council of 9 September 2015 laying down a procedure for the provision of information in the field of technical regulations and of rules on Information Society services (OJ L 241, 17.9.2015, p. 9. 2015, p. 1.

The fourth edition of technical guideline TSG-N-002:2026 fully replaces the third edition of technical guideline TSG-N-002:2021.

The preparation of professional content was carried out by the Electrical Engineering Association of Slovenia in cooperation with the professional public and the Slovenian Chamber of Engineers.
Design and breakage:

INDICATOR

0 INTRODUCTION

0.1 RECOGNITION AND APPLICATION OF THE TECHNICAL GUIDELINES OF "NON-CONOPTITUTIONAL ELECTRIC INSTALLATION"

0.1.1 Legal basis for issuing the technical guideline

(1) This technical guideline was issued by the Minister for the Environment and Spatial Planning on the basis of Article 36(1) of the Construction Act (UL RS Nos 199/21, 105/22 – ZZNŠPP, 133/23, 85/24 – ZAID-A, 47/25 – odl. US and 75/25).

(2) The Construction Act provides that "technical guidelines for the construction of buildings (hereinafter: technical guidelines) specify, for certain types of installations:
- recommended technical solutions to achieve the fulfilment of the essential requirements for the design, construction and maintenance of facilities,
- the selected levels or classes of construction products and materials which may be incorporated and the manner in which they are to be incorporated.

It also provides that the technical guidelines for certain types of installations shall specify the recommended technical solutions relating to compliance with other requirements.

(3) The legal nature and application of the technical guidelines are dealt with in Articles 34 and 36 of the Act. The first provides that regulations on essential requirements are issued by the minister responsible for construction, but in the case of special types of facilities or parts of essential requirements, they may also be determined by the ministers in whose area of work such types of facilities or essential requirements fall. The same article also sets out the relationship between regulations and guidelines when it provides that construction technical and other regulations may refer to standards or technical guidelines or provide for a presumption of conformity with the requirements of a regulation if it meets the requirements of the standards or technical guidelines referred to therein. Where a building technical regulation provides for a presumption of conformity as referred to in the preceding paragraph, those regulations shall also define the methods and procedure by which it is demonstrated that a project in which the designer has applied solutions to the last state of the construction technique provides at least the same degree of reliability as a project prepared using technical guidelines and mandatory or recommended standards.

(4) Other requirements shall be specified in greater detail by the Minister within whose area of work the type of facilities or those requirements fall.

(5) Article 25 of the Act stipulates that facilities must meet essential requirements with regard to the purpose, type, size, capacity, anticipated impacts and other characteristics of the facility. The essential requirements for facilities are:

1. mechanical resistance and stability,

2. fire safety,

3. hygiene, health and environmental protection,

4. safety in use,

5. protection from noise,

6. energy saving and heat retention,

7. universal construction and use of objects,

8. sustainable use of natural resources.

(6) If a particular solution has to comply with the requirements of different regulations, the most unfavourable values are chosen for it – the most stringent requirements as set out in the regulations to be followed.

0.1.2 Rules on requirements for low-voltage electrical installations in buildings – Legal framework for the operation of the guideline

(1) The Rules on low-voltage electrical installations in buildings and the protection of buildings against lightning (Uradni list RS (UL RS; Official Gazette of the Republic of Slovenia) No XXX/YY) are the building regulations which define in more detail part of the essential requirements 'fire safety' and 'safety in use' for buildings. This Regulation lays down requirements for low-voltage electrical installations.

Article 8
(Ensuring safety and security)

(1) Electrical installation:
must prevent or at least limit the harmful effects of electric shock,
it must prevent excessive heating of their elements,
prevent the ignition of a potentially explosive atmosphere,
avoid undervoltage, overvoltage and excessive electromagnetic influences,
it must prevent the risk of power interruption,
avoid other hazards (e.g. arc, uncontrolled mechanical operation),
must ensure the correct and uninterrupted operation of the installed devices,
it must enable the correct and uninterrupted operation of the consumers connected to it,
it must not impair the continuity and quality of the electricity supplied to neighbouring installation systems by excessive voltage fluctuations or other technical disturbances; and
must ensure the correct and uninterrupted operation of the installations for the production and storage of electricity connected to them, in all cases of energy flows in the installation and operating conditions of the installations

ATTENTION:
The scope of this technical guideline is significantly wider than the legal scope of the rules. As is clear from the third paragraph of Article 1 of the Rules, under certain conditions its requirements may be applied mutatis mutandis not only to buildings, but also to other structures – civil engineering structures.

Article 1
(Content and application of the Rules)

(3) The requirements of these Rules shall apply mutatis mutandis to civil engineering works and other interventions in the space if the regulations governing their essential requirements do not contain requirements regarding electrical installation and lightning protection.

(2) In the chapter of the Rules setting out how to meet the prescribed requirements, the following provisions are most relevant for the application of this technical guideline:

Article 9
(Technical guidelines)

(1) The technical guidelines for the construction of the TSG-N-002 Low Voltage Electrical Installation and the TSG N 003 Lightning Protection are the recommended construction measures and solutions for achieving the requirements of this Regulation.
(2) If measures or solutions are fully used in the design and construction of electrical installation and lightning protection in a building (hereinafter: measures) referred to in the technical guidelines referred to in the preceding paragraph and in the documents referred to in those guidelines, there shall be a presumption of conformity with the requirements of this Regulation.

Article 10
(Use of unrecommended measures)

(1) In the design and construction of electrical installations and lightning protection, solutions other than the recommended methods may be used instead of the measures referred to in the technical guidelines, provided that these solutions ensure the fulfilment of the requirements of these Rules and at least the same level of safety as the design and construction prepared and carried out using the technical guidelines referred to in the preceding Article.
(2) The measures referred to in the preceding paragraph shall mean the non-application of the recommended method, in accordance with the law governing construction. Compliance with the requirements of electrical installation and lightning protection shall be ensured in such cases by checking the documentation for the execution of the construction in accordance with Article 17 of these Rules.
(3) Notwithstanding the first paragraph of this Article, in all cases the acts referred to in Articles 13 and 14 of these Rules must be carried out exclusively in the manner set out in the technical guidelines referred to in the first paragraph of Article 9 of these Rules.
(4) Notwithstanding the first paragraph of this Article, lightning protection must always use the

(3) In the chapter of the Rules that determines the content of the project documentation, the following provisions are most important:

Article 17
(Indication of the basis for the design)

(1) The designer must explicitly state in the design documentation whether the documentation for the execution of the work is drawn up on the basis of the technical guideline or on the basis of Article 10 of these Rules.

(2) If the measures referred to in Article 10 of these Rules are applied in the design documentation, the technical report shall describe in detail all the essential assumptions on the basis of which the designer proposed the design solutions.

(3) The project documentation for the construction of electrical installation and lightning protection must include at least:

- description and dimensioning of the power supply,
- descriptions of each system and installation,
- description of the implementation of installation and power supply, with calculations of the dimensioning of electrical installation and devices and calculations of voltage drops,
- protection against electric shock, with calculation of protection,
- power supply system and equalization of potential,
- grounding of the object, with the calculation of the grounding,
- the method of implementation of lightning protection, with calculation of the protection level of the system and risk assessment,
- solutions to prevent harmful effects on the environment and space (noise, electromagnetic effects and compatibility),
- external influences on the installation (moisture, water, dust, heat) and the necessary measures to reduce them,
- compliance with fire safety measures and the safety of explosion-endangered areas,
- compliance with protective measures in use,

the impact of electricity quality.

(4) In addition to the requirements referred to in the preceding paragraph, the project documentation for the implementation of the construction, in the field of lightning protection system, must also include:
- the protective level of the building,
- separation distances between metal masses, by calculation,
- the floor plan of the roofs and facades of buildings with the main characteristics of the catchment system,
- external lightning protection system – catching system, drains and grounding system,
- internal lightning protection system – direct galvanic connections with cross-sections and intended installation of surge protection devices,
- the ground resistance value with the necessary calculations,
- types of grounding and measuring contacts (e.g. tape, ring, foundation ground),
- connectors of metal masses with defined collectors for equalization of potentials,
- type and position of connections with neighbouring facilities (e.g. plumbing, gas installation, electrical installation, information and communication installations, protection),
- Touch and step overvoltage protection system; and
- other data relevant to the installation or lightning protection system (e.g. insulated system).

(5) The plan in the field of electrical engineering must indicate the conformity of all measures or solutions relating to electrical installation and lightning protection, in particular with regard to the common elements of the equalization of potentials, the external catching system with drains and the implementation of the internal lightning protection system.

If the designer chooses design in accordance with Article 10 of the Rules (application of unrecommended measures), Article 18 of the Rules is relevant:

Article 18
(obligation to check the documentation for the execution of the work)

(1) If the designer designs the electrical installation and protection of the building against lightning has not used the recommended method, the part of the documentation for the execution of the construction that relates to the control of the flawlessness and calculation correctness of those parts of the documentation for the execution of the construction of the electrical installation and protection against lightning must be examined. The examination shall demonstrate that the documentation submitted for the execution of the works meets the requirements of these Rules to a level at least equivalent to that which would result from the application of the corresponding technical guidelines and the documents to which they refer.
(2) The verification referred to in the preceding paragraph shall be carried out by a designer who was not involved in the design of the building in question. Verification on behalf of and for the needs of the designer referred to in the preceding sentence shall be carried out by an authorised engineer in the field of electrical engineering, who was not involved in the design of the building in question, as the examiner.
(3) The examiner shall enter in the inspection declaration only the information which is essential for the scope of the verification referred to in the first paragraph of this Article. The subject of the inspection shall be exclusively the control of the correctness and accuracy of the electrical engineering plan contained in the project documentation for the execution of the construction, which proves that the submitted project documentation for the execution of the construction

0.1.3 Legal consequences of (non)application of the technical guideline

a) Application of the technical guideline - presumption of conformity

(1) As can be seen from the previous points of the introduction, this technical guideline merely lists the construction measures or solutions as the recommended way to meet the requirements laid down in the Rules. Compliance with the recommended technical measures gives rise to a presumption of compliance with the requirements of the Rules. In this regard, it must be assumed

that measures to protect buildings against lightning and solutions for the safe use of low-tension electrical installations are, as a rule, interconnected and their final impact cannot be considered solely on the basis of a case-by-case analysis of each measure, that is to say, without taking into account the results of the overall chosen safety design.

(2) Therefore, when selecting the measures under this technical guideline and combining them with the measures listed in the different reference (supporting) documents, the responsible designer should always ensure that they are consistent with each other.

(3) The burden of proof of non-compliance with the requirements of the Rules in the application of this technical guide lies with the competent state authorities or the legally determined participants in the construction, whose role is to control the correctness of the design (inspectors and professional chambers). Where the design has followed the construction measures referred to in this technical guideline, during construction and when obtaining the necessary administrative decisions, it is not necessary to demonstrate compliance with the relevant regulations, as this is automatically presumed under the provisions of the regulations

b) Latest state-of-the-art design of construction techniques

(1) If, in accordance with the Rules, the responsible designer decides to apply (partially or fully) the construction measures from the latest state of construction technology, as defined in Article 10 of the Rules, the assurance of at least the same level of safety of the lightning protection system must be demonstrated by the mandatory verification of that part of the documentation for the execution of the construction relating to the control of the faultlessness and the calculation correctness of those elements of the plan that determine the electrical installations of the building (Article 18 of the Rules), which is the prescribed method of proving to the designer that he has met the prescribed requirement.

(2) Even when designing after the last state of construction technology, it is considered that lightning protection measures are, as a rule, interconnected and their final effect cannot be considered solely on the basis of a case-by-case analysis of each measure, that is, without taking into account the results of the overall chosen concept of ensuring safety.

c) Relationship to the requirements of legal regulations in the field of lightning protection

(1) The content of this technical guideline recommends construction measures, which may exceptionally also be subject to other regulations. In relation to the applicable regulations, the technical guideline is drafted in such a way that the proposed construction measures do not conflict with the requirements of the regulations in question. However, if its application nevertheless reveals that the implementation of a particular proposed measure would infringe the provisions of the applicable legislation, the mandatory requirements of the legislation must be fully respected.

(2) Point 0.2.1 takes into account the state of validity of the regulations at the date of issue of this technical guideline. Changes related to the issuing of new regulations and related repeals must be monitored by users via the Official Gazette of the Republic of Slovenia or the Official Journal of the European Communities for EC legal acts.

0.2 REFERENCE DOCUMENTS[1]

0.2.1 Regulations

0.2.1.1 Construction Act (UL RS Nos 199/21, 105/22 – ZZNŠPP, 133/23, 85/24 – ZAID-A, 47/25 – odl. US and 75/25),
0.2.1.2 Energy Act (Uradni list RS (UL RS; Official Gazette of the Republic of Slovenia) Nos 38/24 and 47/25 – ZOEE-A);
0.2.1.3 Construction Products Act (Uradni list RS (UL RS; Official Gazette of the Republic of Slovenia) No 82/13),
0.2.1.4 the Technical Requirements for Products and Conformity Assessment Act (Uradni list RS (UL RS; Official Gazette of the Republic of Slovenia) Nos 17/11 and 29/23),
0.2.1.5 Decree on the classification of facilities (Official Gazette of the Republic of Slovenia No 96/22),
0.2.1.6 Decree on the provision of occupational safety and health at temporary and mobile construction sites (UL RS Nos 83/05 and 43/11 – ZVZD-1);
0.2.1.7 Decree on the implementation of the Regulation (EU) laying down harmonised conditions for the marketing of construction products (UL RS No 77/12);
0.2.1.8 Decree on electromagnetic radiation in the natural and living environment (UL RS Nos 70/96 and 41/04 – ZVO-1);
0.2.1.9 Decree on self-supply of electricity from renewable energy sources (UL RS No 17/19);
0.2.1.10 Decree on small installations for the production of electricity from renewable energy sources or high-efficiency cogeneration (UL RS No 14/20);
0.2.1.11 Rules on the making available on the market of electrical equipment designed for use within certain voltage limits (UL RS No 39/16),
0.2.1.12 Rules on Electromagnetic Compatibility (UL RS Nos 39/16 and 9/20),
0.2.1.13 Rules on the protection of low-voltage networks and associated substations (UL RS No 90/15),
0.2.1.14 Rules on the ventilation and air-conditioning of buildings (UL RS, 42/02, 105/02, 110/02 – ZGO-1, 61/17 – GZ and 199/21 – GZ-1);
0.2.1.15 Rules on Explosion Protection (UL RS No 41/16),
0.2.1.16 Rules on fire safety in buildings (UL RS Nos 31/04, 10/05, 83/05 and 14/07, 12/13, 61/17 – GZ and 199/21 – GZ-1);
0.2.1.17 Rules on the detailed content of documentation and forms relating to the construction of buildings (UL RS Nos 36/18 and 51/18 – corr.),
0.2.1.18 Rules on low-voltage electrical installations in buildings and the protection of buildings against lightning (UL RS No XXX/YY);
0.2.1.19 Rules on the safety of lifts (Official Gazette of the Republic of Slovenia No 25/16),
0.2.1.20 Rules on the safety of machinery (UL RS Nos 75/08, 66/10, 17/11 – ZTZPUS-1 and 74/11),
0.2.1.22 Rules on requirements for ensuring the safety and health of workers at workplaces (UL RS Nos 89/99, 39/05 and 43/11 – ZVZD-1);
0.2.1.23 Rules on the universal construction and use of buildings (Official Gazette of the Republic of Slovenia, Nos 41/18 and 199/21 – GZ-1),
0.2.1.24 Rules on alternating voltages above 1 kV (UL RS No 63/16),
0.2.1.25 Rules on the Maintenance of Electric Power Plants (Official Gazette of the Republic of Slovenia, No. 98/15),
0.2.1.26 Rules on the Operation of Electric Power Plants (Official Gazette of the Republic of Slovenia, No. 56/16),

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1The user shall use the latest applicable reference documents listed in:
- Point 0.2.1, available at: http://www.pisrs.si/Pis.web/
- point 0.2.2, accessible at the Slovenian Institute for Standardisation (SIST),
- point 0.2.3, which can be found on the website of the Ministry of the Environment and Spatial Planning, SZPV and EZS.

0.2.1.27 System operating instructions for the electricity distribution network (Uradni list RS (UL RS; Official Gazette of the Republic of Slovenia) No 77/24),
0.2.1.28 Commission Regulation (EU) 2016/631 of 14 April 2016 establishing a network code on requirements for grid connection of generators (OJ L 112, 27.4.2016)

0.2.2 Standards

The design, installation, operation and maintenance of electrical installations shall be based on the following standards and the standards and other documents referred to therein:

0.2.2.1	SIST 1050	Dimensional requirements for plugs and sockets for domestic and similar use
0.2.2.2	SIST EN 81-72	Safety rules for the construction and installation of lifts - Particular applications for passenger and goods passenger lifts - Part 72: Firefighter lifts
0.2.2.3	SIST EN 1838	Lighting - Emergency lighting
0.2.2.4	ISO 6707-1	Buildings and civil engineering - Dictionary - Part 1: Dictionary
0.2.2.5	SIST EN 50110-1	Operation of electrical installations - Part 1: General requirements
0.2.2.6	SIST EN 50110-2	Electrical Installation Management - Part 2: National bonuses
0.2.2.7	SIST EN 50160	Characteristics of voltages in public distribution networks
0.2.2.8	SIST EN 50172	Emergency lighting systems for escape routes
0.2.2.9	SIST-TP CLC/TR 50404	Electrostatics - Rules of conduct to avoid hazards from static electricity
0.2.2.10	SIST EN 50549-1	Requirements for parallel connection of generating installations to the public distribution network - Part 1: Connection to low-voltage distribution network - Generating plants up to and including type B
0.2.2.11	SIST EN 50575	Power, control and communication cables - Cables for general use for construction works according to fire resistance requirements
0.2.2.12	SIST IEC 60050-195	International Electrotechnical Dictionary - Earthing and protection against (and in) electric shock
0.2.2.13	SIST IEC 60050-826	International Electrotechnical Dictionary - Electrical Installations
0.2.2.14	SIST EN 60079-2	Explosive atmospheres - Part 2: Equipment protection with "p" overpressure
0.2.2.15	SIST EN 60079-14	Explosive atmospheres - Part 14: Planning, selection and installation of electrical installations
0.2.2.16	SIST EN 60079-17	Explosive atmospheres - Part 17: Inspection and maintenance of electrical installations
0.2.2.17	SIST EN 60079-19	Explosive atmospheres - Part 19: Repair, overhaul and overhaul of equipment
0.2.2.18	SIST EN 60204-1	Safety of machinery - Electrical equipment of machinery - Part 1: General requirements
0.2.2.19	SIST EN 60269-6	Low-voltage fuses - Part 6: Supplementary requirements

		for fusible inputs for the protection of solar photovoltaic energy systems
0.2.2.20	SIST HD 60364-1	Low-voltage electrical installations – Part 1: Basic principles, assessment of general characteristics, definitions
0.2.2.21	SIST HD 60364-4-41, +A11, +A12	Low-voltage electrical installations – Part 4-41: Protective measures - Protection against electric shock
0.2.2.22	SIST HD 60364-4-42	Electrical installations of buildings — Part 4-42: Safeguards - Protection against thermal effects
0.2.2.23	SIST HD 60364-4-43	Electrical installations of buildings — Part 4-43: Safeguards – Overflow protection
0.2.2.24	SIST IEC 60364-4-44	Electrical installations of buildings — Part 4-44: Protective measures – Protection against overvoltages – Protection against voltage disturbances and electromagnetic disturbances
0.2.2.25	SIST HD 60364-4-442	Low-voltage electrical installations – Part 4-442: Safeguards - Protection of low voltage installations against current overvoltage due to ground contact in the high voltage system and due to faults in the low voltage system
0.2.2.26	SIST HD 60364-4-443	Electrical installations of buildings — Part 4-443: Protective measures - Protection against voltage and electromagnetic disturbances - Protection against atmospheric and switching overvoltages
0.2.2.27	SIST HD 60364-4-444	Low-voltage electrical installations – Part 4-444: Protective measures - Protection against voltage and electromagnetic disturbances
0.2.2.28	SIST IEC 60364-4-44/AMD2	Low-voltage electrical installations – Part 4-444: Protective measures — Protection against voltage and electromagnetic disturbances, Appendix 2
0.2.2.29	SIST HD 60364-5-51	Electrical installations of buildings — Part 5-51: Selection and installation of electrical equipment - General rules
0.2.2.30	SIST HD 60364-5-52	Low-voltage electrical installations – Part 5-52: Selection and installation of electrical equipment - Installation systems
0.2.2.31	SIST HD 60364-5-53	Low-voltage electrical installations - Part 5-53: Selection and installation of electrical equipment - Switching and control devices
0.2.2.32	SIST HD 60364-5-53 / A11	Electrical installations of buildings — Part 5-53: Selection and installation of electrical equipment - Switchgear and controlgear
0.2.2.33	SIST HD 60364-5-54	Low-voltage electrical installations - Part 5-54: Selection and installation of electrical equipment - Grounding and protective conductors
0.2.2.34	SIST IEC 60364-5-55	Electrical installations of buildings — Part 5-55: Selection and installation of electrical equipment - Other equipment
0.2.2.35	SIST HD 60364-5-56	Low-voltage electrical installations — Part 5-56:

		Selection and installation of electrical equipment - Safety supply
0.2.2.36	SIST HD 60364-5-534	Low-voltage electrical installations – Part 5-534: Selection and installation of electrical equipment - Separation, contact and control - Surge protection devices
0.2.2.37	SIST HD 60364-5-537	Low-voltage electrical installations - Part 5-53: Selection and installation of electrical equipment - Switchgear and control gear - Section 537: Separation and contact
0.2.2.38	SIST HD 60364-5-551	Low-voltage electrical installations – Part 5-551: Selection and installation of electrical equipment – Other equipment – Low-voltage generators
0.2.2.39	SIST HD 60364-5-557	Low-voltage electrical installations - Part 5-557: Selection and installation of electrical equipment - Auxiliary circuits
0.2.2.40	SIST HD 60364-5-559	Low-voltage electrical installations – Part 5-559: Selection and installation of electrical equipment - Lamps and installation lighting
0.2.2.41	SIST HD 60364-6	Low-voltage electrical installations – Part 6: Verification
0.2.2.42	SIST HD 60364-7-701	Low-voltage electrical installations – Part 7-701: Requirements for special installations or locations - Bath or shower facilities
0.2.2.43	SIST HD 60364-7-702	Low-voltage electrical installations – Part 7-702: Requirements for specific installations or locations - Swimming pools and wells
0.2.2.44	SIST HD 60364-7-703	Electrical installations of buildings — Part 7-703: Requirements for special installations or locations - Rooms and cabins with sauna heaters
0.2.2.45	SIST HD 60364-7-704	Low-voltage electrical installations - Part 7-704: Requirements for special installations or locations - Construction sites
0.2.2.46	SIST HD 60364-7-705	Low-voltage electrical installations — Part 7-705: Requirements for special installations or locations — Electrical installations of agricultural and horticultural buildings
0.2.2.47	SIST HD 60364-7-706	Low-voltage electrical installations – Part 7-706: Requirements for specific installations or locations — Restricted conductive spaces
0.2.2.48	SIST HD 60364-7-708	Low-voltage electrical installations – Part 7-708: Requirements for special installations or locations — Electrical installations in campsites and similar locations
0.2.2.49	SIST HD 60364-7-709	Low-voltage electrical installations – Part 7-709: Requirements for specific installations or sites – Marine and similar sites
0.2.2.50	SIST HD 60364-7-710	Low-voltage electrical installations — Part 7-710: Requirements for special installations or locations - Medical facilities
0.2.2.51	SIST IEC 60364-7-711	Electrical installations of buildings — Part 7: Requirements for special installations or rooms -

		Exhibitions, performances and stands
0.2.2.52	SIST HD 60364-7-712	Electrical installations of buildings – Part 7-712: Requirements for special installations or locations - Photovoltaic (PV) systems
0.2.2.53	SIST IEC 60364-7-713	Electrical installations of buildings — Part 7: Requirements for specific installations and locations – Section 713: Furniture
0.2.2.54	SIST IEC 60364-7-714	Low-voltage electrical installations - Part 7-714: Requirements for special installations or locations - Outdoor lighting installations
0.2.2.55	SIST HD 60364-7-715	Low-voltage electrical installations – Part 7-715: Requirements for special installations or locations — Low voltage lighting installations
0.2.2.56	SIST HD 60364-7-717	Low-voltage electrical installations – Part 7-717: Requirements for specific installations or locations — Mobile or portable units
0.2.2.57	SIST HD 60364-7-718	Low-voltage electrical installations - Part 7-718: Requirements for special installations or locations - Utilities and workplaces
0.2.2.58	SIST HD 60364-7-721	Low-voltage electrical installations - Part 7-721: Requirements for special installations or locations - Electrical installations in caravans and motorhomes
0.2.2.59	SIST HD 60364-7-722	Electrical installations of buildings – Part 7-722: Requirements for specific installations or locations — Power supply of electric vehicles
0.2.2.60	SIST HD 60364-7-729	Low-voltage electrical installations - Part 7-729: Requirements for specific installations or locations — Operating or maintenance passageways
0.2.2.61	SIST HD 60364-7-730	Low-voltage electrical installations - Part 7-730: Requirements for special installations or locations - Onshore installations for supplying inland waterway vessels
0.2.2.62	SIST HD 60364-7-740	Electrical installations of buildings — Part 7-740: Requirements for special installations or locations - Temporary electrical installations for buildings, amusement facilities and stands in fairgrounds, amusement parks and circuses
0.2.2.63	SIST IEC 60364-7-753	Low-voltage electrical installations — Part 7-753: Requirements for specific installations or locations - Heating cables and related heating systems
0.2.2.64	SIST HD 60364-8-1	Low-voltage electrical installations - Part 8-1: Energy efficiency
0.2.2.65	SIST HD 60364-8-2	Low-voltage electrical installations - Part 8-2: Prosumer electrical installations
0.2.2.66	SIST EN 60529	Level of protection provided by the housing (IP code)
0.2.2.67	SIST EN IEC 60598-2-22	Lamps - Part 2.22: Particular requirements - Lamps for emergency lighting
0.2.2.68	SIST EN IEC 60898	Electrical accessories - Circuit breakers for overcurrent

	series of standards	protection for household and similar installations
0.2.2.69	SIST EN IEC 60947-1	Low-voltage switchgear and controlgear - Part 1: General rules
0.2.2.70	SIST EN IEC 60947-21	Low-voltage switchgear and controlgear - Part 2: Circuit breaker
0.2.2.71	SIST EN IEC 60947-3	Low-voltage switchgear and controlgear - Part 3: Switches, disconnectors, switch-disconnectors and fuse switchgear
0.2.2.72	SIST EN 61000-3-3	Electromagnetic compatibility (EMC) - Part 3-3: Limit values - Limitation of voltage fluctuation and flicker values in low voltage power supply systems for equipment with rated current up to 16 A and not connected under specified conditions
0.2.2.73	SIST EN 61140, +A1	Protection against electric shock - Common aspects for installation and equipment
0.2.2.74	SIST-TP IEC/TR 61439-0	Low-voltage switchgear and controlgear assemblies - Part 0: Instructions for the specification of assemblies
0.2.2.75	SIST EN IEC 61439-1	Low-voltage switchgear and controlgear assemblies — Part 1: General rules
0.2.2.76	SIST EN IEC 61439-2	Low-voltage switchgear and controlgear assemblies — Part 2: Power switchgear and controlgear assemblies
0.2.2.77	SIST EN IEC 61439-3	Low-voltage switchgear and controlgear assemblies — Part 3: Dispensers capable of being handled by non-professionals (DBOs)
0.2.2.78	SIST EN IEC 61439-4	Low-voltage switchgear and controlgear assemblies — Part 4: Specific requirements for construction site assemblies
0.2.2.79	SIST EN IEC 61439-5	Low-voltage switchgear and controlgear - Part 5: Assemblies for the distribution of electricity in public networks
0.2.2.80	SIST EN 61439-6	Low-voltage and control gear assemblies — Part 6: Collector connecting systems (collector buses)
0.2.2.81	SIST EN IEC 61439-7	Low-voltage switchgear and controlgear assemblies - Part 7: Assemblies for special applications such as marinas, camping areas, markets, electric vehicle power stations
0.2.2.82	SIST EN 61511-1	Functional security - Security instrument systems for the process industry sector - Part 1: Framework, definition, system, hardware and software requirements
0.2.2.83	SIST EN IEC 61557 series of standards	Electrical safety in low voltage distribution systems up to 1000 V a.c. and 1500 V d.c. - Equipment for testing, measuring or monitoring of protective measures
0.2.2.84	SIST EN IEC 61851-1	Cable charging system for electric vehicles - Part 1: General requirements
0.2.2.85	SIST EN 61851-21-1	Electric Vehicle Cable Charging System - Part 21-1: EMC requirements for built-in AC/DC power supply cable connection
0.2.2.86	SIST EN IEC 61851-21-2	Electric vehicle charging systems - Part 21-2:

		Requirements for electric vehicles for connection to AC/DC power - EMC requirements for external charging systems of electric vehicles
0.2.2.87	SIST EN 61851-23	Electric Vehicle Cable Charging System - Part 23: DC charging station for electric vehicle
0.2.2.88	SIST EN 62109-1	Safety of power converters used in photovoltaic systems - Part 1: General requirements
0.2.2.89	SIST EN 62109-2	Safety of power converters used in photovoltaic systems - Part 2: Specific requirements for inverters
0.2.2.90	SIST EN 62196-1	Plugs, socket-outlets, vehicle connectors and fittings - Cable charging of electric vehicles - Part 1: General requirements
0.2.2.91	SIST EN 62262	Levels of protection against mechanical impact provided by enclosures to electrical equipment (IC code)
0.2.2.92	SIST EN IEC 62305-3	Lightning protection – Part 3: Physical damage to buildings and danger to living beings
0.2.2.93	SIST EN IEC 62305-4	Lightning protection – Part 4: Electrical and electronic systems in buildings
0.2.2.94	SIST EN 62423	Types F and B residual current circuit-breakers, with or without integral overcurrent protection, for household and similar use
0.2.2.95	SIST EN IEC 62446-1	Photovoltaic systems — Testing, documentation and maintenance requirements — Part 1: Network-connected systems — Documentation, acceptance tests and monitoring
0.2.2.96	SIST EN IEC 62446-2	Photovoltaic systems - Testing, documentation and maintenance requirements - Part 2: Network-connected systems - Maintenance of photovoltaic systems
0.2.2.97	SIST EN IEC 62485-2	Safety requirements for secondary batteries and battery devices - Part 2: Stationary batteries
0.2.2.98	SIST EN 62606	General requirements for arc detectors (AFDDs)
0.2.2.99	SIST EN ISO/IEC 80079-20-2	Explosive atmospheres - Part 20-2: Material properties - Methods of testing combustible dust

0.2.3 Guidelines and other documents

0.2.3.1 Technical Guideline TSG-1-001: Fire safety in buildings;
0.2.3.2 Technical Guideline TSG-N-003: Protection against lightning,
0.2.3.3 Guideline CNGV 408 Fire safety requirements for electrical and piping installations in buildings,
0.2.3.4 CNGV Guideline 411 Electrical door locking systems for escape routes,
0.2.3.5 SZPV Guideline 512 Fire safety of solar power plants,
0.2.3.6 Recommendation of the EZS; Back-up power generators; EZS TPR-02-2013,
0.2.3.7 Recommendation of the EZS; Use of mobile aggregates to provide emergency back-up power to family houses and farms; EZS TPR-5-2018,
0.2.3.8 81 IEEE Guidance for the Measurement of Ground Resistance, Soil Impedance and Ground Surface Potentials of the Grounding System; IEEE 81
0.2.3.9 519 IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Supply Systems; IEEE 519.

0.2.3.10 UN Regulation No. 100 – Uniform provisions concerning the approval of vehicles with regard to specific requirements for the electric power train (2nd corrected edition including Appendices 1-3) (OJ L 87, 31.3.2015, p. 1)
0.2.3.11 EZS TPR 06, Low Voltage Power Lines: Design, construction, operation and maintenance of low-voltage power lines,
0.2.3.12 Lead the inspectors at the takeover of the solar power plant,
0.2.3.13 Lead inspectors in the event of floods and other natural disasters;
0.2.3.14 Leading the owner of the solar power plant,
0.2.3.15 Leading building owners in the event of floods and other natural disasters.

0.3 SCOPE OF EXPENDITURE

(1) Terms in the field of building construction that are not defined in this technical guideline have the meaning as defined in the Construction Act, the Rules on low-voltage electrical installations in buildings and the protection of buildings against lightning or in the SIST ISO 6707-1 standard.

(2) Terms in the field of low-voltage electrical installations, which are not defined in this technical guideline, have the meaning as defined in the Rules on low-voltage electrical installations in buildings and the protection of buildings against lightning or in Slovenian standards SIST IEC 60050-195 and SIST IEC 60050-826.

0.3.1 Terms

0.3.1.1 Additional equalisation of potentials – an electrical connection between foreign conductive parts when necessary to ensure safety and which achieves equality of potentials between accessible foreign conductive parts in order to avoid electric shock.
0.3.1.2 Agreed Touch Voltage, U_L – The conventional touch voltage limit is also the maximum voltage that does not trigger a reaction or even electric shock when touched/contacted. It is determined according to the type of mains voltage (alternating or DC) and environment (normal, humid, special conditions) where the electrical installation is

	Agreed limit for contact voltage U_L in [V]		
Voltage type	The Normal Environment AD1 and AD2	Moist environment AD3 to AD6	Specific situation AD7 and AD8
Alternating (AC)	50	25	6
One-way (DC)	120	60	24

0.3.1.3 Electrical installation – electrical appliances and equipment connected to water and intended to fulfil a specific purpose, with a rated voltage of up to and including 1000 V AC and 1500 V DC respectively.
0.3.1.4 Electrical equipment – an object used for such purposes as the generation, conversion, transmission, distribution or exploitation of electricity, such as electrical machinery, transformers, distributors, measuring instruments, protective devices, wiring systems, equipment that consumes electricity.
0.3.1.5 Electrical installation system – an assembly of electrical installations supplied with electricity from one connection point (measuring point for billing measurements) and running from the main fuses at the connection point to the end connections of the electrical devices. In the case of a permanent connection of the device, the installation system runs to the terminals in the device. It applies harmonised measures to protect against electric shock, overcurrent and overheating.
0.3.1.6 Electrical distributor — Assembly of low voltage switchgear and controlgear.
0.3.1.7 A DBO (distribution board intended to be operated by an ordinary person) is a distribution board that can be used by lay people.
0.3.1.8 Electrically completed installation unit means what is included in the project of performed works (PID).

0.3.1.9 An electricity installation is a switchgear, transformer installation or installation for the generation of electricity in a space-limited location, consisting of several elements and interconnections.

0.3.1.10 An electricity plant is a complete electrical equipment for the generation, transmission, conversion, distribution and use of electricity.

0.3.1.11 Simple separation is separation by basic insulation between electrical circuits or between electrical circuit and local earth.

0.3.1.12 Photovoltaic system (hereinafter referred to as PV) is an electrical device for the generation of electricity consisting of several elements (e.g. PV module, converter, electrical conductors, protective devices, electrical cabinets and the supporting structure of the system).

0.3.1.13 Flexible connection line – is intended to connect devices to the installation system and must have the same number of conductors as the line of the installation system to which it is connected.

0.3.1.14 The main equalization of potentials is the electrical connection between foreign conductive parts, which achieves the equality of potentials that could come under voltage in emergency situations in order to prevent electric shock.

0.3.1.15 An electrical energy storage device is an electrical energy storage device that, depending on the operating state (storage unit), absorbs and stores electrical energy for a certain period of time or supplies electrical energy.

0.3.1.16 Information communication installation (IKI) – a general term for electrical connections and equipment, generally of low voltage, which is intended for the transmission of data management, the transmission of audio/video signals to the connection of information technology devices, signalling, etc., and is not directly related to electrical installation.

0.3.1.17 Installation line – is a line of a single circuit starting at the protection element in the distributor and ending at the last consumer or socket.

0.3.1.18 The verifier or examiner shall be an individual with a national professional qualification or certificate of competence as defined in the Rules on requirements for low-voltage electrical installations in buildings.

0.3.1.19 Small Voltage – is the electrical voltage up to and including 50 V a.c. or 120 V d.c., in special cases the lower resistance of the human body up to and including 25 V a.c. or 60 V d.c. or up to and including 12 V a.c. or 30 V d.c., respectively.

0.3.1.20 Replacement lighting is that part of emergency lighting that allows normal activities to continue substantially unchanged.

0.3.1.21 Residual Current Controller, RCM - signals when not all power currents end up through power lines.

0.3.1.22 In-line voltage is the voltage that occurs between two in-line conductors at a given point in the electrical circuit (formerly also phase-to-phase voltage).

0.3.1.23 An electricity generating installation (production installation) is designed to generate electricity by converting primary energy. It may consist of several generator units and shall include all associated ancillary installations, equipment and production units.

0.3.1.24 AFDD fault arc detection device – a protective device that detects fault arcs in an electrical installation and, in the case of a detected arc, warns or causes disconnection of the shielded end circuit. This protective device usually consists of a fault arc detector (AFD) and a defeat device.

0.3.1.25 The rated value (voltages, … current) is the value indicated by the manufacturer on the installation or in the installation associated instructions.

0.3.1.26 Low Voltage - Electrical voltage up to and including 1000 V AC and up to and including 1500 V DC.

0.3.1.27 NN network – low-voltage network of nominal voltage up to and including 1000 V alternating or 1500 V DC, to which the low-voltage electrical installation system is connected.

0.3.1.28 Normal recharging point means a recharging point that allows for the transfer of electricity to an electric vehicle with a power less than or equal to 22 kW, excluding devices with a power less than or equal to 3,7 kW that are installed in private households or whose primary purpose is not recharging electric vehicles and that are not accessible to the public.

0.3.1.29 Operating grounding is the functional and protective grounding of a point or points in the power system.

0.3.1.30 Compatibility assessment is an examination of the conformity of the implemented connections to the electrical installation of a building with regard to project solutions or project starting points.

0.3.1.31 Equipment with Class II electric shock protection and marked with the symbol  , double insulation comprising:
equipment with basic insulation as a basic protection process and supplementary insulation as a fault protection process, or equipment,
- in which basic protection and protection in the event of failure are provided by reinforced insulation.

0.3.1.32 The basic power supply is the supply of a low-voltage electrical installation from a network or other sources that ensures its intended operation.

0.3.1.33 Charging point means the interface through which one electric vehicle can be charged or the battery of one electric vehicle can be replaced.

0.3.1.34 High power recharging point means a recharging point that allows the transfer of electricity to an electric vehicle with a power greater than 22 kW.

0.3.1.35 Residual current – the algebraic sum of the values of electrical currents in live conductors at the same time at a given point of the electrical circuit in an electrical installation, previously differential current.

0.3.1.36 Verification is a procedure with visual inspection, testing and measurements, by which we determine the fulfilment of the conditions and requirements for each individual case, which are laid down in the applicable technical regulations, standards, technical guidelines and instructions of manufacturers.

0.3.1.37 Connection – is the assembly of high-voltage, medium-voltage or low-voltage power lines and devices required to connect the user to the network and specified by the distribution operator in the connection consent.

0.3.1.38 The first check is the verification of newly implemented low-voltage electrical installations.

0.3.1.39 Distributor – the term Low Voltage Switchgear and Controller Assembly (LV Switchgear) is also used

0.3.1.40 Regular checks on existing low-voltage electrical installations are checks within the deadlines required by regulations.

0.3.1.41 Earth leakage relay, ELR – a life-saving protective device developed to detect leakage currents flowing into the earth. These leakage currents are caused by insulation failures, accidental contact or environmental degradation and are usually measured on power cables. They are usually contained in a package or separate assembly of a leakage current transformer, a leakage current monitor – usually with the option of setting a residual current threshold of $I_{\Delta N}$ and a disconnection time – and a controlled circuit breaker. Characteristics are handled and checked in the same way as for RCDs and requirements are covered by SIST EN IEC 60947-2.

0.3.1.42 IT system – this system separates the protective and operational grounding; operating earthing should be carried out over high resistance, so that only a small current flows at the first failure, which only detects and warns about the failure. The system shall be galvanically separated from the NN network if it is connected to the NN network and shall function as a TN or TT system at the first fault.

0.3.1.43 TN system – this system combines operational and protective grounding. According to the method of implementation of the protective and neutral conductor, the system is divided into three subsystems:

0.3.1.44 TN-S system in which the neutral (N) and protective (PE) conductors are separated.

0.3.1.45 TN-C system in which a neutral (N) and a protective (PE) conductor are combined in a neutral conductor with a protective function (PEN).

0.3.1.46 The TN-C-S. system, where, from the power supply side, the protective (PE) and neutral (N) conductor functions are combined, is first combined into one (PEN) conductor in part of the installation.

0.3.1.47 TT system – in this system, the protective grounding and the operational grounding are separated.

0.3.1.48 General or normal lighting is usually used lighting that is powered from a basic source.
0.3.1.49 Grounding ground is a conductive part (grounding system) buried in the ground under the foundation of the building or, better, built into the concrete foundation of the building, usually in the form of a closed loop (ring).
0.3.1.50 Circuit – is a line or a set of lines bound to the same protection element in a manifold.
0.3.1.51 Foreign conductive parts – are those conductive parts which may come under voltage upon failure of the insulation.
0.3.1.52 Leakage current – electric current following an unwanted conductive path under normal operating conditions.
0.3.1.53 Appropriate measure, test or performance – is a case-by-case measure that ensures that the conditions and requirements set out in the applicable technical regulations, standards, technical guidelines and manufacturers' instructions are met.
0.3.1.54 Safety lighting is lighting that, in the event of a failure of general lighting, allows users to see the exit signs, the direction of the escape routes and the escape route.
0.3.1.55 Safety system – in a system of electrical installations are those devices and wiring that must function in the event of an emergency (fire, burglary, presence of gas, etc.).
0.3.1.56 Maintenance checks – visual checks which may be carried out by another qualified person during the period between periodic checks under other legislation.
0.3.1.57 Emergency lighting is intended for use when the power supply of normal lighting fails.
0.3.1.58 Protective grounding is the grounding of a point or points in a system or in a low-voltage electrical installation or equipment intended for electrical safety.
0.3.1.59 Residual current protection device, RCD (formerly also FID) – (formerly also a differential switch or differential protection) is a device that causes disconnection when not all power currents end up through power supply lines.
0.3.1.60 A combined earthing is a earthing where operational and protective earthing are connected.
0.3.1.61 The characteristic of the supply voltage – defined in the SIST EN 50160 standard – relates to the frequency, size and shape of the wave and the symmetry of the three-phase voltage system.

1 PURPOSE AND SCOPE

(1) In order to ensure the safety of low-voltage electrical installations, their quality and their compatibility with the electricity system (if any), this technical guideline specifies:

1. characteristics and characteristics of low-voltage electrical installations, devices and equipment for carrying out electrical installations,
2. conditions and requirements for the implementation and use of low voltage electrical installations,
3. marking and marking of appliances, equipment and electrical installations which, when used, have an impact on the safety of human life and health,
4. protective technical measures for the use of electrical installations; and
5. the procedure for verifying the adequacy of electrical installations.

(2) In addition to the restrictions set out in the Regulation, this Technical Guideline does not apply to:

1. electrical installations in mines,
2. electric traction,
3. ships and other vessels,
4. aeroplanes,
5. road vehicles, caravans and motorhomes,
6. lightning protection systems,
7. lighting of streets and other public areas that are part of the low-voltage distribution network,
8. buildings and premises for the production and storage of explosives,
9. electric fences,
10. electrical equipment of machinery from the terminals onwards, except for machinery that ensures the operation of the building and is an extension of electrical installations complying with the requirements of the SIST EN 60204-1 standard,
11. other electrical equipment from the terminals onwards,
12. certain types of lift installations.

(3) This technical guideline applies to low-voltage electrical installations of the entire building or of each complete electrical installation system.

(4) The provisions of this Guideline shall apply mutatis mutandis to other types of low-voltage electrical installations, such as the generation and use of electricity and other specific types of low-voltage electrical installations, subject to the limitations set out in the Regulation.

2 TYPES OF ELECTRIC INSTALLATION SYSTEMS

(1) The method of grounding the power supply part of electrical installations and the connection of the PE protective conductor form the basis for determining the type of grounding system.

