REPUBLIC OF SLOVENIA
MINISTRY OF THE ENVIRONMENT AND SPATIAL PLANNING

TECHNICAL GUIDELINE TSG-N-003: 2026

Pursuant to Article 36(1) of the Building Act (Official Gazette of the Republic of Slovenia, Nos 199/21, 105/22 – ZZNŠPP, 133/23, 85/24 – ZAID-A, 47/25 – Constitutional Court Decision and 75/25) the Minister of the Environment and Spatial Planning hereby issues the following technical guideline

PROTECTION AGAINST LIGHTNING

Minister of the Environment and Spatial Planning
mag. POLONA RIFELJ

Number: 007-51/2026-2560
In Ljubljana, on 21 July 2026

This guideline has been issued taking into account the information procedure in accordance with 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. 1).

The fourth edition of Technical Guideline TSG-N-003:2026 fully replaces the third edition of the Technical Guideline TSG-N-003:2021.

Expert content preparation was conducted by the Electrotechnical Association of Slovenia, in collaboration with the professional community and the Slovenian Chamber of Engineers.
Design and layout:

TABLE OF CONTENTS

0 INTRODUCTION....7
0.1 MEANING AND FUNCTION OF THE TECHNICAL GUIDELINE ‘PROTECTION AGAINST LIGHTING’....7
0.1.1 Legal basis for issuing the technical guideline....7
0.1.2 Regulations on the protection of buildings against lightning – the legal framework of the guideline....8
0.1.3 Legal consequences of (non)application of the Technical Guideline....11
0.2 REFERENCE DOCUMENTS....12
0.2.1 Regulations....12
0.2.2 Standards....12
0.2.3 GUIDELINES....14
0.3 DEFINITIONS....14
0.3.1 Terms....14
1 SCOPE AND FIELD OF APPLICATION....20
2 BASIC REQUIREMENTS FOR DESIGN AND IMPLEMENTATION....21
2.1 GENERAL....21
2.2 LIGHTNING CURRENT PARAMETERS....21
2.3 DAMAGE DUE TO LIGHTNING STRIKES....22
2.3.1 Causes of damage....22
2.3.2 Types of damage....23
2.3.3 Types of loss....23
2.3.4 Risks....24
2.4 DENSITY OF ATMOSPHERIC DISCHARGES INTO THE EARTH....26
2.4.1 LPS classes....26
2.5 FUNCTIONAL SAFETY OF PROTECTION AGAINST LIGHTNING....26
3 PLANNING AND IMPLEMENTATION OF THE LIGHTNING PROTECTION SYSTEM....27
3.1 EXTERNAL LPS....28
3.1.1 Selection of external LPS....28
3.1.2 Air-termination system of LPS....28
3.2 DOWN CONDUCTOR SYSTEM....31
3.2.1 Down conductor system for a non-insulated lightning protection system....31
3.2.2 Down conductor system for insulated lightning protection system....33
3.2.3 Separation distance between the metal parts and the LPS....33
3.3 LPS EARTHING SYSTEM....34
3.3.1 Earthing system....35
3.4 IMPLEMENTATION OF AN LPS IN BUILDINGS WITH EXPLOSIVE HAZARDOUS AREAS....36
4 MATERIALS FOR LPS CONDUCTORS....38
5 PREVENTION OF SPARKING AND BREAKDOWN OF THE INSULATION MEDIUM....41
5.1 GENERAL....41
5.2 EQUIPOTENTIAL BONDING....41
5.2.1 General....41

5.2.2 Equipotential bonding of metal installations....41
5.2.3 Equipotential bonding of external conductive parts....42
5.2.4 Equipotential bonding in the internal LPS....42
5.2.5 Equipotential bonding of the supply cables....43
6 PROTECTION AGAINST HAZARDS CAUSED BY TOUCH AND STEP VOLTAGE....44
6.1 PROTECTIVE MEASURES AGAINST TOUCH VOLTAGE....44
6.2 PROTECTIVE MEASURES AGAINST STEP VOLTAGE....44
7 PROTECTION OF ELECTRICAL AND ELECTRONIC SYSTEMS IN BUILDINGS....45
7.1 GENERAL....45
7.2 PROTECTION ZONES....45
7.3 EARTHING AND CONNECTION....45
7.4 MAGNETIC SHIELDING AND TRANSPOSITION....46
7.5 COORDINATED CASCADE SURGE PROTECTION WITH SPDs....46
7.6 DESIGNING, CHOOSING AND THE INSPECTION PROCEDURE FOR LEMP PROTECTION....46
7.7 ELECTRICITY GENERATION EQUIPMENT ON BUILDINGS....46
8 INSPECTION OF THE LPS....47
8.1 GENERAL....47
8.1.1 Inspector jurisdiction....49
8.1.2 Responsibilities of the inspector....49
8.2 VISUAL INSPECTION....50
8.3 TESTS....51
8.4 MEASUREMENT....51
8.5 MAINTENANCE INSPECTION....52
8.6 SAFETY CHECK PERIODS....53
8.7 SAFETY CHECK MINUTES....53
A Appendix A: Knowledge and experience competencies....55
A.1 Knowledge and experience competencies of the inspector for performing specific fields of activity....55
A.2 Power engineering and industrial electrical installations and workplace responsibility....55
A.3 Low-voltage electrical installations and workplace responsibility....55
A.4 Safe work in areas and environments at risk of explosion....55
A.5 Energy, production, transmission and distribution, industry....56
A.6 Low-voltage electrical and lightning protection installations....56
B Appendix B: Measurement procedures and methods....57
B.1 Measurements of main equipotential bonding, resistance of the protective conductor and connection of conductive parts....57
B.1.1 Measurements of shock protection at all points of the electrical installation, connections to foreign conductive parts in the room....57
B.1.2 Measurements of external conductive parts, measurements of galvanic connections and joints....57
B.2 Measurement of the insulation resistance of circuits, installations, isolating transformers....58
B.2.5 Insulation resistance of floors and walls....58
B.3 Measurements of impedance Z, short-circuit currents and fault currents for testing the earthing system....58
B.3.4 Verification methods for safety in buildings constructed before 1985 (zeroing)....59

B.4 Measurements of earthing resistance, protective and operational earthing , touch and step voltage.....
59
B.4.1 Measurements of touch and step voltages in the vicinity of small structures, buildings, devices and constructions.....60
B.4.2 Measurements of touch and step voltages at the edges of earthing systems and in the vicinity of the earthing systems of power installations, areas and centres where large numbers of people are present.....60
B.4.3 High-current integrity testing for earthing systems in installations and structures within industry, the energy sector and distribution.....60
B.4.4 Permissible touch and step voltages.....60
B.5 Lightning protection measurements ZPS.....62
B.5.1 Measurements of internal lightning protection ZPS and surge protection SPD.....63
B.5.2 Measurements of external lightning protection (air-termination loops and down-conductor networks).....63
C Appendix C: Example of a lightning protection system inspection report.....64

0 INTRODUCTION

0.1 MEANING AND FUNCTION OF THE TECHNICAL GUIDELINE ‘PROTECTION AGAINST LIGHTING’

0.1.1 Legal basis for issuing the technical guideline

(1) This technical guideline was issued by the Minister of the Environment and Spatial Planning on the basis of Article 36(1) of the Building Act (Official Gazette of the Republic of Slovenia, Nos 199/21, 105/22 – ZZNŠPP, 133/23, 85/24 – ZAID-A, 47/25 – Constitutional Court Decision and 75/25).
(2) The Building Act stipulates that the ‘Technical Guideline for the Construction of Facilities (hereinafter referred to as the ‘Technical Guideline’) for specific types of facilities shall precisely define the following:
- recommended technical solutions to achieve the fulfilment of the basic requirements for the design, construction and maintenance of facilities,
- selected levels or classes of construction products and materials that may be installed and the method of their installation,
- rules for the classification and ranking of facilities.

It is also stipulated that the technical guidelines for specific types of facilities also specify the recommended technical solutions relating to the fulfilment of other requirements.
(3) The legal nature and application of technical guidelines are addressed in articles 34 and 36 of the Act. The first article stipulates that the regulations on basic requirements are issued by the minister responsible for construction, but in the case of special types of facilities or parts of basic requirements, they may also be determined by ministers responsible for the field of work that includes such types of facilities or basic requirements. The same article also defines the relationship between regulations and guidelines, determining that construction–technical and other regulations may refer to standards or technical guidelines or prescribe that a presumption of conformity with the requirements of the regulation shall apply if it meets the requirements of the standards or the technical guidelines set out therein. If the presumption of conformity referred to in the preceding paragraph is determined in the construction–technical regulation, these rules shall also define the methods and procedure in which it is proved that the project, in which the designer used the solutions of the last state of construction technology, provides at least the same level of reliability as the project that was prepared by using technical guidelines and mandatory or recommended standards.
(4) Other requirements are specified in detail by the minister who is responsible for the field of work that includes the type of facility or this requirement.
(5) Article 25 of the Act stipulates that facilities must meet the basic requirements with regard to their purpose, type, size, capacity, intended impact and other characteristics of the facility. The basic requirements for facilities are:

1. mechanical resistance and stability,
2. **fire safety,**
3. hygiene and health protection, and environmental protection,
4. **safe usage,**
5. noise protection,
6. energy saving and heat retention,
7. universal construction and use of facilities,
8. sustainable use of natural resources.

(6) If a particular solution is required to comply with the requirements set out in several regulations, the most stringent requirements from the applicable regulations shall apply.

0.1.2 Regulations on the protection of buildings against lightning – the legal framework of the guideline

(1) The building regulation which defines in more detail parts of the basic requirements of ‘fire safety’ and ‘safe usage’ is the Rules on Low-Voltage Electrical Installations in Buildings and the Protection of Buildings Against Lightning (Official Gazette of the RS, No. XXX/YY). These Rules establish the following requirements for a lightning protection system (hereinafter referred to as the ‘lightning protection’).

Article 8
(Ensuring safety and security)

…
(2) Lightning protection must:

- dissipate atmospheric discharges into the ground without harmful effects and must not cause hazardous sparking or electric flashovers which could cause a fire,
- prevent failure of electrical, telecommunications and other supply systems or limit such failure to a minimum,
- prevent failure of electrical and electronic devices or limit such failure to a minimum, and
- implement protective measures against touch and step voltages, as defined in Technical Guideline TSG-N-003 ‘Protection against Lightning’, in order to minimise harm to people, animals and property.

CAUTION:
The scope of this technical guideline is significantly broader than the scope of the legal value of

Article 1
(Content and application of the Rules)

(3) The requirements of these Rules can also be reasonably applied to civil engineering works and other spatial interventions if the regulations that regulate their basic requirements do not include requirements regarding electrical installations and protection against lightning.

(2) In the section of these Rules that determines the way of fulfilling regulatory requirements, the most important provisions for the application of this Technical Guideline are the following.

Article 9
(Technical guidelines)

(1) The technical guidelines for construction, which set out the recommended construction measures or solutions for meeting the requirements of these Rules, are the technical guidelines for construction TSG-N-002 ‘Low-voltage electrical installations’ and TSG N 003 ‘Protection against lightning’.
(2) If the measures or solutions (hereinafter referred to as ‘measures’) specified in the technical guidelines referred to in the preceding paragraph and in the documents to which these guidelines refer are fully used in the design and construction of electrical installations and lightning protection in the building, the presumption of conformity with the requirements of these Rules shall apply.

Article 10
(Using non-recommended measures)

(1) When designing and constructing electrical installations and lightning protection systems, solutions that are not recommended methods may be used in place of the measures set out in the technical guidelines, provided that these solutions ensure compliance with the requirements of these Rules and at least the same level of safety as a design and construction project prepared and carried out using the technical guidelines referred to in the preceding article.
(2) The measures referred to in the preceding paragraph constitute a failure to apply the recommended method, in accordance with the law governing construction. In such cases, compliance with the requirements for electrical installations and lightning protection is ensured by checking the construction documentation in accordance with Article 17 of these Rules.
(3) Notwithstanding the first paragraph of this article, all examples of actions stated in the Articles 13 and 14 of these Rules should be applied solely 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, the methodology for analysing the risk of a lightning strike set out in item 2 of technical guideline for construction TSG-N-003 ‘Protection against lightning’ must always be applied in relation to lightning protection.

(3) The following are the most important provisions in the section of these Rules, that determines the content of project documentation:

Article 17
(Design basis statement)

(1) The design engineer must explicitly indicate in the design documentation whether the documentation for the construction is prepared on the basis of a technical guideline or on the basis of Article 10 of these Rules.

(2) If the measures from Article 10 of these Rules are used in the project documentation, all significant assumptions, on the basis of which the designer proposed the design solutions, have to be accurately described in the technical report.

(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,
- a description of the implementation of the installation and power supply, including calculations for the dimensioning of the electrical installation and equipment, and for voltage drops,
- protection against electric shock, with calculation of protection,
- power supply and equipotential bonding system,
- earthing of the building, including earthing calculation,
- method of lightning protection implementation, including calculation of the system's protection level 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 safety measures for areas at risk of explosion,
- compliance with measures for protection during use,

impact of electricity quality.

(4) In addition to the requirements set out in the preceding paragraph, the project documentation for the construction works relating to the lightning protection system must also include:
- the protection level of the building,
- separation distances between metal masses, including calculation,
- floor plans of roofs and facades of buildings with the main characteristics of the air termination system,
- an external lightning protection system – air termination system, down conductors and earth termination system,
- an internal lightning protection system – direct galvanised connections with intersections and planned installations of surge protection devices,
- the value of the earthing device's resistance, including the necessary calculations,
- the types of earthing devices and metering points (e.g. strip, mesh, foundation earthing device),
- metal attachments with specific collectors for equipotential bonding,
- the type and location of connections to neighbouring structures (e.g. water installation, gas installation, electrical installation, information and communications installations, protection),
- the protection system for touch and step overvoltages and
- all other necessary information relevant to the installation of the lightning protection system (e.g. isolated system).

(5) The design of electrical installations and equipment must ensure the consistency of all measures and solutions related to electrical installation and lightning protection, in particular with regard to common equipotential bonding elements, external air termination system with down conductors and implementation of an internal lightning protection system.

-

If the designer has chosen a design in accordance with Article 10 of the Rules (using non-recommended measures), Article 18 of the Rules is important:

Article 18
(Obligation to check the documentation for the execution of the works)

(1) If the designer, when designing the electrical installation and lightning protection of the building, has not used the recommended method, the part of the project execution documentation relating to the verification of integrity and computational correctness of those parts of the electrical installation and lightning protection documentation must be inspected. The inspection demonstrates that the documentation submitted for the execution of the construction works meets the requirements of these Rules to a standard at least equivalent to that which would have been achieved had the relevant technical guidelines and the documents referred to therein been applied.
(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 inspector.
(3) The inspector shall include in the inspection report only those details that are essential to the scope of the inspection specified in the first paragraph of this article. The subject of the inspection is exclusively the verification of the accuracy and correctness of the electrical engineering design contained in the construction project documentation, which demonstrates that the submitted construction project documentation meets the requirements of Article 8 of these Rules to at least an equivalent standard, as if the recommended methods set out in Article 9 of these Rules had been applied.

0.1.3 Legal consequences of (non)application of the Technical Guideline

a) Application of the Technical Guideline — presumption of compliance
(1) As can be seen from the preceding sections of the introduction, the building measures or solutions described in this technical guideline are merely the recommended way to meet the requirements regulated by these Rules. Compliance with the recommended technical measures is the basis for the presumption of compliance with the requirements of the Rules. It should be borne in mind that measures for ensuring the protection of buildings against lightning and solutions for the safe use of low-voltage electrical installations are interconnected and their final effect cannot be considered solely on the basis of the analysis of each measure individually, i.e. without taking into account the results of the entire chosen design for ensuring safety.
(2) Therefore, when the responsible developer is choosing the actions under this Technical Guideline and combining them with the actions set out in the different referenced (supporting) documents, the developer shall always ensure coherence between them.
(3) The burden of proof of non-compliance with the requirements of these Rules is, in the application of this Technical Guideline, on the side of the relevant national authorities or construction participants, determined by the legislation, whose role is to supervise the correctness of the project design (inspectors and the chamber of commerce). When the project design follows the building measures in this guideline, it is not necessary to demonstrate compliance with the relevant rules during construction and obtaining the necessary administrative decisions because it is automatically assumed on the basis of the provisions of these Rules.

b) Project design based on the current state of construction technology
(1) If the designer responsible decides, in accordance with the regulations, to use (in part or in whole) the construction measures from the previous construction techniques as determined in Article 10 of these Rules, the same level of safety of the lightning protection system must be ensured and be visible to the obligatory inspection of that part of the documentation for the execution of the construction, which refers to the control of the faultlessness and calculation accuracy of those components of the plan that determine the electrical installations of the building (Article 18 of the Rules), which is the required means of proving that the designer has fulfilled the required criteria.
(2) When planning a project that arises from the previous construction technique it is considered that measures regarding the protection of buildings from lightning strikes are generally related to each other and the final result cannot be dealt with on the basis of an analysis of each separate measure without taking into account the results of the entire chosen concept for ensuring safety.

c) Relating to the legal provision requirements in the field of lightning protection
(1) The content of this guideline recommends building measures that can occasionally be the subject matter of other provisions. In relation to the applicable provisions, the Technical Guideline is written in such a way that the proposed building measures are not inconsistent with the requirements of relevant provisions. However, if it is determined in its application that the implementation of the specific proposed action constituted a breach of the applicable provision, it is necessary to fully comply with the mandatory requirements of the law.
(2) Paragraph 0.2.1 considers the provisions valid on the date of issue of this guideline. Users must monitor changes arising from the adoption of new regulations and the related repeals through the Official Gazette of the Republic of Slovenia or, in the case of EU legal acts, the Official Journal of the European Union.

0.2 REFERENCE DOCUMENTS[1]

0.2.1 Regulations

0.2.1.1 Building Act (Official Gazette of the Republic of Slovenia, Nos 199/21, 105/22 – ZZNŠPP, 133/23, 85/24 – ZAID-A, 47/25 – Constitutional Court Decision and 75/25),
0.2.1.2 Energy Act (Official Gazette of the Republic of Slovenia) Nos 38/24 and 47/25 – ZOEE-A),
0.2.1.3 Construction Products Act (Official Gazette of the Republic of Slovenia, 82/13),
0.2.1.4 Act Regulating Technical Requirements for Products and Conformity Assessment (Official Gazette of the Republic of Slovenia, No 17/11 and 29/23),
0.2.1.5 Decree on the Classification of Structures (Official Gazette of the Republic of Slovenia, No 96/22),
0.2.1.6 Decree on Self-supply of Electricity from the Renewable Energy Sources (Official gazette of the Republic of Slovenia, Nos 43/22, 112/25 – ZSROVE-1 and 8/26),
0.2.1.7 Rules on Low-Voltage Electrical Installations in Buildings and the Protection of Buildings Against Lightning (Official Gazette of the Republic of Slovenia, No XXX/YY),
0.2.1.8 Rules on Making Available on the Market Electrical Equipment Designed for Use within Certain Voltage Limits (Official Gazette of the Republic of Slovenia, No 39/16),
0.2.1.9 Rules on Fire Safety in Buildings (Official Gazette of the Republic of Slovenia, Nos. 31/04, 10/05, 83/05, 14/07, 12/13, 61/17 – GZ and 199/21 – GZ-1),
0.2.1.10 Regulation on Small-scale Installations for the Generation of Electricity from Renewable Energy Sources or through High-efficiency Cogeneration (Official Gazette of the Republic of Slovenia, Nos. 14/20, 121/21 – ZSROVE, 132/23, 102/24 – ZSROVE-B and 112/25 – ZSROVE-1),
0.2.1.11 Electromagnetic Compatibility Rules (Official Gazette of the Republic of Slovenia, Nos 39/16 and 9/20),
0.2.1.12 Rules on the protection of low-voltage networks and associated substations (Official Gazette of the Republic of Slovenia, No. 202/21 and 38/24 – EZ-2),
0.2.1.13 Explosion Protection Rules (Official Gazette of the Republic of Slovenia, No 41/16),
0.2.1.14 Rules on the Detailed Content of Documentation and Forms related to Construction (Official Gazette of the Republic of Slovenia, Nos 36/18, 51/18 and 197/20),
0.2.1.15 Rules on the Maintenance of Electricity Installations (Official Gazette of the Republic of Slovenia, Nos. 98/15 and 38/24 – EZ-2),
0.2.1.16 Rules on Electricity Installations of Alternating Voltage Exceeding 1 kV (Official Gazette of the Republic of Slovenia, No. 63/16 and 38/24 – EZ-2),
0.2.1.17 Rules on the Technical Requirements of Devices for Self-supply of Electricity from the Renewable Energy Sources (Official Gazette of the Republic of Slovenia, Nos 1/16, 46/18 and 121/21 – ZSROVE).

0.2.2 Standards

The design, installation, functioning and maintenance of the lightning protection system (hereinafter referred to as the ‘LPS’) is based on the following standards and the standards stated within them, as well as other documents:

0.2.2.1	SIST ISO 6707-1	Buildings and civil engineering works – Vocabulary – Part 1: Vocabulary
0.2.2.2	SIST HD 60364-4-41	Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock

1 Reference documents, listed in:

- paragraph 0.2.1 are available on the website: http://www.pisrs.si/Pis.web/
- paragraph 0.2.2 are available at the Slovenian Institute for Standardization (SIST),
- paragraph 0.2.3 are available on the central website of the state administration.

0.2.2.3	SIST EN IEC 60664-1	Insulation coordination for equipment within low-voltage supply systems – Part 1: Principles, Requirements and Tests
0.2.2.4	SIST EN IEC 61557-1	Electrical safety in low-voltage distribution systems up to 1000 V AC and 1500 V DC – Equipment for testing, measuring or monitoring of protective measures – Part 1: General requirements
0.2.2.5	SIST EN IEC 61557-2	Electrical safety in low-voltage distribution systems up to 1000 V AC and 1500 V DC – Equipment for testing, measuring or monitoring of protective measures – Part 2: Insulation resistance
0.2.2.6	SIST EN IEC 61557-4	Electrical safety in low-voltage distribution systems up to 1000 V AC and 1500 V DC – Equipment for testing, measuring or monitoring of protective measures – Part 4: Resistance of earth connection and equipotential bonding
0.2.2.7	SIST EN IEC 61557-5	Electrical safety in low-voltage distribution systems up to 1000 V AC and 1500 V DC – Equipment for testing, measuring or monitoring of protective measures – Part 5: Resistance to earth
0.2.2.8	SIST EN IEC 61557-10	Electrical safety in low-voltage distribution systems up to 1000 V AC and 1500 V DC – Equipment for testing, measuring or monitoring of protective measures – Part 10: Combined measuring equipment for testing, measuring or monitoring of protective measures
0.2.2.9	SIST EN IEC 62305-1	Protection against lightning – Part 1: General principles
0.2.2.10	SIST EN IEC 62305-2	Protection against lightning — Part 2: Risk management
0.2.2.11	SIST EN IEC 62305-3	Protection against lightning – Part 3: Physical damage to structures and life hazard
0.2.2.12	SIST EN IEC 62305-4	Protection against lightning – Part 4: Electrical and electronic systems within structures
0.2.2.13	SIST EN IEC 62561-1	Lightning protection system components (LPSC) – Part 1: Requirements for connection components
0.2.2.14	SIST EN IEC 62561-2	Lightning protection system components (LPSC) – Part 2: Requirements for conductors and earth electrodes
0.2.2.15	SIST EN IEC 62561-3	Lightning protection system components (LPSC) – Part 3: Requirements for isolating spark gaps
0.2.2.16	SIST EN IEC 62561-4	Lightning protection system components (LPSC) – Part 4: Requirements for conductor fasteners
0.2.2.17	SIST EN IEC 62561-5	Lightning protection system components (LPSC) – Part 5: Requirements for earth electrode inspection housings and earth electrode seals
0.2.2.18	SIST EN IEC 62561-6	Lightning protection system components (LPSC) – Part 6: Requirements for lightning strike counters (LSC)
0.2.2.19	SIST EN IEC 62561-7	Lightning protection system components (LPSC) – Part 7: Requirements for earthing enhancing compounds
0.2.2.20	SIST EN 61643-11	Low-voltage surge protective devices – Part 11: Surge protective devices connected to low-voltage power systems

		– Requirements and test methods
0.2.2.21	SIST TS CLC/TS 61643-12	Low-voltage surge protective devices – Part 12: Surge protective devices connected to low-voltage power distribution systems – Selection and application principles
0.2.2.22	SIST EN 61643-21	Low-voltage surge protective devices – Part 21: Surge protective devices connected to telecommunications and signalling networks – Performance requirements and testing methods
0.2.2.23	SIST-TS CLC/TS 61643-22	Low-voltage surge protective devices – Part 22: Surge protective devices connected to telecommunications and signalling networks – Selection and application principles
0.2.2.24	IEEE 81	IEEE lead for measuring earthing resistance, soil impedance and earth surface potentials of the earthing system

0.2.3 GUIDELINES

0.2.3.1 Technical guideline TSG-1-001 Fire Safety in Buildings,
0.2.3.2 Technical guideline TSG-N-002 Low-Voltage Electrical Installations.