(2) The following symbols shall be used in electrical installation systems:

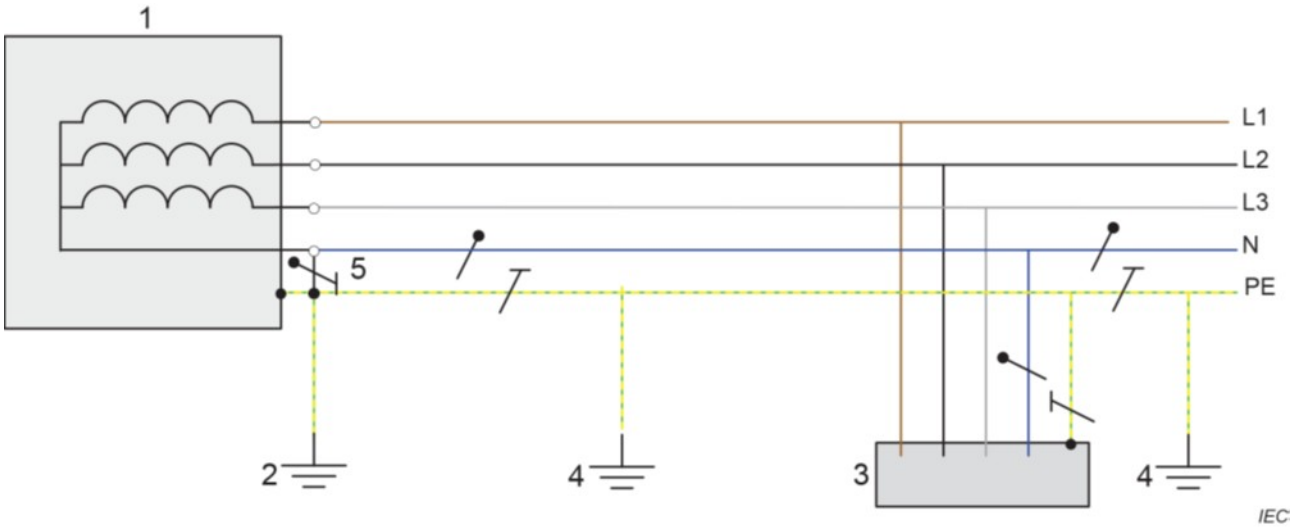
1. The first letter - indicates how the live parts of the electrical system are connected to the earth:
   a. **T** – direct connection of one live part to the earth at one point,
   b. **I** – all live conductors are insulated against the earth or one live part is connected to the earth after high impedance,
2. The second letter - indicates how exposed conductive parts are grounded:
   a. **T** — direct electrical connection of exposed conductive parts to the earth, independently of the earthing of any live part,
   b. **N** – direct connection of exposed conductive parts to the grounding point ,, where live parts are connected to the earth (in alternating systems the grounding point is normally neutral),
3. The following letters (if any) — arrangement of neutral and protective conductors:
   a. **S** – the neutral and protective functions are provided by separate conductors;
   b. **C** – Neutral and protective functions are combined in one guide (PEN).
4. **PE** – Protective Guide,
5. **N** – neutral conductor in the alternating system,
6. **SRC** – System-referencing-conductor
7. **L1, L2, L3** – alternating line conductors,
8. **M** – centre guide,
9. **L+, L-** – line conductors in DC system.

(3) Depending on the number of live conductors, electrical installation systems are divided into:

1. single phase dual-conductor AC systems (L-N or L-PEN or L1-L2),
2. three-conductor single-phase AC systems (L-N-PE),
3. three-conductor two-phase AC systems (L1-PE-L2, L1-PEN-L2),
4. two-phase four-conductor alternating systems (L1-L2-N-PE),
5. three-phase three-conductor alternating systems (L1-L2-L3),
6. four-conductor three-phase AC systems (L1-L2-L3-PE or L1-L2-L3-N or L1-L2-L3-PEN),
7. five-conductor three-phase AC systems (L1-L2-L3-N-PE),
8. two-conductor DC systems; and
9. three-conductor unidirectional systems.

(4) The types of AC power supply systems are:

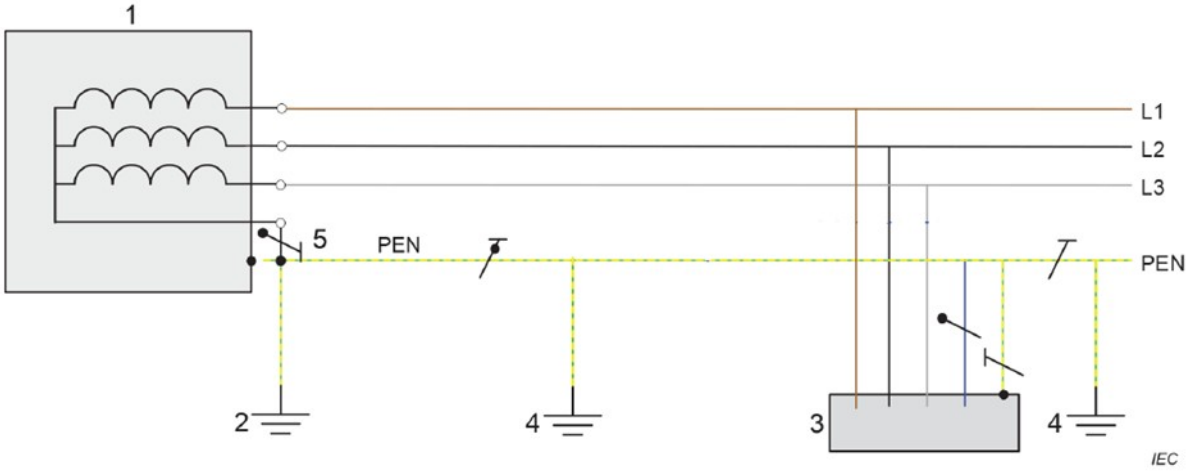
1. TN system in which one live part is directly connected to the reference conductor grounding system (SRC). Operating and protective grounding are combined. Depending on the method of implementation of the protective and neutral conductor, three subsystems are distinguished:
   - **TN-S** system in which the neutral (N) and protective (PE) conductors are separated. They must be separated whenever the cross-section of the conductors is less than 10 mm^2 Cu or 16 mm^2 Al (Figure 1).



Legend:
1 - power source
2 - ground at power source
3 - Electrical equipment with exposed conductive parts
4 - additional ground that can be installed
5 – SRC reference guide

Figure 1: TN-S system with one power source and separate neutral and protective conductor throughout the system

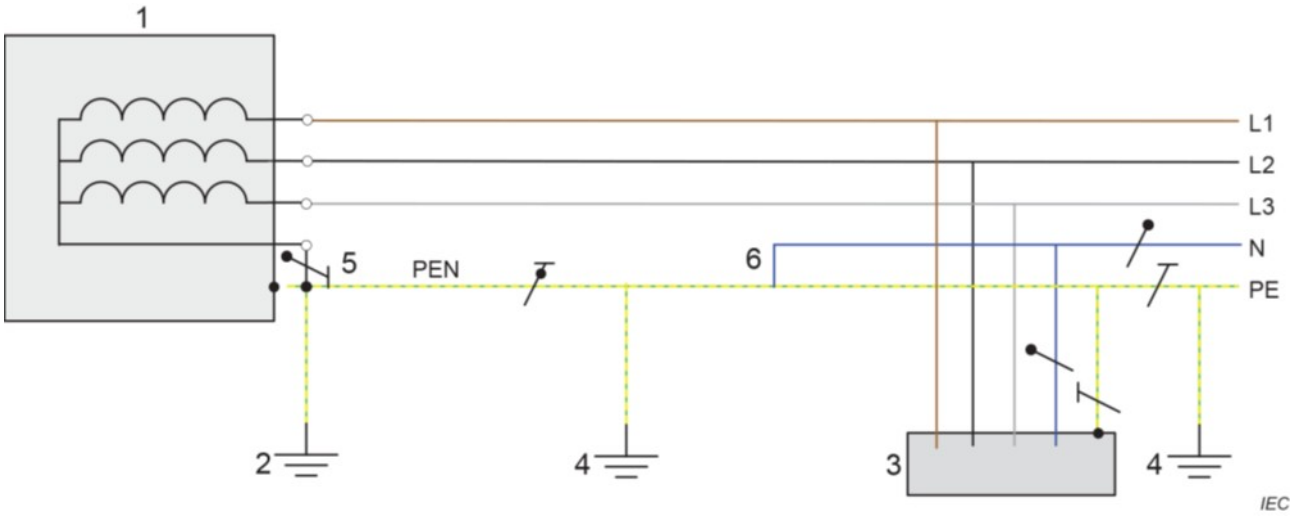
- TN-C system in which a neutral (N) and a protective (PE) conductor are combined in a neutral conductor with a protective function (PEN) when the cross-section of the conductors is equal to or greater than 10 mm^2 Cu and 16 mm^2 Al respectively (Figure 2). The PEN Guide is directly connected to the grounding system.



Legend:
1 - power source
2 - ground at power source
3 - Electrical equipment with exposed conductive parts
4 - additional ground that can be installed
5 – SRC reference guide

Figure 2: Single power supply TN-C system with combined neutral and protective conductor functions in one conductor throughout the system

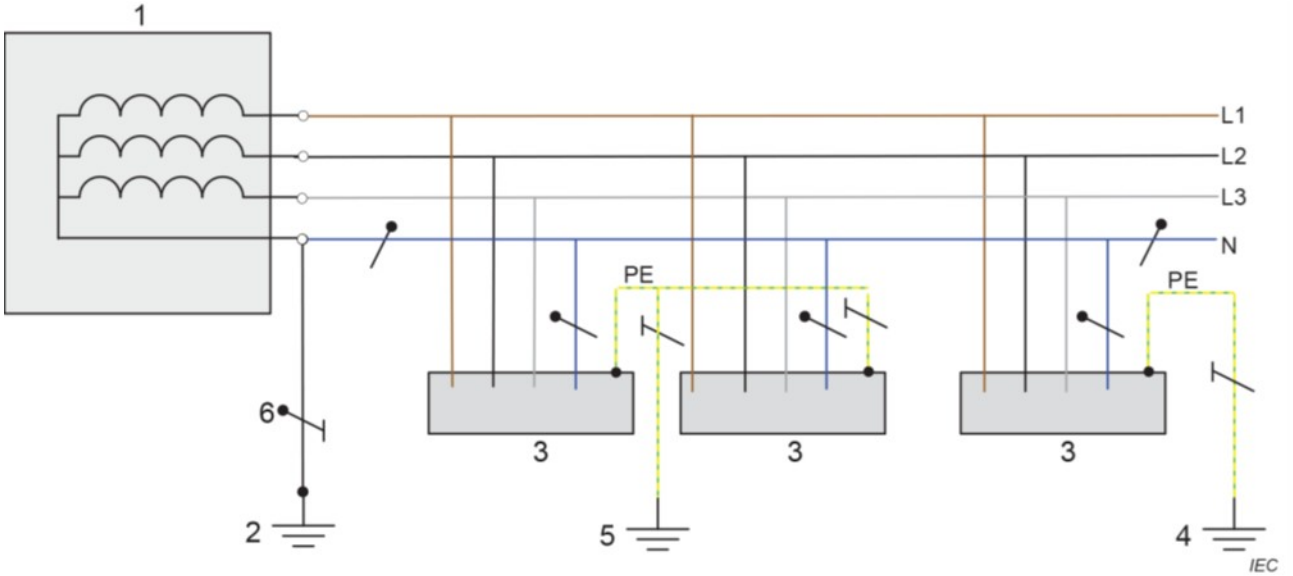
- The TN-C-S system, where, when viewed from the power supply side, the protective (PE) and neutral (N) conductor functions are combined, is first combined into one (PEN) conductor in part of the installation. After separation, they may no longer be merged (Figure 3).



Legend: 1 - power source
2 - grounding for power source grounding
3 - Electrical equipment with exposed conductive parts
4 - additional ground that can be installed
5 – SRC reference guide

Figure 3: TN-C-S system in a three-phase four-water system with one power source: the PEN conductor is separated at any installation location into a protective conductor (PE) and a neutral conductor (N)

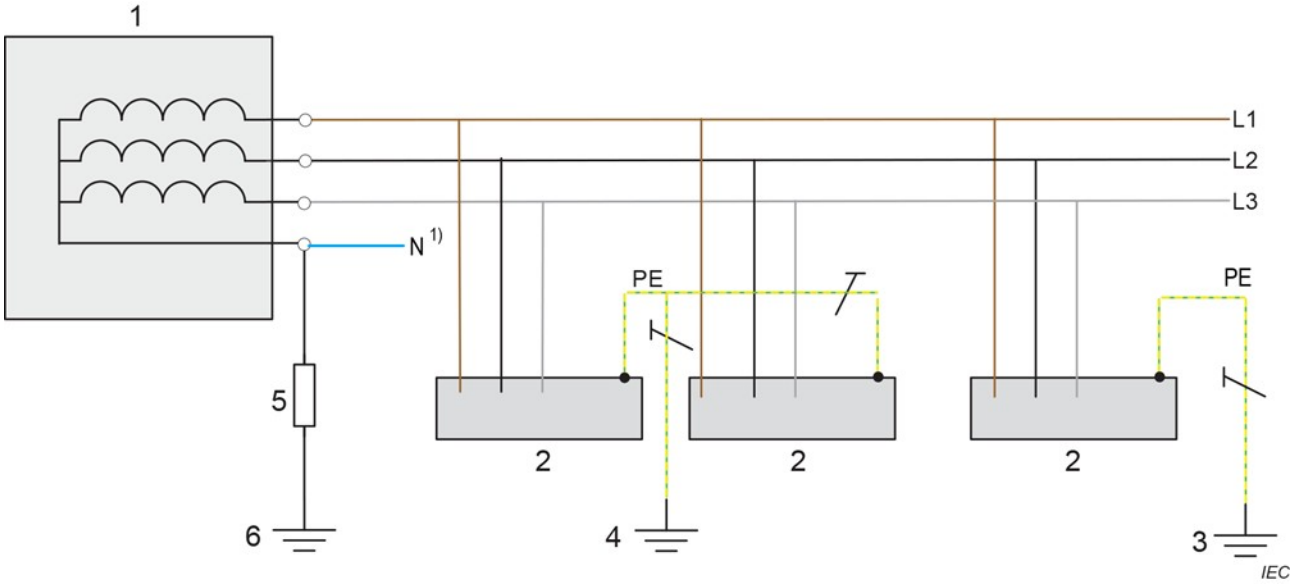
2. **TT** system in which protective and operational grounding are separated. The protective grounding must be located at the building, and for the operational grounding, the grounding in the transformer station may be used via the N-line when the low-voltage electrical installation is connected to the distribution network. If this is not sufficient or required by the distribution operator, the operational grounding must be carried out at a building separate from the protective grounding (Figure 4).



Legend: 1 - power source
2 - ground at power source
3 - Electrical equipment with exposed conductive parts
4 - individual protective grounding of exposed conductive part in the installation
5 - joint protective grounding of exposed conductive parts in the installation
6 - SRC Reference Guide

Figure 4: Single power supply TT system with separate neutral and protective conductor throughout the installation

3. The IT system shall have all live parts isolated from the earth or grounded with high impedance, which shall be high enough to generate only a small current at the first fault, which shall only detect and warn of the fault. The system shall be galvanically isolated from the NN network and shall function as a TT system in the event of another failure. There may also be a neutral conductor in the system (Figure 5).



1) Neutral conductor may be present in the installation

Legend: 1 - power source
2 - Electrical equipment with exposed conductive parts
3 - individual protective grounding of exposed conductive part in the installation
4 - total protective grounding of exposed conductive parts in the installation
5 — Grounding impedance of the system at the supply source, if any
6 — Impedance grounding at supply source

Figure 5: IT system with all exposed conductive parts interconnected by a protective conductor that is grounded collectively or individually

(5) All AC and DC systems and subsystems regarding the grounding of power supply systems are defined in the SIST HD 60364-1 standard.

3 REQUIREMENTS FOR THE PROJECTION AND IMPLEMENTATION OF NON-EXTRACTIVE ELECTRIC INSTALLATIONS

3.1 GENERAL

(1) In order to design the electrical installation system economically and reliably, a maximum peak power must be determined, taking into account the simultaneity factor with the installed power.

(2) When designing the system and selecting elements of electrical installations, the following external environmental influences must also be taken into account in accordance with SIST HD 60364-1 or SIST HD 60364-5-51:

1. ambient temperature AA,
2. atmospheric humidity AB,
3. elevation AC,
4. presence of AD water,
5. presence of foreign AE solids,
6. presence of corrosive or polluting AF substances,

7. mechanical loads - impacts AG,
8. mechanical loads - vibrations AH,
9. presence of AK flora,
10. presence of AL fauna,
11. electromagnetic, electrostatic or ionization effects of AM,
12. solar radiation from AN,
13. seismic effects of AP,
14. the effects of AQ lightning,
15. air movement AR and wind AS,
16. the ability of persons to handle the BA installation system,
17. electrical resistance of the human body BB,
18. touch of a person with the terrestrial potential of BC,
19. possibility of evacuation in an emergency BD,
20. the nature and composition of the material to be processed or stored by BE; and
21. the construction features of the building (CA construction materials and CB building design) in which the electrical installation system is located.

(3) Each installation shall be divided into several circuits in order to limit the harmful effects in the event of failure, to facilitate checks, testing and maintenance, and to deal with hazards which may arise in the event of failure of one of the circuits, such as the lighting circuit. Special circuits must be provided for parts of installations which are separately controlled so that they are not endangered by failures or failures of other circuits.

(4) In each installation, appropriate measures shall be taken to ensure that the characteristics of their equipment which cause transient overvoltages, rapid load variations, engine starting currents, higher harmonic currents, DC components, high-frequency oscillations, current leakages, the need for additional ground connection, etc., do not cause interference or adverse effects to the other installation or other electrical equipment.

(5) Between electrical and other installations (water, sewage, gas, heating/cooling, information communication installations (safety installations, telephony, information installations, etc. …) the spacing must be in accordance with the applicable regulations for individual specific installations, or at least such that the maintenance of one installation does not endanger the other.

(6) The electrical installation system shall not be situated under other installations on which liquid may accumulate (condensation), unless additional protective and safety measures are applied to avoid negative environmental impact.

(7) The permitted voltage drop from the supply point on the low voltage public network to any point of electrical installation shall be 3 % for lighting circuits and 5 % for other consumer circuits. If the low-voltage electrical installation is supplied from a transformer station connected to the SN network, the allowed voltage drop from the supply point to any installation point shall be 5 % for lighting circuits and 8 % for circuits of other consumers. For waters in electrical installations of more than 100 m in length, the permissible voltage drop may be increased by 0,005 % for each metre above 100 m in length, but by not more than 0,5 %.

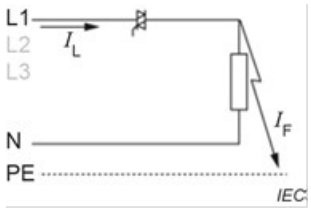
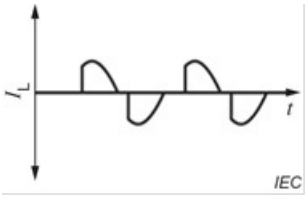
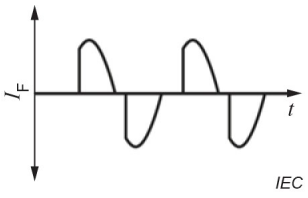
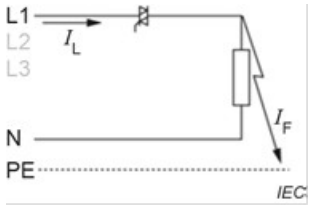
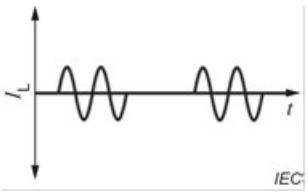
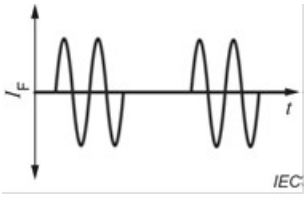
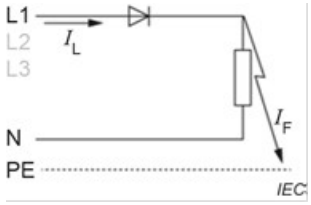
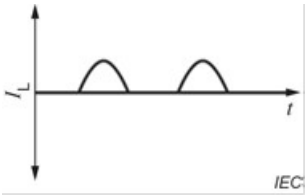
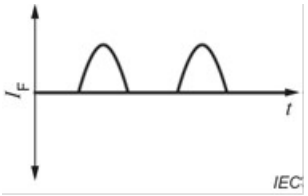
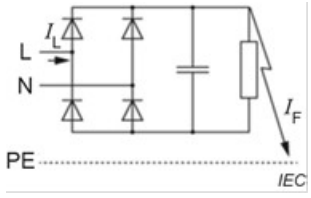
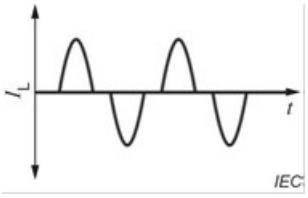
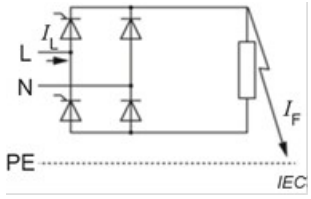
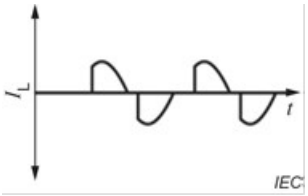
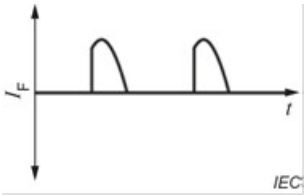
(8) For each low-voltage electrical installation, the frequency and extent of maintenance required must be assessed, taking into account the prescribed periodic inspections, tests, maintenance and repairs that are assumed to be necessary during the intended lifetime of the installation, the effectiveness of the safety precautions during that period and the reliability of the equipment to achieve proper operation within the intended period.

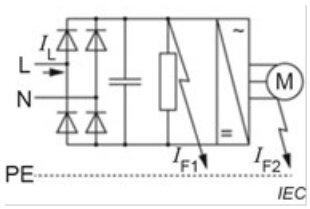
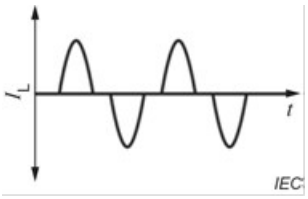
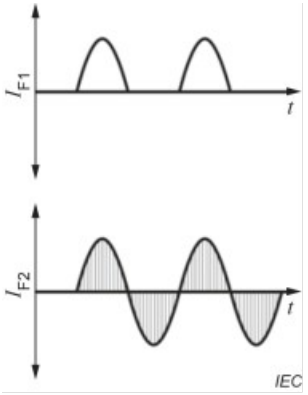
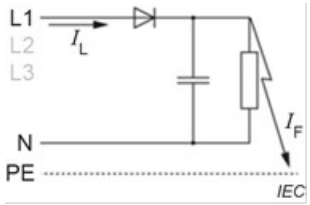
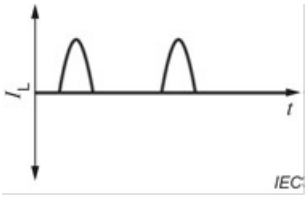
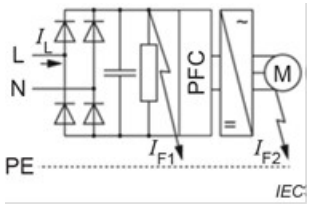
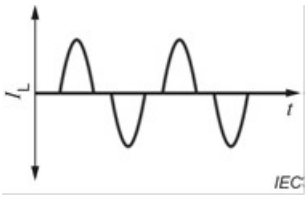
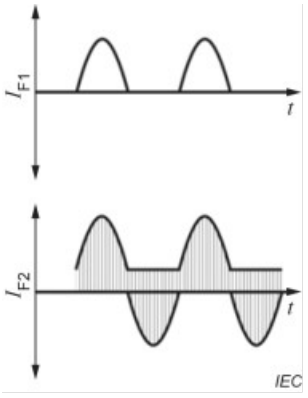
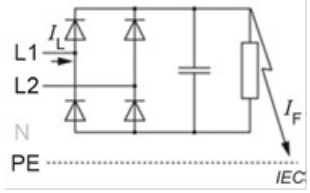
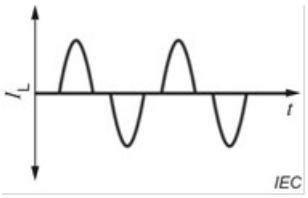
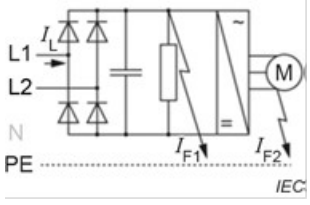
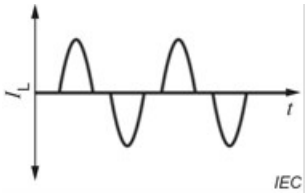
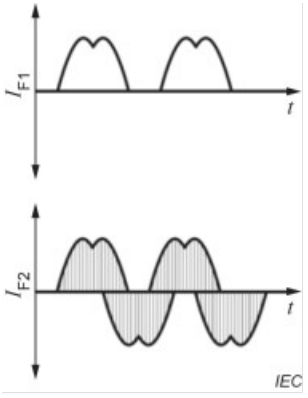
(9) The design of the electrical installation shall take into account the conditions as provided by the distribution system operator. Among the conditions, there is also a grounding system, with which the distributor ensures the safe operation of low-voltage installation even in the case of short circuits on the high-voltage side of the power supply system. The dangerous voltage that can occur on the low-voltage side in this case is the subject of the distributor and cannot be influenced by the low-voltage part of the electrical installation project, nor can the inspector assess the impact on the verification result.

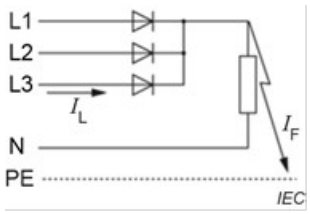
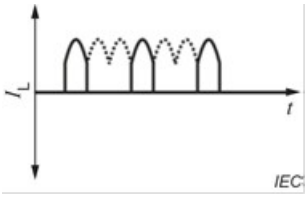
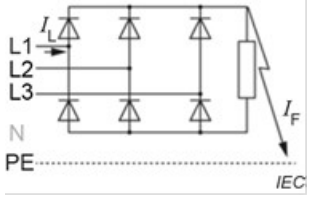
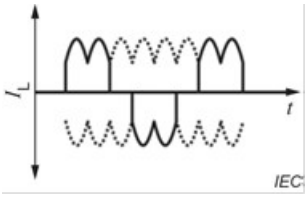
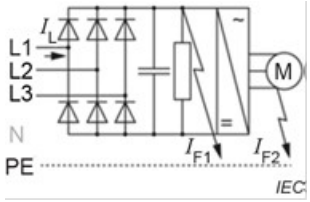
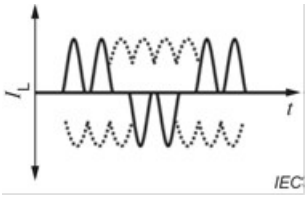
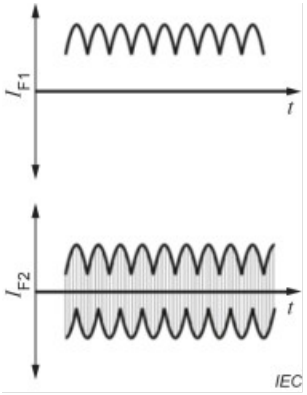
(10) In a low-voltage electrical installation to which electricity generation and storage facilities are connected, the determination and dimensioning of protection against electric shock and overload of conductors must take into account the changed electricity flows, the different operating conditions in which the installation operates and, in particular, the failures that may occur.

(11) When installing an RCD, it is necessary to choose the right type that will activate depending on the possible fault current. It is recommended to install at least RCD A, because in many cases devices containing rectifiers are usually connected. RCD AC can only be used where passive loads are connected, e.g. motors, transformers, resistance loads (heaters). This is the case when the voltage design is as defined in the SIST EN 50160 standard.

Table 1: Examples of potential fault currents in systems with semiconductor devices and the type of RCD to be used in each such case (source: SIST HD 60364-5-53)

Type of RCD	**Circuit**	**Bremen current I_L**	**Impairment current I_F**
AC,A,B,F	Phase regulation 		
AC,A,B,F	Package regulation 		
A,B,F	Single phase rectifier 		
A,B,F	Rectifier bridge 		
A,B,F	Rectifier bridge with half regulation 		

Type of RCD	Circuit	Bremen current I_L	Impairment current I_F
B,F	Frequency converter with full rectifier bridge 		
B	Single phase rectifier with smoothing 		
B	Frequency converter with full rectifier bridge and PFC 		
B	Interphase rectifier bridge 		
B	Frequency converter with full rectifier bridge interphase 		

Type of RCD	Circuit	Bremen current I_L	Impairment current I_F
B	Three-phase half-wave guidance 		
B	Six-phase rectifying bridge 		
B	Frequency converter with six-phase rectifier bridge 		

3.2 VODI

3.2.1 Protection of ducts

(1) Insulated conductors and cables must be protected against mechanical, thermal, chemical and other external influences specified in the SIST HD 60364-5-51 standard.

(2) Couplings between conductors and connections between conductors and other equipment shall ensure continuous electrical conductivity, adequate mechanical strength and protection of at least IP 2X or IP XXB.

(3) The system of electrical installations near the heating system must be protected by thermal insulation or by screens.

(4) Insulated conductors and cables may only be connected in installation doses of electrical installation, cable couplings or electrical dividers. In the case of joints, the conductors shall not be subjected to tensile or bending forces.

(5) The guides of the installation stack must be permanently sealed at the exits and entrances to/or from the walls, and additional mechanical protection (forehead, pipe) is required at the passages, the edges of which must be rounded.

3.2.2 Method of installation/laying of ducts

(1) As a rule, the electrical installation should not be in the same channel with other installations. If it is in the same duct, it shall be protected against electric shock by automatic disconnection of the power supply or by the use of class II insulation (double insulation) and by adequate protection against the effects of other installations.

(2) The low-voltage installation system shall not be placed in the same mantle or pipe nor near a higher voltage installation system, unless there is an insulating barrier in between which the test voltage of the higher voltage system can be withstood.

(3) Only the conductors of one circuit, as well as the control and auxiliary circuits for the corresponding circuit, may be in one installation pipe or duct or in one cable sheath of a multi-core cable.

(4) Guides in electrical installations in the sub-metal and surface versions must be installed parallel to the edges of the room (horizontal or vertical); horizontally: 30 cm to 110 cm from the floor and 200 cm from the floor to the ceiling, and vertically at least 15 cm from the edges of windows and doors.

(5) Cables can be laid above ground, freely tensioned or fixed (bearing hooks, clamps) or laid on cable shelves. When vertical laying, they must be relieved of their own masses. The tensile load shall not exceed 60 N/mm2 of the overall cross-section for copper or 30 N/mm2 of the overall cross-section for aluminium.

(6) Cables may be mounted on walls provided that they are insulated from thermoplastic materials with a filler and jacket, provided that they are mounted on clamps and provided that they are additionally protected from the ground up to a height of 2 m.

(7) Cables placed directly in the plaster or wall must be covered throughout with plaster at least 4 mm thick.

(8) Cables in openings at points of passage through the boundary structural elements of the fire sector shall be lined with non-combustible material which seals the openings and has the same fire resistance as the boundary structural elements.

(9) Cables may be buried in the ground if they have a suitable sheath to protect against mechanical and other influences. The laying depth must be at least 0,6 m or at least 0,8 m if they are laid under pressure or under the conditions of infrastructure managers. The depth may be reduced, but only in the case of additional protective measures against mechanical stresses and other influences.

(10) Information and communication installations must be kept separate from electrical installations. The minimum distance without partitions is 200 mm, in a closed steel parapet with a wall thickness of 1.5 mm, the distance can be 0 mm. More detailed requirements are given in the SIST IEC 60364-4-44/A2 standard. If a different distance is required for safety reasons, the greater shall be taken into account.

3.2.3 Dimensioning of conductors

(1) In order to ensure the necessary durability of insulated conductors and cables in electrical installation systems, the SIST HD 60364-5-52 standard should be taken into account when sizing them, with an emphasis on taking into account the exposure of insulation to the thermal effects of the permanently allowed current and external influences during operation.

(2) When sizing the conductors and cables, it should be borne in mind that the maximum ambient temperature for:

1.	insulated conductors and cables in the air, regardless of the method of laying	30 °C,
2.	cables buried in the ground or laid in pipes underground	20 °C.

(3) When sizing conductors and cables, it should be borne in mind that the maximum permissible temperatures to which each type of insulation may be heated are:

1.	Polyvinyl chloride (PVC)	70 °C on the conductor,
2.	Networked polyethylene (XLPE) or ethylene propylene rubber (EPR)	90 °C on the conductor,
3.	Mineral (with or without PVC, accessible for touch)	70 °C on the coat,
4.	Mineral (uncovered and inaccessible to touch and not in contact with flammable material)	105 °C in isolation.

(4) Depending on the method of laying, the number of veins in the conductors and cables and for groups with more than one circuit or for more than one wire, appropriate correction factors should be taken into account when sizing them.

(5) The cross-section of the neutral conductor shall be equal to that of the line conductor in installations with copper conductors of a cross-section not exceeding 16 mm2 and in installations with aluminium conductors of a cross-section not exceeding 25 mm2. The cross-section of the neutral conductor on which higher harmonic currents flow is determined according to the SIST HD standard 60364-5-52.

(6) The cross-section of conductors in permanent electrical installations shall not be less than 1,5 mm2 if copper or 2,5 mm2 if aluminium (this shall not apply to conductors in manifolds).

(7) A minimum conductor cross-section of 0,5 mm2 is permitted for control and signal circuits. A minimum conductor cross-section of 0.1 mm2 is permitted in control and signal circuits intended for electronic equipment.

(8) Detailed requirements for minimum conductor cross-sections are described in the SIST HD 60364-5-52 standard.

(9) The minimum cross-section of the protective conductor shall be consistent with the impedance of the fault loop and shall:

1. when performing protection with automatic disconnection of the power supply in the event of a failure, the time of which does not exceed 5 s, correspond to the root mean square of the earth contact current or to the root mean square of the earth contact current in the event of the occurrence of the first failure in the IT system passing through the protective device, if the impedance is negligible,
2. correspond to the operating time of the protective device, taking into account current limitations with electrical circuit impedances and the possibility of limitation (joule integral) of the protective device,
3. correspond to the metal type of the protective conductor, insulation and other parts, as well as the initial and final temperatures, taking into account the maximum permissible contact temperature.

(10) The ground line must comply with the same conditions as the protective conductor, but if it is dug in, it must be:

1. insulated, mechanically unprotected line having a cross-section of 16 mm^2 Cu or Fe,
2. non-insulated line with a cross-section of 25 mm^2 Cu, or 50 mm^2 Fe - hot dip galvanized,
3. strip with a cross-section of 100 mm^2 Fe - a minimum thickness of 3 mm - hot galvanized.

(11) For ground waters, conductors equivalent to those referred to in the preceding paragraph may also be used.

(12) More detailed requirements for the implementation of grounding are described in the standard SIST HD 60364-5-54.

(13) Connections of grounding lines and grounding devices must be implemented with standardised coupling elements in accordance with Technical Guideline TSG-N-003 Lightning protection.

(14) The dimensioning of conductors and cables should take into account overloads and fault conditions in cases that may occur when electricity generation and storage facilities are connected to the low-voltage installation.

3.3 INSTITUTIONAL AND PROTECTIVE DEVICES

3.3.1 Switchgear

(1) Switching devices shall not interrupt the protective conductor.

(2) In the case of multipole switchgear, the in-line conductor contacts shall be mechanically stacked or separated simultaneously. The same shall apply to a neutral conductor, in which case the neutral conductor shall not be interrupted when the line lines are closed.

(3) A single pole switchgear in a multiphase circuit shall not be incorporated into a neutral conductor unless there is a residual current protection device on the supply side which automatically disconnects all supply lines in the event of failure.

3.3.2 Protective devices

(1) In the TN system, the overcurrent protective device intended to protect against electric shock by automatic disconnection of the power supply shall be connected at the beginning of each circuit and at positions where the cross-section of the conductor is reduced, unless the required protection is already provided by a short-circuit protective device placed in front of that position.

(2) The residual current protection device used for protection against indirect contact shall ensure that all power lines are switched off.

(3) In the TN-S system, the neutral conductor need not be interrupted, except in electrical installations in explosion-threatening environments, where the neutral conductor must also be separated.

(4) The protective conductor shall not pass through the magnetic circuit of the protective device to the residual current.

(5) The residual current protection device for protection against indirect contact shall not act on the residual current occurring during normal operation.

(6) A protective device on residual current in a circuit without a protective conductor is not considered sufficient protection in the event of failure.

(7) If one protective device per residual current is used for protection in the TT system, it shall be positioned at the installation supply point. If there are more than one power supply point, it shall be located at each power supply point.

(8) For type D fuse bases in overcurrent protection devices, the centre contact shall be connected to the supply side.

(9) In the case of type B fuse holders, it must be excluded that the holder of the fuse holder will cause contact between the conductive parts of adjacent fuse holders.

(10) Circuit breakers shall display an indication of the setting value of the overcurrent actuator.

(11) When a multi-phase or DC circuit is shielded by (installation) circuit breakers, the protective device shall disconnect all line conductors in the event of failure or overload in a single line conductor of the circuit.

(12) In electrical installation systems, the selectivity of the protection must be ensured by an appropriate selection of protective devices.

(13) The current limiter (tariff circuit breaker) can be used as a tariff current limiter in electrical installation systems. However, if the device combines electric shock and overcurrent protection functions, it may only be used when there is a document of compliance with the regulations and standards for electric shock and overcurrent protection devices and if it also meets the conditions regarding overload and short-circuit discharge performance at the installation site.

(14) If a residual current protective device is incorporated into, or combined with, an overcurrent protective device, the characteristics of such a protective device shall, in addition to the conditions of rated current, also meet the conditions of overload and short-circuit breaking capacity.

(15) If the residual current protective device is not incorporated in the overcurrent protection, it shall withstand thermal and mechanical loads in short contact on the load side without damage.

(16) The residual current protection device can also be used as the main switch. The installation circuit breaker can be used as a switch.

(17) A separator that cannot break the load current must be protected against unauthorized opening by locking, or installation in a special room.

3.3.3 Switching and protection devices of reactive energy compensation devices

(1) Reactive energy compensation devices must use switchgear specially designed for this purpose and must ensure that no re-ignition of the arc at the contacts of the switchgear resulting in high overvoltages can occur during their operation or handling. If the contacts move when opening and closing manually, it should be possible to handle the switch as quickly as possible.

(2) The switching and protective devices and couplings of reactive energy compensation devices shall be so designed as to be capable of continuously conducting a current 1,3 times the current obtained by the sinusoidal voltage of an effective value equal to the rated voltage of the rated frequency.

(3) In the case of couplings, protection devices and couplings of reactive energy compensation devices, account shall be taken of the fact that higher harmonic components, if any, have a greater thermal effect than the equivalent basic component due to the "skin effect".

(4) In the case of switching devices, protective devices and reactive energy compensation device couplings with capacitors, account shall also be taken of transients with high amplitude and frequency current generated when the capacitor group is switched on in parallel with other live groups.

3.4 DEVELOPMENTS FOR EXCLUSION AND FEEDING

3.4.1 General

(1) According to the fire study for demanding buildings, the designer of electrical installations must provide, in an accessible place, a device for switching off electrical installations in emergency situations.

(2) Devices for shutting off the electrical installation must be placed in the main supply circuit.

(3) If a switch is used to switch off, it shall be capable of interrupting the current of all or part of the electrical installation; the execution must prevent unintentional shutdown.

(4) The design of the switch and the method of its installation must prevent unwarranted switching off.

3.4.2 Off-setting devices

(1) Power-driven control circuit may be switched off only if additional locking protection is used before uncontrolled disconnection.

(2) The emergency shutdown shall be carried out by means of one switchgear or the disconnection shall be initiated by means of a single operation.

(3) The emergency shutdown shall be carried out by means of a switch in the main circuit or by means of a control switch in the control or auxiliary circuit.

(4) Circuit disconnection and emergency stop must be provided for in electrical installations, such as flammable liquid pumps, data centre ventilation systems, high-voltage luminous pipes and all

other electrical installations in which there may be a risk to the start-up and operation of installations and equipment.

(5) The emergency/emergency shut-off device shall be capable of withstanding the interruption of the full load current, including any currents of rotated engines.

(6) The elements (push button, lever) used for emergency/emergency shut-off shall be red and the front panel yellow. They shall be easily accessible, latched and visibly marked with an O or STOP. The release of the shut-off element shall not reactivate the electrical installation.

(7) Protection by separation, switching off and functional switching on and off of hazard-removing circuits originating from electrical installation or equipment must be provided by non-automatic local or remote separation.

(8) Protection by separating, switching off and functional switching on and off of de-hazard circuits shall take into account:

1. The PE-guide shall not be separated or interrupted in any installation system;
2. The PEN-guide shall not be separated or interrupted in the TN-C system;
3. In TN-S and TN-C-S systems, there is no need to separate or break the neutral conductor N.

3.4.3 Control devices

(1) Functional control devices shall meet the most severe environmental conditions. A switch, semiconductor device, circuit breaker, contactor, relay and socket up to 16 A may be used. Separator, fuse and bridging connector shall not be used.

(2) Functional control devices which provide for the replacement of the power supply by a replacement shall act on all live conductors and shall not bind the sources in parallel.

(3) Replacing the direction of rotation of electric motors, for any reason, must be carried out exclusively with control devices, when required by the working process.

(4) A single-pole switchgear for functional control shall not be placed in a neutral conductor.

(5) A device for protection against voltage reduction and voltage failure must be fitted when the reduction, loss or restoration of voltage is likely to cause danger to persons or equipment.

(6) The device for protection against voltage depression and failure shall be allowed to operate with delay if the protected apparatus withstands short-term interruption or reduced voltage. If contactors are used, the delay shall not prevent immediate disconnection by the steering or protective device.

(7) The undervoltage protection device shall be installed in power supply circuits for engines where restarting after a shutdown due to the operation of the protection may be dangerous.

(8) All circuits must be capable of being separated from all live conductors. PE conductors in all installation systems and PEN conductors in TN systems shall not be separated.

(9) The control circuits of the engines must be so arranged that the engines cannot be brought into operation unattended. If safety depends on the direction of rotation of the engine, failure or change of phase shall prevent the engine from running in the wrong direction. In electrical installations of reciprocating engines, rotation in the opposite direction shall be prevented after the end of braking.

3.5 SECURITY SYSTEMS

Safety system - in the system of electrical installations are those devices and wiring that must work in the event of the occurrence of emergencies (fire, burglary, the presence of gas, etc.).

3.5.1 General

(1) Safety system circuits shall be separated from other circuits by non-combustible insulating materials, by wiring elsewhere or by casing in such a way that an electrical failure or any intervention or change in one system will not affect the faultless operation of the other system.

(2) Safety systems shall be protected against electric shock.

(3) The switchgear of safety systems must be different from the switchgear of general installations and must be located in a room accessible only to authorised professionals.

3.5.2 Power supply

(1) Safety systems required to operate in the event of an emergency, in particular in the event of a fire, must be supplied with electricity for a specified period of time and the equipment must be so designed or arranged as to be fire-resistant for a specified period of time.

(2) As power sources in safety systems, in the event of a power failure, accumulators, primary cells and batteries, generator generator sets independent of normal power supply, and special power lines that are completely independent of normal power supply can be used.

(3) In the event of a power failure, the power management of the safety system shall be either manual when the source is activated by the operator or automatic, independent of the operator. Depending on the start of operation after the mains voltage failure, the automatic power mode is divided into:

1. uninterruptible automatic back-up power supply that provides a permanent power supply under specified conditions even during a transitional period of network voltage outage, e.g. voltage and frequency fluctuations;
2. an automatic power supply with very short interruption, which shall be established within 0,15 seconds;
3. an automatic power supply with a short interruption, which shall be established within 0,5 second;
4. an automatic power supply with a medium-long interruption, which shall be established within 15 seconds.

This content is discussed in more detail in the SIST HD 60364-1 standard.

(4) If there is only one power source for the safety system, it shall not be used for any other purpose.

(5) Where safety and other systems are supplied from parallel sources, measures shall be taken to limit the flow between neutral points of these sources. However, short-circuit protection and protection against electric shock must be provided regardless of the source from which the installation is powered. It is further defined in the SIST HD 60364-444 standard.

(6) The power supplies of safety systems shall be so located and secured that they cannot be damaged by failures that may occur in the main power supplies.

3.6 DESIGNATION AND LABELLING OF ELECTRICAL EQUIPMENT, GUIDELINES AND CABLE

3.6.1 General

(1) Electrical equipment (including conductors and cables) must be installed in such a way that it is easily checked and maintained and its connections are easily accessible.

(2) Sign-plates and other identification markings must be affixed to the switchgear.

(3) Guides and cables must be laid and marked in such a way that they can be easily identified when tested, repaired or replaced.

(4) The protective conductor (PE) shall be colour-coded with yellow-green, the protective neutral conductor (PEN) shall be colour-coded with yellow-green throughout its length and with blue markings on the connectors, and the neutral conductor shall be colour-coded with blue. These coloured markings may not be used for other markings.

(5) The protective device shall be positioned in the distributor and marked in such a way that its associated circuit is readily recognisable.
(6) Separators shall be marked in such a way that it is unequivocally identifiable which circuit is

separating.

3.6.2 Inscription plates on dividers

(1) On the outside of the distributor there must be a plate with the name of the manufacturer, a type designation or identification number, an indication of the system used (TT, TN, IT...). Labels must comply with the provisions of the SIST EN IEC 61439-1 and SIST EN IEC 61439-2 standards.

(2) The nameplates must be positioned in such a way that they are visible and legible even after installation and throughout the use of the divider,

(3) In the electrical divider, the nameplate or the documentation of the divider or the electrical or other scheme contained therein shall indicate:

1. voltage type (and frequency in case of AC voltage),
2. rated operating voltage,
3. rated insulation voltage,
4. rated voltage of auxiliary circuits,
5. operating limits
6. rated current,
7. rated current of each circuit,
8. short-circuit strength,
9. level of protection (IP code),
10. measures to protect against electric shock,
11. operating conditions for indoor and outdoor installation or for specific use if different from normal operating conditions,
12. the earthing system for which the divider is intended,
13. dimensions (mainly height, width and depth),
14. mass.

(4) Labels or nameplates in electrical distributors must be permanently marked and permanently affixed and must comply with the technical data contained in the documentation and the operating and maintenance instructions. The markings shall make it possible to identify the individual circuits and their protective devices within the distributor.

(5) If individual devices are marked in the manifold, the markings shall be identical to the markings in the operating schemes. In manifolds, protective switchgear or all elements thereof shall be clearly marked according to the purpose and the circuit to which they belong. Distributors should have additional markings for specific types of power supply purposes.