0.3 DEFINITIONS

(1) Terms from the field of building construction that are not defined in this technical guideline are defined in the Building Act, in the Rules on Low-Voltage Electrical Installations in Buildings and the Protection of Buildings Against Lightning or in the standard SIST ISO 6707-1.
(2) Terms from the field of protection against lightning that are not defined in this technical guideline are defined in the Rules on Low-Voltage Electrical Installations in Buildings and the Protection of Buildings Against Lightning or in the series of standards SIST EN 62305.
(3) Terms from the field of low-voltage electrical installations which are not defined in this technical guideline are defined in technical guideline TSG-N-002 ‘Low-voltage electrical installations’.
(4) The acronyms have the following meaning:

LPS – lightning protection system;
LPL – lightning protection level;
LPZ – lightning protection zone;
LEMP – lightning electromagnetic pulse;
SPD – surge protection device;
SPM – safety protection measures.

0.3.1 Terms

0.3.1.1 The head time of the strike current T_1 – virtual parameter defined as 1.25 times the time interval between the moments when 10 % and 90 % peak values are reached.
0.3.1.2 The time of the half value of the lightning current at the back of the impact wave T_2 – the virtual parameter, defined as the time interval between the virtual start O_1 and the moment in which the current falls to half the peak value.
0.3.1.3 A direct strike is a direct lightning strike into the building or to the lines connected to building.
0.3.1.4 Short-lasting strike – discharge lightning current corresponding to the strike current. The duration of the T_{LONG} (i.e. the time from 10 % at the head to 10 % of the value on the back) of the continuous current is typically longer than 2 ms and shorter than 1 s.
0.3.1.5 Electrical installation system – is a set of low-voltage electrical installations that are powered by electricity from one connection point (measuring point for accounting

measurements) and run from the main fuses on the connection to the final connections of electrical devices. In the case of a permanent connection of the device, the installation system runs to the terminals in the device. It uses harmonised measures to protect against electric shock, over-current and excessive heating.

0.3.1.6 Electrical installations comprise installed lines and the associated installed equipment and devices intended for the operation of the building, as well as fixed connected devices with rated voltages up to and including 1 000 V AC or up to and including 1 500 V DC;

0.3.1.7 A fixed connected device is a device and equipment for the production, conversion or consumption or storage of electricity;

0.3.1.8 Lightning electromagnetic pulse (LEMP) – electromagnetic effects of lightning current. LEMP includes conductive strike effects as well as radiation effects of the pulsed electromagnetic field.

0.3.1.9 Lightning electromagnetic pulse (LEMP) – all electromagnetic effects of electrical current of lightning over a resistive, inductive and capacitive set that cause over-voltages and radiation electromagnetic fields.

0.3.1.10 Electronic system – a system that includes sensitive electronic equipment such as: telephone equipment, computers, monitoring, control and regulation systems, radio systems, power electronic installations.

0.3.1.11 Power lines – distribution lines that supply energy to the buildings and installed electronic equipment, such as LV and HV dedicated devices.

0.3.1.12 Physical damage – damage to the building (or its contents) due to mechanical, thermal, chemical and explosion effects when lightning strikes.

0.3.1.13 Insulated external lightning protection system – the external air termination of the lightning protection is constructed separately from the metal parts of the building at a safe distance and integrated in the earthing system in the basic equipotential plane.

0.3.1.14 Insulation interfaces – devices capable of reducing over-voltage transmission on lines entering LPZ protection zones. This includes insulation transformers with an earthed metal screen between windings. The insulating resilient characteristics of these devices can be independent or common with the SPD.

0.3.1.15 Short-lasting strike – discharge lightning current corresponding to the strike current. The duration of half-wave T_2 of this current is shorter than 2 ms.

0.3.1.16 Coordinated surge protection system (SPD) – surge protective devices, properly selected, mutually coordinated and installed, reducing electrical and electronic system faults.

0.3.1.17 LEMP safety protection measures (SPM) – protection measures to protect internal electrical and electronic systems against the effects of lightning electromagnetic pulse (LEMP). This is part of the entire lightning protection.

0.3.1.18 Separation distance is the required distance between the conductor that carries part of the lightning current and other conductive parts to prevent dangerous sparks.

0.3.1.19 The air-termination system – a part of an entire lightning protection system consisting of metallic elements such as metal bars, metal meshes or wire ropes designed to intercept a lightning electric current.

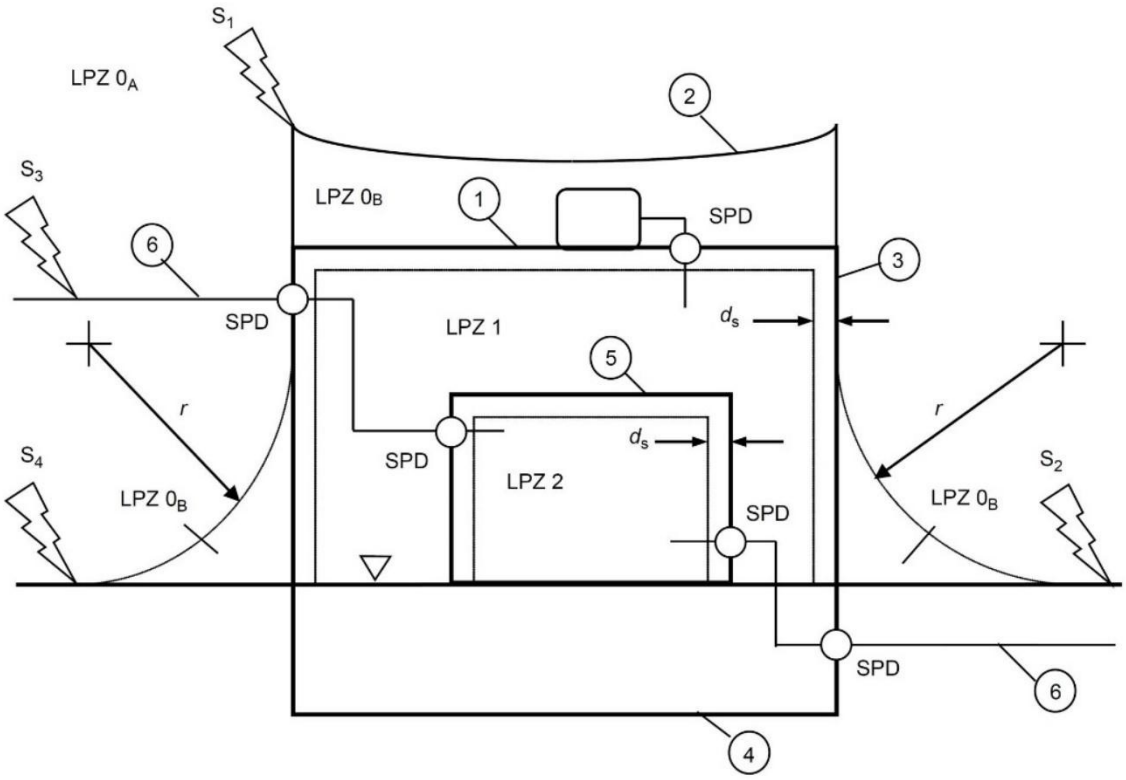
0.3.1.20 Magnetic protection – finished metal plating, made of mesh or massive metal sheet, which embraces the building or its part, with the aim of reducing defects in electrical and electronic devices;

0.3.1.21 Measuring joint – measuring joint intended to check the connection of the down conductor with the earthing system, installed in all main lightning protection conductors at the junction between the down conductor and the grounding electrode. In the case of a reinforced concrete wall it is made at the transition from a reinforced concrete wall to the roof of the building.

0.3.1.22 Measuring contact – made at the main down conductor points when the walls of the building are made of reinforced concrete, in the form of a welded metal connector made of stainless round steel on a reinforcing mesh, of the same cross-section as the main lightning conductors installed at a height that is easily accessible from the ground.

0.3.1.23 Mesh method – a method to define the protection area of the LPS which is similar to a metal cage.

0.3.1.24 Rolling sphere method – adopted basic methodology in planning LPS which determines the protected area around a building in the event of a direct lightning strike.
0.3.1.25 Protection angle method – defining the protection area to within a covered area of a cone that occurs between the exposed points on the down conductors and the reference plane below the protection angle toward the vertical, in all directions.
0.3.1.26 Natural components of the LPS – metal roof parts that conduct electrical currents (the reinforcement in concrete, metal coverings, fences, etc.).
0.3.1.27 Indicated resilient voltage, U_W – resilient shock voltage specified by the manufacturer of the equipment or a part thereof and is indicating the endurance of its insulation against over-voltages. This standard only takes into account the resilient voltage between the conductor under voltage and the earth. It depends on the voltage level at which the device is installed.
0.3.1.28 Long-lasting strike charge Q_{LONG} is a time integral of the lightning current of the long-lasting strike.
0.3.1.29 Short-lasting strike charge Q_{SHORT} is a time integral of the lightning current of the short-lasting strike.
0.3.1.30 Lightning strike charge $Q_{LIGHTNING}$ – time integral of the lightning current during the entire duration of the lightning strike.
0.3.1.31 Apparent initial lightning current O_1 – the point of intersection of the time axis and the line passing through the 10 % and 90 % reference points at the head strike current; the point at $0.1T_1$ precedes the moment when the current reaches 10 % of the peak value.
0.3.1.32 Internal LPS – part of the LPS inside the building which consists of the equipotential bonding (disabling touch and step high-voltage) and the coordinated isolating distances between parts of the lightning conductor installation itself and parts of the building (disabling the occurrence of sparks within the building).
0.3.1.33 Internal systems – electrical and electronic systems in the building.
0.3.1.34 Facilities to be protected against lightning – buildings requiring protection against lightning in accordance with the regulations.
0.3.1.35 Down conductor system – part of the entire lightning protection system, which is intended to conduct the electric lightning current into the earthing system.
0.3.1.36 Lightning arrestor – a protective device whose purpose is to protect the electrical installation and equipment from lightning discharge surge currents.
0.3.1.37 Supply line – a cable, above-ground line or pipeline which comes into the building from outside and serves to supply the building with energy, water, gas, data, etc.
0.3.1.38 Earthing impedance – is the ratio of the maximum value of the voltage on the earthing system and the earthing current, which usually do not occur at the same time.
0.3.1.39 Earthing system – part of the entire lightning protection system, which is intended to conduct and disperse the electric lightning current into the ground.
0.3.1.40 Earthing system LPS and earthing resistance R_E – part of the entire lightning protection system, which is intended to conduct and disperse the electric lightning current into the ground and to reduce potentially dangerous over-voltage.
0.3.1.41 The earthing system LPS and earthing resistance R_C is a system consisting of the earthing resistance R_E of the basic earthing system and from the additional resistance to the different connectors per building.
0.3.1.42 Earth electrode – a conductor placed into the earth with the purpose of discharging and spreading the lightning current into the earth (e.g. earth rod, horizontal earth electrode, flat earth electrode, earth electrode mesh, etc.).
0.3.1.43 A single lightning strike is a one-off electrical discharge into the ground.
0.3.1.44 Indirect strike – lightning near the protected building or in proximity to the line connected to the building.