(6) Before issuing the declaration of conformity for the distributor and at the latest before putting it into service, the assembly markings, documentation, identification of devices and components provided by its manufacturer for the distributor must be checked.

4 PROTECTION BEFORE ELECTRICAL ADMINISTRATION

4.1 GENERAL

(1) The basic rule of protection against electric shock according to SIST EN 61140 is that dangerous live parts must not be accessible and that accessible conductive parts must not become dangerous live parts either under normal conditions or in the event of failure.

(2) The protection against electric shock must include:

1. an appropriate combination of a basic protection measure and an independent failure protection measure; or
2. an enhanced protection measure covering both basic protection and protection in the event of failure.

(3) The chosen protective measures must be taken into account in the selection and layout of the equipment. Particular attention should be paid to the choice of protective measures in specific and specific installations and/or locations.

(4) All protective measures must be designed and implemented in such a way as to be effective for the intended duration of the installation, system or equipment, provided that they are used for their intended purpose and are properly maintained.

(5) The environment must also be taken into account. Attention shall be paid in particular to ambient temperature, climatic conditions, the presence of water, mechanical stress, the qualifications of persons and the area of contact of persons or animals with earth potential.

(6) If certain conditions of the protection measure cannot be met, supplementary measures must be applied in such a way that the protection as a whole ensures the same level of safety.

(7) The various protective measures applied throughout the installation, its part or equipment must not affect each other in such a way that the failure of one protective measure would adversely affect the other measures.

(8) One or more protective measures must be applied in each part of the installation, depending on external influences. The designer must choose the type and implementation of protection against electric shock. In doing so, it shall take particular account of:

1. ambient temperature,
2. climatic conditions,
3. presence of water and dust,
4. mechanical loads,
5. the qualifications of the persons,
6. the electrical resistance of the human body to the moisture of the skin due to external influences,
7. touching people with the potential of the earth,
8. selection of equipment,
9. other local conditions and external influences,
10. the nature of the equipment powered by electricity,
11. conditions dictated by the specificity of the premises in which the electrical installations are located; and
12. the conditions imposed by the distribution operator if the electrical installation is connected to the distribution network.

(9) Descriptions of the choice of equipment according to external influences are given by the standard SIST HD 60364-5-51. Protection against electric shock must be carried out in accordance with the standard SIST HD 60364-4-41.

4.2 TYPES OF IMPLEMENTATION PROTECTED

(1) Protection of devices against electric shock is carried out by:

1. automatic disconnection of the power supply, which, in the event of failure of the insulation, prevents the formation of a voltage of contact with a value and duration dangerous to physiological function, and must consist of a combination of two conditions:
    a. the existence of a conductive path (defective loop) and consequently a fault current, depending on the type of system (TN, TT or IT) and the conditions of the public network, which the distribution operator is obliged to publish,
    b. disconnection of the fault current by a protective device during a time which depends on the probability of occurrence of the failure, the probability that a person touches the faulty equipment and the contact voltage to which the person can be exposed, depending on the effect of the current on the human body.
2. double or reinforced insulation (use of class II or appropriate insulation),
3. electrical separation,
4. a little tension,
5. protection by bulkheads or enclosures at least at protection level IP 2X or IP XXB,

6. obstacle protection, where the upper accessible horizontal surfaces are at least at protection level IP 4X,
7. out of reach of the hand,
8. placement in non-conductive spaces,
9. local assimilation of potentials without connection to the earth,
10. electrical separation for powering more than one electric consumer.

(2) The basic protection against electric shock must prevent any contact with live parts. Under the basic protection, the live parts are completely covered with insulation, which can be removed only by its destruction.. It must be able to withstand permanently the mechanical, chemical, electrical or thermal influences to which it may be exposed. If the insulation is installed when the installations are carried out, it must be verified by appropriate tests that its quality is the same as that of the factory-made equipment.

(3) The protective barrier or enclosure may only be removed by means of a key or tool after disconnection of the power supply to the live parts or if another equivalent barrier is inserted before its removal.

(4) Obstacle protection shall prevent accidental contact of live parts in regular operation. Barriers must be so fixed that they cannot be removed at random, but can be removed without the use of a key or tool.

4.3 PROTECTIVE MEASURES APPLICABLE GENERAL

4.3.1 PROTECTION BY AUTOMATIC DEROGATION

(1) Protection against electric shock by automatic disconnection of the power supply in electrical installation systems must, in the event of failure of the insulation, prevent the formation of a contact voltage of such a value and duration that it could be dangerous for physiological operation.

(2) For the effectiveness of protection against electric shock by automatic disconnection of the power supply, the equalization of potentials and coordination between the types of installation systems, the characteristics of the protective conductor and the protective device must be carried out. Any failure in the insulation of electrical equipment must result in a fault current that ensures automatic disconnection at such a speed that the health or life of humans and animals is not endangered.

(3) In each building, metal elements that are externally routed inside the building (metal water pipes, metal gas pipes, metal heating pipes, etc.) and are not part of the electrical installation must be connected to the potential equalisation system in accordance with Chapter 5 of this Guideline.

(4) The fault loop in the TN system is a galvanic circuit comprising a faulty live conductor and a protective conductor directly connected to a neutral point (PE or PEN conductor, depending on whether the system is TN-S or TN-C).

(5) Protection against electric shock by automatic disconnection of power supply shall not apply to parts of installations where the necessity of power supply is essential and/or where protection is not effective.

(6) In the event of failure, the protective device shall automatically disconnect the power supply during:
- Table 2 for the TN system;
- Table 3 for the TT system;
- as described in paragraph 8 for specific cases.

Table 2: Defeat time - TN system

Rated earth voltage U_0 (V)	**AC**	**DC**
	T(s)	***T(s)***

50 to 120	0,8	*
121 to 230	0,4	1
from 231 to 400	0,2	0,4
above 400	0,1	0,1

Table 3: Defeat time - TT system

Rated earth voltage U_0 (V)	**AC**	**DC**
	T(s)	***T(s)***
50 to 120	0,3	*
121 to 230	0,2	0,4
from 231 to 400	0,07	0,2
above 400	0,04	0,1

(7) The cut-off times given in Tables 2 and 3 apply to end-circuits where the rated current does not exceed:

- 63 A with one or more sockets, and
- 32 A for powering only the permanently connected consumer.

(8) Longer off periods, which shall not exceed 5 seconds, shall be permitted in the TN system for:

1. supply/distribution circuits,
2. end-circuits supplying only non-transferable equipment, if connected to an electrical distributor to which no circuits requiring shorter disconnection times according to Table 2 are connected,

(9) In the TT system, a disconnection time of up to one second is permitted for distribution circuits and circuits not covered by paragraph 7 of this chapter.

(10) Automatic disconnection of the power supply due to the operation of protection in the event of failure is also necessary due to the risk of fire.

(11) Additional protection with residual current protection devices may only be used as a protection measure in addition to other protection measures against direct contact. When a protection measure with automatic disconnection of power supply is applied, additional protection using a residual current protection device with a rated residual operating current not exceeding 30 mA shall be provided for:

1. socket-outlets with a rated alternating current not exceeding 32 A, for use by lay persons and intended for general use,
2. Portable equipment for outdoor use with rated alternating current up to and including 32 A.

(12) If the conditions for protection against electric shock cannot be met by the application of the protection measure with automatic disconnection of overcurrent power supply, an additional equalisation of potentials or protection device to the residual current shall be applied.

(13) In the premises of individual households, additional protection should be provided by means of a residual current protection device with a rated operating current not exceeding 30 mA for alternating end-circuits feeding the lamps.

(14) In TN systems with automatic disconnection of power, overcurrent protection devices and residual current protection devices may be used to protect against electric shock, taking into account:

1. in a TN-C system with a PEN conductor, protection shall be provided by overcurrent protection;
2. If a residual current device is used for protection, the PEN conductor shall not be used on the load side of the device, but the TN-C-S system shall be implemented;
3. If a residual current device is used for protection, the connection of exposed conductive parts to the protective conductor shall be made on the supply side.

(15) In the TT system, the fault loop consists of the in-line conductor in which the failure occurred, the protective conductor connecting the exposed conductive part to the ground, the ground of the exposed conductive part of the installation and the ground of the neutral power point. In order to protect against electric shock by applying a protective measure with automatic disconnection of the power supply, the condition shall be fulfilled in the TT system that the value of the product of the resistance of the fault loop and the value of the current ensuring the operation of the protective device does not exceed the value of the permissible upper limit of low voltage depending on the ambient conditions. Defeat times shall not exceed the values set out in Table 3 or in paragraph 9 of this Chapter.

(16) When using the FELV system, protection against electric shock shall be provided by:

1. connection of exposed conductive parts to the protective conductor of the primary low-voltage circuit, which is protected by automatic disconnection of the power supply within the prescribed time,
2. connection of exposed conductive parts to an unearthed conductor to equalise the potentials of the primary low-voltage circuit protected by electrical separation.

(17) If the electrical installation with the TT system is powered by a low-voltage public network for which the resistance of the ground of the neutral point (operating ground) is not known, the resistance value of the protective ground of the installation system can be obtained by measuring the impedance of the fault loop.

(18) To protect against electric shock by automatic disconnection of the power supply, the following may be used in TT systems:

1. residual current devices in all cases,
2. overcurrent protection devices in case of sufficiently low ground resistance.

(19) In IT systems, the installation must be:

1. isolated from the earth; or
2. connected to the earth through a sufficiently large impedance.

(20) In order to avoid the need to disconnect the electrical installation in the IT system at the first failure, the fault current during the occurrence of the first failure on the insulation shall be limited in such a way that a dangerous touch voltage higher than the permanently allowed one cannot occur.

(21) After the first failure, the installation with the IT system shall continue to operate as an installation with the TN or TT system and, in accordance with its provisions, an automatic disconnection of power shall be operated if a second failure occurs before the first failure is removed or if two failures occur simultaneously.

(22) The connection of the IT system installation to the ground via impedance should be used primarily where overvoltages or voltage fluctuations in the installation due to resonance are expected.

(23) In most cases, it is sufficient that the value of ground impedance in the IT system is 5 to 6 times the line-to-line voltage expressed in Ω (2,0 kΩ – 2,4 kΩ for line-to-line voltage 400 V), and in all cases such a ground impedance value must be provided:

1. that there are no fluctuations in tension,
2. that a fault current can be detected; and

3. that the fault current does not warm up the protective conductors and ground beyond the permitted values.

(24) Exposed conductive parts in the IT system must be grounded individually, collectively or collectively, and the condition must be fulfilled that the value of the product of ground resistance of exposed conductive parts and the value of the fault current of the first fault with negligible impedance between the line conductor and the exposed conductive part, which takes into account the leakage current and the total earthing impedance of the electrical installation, ensures the operation of the protective device in such a way that, depending on the ambient conditions, the value of the permissible upper limit of low voltage will not be exceeded.

(25) The insulation control device in the IT system reporting the first failure of the live part towards exposed conductive parts or towards the ground shall emit an audible and/or visual signal.

(26) In an electrical installation with a neutral conductor in an IT system, when using a neutral conductor not connected to the ground, it shall be ensured that:

1. that, in the event of two failures occurring in an installation of two circuits of different cross-sections, no more current is flowing through the neutral conductor than is permanently permitted in relation to its cross-section,
2. that the apparatus used is not exposed to voltages greater than its rated voltage.

(27) In the event of a first failure of the IT system, account shall be taken of the dependence of the disconnection conditions of the second failure on whether all exposed conductive parts interconnected by the protective conductor are grounded together, collectively or individually:

1. in the case of individually or collectively grounded exposed conductive parts, protection against electric shock shall be carried out in accordance with the requirements for TT systems, except that a neutral point or one of the in-line conductors need not be grounded in the absence of a neutral point of the transformer or generator,
2. in the case of jointly grounded exposed conductive parts, protection against electric shock shall be carried out in accordance with the requirements of the TN system.

(28) Insulation monitoring devices, overcurrent protection devices or residual current devices are used as protection devices in IT systems. More detailed protection against electric shock in the IT system is defined by the standard SIST HD 60364-4-41.

4.3.2 Double or reinforced insulation (Class II or equivalent)

(1) In order to prevent electric shock on accessible parts of electrical equipment in the event of a failure of the basic insulation, Class II devices or appropriate insulation may be used as a protective measure.

(2) The protection of live parts by insulation must prevent any contact with them. The insulation must be able to withstand the mechanical, chemical, electrical or thermal influences to which it may be exposed. If the insulation is installed when the installations are carried out, it must be verified by appropriate tests that its quality is the same as that of the equipment manufactured in the factory.

(3) Electrical equipment must be type-tested, marked according to the applicable standards and be of the following designs:

1. Electrical equipment with double or reinforced insulation (equipment of protection class II, symbol is);
2. electrical equipment which complies with the relevant standards as equivalent to Class II and constitutes a combination of electrical equipment with total insulation (see SIST EN 61439-1).

(4) Where protection against electric shock is applied by means of Class II devices or equivalent insulation, all conductive parts of electrical equipment which are separated from live parts only by basic insulation shall be enclosed in insulated enclosures which have a degree of protection of at least IP 2X or IP XXB and which withstand the prescribed mechanical, electrical and thermal loads.

(5) When providing protection against electric shock by means of Class II devices or equivalent insulation, a symbol shall be affixed conspicuously so that no grounding is required.

(6) Coatings with paint, varnish and similar materials are not suitable for protection against electric shock as Class II devices unless they pass the relevant type tests.

4.3.3 Electrical separation

(1) Protection against electric shock by electrical separation of the installation circuit is intended to prevent electric shock due to contact with exposed conductive parts that could come under voltage due to the failure of the basic insulation of the circuit. This safeguard shall be limited to one electric consumer powered by a single source with easy separation. The supply source is a product and must comply with the product standard.

(2) Protection by electrical separation must be carried out as follows:

1. the rated voltage of the electrically isolated circuit shall not exceed 500 V;
2. portable separating sources of protection by electrical separation connected to an electrical installation must be selected and installed as specified by the requirements for protection using Class II devices or devices with appropriate insulation;
3. Fixed separating sources of electrically separable protection must be so selected and positioned as to separate the secondary circuit from the primary circuit and the enclosure by means of insulation meeting the requirements for protection by the use of Class II devices or devices with appropriate insulation.
4. the live parts of the separate circuit must not have a common point with the other circuits or a connection to the earth. In order to avoid the danger of ground contact, particular attention should be paid to the insulation of these parts against the ground, especially in the case of flexible cables and conductors. The arrangement must ensure electrical separation, as in the case of a separating transformer;
5. flexible cables and conductors must be visible throughout the length on which they could be mechanically damaged;
6. a special electrical separation is required between the live parts of the electrical equipment, such as relays, contactors, auxiliary switches, etc., and any part of the other circuit;
7. the installation systems of electrically isolated circuits must be laid separately. If this is not feasible, multi-core cables without metal sheath or insulated conductors installed in insulating pipes or ducts must be used, provided that these cables and conductors are insulated for a voltage at least equal to the highest voltage used and that each circuit is separately protected against overcurrent;
8. if the separate circuit feeds only one device, the exposed conductive parts of the separate circuit shall not be connected to the protective conductor nor to the conductive parts of other circuits;
9. if the conductive parts of an electrically isolated circuit are capable of deliberately or accidentally contacting the exposed conductive parts of another circuit, then the protection measures against electric shock shall no longer depend solely on the protection by electrical separation but on the protection measures applied to those exposed parts;

4.3.4 A little tension

(1) The little tension is:

1. for dry rooms up to 50 V alternating voltage or 120 V DC voltage,
2. for humid and wet rooms (buildings, agriculture, horticulture, etc.) 25 V alternating voltage or 60 V DC voltage,
3. for rooms where the skin has a direct contact with water (smokes, pools, etc.), 12 V alternating or 30 V DC voltage,
4. as set out in other regulations or standards.

(2) Two systems are used as protection against low voltage electric shock:

1. SELV (Safety Extra Low Voltage)
2. PELV (Protective Extra Low Voltage).

(3) If the circuit is supplied from a higher voltage circuit by means of devices such as autotransformers, potentiometers, semiconductor devices, etc., such secondary circuit shall be an integral part of the primary circuit and shall be subject to the primary circuit protection measures.

(4) The power sources for SELV and PELV protection are:

1. safety separating transformers in accordance with SIST EN IEC 61558-2-6,
2. power supplies that provide the same level of safety as safety separating transformers,
3. electrochemical sources (batteries or accumulators),
4. other sources not dependent on higher voltage circuits (e.g. diesel generator),
5. electronic devices for which measures are provided to ensure that, in the event of an internal failure, the voltage at the output terminals does not exceed the permissible limit — higher voltage is permitted only if it is ensured that, in direct or indirect contact, the voltage at the output terminals falls below or to the permissible value without delay.

(5) SELV and PELV protection circuits shall be electrically separated from higher voltage circuits equivalent to the electrical separation between the primary and secondary winding of the safety separating transformer.

(6) SELV and PELV protection conductors must be physically separated from conductors of all other circuits. If this is not possible, they must be installed in a non-metallic sheath that complements the basic insulation. They must be separated from circuits with different voltages by a grounded metal screen or sheath.

(7) Multi-core conductors or bundles of conductors may have circuits of different voltages provided that the conductors of the protection circuits SELV and PELV are isolated individually or together for the highest voltage present.

(8) Exposed conductive parts of SELV circuits shall not be connected to earth or to protective conductors or to exposed conductive parts of other circuits. PELV protection circuits and/or exposed conductive parts of equipment powered by PELV circuits may be grounded.

(9) When, for functional reasons, a FELV (Functional Extra Low Voltage) operating low voltage other than protection is used, an appropriate protection measure against electric shock shall be applied when using the FELV.

(10) Protective devices may be installed in SELV and PELV circuits but have a function other than protection against electric shock by automatic disconnection of the power supply.

4.4 OTHER PROTECTIVE MEASURES

4.4.1 General

(1) The protection measures against electric shock referred to in the sixth and seventh indents of the first paragraph of point 4.2 may be used in installations accessible to professional or qualified personnel or persons under the supervision of professional or qualified persons.

(2) The protection measures against electric shock referred to in the 8th, 9th and 10th indents of the first paragraph of point 4.2 may be applied in installations under the supervision of qualified or qualified personnel.

4.4.2 Obstacles

(1) Obstacle protection shall prevent accidental contact of live parts in regular operation. Barriers must be so fixed that they cannot be removed at random, but can be removed without the use of a key or tool.

4.4.3 Layout out of reach

(1) Out-of-hand protection may only be used to prevent accidental contact with live parts. At the same time, accessible parts with different potentials should not be within reach. Two parts are simultaneously accessible if they are less than 2.5 m away. The area of contact with bare hands, without utilities, is considered to be a space of reach of the hands.

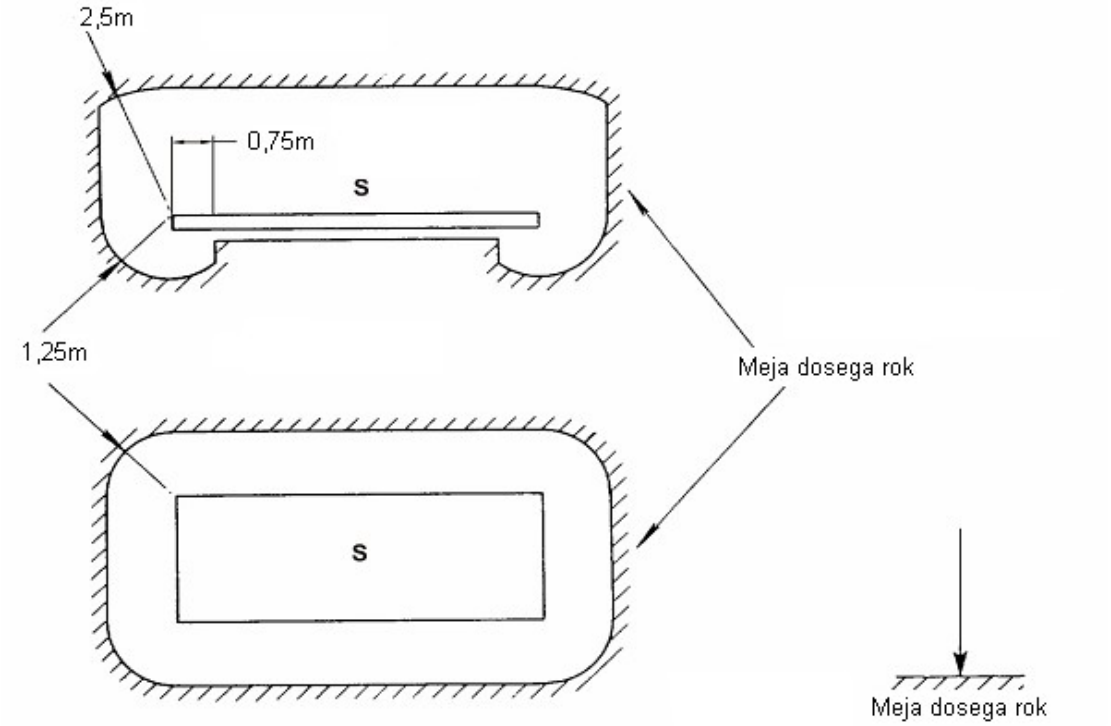
(2) In rooms where very long conductive elements are used, the distances of reach of the hands should be increased in relation to the lengths of these elements.

(3) If the space is bounded in a horizontal direction by an obstacle (e.g. a protective rail, fence or grid) giving a degree of protection below IP 2X or IP XXB, the space shall be within reach of the hand starting from that obstacle.

(4) In the vertical direction, the space of reach of the arm is up to 2.5 m in height relative to the surface of the movement, regardless of intermediate obstacles with a degree of protection below IP 2X or IP XXB (see Figure 6).

(5) Obstacle protection and out-of-hand placement shall be permitted only in places accessible to educated persons, provided that the following conditions are met:

1. the rated voltage at such points does not exceed 1000 V AC voltage or 1500 V DC voltage,
2. that such places are clearly and visibly indicated by standardised signs,
3. after installation and closure of all parts of the billboard, a minimum clearance width of 0,7 m in front of, or between, obstacles or controls and the wall is also ensured, and a minimum clearance height of 2 m;
4. maintenance and operation corridors longer than 20 m are accessible from both sides, as are passageways longer than 6 m.



S — area where persons are expected to move

Figure 6: Layout out of reach

(6) The working distance for maintenance, handling, inspection and the like shall be determined by calculation or assessment according to the risk assessment. For each workflow, this distance is different and is determined during the preparation of the work. The formula should be used according to the working method, voltage, type of work and type of tool, device or equipment used. This applies in particular to work with long conductive elements (ladders and the like) (point 4.11.3. SIST EN 50110).

(7) The walls and ceiling of the hallway for use or passage must make it impossible to touch the live parts. The dimensions of the height and width of the corridor must be free of protruding parts (switch drives and the like).

(8) Width and height of corridors:

- a width of at least 1 m when serving only from one side,

- a width of not less than 1,2 m when serving from both sides,
- a width of not less than 0,8 m only for passage and escape, the door must be closed in the direction of escape,
- the length of the escape route for retreat in one direction shall not exceed 20,0 m, otherwise it shall be possible to retreat in both directions.
- a height of at least 2,0 m, except in cable rooms (see, mutatis mutandis, SIST EN 61936-1).

(9) Maintenance may start after safe working measures have been implemented. Typically, this is to ensure the voltage-free condition of the device or part of it, the erection of protective barriers, movement restrictions and the like, in accordance with the regulations on safety and health at work. The designer must foresee different corridor dimensions in the design for execution, which may be larger than the minimum if maintenance or operation so requires.

4.4.4 Installation in non-conductive spaces

(1) Protection against electric shock by placing in non-conductive spaces prevents simultaneous contact with parts with different potentials in the event of failure of the basic insulation of live parts.

(2) In order to protect against electric shock by placement in non-conductive spaces, it is permitted to use equipment with only basic insulation, provided that exposed conductive parts are arranged in such a way that, under normal conditions, personnel do not come into contact simultaneously with two exposed conductive parts, or with exposed conductive parts and any foreign conductive part on which different potentials could arise due to a failure of the basic insulation of live parts.

(3) Protection against electric shock by placement in non-conductive spaces is appropriate if the space has insulated floors and walls and if the distance between exposed conductive parts and foreign conductive parts is reached and the distance to exposed conductive parts between two elements is at least 2,5 m, which may be reduced to 1,25 m outside the reach of the hand.

(4) The requirement for protection by placement in non-conductive spaces is also appropriate when using equipment with only basic insulation if effective barriers are placed between exposed conductive parts and foreign conductive parts. Such obstacles shall be sufficiently effective if they are outside the reach range of the hand at distances exceeding 2,5 m and 1,25 m respectively. However, they shall not be grounded or connected to exposed conductive parts and shall, as far as possible, be of insulating material.

(5) The requirements of the second paragraph of this point shall also be met by insulating the foreign conductive parts or by achieving their insulating arrangement. The SIST HD 60364-4-41 standard specifies the requirements for this action.

(6) For effective protection against electric shock by placing in non-conductive spaces, the wall and floor impedance must be at any point:

1. Greater than 50 kΩ if the rated installation voltage is less than or equal to 500 V, otherwise the walls or floor shall be considered as foreign conductive parts for protection against electric shock,
2. greater than 100 kΩ if the rated installation voltage is higher than 500 V, otherwise walls or floors shall be considered as foreign conductive parts for protection against electric shock.

(7) Where protection against electric shock by placement in non-conducting spaces is used, it must be ensured that moisture does not reduce the insulation resistance of the insulation of floors and walls and that foreign conductive parts do not transfer the potential from the non-conducting space to the surrounding area.

(7) The connections of conductors in non-conductive spaces must be durable and efficient and must also ensure the protection of the mobile and portable apparatus, if its use is envisaged.

(8) For electrical installations where a protection measure against electric shock is applied to the placement in non-conductive spaces, the danger arising from the subsequent introduction of new conductive parts, such as movable and portable apparatus with a connection to a protective conductor or conductive elements, such as metal plumbing pipes, must be taken into account.

4.4.5 Electrical separation for powering more than one consumer

(1) The purpose of electrical separation is to prevent the current of impact when touching exposed conductive parts that could be energized in the event of failure of the basic insulation. All electrical equipment must comply with one of the basic protection measures as defined in standard SIST HD 60364-4-41.

(2) Provided that measures are in place to protect the separate circuit against all insulation damage and faults, a circuit meeting the requirements for circuits supplied from the separating source shall be capable of supplying several devices, provided that the following requirements are met:

a) exposed conductive parts of separate circuit devices must be interconnected by insulated non-terrestrial conductors to equalise non-soil bound potentials. These conductors shall not be connected to protective conductors nor to exposed conductive parts of other circuits, nor to foreign conductive parts;
b) all sockets must have protective contacts, which must be connected to conductors to equalize potentials that are not bound to the earth. These conductors shall not be connected to protective conductors nor to exposed conductive parts of other circuits, nor to foreign conductive parts;
c) all flexible cables shall be provided with a protective conductor used as a protective equalisation conductor, unless they power Class II equipment;
d) if two failures occur simultaneously on exposed conductive parts supplied by conductors of different poles, the protective device shall cut off the power supply within 0,2 seconds.

5 PROTECTIVE AND OPERATIONAL (FUNCTIONAL) TREATMENT

5.1 PROTECTIVE LIMITATION

(1) The electrical installation shall be provided with protective earthing where protection against electric shock is provided by means of automatic disconnection of the power supply and where this is prescribed by other regulations.

(2) In each installation, one main ground connection must be provided to which they are connected:

1. ground ducts,
2. protective conductors (PE),
3. protective neutral conductors (PEN),
4. the main guides for equalizing potentials,
5. conductors for operational earthing (if required by the installation and earthing system used).

(3) Where overcurrent protection devices are used to protect against electric shock, the protective conductors with live conductors shall be in the same cable, conductor jacket or installation hose.

(4) If the protective earthing is carried out with its own grounding, this grounding shall be electrically separate and independent from all other grounded parts and at a minimum distance of 10 m from the grounding of all grounded metal parts.

(5) The protective conductor must be connected only to exposed conductive parts of electrical devices, the power supply of which is interrupted by the action of the protective device of the associated circuit in the event of failure.

(6) If the combined protective and operational earthing function is, the one relating to the protective earthing shall be decisive for the different requirements.

(7) If low-voltage installations of the TN system and low-voltage installations of the TT system are connected to the same low-voltage network, the grounding resistance of the combined earthing shall meet the requirements of the TN system.

(8) Where protective earthing continuity monitoring is used, dedicated devices (e.g. operating sensors, coils, currents) shall not be connected sequentially to the protective conductor. The continuity control of the protective earthing of the devices shall ensure the disconnection of the power supply in the event of failure and disconnection of the protective conductor.

(9) The grounding resistance value must meet the requirements of protection and operation of electrical installations and must be maintained so that the ground current and leakage current can always flow without danger in terms of thermal, thermomechanical and electromechanical loads.

(10) The strength and mechanical protection of the grounding system must be assured depending on the assessed external influences.

(11) The following may be used for protective and operating earths:
1. pipes or rods,
2. strips or wires or plates,
3. the grounding ground,
4. metal reinforcement for prestressed concrete, if φ bars > 10 mm,
5. other built-in structures, excluding pipelines for the flow of flammable liquid or gas, central heating, etc., but not excluding the assimilation of potentials to other systems.

(12) In the design of the ground(s) and in order to carry out the measurements, provision shall be made for a detachable connection — the measuring connection and:
1. for the measurement of accessible main collectors of protective, grounding and neutral lines,
2. in a system with more than one earth, provision must be made, for each earth connection, for the installation of at least one current clamp at a conveniently accessible location,
3. in an urban environment, provision must be made for the possibility of double-click measurements at each connection, allowing a distance of at least 300 mm for the use of separate current pliers on the same connection, with one connection of the current pliers, which must allow easy adhesion of the earth connection with double current pliers 60 mm thick and an external jaw diameter of 120 mm,
4. the measuring points must be so designed as to be accessible both for acceptance testing and for periodic and post-maintenance testing and repairs.

(13) When designing new electrical installations, provision should also be made for a protective conductor for lighting circuits, and a protective conductor should be added when refurbishing existing circuits.

(14) The current in the protective conductor shall not exceed the value given by the expression

$$I_{PE} < U_L / R_L,$$

where:
I_{PE} current in the protective conductor,
U_L the agreed limit of contact tension; and
R_L resistance (impedance) of the fault loop.

5.2 CONTROL (FUNCTIONAL) TREATMENT

(1) If the electrical installation is connected to the distribution network, the operational (functional) earthing must be carried out in accordance with the requirements of the distribution operator in the connection consent. If consent for the connection of the operational (functional) earthing is not required, it shall be sufficient for the installation of the operational (functional) earthing of the network.

(2) Where leakage currents are present in the installation, the protection against electric shock must be adjusted accordingly and earthing compositions carried out. The continuity of the protective conductors of such earthing assemblies shall be checked and tested at installation and acceptance, periodically and after each modification

(3) If electronic equipment is connected to the electrical installation, periodically and after each change in the installation, it should be borne in mind that filters to reduce electromagnetic

interference can cause large leakage currents, and therefore it should be borne in mind that when the protective connection with the earth is broken, dangerous contact voltages may occur.

(4) Where leakage currents occur in an electrical installation, it shall be ensured that the leakage current does not trigger a protective device to the residual current when used for protection against electric shock.

(5) For devices with high leakage current, earthing continuity must be tested at installation set-up and acceptance, periodically and after each change.

5.3 REQUIREMENTS FOR GUIDELINES AND ELEMENTS

(1) In TN systems, the role of protective conductor and neutral conductor may be combined if, in permanently installed installations, the protective conductor has a cross-section equal to or greater than 10 mm2 of copper or 16 mm2 of aluminium and if that part of the installation is not protected by a residual current protective device.

(2) The section of the protective conductor shall be the same as that of the live conductors. For copper conductor cross-sections above 35 mm ^{2,} the cross-section may be half that of live conductors, taking into account the special conditions of installations requiring larger cross-sections, see Table 4.

Table 4: Minimum cross-sections of protective conductors

Liner conductor cross-section, *S* mm² Cu	**Minimum cross-section of the associated copper protective conductor, mm²**	
	The protective conductor is made of the same material as the liner conductor	**The protective conductor is made of a different material than the liner conductor**
$S \leq 16$	S	$\frac{k_1}{k_2} xS$
$16 < S \leq 35$	16 [a]	$\frac{k_1}{k_2} x 16$
$S > 35$	$\frac{S}{2}$ [a]	$\frac{k_1}{k_2} x \frac{S}{2}$
For k_1 and k_2, see SIST HD 60364-5-54.		
[a] reduction of the cross-section of the PEN conductor is only permitted in accordance with the rules for determining the size of the neutral conductor (see SIST HD 60364-5-52).		

(3) The PEN conductor must be insulated for the maximum voltage to which it may be subjected.

(4) Inside the switchgear there must be special terminals for PE and N conductor.

(5) Protective conductors must be protected against mechanical and chemical influences and against electrodynamic damage.

(6) Protective conductor joints must be accessible for checking purposes unless they are watered and must be so arranged that they can only be separated by tools.

(7) The winding of the earthing continuity control device or switching apparatus shall not be connected in series to the PE or PEN circuit of the conductor.

(8) Exposed conductive parts of equipment which must be connected to a protective conductor shall not be connected sequentially to a protective circuit unless a coating of factory-mounted or pre-fabricated metal installation ducts is used as a protective conductor.

(9) Metallic non-insulated or insulated insulating ducts of certain electrical installations, in particular external insulating ducts in which mineral insulating cables, metallic insulating pipes and metallic insulating ducts are placed, may be used as a protective conductor of the relevant circuit, provided that they meet the condition set out in the preceding paragraph.

(10) Conductors in multi-core cables, bare or insulated conductors in a common duct, installation duct or pipes with conductors, special insulated or bare conductors, metal cladding (e.g. braids, screens, fittings of certain cables), metal installation pipes or installation ducts and certain conductive parts may be used as protective conductors.

(11) Foreign conductive parts may be used as a protective conductor if:

1. their electrical continuity is ensured by design or galvanic connections in such a way as to protect them against mechanical, chemical or electrochemical damage,
2. their conductivity is at least equal to the necessary cross-sections of the protective conductors,
3. cannot be dismantled, except where suitable replacement measures are provided for; and
4. are designed and adapted for this purpose.

(12) Metal plumbing pipes, gas pipes, metal installation pipe connections, collecting trough system, flexible metal parts, flexible metal pipes (unless they are designed for this purpose) and spare wires, cable trays and cable ladders may not be used as protective conductors.

(13) Foreign conductive parts not belonging to electrical installation circuits should not be used as PEN conductors.

5.4 EVALUATION OF TERRITORIAL WATER

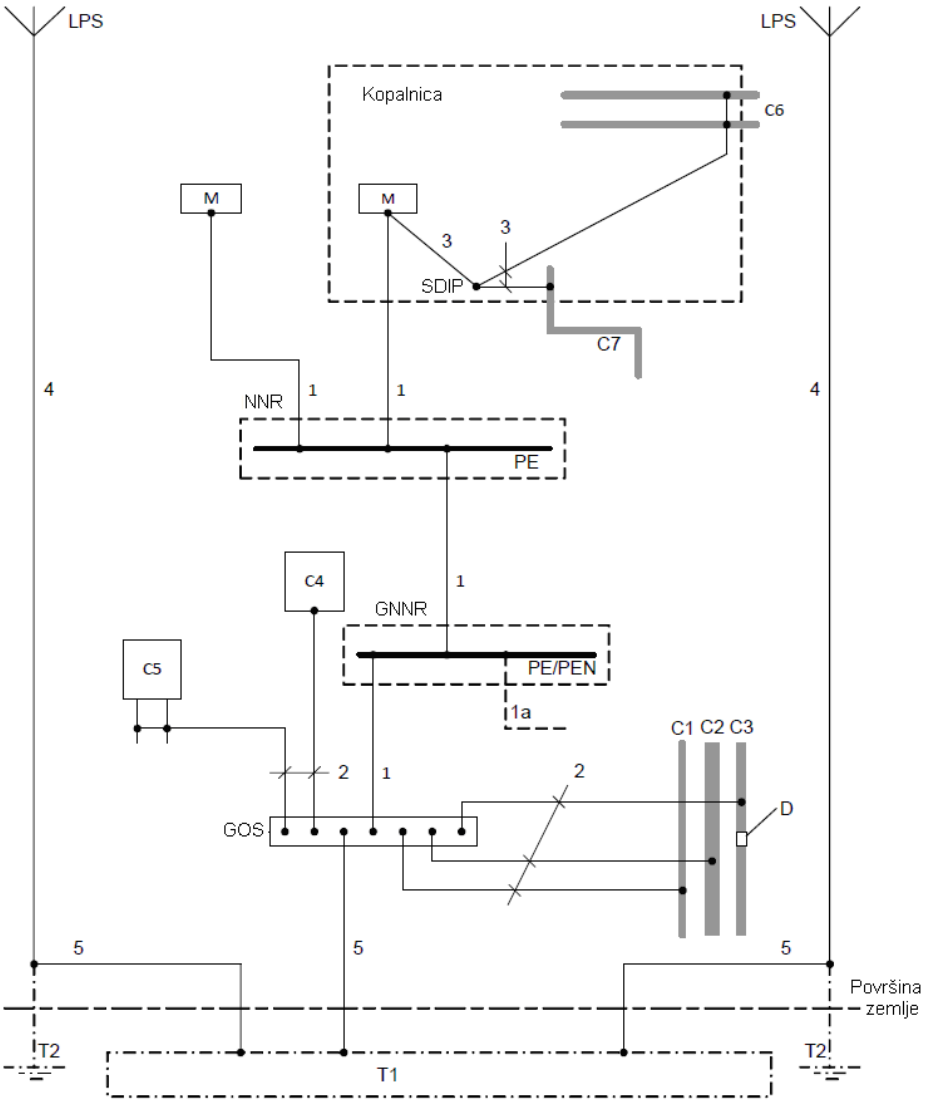
(1) The methods of laying the grounding line and the specific implementation of the grounding shall be carried out in accordance with the standards SIST EN IEC 62305-3, SIST EN IEC 62305-4 and SIST HD 60364-5-54 and the technical guideline TSG-N-003 Lightning protection.

(2) The grounding shall be installed at least in the outer perimeter of the foundation of the building in the form of a closed ring made of galvanised steel strip with a cross-section of 100 mm2 and a minimum thickness of 3 mm, or of fully galvanised steel, iron reinforcement or stainless steel if φ bars > 10 mm. The tape must be placed upright and poured into the lower layer of concrete with a minimum of 300 kg of cement per 1 m3 of concrete. The minimum thickness of concrete between the ground and the earth should be 10 cm.

(3) The grounding line shall have a separable connection at an accessible location that allows the measurement of the grounding resistance (this may also be the main grounding connection), shall be mechanically solid and galvanic, and shall be separable only by means of tools.

(4) The part of the grounding water above the ground must be protected from mechanical influences and corrosion and be visible. If it is covered, it must be accessible throughout its length.

(5) In installation systems, the principle of connecting grounding and protective conductors must be observed in the ways shown in the SIST HD standard 60364-5-54 (Figure 7).



The codes shall mean:

C Foreign conductive part:
C1 External metal plumbing
C2 External hot water supply
C3 External metallic gas pipeline with insulating liner
C4 Climate
C5 Heating system
C6 Metal plumbing, e.g. in the bathroom
C7 Metal plumbing for hot water, e.g. in the bathroom
D Insulating insert
GNNR Main distributor
NAP Distributor
GOS Main grounding clamp (collector)
SDIP Buckle (collector) for additional equalization of potentials
T1 Ground ground or ground in the ground
T2 Grounding of lightning protection system, if necessary
LPS Lightning protection system
PE Buckle (collector) PE in the distributor
PE/PEN Buckle (collector) PE in main distributor
M Exposed conductive part
1 Protective grounding conductor
1a PE-guide or PEN-guide, if any, from the power supply network
2 Equalization of potentials guide, for connection to the main grounding clamp/collector
3 Protective guide for further equalization of potentials

4 Lightning protection drain
5 Grounding Guide

N.B.: In addition to the image, the designer must indicate the maximum permissible resistance of the ground connections.

Figure 7: Grounding systems, protective conductors and protective equalisation of potentials conductors

5.5 MAIN AND ADDITIONAL IMPLEMENTATION OF POTENTIALS

5.5.1 Main Equalization of Potentials

(1) The main equalization of potential is carried out by galvanic connection of all foreign conductive parts, which do not belong to electrical installation circuits, with each other and with protective grounding.

(2) The guide to the main equalization of potentials must interconnect the foreign conductive parts in the building with each other and with protective grounding:
1. pipes and similar metal structures within the building,
2. metal parts of structures, central heating and air conditioning system, etc.

(3) In TT and IT systems, the N conductor shall not be coupled to the grounding collector.

(4) All individual guides for the main equalization of potentials must be connected to the ground collector of the main equalization of potentials.

(5) The grounding collector of the main equalization potentials, to which the individual equalization potentials conductors are connected, must have permanently and clearly marked terminals for the connection of the individual equalization potentials conductors.

(6) The cross-section of the guides for the main equalization of potentials is determined according to the SIST HD standard 60364-5-54.

(7) The cross-section of the grounding conductor of the collector for the main equalization of potentials shall be in accordance with the provisions for protective and grounding conductors.

(8) The potential equalisation system must connect to the protective conductors of all equipment, including sockets.

5.5.2 Further equalization of potentials

(1) Additional equalisation of potentials is a compensatory safeguard that must be applied if the protective conditions for a particular installation system are not appropriate.

(2) Additional equalization of potentials is required in TN, TT or IT systems in very long circuits and when the impedance of the fault loop is too large to ensure the operation of the protective device in the prescribed time.

(3) By further equalizing the potentials, the tension of the touch must be lowered to a value that is not dangerous, and which can remain indefinitely long.

(4) Local additional equalization of the potentials must be carried out in the case when a device providing protection against indirect contact of the circuit or equipment in the event of insulation failure does not provide the disconnection of the circuit during a time that would prevent the maintenance of the voltage:
1. Above 50 V AC 15 – 1000 Hz (or 24 V due to wet skin or 12 V due to wet skin under specific ambient conditions); or
2. Exceeding 120 V DC voltage with a wavelength not exceeding 10 % of the nominal value (respectively 60 V due to wet skin or 30 V due to wet skin under specific ambient conditions); or

3. above 140 V maximum peak DC voltage (respectively 70 V due to moist or 35 V due to wet skin under specific environmental conditions).

(5) The additional equalisation of potentials should cover all simultaneously accessible exposed conductive parts of the fixed equipment and external conductive parts including, where possible, the main metal concrete reinforcements used in the building. The potential equalisation system must be connected to all protective conductors of all equipment, including protective conductors in sockets.

(6) The resistance (R) between simultaneously accessible exposed conductive parts and external conductive parts must comply with the condition:

$$R \leq \frac{U_L}{I_a}$$

Where it is

U_L Agreed Touch Voltage Limit (under normal conditions 50 V a.c. or 120 V d.c.)

I_a Current providing automatic overcurrent protection device operation in 5 s or $I_{\Delta n}$ for residual current protection devices.

(7) All individual leads for the additional equalization of potentials must be connected to a collector for the additional equalization of potentials, which must have permanently and clearly marked terminals for the connection of individual leads for the additional equalization of potentials and be connected to the collector of the main equalization of potentials.

5.6 ACCESS TO THE STEP AND TOUCH

(1) Step and contact voltages shall be measured at the edges of uniformly connected large-scale earthing systems in the case indicated by the tenth paragraph of point 4.5 or in the case of high leakage currents into the earthing system. The step-to-touch voltage shall be calculated to the maximum current that may occur in such a system and shall not exceed the conventional limits of the touch voltage, i.e. 50 V for AC voltage systems and 120 V for DC voltage systems.

(2) The designer must foresee measures to avoid the problem of dangerous tension of touch or step. The appropriateness of the measures should be checked by means of measurement.

(3) In the case of additionally identified hazards due to excessive step and touch voltage, the designer shall determine the necessary additional measures at the time of the measurement referred to in the preceding paragraph.

5.7 CONNECTIVE TREATMENT SYSTEM

(1) Usually the problem is the grounding system of the VN transformer station or other VN installation, which is located near the grounding system of the NN (public) electrical installation, and this can lead to interference or even the transfer of dangerous potentials in the event of failure on the VN side.

(2) The grounding systems must be:

- sufficiently separated; or
- connected together in the event of a short distance.

(3) VN and NN grounding systems must be connected in the event that the NN system is completely enclosed in the VN system.

6 CONTROL PROTECTION OF WATER PROTECTION

6.1 GENERAL

(1) The live conductors shall be protected against overload and short-circuit by one or more automatic disconnection devices.

(2) The coordination of protection against overload of conductors and short-circuit must comply with the standard SIST HD 60364-4-43.

(3) Devices providing overcurrent protection must be capable of disconnecting any overcurrent or short-circuit current flowing in the conductors before it causes heating harmful to insulation, joints, buckles or the environment.

(4) If the protection provided by devices for automatic disconnection of power supply when overloading the conductor with a long overcurrent of less than the current ensuring reliable operation of the overcurrent protection device does not provide full protection, the circuits shall be designed in such a way that small overloads cannot occur frequently.

6.2 INSTALLATION OF THE GUIDE PROTECTION DEVICE

(1) The overcurrent protection device for conductors and cables must be positioned according to the requirements of the SIST HD 60364-4-43 standard.

(2) Overload protection may be omitted in spaces where there is no risk of fire or explosion as required by SIST HD 60364-4-43.