Key

1	building (LPZ 1 shielding)	S_1	lightning in the building
2	air closing system	S_2	lightning in the vicinity of the building
3	down conductor system	S_3	lightning in the lines connected to the building
4	earthing system	S_4	lightning in the vicinity of the building lines
5	room (LPZ 2 shielding)	r	radius of the rolling sphere
6	lines connected to the building	d_s	safe distance to excessive magnetic field

▽ ground level

○ lightning conductor equipotential connections from the SPD point of view

LPZ 0_A direct lightning, entire lightning current, entire magnetic field

LPZ 0_B indirect lightning, partial lightning current or induced current, entire magnetic field

LPZ 1 indirect lightning, limited lightning current or induced current, suppressed magnetic field

LPZ 2 indirect lightning, induced current, even more suppressed magnetic field

the protected spaces within LPZ 1 and LPZ 2 must correspond to the safe distance d_s

0.3.1.45 The average gradient of the increase of the strike current – the average speed of the change in the lightning current in the time interval $\Delta t = (t_2 - t_1)$. It is expressed as the change in the lightning current at the start and end of this interval: $i = i(t_2) - i(t_1)$, divided by the time interval $\Delta t = t_2 - t_1$.

0.3.1.46 Damage to living beings – permanent damage, the loss of life of humans or animals, due to the lightning strike, contact voltage when lightning strikes. Living beings can also be injured in other ways. In this standard, the term ‘damage to living beings’ is treated as a result of an electric shock (type of damage D_{1D} or D_{1T}).

0.3.1.47 Over-voltage – transient over-voltages as a result of a lightning electromagnetic pulse (LEMP), which causes over-voltages and over-currents or both at the same time.

0.3.1.48 Surge protection devices (SPD) – devices designed to limit transients below the level of sustainable impact voltage UW and to conduct shock currents. It contains at least one nonlinear component.

0.3.1.49 Surge arrester – a protection device which, when a surge occurs, is activated by diverting the lightning current to earth and reduces the residual voltage to below the UW level in the protected area.

0.3.1.50 The reference earth – (neutral earth) is part of the earth, in particular the surface of the earth, outside the influence area of the earthing in a building, in which there is no perceptible voltage effect due to formation of an electric current between the compared points.

0.3.1.51 Lightning protection system (LPS) – the entire lightning protection system used to reduce physical damage to buildings and reduces physical damage from lightning strikes to buildings. It consists of an internal and external lightning protection system.

0.3.1.52 Common earthing device – in buildings with electrical wiring it is necessary to make a common earthing device which must enable safe functioning of electrical installation and lightning protection system.

0.3.1.53 Specific energy of the lightning current – the time integral of the squared strike current of the lightning during the strike current. The specific energy of a long-lasting strike is negligible here.

0.3.1.54 Specific energy *W/R* – time integral of the squared lightning current during the entire lightning stroke. The energy released by the lightning current per unit of resistance.

0.3.1.55 The specific resistance of the ground ρE – is a material-geometric property and represents the earth's ability to resist the flow of electric current.

0.3.1.56 Tolerable risk (R_T) – the highest risk value still acceptable for a protected building. Typical tolerable risk value $R_T = 10^{-5}$/year. Other values may be determined following a detailed investigation.

0.3.1.57 Lightning protection zone (LPZ) – an area where the electromagnetic environment is defined as a result of a lightning strike. LPZ boundaries are not usually physical boundaries of the building (e.g. walls, ceilings, floors).

0.3.1.58 Lightning conductor equipotential bonding (EB) – the connection of foreign conductive parts with LPS on the basis of a direct conductive contact or through a surge protective device in order to achieve a reduction in the potential differences caused by the lightning current.

0.3.1.59 Damage to electrical and electronic systems – permanent damage to electrical and electronic systems due to lightning electromagnetic pulse (LEMP).

0.3.1.60 Telecommunications lines – lines intended for communication between devices which can be installed in separate parts of the building, such as telephone and information lines.

0.3.1.61 The peak value of the lightning current Iu – the maximum lightning current value.

0.3.1.62 The strike point is the point where the lightning hits the ground or exposed object (e.g. building, LPS, line, tree, etc.). A lightning strike may have several strike points.

0.3.1.63 Lightning current i – current flowing through the strike point.

0.3.1.64 Duration of the discharge process T_{LONG} – the time when the lightning current flows through the strike point.

0.3.1.65 The duration of the long-lasting strike is the duration of the discharge current when the current between the points of a long-lasting lightning strike reaches a value from 10 % of the peak value in an increase up to 10 % of the peak value in a decrease.

0.3.1.66 Risk, *R* – value of probable annual losses (of people and goods) as a result of a lightning strike, relative to the total value of (people and goods) in the protected building.

0.3.1.67 A lightning strike near a protected building (M) – a lightning strike that strikes near a protected building can cause dangerous over-voltages.

0.3.1.68 Other conductive parts – are those conductive parts that may become electrically energised in the event of insulation failure.

0.3.1.69 Lightning strike toward earth – atmospheric electrical discharge between the cloud and ground, consisting of one or more successive strikes. A lightning strike that is directed from the cloud toward the ground with a leading strike. The downward-moving lightning consists of the first strike which may be followed by short-lasting strikes. One or more short-lasting strikes may be followed by a long-lasting strike.

0.3.1.70 Lightning strike toward a cloud – a lightning strike that is directed from the object to the cloud by a leading strike. The upward-moving lightning consists of the first strike which may or may not be followed by short-lasting strikes. One or more short-lasting strikes may be followed by a long-lasting strike. A lightning strike that is directed from the object toward the cloud with a leading strike.

0.3.1.71 A multiple strike is a lightning strike, which is usually composed of three to four strikes with a typical interval duration of about 50 ms. Multiple strikes with several intervals of ten ranging from 10 ms to 250 ms have been identified.

0.3.1.72 A lightning strike in a building – is an atmospheric discharge into the building.

0.3.1.73 The safety distance is the required distance between the internal system and the shield of the lightning protection zone, in which the effect of the shield of the lightning protection zone against the influence of the magnetic field still applies.

0.3.1.74 Lines – power lines or telecommunications lines that are connected to buildings.

0.3.1.75 Maintenance inspections – visual inspections that may be carried out by another qualified person during the period of regular verification under other legislation.

0.3.1.76 Maintenance – a combination of technical, administrative and managerial measures during the lifetime of a device with the goal of restoring the device to the state or returning the device to the state in which it can perform its function.

0.3.1.77 Lightning protection (LP) – the entire lightning protection system of buildings, including internal systems, content and personnel, and is generally composed of lightning protection and surge protective measures (LPS and SPM).

0.3.1.78 Protective zone – the area where only certain electromagnetic effects can occur when lightning strikes.

0.3.1.79 Protective rope – metal wires used to reduce physical damage due to a lightning strike to the supply lines.

0.3.1.80 Protection level – the complete set of protective measures defined by the parameters of the lightning current for a specific type of risk.

0.3.1.81 Lightning protection level (LPL) – number associated with the selection of lightning electric current parameters, which relate to the probability that for the designed maximum and minimum structural solutions will not be compromised in the normal circumstances of the selected parameters in the event of a lightning strike in the building. The protective level of lightning protection shall be used for designing in accordance with the relevant group of lightning electric current parameters.

0.3.1.82 Protective measures – measures taken on a protected building in order to reduce the risk.

0.3.1.83 External LPS – part of the LPS outside the building which consists of the air-termination system, down conductors and an earth-termination system.

0.3.1.84 External conductive parts – part of the entire lightning protection system, which is intended to conduct and disperse the electric lightning current into the ground.

0.3.1.85 The combustibility of materials is determined by the SIST EN 13501-1 standard. Materials are non-combustible; combustible materials are classified as difficult to ignite, normally flammable, and easily flammable. See guideline SZPV 412 for explanation and examples.

1 SCOPE AND FIELD OF APPLICATION

(1) This technical guideline recommends, on the basis of the European standards mentioned in item 0.2.2, the construction measures for lightning protection whose aim is to limit the danger to people, and, indirectly, to animals and property in buildings and in the nearby surroundings to the minimum. If this guideline is followed, safety of the building is greatly increased as well as fire safety, which may also be compromised due to lightning strikes.

(2) This technical guideline defines the way of fulfilling the following requirements:

- technical specifications for the LPS on and in buildings and their installation;
- technical specifications and other requirements for products intended for connections within the LPS as well as to be built in;
- the functionality of the LPS during the life span of the building;
- designing, implementation of works and inspections of the LPS.

(3) This technical guideline does not apply to:

- railway systems;
- vehicles, boats, aeroplanes and off-shore platforms;
- underground high-pressure pipelines;
- pipelines, electricity and telecommunications lines that are not connected to buildings.

(4) This technical guideline may also apply mutatis mutandis to other objects where lightning can cause damage.

2 BASIC REQUIREMENTS FOR DESIGN AND IMPLEMENTATION

2.1 GENERAL

(1) In accordance with the provisions of the fourth paragraph of Article 8 of the Rules on Low-Voltage Electrical Installations in Buildings and the Protection of Buildings Against Lightning, compliance with this item is mandatory.

(2) The LPS is an integral part of the building and must be compatible with as well as reasonably connected to other installations in the building. The decision regarding the choice of suitable protection is based on the choice of protection level on the basis of an acceptable risk for the building, necessary to protect from the effects of lightning.

(3) In view of the risk assessment and a certain acceptable risk, the level of lightning protection LPL (I to IV, see item 2.5.1) shall be determined for buildings. For each protection level, the maximum and minimum lightning current parameters are defined (see Table 1). The probability of a lightning current, where the greatest parameter values will not be exceeded, amounts to 99 %. The maximum lightning current values that apply to protection level I are decreased to 75 % at protection level II, and to 50 % at protection levels III and IV (linear for *I,Q* and d*i*/d*t*, but with the square of the value for *W/R*).

(4) The LPS must be constructed in such a way that it can dissipate the atmospheric discharge into the earth without harmful consequences and living beings are not harmed, and that electrical flashovers and dangerous sparks do not occur.

(5) A suitable type and place of LPS installation must be chosen in the planning phase so as to maximise the utilisation of their electrical conductive parts and to create an effective LPS with the lowest costs, as well as aesthetically integrate it into the building and surroundings.

(6) The technical characteristics of the LPS must, at the time of the building's use, ensure all the design requirements, taking into account the necessary maintenance in accordance with this guideline.

(7) Even after a change in a building or lightning protection system, the LPS must meet all the prescribed technical properties.

(8) For buildings constructed before the entry into force of the Rules on Low-Voltage Electrical Installations in Buildings and the Protection of Buildings Against Lightning, the technical solutions required in the documents for obtaining a building permit shall apply and shall be valid until the end of the lifetime of the building or until the reconstruction of the lightning protection system.

(9) Depending on its position in the building, the LPS consists of an external and internal LPS.

(10) In individual cases, when an external LPS is not needed, it is recommended to construct only an internal LPS.

2.2 LIGHTNING CURRENT PARAMETERS

(1) Mechanical, thermal and electromagnetic effects depend on the peak value of the lightning current (*I*), the whole discharge charge (including the short-lasting and long-lasting lightning strike charge) and the specific energy (*W/R*). The parameters shown in Table 1 are the basis for the selection of down conductors.

Table 1: Maximum values of lightning current parameters with respect to LPL protection levels

Lightning current parameter	Lightning protection level (LPL)		
Initial positive strike	I	II	III-IV
Peak value of the current *I v* [kA]	200	150	100
Lightning strike charge $Q_{lightning}$ in (C)	300	225	150
Specific energy *W*/*R* [MJ/Ω]	10	5.6	2.5

(2) Harmful effects caused by changes in the electromagnetic field depend on the gradient of the lightning current increase. For the purposes of design, the average gradient of 30–90 % of the peak value of the increase in the lightning current is used.

2.3 DAMAGE DUE TO LIGHTNING STRIKES

Due to the effects of lightning strikes, the following are endangered:

- building structures (e.g. wood, bricks, concrete, reinforced concrete, iron constructions);
- the purpose of the building (e.g. residential buildings, offices, farms, theatres, hotels, schools, hospitals, churches, museums, prisons, trading houses, banks, factories, industrial facilities, sports grounds);
- users of buildings (mainly people but also animals);
- combustible and non-combustible materials, explosive and non-explosive materials, electrical and electronic equipment);
- utility lines (e.g. power lines, telecommunications lines, pipelines).

2.3.1 Causes of damage

(1) The lightning current is the basic cause of the damage. Damage can occur due to (see Table 2):

S1: discharges into the building,
S2: discharges near the building,
S3: discharges into the supply lines of the building,

S4: discharges near the supply lines of the building.