(3) Overload and short-circuit protection devices shall not be installed in excitation circuits of machinery, electromagnetic lifts, secondary circuits of current transformers and the like, nor shall short-circuit devices be installed in measuring circuits. In these cases, an overload alarm shall be provided.

(4) The overload protection shall be fitted to each line conductor and shall only be capable of switching off the conductor in which the overflow occurred.

(5) In an IT system where there is no neutral conductor, an overload protection device may be provided in only two lines, provided that in this three-phase system there is a residual current protection device on the power supply side which cuts off all in-line conductors.

(6) If the cross-section of the neutral conductor in TT and TN systems is at least equal to the cross-section of the line conductors and the current in the neutral conductor is not expected to exceed the value of the current in the line conductors, neither the overload protection in the neutral conductor nor the device for breaking this conductor shall be required.

(7) If the cross-section of the neutral conductor in TT and TN systems is smaller than the cross-section of the line conductors, the detection of overload current in the neutral conductor shall be provided to cause disconnection of the line conductors, but not necessarily of the neutral conductor.

(8) Where higher harmonic currents also run on a neutral conductor, the following shall apply:
- if, due to the harmonic content of the line currents, the current in the neutral conductor is expected to cause its temperature to exceed the maximum allowable cable conductor temperature, the neutral conductor must be equipped with means to detect overload resulting in disconnection of the line conductors, but not necessarily of the neutral conductor; or
- The cross-section of conductors shall be selected taking into account the reduction factor for current loading as specified in SIST HD 60364-5-52.

(9) Overcurrent protection of several parallel conductors must be carried out in accordance with the standard SIST HD 60364-4-43.

6.3 PROTECTION BEFORE SIMPLIFICATION

(1) Devices providing only short-circuit current protection may be installed where overload protection is achieved by other means or where overload protection is not mandatory. They must cut off the short-circuit current flowing through the conductors of the circuit before it could cause danger due to thermal and mechanical effects in the conductors and contacts.

(2) The expected short-circuit current must be determined at each individual point of installation. It can be determined by calculation or measurement.

(3) The short-circuit device shall meet the following requirements:

1. The cut-off capacity shall not be less than the expected short circuit current at the point of installation, unless another protective device having the required cut-off capacity is used on the power supply side. The protection characteristics must be set in such a way that the energy passing through these two devices does not exceed the value which the device can withstand without damage on the load side and the conductors protected by this device. Other characteristics, such as dynamic loads and arc energy, for the load side devices declared by the manufacturer shall also be taken into account.
2. Any short-circuit current occurring at any point in the circuit must be cut off in time before the conductors are heated to the permissible limit temperature. For short-term contacts lasting up to
   5 s, the time during which a given short-circuit current heats the conductors to the limit temperature is determined approximately by taking into account the conductor cross-section, the root mean square of the actual short-circuit current and the correction factor according to the type of insulation of the conductor.

When calculating the conductor heating to the limit value, the designer must follow the formula and table for k values for conductor insulation types according to the SIST HD60364-4-43 standard.

(4) For the operating times of protection devices t < 0,1 s, where asymmetry of current is relevant, and for current limiting devices, the maximum permeable energy (I^2t) indicated by the manufacturer of the protection device must be taken into account in order to prevent overheating of the conductors.

7 PROTECTION FROM TOTAL EFFECTS AND PREVENTION

7.1 PROTECTION AGAINST THE IMPACT

(1) In order to prevent fire, heat, electric arc, burns and overheating in electrical installation systems, persons, animals, fixed electrical equipment and material in the vicinity of electrical installations and equipment must be protected against the harmful action of heat or heat radiation developed by electrical installations and devices.

(2) Fixed electrical equipment must, where it could reach surface temperatures likely to cause a fire hazard to the installation conductors or surrounding material:

1. placed on or next to materials which withstand such temperatures and have low thermal conductivity, or
2. screened in front of structural elements with materials that withstand such temperatures and have low thermal conductivity; or
3. positioned in such a way as to permit the emission of heat at a sufficient distance from a material which would be adversely affected by such a temperature or from a carrier which has low thermal conductivity.

(3) Permanently attached electrical equipment in which arcing or sparking may occur during operation must be:

1. fully lined with arc-resistant material, non-flammable, poorly conductive in terms of heat and appropriate dimensions to ensure mechanical stability; or
2. screened with an arc-resistant material that is non-flammable, has poor thermal conductivity and adequate dimensions to provide mechanical stability against elements of the building on which the arc could have a destructive thermal effect; or
3. positioned in such a way as to permit reliable extinguishing of the arc at a sufficient distance from structural elements on which the arc may have a destructive thermal effect.

(4) Fixed electrical equipment which causes the focus or concentration of heat must be sufficiently distant from any fixed object or element of design so that under normal conditions they are not exposed to a dangerous temperature.

(5) If electrical equipment contains more than 25 litres of flammable liquid in one place, precautions must be taken to prevent the spread of flammable liquid, flame, smoke or toxic gases to other parts of the building:

1. a place must be provided in which the expired liquid is collected and which allows it to be extinguished by burning, or
2. install equipment in a fire-resistant space,
3. the enclosure must have a threshold or other means to prevent the spread of burning liquid to other parts of the building and must therefore only be ventilated by ambient air.
4. If electrical equipment contains a significant amount of flammable liquids (e.g. more than 25 litres), measures must be provided to prevent the spread of flames and combustion products.

(7) Lightning arresters and various spark-lamps shall not be placed in spaces where there is a risk of fire or explosion.

(8) In the event of a fire, it must also be possible to interrupt the power supply manually. The power supply shall not be switched off for safety purposes.

(9) The materials used for the enclosures of electrical equipment must be capable of withstanding the maximum temperature which that equipment is capable of producing. Combustible material is not suitable unless anti-ignition measures are provided, such as covering with non-flammable or highly flammable and poorly conductive thermal material.

(10) Circuits supplying electrical equipment or passing through spaces where there is a risk of fire must be protected against overload and short-circuit with a protective device placed outside such spaces.

(11) Live parts in safety-safety-small-voltage circuits located in areas where there is a risk of fire shall be protected by an enclosure with a degree of protection of at least IP 2X or IP XXB, or be insulated with an insulation capable of withstanding a test voltage of 500 V DC for one minute.

(12) With regard to thermal protection in electrical installation systems, it should be borne in mind that higher harmonic components have a higher thermal effect than the corresponding basic component due to a 'skin phenomenon'.

(13) Where external influences pose a particular risk to and during fire, measures must be taken in accordance with SIST HD 60364-4-42.

7.2 Fire protection due to faulty currents

(1) In order to protect against fire in the event of a failure in the installation, each short-circuit current must be cut off within a period of not more than 5 s.

(2) The exception is the first failure in the IT installation.

(3) An exception is when additions A, B or E of SIST HD 60464-4-43 are used.

7.3 Protection against defective arcs

(1) Where a fault arc protection device (AFDD) is used to protect against fault arcs in accordance with SIST HD 60364-4-42 plus A1, the following shall apply:
- The AFDD shall comply with SIST EN IEC 62606;
- The AFDD shall be installed at the source of the final circuit it protects;
- The AFDD shall be installed and coordinated in accordance with the manufacturer's instructions.

7.3.1 Protection against thermal effects caused by fault arcs of end circuits

(1) The locations where protection against end-circuit fault arcs is to be used are:
- intended for the sleep of persons (homes of the elderly and people with disabilities, hotels and guesthouses/pensions, primary schools and kindergartens, dwellings),
- those occupied by groups of persons (facilities for the elderly and disabled, primary schools and kindergartens, worksites in higher buildings),
- stores of combustible materials or environmentally hazardous products (including batteries), or both, classified as BE2 (homes for elderly and disabled people, hotels and guesthouses/pensions, primary schools and kindergartens),
- stores of irreplaceable goods (museums, historical buildings, libraries, archives documentation centres),
- Agricultural facilities for animals.

(2) Protection against the effects of end-circuit fault arcs:
- it must be provided for end-circuits containing one or more sockets; and
- be provided for all other end-circuits.

The use of AFDD shall meet these requirements.

(3) Where AFDD cannot be used, other useful methods should be used. Consideration shall be given to methods which do not exclude all circuits where such disconnection may lead to hazards such as circuits for:
- excitation circuits of rotating machines,
- powering of lifting magnets,
- powering firefighting equipment such as sprinkler pumps, smoke extraction fans, fire hoists,
- powering safety equipment such as fire alarm or gas alarm,

- power supply of medical equipment used for resuscitation procedures in certain medical locations where an IT system is installed.

(4) The use of AFDD does not preclude the requirement to apply one or more of the other measures listed in this document.

7.3.2 Protection against internal defect arcs of assemblies

(1) Electrical installations must be designed and implemented in order to protect persons from the effects of the internal fault arcs of the assembly as practically as possible.

(2) In AC systems where:
- rated current of at least 800 A composition; and
- a maximum short-circuit current at the installation site of a composition of at least 25 kA,

one or more of the following measures must be applied to protect against hazards arising from internal fault arcs of assemblies:
a) installation of the assembly in an electrically closed environment with restricted access for qualified persons (BA5). The assembly shall not constitute a fire hazard to adjacent materials in this environment in the case of an internal fault arc.
b) Use of assemblies that follow the design and test recommendations of IEC TR 61641.
c) Current limitation using overcurrent protection devices on the supply side of the assembly.
d) Decrease the power of the fault arc by using:
   - internal fault arc mitigation systems (IAMS) using one or more effects on the fault arc, such as light, gas pressure, current or voltage harmonics, and possibly detecting the magnitude of the fault arc current within the manifold assemblies; or
   - instantaneous overcurrent protection on the supply side of the assembly.

Where the assembly is frequently serviced and maintained without interruption of power supply, protective measures (c) or (d) shall be taken into account.

(3) It is necessary to take into account the need to protect the assemblies themselves. Discontinuation of the composition can lead to interruption of the power supply with unpredictable consequences (including for the environment).

(4) The risk assessment should determine the measures to be taken to protect against the defective arc.

7.4 PROTECTION BEFORE PREVENTION

(1) The surge arrester must be so positioned that, at the moment of operation, it does not pose a danger to humans to animals or devices in the vicinity.

(2) In places where atmospheric overvoltages can cause danger, surge arresters must be installed.

(3) When electrical installations are connected to the public electricity network, surge arresters may be placed in a connection measuring cabinet in accordance with the requirements of the consent for the connection of the distribution operator.

(4) The surge arresters shall be grounded by the shortest route.

(5) The resistance of the ground for grounding surge arresters, even in the most arid weather conditions, must not be greater than that provided by the manufacturer of the used arresters as an upper limit for the effective operation of the arresters. The ground of the surge arrester shall be connected by the shortest route to the combined ground system in the building or integrated into the ground system in the building where the surge arrester is installed. The lightning arrester shall meet the requirements of the internal overvoltage protection as part of lightning protection. In general, a low ground resistance of less than 10 Ω is preferred. With a specific soil resistance greater than 250 Ωm, the earth resistance shall not be greater than 4 % of the measured value of the specific soil resistance in Ω.

(6) Existing earths may be used for the grounding of the surge arrester if they meet the requirements of the preceding paragraph.

(7) When a building has built-in lightning protection, coordination of the installation of surge arresters with internal protection against surges in the lightning protection system must be carried out, and for the grounding of surge arresters, a coordinated earthing system in accordance with the requirements of the overall protection concept with regard to the level of lightning protection is applied mutatis mutandis.

(8) The conductors of the low-voltage and low-voltage voltage range shall not be placed in the same installation channel unless measures are provided to ensure that they are not exposed to a voltage higher than their network frequency test voltage.

(9) Overvoltage protection procedures with integrated overvoltage management or safety overvoltage management must be carried out in accordance with the standard SIST HD 60364-4-443.

(10) Where surge arresters are used to protect reactive energy compensation devices against overvoltages, they shall be installed as close as possible to these devices.

(11) Where surge arresters are used to protect reactive energy compensation devices with large capacitor batteries from overvoltage, the discharge currents of the capacitors shall be taken into account and special design surge arresters shall be used.

8 ELECTRIC DISTRIBUTORS

8.1 GENERAL

(1) Each assembly must be designed, manufactured, checked and labelled in accordance with the requirements of the SIST EN IEC 61439 series standards.

(2) There shall be a minimum operating and maintenance space of 0,8 m in front of the electrical distributors. The width of the working space must allow safe operation, maintenance and disconnection.

(3) Depending on the intended use and the environment, the splitter requires minimum air and creeping distances, which constitute the basic insulation, with at least double insulation of all accessible parts against supply lines or conductors and other live parts. Only if the accessible conductive parts are connected to the grounding circuit, basic insulation is allowed.

(4) The conductors for powering the measuring apparatus and instruments on the covers or doors of the manifolds shall be flexible. In the case of flexible connections (doors, covers), flexible veins with mechanical protection against tearing must be used; the connection must remain electrically reliable throughout the range of motion.

(5) The distributor shall be complete with electrical equipment for the same types of current or voltage. Separation shall be provided between different circuits to avoid interactions, in accordance with the separation rate (separation format) of Type 1 to 4 as specified in the standard.

(6) If the distributor - product is installed and used according to the manufacturer's instructions, then it is subject to the specifications as given and guaranteed by the manufacturer. The assembly manufacturer must carry out design and individual design verifications; responsibility for compliance after installation shall be assumed by the assembler.

(7) Distributors shall meet the following design requirements in the intended environment:
1. mechanical strength of materials and parts (corrosion resistance, thermal stability of insulation materials, resistance to UV radiation, lifting, mechanical shocks, markings mechanical operation),
2. the level of protection of enclosures (appropriate IP level corresponding to the standard SIST EN 60529),
3. air and crawl distances,
4. protection against electric shock and integrity of protective circuits,
5. installation of switchgear and components,
6. internal electrical circuits and connections,
7. connectors for external conductors.

The design requirements must be verified by design verification; IP protection must be at least as determined by the environment of use, and IK protection checked according to IEC 62262

(8) Distributors in the intended environment shall comply with the following characteristics:
1. voltage abstinence,
2. increased temperature,
3. short-circuit abstinence,
4. electromagnetic compatibility.

Verification of the characteristics must be carried out by means of measurements or a comparative design; EMC is required to comply with SIST EN IEC 61000-6-2 and 61000-6-4.

(9) Distributors must provide adequate functional safety, especially in the case of a type of DBO where the influence of a lay user is present. The DBO must provide safe operation and protection against misuse.

(10) Depending on the area of use, the requirements for distributors should take into account the basic standard SIST EN IEC 61439-1 and the relevant part of the batch standards covering each area of use.

(11) The devices installed in the manifold must meet their product standards, including the SIST EN IEC 60947 series of standards. In addition, compliance with the relevant standards for RCD (SIST EN 61008, 61009), circuit breakers (SIST EN IEC 60898, 60947-2) and fuses (SIST EN IEC 60269) shall apply.

(12) In the chain of sequentially coupled protective devices, the principle of alignment must be observed, that is, in the event of a failure, the protective device must operate closest to the failure when viewed in the direction of supply. The coordination of protective devices must be confirmed by design verification or test; selectivity and energy limitation must be demonstrated by documentation from the appliance manufacturer.

8.2 IMPLEMENTATION OF THE ELECTRICAL DISTRIBUTOR

(1) In order to ensure the correct operation and use of the electrical divider, the following characteristics must be given, which must be clearly indicated in the technical documentation or on the label of the divider (data table). The data shall be consistent with realistic operating conditions, including ambient temperature, method of installation and level of contamination.

1. The rated voltage of the composition U_n shall be at least equal to the rated voltage of the electrical system. (U_n is the maximum voltage at which the assembly is designed to be operated; shall be specified for each voltage system (AC/DC).
2. The rated voltage of the circuit in the assembly U_e shall not be lower than the rated voltage of the electrical system to which it is connected.
3. The rated insulation voltage U_i shall be equal to or higher than U_n, or U_e for the same circuit. (U_i refers to the test voltage for insulation and must be verified by design verification).
4. The rated sustainable impulse overvoltage U_{imp} shall correspond to the overvoltage category and the level of pollution. For 230/400 V system is usually 4 kV (distributor in the building) or 6 kV (at the connection point).
5. The rated current of the composition I_{nA} is the maximum current that can be transmitted by the main circuits of the composition under normal operating conditions.
6. The rated current of the network circuit $I_{nc\ determines}$ the current load under normal conditions.
7. The rated peak value of the sustained current *circuit* I_{pk} shall be equal to or higher than the peak value of the potential short circuit current of the supply system.
8. the rated short-term sustained current I_{cw} shall correspond to the expected short-circuit load.
9. the rated conditional short-circuit current of assembly I_{cc} shall be used when the protective device is not part of the distributor and is specified by the user.
10. The rated conditional short circuit current in assembly I_{ca} is determined with respect to the external protective device, if not integrated.
11. The rated concurrence factor RDF shall be determined by the number of main circuits. The RDF shall reflect real use; in the case of industrial distributors, it is often determined by measuring heating.
12. Rated frequency f_n — usually 50 Hz, unless otherwise stated.
13. Pollution level – in residential and commercial premises usually level 2 (IEC 60664-1).
14. The type of grounding system for which the divider is developed (TN, TT, IT) for which the divider is developed.
15. Indoor or outdoor use – to be specified by the manufacturer of the assembly.
16. Splitter for permanent installation or movable – must be clearly marked.
17. Protection level (IP code) – determined according to SIST EN 60529.
18. Electromagnetic Compatibility Class (EMC) — Class A (industrial) or B (residential).
19. Specific operating conditions – e.g. ambient temperature above 40 °C, altitude above 2000 m, etc.
20. overall dimensions, and
21. mass, if necessary for assembly or transport.

All this information must be provided by the assembly manufacturer in the technical file and confirmed by verification of the individual design (piece test).

(2) Where actual current data are not available, the concurrence factors in Table 5 shall be taken into account when calculating the distribution line current load or part of the distribution line.

Table 5: Concomitance factors depending on the number of circuits

Number of main circuits	Simultaneous factor
2 and 3	0,9
4 and 5	0,8
6 to 9	0,7
10 and more	0,6

When calculating heating, it is also necessary to take into account the internal arrangement of the components and the actual dissipation of power. If additional devices (e.g. controllers, communication modules) are used, thermal analysis or measurements should be used.

(3) For altitudes above 2000 m to 3000 m, greater air distances should be taken into account, the factor being 1.14.

(4) The safety lighting divider shall be visibly different from the general lighting divider in the case of use of a central battery. The system shall be clearly marked and have separate protection and a service warning label.

(5) General and safety lighting dividers may be combined provided that the operation does not lead to error and there is no interaction.

[SIST EN IEC 61439-1, point 10.6.3: separation by a non-combustible barrier or equivalent structure must be ensured.]

(6) The safety lighting distributor must have a switch to switch on the entire safety lighting, without affecting the automatic switching. The switch shall enable a functional test and shall not disable automatic operation in the event of a power failure.

(7) Where a residual current device (RCD) that does not protect the distributor itself is installed to protect against electric shock in the installation manifold, additional protection shall be provided:
1. the power cable must be placed in an insulated pipe,
2. in the case of TT systems, the cable must not contain a PE conductor,
3. In the case of a TT system, the inlet shall be further insulated to the first connections of the protective device.
   (SIST HD 60364-4-41: supplemented by dual protection requirements if the RCD is not integrated in the distributor itself.)

(8) The installation of devices and equipment on or in the distributor must not affect the required level of protection (IP). After each processing or additional installation, it is necessary to check that the IP protection is not reduced; verification is part of the verification of an individual performance.

8.3 Assemblies for photovoltaic installations (PV distributors)

(1) These are assemblies where, in the DC part of the photovoltaic installation, energy from PV modules is received and distributed in one or more circuit outputs. PV distributors are a special type of low-voltage switchgear and control assemblies intended for use in photovoltaic systems and must meet the requirements of SIST EN IEC 61439-1 and the special requirements of SIST EN IEC 61439-7.

(2) They are used for a combination of electrical power where the input and output voltages do not exceed 1500 V DC and are supplied for support and control functions from electrical networks where the voltage does not exceed 1000 V AC. PV distributors shall be designed to withstand the highest open circuit voltage of the PV field ($U_{oc\ max}$) at the lowest ambient temperature.

(3) They are stationary compositions in the housing. PV dividers, as a rule, are stationary; movable or modular systems are only allowed for test and portable applications if they meet all safety conditions.

(4) Only authorised persons may work with them, but they may be placed in places with access for lay persons, provided that they have appropriate protection and markings. As a minimum, IP2X

protection and additional indication of the danger of DC voltage must be provided when accessing laypersons.

(5) They are suitable for installation in internal or external environments, with protection according to exposure conditions. For outdoor use, PV distributors must have at least IP54 and UV resistance and a temperature range of -25 °C to +60 °C.

(6). The characteristics of the assemblies must ensure compliance with the capabilities of the circuits to which they are connected and with the conditions of installation. These characteristics must be given by the manufacturer of the assembly. All rated values must be verified by design verification.

(7) The rated operating voltage must be given by the assembly manufacturer and must be at least Uocmax of DC circuits. It is necessary to take into account the combination of voltage at low temperatures, when U_{oc} PV modules increase; the recommendation is 1,25 × the nominal value of the module.

(8) The rated current of the DC part shall be equal to or greater than the sum of the short circuit currents of Isc max of all connected input circuits. Current values shall take into account cooling and shading conditions; the overload protection shall be aligned with the nominal current of the busbars and conductors.

(9) If the distributor is powered from more than one source, it shall bear a warning sign indicating that the assembly may be powered from more than one source and that the parts inside may remain energised even after the main power supply has been switched off. The warning labels must be durable, visible and UV-resistant.

(10) The manufacturer must provide warnings on the appropriate location of use (indoors, outdoors, in the shade or in the sun). When exposed to direct sunlight, materials with high resistance to heat and UV radiation must be used.

(11) Where the assembly is in direct sunlight, it shall bear a warning that sun-exposed points may be hot and dangerous to touch. Warning labels shall comply with SIST EN ISO 7010 (sign W012 – hot surface).

(12). Where an indoor assembly is accessible to lay persons, it shall have a degree of protection of at least IP2XC. In the case of lay access, mechanical protection must also be provided (IK08 or more)..

(13) The effectiveness of mechanical activation elements, latches and latches should be regularly checked. Verification of the functioning of mechanical parts shall be carried out during periodic inspections; must be recorded in the technical documentation as part of the maintenance.

(14) The PV manifold must be able to disconnect the DC isolator in accordance with SIST EN IEC 60947-3 and SIST EN 62446-1, point 6.2.4. If the PV distributor is used in combination with an inverter, it is recommended that it be coordinated with the inverter manufacturer's instructions for maximum input parameters.

8.4 Compositions that lay people can handle (DBO)

(1) The requirements apply to distributors with a rated voltage of up to 440 V AC intended for use in buildings where they can be handled by lay persons:

a) The distributor shall comply at least with the surge category III and contamination level 2. Surge category III applies to equipment connected directly to fixed installations; Pollution 2 is suitable for ordinary residential and commercial premises.
b) The assembly manufacturer shall provide in the documentation the requirements for the bulky verification by the assembly manufacturer that the DBO meets the requirements of SIST EN IEC 61439-3 after installation.
c) Where the RCD protection device supplies more than one end-circuit, the user shall be able to identify which circuits are protected by the device. The markings must be durable, legible and clearly linked to the output connections.
d) The level of contamination must be at least 2 unless otherwise specified by the manufacturer

for a specific environment.

e) After installation according to the manufacturer's instructions, the level of protection must be at least IP2XC, in accordance with SIST EN 60529. IP2XC must be maintained even during normal operation (opening doors, typing RCD test keys, etc.).

f) IP2XC must also be maintained when operating and utilizing devices (e.g. switching, test keys, changing fuses). The structure shall prevent contact with live parts during all normal manipulations.

g) The level of protection may be temporarily reduced if product standards allow it (e.g. SIST EN IEC 60269-3 for D-type fuse change). Short-term loss of IP2XC protection is permitted when components are replaced, if this is described in the manufacturer's instructions.

h) The bare conductors shall be inside the enclosure or protected by a barrier with the enclosure or barrier providing protection of at least IPXXC. Protective barriers shall be made of non-combustible materials (flammability class at least V-2 according to IEC 60695-11-10).

i) If the output circuit does not contain a connection for a neutral conductor, the number of connections for an N conductor shall be at least equal to the number of circuits that require it. These connections must be arranged or marked in the same order as the corresponding connections of line conductors. The marking of neutral clips must be clear, unambiguous and permanent.

j) The DBO shall have at least two connectors for protective conductors (PE) of electrical installations dimensioned in accordance with SIST HD 60364-5-54. The PE collector shall be reliably fixed, unwind-proof and electrically continuous with the main grounding.

(2) Additional thermal performance requirements:

- the limits of heating in the manifold must not exceed those laid down in SIST EN IEC 61439-1;
- The distributor shall be verified on the basis of I_{nA} (designated current composition) with all circuits operating simultaneously with the corresponding RDF;
- when heated, it must be ensured that the materials do not exceed the permitted operating temperature (e.g. 105 °C for insulation, 140 °C for contacts).

(3) Additional mechanical resistance requirements:

- DBO must have at least IK07 resistance according to SIST EN 62262 (impact resistance);
- the housing must be of non-combustible material (flammability class V-2 or better).

(4) The DBO shall contain at least the following information:

- rated current I_{nA},
- nominal voltage U_n,
- frequency f_n,
- the level of IP protection,
- the DBO symbol or the text "Divider for laymen",
- manufacturer's code, serial number, year of manufacture,
- Multi-source power warning (if any).

(5) For each DBO installed, the assembler must carry out a bulky check that includes:

- visual inspection and verification of the completeness of the composition,
- insulation test at rated voltage (1,5 kV AC),
- verification of protective circuits (PE continuity),
- checking the correct marking and IP protection after installation,
- checking the functionality of RCDs and protective devices,
- Review of correct grounding and neutral connections.

(6) Particular attention is paid to the arrangement of components – RCDs, circuit breakers, clips, collectors – in such a way as to allow safe and transparent use even for lay people. A DBO must have at least two connections for the protective conductors of electrical installations. Mechanical and electrical reliability of the PE collector is required, in accordance with SIST EN IEC 61439-3,

point 10.7.1.

(7) For residential distributors, it is recommended that they also have space for the installation of communication and smart modules (e.g. energy meters, controllers, KNX or Modbus modules), provided that thermal conditions and IP protection are not affected.

8.5 COMPOSITIONS FOR CONSTRUCTION (ACS)

(1) Construction site assemblies are intended for temporary use on construction sites and similar work areas where mechanical, climatic and electrical loads greater than normal are expected.

(2) They must meet all the general requirements of Part 1 of SIST EN IEC 61439:2021, unless additional or more stringent requirements are specified in Part 4 of this standard.

(3) Construction and materials:

- The housing must be made of mechanically resistant, non-combustible and weather-resistant materials (steel, aluminium or UV-stable plastic).
- The assembly shall be resistant to mechanical shocks of at least IK08 according to SIST EN 62262.

- The degree of protection of the housing must be at least IP44; in outdoor conditions or heavy rainfall IP65.

In the case of portable splitters, IP protection must be maintained even after repeated transmissions and shocks.

- Handles, bolts and sockets must be resistant to corrosion and wear.
- The construction must prevent the ingress of water, dust and mechanical particles.

(4) Mechanical strength and stability:

The housing must withstand a fall from a height of 1 m without functional damage. Distributors must be equipped with supports or pedestals that allow a stable layout.

(5) Electrical characteristics:

a) Rated voltage U_n: up to 1000 V AC or 1500 V DC, depending on the system.
b) Rated current I_{nA}: normally up to 1250 A, unless otherwise specified by the manufacturer.
c) Short-circuit capacity: determined according to the highest possible current of the power supply. The ACS shall have short-circuit abstinence verified by design verification (test or computational analysis).
d) Overvoltage category: at least III; Level of pollution: At least 3.

(6) Thermal requirements:

a) Internal components must be arranged in such a way as to allow efficient air cooling.
b) Ambient temperature for the tests: –25 °C to +40 °C. The ACS shall operate without degradation throughout the temperature range.]

(7) Safety requirements:

a) Each distributor shall be equipped with a main protective device (RCD or circuit breaker) to protect all output circuits.
b) The RCD shall have a rated residual current $I_{\Delta n} \leq 30$ mA for the protection of persons. The protection shall be divided into individual circuits to ensure selectivity and prevent failure of the entire distributor.
c) PE and N collectors must be firmly fixed and grounded.
d) Metal parts must be connected into a common protection system.
e) The marking of the connections should be durable, resistant to water and UV.

(8) Functional requirements:

a) The ACS shall be capable of fully disconnecting all circuits with one main switch.
b) The sockets shall comply with SIST EN 60309-2 (industrial sockets).
c) If the distributor is powered by more than one system, this shall be clearly indicated by the inscription:

‘Warning – multiple power sources!’ The markings must be permanent and located in the immediate vicinity of the main switch.

(9) Labels and documentation:

a) A permanent plate must be installed on the divider with the following information:
   - rated voltage (U_n),
   - rated current (I_{nA}),
   - frequency (f_n),
   - IP and IK protection,
   - the name of the manufacturer or manufacturer of the assembly,
   - year of manufacture,
   - voltage tell-tales,
   - reference to SIST EN IEC 61439-4.

b) The documentation must include a wiring diagram, a description of the protective devices, a list of components and a declaration of conformity (CE + SIST EN IEC 61439-4).

(10) Verification:

The ACS must be checked for the following points:
- mechanical resistance (fall, vibration),
- IP and IK protection,
- Electrical sustainability and insulation;
- operation of protective devices,
- heating and current carrying capacity,
- operation under conditions of moisture and dust,
- EMC compliance according to SIST EN IEC 61000-6-2 and -6-4.

(11) Transmission splitters:

The portable ACS must be equipped with handles or wheels, be stable in a vertical position, and cable connections must be protected from mechanical damage. All connectors shall be colour coded and correspond to the rated current and voltage values (blue – 230 V, red – 400 V).

(12) Wiring and internal connections:

All conductors must be flexible, with additional protection against tearing; cross-sections shall correspond to the nominal current loads and shall be mechanically fixed by means of clamps.

(13) Specific requirements for construction sites:

a) The ACS shall be capable of connecting mobile machinery, tools and lamps.
b) The output sockets must be arranged in such a way as to prevent mechanical damage to the cables.
c) The housing should be colour contrasting (yellow, orange or gray) to facilitate visibility.

N.B.: colour coding is not normative, but is recommended for security and identification reasons.

(14) Maintenance and periodic reviews:

Due to difficult working conditions, a visual inspection of the ACS at least every 6 months and a test of the performance of the RCDs is recommended.]
- all mechanical components (locks, bolts) must be inspected regularly,
- IP protection, seals and mechanical joints should be checked,
- check the functionality of the main switch and protective devices.

(15) Incorrect or non-standard ACS completions by the user are not allowed. Any change or addition must be made by a qualified assembly manufacturer and re-verified according to the requirements of the verification of the individual implementation (piece verification) in accordance with SIST EN IEC 61439-1:2021.

8.6 MEETINGS FOR DISTRIBUTION IN PUBLIC NETWORKS

(1) Assemblies for distribution in public networks are intended for use in public power distribution systems, which are usually located in street cabinets, cable shafts or free-standing distribution systems.

The scope of application is d electricity distribution:
- in public low-voltage networks (e.g. street cabinets, connection points, light distributors),

- for powering lighting, signalling, electric vehicle charging stations, measuring devices and telecommunication elements.

General requirements:
The compositions must meet all the requirements of SIST EN IEC 61439-1, with additional conditions regarding resistance to weather and mechanical influences. ACS-PD must be resistant to corrosion, UV radiation and moisture; materials must be tested for external use (IEC 60068-2-11, -2-75).]

Construction and materials:
a) The enclosure shall provide a protection degree of at least IP44 recommended IP54 or higher.
b) Mechanical resistance must be at least IK08.
c) The housing must be made of metal, glass plastic or UV-stable plastic.
d) The composition must be resistant to precipitation, condensation and temperature changes.

In the case of distributors installed underground, resistance to water ingress (IP67) and corrosion must be ensured.

Electrical characteristics:

a) Rated voltage: up to 1000 V AC or 1500 V DC.
b) Rated current: Usually up to 1600 A.
c) Overvoltage category: at least III.
d) Level of pollution: At least 3.
The specific conditions for external installation – humidity, UV, salt, dust and mechanical vibration – must be taken into account.

(1) Safety requirements:
All metal parts must be grounded and interconnected.
A double insulation or barrier must be provided to protect users.
Doors and lids shall be capable of being locked.
Protective devices (fuses, RCDs, circuit breakers) must be accessible only to qualified personnel. Protection against accidental contact during servicing must be provided.

(2) Labelling:
- rated voltage and current,
- IP and IK level,
- the name of the manufacturer,
- year of manufacture,
- the warning "Only for qualified persons",
- reference to SIST EN IEC 61439-5.

(3) Verification:
Verification of the following characteristics is required:
- mechanical resistance,
- resistance to weathering,
- Electrical sustainability and insulation;
- heating,
- IP and IK level,
- EMC compliance according to IEC 61000-6-2 and -6-4.

8.7 COMPOSITIONS FOR TESTING, LABORATORY AND SPECIFIC USE

(1) They are assemblies intended for laboratories, test facilities, development and production premises where high values of current, voltage or short-circuit phenomena are expected.

(2) Scope:
- testing laboratories,
- production lines with electrical tests,
- test apparatus for motors, transformers, cables, etc.,

- mobile testing systems.

(3) Specificity of operation:
a) frequent and fast switching,
b) variable voltages and frequencies,
c) high current loads in short periods of time,
d) the possibility of manual or remote control.

The assemblies shall withstand the dynamic mechanical and thermal loads encountered during the tests.

(4) Design requirements:
a) the enclosure must have a minimum IP2X protection; Recommended IP3X.
b) protection shall be provided against electric shock during the tests.
c) the housing must have a mechanical resistance of at least IK08.
d) the materials used must have a high temperature stability.

Materials must withstand heating up to 125 °C without deformation.

(5) Electrical requirements:
a) rated voltage: up to 1000 V AC or 1500 V DC.
b) Nominal current: to be specified by the manufacturer (may exceed 1600 A).
c) Overvoltage category: minimum III, sometimes IV (according to test conditions).
d) Level of pollution: At least 2.

(6) Safety requirements:
a) mechanical separation of the test area from the supply zone must be ensured.
b) Interlocks must be fitted to prevent access to live parts.
c) a forced ventilation system must be provided if high temperatures are expected.

A door safety lock is required that prevents opening during power supply.

(7) Labelling and documentation:
- nominal parameters,
- the warning “PREISIONAL INTEGRITY SYSTEM – NON-SECURITY FOR LIFE”,
- a plan of electrical connections and protections,
- documentation on security measures.

(8) Verification:
- heating test,
- mechanical strength test,
- dielectric strength test,
- a test of the correct functioning of the blockages,
- EMC verification.

8.8 COMPOSITIONS FOR SPECIAL LOCATIONS - PUBLIC SPECIAL VERSIONS, CORRESPONDENCE, CAMPS, MARKETS AND APPLICABLE POSITIONS FOR ELECTRICAL VEHICLES

(1) They are designed to power equipment in public spaces and in special locations where the influences of moisture, mechanical stress, dust and access by laymen are present. The requirements also apply to assemblies powering recharging points for electric vehicles, including stationary and free-standing power supply units (AC and DC).]

(2) Scope:

- Distributors for the connection of motorhomes, trailers and campsites,
- Distributors for markets, fairs, parking lots, swimming pools and marinas,
- charging stations for electric vehicles (AC and DC),
- Distributors for supporting circuits of EV systems (illumination, control, communication, charge

control).

(3) Environmental conditions:

a) minimum enclosure protection IP44, recommended IP55 or higher for outdoor use,
b) mechanical resistance of at least IK08, in public EV stations IK10,
c) Temperature range of operation: –25 °C to +40 °C,.
d) resistance to UV radiation, salt, moisture and corrosion.

Power stations for electric vehicles shall be resistant to shocks and vibrations due to possible collisions or vandalism (IEC 62262 test).

(4) Electrical requirements:

a) rated voltage: up to 440 V AC or 1500 V DC,
b) Nominal current: up to 250 A (AC) or up to 400 A (DC for fast charging),
c) Overvoltage category: III,
d) Level of pollution: 3.

Additional requirements for EVs:

EV stations shall be designed for continuous operation at rated load and short-term current shocks during activation. All DC charging circuits must be separated from the AC part by a physical and electrical barrier and checked for insulation resistance (IEC 61851-23).

(5) Safety requirements:

a) each output circuit shall be protected by an RCD ($I\Delta n \leq 30$ mA) or functionally equivalent protection according to SIST EN IEC 62955 (DC fault detection),
b) complete separation between the circuits of different users must be ensured,
c) sockets must be of type SIST EN 60309-2 or IEC 62196 (Type 2 / CCS / CHAdeMO) for EV,
d) covers and connections must be protected against ingress of water during connection,
e) protection against electric shock must be provided even when the cable is disconnected (contacts must not be energized without the presence of the vehicle),
f) all metal parts must be grounded and electrically connected,
g) the housing must be capable of locking and blocking access to lay people.

Additional requirements for recharging points:
Power stations shall have a system protection against DC leakage current ≥ 6 mA which, in the event of a fault, disconnects the power supply and disables reactivation without reset. In the case of combined AC/DC charging stations, the condition of galvanic separation between the network and the vehicle according to SIST EN 61851-23 shall be fulfilled.

(6) Labelling:
- rated voltage and current,
- IP and IK protection,
- the indication "PACKING COMPONENTS FOR PUBLIC APPLICATION" or "EV FILLING POSITION",
- the name of the manufacturer and the year,
- the warning "Do NOT OPEN UNDER PROGRESS",

Additional requirements for recharging points:
- connector type designation (e.g. ‘IEC 62196 Type 2 — AC’ or ‘CCS Combo 2 — DC’),
- maximum permissible voltage and current warning,
- reference to SIST EN IEC 61439-7:2021 and SIST EN IEC 61851-1.

(7) Design requirements:
a) electronic and control parts (meters, RFID readers, communication modules) must be installed in a separate dry part of the housing,
b) connectors shall have protection IPXXD when not in use,
c) the cables must have mechanical breakage protection (tensile stress test 500 N),

d) The control circuits for communication with the vehicle (PWM, PLC, ISO 15118) shall be protected against electromagnetic interference.

Electronic charging station units shall be tested according to IEC 61000-6-1 and IEC 61000-6-3 (EMC).

(8) Functional requirements:
a) The EV station shall provide automatic power cut-off in the event of insulation failure or current overrun,
b) for DC charging, a system for measuring and limiting current must be installed,
c) protection against overheating and short-circuit must be fitted,
d) communication with the vehicle shall comply with SIST EN ISO 15118-1/-2 (vehicle-to-grid communication),
e) on-board systems shall be capable of operating control and reading (SoC, fault, temperature, current),
f) the charging station shall have a self-diagnosis system that, if a malfunction is detected, prevents further operation until the malfunction is rectified.

(9) Verification:
- IP and IK protection test,
- electrical safety and insulation test,
- a test of the correct functioning of the RCD/DC detector,
- thermal stability test at full load,
- a test of the functioning of the communication interfaces,
- EMC compliance test.

(10) Additional requirements for public EV stations:
- a safe case against vandalism must be provided,
- the charging cable must be capable of being automatically retracted or hung securely,
- safe voltage disconnection must be ensured when the connector is removed,
- it must be possible to remotely monitor and update the software,
- must comply with the requirements of the MID (Measurement Instruments Directive) if it includes energy metering for billing.

9 ENERGY EFFICIENCY OF ELECTRIC INSTALLATIONS

9.1 GENERAL

(1) In order to care for the environment, to optimise the allocation and management of energy sources and consumers, due to the use of dispersed energy sources that are connected to the public low-voltage electricity network also through electrical installations of end users, this should also be taken into account when designing new or designing changes to existing low-voltage electrical installations. The design shall ensure compliance with the ‘energy-efficient design’ principles of SIST HD 60364-8-1, including determination of energy flows, active and reactive energy consumption, use of Energy Management System (EMS) and planning of interactions with other building systems (BACS, HVAC, lighting).

(2) The requirements and recommendations for energy efficiency should not affect the level of safety achieved so far. People's safety is always a priority. When selecting efficiency measures, it should be ensured that protection against electric shock, fire, overload and electromagnetic influences remains equivalent to or higher than the requirements of SIST HD 60364-4 (parts 41-44) and SIST HD 60364-5 (parts 51-55).

(3) Energy efficiency management shall not reduce the availability of electricity and services below the level agreed with the user. Where automatic load control or resource allocation is used, the system shall at all times maintain power priorities for critical functions such as security systems, evacuation lighting and communications.

(4) Areas where energy efficiency is planned are:
1. electrical accommodation of dwellings,
2. electrical installations of business premises,
3. industrial electrical installations; and
4. Infrastructural electrical installations.

For each area, an "energy use boundary" must be defined in accordance with SIST EN ISO 52000-1, which covers all relevant energy sources and consumers, as well as interconnections with other building systems.

(5) The starting points for the design of energy-efficient electrical installations are:
1. energy profile of the load (labour and reactive energy),
2. availability of local resources (photovoltaic installations, wind turbines, generators, etc.) and storage,
3. reduction of energy losses in electrical installations,
4. distribution of circuits according to energy efficiency (grids),
5. use of energy on the basis of user requirements,
6. the structure of tariffs in the electricity supplier’s offer, while maintaining the quality of the supply.

When planning, it is recommended to use Energy Performance Indicators (EnPI), such as: distribution efficiency (ηD), specific energy use (kWh/m²·year) and energy availability factor. These indicators shall be consistent with the SIST EN ISO 52000-1 methodology.

(6) The implementation of electrical energy efficiency measures may require the efficiency of other energies, in which case the whole should be taken into account in the assessment of energy efficiency. The overall energy performance of a building is determined in accordance with SIST EN ISO 52000-1 as the ratio of total energy supplied to usable energy (overall energy performance).

(7) More detailed requirements for managing the energy efficiency of electrical installations are given in the standard SIST HD 60364-8-1. According to this standard, the project documentation must include:

- the energy plan of the system (chart of energy flows),
- description of measuring points and control strategy,

- requirements for the collection and archiving of data on energy use,
- the criteria for estimating the savings achieved.

9.1.1 MEASUREMENT AND MONITORING OF ENERGY EFFICIENCY

(1) In order to ensure and verify the energy efficiency of electrical installations, it is necessary to ensure the measurement, collection and analysis of data on energy use. In accordance with SIST HD 60364-8-1, Chapter 7, the design of electrical installation must be prepared in such a way that it is possible to measure at least the following quantities:

- consumed active and futile energy,
- return of energy flow from local sources,
- power and power factor by main circuits,
- voltage, current and frequency,
- Harmonic components and voltage distortion factor.

(2) Measurement points should be arranged in such a way as to allow separate monitoring of the main load and resource groups (e.g. lighting, HVAC, office equipment, EV chargers, PV systems). The design of the measuring points must take into account the hierarchical structure of the circuits and allow for the energy balance of the building as defined by SIST EN ISO 52000-1.
(3) The measuring and communication equipment must be capable of remotely collecting, archiving and processing data. The user must be able to view the measurement data.
The data shall be accessible through standardised communication interfaces (e.g. Modbus, BACnet, KNX, IEC 61850) and integrated into the energy management system (EMS). The user should have an overview of the current and cumulative state of consumption and efficiency indicators (EnPI).

(4) The measuring equipment shall have an accuracy class in accordance with SIST EN 50470-3 or IEC 62053. For the purpose of reporting according to SIST EN ISO 52000-1, accuracy of at least Class 1 is recommended, and for power measurement with non-linear loads Class A is recommended.
(5) The measurement system shall be capable of automatically calculating energy indicators and monitoring trends at intervals not exceeding 15 minutes. A warning function in case of exceedance of limit values is recommended, as well as the possibility to export data to building management systems (BMS/BACS).

(5) Energy efficiency reports should show:
- monthly and annual energy consumption by load group,
- utilization of distribution and transmission pathways,
- the share of renewable energy and the share of return to the grid;
- estimate of energy losses in cables and transformers.

These data form the basis for continuous performance improvement according to the PDCA (Plan-Do-Check-Act) principle in accordance with SIST EN ISO 50001.

9.2 CONSUMER/PRODUCTOR (PROSUMER)

(1) The consumer/producer electrical installation (PEI) may or may not be connected to the public electricity grid and may operate with:
1. local power supplies; or
2. local reservoirs and

control and manage the energy of connected resources to supply them:
1. energy-consuming equipment,
2. local reservoirs or,
3. in the public electricity grid.

SIST HD 60364-8-2 defines PEI (Prosumer's Electrical Installation) as an installation that enables two-way power flow, management of self-generation, storage and consumption, and interaction with the public network through a control system (EMS). The PEI must be designed to operate under different regimes:
- on-grid (connection to the public network),
- off-grid (island operation),

- microgrid (local interconnection of multiple resources and loads).

(2) The requirements and recommendations shall be applied in accordance with the requirements of all parts of the SIST HD 60364 standard for new installations and modification of existing installations. When reconstructing existing installations, it must be ensured that the PEI maintains compatibility with the protection and grounding system in accordance with SIST HD 60364-4-41 (TT, TN, IT systems).

(3) Smart grids have an impact on PEI:
1. addressing the needs of the user must take into account the limitations of the public network; and
2. designing and designing installations that allow the allocation of loads and the selection of resources.

The PEI should allow for participation in flexibility programmes. Demand Response), where the EMS manages burdens, storage and local resources by:
- optimizes consumption according to the tariff signal,
- decreases peak power,
- Supports voltage and frequency stability.

The communication shall be carried out according to the protocols as defined in SIST EN IEC 61850, SIST EN IEC 63110 or OCPP when used for electric vehicle charging infrastructure.