(2) Discharges into the building may cause:

- direct mechanical damage, fire and/or explosion due to hot electric current during ohmic heating, due to the passage of the electric current, material erosion caused by a lightning strike (melting of metal);
- fire and/or explosion caused by a spark due to galvanic and inductive connection and the passage of a part of the lightning current;
- damage to people due to the voltage of contact and step, due to galvanic and inductive connection;
- damage or malfunction of interior equipment due to LEMP.

(3) Discharges near the building may cause damage and malfunction of interior equipment in the building due to LEMP.

(4) Discharges into the building supply lines may cause:

- fire and/or explosion caused by sparks due to over-voltages and the lightning current that is transferred through the supply line;
- damage to people due to the voltage of contact and step as a result of the lightning current through the supply line;
- breakdowns and malfunction of the interior equipment due to over-voltage in the supply lines that are transferred to the building.

(5) Discharges near the building supply lines may cause breakdowns and malfunction of the interior equipment due to over-voltage in the supply lines that are transferred to the building.

2.3.2 Types of damage

(1) The lightning current can cause damage depending on the characteristic specifications of the specific building (e.g. its construction, contents and use, type of supply lines and the protective measures against lightning used).

(2) The four types of typical damage occurring due to lightning strikes are (see Table 2):

D_{1D} Electric shock of a person due to direct lightning into the person,

D_{1T} Electric shock of a person due to resistive or inductive coupling,

D_2 A dangerous impact inside a building that causes a fire or explosion, or results in mechanical or chemical effects, or both, which may also pose a risk to the environment,

D_3 Impacts due to all sources of damage causing damage to internal systems.

(3) Individual types of damage can be limited to the actual building, to the inside of the building, to neighbouring buildings and the surroundings (e.g. chemical and radioactive emissions). Lightning strikes can cause damage to supply lines going into the building (pipelines, electrical and electronic systems) which can then transfer directly to the actual building.

2.3.3 Types of loss

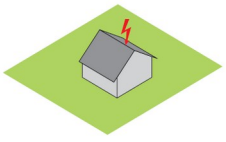
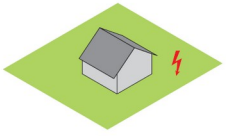
Any cause of damage relevant to a protected building, alone or in combination with others, may result in different types of loss. The type of loss depends on the characteristics of the building itself; the following factors are taken into account (see Table 2):

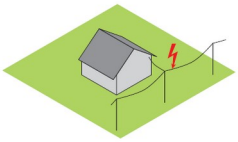
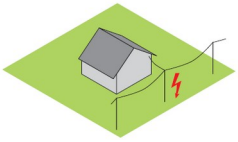
L_1: loss due to injury to persons, i.e. caused by causes D_{1D}, D_{1T}, D_2 and also D3 in buildings where the failure of internal systems endangers human life,

L_2: loss due to physical damage to the building and its contents, i.e. due to cause D_2 and also D3 in buildings with explosion risk,

L_3: loss due to internal system failure, caused by cause D_3.

Table 2: Sources of damage, causes of damage, type of losses and risk components with regard to lightning strikes

LIGHTNING STRIKE SPOT		SOURCE OF DAMAGE	CAUSE OF DAMAGE	TYPE OF LOSS	RISK COMPONENTS
Building		S1	D_{1T}	L_1	R_{AT}
			D_{1D} [c]	L_1	R_{AD}
			D_2	L_1, L_2	R_{B1}, R_{B2}
			D_3	L_1 [a], L_2 [b]	R_{C1}, R_{C2}
Vicinity of the building		S2	D_3	L_1 [a], L_2 [b]	R_{M1}, R_{M2}

Line connected to the building		S3	D_{1T}	L_1	R_U
			D_2	L_1, L_2	R_{V1}, R_{V2}
			D_3	L_1 [a], L_2 [b]	R_{W1}, R_{W2}
Proximity of the line connected to the building		S4	D_3	L_1 [a], L_2 [b]	R_{Z1}, R_{Z2}
The types of risk in the last column are calculated on the basis of the types of loss taken into account (see the 'Type of loss' column). [a] General for buildings where the failure of internal systems endangers human lives, for example buildings with a risk of explosion and hospitals. [b] General for buildings at risk of explosion. [c] This applies only to persons exposed on the building, for example on roof or terrace car parks and balconies.					

2.3.4 Risks

Risks from source S1

R_{AD}	Risk related to the type of loss L_1 caused by lightning strike on an exposed person on a building.
R_{AT}	Risk related to type of loss L_1, caused by an electric shock to a person due to touch and step voltages inside a building and outside within a zone of up to 3 m around exposed conductors.
R_B	Risk related to the type of loss L_1 (R_{B1}) and L_2 (R_{B2}) caused by hazardous sparks in a building which cause fire or explosion or cause mechanical or chemical effects which may also endanger the environment.
R_C	Risk related to the type of loss L_1 (R_{C1}) and L_2 (R_{C2}) caused by failure of internal systems due to LEMP. In general, losses can occur in buildings where there is a risk of explosion, as well as in hospitals or other buildings, where a failure of internal systems can lead to injury to people or a risk to the environment.

Risks from source S2

R_M	Risk related to the type of loss L_1 (R_{M1}) and L_2 (R_{M2}) caused by failure of internal systems due to LEMP. Losses can occur in buildings where there is a risk of explosion, as well as in hospitals or other buildings, where a failure of internal systems can lead to injury to people or a risk to the environment.

Risks from source S3

R_U	Risk related to the type of loss L_1 caused by electric shock to a person due to contact voltage in the building.
R_V	Risk related to the type of loss L_1 (R_{V1}) and L_2 (R_{V2}) caused by fire or explosion (caused by dangerous sparking between the outdoor installation and metal parts in general at the entry points of lines into the building) or caused mechanical or chemical effects due to the transfer of current of lightning in or on the connecting

	lines.
R_W	Risk related to the type of loss L_1 (R_{W1}) and L_2 (R_{W2}) caused by failure of internal systems due to induced over-voltage on connecting lines and transferred to the building. In general, losses can occur in buildings where there is a risk of explosion, as well as in hospitals or other buildings, where a failure of internal systems can lead to injury to people or a risk to the environment.

The assessment should take into account all lines connected to the building.
Lightning strikes on or near metal pipes are regarded as a source of damage, unless the pipes are connected to an equipotential conductor or an LPS earthing system at the building's entrance.

Risk from source S4

R_Z	Risk related to the type of loss L_1 (R_{Z1}) and L_2 (R_{Z2}) caused by failure of internal systems due to induced over-voltage on connecting lines and transferred to the building. In general, losses can occur in buildings where there is a risk of explosion, as well as in hospitals or other buildings, where a failure of internal systems can lead to injury to people or a risk to the environment.

The assessment should take into account all lines connected to the building.
Lightning strikes on or near metal pipes are regarded as a source of damage, unless the pipes are connected to an equipotential conductor or an LPS earthing system at the building's entrance.

Factors affecting the risks for the building
Table 2a sets out the main factors, taking into account the characteristics of the building, possible protective measures and relevant provisions.

Table 2a: Factors affecting risk components

Characteristics of the building or internal systems – Protective measures	R_{AT} [h]	R_{AD} [h]	R_B [h]	R_C [h]	R_M	R_U	R_V	R_W	R_Z
Meeting point	X	X	X	X	X	X	X	X	X
Specific resistance of earth	X								
Resistance of the soil	X					X			
Physical constraints, isolation, warning, earth potential equalisation	X					X			
Structural characteristics of the building	X		X						
LPS	X	X	X	X	X[a]	X[b]	X[b]		
SPD equalising connection	X		X			x	x		
Insulation Interfaces				X[c]	X[c]	X	X	X	X
Harmonised SPD system [f]				X	X			X	X
Room shielding				X	X				
Shielded external lines						X	X	X	X
Shielded internal lines				X	X				
Guidance measures				X	X				
Connection network				X					
Fire-safety measures			X				X		

Flammability			X				X		
Impulse resilient voltage				X	X	X	X	X	
Storm warning systems [g]	X[d]	X[e]		X	X	X[e]	X[e]	X[e]	X[e]
Presence of people	X	X	X	X	X	X	X	X	X
The equipment is typically connected to two lines, a supply line and data lines. If the equipment is connected to only one line, the result may overestimate the risk.									

[a]	Only for external LPS from a grid that acts as a shield.
[b]	Because of the equalization link.
[c]	Only if they are part of the equipment.
[d]	Only for outdoor risk zones, in accordance with the requirements triggered by the storm warning system measures as set out in SIST EN IEC 62793. The storm warning system must operate continuously and send a message in the event of a failure.
[e]	In accordance with the requirements activated by the storm warning system measures according to SIST EN IEC 62793.
[f]	Mainly for buildings where a failure of internal systems poses a risk to human life, for example in buildings where there is a risk of explosion and in hospitals.
[g]	The requirements taken into account must be appropriate to the case under consideration.
[h]	When damage source S1 is taken into account, protective measures are effective only in buildings protected by an LPS or in buildings with a continuous metal or reinforced concrete frame that acts as a natural LPS.

2.4 DENSITY OF ATMOSPHERIC DISCHARGES INTO THE EARTH

The density of atmospheric discharges into the earth, expressed as the number of lightning strikes into the earth per square kilometre per year, is determined by metering. In the absence of metering, the number of maximum values of lightning density specified in Annex 3 to the Rules shall be taken into account.

2.4.1 LPS classes

(1) With regard to the chosen level of protection against lightning, four classes (I–IV) of LPS implementations are available, shown in Table 3.

Table 3: Connection between protection levels and LPS classes

Lightning protection level LPL	**LPS class**
I	I
II	II
III	III
IV	IV

(2) LPS classes differ from each other by:

- lightning current parameters;
- the radius of the final puncture distance, the size of the air terminal ring and the protection angle;
- the typical distance between down conductors;
- the separation distances between individual parts between which flashovers can occur;
- the minimal earth electrode length.

(3) The LPS class is selected on the basis of a risk assessment.

2.5 FUNCTIONAL SAFETY OF PROTECTION AGAINST LIGHTNING

(1) When designing lightning protection systems, a risk analysis must also be carried out to assess the risks arising from:

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

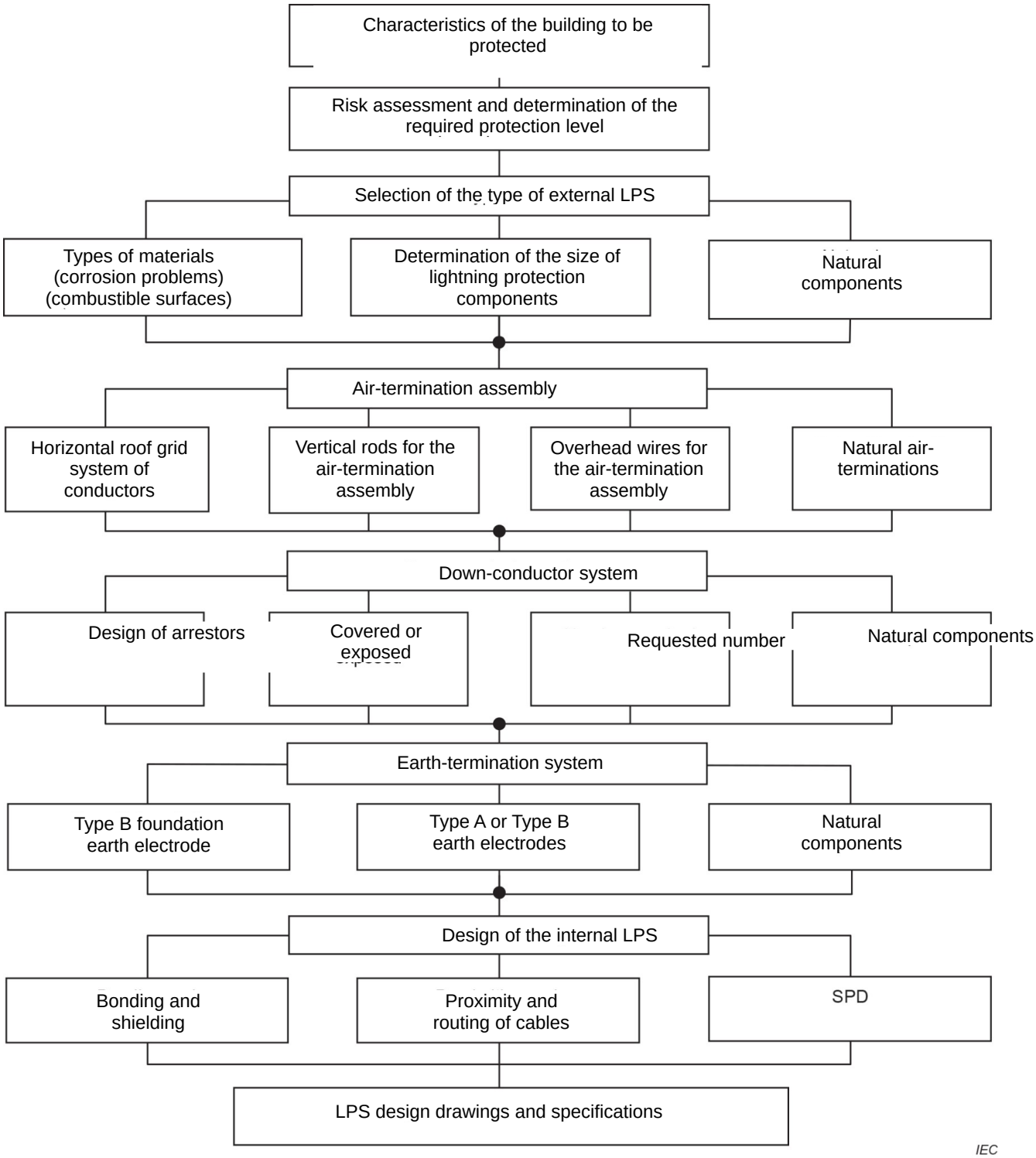
(2) On the basis of the analysis, additional protective measures must be implemented in order to reduce the risks to the permissible limit.