(4) The consumption and production of energy from certain renewable sources (such as photovoltaic and wind) is interruptible and it is therefore recommended to use local energy storage facilities that allow island or isolated operation.

Reservoirs shall comply with SIST EN IEC 62933-5-2 or SIST EN IEC 62619 for lithium-ion batteries. The control shall include overvoltage, overheating and short-circuit protection and ensure charge/discharge control in coordination with the EMS.

(5) The security of the PEI shall not be inferior to that required by this Guideline and other parts of the SIST HD 60364 series of standards. Safety also includes the prevention of back-up to the public network in the event of a failure (Anti-Islanding Protection) and proper synchronisation of phases when reconnected.

(6) A low-voltage PEI is considered to be a set of system functions:
1. power supply (connection to the public grid, local generators, PV, wind installations, … batteries);
2. distribution (distributors, wiring systems);
3. consumption (motors, heating, lighting, EV charging stations, … lifts);
4. energy management (burden-scheduling, control and storage devices …);
5. interaction with the public network (including bidirectional current measurement and tariff control),
6. Communication with other Building Automation and Control Systems (BACS)
7. energy reporting and archiving of energy flow data for at least 12 months.

(7) More detailed requirements for PEI are given in the standard SIST HD 60364-8-2.

(8) The PEI shall specify:
- operation in all regimes (on-grid, off-grid, micro-network),
- Reservoir filling/discharging strategy;
- the method of protection against island operation,
- type and configuration of converters (DC/AC, AC/DC),
- synchronisation and automatic reconnection,
- the method of connection of communication and measuring devices.

The PEI shall be capable of being connected to an energy management system (EMS) and shall be designed to allow future extensions (e.g. additional storage tanks or EV chargers).

9.3 LOCAL PRODUCT SOURCES OF ELECTRIC ENERGY

(1) The requirements for electricity generation sources are set out in the normative documents of the DSO.

In addition, local production sources must meet the requirements of SIST HD 60364-8-2, in particular with regard to safety, selectivity and compatibility of protection, and the standard SIST EN 50549-1 (conditions for connection to the public low-voltage network).

(2) The maximum total renewable power for final customers is determined by the Regulation on self-consumption of electricity from renewable energy sources and the Regulation on small-scale installations for the production of electricity from renewable energy sources or high-efficiency cogeneration.

(3) When determining the power of generating installations, the designer must take into account both the rated power and the dynamic limits set by the system operator (SODO or DSO of the local distribution operator), including the requirement to regulate voltage, frequency and power factor.

(4) Normal plug/socket combinations should not be used to connect local generation resources. The connection shall be permanent and shall allow mechanical locking and electrical safety disconnection (Lock-out/Tag-out). The use of plug-in connections is only allowed for transmission units with SELV or PELV voltage.

(5) The local production source referred to in the second paragraph of this point up to the total power specified in the normative documents of the DSO may be connected to the final circuit of the in-house low-voltage installation of the final pantograph with a minimum cross-sectional area of 1,5 mm2. The user shall not load this circuit above the design value or above the value determined by the nominal value of the fuse protecting the final pantograph. Selective operation of protective devices and voltage and frequency control must be ensured in the circuit. In the case of diffuse sources operating simultaneously, an "source coordination" function shall be provided.

(6) Reprocessing of the electrical installation of a building, the electrical installation of local resources (self-supply units) and the processing of distributors, including the possible reprocessing of the measuring point, must comply with the conditions of the connection consent. Each change must be documented with revised technical documentation and include an analysis of the impacts on the energy performance of the building in accordance with SIST EN ISO 52000-1, taking into account the energy balance and the emission factor of the source.

(7) The load-bearing structures of local production low-voltage sources and their associated converters and other associated equipment are part of the building. The metal parts of load-bearing structures which are not live shall be interconnected and grounded in accordance with Chapter 5 and, for photovoltaic installations, in accordance with point 11.3.7 of this Guideline.

(8) In order to prevent electric shock, the self-supply device shall be capable of being disconnected from the distribution network at any time and shall ensure that a safe low voltage (SELV or PELV) is provided in the self-supply device in the off-mode. The switch-off must be performed automatically via a protective relay that detects overvoltage, undervoltage, over- or under-frequency and asynchronism. These parameters must be set in accordance with SODO Technical requirements and SIST EN 50549-1.

(9) In the event of failure of the distribution network or detection of exceeding the prescribed voltage and frequency limits in the distribution network, the self-supply device shall be automatically switched off and shall not transmit electricity to the distribution network. Anti-islanding protection must be carried out by detecting changes in phase angle, frequency or voltage and must turn off the device no later than 0.2 s after detection of the deviation.

(10) Notwithstanding the requirement of the preceding paragraph (8), in the event of failure of the distribution network or detection of exceeding the prescribed voltage and frequency limits of the distribution network, the self-supply device may be operated in island operation mode, provided that the separation of the entire low-voltage electrical installation of the building from the distribution network is ensured. Island operation must be enabled by an EMS that coordinates flows between generation sources, storage tanks and loads and prevents reverse power. When switching from island to network mode, the synchronization of phases and the verification of voltage conditions must be carried out.

(11) Management of local production resources
The PEI must include an Energy Management Control Function (EMCF) that:

- optimises the operation of local resources and reservoirs,
- enables power control according to the DSO signal,
- records the energy balance of the building,
- enables dynamic operation in accordance with the requirements of EN ISO 52000-1 and the guidelines for the energy balance of buildings.

(12) Reporting and analysis

For local sources exceeding 10 kW, it is recommended to provide automated energy data logging and an annual report including:

- energy produced, consumed and delivered,
- efficiency of converters,
- self-consumption ratio,
- Self-sufficiency ratio.

These indicators shall be determined in accordance with SIST EN ISO 52000-1 and SIST HD 60364-8-2.

10 PROTECTION OF ELECTRICAL EQUIPMENT

10.1 GENERAL

(1) All installed electrical equipment of electrical installation shall comply with the provisions of point 0.1.3 of this Guideline.

(2) Appliances and equipment in the electrical installation system must comply with the Rules on making available on the market electrical equipment designed for use within certain voltage limits.

(3) Appliances and equipment in the electrical installation system must be electromagnetically compatible with the intended environment. For those appliances and equipment in the electrical installation system which cause excessive disturbances due to their operation, such as: rapid and slow voltage changes, flicker strength, harmonic voltage and harmonic current, inter-harmone voltage and inter-harmone current, voltage asymmetry, direct current and others, shall be ensured by appropriate measures to ensure that:

a) these disturbances do not exceed the prescribed limits in accordance with the SIST EN 50160 standard and the SODO normative instructions,
b) do not interfere with the operation of other devices and equipment in the installation system,
c) do not interfere with devices and equipment in other installation systems,
d) not transmit excessively high disruptive flows to the public electricity grid that could cause interference to other consumers in accordance with IEEE 519;
e) an appropriate cross-section of the neutral conductor is selected.

The entire assembly of low-voltage electrical installations, together with the fixed-connected equipment, falls under the Electromagnetic Compatibility Rules in the field of stationary assemblies and is subject to the requirements as stated in the said Rules.

(4) Each piece of equipment shall conform to such standards as are compatible with and additionally applicable to ISO standards.

(5) In the absence of appropriate standards or additional ISO standards, such a piece of equipment must be selected by special agreement between the person determining the installation and the installer.

(6) Electrical apparatus with electrodes or non-insulated heaters which immerse themselves in water must not be connected directly to the electrical installation, with the exception of cathode protection devices.

(7) After each intervention or servicing in the installation of the installed apparatus or devices, they must be guaranteed the same level of safety as originally laid down.

(8) The equipment must be suitable for the nominal installation voltage.

(9) The equipment must be selected for the planned current to be flowing in normal operation.

(10) If the frequency affects the characteristics of the equipment, the rated frequency of the equipment shall correspond to the system frequency of the installation.

(11) The power of the equipment must correspond to normal operating conditions, taking into account the load factor.

(12) Equipment must also meet the requirements of external influences, see 3.1. The following classes are recommended:

AA ambient temperature AA4 (-5 °C to +40 °C)
AB atmospheric humidity AB4 (-5°C +40°C, 5% to 95%)
AC elevation AC1 (≤ 2000 m)
Other environmental conditions (AD to AR) XX1 for each parameter
Use and construction of buildings (B and C)XX1 for each parameter except XX2 for parameter BC
However, Table 51 A of SIST HD 60364-5-51 should be used to adapt to the specific requirements, and the list of externalities can be found in Appendix A of the same standard.

(13) All equipment, including wiring, must be so arranged as to facilitate its operation, inspection and maintenance and access to its connections.

(14) Equipment must be selected and constructed in such a way as to avoid any adverse effects between the electrical installation and other non-electrical installations.

(15) Appropriate measures must be taken to prevent excessive currents in the protective conductor in the installation and equipment which reduce the safety or normal use of the electrical installation. Electrical equipment which, under normal conditions, generates a current in the protective conductor of its supply shall comply with the protective provisions.

Table 6:Limits of alternating current components of the protective conductor of electric consumers for frequencies up to 1 kHz

Rated AC current	Maximum protective conductor current for frequencies up to 1 kHz
$0 < I \leq 2$ A	1 mA
2 A < $I \leq 20$ A	0,5 mA/A
> 20 A	10 mA

Table 7: Limits of DC components of protective conductor current

Rated AC current	Maximum current of protective conductor d.c.
$I \leq 2$ A	5 mA
2 A < $I \leq 20$ A	2,5 mA/A
> 20 A	50 mA

(16) Plug-in electrical equipment with rated input power ≤ 4 kVA shall be designed so that the current in the protective conductor has a smoothly superimposed DC component limited to ≤ 6mA. For plug-in electrical equipment with a rated input power > 4 kVA and permanently connected electrical equipment independently of the rated input power, the protective measures shall be specified in the instructions for use. In the case of a protective conductor current >6 mA d.c., an appropriate protective device, e.g. type B RCD, shall be selected.

10.2 INSTALLATION OF ELECTRICAL EQUIPMENT

(1) Electric generators must be installed in special rooms and protected by appropriate partitions or, if this is not possible, the operation must be accessible only to specialists.

(2) Stationary batteries must be installed in a special enclosed space. If the nominal DC voltage of the battery exceeds 150 V, the battery must be placed insulated from the ground.

(3) Lamps shall not be suspended on the supply line.

10.3 PROTECTION OF ELECTRICAL EQUIPMENT

(1) Electric motors, except in the case referred to in the third paragraph of point 10.4, shall be equipped with suitable starting and, if necessary, regulating devices. If the control devices generate higher harmonic components, care must be taken to ensure that this does not disturb other electricity consumers and that the values of higherharmon components do not exceed those permitted.

(2) Apparatus for heating spaces endangered by flammable materials must have a temperature limitation device or a device for reducing the emission of heat.

(3) The circuit powered from the secondary winding of the transformer must be carried out according to the requirements for the maximum voltage value of the secondary winding. The voltage of the secondary circuit of the autotransformer between the conductors shall not exceed 1000 V.

(4) In the case of AC converters, the circuit behind them must be specially protected with regard to the characteristics of the converter, in particular with regard to selectivity.

(5) Lamp casings with switch or key must be in the insulating casing. For lamp holders with lever-operated switches, the operation of the switch shall be protected by an insulating cord or a metal chain with an intermediate insulating part.

10.4 CONNECTION OF ELECTRICAL EQUIPMENT

(1) The same number of conductors as the installation shall be used to connect electrical equipment and devices to the electrical installation, either directly or by means of an extender flexible line, unless a protective conductor is not required. The flexible connection line must have adequate electrical and mechanical strength. The colour of the protective conductor in the extension bevel shall be yellow-green and the colour of the neutral conductor shall be light blue. These colours should not be used for other conductors. The three-phase sockets must have a uniform right-hand direction of the rotational field.

(2) Apparatus with open incandescent heaters must not be connected to an electrical installation in spaces where there is a risk of fire or contact with flammable materials.

(3) Electric 0.4 kV short-circuit rotor motors may be connected directly to the installation system if:
1. the voltage drop at start-up does not reach a value that would reduce engine torque that would compromise reliable running;
2. the start-up and operating regime does not affect the quality and characteristics of the supply voltage, which would affect the stable operation of other electricity consumers; and
3. the start-up cannot trigger the operation of the protection of electrical installations.

(4) The converters must be powered by a transformer with electrically separated windings.

10.5 INSTRUCTIONS FOR THE COMPENSATION OF JALE ENERGY

(1) For electrical installation loads, account shall be taken of the fact that reactive energy compensation devices parallel to the mains are in operation with full load or with loads fluctuating with voltage fluctuations when live.

(2) When installing reactive energy compensation devices, it shall be taken into account that it may lead to adverse operating conditions such as:
1. change in network resonance frequency or input of additional resonance frequency,
2. Modified network impedance may increase harmonic currents and/or harmonic voltages in the network;
3. self-promotion of electrical machines,
4. overvoltage when switched on.

(3) Before and after the installation of the reactive energy compensation device, the harmonic content of the voltage and current at the connection point in the various operating conditions, network and devices connected to it must be determined by means of appropriate measurements.

(4) Before connecting the filter compensation, it is necessary to study the impedance characteristic of the entire network to the power transformer, and on the basis of this determine the appropriate value of the damper (p factor) so as not to cause unfavorable resonant conditions in the network. Such compensation shall also be frequency tuned at a sufficient distance from the frequencies used for the transmission of MTK signals in the distribution network.

(5) Since overloads and overheating reduce the service life of reactive energy compensation devices, it is necessary to continuously control the temperature, voltage and current that determine their operating conditions.

(6) Due to the different types and impacts of reactive energy compensation devices, the instructions of reactive energy compensation device manufacturers and the requirements of the distribution operator must be followed to switch them off at low loads.

(7) If reactive energy compensation devices are used to compensate for the reactive power of asynchronous generators, the network operator’s instructions to which the network user is connected shall be followed with regard to switching on and off the reactive energy compensation device.

(8) The rated voltage of reactive energy compensation devices shall be equal to the actual and not rated voltage of the network to which the reactive energy compensation device is connected, also taking into account the influence of the reactive energy compensation device itself.

(9) When devices for reducing the impact of harmonic components (filter compensation) are included in reactive energy compensation devices, the resulting higher voltage at the connections shall be taken into account when selecting the rated voltage of the reactive energy compensation device (factor p).

(10) In determining the expected voltage at the connections of reactive energy compensation devices, account shall be taken of:

1. to cause an increase in voltage at the point of connection. Depending on the impedance characteristic of the network, the capacitor can also cause a resonance point for a certain harmonic voltage. In this case, for this frequency, the voltages can be even higher. As a result, reactive energy compensation devices with a higher voltage than the voltage measured prior to their connection shall be operated;
2. Whereas, since the voltage at the connections of the reactive energy compensation device may be greatly increased, the reactive energy compensation device must also adapt automatically to the load in such a way as to avoid voltage overloads and excessive voltage rises during low load periods;
3. in urgent cases only, reactive energy compensation devices may be operated for a short time at the maximum permissible voltage at the maximum ambient temperature.

(11) Reactive energy compensation devices exposed to high overvoltages due to lightning shall be adequately protected against the effect of lightning. See point 7.2 of this Guideline.

(12) Reactive energy compensation devices must correspond to the current expected at the maximum allowable operating voltage of the compensation device.

(13) Where transient currents of high amplitude and frequency which are generated when reactive energy compensation devices are connected need to be lowered to permitted values, provision shall be made for resistance coupling or a reactance shall be installed in the supply circuit to the reactive energy compensation device. When connecting the reactance, care must be taken not to cause unfavourable operating conditions in the network in terms of harmonic voltage.

10.6 SPECIFIC REQUIREMENTS

(1) A special device for limiting the number of switches must be installed for equipment with a rated current up to 16 A which does not meet the requirements of the SIST EN 61000-3-3 standard and is not connected under special conditions, as follows:

1. For single phase connector with start-up current up to 18 A: 6 turn-on/hour,
2. For single phase connector with start-up current up to 24 A: 3 turn on/hour,
3. 3-phase connector with start-up current up to 30 A: 6 turn-on/hour,
4. Three-phase connector with start-up current up to 40 A: 3 turn on/hour.

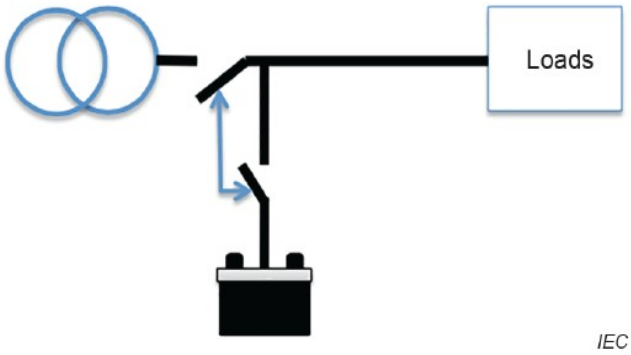
If such equipment passes the test, its instruction shall be given in accordance with the requirements of SIST EN 61000-3-3, the maximum permissible impedance of the power supply network. This value is indicated in the connection consent or the connection must be agreed with the distributor. An example of such equipment is a heat pump.

(2) It is necessary to take into account the specific requirements of the normative documents of the DSO.

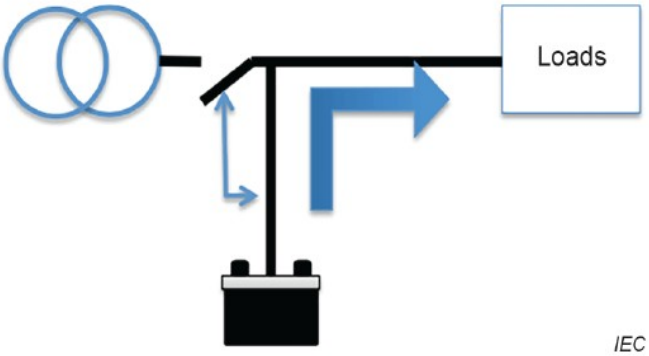
10.7 ESTABLISHMENT OF STATIONAR AKUMULATORS (Storers)

10.7.1 Operating modes

(1) The storage tank is permanently connected to the network, in the event of a failure of the network, the storage tank must automatically disconnect from the installation.



(2) Island mode, the storage tank feeds the installation even when the installation is disconnected from the network.



10.7.2 Reservoir batteries

(1) Batteries must be designed for permanent installation and permanent connection to the electrical installation.

(2) For the selection of batteries, it is necessary to take into account various parameters, including:

1. Characteristics of the charge
2. Battery voltage
3. Useful battery capacity
4. charging and discharging times
5. Connection of the converter.

(3) Capacity can be given in two ways in Ah (available electricity) or in Wh (available energy):

Capacity (Ah) = (load power (W) x operating time (h))/battery voltage (V)

Capacity (Wh) = (load power (W) x operating time (h))

The capacity is also influenced by the temperature and the number of charging cycles.

(4) The inverter used must be selected according to the type of battery and the purpose of use.

(5) The battery is both a source and a load, energy flows in both directions.

(6) Voltage on the battery connectors is constantly present, so appropriate safety measures must be installed.

(7) For proper operation, safety and protection of the battery, it is necessary to follow the manufacturer's instructions.

(8) The converter must have galvanic separation if the grounding is connected to the DC side.

(9) The system should be grounded at only one point to avoid circular flows.

(10) In the case of a grounded DC side, the risk of electrolytic corrosion due to DC currents should be avoided.

(11) Where the storage tank is intended to operate in island mode, the grounding of the batteries must be carried out in accordance with the requirements of SIST HD 60364-8-2 and SIST HD 60364-5-54.

10.7.3 Protection against electric shock

(1) Where the protection measure consists of automatic disconnection of the power supply or PELV, the battery racks or cupboards made of conductive material must be connected to the protective conductor, otherwise they must be isolated from the storage tank and its location in the installation.

(2) Where storage tanks are located in a special room, this must be accessible only to educated or experienced persons, and a supportive equalisation link must be provided.

(3) Where the storage tanks are in a special housing, the housing can only be accessed using a key or tool.

(4) Converter without galvanic separation; protection against electric shock must be provided:

	TN-TT systems	IT systems
Connected network	Type B RCD at the origin of the specific circuit for the reservoir	Automatic disconnection of the power supply at the starting point of the special circuit for the reservoir at first failure is required
Island mode	Type B RCD on AC side of converter and RCD on special circuit for storage tank	Automatic disconnection of the power supply at the starting point of the special circuit for the reservoir at first failure is required

(4) Converter with galvanic separation
- In TN and TT systems, the converter must be switched off on the DC side at the first failure, the reference conductor must be switched off
- In IT systems, the converter must be switched off on the DC side at the first failure.

10.7.4 Short-circuit protection

The calculation of the reference short circuit current shall be carried out in accordance with SIST EN 61660-1, SIST EN 61660-2 and SIST EN 60896-21.

10.7.5 Reservoir installation

(1) Reservoirs must be installed in a protective way. If necessary, electrical installation or limited access should also be provided.

(2) The following can be selected:

- separate storage rooms in the building,
- special separate fields in the case of electrical installation,
- cabinets or enclosures inside or outside buildings; and
- battery cases in devices.

(3) When choosing, it is necessary to take into account the protection against:

- external threats, such as: fire, water, blows, vibrations, pests,

- battery-related hazards, such as: high voltage, explosion hazard, electrolyte hazard, corrosion and earth contact effects,
- access for ordinary people,
- extreme environmental impacts, such as: temperature, humidity, air contamination.

(4) Certain accumulators emit gases that can cause an explosion, so it is necessary to avoid the concentration of these gases through ventilation.

10.8 FUNCTIONAL SAFETY OF ELECTRIC INSTALLATIONS

(1) When designing electrical installations, it is also necessary to carry out a risk analysis due to:

- foreseeable failures of protective measures,
- certain states of external influence,
- foreseeable misuse or negligence of users.

(2) On the basis of the analysis, additional protective measures should be implemented in order to reduce the risks to the tolerable limit.

(3) The risk analysis should also provide additional requirements for the verification of electrical installations.

(4) Risk analysis, additional measures and additional verification requirements are annexed to the project and implementation documentation.

11 REQUIREMENTS FOR SPECIAL PREPARATIONS OF ELECTRICAL INSTALLATIONS AND LOCATIONS

11.1 GENERAL

In all premises, especially hospitals and health centres, where the danger to human life and health due to electric shock and interruption of power supply is very high, it is recommended that the installation be carried out with an IT system, with a continuous back-up power supply and with protection against electric shock by automatically disconnecting the power supply in the event of another failure, with a protective device on the residual current, the operating residual current of which does not exceed 10 mA.

11.2 SPECIAL EXAMPLES OF ELECTRICAL INSTALLATIONS

11.2.1 Emergency lighting

(1) Emergency lighting is intended for use when the power supply of normal lighting fails and therefore requires a power supply that is independent of the power supply of normal lighting. It is divided into safety lighting, local lighting and replacement lighting.

(2) Safety lighting is that part of emergency lighting that allows persons to safely withdraw from a room or building or allows persons to complete a potentially dangerous work process before withdrawing. It consists of:

1. safety lighting of the escape route,
2. anti-panic security lighting; and
3. security lighting of particularly endangered workplaces.

(3) Safety lighting of escape routes is that part of the safety lighting which allows participants to be safely removed from the location by providing appropriate visibility and directional conditions on escape routes and special locations, and ensures that fire-fighting and safety equipment can be easily found and used. In the axis of the escape route, the safety lighting shall provide maintained ground illumination of at least 1 lx. The other requirements are given in the SIST EN 1838 standard.

(4) Anti-panic safety lighting is the part of the safety lighting that reduces the likelihood of panic and allows participants to safely move towards the withdrawal by providing appropriate visual conditions and orientation, as well as to identify and use firefighting and safety equipment. It is used wherever, due to the size of the room or other factors, it is not possible to accurately determine the evacuation route, e.g. in halls and halls. It shall provide maintained illumination of at least 0,5 lx on the ground. The other requirements are given in the SIST EN 1838 standard.

(5) Safety lighting for workplaces at particular risk is that part of the safety lighting which contributes to the safety of persons working in potentially hazardous processes or situations and allows appropriate stopping operations to be carried out for the safety of other participants in that location. In the field of work, safety lighting shall provide a maintained illumination greater than or equal to 10 % of that of general lighting but not less than 15 lx. In addition, it should not cause a stroboscopic phenomenon if, for example, it illuminates rotating machines. The other requirements are given in the SIST EN 1838 standard.

(6) Local lighting is that part of emergency lighting that allows persons to temporarily stay in the room despite the failure of normal lighting. Evacuation of these persons may be ordered at a later stage if the supply of normal lighting is not established in time, taking into account the duration of the security lighting. In some cases, this is a safer option, as evacuating, for example, residents of a nursing home from a building to the street for an unknown period of time could be impractical and potentially dangerous. Maintained illumination shall be based on a risk assessment, but at least as

required for safety lighting. The other requirements are given in the SIST EN 1838 standard. Local lighting can be part of security lighting.

(7) Replacement lighting is that part of emergency lighting which provides sufficient illumination to ensure that normal activities continue substantially unchanged after the failure of general lighting. Replacement lighting does not replace security lighting. Its lamps must meet the requirements of SIST EN IEC 60598-1 and the relevant parts of SIST EN 60598-2. Replacement lighting is powered from a separate source. In buildings or areas with safety lighting, emergency lighting may be used provided that the operation of the safety lighting is ensured for the entire nominal duration of the replacement lighting. In the event of failure of replacement lighting, it must be possible to exit the building or area safely during the nominal duration of the safety lighting. In practice, this means that the safety lighting must be connected to the power source of the replacement lighting and act on its power source (batteries) only after the replacement lighting has failed.

(8) The capacity of the power source must, without the help of the network, ensure the uninterrupted operation of the security lighting for at least one hour. Safety lighting autonomy of three hours is required if required by the SIST EN 1838 standard, the fire safety study or the TSG-1-001 — Fire safety in buildings. The autonomy of the safety lighting of particularly endangered workplaces may also be reduced if the time is sufficient to eliminate all hazards.

(9) The power supply of the safety lighting can be from a common battery (group or central, hereinafter referred to as a central safety power supply system) or from individual batteries in lamps.

(10) If the supply voltage of emergency lighting is lower than that of general lighting, the voltage for supplying emergency lighting should be lowered by a transformer with galvanically separated windings. The use of an autotransformer is not allowed.

(11) The replacement lighting may, in its normal operating condition, be supplied from the same source as the general lighting with the possibility of automatically switching to another source (diesel generator, battery, etc.) in the event of failure of the basic power supply.

(12) In the event of failure or drop in the voltage of the basic supply for general lighting below the value allowing normal lighting to operate, the safety lighting shall automatically switch to an auxiliary energy source:

1. Retraction path safety lighting and anti-panic safety lighting shall provide 50 % of the required illumination within 5 seconds and 100 % of the required illumination within 60 seconds after failure or reduction of the basic power supply.
2. Safety lighting for particularly endangered workplaces must permanently provide 100 % illumination or reach 100 % illumination within 0,5 seconds, depending on the location of use.

(13) Safety lighting luminaires must be visibly marked and located near each safety exit; on stairways so that each step is illuminated; in the vicinity of any changes in the height of the ground; in the event of any change of direction, if the course of the retreat route is not clear; at intersections of corridors; outside the building near security exits and to a safe area (assembly point); in the vicinity of each first-aid kit, so that at least 5 lx of vertical illumination is provided on the kit; in the vicinity of each part of the fire-extinguishing equipment and fire call points, so that at least 5 lx of vertical illumination is provided at the fire call points, fire-fighting equipment and markings; in the vicinity of equipment intended for the evacuation of persons with disabilities, so that at least 5 lx of vertical illumination is provided on the equipment; in the vicinity of the place where an alarm call is received from the cabin of the passenger lift and the associated means of escape from the lift; in corridors, from each lift to the nearest escape route; in the vicinity of hand-held controls for unlocking electronically locked doors so that at least 5 lx of vertical illumination is provided. The installation of lamps should allow people to leave the endangered place by the shortest route and go to the open air or another safe place.

(14) Where a central safety power supply system is used as the only auxiliary source of safety lighting, the following conditions shall be met:

1. the circuits shall be loaded with not more than 20 lamps with a total current not exceeding 6 A, both conductors being protected by fuses with a nominal current of 10 A;
2. in rooms with two or more safety-lamps, at least two circuits must be operated;

3. the installation of safety lighting from the battery to the main divider and between the dividers must be located outside spaces where there is a risk of fire. If this is not practicable, it shall have fire-safe insulation and loop-operated manifolds;
4. the installation of safety lighting under or in plaster, on shelves or in ducts must be at least 50 mm from any other electricity installation. The clearance may be less than 50 mm if they are separated from other electrical installations by a fire-resistant barrier or placed in their fire-resistant, non-combustible hose.

(15) The switch to switch off the safety lighting should only be in the main divider. There shall be no switches in individual safety lighting circuits.

(16) Only conductors having a cross-section of at least 1,5 mm ^{2} and having an insulation resistance of at least 1 MΩ and an insulation temperature class F or H may be used for safety lighting installations.

(17) Safety lighting luminaires with individual accumulator batteries should be fitted with accumulators with a minimum lifetime of 3 years. They must be constructed in such a way that they do not need to be maintained during this time. The power supply for charging them must be sized in such a way that it recharges the fully discharged battery within 36 hours. Each lamp should have an indication of the operating regime.

11.2.2 Mechanical ventilation and air conditioning

(1) Mechanical ventilation or air conditioning systems must be equipped with devices for automatic disconnection in the event of overload, short-circuit or ground contact. Defeat devices must be dimensioned as follows:
1. to be able to cut off the maximum short-circuit current,
2. the short-circuit protection cut-off time at minimum short-circuit current is less than 0,1 second for electrical installations in zone 0 and zone 1 and less than 0,5 second in zone 2 of explosion risk.

(2) Electrical installations and installations of ventilation and air conditioning systems in explosion hazard zones must be explosion-proof. If they are placed in rooms threatened by dust, they must also be protected against dust.

(3) Appliances of ventilation and air conditioning systems used in explosion hazard zones shall be specially marked so that the type of explosion protection and the area of use are visible.

(4) Cables connecting electrical installations of ventilation or air conditioning systems in zone 0 of explosion hazard shall be subject to regular monitoring and may only be used if the insulation resistance is higher than 1 MΩ of the nominal voltage. If, for any reason, the resistance decreases below the permissible value, the cable should be immediately put into a voltage-free state.

(5) Electric cables used to power appliances of ventilation and air-conditioning systems operating during fire must be fire-resistant or protected.

(6) Ventilation and air conditioning systems must be grounded.

11.2.3 Operation of electrical installations in the event of fire

(1) With regard to the operation of electrical installations in the event of fire, the applicable Rules on fire safety in buildings and the technical guideline for the construction of TSG-1-001 Fire safety in buildings and the supporting documents referred to therein shall be taken into account.

(2) A residual current protection device (RCD) with a rated current of not more than 0,1 A shall be installed and operated in areas at risk of fire.

11.2.4 Limited conductive spaces

(1) Where a safety low voltage of not more than 25 V alternately is used, protection against electric shock, whatever the value of the rated voltage, shall be provided by bulkheads or enclosures providing a protection degree of at least IP 2X or IP XXB, or by insulation capable of withstanding a test voltage of 500 V alternately over a period of not less than 1 min.

(2) Obstacles or out-of-hand positions shall not be used to protect against electric shock.

(3) For the supply of power to hand-held portable power tools and portable measuring apparatus, a safety low voltage or electrical separation shall be used as protection against electric shock, provided that only one apparatus of Class II is supplied from the secondary winding of the separating transformer, which may have several secondary windings, or an apparatus with a grounded protective conductor, which must have insulating handles or handles coated with an insulating layer.

(4) As protection against indirect contact of hand-held lamps, even fluorescent lamps with a built-in transformer with two windings, a safety low voltage of up to 25 V alternately should be used.

(5) For non-portable appliances, protection against electric shock must be provided by automatic power disconnection and additional equalisation of potentials, which must connect exposed conductive parts of non-portable appliances and conductive parts of the room, or safety low voltage or electrical separation, provided that only one appliance is powered from the secondary winding of the separating transformer.

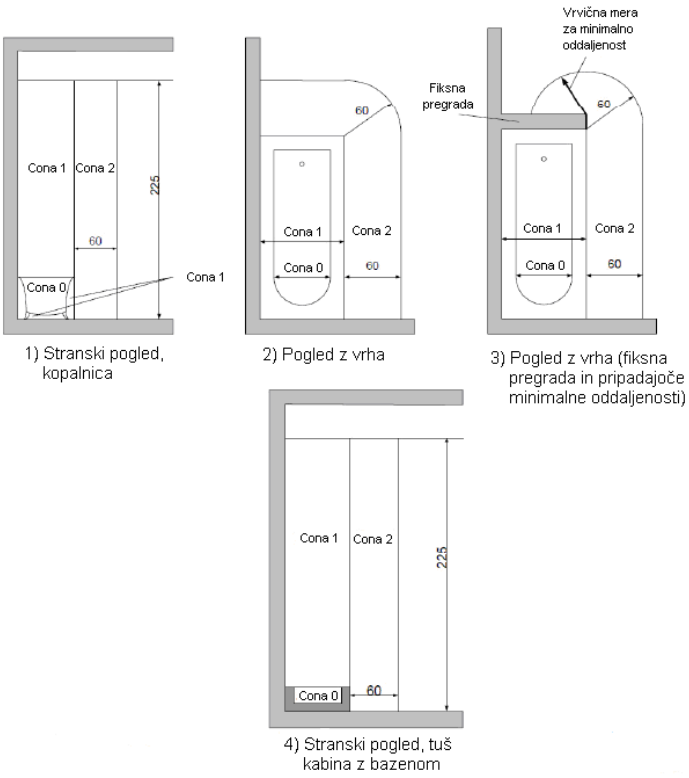
(6) Low-voltage safety sources and sources of electrical separation must be located outside restricted conductive spaces, unless they are necessary for the power supply of hand-held lamps.

(7) If an operational/functional earthing is required for individual non-portable appliances, such as measuring and control apparatus, the equalization of potentials must connect all exposed conductive parts, all foreign conductive parts inside the limited conductive space and the operational earthing.

11.3 SPECIAL SPECIAL SPECIAL SPECIES

11.3.1 Bathrooms

(1) The bathroom with a bath or shower should be considered as a room divided into three zones. Description and presentation is given by the standard SIST HD 60364-7-701. Depending on these zones, it is necessary to choose protection against electric shock, additional equalization of potentials, as well as the selection and layout of electrical equipment and devices.

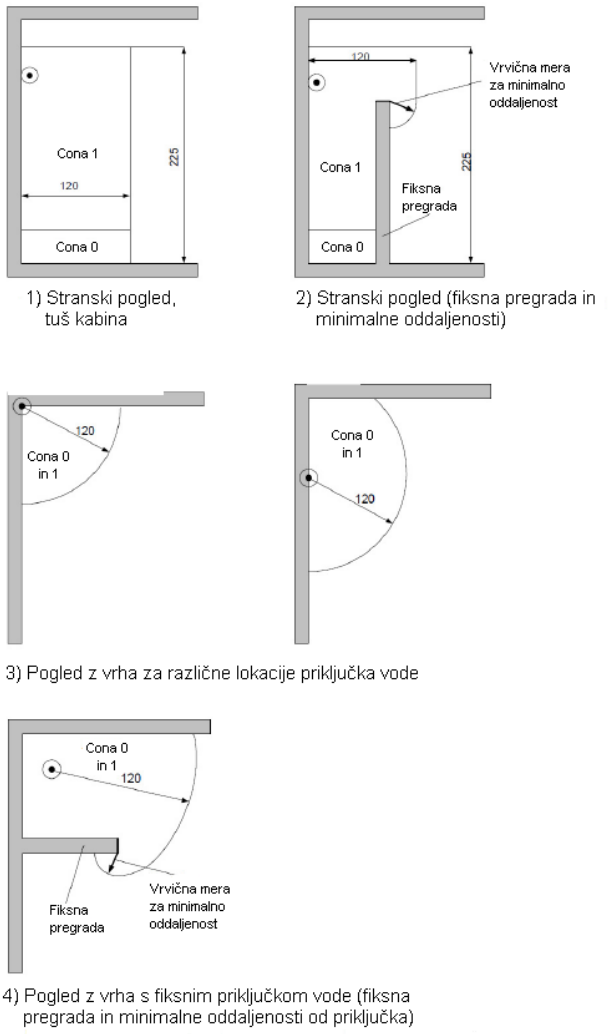


1) Stranski pogled, kopalnica

2) Pogled z vrha

3) Pogled z vrha (fiksna pregrada in pripadajoče minimalne oddaljenosti)

4) Stranski pogled, tuš kabina z bazenom



All dimensions are in centimeters

Figure 8: Dimensions of zones in a bathroom or a cabin with a shower

(2) In a room with a bath or shower, additional equalization of potentials with connection to the ground must be carried out, so that all simultaneously accessible exposed and foreign conductive parts are connected with protective conductors:

1. conductive drainage element on the bath or shower tray,
2. metal tub,
3. metal shower tray,
4. metal plumbing; and
5. other metallic piping and ventilation systems.

(3) Foreign metal parts do not need to be interconnected with guides to equalize potentials. These are:

1. window and door,
2. handles,
3. soil effluent cover,
4. toilet washer; and
5. similarly.

(4) Additional equalization of potentials should be carried out even if there is no electrical equipment in the room with a bath or shower.

(5) The cross-section of the guides for further equalization of potentials shall be selected in accordance with the requirements of the SIST HD 60364-5-54 standard.

(6) If the bathtub and drain pipe are made of non-conducting (synthetic) material and have a metal effluent, it does not need to be tied to the equalization of potentials.

(7) If the bathtub is metal and has a metallic outlet and the drain pipe is made of non-conducting (synthetic) material, only the metal bathtub should be connected by equalizing the potential.

(8) The movable bathtub and shower cabin must be connected with the help of a guide for equalizing the potentials with the protective conductor of the installed electrical equipment.

(9) For protection against electric shock, only a protective measure with a safety low voltage not exceeding an alternating voltage of 12 V or 30 V DC voltage is permitted in zone 0 if the safety supply is not in zone 0. No protective measures shall be permitted in the event of failure by means of partitions and placement out of the reach of the hand.

(10) Complementary protection against electric shock shall be provided by applying one or more residual current protection devices of at least type A with a rated residual current operating at not more than 30 mA. The application of this measure shall not be permitted in circuits where the protection measure is electrical separation or low voltage.

(11) In zones 0, 1 and 2, only conductors and cables for powering appliances in these rooms built up to a depth of 5 cm, or cables laid on a wall, may be installed.

(12) Zones 0, 1 and 2 shall be free of junction boxes and switchgear.

(13) Only fixed and permanently connected equipment may be installed in Zone 1. The equipment must be suitable for installation in zone 1 in accordance with the equipment manufacturer's instructions. Such equipment is:
1. water-swirling equipment;
2. shower pumps;
3. Equipment with protection against low voltage electric shock;
4. Ventilation equipment;
6. towel dryers;
7. water heating devices;
8. lamps.

(14) Switches and sockets must be located at a minimum distance of 0,6 m from the door opening of the factory-made shower cabin.

(15) In zone 0 only those electrical equipment and apparatus which are supplied with a low voltage safety rating not exceeding 12 V and which have a protection degree of at least IP X7 may be used.

(16) Only a water heater with a protection level of at least IP X5 may be placed in zone 1.

(17) Only a water heater with a protection level of at least IP X4 and class II lamps may be placed in zone 2. In public baths, however, even in this zone, the water heater must have a protection degree of at least IP X5.

(18) Additional requirements for the implementation of electrical installations in bathrooms are given by the standard SIST HD 60364-7-701.

11.3.2 Pools

(1) For electrical installations in rooms with swimming pools, foot-disinfecting pools and on the swimming platform, the increased risk of electric shock due to the reduced resistance of the damp human body and the reduced resistance of the human body immersed in water should be taken into account.

(2) The space of the pools should be considered divided into three zones, as can be seen in Figure 9. Depending on these zones, it is necessary to choose protection against electric shock, additional equalization of potentials, as well as the selection and layout of electrical equipment and devices.

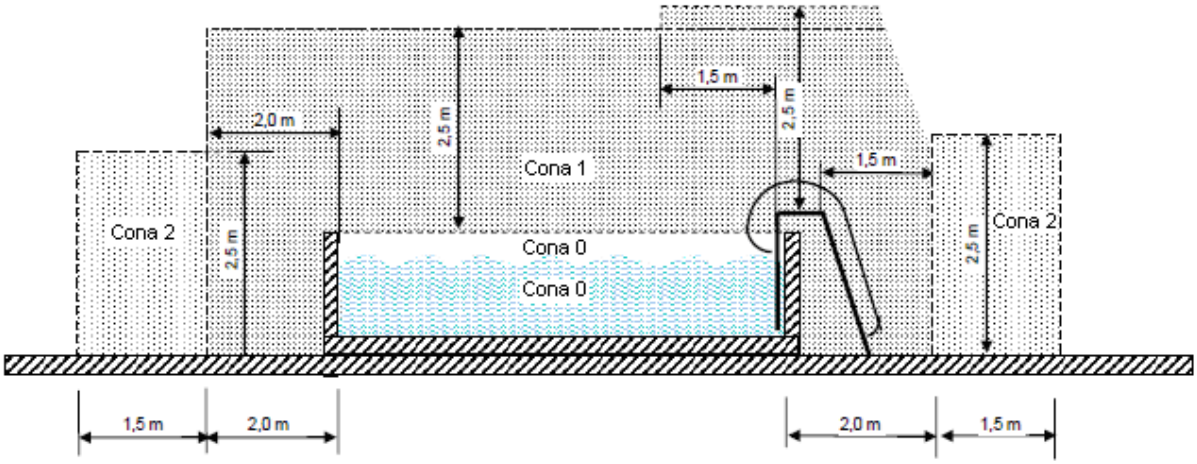


Figure 9: Zone dimensions for swimming pools above ground level

(3) Only a safety low voltage not exceeding an alternating voltage of 12 V may be used in zone 0 if the source of the safety low voltage is not in that zone. Protection against electric shock shall be provided by means of a barrier or enclosure with the lowest degree of protection IP 2X or IP XXB, or by means of insulation withstand a test voltage of 500 V for 1 minute.

(4) In zone 0 protective measures with obstacles, placing equipment out of reach, placing in an insulated space and equalising potentials without grounding are not permitted.

(5) In zones 0, 1 and 2, additional equalization of potentials must be carried out by connecting all foreign conductive parts located in these zones.

(6) In the case of electrical installation systems which have an electrical installation built into the walls at least 5 cm deep and which are carried out with single-core cables in insulated installation pipes or with multi-core cables with an insulating sheath, the insulation shall comply with the requirements for insulation of Class II apparatus or equivalent insulation.

(7) In zones 0 and 1, the electrical installation must be limited to powering appliances in these zones. The installation of junction boxes, switchgear and accessories in these zones is not allowed.

(8) In zone 2, socket-outlets may be installed if they are powered individually by a separating transformer, if they are powered by a safety low AC voltage up to 25 V, or if they are protected by a residual current protection device (RCD) with an operating residual current not exceeding 30 mA.

(9) In zone 0 only apparatus and lamps such as underwater lamps and pumps supplied with a low voltage safety voltage not exceeding 12 V alternating voltage are allowed to be used.

(10) In zone 1, appliances shall be supplied with a safety low alternating voltage up to 25 V and class II appliances may be non-transmissible.

(11) In zone 2, in addition to apparatus supplied with a safety low alternating voltage up to 25 V, the following installation is permitted:
1. Class II appliances,
2. apparatus the housing of which is bound to a grounded protective conductor and protected by a residual current protection device with an operating residual current not exceeding 30 mA; or
3. appliances powered by a separating transformer.

(12) Heaters installed in the ground may be installed in zones 1 and 2, provided that they are covered with a metal grille or ground with a metal sheath associated with additional equalisation of potentials.

(13) The SIST HD 60364-7-702 standard provides additional requirements.

11.3.3 Saunas

(1) The sauna space should be considered divided into four zones, as can be seen in Figure 10, especially with regard to protection against electric shock and thermal resistance of equipment and materials.

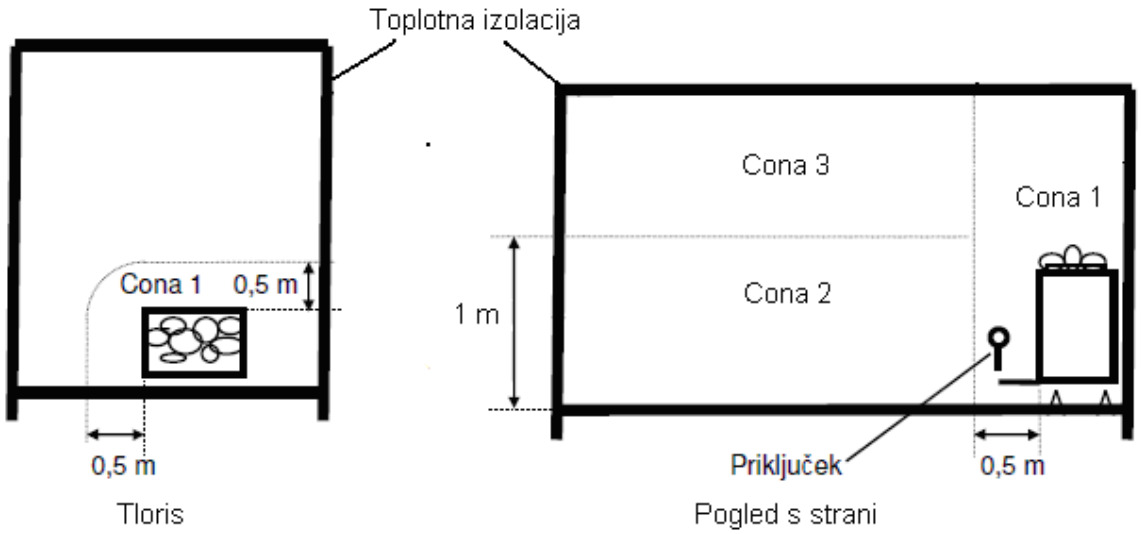


Figure 10: Dimensions of zones in the sauna

(2) Protection against electric shock must not be carried out by means of obstacles, by installation out of reach of the hand, by placing equipment in non-conductive spaces or by equalizing potentials without connection to earthing.

(3) If a safety low voltage of up to 25 V is used, at any rated voltage value, protection against electric shock shall be provided by means of bulkheads or enclosures providing a degree of protection of at least IP 2X or IP XXB, or by means of insulation capable of withstanding a test voltage of 500 V alternately over a period of 1 min.

(4) Electrical equipment shall have a protection level of at least IP 24.

(5) In zone 1 there should be only equipment that belongs to the electric sauna stove.

(6) Zone 2 may contain equipment for which no specific thermal resistance of the material is required.

(7) In zone 3, the insulation of the conductors shall withstand at least 170 °C and the equipment shall withstand at least 125 °C.

(8) In zone 4, the insulation of the conductors must withstand a minimum temperature of 170 °C and the equipment must withstand a minimum temperature of 125 °C. Only devices for controlling electric sauna stoves (thermostats, thermal fuses) and the electrical installation belonging to these devices may be installed there.

(9) The electrical installation shall be insulated in Class II or equivalent and shall be free of metallic sheath or metallic pipes.

(10) The switch apparatus, which is not built into the electric sauna stove, must be placed outside the sauna.

(11) Sockets should not be installed in the sauna.

(12) A temperature limiting device must be installed in the sauna which switches off the power supply to the electric sauna stove when the temperature measured in zone 4 exceeds 140 °C.

(13) The SIST HD 60364-7-703 standard provides additional requirements.

11.3.4 Gas boiler rooms

(1) Electrical equipment and electrical installation in gas boiler rooms and associated ventilation systems must be carried out under appropriate explosion protection as required by the regulations.

(2) The control room of the gas boiler room shall be provided with an audible alarm and a light signal, which shall be activated each time the gas firing line is blocked.

(3) The main switch to switch off the electricity in the boiler room must be located outside the boiler room if the total heat output of the boiler room is greater than 100 kW.

(4) Each gas boiler room shall have an emergency/emergency switch at least in one place at the exit of the boiler room and/or in the immediate vicinity of the escape route (retreat routes). All power consumers shall be switched off by means of the emergency/emergency switch, with the exception of the safety lighting installation and the pumps of the power supply system of the installation.

11.3.5 Non-residential agricultural buildings

(1) In buildings with animals, e.g. sheds, hens, pigs, etc., in buildings for the preparation of animal feed, in hayracks and similar rooms for straw and fertiliser, in greenhouses, etc., the greater sensitivity of livestock to electric shock and room humidity must be taken into account when carrying out electrical installations. Details are defined in the SIST HD 60364-7-705 standard.

(2) Where a safety small alternating voltage of not more than 25 V is used, protection against direct contact shall be provided, regardless of the voltage, by means of bulkheads or enclosures having at least protection degree IP 2X or IP XXB, or by means of insulation withstand a test alternating voltage of 500 V for 1 minute.

(3) All circuits, including those containing sockets, shall be protected against indirect contact by means of a residual current protection device with a residual current rating of not more than 30 mA.

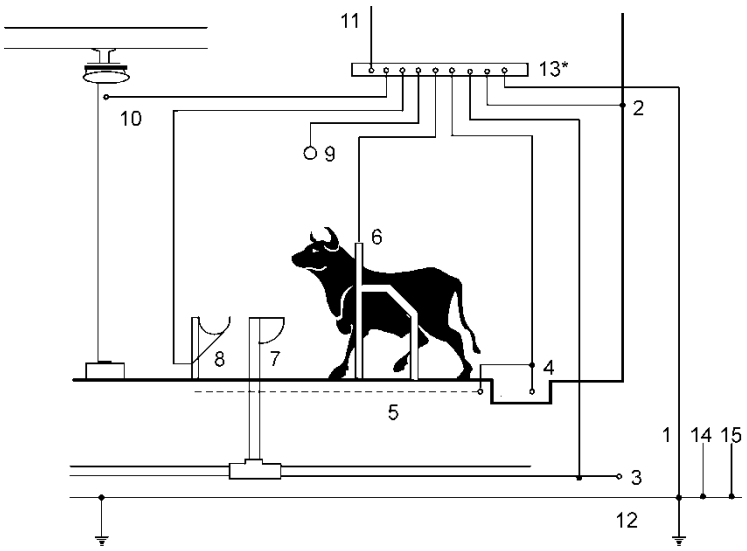
(4) Electrical equipment shall have a protection level of at least IP 35.

(5) The maximum shut-off times of the protection with automatic disconnection of the power supply at the places where the livestock is kept and at the places directly related to the foreign conductive works at the place where the livestock is reared are given in Table 8.

Table 8: Maximum cut-off times of livestock rooms

Expected Touch Voltage (effective value) (V)	Maximum allowed cut-off time (s)
25	> 5
50	0,47
75	0,30
90	0,25
110	0,18
150	0,10
230	0,035

(6) In places where livestock are kept, all exposed conductive parts and all foreign conductive parts that can be touched by livestock must be connected to the protective conductor of the installation by additional equalisation of potentials (see Figure 11). On the floor, it is recommended to install a metal mesh, which is also connected to the protective conductor.



1	Grounding line
2	metal partitions
3	metal plumbing pipes
4	metal sewer pipes
5	further equalization of potentials, e.g. metal mesh
6	metal fence
7	power supply
8	crèche
9	milking machine
10	steel construction of the building
11	Protective Guide (PE)
12	ground, ground, other ground, bound to this ground
13	Collector for equalization of potentials
14	lightning conductor
15	Grounding of a metal fence of pasture

Figure 11: Implementation of protection with equalization of potential in the barn

(7) Apparatus for heating the premises where livestock are kept must be fixed so that they are at an appropriate distance from livestock and flammable materials in order to avoid burns to livestock and fire.

(8) Emergency shut-off devices, including emergency shut-down devices, shall not be placed where livestock would be accessible or where livestock might be at risk. Special conditions should also be taken into account if the livestock is in a state of panic.

(9) If electrical fences are located in the vicinity of overhead power lines, appropriate distances and measures against induced voltages and protective measures against the fall of overhead lines shall be taken.

(10) When using an RCD switch, the requirements are as follows:
- Final circuits to sockets: up to 32 A: RCD with $I_\Delta \leq 30$ mA,
  above 32 A: RCD with $I_\Delta \leq 100$ mA;
- Other circuits: above 32 A: RCD with $I_\Delta \leq 300$ mA.

11.3.6 Campsites

(1) The electrical connection manifold must have a housing with a degree of protection of at least IP X4 and one or more sockets designed solely for connecting the connection cables of rest vehicles or camping equipment. In this case, the connection cable with the corresponding plug is part of the vehicle's rest equipment or part of the camping equipment.

(2) The electrical connection point shall be located in such a way that it is easily accessible to all camping units and camping equipment and shall not be more than 20 m from the socket on the rest vehicle or from the tent. A maximum of 8 rest vehicles or tents may be connected at one connection point.

(3) At each connection point there shall be a mark at least 100 mm high. It must show the following information:
1. the name of the product,
2. connection point number,
3. the number of the distributor from which the connection point is fed,
4. the electrical installation system used,

5. rated voltage,
6. the rated frequency,
7. Rated residual current protective device (RCD) operating current,
8. IP protection level; and
9. the rated current of each connection socket.

(4) At least one socket shall be provided for each location of the rest vehicle or camping equipment. It is recommended to connect all single-phase sockets to one phase.

(5) Each socket must have its own overcurrent protection device. Each socket shall be protected against electric shock by a residual current protection device with an operating residual current not exceeding 30 mA.

(6) The sockets shall have a protective ground contact at the connection point of the resting vehicles. Sockets must be installed at a height of 0,8 to 1,5 m from the ground, and the rated value of the socket current must not be less than 16 A. Sockets must provide a level of protection of at least IP 44 or this level must be provided by the cabinet in which the socket is installed.

(7) If the sockets are in a locked cabinet, the part of the cabinet where the remaining equipment is located should not be opened with the same key.

(8) The SIST HD 60364-7-708 standard provides more detailed requirements for the implementation of electrical installations and distributors in campsites.

11.3.7 Integrated photovoltaic installations and photovoltaic power grids

(1) The supporting structure and the metal frames of the PV modules shall be grounded at least at the beginning and end of the PV field with a 16 mm2 copper conductor. The frames of the PV modules are grounded and galvanically connected according to the instructions of the manufacturer of the PV modules.

(2) When installing and installing cables, the following requirements must be observed:
1. cables on the d.c. side must be selected and laid in such a way that the risk of short-circuit and ground contact is minimal, which can be done by:
   - single-core cables with a non-metallic sheath,
   - an insulated (single-core) conductor placed in an insulated electrical installation pipe or duct,
   - conductors, which must be protected against UV radiation;
2. protection against electric shock is carried out with special care, because equipment on the DC side is considered to be energized even if the AC side is separated from the mains or the converter is separated from the DC side

and the requirements of the SIST HD 60364 series standards, and in particular the SIST HD 60364-7-712 standard.

(3) On the one-way side, it can be used:
1. double or reinforced insulation,
2. SELV or PELV voltage.

(4) On the alternating side:
1. protection against thermal effects, as provided for in CFSP Guideline 512, the fire safety of solar power plants; and
2. insulation failure protection:
   - is carried out by separation inside the adaptor or on the alternating side,
   - Insulation Controller (IMD) shall be installed to check insulation according to SIST EN IEC 61557-8 throughout the life of the PV system,
   - The IMD function may be integrated into the converter.

(5) PV system circuits must have installed gPV type fuses according to the SIST EN 60269-6 standard or other devices in accordance with the standards of the SIST EN IEC 60947 series or with the standards of the SIST EN IEC 60898 series, which must, however, transfer the operating conditions of the places where these other devices are installed.

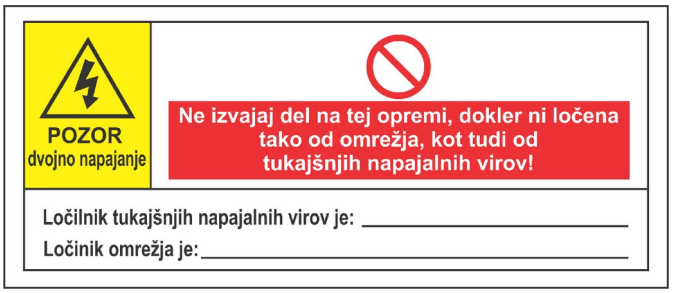
(6) AC circuits shall incorporate type B RCD protection in accordance with SIST EN 62423 unless:

1. at least a simple separation between the DC and AC sides is carried out in the converter,
2. or if there is at least a simple separation in the installation between the converter and the RCD with a separate winding in the transformer,
3. or if the adaptor complies with SIST EN 62109-1 and there is no type B RCD requirement, which must be written in the adaptor manufacturer's instructions.

(7) The permanent label must be placed on all access points on the d.c. page, such as connecting doses, dividers and cabinets.

The minimum size of the label shall be 150 mm x 24 mm.

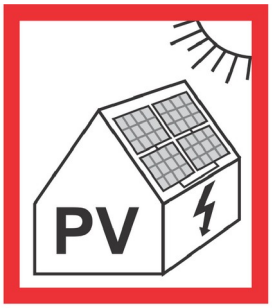
(8) Each power conversion equipment (PCE) shall bear a marking indicating that the converter must be isolated from all power supplies before works on it are carried out.



The minimum size of the warning sign shall be 180 mm x 76 mm.

(9) For the safety of maintenance workers, inspectors, distributors, firefighters and rescue workers, it is essential that the presence of PV installation in the building is indicated. The sign must be placed on:

1. entrance door or near the main entrance in a clearly visible place from the outside,
2. the point of charging the electrical installation,
3. the measuring point, if remote from the point of charging the electrical installation,
4. per consumer or distributor to which the PCE power supply is connected.



POZOR!
NEVARNOST ELEKTRIČNEGA UDARA
PRI GAŠENJU Z VODO

The minimum size of the sign, together with the inscription, shall be 180 mm x 136 mm.

(10) The symbol shall be placed on the installation power supply point, on the meter if it is not near the power supply point and on the distributor to which the adaptor is connected.

(11) The basic minimum requirements for system documentation, acceptance tests and monitoring are set out in the SIST EN IEC 62446-1 standard, which applies to grid-connected photovoltaic systems that do not use energy storage (e.g. batteries) or hybrid systems.

(12) The life expectancy of network-connected photovoltaic systems, if properly maintained, should be a few tens of years.

(13) Upon acceptance of the installed and network-connected photovoltaic system, for the long-term maintenance and safety of the system, the user must be handed useful documentation, which must meet the documentation and verification requirements laid down in the SIST EN IEC 62446-1 standard.

(14) The minimum basic data and information on the photovoltaic system must be collected in the operating and maintenance instructions:

1. Information about the system
Basic information about the system
- Designer information
- Information about the installer
2. Wiring plan
- At least a single-line plan with specifications on:
- Photovoltaic field
- Photovoltaic array
- Electrical details about the field
- Alternating system
- Grounding and overvoltage protection
3. Layout of the series
For systems with three or more arrays, a plan must be made showing how the array is divided and linked into arrays.
4. Data lists
At least for all types of modules – according to SIST EN IEC 61730-1.
5. Mechanical execution information
A list of installation system data must be provided. If the installation structure is made to order, the list must contain the relevant documentation.
6. Emergency systems
Documentation of each emergency system connected to the photovoltaic system (fire and smoke alarms, etc.), with details of the implementation and operation of the devices.
7. Operation and maintenance information
They shall contain at least:
procedures for verifying the proper functioning of the system;
b) checklists of what is done in case of system failure,
c) emergency shutdown/separation procedures;
d) recommendations for maintenance and cleaning (mechanical, construction and electrical) – if any;
e) advice for any future construction work related to the photovoltaic field (e.g. roof work),
f) warranty documentation for photovoltaic modules and inverters,
g) guarantee documentation on the craft work carried out or on the weather resistance of the sealing.
8. The test results and take-over data must contain at least the test results of the checks dealt with in point 5 of SIST EN IEC 62446-1.

(15) Verification is the information expected for the first (or periodic) verification (review and testing) of the installed system.

(16) Checks on grid-connected photovoltaic systems should be carried out with reference to SIST HD 60364-6.

(17) Any installation of subsystems and components should be checked by reference to SIST HD 60364-6 during installation, as far as is practically reasonable, and after its implementation, before it is put into service by the user. The first check should include a comparison of the results against the relevant criteria to confirm that the requirements of SIST HD 60364-6 are met.

(18) When adding to or modifying an existing installation, it should be verified that the addition or modification according to SIST HD 60364-6 and that it will not deteriorate the security of the existing installation.

(19) For a photovoltaic system, the interval between verifications shall not exceed the interval required by the AC electrical system to which it is connected.

(20) The inspection of m ora should be carried out before testing and before connecting the installation live, according to the requirements of SIST HD 60364-6.If the wiring will not be accessible after installing the installation, it should be inspected before or during the installation works. The review should include the following points:

1. One-Way System - General

a) has been designed, specified and installed in accordance with SIST HD 60364 and IEC TS 62548:2016 (Note: In Slovenia, SIST HD 60364-7-712 is used instead of IEC TS 62548:2016);
b) The maximum voltage of the PV field corresponds to the location of the field;
c) the components and fastening structures of the system shall withstand the expected external influences (wind, snow, temperature and corrosion):
d) Roof fixtures and cable introductions are waterproof.

2. DC system - protection against the effects of insulation failures
3. One-way system - overcurrent protection
4. One-way system — earthing and potential equalisation assemblies
5. One-way system - protection against lightning effects and overvoltages
6. DC system - selection and installation of electrical equipment
7. Alternating system
8. Labelling and identification

a) all circuits, protection devices, switches and connectors must be properly marked in accordance with SIST HD 60364 and IEC TS 62548:2016 (Note: In Slovenia, SIST HD 60364-7-712 is used instead of IEC TS 62548:2016);
b) all DC junction boxes (photovoltaic generator and photovoltaic field cabinets) shall bear warning markings indicating that the cabinets contain live parts fed by the photovoltaic field and therefore may still be live after separation from the PV inverter and the public network);
c) the means of separation shall be clearly marked on the alternating side;
d) there are double-power tell-tales at the interconnection point;
e) a single-line wiring plan is installed on site;
f) the details of the installation are displayed on site;
g) the switch-off procedures are displayed on site;
h) on-site (where necessary) demonstration of emergency procedures;
i) all signs and markings are properly affixed and durable.

All requirements are specified in detail in chapter 13 and in the standard SIST EN IEC 62446-1 .

(21) Testing

1. General

The electrical installation must be tested in accordance with the requirements of SIST HD 60364-6. Measuring instruments, monitoring equipment and methods must be selected in accordance with the relevant parts of SIST EN IEC 61557 and SIST EN 61010.

Each test must be carried out as required by point 6 of SIST EN IEC 62446-1. All tests should be carried out where necessary and in the order indicated. If any test shows non-conformity or failure with the requirements, this test and any previous tests which may have been affected by the failure shall be repeated after the failure has been rectified.

2. Test regimes and additional tests

- Category 1 tests — standard set of tests to be carried out on all systems.
- Category 2 tests - Extended test sequence assuming that all Category 1 tests have already been carried out
- Additional tests - other tests that may be carried out in certain circumstances.

The tests are described in detail in point 12.

3. Test regimes for systems with electronic modules.

For these systems, Table 9 should be used to determine the correct test regime.

Table 9: Changes to the test regime for systems with electronic modules

System	Modification of the standard test regime
Alternating module	- No one-way test or examination required
Micro inverter	- No DC circuit testing required

No on-site wiring is used (all connections use wired connections of module and inverter)	- A review of the one-way part is required
Micro inverter *Wiring carried out on site is used*	- DC testing required - A review of the one-way part is required
Modules with built-in electronics	- Where possible, a standard test regime shall be used. - Consultation with the manufacturer to determine any test limitations (e.g. insulation resistance test) - Manufacturer consultation on good/bad test criteria (e.g. expected *VOC)*

Due to the variety of electronic equipment implementations of the different modules available, it is not possible to determine which tests could be safely performed. For all implementations of systems containing any type of module electronics (e.g. power optimizers), consult the manufacturer before commissioning.

Measurement of the I-U curve and examination of electroluminescence for these systems is not possible.

Instructions for the maintenance of photovoltaic systems, after connection to the network, are given in the standard SIST EN IEC 62446-2.

(22) In photovoltaic systems all alarms indicating hazardous and harmful conditions due to:
- fault arcs (AFDD),
- problems in monitoring insulation resistance (IMD) and leakage currents (RCM),
- excessive DU voltage drops,
- excessive differences in power impedances of DZ,
- residual leakage currents (RCD) and others.

These dangerous harmful states can cause electric shock, fire or other harmful events.

11.3.8 Portable photovoltaic devices (Plug & Play devices)

(1) A portable PV device with a plug (the "Plug & Play" device), where the maximum total power per metering point must not exceed the value specified in the normative documents of the DSO, may be connected to one socket, which can also be located on the balcony or terrace and is connected to the final circuit.

(2) Only a portable photovoltaic installation that complies with SIST EN 62109-1 and SIST EN 62109-2 and has a valid EC declaration of conformity may be connected.

(3) When connecting such an installation, the owner must provide the distribution operator with the following information:
1. estimated date of connection,
2. measuring point number,
3. ‘EC — declaration of conformity’ or other document from the manufacturer giving the product information and the standards for the appliance,
4. a copy of the assembly and connection instructions showing:

- at least a simple AC-DC separation is implemented in the portable photovoltaic installation, or
- that the device meets the requirements of SIST EN 62109-1 and SIST EN 62109-2 and does not require the installation of an RCD type B,
- if markings or warnings must be affixed, which markings and warnings must be given and where,

(4) The cross-section of the supply lines of the final circuit to which the portable photovoltaic device is connected shall be at least 1,5 mm2

(5) The circuit to which the portable photovoltaic device is connected shall not be loaded above the design value or the nominal value of the fuse protecting the restricted circuit.

(6) If the connection between the portable photovoltaic device and the socket is extended, the same type of conductor used by the device manufacturer or UV-resistant conductor must be used (for example: H07 RN-F).

(7) If the owner doubts the integrity of the installation, he should consult a specialist before connecting. Consultation with an expert is also mandatory if the device is connected to an installation carried out with two guides in buildings built before 1985.

11.3.9 Charging stations for electric cars

(1) Electrical installations for charging electric cars contain specific requirements and are based on the basic parts of the SIST HD 60364 standard (parts 1 to 6), the basic parts of the SIST EN IEC 61851 standard (parts 1 and 23).

(2) The load-bearing column and metal frames of charging stations of electric cars modules must be grounded with a copper conductor of 16 mm2. A potential ring with a grounding tape should be made around the foundation.

(3) When carrying out charging stations for electric cars, the requirements of the SIST HD 60364-7-722 standard and the following requirements must be observed:

1. in normal use, each individual connection point shall be used with a rated current,
2. all connection points can be used at the same time, so the availability factor of the supply installation should be equal to 1, this factor can be reduced only if load filling control (local or remote) is available,
3. in the case of a TN system, the final circuit supplying the connection point shall be in the TN-S version,
4. protection against water ingress must be at least IPX4,
5. the protection against solid particles must be at least IP4X,
6. if the filling station is located in public areas (parking area), protection against mechanical damage and violent impacts of level AG3 (IK08) must be provided. The measures to ensure this protection are:

- the choice of a location that prevents injury from a possible collision,
- provision of local or general mechanical protection of equipment,
- selection and installation of equipment with the lowest level of protection of IK08 against external mechanical shocks in accordance with the requirements of the SIST EN 62262 standard.

7. Use of electric shock protection devices with automatic disconnection of the power supply:

- if the charging station is equipped with a socket or a vehicle connector, in accordance with the SIST EN 62196 standard, a protection measure against d.c. fault current must be provided, unless this is provided by the charging station. For each connection point, the following measures must be applied:

– use of a type B residual current protection device,
– use of a type A residual current protection device together with a direct current detection device (RCD-DD) in accordance with SIST EN 62955; or
– use of a type F residual current protection device together with a direct current detection device (RCD-DD) in accordance with SIST EN 62955.

8. Insulation resistance monitor (IMD) compliant with SIST EN IEC 61557-8 shall be used in electric vehicle charging IT circuits, except for circuits that have an automatic disconnection of the power supply at first fault.
9. The IMD shall provide an acoustic or light warning with the following requirements:

- Pre-warning: the upper limit of the threshold for the first failure is 300 Ω/V, with the initiated charging continued, the new charging disabled,
- Warning: the upper limit of the threshold for the second failure shall be 100 Ω/V and the charging shall be switched off within 10 seconds.

(4) Additional requirements to ensure greater safety of the charger:

1. it must be located in an explosion-proof location (outside all Ex zones),
2. it must be designed in such a way that heavy snowfall with strong winds does not fill and prevent the operation of the refrigeration unit,

3. the charging cable must be protected from mechanical damage caused by various types of flooring, such as earth, concrete, asphalt, stones, e.g. with an additional holder or cable carrier.

(5) Verifications:
1. Visual inspection of the recharging point at least once a week to verify:
- equipment so that it has no visible damage likely to endanger its safety,
- the correct operation of the charging station so that there are no indications of work defects or malfunctions.
2. The visual inspection shall be carried out by the owner and shall keep a logbook of the checks.
3. Regular preventive maintenance according to the manufacturer's instructions.

(6) When implementing charging stations for electric cars, it is also necessary to take into account that it can be designed as an electricity storage tank (electricity generator) and it is necessary to take into account the following requirements:
1. have their own separating place,
2. the separation point shall be provided with the protection specified in Annex 5 (SONDSEE),
3. Envisage the implementation of the V2G (Vehicle to Grid) concept.

(7) When carrying out charging stations for electric cars, it is necessary to carry out an assessment of the effects of disturbances of devices in the distribution system on the basis of Annex 3(SONDSEE) for:
1. consumers with a rated current greater than 50 A phase for the low-voltage grid; and
2. consumers with a rated current greater than 20 A phase for the medium voltage grid.

11.3.10 Electrical energy storage units

(1) Electrical installations for energy storage contain special requirements and are based on the basic parts of the standard SIST EN IEC 62485 (parts 1, 2, 5, 6) and on the basic parts of the standard SIST EN 62619.

1. Enclosures of electricity storage tanks

The housing of electricity storage tanks shall be chosen for essential reasons such as:

- to provide functionally complete equipment in one housing,
- to protect against hazards caused by power reservoirs,
- protection against external hazards (environmental influences, access by unauthorized persons, fire spread),

When installing power storage tanks in the housing, the following requirements must be observed:

- floor (or canopy) and wall systems must be designed to support the load on the power storage tank,
- partitions inside the housing ensure the efficiency of ventilation, which must be assessed during the design of the housing,
- the distance between the modules must ensure adequate cooling in accordance with the manufacturer's requirements,
- the housing must prevent unauthorised persons from gaining access to dangerous parts,
- the enclosure must provide adequate access for maintenance.

2. The following requirements must be observed when installing and installing cables (Insulation & wiring)

The wiring and insulation of the power storage tank shall be such as to withstand the maximum intended requirements in terms of voltage, current, temperature, altitude and humidity. Hazardous parts of the live battery system must be protected to prevent the risk of electric shock.

The mechanical integrity of the entire battery system (cell/module/BMS) and their connections must be sufficient to adapt to the conditions of use.

3. Protection against electric shock

The safety measures for electricity storage tanks and their installations are based on the SIST EN IEC 62485-1 standard. In stationary installations for charging power storage tanks, the requirements for protection against direct contact (basic protection) and against indirect contact (fault protection) with dangerous voltages, based on the standards SIST HD 60364-4-41 and SIST EN 61140, must be observed.

Safety Extra-Low Voltage (SELV) and Protective Extra-Low Voltage (PELV) are only applicable to battery installations with maximum voltages up to 120 V DC.

Functionally Extremely Low Voltage (FELV) protection.

4. Disconnection and separation

The devices for disconnecting the battery power storage tank shall be capable of disconnecting from all incoming and outgoing circuit lines and from the earthing potential.

These devices can be:

- circuit breakers, switches;
- plugs and sockets;
- removable fuses;
- connecting elements (connector or collector);
- Specially designed clips.

Devices must be usable for direct current and provide the necessary insulation. During disconnection, the power storage tank must not be grounded or exposed to short-circuit.

The terminal contacts of the batteries can be considered as separating contacts. Disconnection of connectors or contacts (plugs) is allowed only when there is no current flowing through the circuit. Before disconnecting the batteries, it is necessary to turn off the charger and the loads to avoid the danger of sparking.

5. Prevention of short circuits and protection against other effects of electric current.

Short-circuits

In addition to the risk of electric shock, the current in battery systems can also cause other hazards. This is because in the event of a fault, very high currents can flow, and the voltage at the connections of the battery cannot be interrupted in the manner required by the standard SIST HD 60364-4-43 (protection against overloads) and SIST HD 60364-5-53 (protection devices).

The design of cells and batteries typically includes built-in protection (e.g. degassing valves) that allow gases to be emitted without breaking the cell or battery casing.

When switching off the protective device, account shall be taken of the possibility that the spark may ignite the emitted electrolyte gases when the current is cut off. These gases may contain hydrofluoric acid (HF), which is highly corrosive and toxic.

To reduce the risk of fire, flame retardant plastics in accordance with IEC 60695-11-20 and/or IEC 60695-11-10 are used to prevent plastic parts from adding heat to a potential fire.

In the prevention of short circuits and protection against other effects of electric current, the following requirements shall be taken into account:

- the overload protector shall have an intermittent or short-circuit capacity higher than the short-circuit current of the lithium-ion battery[BM1] ,
- the main connections on the battery connectors must be designed to withstand mechanical loads caused by electromagnetic forces generated during short-circuit,

- all connections of the battery to the battery protection device must be positioned in such a way as to avoid short circuiting under foreseeable conditions,
- the insulation must be resistant to environmental influences such as temperature, humidity, dust, gases, steam and mechanical loads,
- where connectors and conductors are not insulated (because of construction or maintenance), the use of insulated tools according to IEC 60900 is recommended.

N.B.: Compared to lead-acid batteries, lithium-ion batteries have lower internal resistance and faster charge transfer inside the electrolyte. Therefore, they have a significantly higher short-circuit current at the same voltage and capacity.

Maintenance instructions

When implementing protective measures during the maintenance of electricity storage tanks, the maintenance requirements set out in point 8 must be taken into account.

Leakage currents

Minimum insulation resistance between the battery circuit and other metal parts in the surrounding area
should be greater than 100 Ω / V maximum voltage of the battery system. The insulation must be resistant to: temperature, humidity, dust, gases, steam and mechanical loads.

6. Protection from dangers.

With regard to protection against hazards, the following requirements shall be taken into account:

- in the standard temperature range, secondary cells can be charged with the maximum charge current,
- Lithium-ion cells shall always be used within the operating range specified by the cell manufacturer (voltage, temperature, current) and based on SIST HD 62619 standards (Appendices A and C).

When charging methods for stationary batteries, it is necessary to take into account the following requirements:

- constant current/constant voltage charging (normal charging),
- Reduced charging current at low temperatures (to be specified by the manufacturer)
- overcharging or overdischarging in malfunction (automatic disconnection of the power supply or disconnection of the power flow to and from the battery).

Disconnecting the battery is one of its most important safety features.

Prevention of electrostatic discharges when working with batteries

Care should be taken that staff do not wear clothing or footwear which could cause electrostatic charge accumulation (according to IEC TR 61340-1 or IEC 61340-5-1), except in cases where this would conflict with the requirements for insulating clothing and footwear.

7. Identification labels, warnings and instructions for use, installation and maintenance

The space in which the electricity storage tank is installed must be marked and at least the following warning labels or notices must be placed on the outside:

- "Dangerous voltage" if the battery voltage is higher than Upc 60 V,
- Prohibition sign for "Fire, open fire, smoking prohibited,
- "Electricity storage" warning sign to indicate hazardous materials, voltages and currents.

The power storage shall be provided with the following instructions on or near the site:

- the title of installer,
- the start-up date,
- safety instructions and recommendations for installation, operation and maintenance.
- information on disposal and recycling.
- other labels (Directive EC 2006/66/EC - “Batteries Directive”).

For the safety of maintenance workers, inspectors, distributors, firefighters and rescue workers, it is essential that the presence of HEE installation in the building is indicated. The sign must be placed on:

1. entrance door or near the main entrance in a clearly visible place from the outside,
2. the point of charging the electrical installation,
3. the measuring point, if remote from the point of charging the electrical installation,
4. per consumer or distributor to which the power supply is connected.

The symbol shall be affixed to the installation power supply point, to the meter if it is not near the power supply point and to the distributor to which the adaptor is connected.

8. Basic requirements for system documentation, commissioning, verification and maintenance

The requirements for the minimum documentation to be provided after installation of an electricity storage tank connected to the network are based on the basic requirements of the standard SIST EN IEC 62446-1 (as a model):

- basic information about the system, the system planner and the system installer,
- one-line wiring plan,
- list of data on system components (inverters, electricity storage, ..),
- emergency system documentation,
- information on operation and maintenance.
- test results and take-over data.

This information will provide the user, overseer or maintainer with easily accessible key system data. The documentation shall include basic system data and information to be included in the operating and maintenance instructions.

Putting into service (SIST EN IEC 62548-1)

Batteries may be supplied in different initial conditions and must be correctly put into service in accordance with the manufacturer's instructions. The initial status and associated operational start-up procedures may be as follows:

a) Uncharged (dry) and non-responsive (non-activated) battery (NiCd): electrolyte charging and start-up (forming) charging are required.
b) Uncharged but pre-charged (dry charged) battery (Pb): electrolyte addition is required, final filling if necessary.
c) Filled and filled with electrolyte (Pb; NiCd; Ni-MH): The battery is ready to use.

d) Filled and discharged (NiCd; Ni-MH): Refilling is required before use.

Characteristics of rechargeable electrolyte and refilling water shall comply with IEC 60993 for nickel-cadmium (NiCd) batteries. For other battery systems, such as a lead-acid battery, it must be:

- electrolyte density (specific weight in kg/l),
- quantity and
- electrolyte level

according to the manufacturer's technical specifications.

When starting batteries, all voltages, currents, resting and charging times, as well as temperature limits specified by the manufacturer, must be taken into account.

The maximum allowable storage time and conditioning requirements (preparing the battery before use, such as pre-charging, performance test or electrolyte activation, which are required after prolonged storage in order to return the battery to optimal condition for operation) should be specified by the manufacturer.

Limit conditions and correction factors

Rated discharge capacity and depth

Manufacturer data shall be used and refer to a discharge depth of 100 % at rated current.

When batteries are regularly cyclically charged and discharged – in particular lead-acid batteries – not more than 80 % of the rated capacity shall be discharged. Voltage discharge, which is defined as the final discharge voltage, is considered to be deep discharge, causing irreversible damage and a reduced lifespan of lead-acid batteries. Lead-acid batteries that remain in a low state of charge for a long time also suffer an irreversible loss of capacity. The sensitivity of open (ventilated) nickel-cadmium (NiCd) batteries to deep discharge depends on the shape of the electrodes. However, NiCd batteries are almost insensitive to storage in an empty state. For sealed NiCd and NiMH batteries, the manufacturer's recommendations should be followed.

When determining the required capacity of the system, it is necessary to take into account the loss of capacity due to ageing during the lifetime of the battery. In the case of stationary or traction batteries, the typical ageing factor is 1.25, which corresponds to a reduction in capacity to 80% at the end of life. An additional capacity reserve is also recommended for later expansion of the DC power supply system.

Charging current and charging voltage

The values of the charging currents shall follow the manufacturer's instructions. When using a higher charging voltage than the gassing voltage, the charging current is increased, resulting in: increased release of hydrogen and oxygen, increased water loss, increased temperature and shorter battery life. The accuracy of the charger output voltage shall be better than ±1 %.

Individual cells may have slightly different voltages when charging an already fully charged battery with an even voltage – for example, floating (float) or accelerated (boost) charging. The voltage tolerances of individual cells are specified in the standard for PB, NICd and NIMH batteries are specified in SIST EN IEC 62458-1. Depending on the design of the product, the manufacturer may prescribe different values.

For lithium-ion batteries, the methods of charging and operating the batteries are given in Appendix A of the SIST EN IEC 62485-5 standard.

External short circuit

Batteries can withstand a certain short-circuit current or overload current for a certain time. These values specify the design requirements for DC power systems, which include fuses, circuit breakers and cables. The manufacturer must prescribe appropriate limit values. External short circuits can cause irreversible battery damage and shortened service life.

Battery temperature

Limit values are given in the standard SIST EN IEC 62485-1 and are possible and depend on the battery design and method of use.

Table 10: Operating temperatures

Battery type	Lower limit (fully filled)	Ceiling*
Pb (lead) – Open (ventilated)	−40 °C	+60 °C

Pb (lead) - Closed (VRLA)	−40 °C	+55 °C
NiCd - Open (ventilated)	−50 °C	+70 °C
NiCd - closed portable	−50 °C	+60 °C
NiMH - Closed Portable	−40 °C	+60 °C

Note 1: For other types of batteries, the manufacturer's information shall be taken into account.

*Note 2: The upper limit represents the loading temperature, which is allowed only for a short time. If used permanently, there is an inevitable reduction in life expectancy. The lower operating temperature is determined by the freezing point of the electrolyte.

With lead-acid batteries, the electrolyte density decreases during discharge, which reduces the freezing point.

At very low temperatures, ice crystals in the electrolyte can damage the plates or even the battery casing.

Charge voltage temperature correction
The charging voltage range is limited by *the open-circuit voltage* and *the gassing voltage.*

- High charging voltage → high gas generation rate → large water loss.
- Low charge voltage → low charge acceptance → low charge rate.
- The charging voltage of the battery depends on the temperature, so it needs to be temperature corrected,
  e.g. constant voltage charging.
- High temperature → lower charging voltage.
- Low temperature → higher charging voltage.

Therefore, the output voltage of the charger must be temperature compensated to prevent damage to the battery.

Where no other instructions are given by the manufacturer, the following formula may be used to correct the charging voltage of each cell:

$$U_{CC} = U_C + \lambda_U(\vartheta - \vartheta_n)$$

where it means:
U_{CC} – Temperature compensated charging voltage [V]
U_C – Charging voltage at reference temperature [V]
λ_U – Temperature correction factor [V/K]
ϑ – measured temperature [°C]
ϑ_n – reference temperature [°C].

Table 11: Typical temperature correction factors λ_U for the charging voltage of each cell*

Battery type	Temperature correction factor (λ_U) (per cell)	Temperature range
Lead-acid battery	−0,004 V/K	0 °C to +60 °C
Lead Acid Battery (Voltically Regulated-VRLA)	−0,003 V/K	0 °C to +55 °C
Nickel-cadmium battery	−0,003 V/K	−20 °C to +70 °C

Note*: For other types of battery systems, the manufacturer's information shall be taken into account
For open and ventilated (VRLA) lead-acid batteries, the calculated charging voltage can be reduced by 0 °C to −40 °C. When operating VRLA batteries at higher temperatures, the possibility of thermal runaway should be considered. The exact temperature limits must be specified by the battery manufacturer.

For lithium-ion batteries, charging voltage temperature compensation is recommended when the battery temperature deviates from the nominal conditions (20 °C or 25 °C). The battery manufacturer must give the exact values for: voltage and current at constant current and voltage, and instructions for correct compensation according to temperature. The permissible discharge range is determined by the temperature window prescribed by the battery manufacturer.

Acceptance procedures and maintenance recommendations

For functional and safety reasons, it is necessary to regularly check the battery and its operating environment. In accordance with the manufacturer's requirements and battery manufacturing technology, the inspection must include verifications of:

- protection measures against electric shock (see pt. 3),
- protection against hazards (see point 6),
- identifications, warnings, instructions for use (see pt. 7),
- battery voltage settings on the charger,
- the temperature of the battery,
- ‘float current’,
- strains of individual cells or monoblocks,
- the density of the electrolyte (if applicable) and the electrolyte level,
- cleanliness and possible leakage of electrolyte,
- tightening or moment of tightening of connections of cells and cables (if required),
- airflow for ventilation.

For lithium-ion batteries, regular inspection is mandatory:

- electrolyte leaks,
- Damaged insulation,
- mechanical damage to the housing,
- inflated battery housing (critical state). In such a case, the battery must be immediately disconnected from operation, regardless of whether the manufacturer provides special instructions for such cases or not.

The measurement methods are described in more detail in Chapter 12.

If a capacity test is carried out, IEC-standard test methods according to battery technology shall be used:

- lead-acid battery, open version: IEC 60896-11, points 11 and 13;
- lead-acid battery, valve-regulated: IEC 60896-21, point 6.11;
- NiCd battery, open version: IEC 60623, point 4.2;
- NiCd battery, partial recombination: IEC 62259, point 7.
- NiCd battery, closed version: IEC 60622, point 4.2.4
- Lithium-ion batteries : IEC 62620:2014, point 6.3

Useful information for the control of lead-acid batteries is also given in IEC/TR 62060.

Checks shall be carried out, mutatis mutandis, before the BHEE is brought into service and periodically within the time limits required for checking the electrical installation to which the BHEE is connected.

Maintenance

The battery maintenance instructions must clearly specify that when working on live parts, it is necessary to use appropriate working procedures and exclusively insulated tools in order to reduce the risk of injury from electric shock or short circuit. For details, see IEC 60900.

General instructions for battery maintenance should include:

- relevant working practices;
- the necessary means of protection; and
- procedures to be followed in the work.

When implementing protective measures during the maintenance of electricity storage tanks, the following requirements shall be taken into account:

- the maintenance work must be carried out in accordance with the manufacturer's specifications,
- personnel must be trained to carry out such work and must be trained for any special procedures required,
- For systems where the maximum voltage is above 120 V DC, insulated protective clothing and local insulated coatings are mandatory to prevent staff from coming into contact with ground or grounded parts.
- handle power storage tanks in accordance with the battery manufacturer's instructions.
- divided by power storage tanks with a maximum voltage greater than 120 V DC into sections consisting of 120 V DC or less,
- electricity storage tanks must be clean and dry in order to avoid the risk of fire or corrosion,
- Power storage tanks shall be installed in accordance with the manufacturer's recommendations.

In order to reduce the risk of injury, the battery system shall be designed to include:

- protective covers on the terminals of batteries that allow regular maintenance, while reducing exposure to live parts (water works);
- fuse holders to prevent contact with live parts.

Before starting work, workers must remove all metal objects from their hands, wrists and neck (e.g. rings, watches, necklaces) to prevent the possibility of short-circuits or burns.

If the manufacturer's instructions are not available, then the batteries should not be connected or disconnected as long as the electrical current passes through the circuit. The circuit must first be insulated in another place.

If screw fuses are used, the outlets of the batteries must be connected to the bottom contact of the fuse. Screw fuses are not recommended if both connections remain energized when the fuse is removed, e.g. in parallel-connected battery systems.

In systems where batteries are connected in parallel or via chargers, there may be reverse current that causes the contacts to be energized, even when the fuse is removed.

Electrostatic discharge (ESD) can damage battery cells, especially lithium-ion and others with sensitive electronic protection. Therefore, it is recommended to use antistatic clothing, footwear and earthing strips, except when insulating agents are required for electrical safety.

For battery systems with counters used in PV systems, the recommendations given in SIST EN IEC 62446-2 can be used when maintaining counters and wiring (cable connections between battery and counters).

11.3.11 Uninterruptible power systems (UPS)

Continuous power systems installed in buildings and forming part of an electrical installation may be installed in lay-access environments or in restricted-access spaces in order to supply a constant

frequency alternating voltage and include a reservoir. The requirements are set out in the standards of the SIST EN IEC 62040 group.

Checking the UPS System

1. AC input side (UPS power supply) - measurements as in normal installation:

- Continuity of PE protective conductors - ↔ PE UPS housing
- Insulation resistance L+N to PE
- Impedance of the fault loop — it shall be checked that the protective device on the supply manifold is switched off within the prescribed time, or
- RCD measurement, if fitted
- Voltage and frequency measurement

2. AC output side (powered devices)

- Continuity of PE protective conductors (UPS ↔ consumers)
- Insulation resistance of output conductors to PE
- Impedance of the fault loop:
  - it is measured at the output of the UPS in bypass mode (when the voltage goes directly from the network),
  - In battery mode, impedance is not measured – the protection is provided by the electronics in the UPS.
- Functional test: In the event of a fault, the UPS must turn off the output.

3. DC side (battery set)

- Continuity of protective conductors PE battery cabinets
- Insulation resistance of the battery pack against the ground - plus/minus against the PE (if the system allows it - take care not to damage the batteries)
- Battery pack voltage
- Fuse/circuit breaker test on DC side.

4. UPS Functional Tests
Switch network → battery → network
Switch time
Battery autonomy (if applicable)
Verification of alarms, communication and signalling
Operation of ventilation and cooling.

11.3.12 Power generators

(1) Power generators must be installed in such a way that any safety measure in installations for any intended combination of power supplies remains effective.

(2) Where, in a TN system, an electric generator is intended to be an off-grid power source and the TN system must be maintained, the electric generator must be operated in island mode, the system reference wire and local grounding must be provided.

(3) Where an electric generator is intended to operate in parallel with, or as a switch-over to, a distribution network outside the installation, special requirements shall be imposed by the system distribution operator (DSO).

(4) However, where an electric generator is intended to be used only as a switching substitute, a measure must be provided to prevent parallel operation with another source.

(5) If an electric generator is intended to operate in parallel with another source, adverse effects on that source and installation must be avoided, including, for example:

- power factor,
- Changes in tension,
- change of frequency,
- loss of power,
- harmonic distortion,
- asymmetry of burden,
- contribution to fault current from multiple sources,
- load switching effects, such as start-up and synchronization,
- Equalisation flows.

(6) Where RCD is used:

- in the circuit connecting the generator to the installation, the RCD shall disconnect all power lines; and
- In all other circuits, the RCD shall disconnect all power lines except allowed ones.

(7) Where overcurrent protection of the circuit connecting the generator to the installation is required, the overcurrent protection device shall be located as close as possible to the connections of the generator.

(8) The functional arrangement of switching between back-up power supplies can be achieved by:

- an electrical, mechanical or electro-mechanical interlock between the operating mechanisms or control circuits of the coupling switching equipment; or
- a locking system with a single transfer key; or
- transmission switchgear (TSE) in accordance with SIST EN IEC 60947-6-1; or
- Switchgear of origin (SSE) according to SIST EN IEC 62991.

(9) In installations where the generator is intended to act as an additional power source in parallel with another power source:

- the aggregate shall not be connected to the final circuit;
- the connection of the aggregate to the electrical installation must be carried out in one of the following ways:
  - permanently connected equipment; or
  - installation couplings in accordance with SIST EN IEC 61535 or
  - a dedicated coupling system which is not compatible with national system configurations based on SIST EN IEC 60884-1 or SIST EN IEC 60320 or SIST EN IEC 60309-2 used for other purposes and which provides a level of protection of at least IP2X or IPXXB in all coupling modes;
- measures must be taken to ensure that thermal and mechanical loads resulting from contributions from all sources do not exceed the capacity of the distribution assemblies. One or more of the following measures shall apply:
  - reduction of loads,
  - limiting the total loads connected to the distributor assembly without diversity,
  - selection of electrical equipment such that the sum of the rated current(s) or current setting(s) of the overcurrent protection device (In) input circuit installed in or upstream of the low voltage distributor assembly and the rated output current(s) of the generator(s) (I_{gs}) does not exceed the rated output current of the distributor (I_{nA}).