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

3 PLANNING AND IMPLEMENTATION OF THE LIGHTNING PROTECTION SYSTEM

(1) The design, implementation and testing of the LPS covers a number of technical areas and requires the coordination of all parties involved to ensure the implementation of the chosen level of lightning protection with minimum costs and effort.

(2) Figure 1 shows the prescribed course for designing protection against lightning, which allows for efficient management of the LPS.



The dot (●) in the diagram indicates an interface where collaboration is required between the architect and a qualified electrical engineer responsible for designing the lightning protection system.

Figure 1: LPS design flow chart (source: SIST EN IEC 62305-3)

3.1 EXTERNAL LPS

The external LPS is intended to capture direct lightning strikes into the building and transfer the lightning current from the strike point to the ground. It is also intended to evenly spread this current into the earth without causing thermal and mechanical damage or dangerous sparks which could cause a fire or explosions

3.1.1 Selection of external LPS

(1) In the event that it is not possible to establish safety distances in the buildings, all the earthing connections must be interconnected (galvanic connections, connecting with spark gaps and arrestors).

(2) Isolated LPS should be used when the thermal effects and the effects of an explosion at the strike point or on the conductors leading the lightning current can cause damage to the building or its contents (flammable covering, installed sensitive electrical appliances on the roof, explosion and fire risk areas). The isolated LPS system can also be used when sensitive content in a building requires a reduction in electromagnetic field radiation due to the impact of the lightning current in the down conductors.

(3) The auxiliary components in a building made of conductive materials which will remain permanently in the building or on it and which are not altered can be used as part of the LPS (e.g. connected steel reinforcement, metal frame of the building, etc.) in so far as their dimensions permit a safe path of the lightning current they are conducting.

3.1.2 Air-termination system of LPS

(1) The probability of lightning current infiltration into the building is significantly reduced when installing an appropriately designed air-termination system.

(2)) The air-termination system may consist of various combinations of the following elements:

- metal rods (including free-standing metal pillars, connecting bars, metal portals, etc.);
- tensioned ropes;
- conductors in the form of mesh.

(3) For all types of air-termination, only the actual physical dimensions of metal air-termination systems must be taken into account to determine the protected area.

(4) Individual metal rods should be galvanically connected together at the roof level to ensure the distribution of the lightning current.

(5) Radioactive air terminals are not permitted.

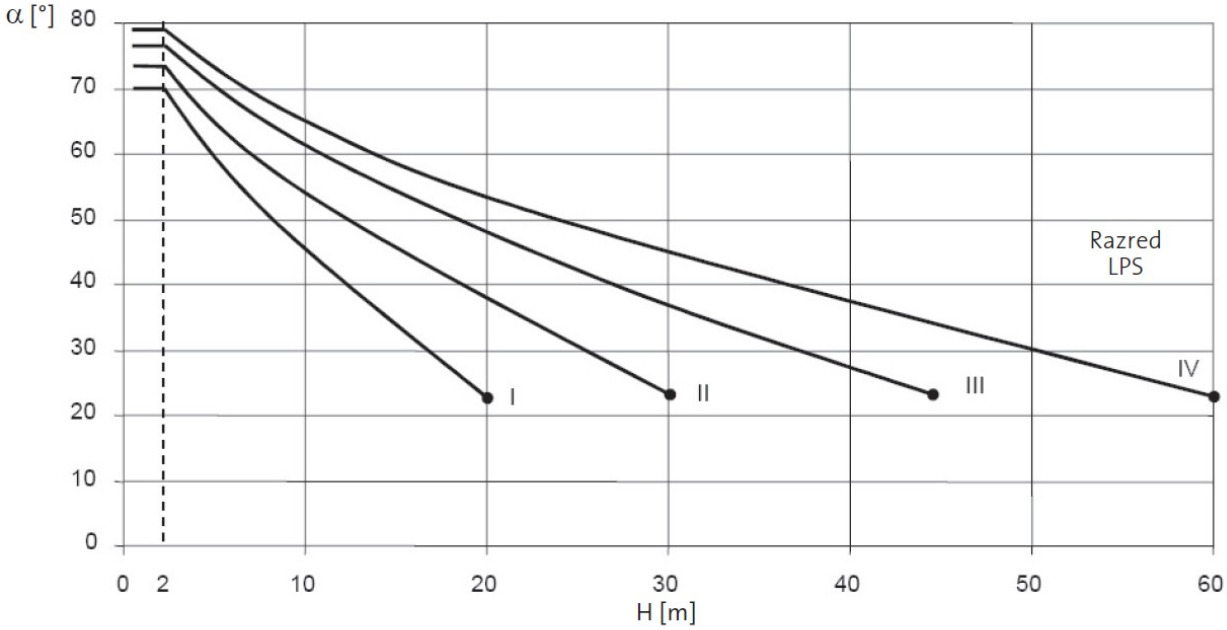
(6) The air-termination elements on the building must be installed on corners and at exposed points and edges in accordance with one or more of the following acceptable methods:

- protective angle method;
- rolling sphere method;
- mesh method.

(7) The rolling sphere method is appropriate in all cases. The protective angle method is suitable for buildings of simple shapes, but restrictions on the height of the air-termination apply, as shown in Figure 3. The mesh method is an appropriate form of protection when protecting flat surfaces. Using the rolling sphere method, we also determine the heights of the air-termination systems.

Table 4: The maximum value of the radius of the rolling sphere and the size of the mesh, depending on the LPS class.

LPS class (protection level)	Acceptable air-termination methods		
	Radius of the rolling sphere *r* [m]	The size of the mesh hoop *w* [m]	Protective angle α [°]
I	20	5 x 5	see Figure 2
II	30	10 x 10	
III	45	15 x15	
IV	60	20 x 20	



Razred LPS

LPS class

Note 1: The protective angle method is not applicable at heights above the markings •. In such case, it is necessary to use the rolling sphere or mesh method due to a possible side-flash.
Note 2: *H* is the height of the individual air terminal installation above the space it is protecting.

Note 3: The protection angle does not change for *H* under 2 m.

Figure 3: The protection angle of the air terminals with a height of *H*, depending on the LPS class

(8) LPS air terminals, which are not isolated from a protected building, can be installed as follows:

- if the roof is made of non-combustible material, the air-termination conductors may be located on the surface of the roof;
- if the roof is made of a material with low flammability (normal – flammable), the air-terminations may be installed directly on the roof surface, provided that the temperature rise caused by the lightning current does not pose a fire risk to the roof material (verification calculation). Otherwise, spacer brackets must be used to maintain the required clearance and ensure the mechanical strength of the fixing joints;
- if the roof is made of highly flammable material, attention should be paid to the distance between the air-termination conductors and the material. For straw roofs where stainless steel rods are not used for the straw connection, a distance of 0.5 m is suitable. For easily flammable materials, it shall be considered an appropriate distance if not less than 0.10 m;

- the flammable parts of the protected building (e.g. wooden plates) must not be in direct contact with the parts of the outer LPS, and not directly under any metal roofing that could be pierced by lightning (see Table 5).

(9) As ancillary components of the LPS air-termination system, the following may be used:

- metal coverings that cover the protected building when the electrical continuity between the various parts is made permanent (e.g. by soldering, welding, pressing, sewing, screwing or riveting); and in this:
  - the thickness of the metal coverings must not be less than t', as stated in Table 5, when melting is permitted at the lightning strike point, and ignition cannot occur below them due to the melting of metal; and
  - the thickness of the metal coverings must not be less than *t,* as stated in Table 5, when it is not permitted to melt materials at the point of the lightning strike because there are flammable materials below it which could ignite due to the melting of metals or thermal effects;
- metal coverings, which are not coated with electrical insulating material;
- metal elements of the roof construction (supporting beams, steel reinforcements, etc.) underneath the non-metal roof, if the damage to this non-metal roof is acceptable;
- metal parts such as decorative items, tracks, pipes, coverings, etc. with cross-sections not smaller than those prescribed for standard air-termination elements;
- metal pipes and tanks on the roof, if they are made of a material with a thickness and cross-sections specified in Table 5;
- metal pipes and water tanks that hold flammable or explosive mixtures must be of dimensions that are suitable for the thickness *t* in Table 5.

Table 5: Minimum thickness of metal roofing or metal pipes of external LPS

LPS class	**Material**	**Thickness *t* [mm]**	**Thickness *t'* [mm]**
I to IV	lead	-	2.0
	steel/zinc plated, rust-proof	4	0.5
	titanium	4	0.5
	copper	5	0.5
	Aluminium	7	0.65
	zinc	-	0.7
t – prevents puncturing *t'* – only for metal plates where it is not important to prevent puncturing, hot spots or ignition			

(10) In the event that the required dimensions are not ensured, it is necessary to include the pipes and water tanks in the area that needs protection.

(11) Pipelines that conduct flammable or explosive mixtures and are coupled with plastic inserts or flanges must be incorporated into the LPS, and flanges and plastic inserts must be bridged with dimensions from the given measures of LPS materials.

(12) For the purposes of interception, a thin coating of paint (up to 0.2 mm), asphalt (up to 1 mm) or PVC (up to 0.5 mm) is not considered to be insulation.

(13) If the roof, roof covering or gutter is made of copper, it is necessary to bolster the steel or aluminium conductors so that rainwater does not run from the copper parts onto the steel or aluminium conductors. If this is not possible, copper conductors should be used due to the possibility of galvanic corrosion.

(14) At the connection points between the copper and aluminium conductors it is necessary to provide an insert made from both materials (Al-Cu) or stainless steel. Zinc-plated steel and aluminium can be directly joined (see Table 7).

(15) On the roofs of galvanised sheet metal or aluminium, it is not permitted to use bare copper wire for an air-termination mesh.

(16) The height of the installation of the metallic conductors of the air-termination mesh over the roof, taking into account all weather conditions, must always be greater than the geometric arrangement of the air-termination mesh of the ball arc of the rolling sphere of the selected protection level. This is achieved with roof supports located at the appropriate distance.

(17) For buildings higher than 60 m, side impacts may occur, especially to the tops, angles, and edges of the surfaces. Flat air-termination meshes should be used (see Table 6). Lightning strikes with small peak lightning currents can also destroy electrical and electronic equipment on walls outside buildings. The design of the air termination system is possible only by the rolling sphere method.

3.2 DOWN CONDUCTOR SYSTEM

The path of lightning conductors depends on the execution of the lightning air-termination mesh or the possibility of maintaining the safety distances on and in the building to other metal parts, metal enclosures and other metal structures, which can lead to an electrical breakthrough when the lightning strikes the building or in its proximity. For this reason, the lightning conductors must be adapted to the given circumstances and be treated in conjunction with other auxiliary down conductors, or installed in a completely insulated design. Down conductors must be installed flat and vertical so as to provide the shortest and most direct way to the ground. The smallest cross-sections of lightning conductors are given in Table 12.

3.2.1 Down conductor system for a non-insulated lightning protection system

(1) Down conductors conduct the lightning current from the strike point to the earth. They enable:

- several parallel current paths;
- the shortest length of parallel paths;
- equipotential bonding with the conductive parts of the building.

(2) The distances between the individual vertical down conductors and the individual horizontal ring connections are shown in Table 6.

Table 6: Distances between down conductors according to LPS class

LPS class	Distances between down conductors [m]
I	10
II	10
III	15
IV	20

(3) The maximum permissible loop resistance between two lightning conductor terminals via the earth electrode is 2 Ω.

(4) Down conductors must establish the shortest possible connection with the earthing system of the building, vertically if possible, without changing direction. Down conductors must be as short as

possible. Down conductors must be installed near the edges of the building and as far away as possible from windows, doors, electrical installations and those metal masses which are not, due to special reasons, connected to the building's lightning protection system. Given the building's floor plan, it is preferable for the down conductors to be positioned symmetrically, so that they form a natural extension of the roof gutters.

(5) The number of down conductors for each non-insulated system shall not be less than two. They should be distributed around the perimeter of the protected building taking into account architectural and practical limitations.

(6) The air-termination mesh on the roof and the LPS conductor system may in some cases be manufactured partly insulated from the metal parts of the building when an adequate safety distance *s* from all other metal parts in the building is not provided. After their passage into the ground, all down conductors must be interconnected with the base potential ring, one meter away from the foundation of the building and simultaneously connected to the earth electrode in the foundation of the building.

(7) Where it is not possible to ensure a sufficient safe distance *s* between the air-termination system and all metal parts within a building, a combined – non-isolated – system may be installed by making the appropriate connections, or an isolated LPS may be installed. Therefore, high-voltage resistive insulated lightning conductors can be used as suitable lightning conductor insulation, which should directly and in the shortest way connect the lightning air-termination mesh with the earthing system of the building. The lightning protection system will thus safely transfer the discharge lightning current to the earth without risk of electrical breakthroughs to other metal parts without the necessary difficulties in establishing a mutually safe distance.

(8) In buildings constructed using reinforced concrete, it is possible to use the reinforcement as lightning down conductors and at the same time as protection against electromagnetic fields. In this context, it is important to ensure the continuity of the galvanic connections and to use round reinforcement bars with a minimum diameter between 8 mm and 10 mm. The electrical continuity of the reinforcing bars must be checked by means of continuous measurements of the electrical resistance between the highest part and ground level. The entire electrical resistance should not be greater than 0.2 Ω. If that value is exceeded then reinforcement cannot be used as a lightning down conductor.

(9) The lightning conductors of an uninsulated LPS from the building may be placed:

- on the surface of a wall or into the actual wall if the wall is made out of non-flammable material;
- on the surface of the wall, provided that the wall is made of normally flammable material and the increase in the conductor temperature due to the passage of lightning current does not pose a danger to the wall material;
- at least 0.1 m away from the wall, if the wall is made of highly flammable material and the temperature increase is dangerous. The load-bearing elements may be in contact with the wall. Where it is not possible to ensure the required distance between the down conductor and flammable materials, the cross-sectional area of the steel (ordinary steel or stainless steel) or thermally equivalent conductor shall not be less than 100 mm^2.
- When installing conductors in or under building insulation, any temperature rise on the conductor surface shall be appropriately limited by using an additional PVC sheath, lining, or conduit. We can use protective plastic pipes that are fire-resistant. In doing so, the entries and penetrations of down-conductors through the building insulation must be structurally processed and sealed.

(10) Metal masses that pass through the building and have a sufficiently large cross-section are also used for conductors, in accordance with the dimensions of the LPS conductors and their electrical continuity between the various parts is permanently guaranteed (reinforced concrete frames are well connected to each other, the steel frame of the building, façade elements, profiled

fences and metal structures of facades). In such case, however, it is necessary to take into account the safety distance *s* to other metal parts in the building.

(11) Down conductors should not be laid in gutters. Gas lines must not be used as down conductors.

(12) A metering contact, which it is possible to galvanically separate for metering reasons, must be made before the point of down conductor connection to the combined earthing system. When using natural metal masses and reinforcements such as natural down conductors in combination with other down conductors, it is also necessary to make a metering joint, or if this is not possible, a metering contact if it cannot be separated due to multiple parallel connections. In such cases, the metering joint is carried out where the down conductor can be galvanically separated (e.g. at the transition from the reinforcement to the roof of the building). The measuring contact is made by welding the stainless steel connection to the metal reinforcement of a building with a minimum diameter of 8 mm, at a height of approximately 60 to 80 cm from the ground, which is intended for measuring the voltage differences in touch and step. It should protrude about 7 cm from the reinforcement wall.

(13) Conductors that are connected to each other and to couplings must be made from the same material. The suitability of the connections of various materials is shown in Table 7. In the event that incompatible materials are being joined, as seen in Table 7, it is necessary to use an insert made out of a neutral material with a thickness of at least 2 mm.

(14) The metal grooves for collecting and the metal pipes for draining water can be used as auxiliary down conductors if their joints are well soldered. In any case, they should be connected with a lightning installation by the shortest route.

(15) Aluminium conductors of the corresponding dimensions, of cross-sections of at least 50 mm^2, may also be used for lightning conductors. In the case of installing into aggressive materials (concrete), they must be protected with a plastic tube. Aluminium should not be placed in the ground.

Table 7: The possibilities of joining different materials depending on their electrochemical potential

	Copper	**Hot zinc-plated steel**	**Stainless steels**	**Aluminium**
Copper	yes	no	yes	no
Hot zinc-plated steel	no	yes	yes	yes
Stainless steels	yes	yes	yes	yes
Aluminium	no	yes	yes	yes

3.2.2 Down conductor system for insulated lightning protection system

The installation of an insulated system must meet the following conditions:

- if the air-termination system consists of metal rods on separate rods (or on one rod) other than metal or connected steel structures, at least one down conductor for each bar is required. For rods that are made of metal or connected steel structures, no extra down conductors are required;
- if the air-termination system consists of tensioned ropes (or one rope), at least one down conductor on each supporting structure is required;
- if the air-termination system consists of conductor mesh, at least one down conductor on each end of the supporting rope is required.

3.2.3 Separation distance between the metal parts and the LPS

(1) The electrical insulation between the air-termination mesh, the down conductors and metal parts can in certain cases be achieved with the establishment of a separation distance between the metal parts in the building and the LPS. The separation distance must be greater than the safety distance. The safety distance s is generally determined with the help of the following equation:

$$s = k_i \frac{k_c}{k_m} y$$

where,
k_i – is the coefficient depending on the chosen LPS class (see Table 8);
k_c – is the coefficient depending on the lightning current that runs down the air-terminal and down conductor (see Table 9);
k_m – is the coefficient depending on the electrical insulation material (see Table 10);
l – is the length of the LPS conductor in m for which it is necessary to establish the separation distance to the nearest point of equipotential bonding.

Table 8: External LPS insulation – coefficient value k_i

LPS class (protection level)	$\boldsymbol{k_i}$
I	0.08
II	0.06
III and IV	0.04

Table 9: External LPS insulation – coefficient value k_c

Number of down conductors *n*	$\boldsymbol{k_c}$
1 (only in an insulated LPS)	1
2	0.66
3 and more	0.44
NOTE: The values apply to all B-type of earth electrode classifications and A-type of earth electrode classifications, provided that the earthing resistance of the adjacent earth electrodes does not differ by more than a factor of 2. If the earth resistances of individual earth electrodes differ by more than a factor of 2, then $k_c = 1$ is assumed.	

Table 10: External LPS insulation – coefficient value k_m

Material	$\boldsymbol{k_m}$
Air	1
Concrete, brick, wood	0.5
NOTE 1 When there are several insulation materials, the lower k_m is taken into account. NOTE 2 When other insulation materials are used, the instructions by the manufacturer on installation and the coefficient value k_m. For an insulator consisting of glass fibre reinforced plastic, PE or PVC with a minimum length of 0.5 m, k_m = 0,7 may be used.	

(2) When integrating lines or external conductive parts into the building, it is necessary to ensure direct equipotential bonding or a connection through the spark gap or SPD.

(3) Where separation distance cannot in any way be achieved in buildings with multiple interconnections of all-metal masses connected to the reinforcing mesh and metal structures, an

appropriate equalisation of potentials with direct connections must be ensured, in accordance with the specified cross-sections of the conductors in Tables 14 and 15. Among the metal parts, which due to various causes (e.g. corrosion) must not be directly connected to the combined earthing system, appropriate spark gaps must be installed. The energy-efficient spark gaps must be installed between the electrical installation conductors and the combined earthing system of lightning protection installation, with protective earthing PE, or PEN in case of a common connection to the operating earthing of the power grid.

3.3 LPS EARTHING SYSTEM

(1) The discharge of electric lightning current into the ground is an important task of the lightning protection system. The discharge lightning current must not cause dangerous over-voltages on its way to the final discharge of the strike charge. Therefore, the form of the earthing systems is important, as their shapes and dimensions are even more important than the specific resistance of the ground into which the earthing has been laid.
(2) From the point of view of lightning protection, it is advisable to design and install a single integrated earthing system, which is useful for all purposes needed in a building (lightning protection, earthing for operational requirements, protective earthing of enclosures and metal parts, protection against electric shock in electrical installations, telecommunications and information devices, maintenance of levels of electromagnetic compatibility, etc.).

3.3.1 Earthing system

(1) By distributing the earth electrodes appropriately, the over-voltage decreases when dispersing the lightning current into the earth. In general, low earth resistance, less than 10 Ω is preferred. Within the specific soil resistivity, greater than 250 Ωm, the earth resistance must not be greater than 4 % of the measured soil resistivity in Ω m.

(2) From the point of view of lightning protection, as well as of electrical and telecommunication devices, a united and integrated earthing system of all the connected earthing electrodes in the buildings is most suitable. In buildings with an electric installation installed, the lightning conductor earthing is always connected with protective earthing PE. In case of operating earthing in an electrical installation, it should be in PEN only when the operating conditions in the supply network permit it or, when this is permitted by the distribution operator in agreement on the connection and when the connection is carried out. Special attention must be given to this part of the wiring so as to ensure correct functioning.

(3) Specially placed conductors, positioned in the earth, can be used as earth electrodes, in the following forms:

- horizontally placed earthing lines and strips (earth strips);
- vertical pipes or profiles (earth rods);
- vertical plates (earth plates);
- earth strip connected to the reinforcement in the foundation;
- metal constructions and meshes as well as pipes in the earth, apart from those which must be kept separate for special reasons (cathode protection);
- as an earth electrode in the foundation (foundation earth electrode).

(4) If an individual building has more than one earth electrode it is necessary to wire them together with a conductor placed in the earth. In this context, priority should be given to the circular ring around the building laid in the ground at a distance of 1 m from the outer walls of the building, at a depth of at least 0.5 m (preferably 0.8 m). The circular ring thus helps to reduce earth-termination resistance and at the same time reduces the potential difference between the wall of the building and the position of the person who accidentally touches the wall the moment the lightning strikes the building. The earthing of the building is also connected in several places to the circular ring, at least at the same distances as defined by the protective level of lightning protection for lightning

conductors. If necessary, several circular earth strips (graded electrodes) can be laid, further improving the distribution of electrical potential and reducing touch and/or step voltage.

(5) Horizontal or vertical earthing located outside the protected building and associated with each lightning conductor or base earthing that does not form a closed loop shall be marked in accordance with the SIST EN IEC 62305-3 standard with the type of earthing distribution A. In this case, the total number of earth electrodes must not be smaller than two. It is not sensible to increase the length of the horizontal electrodes to more than 60 m with the intention of decreasing the electrodes' resistance.

(6) When installing the horizontal multipoint-star (radial) electrodes, where more than one individual conductor goes in different directions from a single point, the angle between two neighbouring electrodes should be more than 60°.