(10) Where a self-contained electric generator is used to power an installation and reliable grounding measures are not available or cannot be maintained, one or more of the following requirements may be applied:

- the electrical equipment must meet one of the requirements for basic protection in Appendix A of SIST HD 60364-4-41.
- Damage protection must be provided by complying with what is stated above and with the following requirements:
  - Electrical separation with Insulation Controller (IMD)
  - electrical separation using RCDs,
  - automatic disconnection of the power supply from the electric generator.

- Exposed conductive parts of the electric generator and all electrical equipment must be connected together with protective conductors.
- All sockets must be provided with protective contacts, which must be connected to a protective equalisation connection in accordance with the previous indent.
- Where:
  - there is a failure between the supply conductor and the protective equalisation connection or earth; and
  - a second failure occurs on the supply conductor with a different potential,

The protective device shall interrupt the fault current for the time given for the TN system in Table 2 of this document.

- Applied requirement: Electrical separation with Insulation Controller (IMD):
  - Insulation monitoring device (IMD) according to SIST EN 61557-8 shall be installed together with the circuit breaker to cause automatic disconnection of consumer circuits within 5 s if the isolation resistance between live parts and the equilibrium protection connecting system drops below 100Ω/ ς (ωιεωεδ λινε-γρουνδ ωολταγε, Υο);
  - the user shall be instructed to check the correct functioning of the IMD and the circuit breaker before commencing consumption.
- Applied requirement: Electrical separation using RCDs:
  - One dedicated RCD shall be used for each socket and permanently connected equipment. Where the rated current of the socket or consumer is ≤ 63 A, the rated residual current of the RCD shall be no more than 30 mA;
  - the selective RCD shall not be used for the final circuit feeding the socket;
  - the user shall be instructed to check the correct functioning of each RCD before commencing consumption.
- Applied requirement: automatic disconnection of the power supply from the generator:
  - The output of the aggregate must be protected by an RCD. This provides protection against faults in distribution circuits;
  - Exposed conductive parts of the aggregate and connected equipment must be connected to the live part at the base of the power supply by a protective conductor.

11.3.13 Electric drive systems (PDS, frequency converters)

(1) Electric powertrains shall be installed in buildings in accordance with the standards of the SIST EN IEC 61800 series, in particular:

SIST EN IEC 61800-1	DC electric power trains
SIST EN IEC 61800-2	AC electric power trains
SIST EN IEC 61800-5-1	General safety requirements
SIST EN IEC 61800-5-2	Functional safety requirements
SIST EN IEC 61800-9	Eco-design for energy efficiency

(2) Electric powertrains include semiconductor power conversion and the means to control, protect, monitor, measure and (AC) motors.

Verification of frequency converters

Protection against electric shock in equipment powered by frequency converters (FPs) shall be validated similarly to conventional power supply systems, but the specifics of the operation of the converters shall be taken into account.

Key for frequency converters:

- there is no longer a pure 50 Hz sinusoidal voltage at the inverter output, therefore fault and short circuit loop impedance and at the output are not implemented;
- As a general rule, measurements shall be made on the input side of the converter (where a 50 Hz grid is standard) and engine protection shall be provided by a combination of:
    - mechanical housing protection (PE connection),
    - electronic protection in FP (current control,),
    - protection in the power manifold (RCD, installation circuit breaker).

Verification steps:

1. Visual inspection

- check the correctness of the protective ground conductor (PE), the connection between the FP, the engine and the conductive parts of the equipment;
- check the markings and the accessibility of the safety features (grounding, fuses, switches, RCD).

2. Continuity measurement of protective conductors

- The meter shall confirm that all conductive parts are reliably connected to the protective conductor.

3. Automatic power disconnection:

- measurement of fault loop impedance
    - the impedance of the fault loop at the entrance shall be measured,

or

- RCD protection check
    - For frequency converters, the use of type B (or at least type A with high frequency capacity) is recommended.

4. Insulation resistance measurement

- a measurement of the phase-to-case insulation (PE) shall be carried out, usually with 500 V DC.
- In the case of frequency converters, this measurement shall be carried out with the input and output cables disconnected in order to protect the electronics (measurement on the engine and power supply conductor only, not on the converter itself)!

5. Functional Off-Shut-Off Test

- A fault shall be simulated to confirm timely disconnection.

11.3.14 Other special types of electrical installations

Other specific types of electrical installations shall be carried out by applying this technical guideline mutatis mutandis and in accordance with the relevant standards and other normative documents. Other specific types of electrical installations include, for example:

1. exhibition rooms, event rooms, stands,
2. marinas and similar locations,
3. electrical installations of hospitals and in-house installations for the connection of medical devices,
4. electrical installations in areas where there is a risk of explosion,
5. electrical installations of construction sites,
6. conductive spaces with limited movement,
7. furniture,
8. outdoor lighting installations,
9. lighting installations for low voltage,

10. utilities and workplaces;
11. service or maintenance passageways,
12. heating cables and related heating systems,
13. underfloor and ceiling heating systems,
14. installations adapted for emergency back-up supply of small portable consumer aggregates.

12 VERIFICATION OF LOW-PERFORMANCE ELECTRIC INSTALLATIONS

12.1 GENERAL

After completion of electrical installations and installation of electrical equipment, machinery and devices, after modifications, renovations, repairs and from time to time, verification of the adequacy and quality of electrical installations, their characteristics, safety, reliability and functionality, and the use of relevant construction products (embedded electrical installations) must be carried out. The Rules therefore provide:

Article 12
(first check of electrical installation and lightning protection)

(1) The investor must ensure the appointment of an inspector before the start of the construction works related to the verification of electrical installations and lightning protection.
(2) As part of the supervision of the construction, the supervisor shall ensure that the inspector carries out verification of those parts of the construction that affect the safety of the electrical installation and lightning protection. If the examiner identifies shortcomings in the design documentation or in the execution of parts of a phase, he or she shall inform the supervisor. The inspector shall carry out his work in cooperation with the construction supervisor.
(3) During verification, the examiner shall verify the compliance and safety of electrical installation and lightning protection with these Rules and with the project documentation for the execution of the construction or with the project documentation of the performed works. The compliance check shall also include an assessment of the compatibility of the installed equipment and installed devices intended for the functioning of the building and the fixed connected devices. The examiner shall draw up the minutes as provided for in Article 14 of these Rules. The minutes shall be a mandatory annex to the proof of the reliability of the facility.

Article 15
(Use and maintenance)

(1) The first check pursuant to Article 12 of the Rules shall cover:
- review
- measurements and
- Tests.

(2) The inspection shall be carried out in a non-voltage state of the electrical installation.
(3) Measurements such as resistance of protective connections, insulation resistance and grounding resistance, and others where meters use their own/internal sources, shall be made in a voltage-free state.
(4) The results of the activities referred to in (2) and (3) must be positive in order to require temporary connection of the voltage.
(5) Certain measurements and tests for the first verification of the safety of electrical installations can only be carried out under actual operating conditions of the electrical installation, therefore these verifications must be carried out with the mains voltage connected — temporary connection, as provided for in Article 12a of the Regulations. (6) The temporary connection may last until the completion of the checks, but no longer than provided for in paragraph 2 of Article 12a of the Rules.

Article 13
(Ordinary and Extraordinary Verification)

(1) Regular and extraordinary checking of electrical installations and lightning protection is part of the maintenance of the facility.
(2) Regular verification of demanding electrical installations and less demanding lightning protection should be carried out within deadlines not exceeding four years.
(3) Regular verification of demanding lightning protection must be carried out within periods not exceeding two years, and regular visual inspections must be carried out within a period not exceeding one year.
(4) Notwithstanding the preceding two paragraphs, the periodic review referred to in the first paragraph of this Article shall be carried out:
- carry out, in the part of the building where explosive atmospheres may occur or in the part of the building and the circuit defined by the Explosive Hazard Assessment, periodic visual inspections within a period not exceeding three years and within a period not exceeding one year; in the part of the building where the corrosive aggressive atmosphere also occurs at the same time, carry out regular visual inspections for periods not exceeding two years and for periods not exceeding one year;
- in the building for the manufacture and storage of explosives, shall be carried out within a period of not more than one year and periodic visual inspections shall be carried out within a period of not more than six months.

(5) Regular verification of less demanding electrical installations must be carried out within a period not exceeding eight years, and regular verification of electrical installations in one and two-dwelling buildings must be carried out within a period not exceeding 16 years.
(6) Notwithstanding the preceding paragraph, regular verification of electrical installations of single-dwelling buildings with a photovoltaic power plant installed shall be carried out within a period not exceeding 8 years.
(7) Exceptional verification of electrical installation and lightning protection shall be carried out after damage, repair or other interventions, including renovation or minor reconstruction, and after the connection of new installed equipment and installed and fixed-connected devices that may have an impact on safety. Exceptional verification shall be carried out only on electrically completed units of electrical installation or lightning protection on which the operation was carried out. Extraordinary checks of lightning protection shall also be carried out after any direct lightning strike into lightning protection, after any damage to the building due to lightning strike or interference with lightning protection. Extraordinary checks are also carried out in cases of construction interventions on the building envelope, including the installation of devices, if these interventions affect the protection against the action of lightning.
(8) In buildings or electrically closed units in buildings with built-in basic protection against electric

12.1.1 Responsibilities of the overseer

(1) At the start of construction, the selected inspector must be present to check the installation of the ground/ground before watering into concrete or before burial. It should be present at all subsequent stages of the construction of the building, which could affect the later unverifiable correctness of the implementation of the system of low-voltage electrical installations and lightning protection. Information on individual construction phases that affect the safety of low-voltage electrical installations is an integral part of the minutes on the first verification of low-voltage electrical installations and lightning protection system.
(2) The entire building or the electrically completed whole of the building shall be checked. The new building should be fully checked. After changes, reconstructions and repairs of the part of the electrical installation system that is part of the electrically completed whole or is connected to one consumption point, it is necessary to carry out a check of all electrical installations connected to the same distribution system, whereby it is necessary to establish the professional correctness and

safety even in that part of the electrically completed whole that has not been changed, reconstructed or repaired.
(3) Where the inspector finds that additional methods of extending the electrical installation, such as fixed extension cords, distributors, extension and branching of the supply system between electrical appliances or machines, are used, this extension shall also be subject to verification in its entirety.
(4) The inspector must take note of and take into account the results and recommendations of the preliminary checks.
(5) Verification of demanding low-voltage electrical installations can be carried out only by individuals who have obtained the professional qualification of NPK for overseer of demanding electrical and lightning protection installations.
(6) Checks of less demanding electrical installations can be carried out by individuals who have obtained the professional qualification of an inspector of less demanding electrical installations and lightning protection installations.
(7) At the first check, the low-voltage electrical installations and the lightning protection system, if fitted, shall be checked simultaneously. If the inspected building should have a lightning protection system but does not have one, it did not pass the verification.
(8) Where a building is fitted with lightning protection, the verification of electrical installations must be carried out within the time limits prescribed by the regulation on the basis of which this technical guideline is issued; within the time limits laid down for the verification of protection against lightning strikes, the verification of protection against electric shock by the electrical installation of the connected lightning protection system.
(9) For buildings without a single-pole installation scheme, a positive assessment report may only be issued if the worst case scenario is taken into account in the verification (the characteristic of the most powerful built-in element to ensure automatic disconnection is taken into account). For less demanding installations, a table of measurements with a recognisable structure or an illustrative diagram of the affiliation of the circuits of the recorded state, which allows the verification to be repeated, is sufficient. For complex installations, the owner must provide project documentation of the implemented state.
(10) In the case referred to in the fourth paragraph of point 12.1.3, the overseer shall propose to the trustee to shorten the period for periodic tests.
(11) After the check has been completed, the examiner may place his/her certificate of competence number and the date of the check on the main distributor, allowing rapid inspection of the statutory checks and of the certified safety of the electrical installation.

12.1.2 Responsibilities of the overseer

Article 11
(verifying body)

(1) The tasks related to the verification of electrical installation and lightning protection referred to in Articles 13 and 14 of these Rules may be performed only by the verification provider (hereinafter: examiner), i.e. an individual with a national professional qualification for the verification of demanding electrical installations and lightning protection, or a national professional qualification for the verification of less demanding electrical and lightning protection in accordance with the law governing national professional qualifications. The examiner must have competences that complement the national professional qualification obtained for specific areas of electrical installations and lightning protection beyond the national professional qualification obtained.[

(1) The overseer shall be responsible for the proper implementation of its areas of activity. In order to properly carry out checks and ensure electrical safety and quality, it must regularly update and update its knowledge and experience in line with technological developments in all areas covered by it. Areas outside the scope of the national professional qualification are defined by skills competences for which the examiner must acquire the relevant knowledge and valid documents.

(2) Competences of the examiner's knowledge and experience are:

- Electrical and industrial electrical installations & responsibility in the workplace
- Low-voltage electrical installations & responsibility in the workplace
- Safe Work in Explosively Endangered Spaces and Environment
- Energy, Production, Transmission and Distribution, Industry
- Low-voltage electrical and lightning installations
- Electrical machinery, equipment, distributors and appliances
- nnELI vehicles, electric cars, converted vehicles with aggregates, emergency vehicles, motorhomes
- Medical and healthcare equipment and installations

Details of these competences and experience are given in Appendix A of this guideline.

(2) The checks must not cause danger to humans and animals and must not cause damage to property and equipment, even if the circuit is faulty.
(3) An examiner with the professional qualification of NPK for less demanding electrical installations and lightning protection installations may not independently carry out checks of demanding electrical and lightning installations.
(4) The overseer shall be liable for inappropriate or falsified records of verifications. The responsibility of the overseer is based on the provisions of the first paragraph of Article 14 of the Rules.

Article 14
(Verification scope and minutes)

(1) In the checks referred to in Articles 12 and 13 of these Rules, the electrical installation and lightning protection shall be checked and a record drawn up to the extent and in the manner specified in both technical guidelines. The record must give a clear and unambiguous assessment of the determined state of the verified electrical installation and lightning protection, with the determination whether the verified electrical installation or lightning protection meets the requirements of these Rules.
(2) If the inspector finds, during the verification, that the electrical installation and lightning protection presents or is likely to present a danger, he shall indicate the irregularities in the report and may also add a proposal for the necessary measures to remedy the situation. The minutes shall be handed over to the building administrator. Irregularities must be corrected within the time

12.1.3 Electrical installations to be checked regularly

(1) The SIST HD 60364-6 standard gives the following reasons for regularly checking electrical installation without disconnection or partial disconnection to ensure:

- the safety of humans and animals from the effects of electric shock and burns,
- protection against damage to property caused by fire and heat due to a fault in the electrical installation,
- confirmation that the electric shock protection devices are correctly selected and adjusted,
- Confirmation that the control devices are correctly selected and set
- confirmation that the installation is not damaged or deteriorated, thereby reducing its safety,
- identification of damage to the installation and non-compliance with the requirements of other standards relating to electrical installations, which may increase the risk,
- Confirmation that protective devices are correctly selected and set.

(2) If the circuits are continuously under the control of isolation resistance monitoring devices and residual current monitoring devices, and these devices are verified and function correctly, it is not necessary to measure isolation resistance.
(3) The measuring and testing instruments and procedures shall comply with the relevant parts of the SIST EN IEC 61557 series standards.

(4) The period for periodic tests may be shortened at the request of the building administrator in the case of:
- working spaces and locations where there is a risk of electric shock, fire and explosion due to degradation,
- working spaces and locations containing low-voltage and high-voltage installations,
- utilities;
- construction sites,
- security installations (e.g. emergency lighting).

(5) In areas where it is necessary to install floor coverings with reduced electrical resistance in order to ensure the measures envisaged by the Explosion Risk Assessment, the employer must prove the adequately low drainage resistances of these floor coverings by means of measurements within the deadline and values as provided by the Assessment.

12.2 VISUAL EXAMINATION

(1) When checking the adequacy of electrical installations, it is necessary to check:
1. that there is a project (and plans) on low-voltage installations or written and graphic information describing the implemented state of electrical installations,
2. that there are documents of conformity (declarations of conformity, attestations) of the installed equipment of electrical installations,
3. measures to protect against the spread of fire and against thermal influences,
4. the correctness of the selection and adjustment of protective and control devices,
5. correctness of layout of switchgear in relation to separation distances,
6. the correctness of the choice of equipment and protective measures in relation to external influences (IP protection level),
7. correct implementation of overvoltage protection and correct installation of surge arresters,
8. identification of neutral and protective conductor,
9. the existence of schemes, warning plates or similar information,
10. identification of circuits, fuses, switches, clamps and other equipment,
11. connections of conductors, joints, cross-sections, paints, marking, to achieve EMC compatibility,
12. divider, including wiring according to SIST EN 61439-1,
13. accessibility and availability of management space (operation and maintenance),
14. correct installation of stationary batteries,
15. the completeness of the isolation of live parts and the compliance of the equipment with the relevant applicable standard,
16. protection against electric shock in accordance with point 4 (protection against electric shock),
17. in the first inspection, the compliance of the type of earthing of the installation system, as well as its compliance with the project and the electricity consent, and the correct marking on the distributors,
18. proper implementation of earthing and implementation of the main equalization of potentials,
19. correct implementation of additional equalization of potentials,
20. proper implementation of protection by local assimilation of potentials without connection to the ground, if any.
21. carry out inspections in accordance with the instructions of the manufacturer of the installed equipment or the operator of the electrical installation.

(2) In the case of periodic inspections, the acts referred to in points 1 and 2 of the preceding paragraph shall be omitted.

12.3 PRESCRIPTIONS

(1) Tests may be carried out only after a visual examination has been carried out.
(2) When checking the adequacy of electrical installations, tests shall be carried out:
1. the continuity of the protective conductor,

2. the continuity of the master guide for equalisation of potentials,
3. the continuity of an additional guide to equalising potentials,
4. protection by electrical circuit separation (SELV, PELV, FELV, galvanic separation),
5. continuity of earthing resistance of surge arresters,
6. operation of protection with automatic disconnection of power supply (RCD, ELR, activation of built-in test functions),
7. the functionality of electrical installations and devices,
8. correct implementation of protection against electric shock,
9. the operation of residual current monitoring devices, if fitted,
10. operation of isolation resistance monitoring devices in the IT system and in non-grounded aggregates,
11. checking the uniform direction of rotation of all three-phase sockets and three-phase electric motors,
12. AFDD failure arc protection device operation test.

12.4 MEASURES

(1) When checking the adequacy of electrical installations, measurements must be carried out in accordance with SIST HD 60364-6:

1. Main equalization of potentials, resistance of the protective conductor and connection of conductive parts:
    1. impact protection at all points of electrical installation, connections to foreign conductive parts in the room,
    2. connections of external conductive parts, continuity of galvanic connections and joints;
2. Insulation resistances between live (including N) conductors, to each other and to the grounded PE (PEN) conductor, where possible; insulation resistance of installations, insulation of separating transformers:
    1. In the case that insulation resistance cannot be measured, the insulation of installations shall be measured by checking leakage currents at rated voltage,
    2. Insulation resistance of direct current conductors of photovoltaic systems,
    3. Insulation resistance of DC sources and associated circuits,
    4. Verification of leakage currents on DC sources and associated circuits,
    5. Insulation resistance of floors and walls when placement in non-conductive spaces is used as protection against impact; floor drainage and other protection against static electricity from technological safety aspects,
    6. Monitoring of insulation resistance and leakage currents;
3. Impedance of fault loops and short-circuit loops Z, short-circuit and fault currents, and determination of the correct disconnection time of protective devices; voltage drops on the conductors between the distributor and the furthest point of the circuit; Residual Current Protection Devices (RCD) correctness of operation:
    1. Impedance Z, short circuit and fault currents on circuits with frequency regulators, UPS systems, converters;
    2. Impedance Z, short circuit and fault currents on DC circuits with battery storage;
    3. Measurements of electric shock protection parameters in supply circuits (RCD, ELR);
    4. Verification of safety conditions in buildings built before 1985 (zeroing);
4. Suitability of protective and operating earths, contact and step voltages;
    1. Tensions of touch and step around smaller objects, buildings, devices and structures;
    2. Tensions of touch and step at the edges of grounding systems and in the field of grounding of energy installations, industrial facilities, areas and centers of presence of a large number of people;
    3. Adequacy of integrity for grounding systems of installations and structures in industry, energy and high-current distribution.
5. Adequacy of lightning protection ZPS
    1. Adequacy of internal lightning protection ZPS, verification of the operation of the break-through threshold of the SPD overvoltage protection and the idling current (leakage current); Suitability of grounding of SPD surge arresters

Descriptions and requirements for measurements are given in Appendix B to this document.

(2) The meters for the aforementioned required measurements must meet the standards of the SIST EN IEC 61557 series.
(3) In accordance with the SIST EN 50160 standard, the quality of the electrical voltage is measured as follows:

1. for less demanding electrical installations in residential buildings, current measurements at load up to the declared connection power shall be carried out:
   - phased consumption, current in N conductor and current in PE conductor for the adequacy of voltage symmetry,
   - total distortion of voltage and content of voltage harmonics;
2. for less demanding electrical installations in buildings for the performance of an activity or buildings with a significant impact on demand, measurements shall be carried out for one working day per week, with an interval of one minute, at the start-up of all major consumers:
   - phased consumption, current in N conductor and current in PE conductor for the adequacy of voltage symmetry,
   - total distortion of voltage and content of voltage harmonics,
   - monitoring of tension by phases, flicers, declines, bumps, outages,
   - rapid voltage quality assessment and phase diagram and asymmetry diagram;
3. for complex electrical installations, measurements shall be carried out over a period of one week with an interval of ten minutes with the most unfavourable working regime:
   - overall assessment of the quality of the voltage at the demand point,
   - electricity consumption corresponding to IEEE 519.

12.5 MAINTENANCE REVIEW

(1) Maintenance checks may be carried out by the owner or by an appropriately qualified authorised person. This check is usually carried out due to other requirements, during regular checks.
(2) During the maintenance inspection, the following must be visually inspected:

1. that the electrical installation is in good condition and does not show any visible damage to the view,
2. that there are no loose joints and accidental interruptions of conductors, joints and connections,
3. that due to corrosion there are no weakened parts of the earthing and equalizing connections, especially in contact with the ground,
4. that all visible ground connections are intact,
5. that all visible conductors and components of the system are fixed to the appropriate substrates and that no parts of the mechanical protection are damaged,
6. that the correct indicators of the installed protective devices are set or switched on,
7. there are no signs of damage to protective devices or fuses,
8. that galvanic connections with neighbouring buildings and the connection of their installations are properly carried out,
9. that the connecting lines, joints and damping devices, the location of the cable laying and the surge protective devices are correctly installed, correctly connected to the grounding system,
10. that the passages of the conductor from the foundation to the ground and from the ground to the above-ground part are carried out with appropriate insulation (bitumen tape, insulated conductor, …),
11. that the underlying ground is galvanically connected to the reinforcement of the building by welded joints or appropriate joining elements.

(3) The owner shall keep records of the maintenance checks.

12.6 VERIFICATION PERIOD

(1) Where a building combines electrical installations of varying complexity, electrical installations and/or a lightning protection system, the period for regular checks as well as maintenance checks shall be determined according to their complexity.

(2) The periods of mandatory visual inspections and checks of the external LPS system should be aligned with the periods of mandatory inspections and checks of the most demanding low-voltage electrical installations or plant in the building and be carried out simultaneously.
(3) Visual inspection and verification of the internal lightning protection system and electrical installations in the same building, where a risk assessment does not specify otherwise and exists, shall be carried out during the periods required for this type of electrical installation.

12.7 MINUTES OF VERIFICATION

(1) Verification report (hereinafter: a record) must contain information showing that the examinations, tests and measurements referred to in points 12.2, 12.3 and 12.4 of this Guideline have been carried out, as well as information on examiners, instruments and measurement methods. The results of all checks carried out must be unambiguous, i.e. all the required verification values for each consumer or group of consumers connected to the same circuit. It must be possible to determine from the record which user is concerned, where it is located and to repeat the verification in the same way.
(2) The record must state the mark, number and date of the valid certificate proving the calibration data of the measuring instruments used.
(3) The minutes must give an assessment of the adequacy of the electrical installation for the whole building or the electrically completed whole as set out in the second paragraph of point 12.1.1 of this technical guideline. Only an assessment demonstrating the adequacy of all checks with the results shall be considered positive. The negative assessment shall include in the minutes an annex with a list of identified inadequacies and, optionally, proposals for necessary corrective measures.
(4) In the event of a negative assessment, the identified inadequacies of the installation must be rectified and the results verified by examination or by tests and measurements. This should be repeated until the inadequacies have been remedied and the verification gives a positive assessment.
(5) The owner/operator shall be informed in writing of the possible dangers arising from unidentified inadequacies or unchecked parts of the building. The written record shall be annexed to these minutes.
(6) If the negative assessment of the determined condition is due to a possible inadequate electrical installation project or written and graphic information describing the implemented state of electrical installations, the inspector must warn the building owner and propose to him to request the designer to coordinate the project or information in such a way that it will correspond to the actual purpose of the electrical installation.

(7) In the event that the assessment of the established situation is negative due to the possible incorrect implementation of the electrical installation project, the inspector must warn the owner of the building of this fact and propose to him to require the contractor to arrange for the situation as determined by the project.

(8) The verification report shall have at least the content specified in the standard SIST HD 60364-6.
(9) The minutes should have pages marked in such a way that they allow to determine the integrity (marks in the header and footer of the document, marked total number of pages of the report, protected *.pdf document, etc.).
(10) On the basis of the trend in measurement results after comparison with measurements of preliminary verifications, as well as the actual state of electrical installations at the time of verification, the inspector may, for reasons of safety of persons and property, propose a shorter period until the next verification regardless of the positive result of the verification. The building administrator must agree to this.

A Appendix A: Competences of knowledge and experience

Competences of the inspector's knowledge and experience are intended for the implementation of specific areas of activity.
Below is a list of recommended competences of knowledge and experience, broken down by field. With the development of techniques and knowledge, new competences of knowledge and experience can be developed.

B Electrical and industrial electrical installations & responsibility in the workplace

Mastering procedures and rules for working under voltage and in the vicinity of live parts, safe execution of works, maintenance, installation and installation.

Reference code	Acronym of competence	Description	Reference documents
ZRZ: D-5/010	**DPN eeELI**	Expert eeELI for live works and near live parts	Rules on protection at work against the dangers of electric current (UL RS Nos 29/92, 56/99 – ZVZD and 43/11 – ZVZD-1)
ZRZ: D-5/009	**BPN eeELI**	Expert eeELI for works in a voltage-free state and near live parts	Rules on protection at work against the dangers of electric current (UL RS Nos 29/92, 56/99 – ZVZD and 43/11 – ZVZD-1)

C Low-voltage electrical installations & responsibility in the workplace

Mastering procedures and rules for working under voltage and in the vicinity of live parts, safe execution of works, maintenance, installation and installation.

Reference code	Acronym of competence	Description	Reference documents
ZRZ: D-5/008	**DPN nnELI**	Expert nnELI for live works and near live parts	Rules on protection at work against the dangers of electric current (UL RS Nos 29/92, 56/99 – ZVZD and 43/11 – ZVZD-1)
ZRZ: D-5/007	**BPN nnELI**	nnELI expert for works in a voltage-free state and near live parts	Rules on protection at work against the dangers of electric current (UL RS Nos 29/92, 56/99 – ZVZD and 43/11 – ZVZD-1)

D Safe Work in Explosively Endangered Spaces and Environment

Reference code	Acronym of competence	Description	Reference documents
EZS: D-5/917	**EXP**	Qualified administrator of demanding installations in facilities with explosion-endangered premises.	Rules on Explosion Protection

E Energy, Production, Transmission and Distribution, Industry

Reference	Acronym of	Description	Reference documents

code	competence		
ZRZ: D-5/922	**EES**	Qualified administrator of earthing systems in electricity systems and grids	IEEE 81, SIST EN IEC 62305, SIST EN 50522
ZRZ: D-5/909	**EEA**	Qualified administrator of electrical installations by providing automatic disconnection	SIST EN 60609-0, SIST EN IEC 60947-2
ZRZ: D-5/712	**PVV**	Qualified administrator of photovoltaic solar power plants, associated installations and devices	SIST HD 60364-7-712, SIST EN IEC 62446
ZRZ: D-5/919	**PQA**	Qualified administrator of the quality of voltage, current, power and energy	SIST EN 50160 & IEEE 519

F Low-voltage electrical and lightning installations

Reference code	Acronym of competence	Description	Reference documents
ZRZ: D-5/164	**EISinsp**	NnELI Electrical Safety Monitor for Low Voltage Electrical Installations	SIST HD 60364-6 Common rules TSG N 002
ZRZ: D-5/106	**EISc**	Qualified contractor / maintainer of nnELI electrical safety of low voltage electrical installations	SIST HD 60364-6 Common rules TSG N 002
ZRZ: D-5/105	**LPSinsp**	Lightning protection monitor	SIST EN IEC 62305 Common rules TSG N 003
ZRZ: D-5/104	**LPSc**	Qualified lightning protection administrator / contractor / maintainer	SIST EN IEC 62305 Common rules TSG N 003

G Electrical machinery, equipment, distributors and appliances

Reference code	Acronym of competence	Description	Reference documents
ZRZ: D-5/439	**ESB**	Qualified distributor electrical safety administrator	SIST EN IEC 61439-1
ZRZ: D-5/204	**EVS**	Qualified Electrical Safety Trustee for Machinery	SIST EN 60204-1
ZRZ: D-5/274	**EVO**	Qualified Electrical Safety Trustee for Welding Equipment	SIST EN IEC 60974-4
ZRZ: D-5/678	**EON**	Qualified Electrical Safety Trustee for Electrical Equipment and Appliances	SIST EN 60745, SIST EN IEC 60335-1, SIST EN 50678, SIST EN 50699

H nnELI vehicles, electric cars, converted vehicles with aggregates, emergency vehicles, motorhomes

Reference code	Acronym of competence	Description	Reference documents
ZRZ: D-5/707	**eMOB**	Qualified Electrical Safety Trustee for vehicles fitted with nnELI	SIST HD 60364-7-717
ZRZ: D-5/702	**EVSE**	Qualified Electrical Safety Trustee for Electric Vehicle Charging Stations	IEC EN 62572, SIST HD 60364-7-722
ZRZ: D-5/700	**EV1/EV2/EV3**	Qualified Electric Vehicle Safety Trustee with DPN Access	UN ECE R100, ISO 6469-3, ISO 6469-4
ZRZ: D-5/700	**EV1/EV2**	Qualified Electrical Safety Trustee for BPN	UN ECE R100, ISO

		Restricted Electric Vehicles	6469-3, ISO 6469-4
ZRZ: D-5/700	**EV1**	Qualified Electrical Safety Trustee for BPN Restricted Electric Vehicles	Basic level UN ECE R100

I Medical and healthcare equipment and installations

Reference code	Acronym of competence	Description	Reference documents
ZRZ: D-5/601	**MEDe**	Qualified Electrical Safety Trustee for Medical Electrical Equipment	SIST EN 60601 / SIST EN 62353

J Appendix B: Measurement procedures and methods

This appendix sets out the measurement procedures, first of all those directly linked to the requirements of this guideline in Chapter 12.4 and then for certain devices which may also be part of a system of low-voltage electrical installations.

K Measurements of main equalization potentials, resistance of the protective conductor and connection of conductive parts

In order to ensure safety and prevent dangerous voltage differences between metal parts, it is necessary to check the quality of the connections in the system of equalization of potentials:

- the minimum requirement is to perform measurement with AC or DC current by changing the measuring poles in the + direction and - to detect the execution of connections with various materials of unauthorised combinations. The current generator shall provide at least 200 mA of test current;
- the limit of resistance of the connection between metal parts shall not exceed 0,1 Ω;
- the measurement may exceed the minimum expected measured values in the case that additional measures allow it when performing automatic disconnection within the allowed time according to the requirements of SIST HD 60364-4-41, taking into account the appropriate implementation of the electrical installation system TN, TT or IT

  $R < U_{c/I\ k}$ failure or $R < U_{c/I\ DN}$ RCD;

- when connecting the conductive parts of an individual distributor, the protection carried out in the previous distributor shall be taken into account;
- measurements shall be carried out on all accessible joints and metal structures that are part of the potential equalisation system.

Difficult installations:

- A four-wire method and a current generator with output current ≥ 1 A (milliohm range), ≥ 10 A (microohm range), ≥ 100 A (nanoohm range) should be used to achieve better results and to perform measurements in industry, hospitals and special rooms or environments in the expected value range below 0,1 Ω;
- where electrical equipment to provide automatic disconnection exceeds the rated current above 63 A, it shall always be verified that the resistance of the connections to the metal parts provides correspondingly low values in relation to the maximum fault current in the range of installations supplied by each distributor. The integrated RCD switches, circuit breakers and fuses and their characteristics shall be taken into account. The worst case should always be considered.

K.1.1 Impact protection measurements at all points of electrical installation, connection to foreign conductive parts in the room

Foreign conductive masses in the room (e.g. metal pipes, structural elements) can transmit a dangerous voltage potential in the event of a fault. It is therefore necessary to check their connection to the equalisation system or appropriate insulation:

- The resistance of the connection between the foreign conductive part and the equalizing conductor should not exceed 0,1 Ω. The resistance of the links may also be higher if the following indents are taken into account.
- If the part is insulated, double insulation or physical separation with adequate distance and offsets must be provided.

Difficult installations:

- all foreign conductive parts shall be connected to the main equalisation conductor, unless isolation with a resistance > 1 MΩ is provided at a safe distance from live parts and a safe distance from conductive parts and conductors capable of carrying lightning current;
- the measurement may exceed the minimum expected measured values if additional measures allow for automatic disconnection within the allowed time according to the requirements of SIST HD 60364-4-41, taking into account the appropriate implementation of the electrical installation system TN, TT or IT.

K.1.2 Measurements of external conductive parts, galvanic connections and joints

External conductive parts, galvanic connections and joints (e.g. rollers, conductive structures, metal fences, pipelines, metal facades) can transmit dangerous potentials and increase contact voltages in the event of lightning strike or network failure. The measurements are aimed at assessing the safety with regard to the contact voltage and the schedule of the voltage gradient:

- The resistance of the connection between the external conductive part and the equalizing conductor shall not exceed 0,1 Ω. The resistance of the links may also be higher if the following indents are taken into account.
- if the part is insulated, double insulation or physical separation with adequate distance and offsets must be provided.

Difficult installations:

- If the parts are within the impact zone of the grounding system, they shall be connected to the grounding or placed within an isolation distance of 2,5 m (SIST EN 50522)
- The tension of touch and step in the gradient range of the voltage funnel shall not exceed the permissible tension of touch.

L Measurement of insulation resistance of circuits, installations, separating transformers

The measurement of insulation resistance is key to preventing electrical shocks, preventing conductive paths of leakage currents and protecting against the occurrence of fire conditions. It is carried out between active conductors and grounded parts:

- Test voltage: 500 V DC for circuits up to 400 V AC;
- Measuring current of the generator: < 1 mA for the protection of installations and devices in buildings;
- Insulation resistance shall be ≥ 1 MΩ for each circuit;
- measurement shall be carried out between live lines and the protective line (PE) with consumers switched off. When consumers are connected, lower the test voltage to 250V DC to make measurements in the range below the threshold of SPD and varistoric protection.

Insulation measurements on transformers and cables of external installations and in the areas of electromagnetic influences of high and low frequencies should be carried out with dedicated meters that allow for a higher measurement current of the generator and provide adequate immunity to disturbances from the surrounding area.

Difficult installations:

- Test voltage: >1000 V DC for circuits exceeding 400 V AC or DC;
- Measuring current of the generator: > 3 mA for larger systems with a capacitive character;
- the isolation resistance of the system shall not be less than 1 GΩ;
- for measurements of longer circuits and larger systems, the measurement time must be extended in order to fill the capacitances of the insulating material and complete the polarisation process of the material. As a result, the polarisation indices PI and the material discharge capability DD shall be given in the minutes;
- the influence of temperature must be taken into account when measuring supply cables, air cables, transformers and installations exposed to external influences. When the temperature rises for every 10 °C, the insulation resistance value is reduced by half.

L.1.1 Measurement of leakage currents

If the insulation resistance cannot be measured due to the voltage present or the connected consumers, the insulation of the installations shall be measured by checking the leakage currents at the rated voltage. Measurements shall be made during operation at the consumers involved, using current clamps with a resolution of < 0,1 mA, TRMS filtered at a low frequency of the first harmonic component:

- the method of measuring leakage currents includes direct measurement on PE conductors and a differential method on the supply cable to the distributor (we enclose all conductors under voltage, the clamp gauge shows the difference between the currents of L conductors flowing into the consumer and the current in the N conductor, the indicated value is the current escaping from the installation through parts of the insulation into the surroundings,);
- leakage current limits shall not exceed:
  - < 1/3 x Idn at the manifold inlet, with built-in RCD protection,
  - < 100 mA fire protection
  - < 1 mA per kW of connected power,
  - < 3,5 mA per circuit,
  - < 5 mA maximum per single major device or machine.

L.1.2 Measurement of insulation resistance of photovoltaic systems

The insulation measurements of photovoltaic systems shall be carried out between positive and negative poles towards the grounded conductor (PE), with the converter switched off and separate fields:

- Test voltage: 1000 V DC for systems above 500 V nominal voltage level;
- the isolation resistance shall be ≥ 1 MΩ for each half towards the earth;
- when measuring an individual + or - pole against a p.e., there is usually a problem of moving voltage levels towards the p.e., which should be taken into account when evaluating the results. Dedicated meters usually already take this into account in the result – check in the instructions.

Difficult installations **and** additional competences:

- shift of voltage levels can be successfully eliminated by temporary shortening of a set of panels. In doing so, it is necessary to use an appropriate switch that withstands repeated shutdowns of the short circuit at full power of a set of panels;

- account shall be taken of the possibility that a malfunction may already be present and, if the measurement method is used incorrectly, a short circuit and an arc through the meter may be induced;
- measurements are carried out in accordance with SIST EN IEC 62446 and SIST HD 60364-6, using only dedicated testers in the appropriate voltage category.

L.1.3 Measurement of insulation resistance of storage tanks, DC sources and associated circuits

(1) For DC sources (e.g. battery systems, DC power supplies), insulation is checked between the positive and negative poles towards the grounded parts.
(2) To check the insulation resistance of smaller systems up to 100 V of the total rated voltage of the storage tank or battery system, the insulation can be measured by the usual method of insulation verification, with a test voltage of 250 V. The insulation resistance should be ≥ 1 MΩ, measured from the negative or positive pole of the battery towards the grounded part of the housing. Since the internal resistance of the battery is low, it does not affect the result of the measurement.
(3) If the measured value is lower than 1 MΩ, use the U-I method of measuring AC generator leakage currents described in B.2.4 below.
(4) To check the insulation resistance of larger systems above 100 V of the total rated voltage of the storage tank or battery system, the insulation is measured according to the UN ECE R 100 method:

Difficult installations and additional competences:
- Measurements shall be made at the present voltage of the DC source, which cannot be discharged or switched off for the purpose of the measurements, and the short-circuit measure shall not be used as for photovoltaic systems;
- The measurement method according to UN ECE R 100 with the resistance matrix on the live system shall be used;
- For the test voltage, the voltage of the DC source is used. Typically, meters have the ability to perform measurements for voltages up to 1000 V DC. If the system voltage is higher, the measurement is carried out on larger sub-assemblies of the battery system;
- The insulation resistance shall be ≥ 100 Ω/V for each half or sub-assembly of the battery system.

L.1.4 Measurement of leakage currents on DC sources and associated circuits

(1) The leakage current in DC systems is determined to check for the presence of the first malfunction and find the location of the malfunction. For this purpose, measurements are carried out when the inverter is turned off from the loads and the network, and individual battery units are included and functioning.
As long as there are no suitable clamp gauges on the market for accurate measurement of DC leakage currents, we use an alternative to superponing the AC component of the current to DC circuits:
- on the side of the main divider, use a tester with an alternating current generator that inserts an alternating frequency signal into the DC source system at + or – half towards the grounded part of the DC source housing, where there are no ambient interferences;

- to track the alternating component of leakage currents through the installation system, use an additional TRMS clamp gauge with a filter of the same frequency of origin;
- such a system shall be capable of tracking leakage current and finding faults and insulation defects in DC circuits and installations;

- when evaluating the results, we use the comparative method of the same battery units, where the expected leakage current is equal to the reference leakage currents of a healthy system. It is necessary to take into account the even distribution of flows of all units of the storage tank involved.

L.1.5 Insulation resistance of floors and walls

(1) Resistance of floors and walls

The insulation resistance of floors and walls is measured to check electrical safety, especially in rooms where contact with electrical appliances or metal parts is possible.

- Measurement method: measurement between the floor/wall surface and the grounded part (e.g. metal tube or PE conductor). The contact surface of the measuring probe is 625 cm2, which is lined with a damp cloth during the measurement. Pressure on the probe during the measurement shall be applied to the floor with a minimum of 750 N and to the walls with a minimum of 250 N.
- Test voltage: 500 V DC.
- Limit value:
    - ≥ 1 MΩ for dry areas,
    - ≥ 0,5 MΩ for wet or wet surfaces

(2) Drainability of floors and other protection against static electricity
Protection against static electricity is important in rooms with sensitive electronics, explosive atmospheres or medical equipment. Measurements shall be made between the floor surface and the grounded part (e.g. PE conductor or metal structure).

Difficult installations and additional competences:

- measurement method: measurement of the resistance between the ground surface and the ground using a mega-ohm meter. The contact surface of the measuring probe is a circle 65 mm in diameter, which is lined with a damp cloth during the measurement. To measure the discharge of static electricity on the surface, two probes with a weight of 2 x 2.5 kg are used, separated from each other by at least 30 cm. To measure the discharge of static electricity through the substrate, a probe of 5 kg weight is used (it is possible to place two probes one on the other);
- Test voltage: 100 V DC or 500 V DC, depending on the standard (e.g. SIST EN 61340-4-1);
- Limit value:
    - < 1 GΩ for antistatic surfaces,
    - 10^5 Ω to 10^9 Ω for ESD protected areas,
    - Area 10^6 Ω for Explosive Environments (ATEX requirements).

L.1.6 Insulation resistance and leakage current monitoring

(1) Protective devices and monitors ELM and IMD for permanent monitoring of insulation or leakage current must provide adequate information, indication, alarm or shutdown whenever a major change occurs. (2) In order to ensure adequate electrical and fire safety, it is necessary to regularly check their operation:

- protection devices and monitors ELM and IMD shall be checked by means of a circuit which gradually lowers the resistance of the insulation and consequently increases the leakage current from the live conductors towards the grounded part of the installations. The leakage current is converted to the nominal voltage of the system;
- the operation of the acoustic and visual alarm shall be set to an insulation drop of at least below < 50 kΩ, ρεχομμενδεδ < 75 κΩ, ορ ατ λεακαγε χυρρεντ φορ α ωολταγε οφ 230 ς αβοωε 4,6 μA, ρεχομμενδεδ αβοωε 3 μA;
- Insulation resistance and leakage current monitoring also represents fault current control and is further described in section B.3 below.

M Measurements of Z impedances, short-circuit and fault currents, verification of the operation of automatic disconnection and verification of the operation of protective devices on residual RCD current

(1) Protective devices, switches, ELR, ELM, IMD devices, fuses, circuit breakers, RCD switches, alone or in combination, taking into account selectivity, must ensure disconnection of the power supply within an appropriate short time according to the implementation of the electrical installation system. The verification shall be carried out first at the inlet part of each distributor and at the outlet of the distributor.

(2) Impedance measurements and calculation of short-circuit and fault currents at each connection point, manifold input and output shall be carried out and the results shall be compared with the characteristics of the installed devices and with each other for each phase conductor:

- measurement of loop impedances up to 63 A rated current can be carried out with conventional meters according to SIST EN IEC 61557, the method of measuring two-wire or three-wire;
- The measurement of manifold impedance shall be taken as the reference value for the calculation of voltage drops on the conductors.

Difficult installations:

- Measurement of loop impedance above 63 A rated current shall be performed with an increased measurement current to ensure adequate accuracy of the measurement results, a four wire measurement method shall be used to eliminate the influence of contact resistances;
- when measuring impedance on transformer shielding fuses (the first fuses in the selectivity system of the transformer winding shielding), the heating safety factor of 50 % on the resistive part of the transformer winding must be taken into account. The measured and calculated values are compared with the characteristics of built-in protective and defeat devices. To ensure an adequate disconnection time, it is necessary to take into account the system of electrical installations, rated voltages and energy at the inlet;
- Correction of impedance to maximum operating temperature: $Z_k = \sqrt{(1{,}5\,R)^2 + X^2}$. This Zk impedance determines the minimum short-circuit current: $I_{kmin} = c_{min} U_n / Z_k$. This I_{kmin} shall be higher than *the* I_a active current of the overcurrent protection at the estimated time. Here they are:
  - U_n the nominal system voltage of the electrical installation; and
  - c_{min} [0,95 if the system voltage has a tolerance of +- 6%; 0,90 if the system voltage has a tolerance of +- 10%]

(3) Measurement and calculation of short-circuit currents, fault currents and voltage drops on conductors shall be performed at all endpoints of the circuits:

- measurements of the impedance of the short-circuit loop ZL are carried out on all installation systems with a high test current for an appropriately accurate comparison of the characteristics of the fuse or circuit breaker to the calculated short-circuit current. From the difference of impedance at the end and at the beginning of the circuit in the divider and the rated current of the circuit, calculate the voltage drop on the conductors. The voltage drop on lighting circuits must not exceed 3% of the rated voltage, and on other circuits to consumers and sockets 5% of the rated voltage;
- measurement of the impedance of the fault loop ZPE is carried out according to the system of electrical installations, where an appropriate method of measurement and evaluation of the result according to the installed devices is used. Some of the most common examples:
  - TN system without RCD — ZPE method equal to ZL measurement, results comparable to each other, values lower than permissible with regard to circuit breaker or fuse characteristics;

- TN system with RCD — ZPE method with lower measuring current ZS, taking into account RCD Idn, calculate Uc, which shall not exceed the permissible value;
- TT system with RCD — ZPE method with lower measuring current ZS, taking into account RCD Idn, calculate Uc, which shall not exceed the permissible value;
- IMD-based IT system — the fault loop shall be checked for the size of the fault currents at the first ISFL malfunction. The IMD/ELM device shall be set to the operation of the alarm in the event of a drop in insulation at least below < 50 kΩ ορ ιν τηε εωεντ οφ α λεακαγε χυρρεντ αβοωε 4,4 μA.

M.1.1 Measurements of impedance Z, short-circuit and fault currents on circuits with frequency regulators, UPS systems, converters

(1) Measurements of impedance and fault currents in active component circuits shall be performed using the screening method at the extraction of each non-linear device.

(2) One of the following methods shall be used:

- impedance measurements shall be performed at the input of a non-linear device, UPS, frequency or converter. In addition, the resistance of the conductors of the circuit to the load is measured, the value obtained is added to the result of the measurement of impedance at the inlet and the short-circuit or fault current is calculated;
- when we perform measurements on frequency and inverters and we want the meter to perform the comparison and calculation, we can perform measurements in such a way that the frequency or inverter is turned off, we perform a short circuit on the side of the connected load (increase all conductors energized to each other and towards the PE), and we perform measurements on the device of the frequency or inverter itself: L1 Inlet – L1 Output, L2 Input – L2 Output and L3 Input – L3 Output;
- When performing measurements of UPS devices, measurements can be performed by comparing the measured value immediately at the output of the UPS device with the measured values at the end of the circuit. If the measured values are already inadequate at the UPS output, we load the UPS device by attaching a stronger load. This establishes reference conditions when measurements can be made on UPS circuits. The reference conditions shall be properly documented so that measurements can be repeated and changes detected at subsequent checks;
- the values obtained are compared with the characteristics of the built-in fuse or circuit breaker, measurements at individual stages with each other, and measurements at the end of circuits with reference values at the beginning of circuits.

M.1.2 Measurements of impedance Z, short circuit and fault currents on DC circuits with battery storage

In DC circuits, impedances are measured using specific DC meters that allow the internal resistance of the system to be assessed. Meters in AC systems detect the passage of an AC signal through 0, which is not the case with DC systems. Therefore, special meters are developed for DC systems that can perform on and off on DC systems.

Difficult installations:

- Measurements of internal resistance or DC source impedance shall be made between the positive and negative poles. Limit values shall be determined according to the capacity of the battery system and the characteristics of the protective devices;
- The short-circuit current shall be calculated from the measured impedance and voltage of the source. Due to the low expected values, measurements are carried out four-wire. We must use meters with the appropriate category;

- the values obtained are compared with the characteristics of the built-in fuse or circuit breaker, and the measurements at the end of the circuits with the reference values at the beginning of the circuits.

M.1.3 Measurement and validation of RCD and ELR

(1) Verification of RCD and ELR protection is crucial to ensure safety against electric shock, to additionally provide disconnection when fault currents increase, to protect against fire or to protect connected devices.

(2) The RCD check is performed with an RCD meter, which simulates the fault leakage current between the phase and PE conductors and measures the off-mode response time and the off-mode current at different current forms depending on the type of RCD; AC, A, F, B or B+. The response shall be tested at various factors of RCD IΔn rated current (nominal residual current), at half ½IΔn (not to be switched off), 1×IΔn (must be switched off) and at an elevated value of 5×IΔn (must be switched off rapidly):

- Off time at $1\times I_{\Delta n}$: ≤ 300 ms,
- Off time at $5\times I_{\Delta n}$: ≤ 40 ms,
- Touch voltage during test: ≤ 50 V (25 V in special environments)
- the selective RCD protection shall provide an off-set time delay of 130 ms at rated current value $I_{\Delta n}$,
- the cut-off current shall be within the permissible limits given the shape of the fault current.

Difficult installations
ELR devices (Earth Leakage Relay) are used in industrial systems with higher rated currents and complex earths. The verification shall include a simulation of leakage current of different shapes depending on the type of ELR; AC, A or B by measuring the total response time of fault detection, circuit response and relay disconnection. Verification of ELR in complex installations is carried out with a meter, which enables the generation of flows through a conductor, which is coated during measurements through an ELR control coil in addition to protected conductors:

- adjustable disconnection current from 30 mA to 30 A, depending on the ELR setting,
- test at 50 %, 100 % and 150 % of the set nominal values,
- Off time: ≤ 300 ms for settings up to 30 mA,
- for higher settings (e.g. 300 mA, 1 A): ≤ 500 ms,
- Touch voltage during test: ≤ 50 V (25 V in special environments).

M.1.4 Verification methods for security in buildings built before 1985 (zeroing)

(1) According to SIST HD 60364-4-41, the resistance of local earthing must be low enough to allow the rapid operation of protective devices in the event of failure, but it must be high enough not to cause the division of currents during operation that could endanger safety.

(2) It is necessary to ensure a minimum leakage of current into the soil, because:

- the current flowing into the ground system passes into the terrain in certain parts, where it carries with it the material of the conductive metal, the ground disappears with time, the resistances increase, thereby also changing the proportions in the grounding resistance system and the condition for permissible zeroing;
- the outflow of currents into the system and the passage of currents into the terrain create dangerous paths of current in the surroundings, which cause a dangerous voltage of touch.

(3) The first measure of lowering the current into the ground is lowering the current in the PEN conductor. This is ensured in a three-phase system by carefully planning the symmetric load.

(4) When zeroing is carried out in single-phase systems, part of the current always passes from the PEN conductor to the rollers and into the ground.

(5) Zeroing is only allowed if the resistance of the PEN conductor (RPEN) is significantly lower than the local ground resistance (RL). The recommended ratio is 1 : 10.

(6) We must use a TRMS clamp gauge with a suitable measuring range and a suitable anti-interference shield. The current in the zeroing connection shall be at least 10 x less than the current in the PEN conductor.

(7) Both relationships must be taken into account in order for zeroing to be permitted.

Difficult installations:

- ensuring compliance with the SIST HD 60364-4-41 standard proposes the use of a ratio defined by the permissible touch voltage limit and the rated voltage:

  (Uo – 50)/50 V,

  which for Uo = 230 V means the recommended ratio of 1 : 3.6;
- Zeroing is only permitted if the reference ground resistance R_B is at least 3,6 x less than the local ground resistance R_E.

N Measurements of grounding resistance, protective and operational grounding, touch and step voltage

(1) Efficient grounding is essential for the safety of people, animals, installations, facilities and installations. Measurements are carried out using different methods depending on the accessibility and size of the facility. Measurements shall be made using frequencies outside the interference range (55 Hz, 82 Hz, 94 Hz, 105 Hz, 111 Hz, 128 Hz, 164 Hz, 329 Hz, 659 Hz, 1.31 kHz, 1.50 kHz, 2.63 kHz, 3.29 kHz, 6.59 kHz, 13.1 kHz, 15.0 kHz):

- U-I method two-wire, three-wire or four-wire with measuring current ≥ 25 mA, suitable for standalone TT, IT or standalone separate installations and grounding systems.
- Alternative method with double-length measurement of closed loops - SIST HD 60364-6, suitable for lightning systems, roof drains, connections for equalization of potentials, suitable especially for the measurement of earth resistance on TN installation systems in urban environments, where the measurement is carried out on an inlet PE or PEN conductor.
- The grounding resistance shall be sufficiently low to permit the operation of a fault current that ensures the successful automatic disconnection of the power supply.
- In the event of excessive ground resistance, RCDs and ELRs may be used to provide disconnection of the power supply before the contact voltage rises above the allowable. The most common limits for the RCD used are shown in the following table:

Rated residual current I_{DN} [mA]	10	30	100	300	500	1000
R_{earth} max.[Ω], (U_c<25 V)	2500	833	250	83,3	50	25

- Where an LPS external lightning protection is fitted to a building, facility or installation, the measured value shall not exceed 10 Ω or 4 % of the value of the specific resistance of the soil in the area.

N.1.1 Measurement of Touch and Step Voltage around Small Objects, Buildings, Appliances and Structures

In order to assess the safety of persons in the event of failure, it is necessary to measure the actual contact voltage between the conductive parts and the reference potential in the vicinity of the facility, as well as the step voltage, in installation systems with an installed power source, a transformer in the vicinity of the facility or in the vicinity of the lightning conductor system.

Difficult installations:

- an alternative method with simple measurement of the touch and step voltage for smaller probe objects in the immediate vicinity of the building, facility or grounded device during the performance of the fault loop impedance test (meter with additional P/S terminal for probe measurement), suitable for all installation systems to check the effectiveness of the impact protection measures implemented;
- measurement must be carried out whenever there is a possible change in the installation system, e.g. from TT to TN, from TNC to TNS, when excavations are carried out around buildings and structures, when new grounding or external installation systems are installed, such as photovoltaic power plants, vehicle chargers, pillars and parking ramps, advertising billboards and displays, outdoor lighting and the like.

N.1.2 Measurements of the voltage of touch and step at the edges of grounding systems and in the field of grounding of energy devices, areas and centers of presence of a large number of people

Measurements of grounding of larger complexes and objects are carried out according to the U_I method by injecting larger currents into the system of the measured whole and using a synchronized precision voltage drop meter when using frequencies outside the range of frequencies outside the range of interference (e.g.: 55 Hz, 82 Hz, 94 Hz, 105 Hz, 111 Hz, 128 Hz, 164 Hz, 329 Hz, 659 Hz, 1.31 kHz, 1.50 kHz, 2.63 kHz, 3.29 kHz, 6.59 kHz, 13.1 kHz, 15.0 kHz)

Difficult installations:

- in the field of measurements, we must ensure the distribution of the voltage funnel into the surroundings by injecting appropriately large currents to eliminate disturbances from the surroundings and display the right values. Test the measuring system with the generator switched on and off. When the generator is switched off, the voltage meter of the filtered signal shall display values of 0,0 mV;
- an appropriate distance must be provided between the area to be measured and the auxiliary probe, which must not be less than 2,5 x the diagonal of the area to be measured, 5 x the diagonal recommended. In doing so, it is necessary to take into account the back-up measurement error factor;
- after the establishment of a voltage funnel in the surroundings of the object by measuring voltage drops at steady distances, we first confirm the establishment of a voltage funnel to the auxiliary probe, which must show the shape of the S curve;
- From the S curve and the size of the injected current, we estimate and calculate the ground resistance of the whole.
- in the sphere of influence, we measure the tension of touch and step around the assemblies of conductive parts. We evaluate all sets of conductive parts that are distant from each other < 2.5 m;
- Touch voltage measurements are carried out at a distance of 1 m from the contactable conductive parts to the substrates, which represent the gradient of the fall of the voltage funnel (soil, lawn, vegetation), using two interconnected probes made of conductive material, contact surface 2 x 200 cm2, weighing at least 75 kg, in good contact with the substrate;
- measurements of the voltage of the step are carried out between two probes on a substrate representing the gradient of the fall of the voltage funnel (soil, lawn, vegetation), using two separate probes, made of conductive material, 1 m apart, contact area 2 x 200 cm2, weighted at least 75 kg, in good contact with the substrate;
- the measured values of touch voltage and step voltage shall not exceed the permissible touch voltage.

N.1.3 Integrity measurement for grounding systems of installations and structures in industry, energy and high-current distribution

In order to provide adequate safety and protection against dangerous stride and contact voltages, grounding systems with rollers and conductive grids can be installed in the ground in the area of larger systems. Buildings, structures, devices, structures, pipe systems, lightning conductor installations, bases and rails are connected to the grounding in several places.

Difficult installations:

- to check partial connections of parallel connected systems, we use the method of checking partial connections with high test current, measuring partial flows through an individual connection to the ground and measuring voltage drops towards the immediate surroundings;
- Measuring current: from at least > 5 A to a few 100 A, depending on the quality of the partial current meter and synchronised voltmeter;
- partial resistances shall be comparable and suitably low to ensure safe contact and step voltages around the performance of the suitability assessment.

N.1.4 Touch and step voltages allowed

(1) The earthing resistance shall ensure a suitable low permissible contact voltage in relation to the expected current and the duration of the failure for failures on the low-voltage network, medium-voltage network or lightning strike.

(2) The following equation shall be used to calculate the contact voltage (U_{Tp}):

$$U_{Tp} = I_B \times HF \times Z_T (U_T) \times BF$$

Factor	Description
I_B	Permissible flow through the body according to fault duration (SIST EN 50522)
HF	Heart current factor, 1.0 for left arm-leg combination
Z_T (U_T)	Touch tension-dependent body impedance (e.g. 1000 Ω)
BF	Body factor, e.g. 0.75 for hand-to-foot combination

(3) The connection between the duration of the failure or operation of voltage shocks in relation to the current through the human body IB and the calculated permissible contact and step voltage is given in graphical and tabular form in the following figure (Figure B.1), aligned with the safety curves in SIST IEC 60479-1.

Table B.1: Touch and step voltages allowed

Duration of error [s]	Permissible current I_B [mA]	Permissible voltage U_{Tp} [V]
0,01	1000	800
0,05	900	716
0,10	750	654
0,20	600	537
0,30	180	410

0,50	200	220
0,80	70	130
1,00	80	117
2,00	60	96
5,00	51	86
10,00	50	85

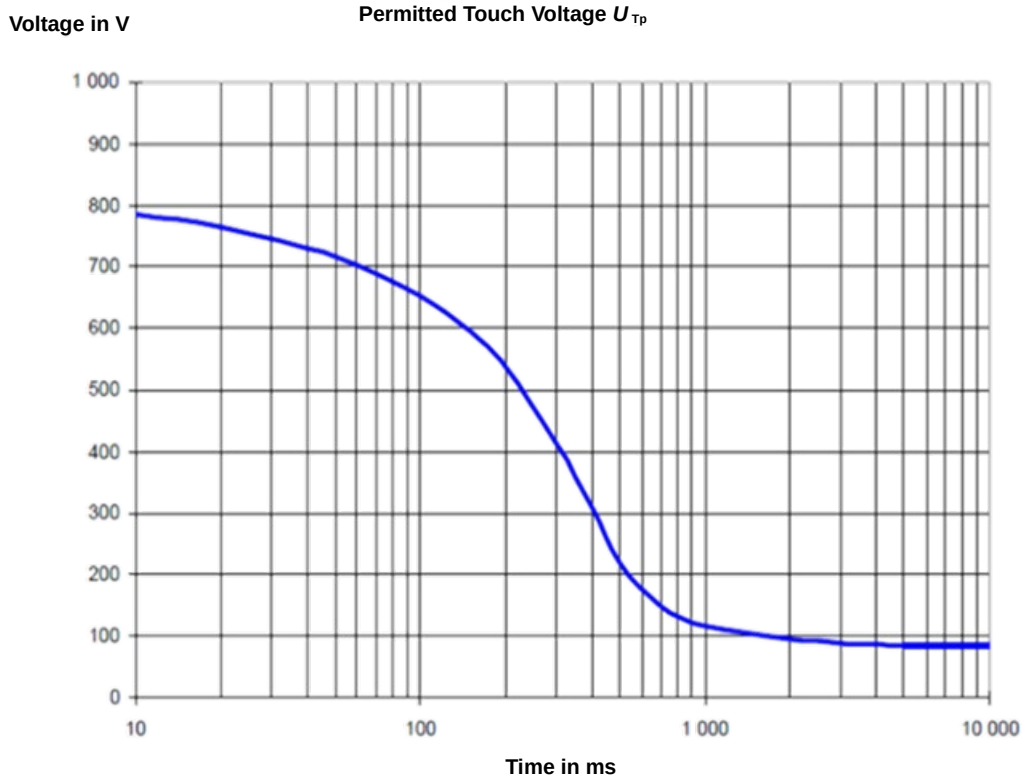


Figure B.1: Permitted Touch Voltage U_{Tp}

The following figure shows three examples of danger, the worst case should always be considered:

- lightning strike, a minimum of 50 kA shall be taken into account: (<0,05 s), permissible body current 900 mA, permissible touch voltage U_{Tp}: 716 V
- line conductor disconnection time to SN, consider line conductor failure current to ground, e.g. 100 A: (<0,2 s), tolerable body current 600 mA, tolerable touch voltage U_{Tp}: 537 V
- permanent fault on the NN side, consider fault current, e.g. 5 kA (> 5 s), allowable body current 50 mA, allowable touch voltage U_{Tp}: 85 V for work in the protected area of switchgear
- permanent fault on the NN side, consider fault current, e.g. 5 kA (> 5 s), allowable body current 50 mA, allowable touch voltage U_{Tp}: 50 V for a wider accessible environment

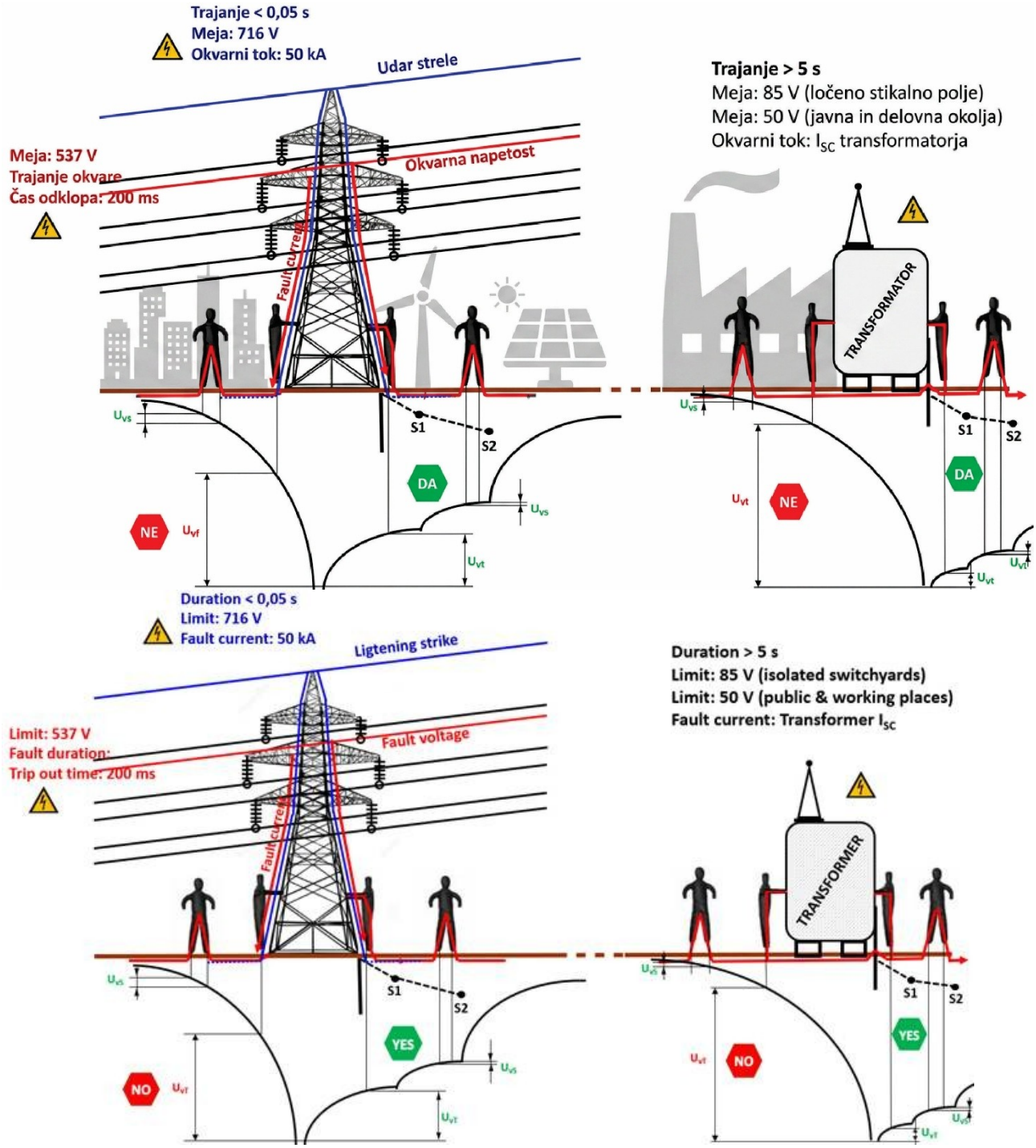


Figure B.2: Examples of Ground Resistance Effects

N.2 Lightning protection measurements ZPS

(1) In order to check the lightning protection, an inspection of the internal and external lightning protection shall be carried out. Measurements must be made on the lightning protection system as a whole, which includes all conductive parts in the building, conductive parts, devices and objects on the outer part of the building, in the immediate surroundings of the building and in the area of impact. The area of impact is considered to be the distance of the effects of the transfer of potential to the surroundings and the type of protective measures applied against the tension of touch and step. Normally, the impact of a direct impact shall be terminated to the greatest extent within 6 m x 6 m of the point of impact when good connections to low grounding resistance in the ground are

made. For the lightning impact zone, a distance of 20 m from each object or building shall be taken into account.

(2) For internal lightning protection, the verification methods set out in points B.1 and B.2 of this Annex and in point B.5.1 shall be used.

N.2.1 Measurements of internal lightning protection ZPS and surge protection SPD

(1) Lightning arresters shall operate reliably in the event of lightning or overvoltage. Coordinated protection from the same manufacturer of grades T1 and T2 (B and C) must be installed.

(2) The verification method includes the inspection and measurement of the binding mode according to the installation system TT (3 + 1), TNC (3-0), TNS (4-0), IT(3+1 or 4-0) and verification of the operating threshold:

- The test of surge arresters is carried out with a high voltage generator with the output of a DC ramp that raises the voltage above the threshold level of operation of the SPD. It is recommended to use a meter that allows the voltage to rise above 2.5 kV.
- The measured operating threshold shall correspond to the manufacturer's data. The measured value with DC voltage ramp shall be located in the range between:

  1,41 x U_{AC} rated voltage SPD > U measured < U_P shielded level SPD

  U_P shielded level SPD < 1,5 kV - for electronic devices
  U_P shielded level SPD < 2,5 kV - for passive consumers, heaters, engines without control

(3) For external lightning protection, the verification methods set out in points B.1, B.2, and B.4 of this Annex and in point B.5.2 shall be used.

O APPENDIX C: Examples of records of verification of low-voltage electrical installation

MINUTES ON THE VERIFICATION OF ELECTRICAL INSTALLATION

GENERAL DATA					
Client:			**Contractor:**		
Installation address:					
The minutes shall relate to:					
☐ New installation	☐ Repair	☐ Change			
☐ Periodic test	☐ Addition	☐			
Test as appropriate with:					
☐ All right. NNELI url RS …	☐	☐	Beginning		
☐ SIST HD 60364-6	☐	☐	End		
Measuring instruments used:					
Model:	Model:	Model:			
Serial No:	Serial No:	Serial No:			
Representative of the party:			**Reviewer:**		
System ☐ TN-C	☐ TN-C-S	☐ TN-S	☐ TT	☐ IT	
Voltage:		RTP:			

VERIFICATION RESULTS									U- Corresponds to N- Does not fit
Verified electrical installation ☐ **Corresponds to** ☐ **Conditionally applicable** ☐ **Not applicable** ☐ List of deficiencies attached									
Details									
Visual inspection:	**U**	**N**		**U**	**N**		**U**	**N**	
Selection of electrical equipment	☐	☐	Identifier., power supply circuit, equipment	☐	☐	Accessibility	☐	☐	
Separators and switches	☐	☐	Identification of N and PE	☐	☐	Primary equalization. link	☐	☐	

			conductors					
Fire barriers	☐	☐	Cable connections	☐	☐	Additional bar equalized. connection	☐	☐
Cables, wires, dividers	☐	☐	Protection against direct contact	☐	☐	Documentation	☐	☐
System installation	☐	☐	Protection and surveillance installation	☐	☐	See complementary pages	☐	☐
Test:	**U**	**N**		**U**	**N**		**U**	**N**
Functional test	☐	☐	Protective, security, surveillance devices	☐	☐	Direction of the 3-f. socket rotation field	☐	☐
Remaining Current (RCD)	☐	☐	Direction of rotation of the engine	☐	☐	System installation of the building	☐	☐

MEASURES OF DISCONTINUED GUIDELINES, IMPLEMENTATION LINKS AND LOCATION

Continuity of grounding conductors ☐		Ground resistance: (Ω)	
Continuity of equalisation links			
☐ Ground ground	☐ Main Grounding Guide	☐ Elevator installation	☐ The antenna installation
☐ Width of the equalisation link	☐ Indoor gas installation pipes	☐ Computer installation	☐ Construction of the building
☐ House water meter	☐ Heating installation	☐ Telephone installation	☐
☐ Main water pipes	☐ Air conditioning installation	☐ Lightning installation	☐

SUPPORT AND STAMP			
	Date of next verification:		
	Attached checker sticker:	☐ YES	☐ NO
Client:	**Measuring device:**		
Location:	Location:		
Date:	Date:		
Signature:	Signature:		

MEASURES																				
Electricity distributor:																				
Supply circuit		**Line / Cable**			**Continuity grounding conductors**		**R ISO**	**Overcurrent protection of the installation**					**Residual Current Device (RCD)**						**Error codes**
No.	Dedicated code	Type	Guide No.	Guide Cross-section (mm^2)	Main equalized. link (Ω)	Additional Equalized Link (Ω)	☐ L-N ☐ L-PE (MΩ)	Characteristics-Contacts fuses	I_n (A)	Defeat time (s)	$Z_{S/I\,k}$ (Ω) / (A)	Z_L / I_k / Δ U (Ω) / (A) / (%)	I_n / Art (A)	I_{dn} (mA)	I_d (mA)	td (1x I_{dn}) (ms)	td (5x I_{dn}) (ms)	U_c (V)	

□ Annex to these minutes   □ Error status in annex

GENERAL DATA	
Client:	**Contractor:**
Installation address:	
E.E. counter:	E.E. counter status: kWh

STRUCTURE OF INSTRUCTIONS		**Location/Selected Space**																								
Significance of labels □ No of equipment □ Error code																										
Electrical installation equipment																										

VERIFICATION RESULT, SUPPORT AND SIG	
Client:	**Measuring device:**

◻ E. Installation conforms to these minutes at handover	☐ Electrical installation has been fully checked
Status report adopted	☐ Errors detected in installation
	☐ Documentation handed over
Location:	Location:
Date:	Date:
Signature:	Signature:

STRUCTURE

MINUTES ON THE VERIFICATION OF THE ELECTRICAL VEHICLES

GENERAL DATA					
Client:			**Contractor:**		
Address of EV charger:					
The minutes shall relate to:					
☐ First review	☐ Repair	☐ Change			
☐ Periodic test	☐ Addition	☐			
Test as appropriate with:					
☐ All right. NNELI url RS …	☐	☐	Beginning		
☐ SIST HD 60364-6	☐	☐	End		
Measuring instruments used:					
Model:	Model:	Model:			
Serial No:	Serial No:	Serial No:			
Representative of the party:			**Reviewer:**		
System ☐ TN-C	☐ TN-C-S	☐ TN-S	☐ TT	☐ IT	
Voltage:		RTP:			

VERIFICATION RESULTS									U- Corresponds to N- Does not fit
Verified EV charger ☐ **Corresponds to** ☐ **Not applicable** ☐ List of deficiencies attached									
Details									
Visual inspection:	**U**	**N**		**U**	**N**		**U**	**N**	
Selection of electrical equipment	☐	☐	Identifier., power supply circuit, equipment	☐	☐	Accessibility	☐	☐	
Separators and switches	☐	☐	Identification of N and PE conductors	☐	☐	Primary equalization. link	☐	☐	
Fire barriers	☐	☐	Cable connections	☐	☐	Additional bar equalized. connection	☐	☐	
Cables, wires, dividers	☐	☐	Protection against direct contact	☐	☐	Documentation	☐	☐	
System installation	☐	☐	Protection and surveillance installation	☐	☐	See complementary pages	☐	☐	
Test:	**U**	**N**		**U**	**N**		**U**	**N**	

Functional test	☐	☐	Protective, security, surveillance devices	☐	☐		☐	☐
Remaining Current (RCD)	☐	☐	System installation of the building	☐	☐		☐	☐

EXAMINATION MEASURES OF LANDED GUIDELINES, FUNCTIONAL TEST

Continuity of grounding conductors ☐	Ground resistance: (Ω)
Continuity of equalisation links	**Functional tests**
☐ Ground ground ☐	☐ Normal use ☐ Contact Manager. Lines on PE
☐ Width of the equalisation link ☐	☐ Disconnection during operation ☐
☐ Main Grounding Guide ☐	☐ Protection against overflow. ☐
☐ Lightning installation ☐	☐ Interruption of the LIN communicator. ☐

SUPPORT AND STAMP			
	Date of next verification:		
	Attached checker sticker:	☐ YES	☐ NO
Client:	**Measuring device:**		
Location:	Location:		
Date:	Date:		
Signature:	Signature:		

MEASURES																				
Electricity distributor:																				
Supply circuit		**Line / Cable**			**Continuity grounding conductors**		**R ISO**	**Overcurrent protection of the installation**					**Residual Current Device (RCD)**						**Error codes**
No.	Dedicated code	Type	Guide		Main equalized. link (Ω)	Additional Equalized Link (Ω)	☐ L-N ☐ L-PE (MΩ)	Characteristics-Contacts fuses	I_n (A)	Defeat time (s)	$Z_{S/I\,k}$ (Ω) / (A)	Z_L / I_k / Δ U (Ω) / (A) / (%)	I_n / Art (A)	I_{dn} (mA)	I_d (mA)	td (1x I_{dn}) (ms)	td (5x I_{dn}) (ms)	U_c (V)	
			No.	Cross-section (mm^2)															

□ Annex to these minutes □ Error status in annex

GENERAL DATA	
Client:	**Contractor:**
Installation address:	
E.E. counter:	E.E. counter status: kWh

STRUCTURE OF THE EV OLNILNICE		Location/Selected Space																								
Significance of labels □ No of equipment □ Error code																										
EV charging station equipment																										

VERIFICATION RESULT, SUPPORT AND SIG	
Client:	**Measuring device:**
□ E. Installation conforms to these minutes at handover	☐ Electrical installation has been fully checked
Status report adopted	☐ Errors detected in installation

	□ Documentation handed over
Location:	Location:
Date:	Date:
Signature:	Signature:

STRUCTURE

MINUTES ON THE VERIFICATION OF THE PHOTOGRAPHY SYSTEM

GENERAL DATA			
Client:		**Contractor:**	
Installation address:			
The minutes shall relate to: ☐ Initial verification ☐ Repair ☐ Change ☐ Periodic test ☐ Addition ☐			
Test as appropriate with: ☐ SIST EN IEC 62446-1 ☐ SIST HD 60364-6 ☐ ☐ All right. NNELI url RS … ☐ ☐			Beginning End
Measuring instruments used: Model: Model: Model: Serial No: Serial No: Serial No:			
Representative of the party:		**Reviewer:**	

Description of installation			
Location		Declared power – kW d.c.	
Date of verification		Tested circuits	

Reference of the SIST HD 60364-6 inspection report:	
Reference of SIST HD 60364-6 test report:	
Field PV check reference:	
Sketch per field PV test:	

Verified FE system	☐ **SUCCESS**	☐ **No success**
the requirements as laid down in SIST EN IEC 62446-1.		

PROJECT, IMPLEMENTATION, EXAMINATION AND TESTING
I am the person(s) responsible for the design, execution, inspection and testing of the electrical

<table>
<tr><td colspan="3">installation (as indicated by the signatures below) of the details described above, who, with knowledge and experience, cares for and carries out the design, execution, inspection and testing, hereby certify that I have carried out the work for which I am responsible conscientiously, as best I can in accordance with: ……..</td></tr>
<tr><td>Signature(s):

Name(s):

Date:

(The scope of responsibility of the signatory(s) is limited to the work described above)</td><td>The following review is recommended no later than:</td><td></td></tr>
<tr><td></td><td colspan="2">COMMENTS:</td></tr>
</table>

General

The entire system has been inspected as required by SIST HD 60364-6 and an inspection report based on SIST HD 60364-6 is attached.

D.c. system, general

☐ has been designed, defined and manufactured in accordance with SIST HD 60364 and IEC 62548;
☐ the maximum voltage PV of the field shall correspond to the location of the field;
☐ all selected and installed components and building blocks shall withstand the expected effects of wind, snow, temperature and corrosion;
☐ fixings on the roof and cable outlets are waterproof.

D.c. system, protection against electric shock

☐ the protection measure is provided by safe low voltage (SELV/PELV);
☐ the d.c. side is protected using class II or equivalent;
☐ PV string and array cables are selected and used to reduce the risk of ground contact or short circuit (reinforced or double insulation)

D.c. system, protection against the effects of insulation failures

☐ The galvanic separation is in the converter or on the a.c. side;
☐ functional grounding for all d.c. conductors;
☐ integrated detection and alarm of insulation resistance PV field to earth based on IEC 62548 requirements;
☐ built-in detection and alarm of residual current monitoring PV field based on IEC 62548 requirements.

D.c. system, overcurrent protection

☐ for systems without overcurrent protection:
  - $I_{MOD\_MAX\_OCPR}$ (designated module serial fuse current) is a higher, goat-like reverse current,
  - the wiring of the arrays shall be designed to withstand the highest combined currents of parallel arrays;

☐ for systems with built-in overcurrent protection, this protection shall correspond to the required IEC 62548;
☐ for systems with built-in protection against overcurrent of a field or parts of a field, this protection shall correspond to the required IEC 62548;
☐ In systems where the converter can inject reverse current into the d.c. system, reverse current is lower than the highest rated circuit of the module fuse and the current capacity of the wiring string.

D.c. system, earthing and equalizing compositions

☐ if the connection of the functional grounding includes one of the d.c. conductors, the connector shall be provided and fitted with the corresponding required IEC 62548;
☐ where the PV system has a direct connection to the grounding on the d.c. side, an interrupter must be provided in the event of a grounding failure properly required IEC 62548
☐ the equalizing composition in the frame of the PV field must be given and installed in accordance with the requirements of IEC 62548;
☐ where protective conductors and equalisation connections are installed, they must be parallel and in a bunch with d.c. cables.

D.c. system, lightning protection and overvoltage

☐ in order to reduce the induced voltage due to lightning, the area of the loops in the wiring should be as small as possible;
☐ measures to protect long cables (salting or use of SPD) must be installed;

☐ where SPDs are installed, they shall comply with the requirements of IEC 62548.

D.c. system, selection and installation of electrical equipment

☐ PV modules must be designed for maximum d.c. voltage;
☐ all d.c. components must be designed for continuous operation for d.c. and the highest possible system voltage and angle specified in IEC 62548;
☐ wiring systems must be selected and implemented in such a way as to withstand the expected external influences of wind, ice formation, UV temperature and solar radiation;
☐ based on the requirements of IEC 62548, measures must be provided to separate and disconnect arrays and parts of array PV;
☐ on the basis of the requirements of IEC 62548, a d.c. circuit breaker must be installed on the d.c. side of the converter;
☐ if locking diodes are installed, their interlocking voltage shall be at least 2x U_{oc} (stc) PV of the array in which they are installed;
☐ the associated plugs and sockets must be of the same type and manufacturer and meet the requirements of IEC 62548.

A.c. system

☐ on the a.c. side, a separator must be provided;
☐ all disconnection and switching devices must be connected in such a way that the PV installation is connected to the load side and the public power supply to the source side;
☐ the operating parameters of the inverter must comply with local regulations;
☐ Where an RCD is installed on the a.c. power supply side of the converter, check that it has been selected as required by IEC 62548.

Labelling and recognition

☐ all circuits, protection devices, switches and connectors shall be marked as required by SIST HD 60364 and IEC 62548;
☐ all d.c. junction doses (doses of PV generator and PV field) shall have a warning signal indicating that there are live parts inside which are supplied from the PV field and which may still be on the hazardous voltage after separation of the PV converter and the public power supply;
☐ the a.c. page separator shall be clearly marked;
☐ they shall be equipped with dual power warning signs at interconnection points;
☐ a single-pole diagram is displayed on the site;
☐ the details of the contractor are displayed on the site;
☐ the off-mode procedures are displayed on the site;
☐ emergency shutdown procedures are displayed on the site;
☐ all signs and labels must be properly affixed and durable.

Installation address	Reference
	Date
Circuit inspected	Reviewer
	Measuring instruments

String	String code	1	2	3	4		n
	Module						
	Quantity						
Field parameters (as given)	V_{oc} (stc)						
	I_{sc} (stc)						
String overcurrent protection device	Type						
	Capacity (A)						
	D.c. capacity (V)						
	Capacity (kA)						
String Wiring	Type						
	Phase (mm^2)						
	Earth (mm^2)						
String test	V_{oc} (V)						
	I_{sc} (A)						
	Illumination						
Correctness of links							
Insulation resistance of the field	Test voltage (V)						
	Plus — Earth (MΩ)						
	Minus-Earth (MΩ)						
Continuity of grounding (where applicable)							
Field separator	Capacity (A)						
	Capacity (V)						
	Location						
	Functional test						
Converter	Manufacturer and model						
	Serial number						
	Functioning of OK						

MINUTES ON THE VERIFICATION OF ELECTRICAL ENERGY QUALITY

GENERAL DATA	
Client:	**Contractor:**
Installation address:	
The minutes shall relate to: ☐ New installation ☐ Repair ☐ Change ☐ Periodic test ☐ Addition ☐	
Test as appropriate with: ☐ All right. NNELI url RS … ☐ SIST EN 50160 industr. ☐ ☐ SIST EN 50160 accommodation ☐ IEEE 519 ☐	Beginning End
Measuring instruments used: Model: Model: Model: Serial No: Serial No: Serial No:	
Representative of the party:	**Reviewer:**
System: ☐ single phase ☐ 3-phase 4-wire ☐ 3-phase, 3-wire ☐ ☐	
☐ Local sources of electricity	Connecting power of local resources: kVA

VERIFICATION RESULTS								
Quality of electricity ☐ **Corresponds to** ☐ **Not applicable**						☐ List of deficiencies attached		**U**- Corresponds to **N**- Does not fit
Details								
Continuous phenomena	**U**	**N**	**Voltage events**	**U**	**N**	**Particularly**	**U**	**N**
Frequency	☐	☐	Supply voltage interruptions	☐	☐	Harmonics of current	☐	☐
Changing the tension	☐	☐	Humps and humps	☐	☐		☐	☐
Sudden Voltage Changes	☐	☐	Transient overvoltages	☐	☐		☐	☐
Flickers	☐	☐		☐	☐		☐	☐
Asymmetry	☐	☐		☐	☐		☐	☐
Voltage harmonics	☐	☐		☐	☐		☐	☐

Interharmonics	☐	☐		☐	☐		☐	☐
Signalling	☐	☐		☐	☐		☐	☐

Measurement parameters

Duration of measurement			Rated voltage V	☐	EN 50160 limits for dwellings
Measuring interval			Rated frequency Hz	☐	EN 50160 limits for the industrial environment
☐ 1 minute.	☐ 10 min	☐	Coupling power kVA	☐	Limits IEEE 519
Period considered for the duration of the measurement			☐ Normal operating conditions	☐	
☐ 95 %	☐ 100 %	☐	☐ Special operating conditions	☐	

SUPPORT AND STAMP			
	Date of next verification:		
	Attached checker sticker:	☐ YES	☐ NO
Client:	**Measuring device:**		
Location:	Location:		
Date:	Date:		
Signature:	Signature:		

Measurements of permanent phenomena

Frequency

Nominal value	
Method of measurement	Averaging in 10 s period
Condition	Synchronisation

Request	Must be	Measured	Status
49,50 Hz – 50,50 Hz	99.5% over the period (week)		
47,00 Hz – 52,00 Hz	100% during the period (week)		

Changing the tension

Nominal value	
Method of measurement	Mean effective values over the 15-minute period
Condition	Synchronisation

Request	Must be	Measured	Status
207,00 V – 253,00 V	95 % over the period (week)		
195,50 V – 253,00 V	100% during the period (week)		

Flickers

Measured quantity	Long-term flicker (Plt)

Request	Must be	Measured	Status
Plt < 1	95 % over the period (week)		

Voltage asymmetry

Method of measurement	
☐ Industrial environment	Mean effective values of inverse parts u^- in the 15 min period
☐ Living environment	Mean effective values of inverse parts u^- in 1 min. period

Request	Must be	Measured	Status
u^- < 2,00 %	95 % over the period (week)		

Phase situation indicator diagram

N Upholstery harmonics (EN 50160)

Method of measurement	harmonics and total harmonic distortion (THD)
☐ Industrial environment	In the 15-minute period
☐ Living environment	In the 1-minute period

		L1		L2		L3	
Harmonic	Request	Measured	Status	Measured	Status	Measured	Status
THD	< 8,00 %						
2	< 2,00 %						
3	< 5.00%						
4	< 1,00 %						
5	< 6,00 %						
6	< 0.50%						
7	< 5.00%						
8	< 0.50%						
9	< 1,50 %						
10	< 0.50%						
11	< 3,50 %						
12	< 0.50%						
13	< 3,00 %						
14	< 0.50%						
15	< 0.50%						
16	< 0.50%						
17	< 2,00 %						
18	< 0.50%						
19	< 1,50 %						
20	< 0.50%						
21	< 0.50%						
22	< 0.50%						
23	< 1,50 %						
24	< 0.50%						
25	< 1,50 %						

Voltage events

Supply voltage interruptions

Rated voltage	
Measured quantity	Number of interruptions by duration
Method of measurement	Voltage interruption begins when the effective voltages of all channels fall below the break threshold and ends as soon as the voltage of all measured channels exceeds the threshold plus hysteresis
Interruption threshold	5,00 % of rated voltage
Hysteresis	2,00 % of rated voltage

Number of interruptions

Remaining tension	Duration (s)	
	t ≤ 2,00 s	t > 2,00 s
U < 5.00%		

Udori

Rated voltage	
Measured quantity	Number of penetrations with a certain voltage and duration
Method of measurement	The one-period rms value shall be refreshed every half period The rupture begins when the voltage of at least one channel is higher than the hump threshold and ends when it exceeds the rupture threshold plus hysteresis
Hysteresis	2,00 % of rated voltage

Number of collapses

Tension of collapse (% of nominal)	Duration (ms)				
	10 ≤ t ≤ 200	200 < t ≤ 500	500 < t ≤ 1000	1000 < t ≤ 5000	5000 < t ≤ 60000
90 > U ≥ 80					
80 > U ≥ 70					
70 > U ≥ 40					
40 > U ≥ 5					
U < 5					

Grbine

Rated voltage	
Measured quantity	Number of humps with a certain voltage and duration
Method of measurement	The one-period rms value shall be refreshed every half period The collapse begins when the voltage of at least one channel falls below the threshold of the collapse and ends when it falls below the threshold of the hump minus the hysteresis

Number of humps

Tension of the coat of arms (% of nominal)	Duration (ms)		
	10 ≤ t ≤ 500	500 < t ≤ 5000	5000 < t ≤ 60000
120 > U > 110			
U ≥ 120			

Short-term harmonics of current and TDD for 95% of the time

Method of measurement	15 min. average of the effective values of harmonics and total distortion required (TDD). All harmonic values are expressed in % per maximum required current I_L	
Percentage of unmarked periods	☐ 99,55 %	☐ 100 %
Rated voltage at the site of burial		
Maximum required load current I_L (Basic Harmonic)		
Maximum short-circuit current Isc		
Criteria for U_{BUS} and Isc/I_L		
Boundaries	95 % of the total required distortion (THD) measurements shall be less than 8 % 95 % of the measurements of individual current harmonics should be less than those given in the table below	

Harmonics of current

		L1		L2		L3	
Harmonic	Limit [%]	Measured	Status	Measured	Status	Measured	Status
TDD	8,00						
2	1,75						
3	7,00						
4	1,75						
5	7,00						
6	1,75						
7	7,00						
8	1,75						
9	7,00						
10	1,75						
11	3,50						
12	0,88						
13	3,50						
14	0,88						
15	3,50						
16	0,88						
17	2,50						
18	0,63						
19	2,50						
20	0,63						
21	2,50						
22	0,63						
23	1,00						
24	0,25						
25	1,00						
26	0,25						

Short-term harmonics of current and TDD for 99% of the time

Method of measurement	15 min. average of the effective values of harmonics and total distortion required (TDD). All harmonic values are expressed in % per maximum required current I_L	
Percentage of unmarked periods	☐ 99,55 %	☐ 100 %
Rated voltage at the site of burial		
Maximum required load current I_L (Basic Harmonic)		
Maximum short-circuit current Isc		
Criteria for U_{BUS} and Isc/I_L		
Boundaries	99% of total required distortion (THD) measurements should be less than 12% 99% of the measurements of individual current harmonics should be less than those given in the table below	

Harmonics of current

		L1		L2		L3	
Harmonic	Limit [%]	Measured	Status	Measured	Status	Measured	Status
TDD	12,00						
2	2,63						
3	10,50						
4	2,63						
5	10,50						
6	2,63						
7	10,50						
8	2,63						
9	10,50						
10	2,63						
11	5,25						
12	1,31						
13	5,25						
14	1,31						
15	5,25						
16	1,31						
17	3,75						
18	0,94						
19	3,75						
20	0,94						
21	3,75						
22	0,94						
23	1,50						

24	0,38						
25	1,50						
26	0,38						