(7) Ringed earth electrodes outside the building forming a closed loop (at least 80 % of the total length) and connected to a mesh, are marked with the type of earthing B. This design is recommended in bare rocky ground and in buildings with extensive electronic systems or high fire risk.

(8) The earth conductor's dimensions and materials are shown in Table 13.

(9) In order to minimise the impact of possible interference, the earthing resistance of the interconnected earth electrodes should be measured at the highest possible electrical current and at a low frequency, which is different from the network, or at its multiplier.

(11) If the pipes of the plumbing are connected to the earth electrodes, it is necessary to bridge all the water meters and similar devices which are built-in between the places where the various metal parts may have different potentials. Cross-sections of these conductors are given in Table 14.

(12) Earth rods must be interconnected to the potential metal ring in the vicinity of the building. They must be separated at least by the length of the earthing.

(13) Where underground power cables are located in the vicinity (less than 1 m) of earthing or down conductors, these cables should be placed in a protective tube made of non-conducting and moisture-repellent material.

(14) Plumbing and gas networks may not be used for earthing.

(15) In principle, individual earthing should not be placed below places where people or animals are gathering during the storm. If this cannot be avoided, the danger due to the step voltage resulting from lightning should be avoided by appropriate measures.

(16) The earthing of adjacent lightning conductors and the earthing of metal parts should be connected to lightning earthing systems, if possible, up to a distance of 20 m.

(17) Earthing of rail road tracks and lightning conductors in the same reference earth can be connected with spark gaps or insulated interfaces (electrical corrosion). In certain cases, it is necessary to insulate the railway track at the entrance to the protected structure using insulating inserts between the rails.

(18) Elevator guides extending to the top of the building (the last floor) must be connected to the lightning installation at their upper and lower ends by the shortest route. At the lower end, they must be connected to the earthing mesh in the foundation of the building and at the upper end connected to the lightning installation as an auxiliary lightning conductor in so far as the lightning installation permits (insulated or non-insulated).

(19) When constructing the earthing system, the shape of the potential funnel must be taken into account, and the design of the earth electrode must be appropriately adapted in the presence of external metallic masses to reduce touch and step voltages. In general, the following protective measures can be used to reduce touch and step voltages:

- the use of non-conductive materials,
- avoiding the earthing of conductive parts, where reasonable,
- shaping the potential through an appropriately constructed earthing system,

- the use of insulation layers and connections to the earthing,
- the implementation of a separation between connected and isolated metal parts,
- the implementation of electrical separation between connected and isolated parts.

3.4 IMPLEMENTATION OF AN LPS IN BUILDINGS WITH EXPLOSIVE HAZARDOUS AREAS

(1) Based on the risk assessment, an appropriate level of protection against lightning is chosen. Protection levels I and II for external LPS are suitable for all cases where the contents of the building are especially sensitive to the effects of lightning. The choice of protection level must also take into account explosive and flammable substances installed in the building. When installing lightning protection, the explosion risk assessment report must be taken into account. Ex area is defined as a separate protection zone requiring the highest order of protection against the effects of lightning. The level of protection for the external and internal LPS is determined in accordance with the standard procedure set out in SIST EN IEC 62305-2, taking into account all possible additional protective measures.

(2) If a part of a structure containing explosive and flammable mixtures is located indoors and constitutes a negligible part of the whole, and a direct lightning strike on the structure does not pose a risk of ignition, an explosion or other damage, such a part may be disregarded when calculating the risk assessment, but must be taken into account when carrying out equipotential bonding and installing internal lightning protection.

(3) A more detailed selection procedure is provided in Annex C of the SIST EN IEC 62305-3 standard.

4 MATERIALS FOR LPS CONDUCTORS

(1) The materials listed in the Table 11 may be used for lightning conductors under the following conditions:

Table 11: LPS materials and terms of use[a]

Material	Use			Corrosion		
	In Air	**In the earth**	**In concrete**	**Resistance**	**Increased due to**	**Can be destroyed with galvanised joints to**
Copper	Solid Stranded	Solid Stranded Coated	Solid Stranded Coated	Good in many environments	Sulphur compounds Organic materials	–
Hot zinc-plated steel[c, d, e]	Solid Stranded[b]	Solid	Solid Stranded[b]	Acceptable in air, concrete and neutral soil	High level of chlorides	Copper
Copper-plated steel	Solid	Solid	Solid	Good in many environments	Sulphur compounds	
Stainless steels	Solid Stranded	Solid Stranded	Solid Stranded	Good in many environments	High level of chlorides	–
Aluminium[h]	Solid Stranded	Unsuitable	Unsuitable	Good in atmospheres with low concentrations of sulphur and chlorides	Alkaline solutions	Copper
Lead[f g]	Solid Coated	Solid Coated	Unsuitable	Good in atmospheres with a low concentration of sulphates	Acid soil	Copper Stainless steels

[a] The table provides general guidance only. In special circumstances, the requirements for corrosion resistance should be taken into account with greater caution (see Appendix D of SIST EN IEC 62305-3).

[b] Stranded conductors are more prone to corrosion than solid materials. Stranded conductors are also not as resistant at transitions from soil to concrete. That is why it is not recommended to place stranded zinc-plated steel into the soil.

[c] Zinc-plated steel can also corrode in clay or damp soil.

[d] Zinc-plated steel in concrete should not continue on into the soil due to the danger of steel corrosion at the point of transitioning from the concrete.

[e] Zinc-plated steel in contact with the reinforcement in the concrete should not be used in coastal areas where salt may be present in the soil.

[f] Underground connections requiring removal of the conductor cover are not recommended without adequate subsequent protection against corrosion.

[g] The use of lead in the soil is usually forbidden due to environmental requirements.

[h] To prevent corrosion, bare aluminium and aluminium alloys should not be used in direct contact with soil, gravel, limestone or lime mortar.

(2) Types of materials and shapes as well as the smallest cross-section of air-termination mesh conductors and earth electrodes are shown in Table 12.

Table 12: Material, the shape and the smallest cross-section of the air-termination conductors, air-termination rods, bar earth conductors and down conductors[a e f]

Material	**Shape**	**Cross-section** (mm^2)
Copper Tin-plated copper	Solid strip Solid round[b] Stranded Laid rope conductor Smooth-woven braid Solid round[c]	50 50 50 50 50 176
Aluminium	Solid strip Solid round Stranded Laid rope conductor Smooth-woven braid	70 50 50 50 50
Aluminium alloy	Solid strip Solid round Stranded Laid rope conductor Smooth woven braid Solid round[c]	50 50 50 50 50 176
Copper-plated aluminium alloy	Solid round	50
Hot zinc-plated steel	Solid strip Solid round Stranded Solid round[c]	50 50 50 176
Copper-plated steel Tin-plated copper-plated steel	Solid round Solid strip	50 50
Stainless steel[g]	Solid strip[d] Solid round Stranded Laid rope conductor Smooth-woven braid Solid round[c]	50 50 70 70 70 176
Steel with copper coating	Solid round[c]	176

[a] The mechanical and electrical specifications as well as resistance to corrosion must all be in compliance with the requirements of the set of standards SIST EN IEC 62561-2.

[b] 50 mm^2 (8 mm diameter) can be decreased to 28 mm^2 (6 mm diameter) in special cases when the mechanical resistance is not a key issue. The distance between the beams should be suitably adjusted with regard to this.

[c] Suitable for air-termination rods and earth conductors (except for earth conductors made of aluminium or aluminium alloys). If the mechanical load, e.g. wind resistance, is not critical, rods with a diameter of 9.5 mm and a length of 1 m can be used instead as air-termination rods.

[d] If the thermal and mechanical characteristics are of key importance, these values should be increased to 75 mm^2.

[e] If the earth conductor is partially buried in the ground, it shall comply with the requirements set out in Table 7 (SIST EN IEC 62305-3 standard).

[f] If the separating down conductor has been successfully tested according to IEC TS 62561-8:2018, 5.5.7 (electrical tests), the cross section can be reduced to the tested cross section.

[g] Chromium ≥ 16 %; nickel ≥ 8 %; carbon ≤ 0.08 %.

(3) The dimensions of the lightning conductors that are used for the earth-termination system are shown in Table 13.

Table 13: The material, shape and smallest dimensions of the earth electrodes[a]

Material	**Shape**	**Dimensions**		
		Earthing rod diameter [mm]	**Earthing conductor** [mm^2]	**Earthing plate** [mm]
Copper [g] Tin-plated copper	Stranded Solid round Solid strip Hose Solid plate Mesh plate [c] Earthing network for equipotential bonding	15 20	50 50 50	500 x 500 600 x 600 Typical mesh size 250 mm to 500 mm, conductor diameter 4 mm [h]
Hot zinc-plated steel	Solid round Hose Solid strip Solid plate Mesh plate [c] Profile [d] Earthing network for equipotential bonding	14 25	78 90	500 x 500 600 x 600 Typical mesh size 250 mm to 500 mm, conductor diameter 4 mm [h]
Bare steel [b]	Stranded Solid round Solid strip		70 78 75	
Copper-plated steel Tin-plated copper-plated steel	Solid round Solid strip	14	50 90	
Stainless steel [f]	Solid round Solid strip Earthing network for equipotential bonding	15	78 100	Typical mesh size 250 mm to 500 mm, conductor diameter 4 mm [h]

[a] The mechanical and electrical specifications as well as resistance to corrosion must all be in compliance with the requirements of the standard SIST EN IEC 62561-2.
[b] Must be covered in concrete at a depth of at least 50 mm.
[c] The mesh plate made out of a conductor with a combined length of at least 4.8 m (for cross-sections see SIST EN IEC 62561-2).
[d] Various profiles with cross-sections of 290 mm^2 are permitted, a minimal thickness of 3 mm, e.g. a cross profile.
[f] Contents of the additions: Cr ≥ 16 %, Ni ≥ 5 %, Mo ≥ 2 %, C ≤ 0.08 %.
[g] A copper earthing electrode buried in the ground must not be used due to the risk of corrosion when in contact with steel components, steel pipes or steel bars associated with the building structure.
[h] For earthing networks used for equipotential bonding, the dimensions vary depending on the area designated for it.

5 PREVENTION OF SPARKING AND BREAKDOWN OF THE INSULATION MEDIUM

5.1 GENERAL

(1) When the lightning current is transferred from the air-termination system through the down conductors into the earth-termination system, negative effects may be transferred into the building through the metal connection and electromagnetic field; these may cause dangerous sparking and flashovers between:

- metal constructions;
- internal connections of various installations;
- external conducting parts and connections from the building to its surroundings.

(2) Sparking inside the building poses a fire and explosion hazard as well as a risk of the destruction of functioning devices within the building. Then it is necessary to implement additional protective measures.

(3) Dangerous sparking between various parts of internal devices and installations can be prevented by equipotential bonding and electrical insulation.

5.2 EQUIPOTENTIAL BONDING

5.2.1 General

(1) Equipotential bonding is achieved by connecting:

- the metal parts in the building;
- metal installations;
- the internal supply installation systems;
- the foreign conductive parts and installation connections of the building.

When establishing equipotential bonding connections it is necessary to take into account the fact that part of the current can also end through these connections.

(2) Equipotential bonding is carried out with:

- bonding conductors;
- surge protection devices (SPD) where connection to the conductors is not possible;
- spark gaps, where direct connection to connecting conductors is not permitted.

The choice of method also depends on the specifications of other installations in the building (electrical, telecommunications, fire, security, etc.).

(3) The maximum allowable value of equipotential bonding links is 1 Ω.

5.2.2 Equipotential bonding of metal installations

(1) In the event that the external LPS is installed as an insulated implementation, equipotential bonding is only made at the level of the earth-termination system (a connected ring of potential around the building). In the case of such implementation, it is necessary to also follow the fourth and fifth paragraphs of this item.

(2) For external LPSs that are not isolated from internal metal masses, equipotential bonding is carried out in the following places:

- on the ground floor at the level of the connections of the earthing system and it must also be constructed in such a way as to be easily accessible to inspection;

– where the insulation requirements are not fulfilled.

(3) Equipotential bonding connections must be installed directly and connected via the shortest route to the local or main equipotential bonding bar.

(4) The smallest cross-sections of the connections for equipotential bonding that connect the individual metal parts of the LPS, the various equipotential bonding bus bars or connect the equipotential bonding bus bars to the earthing system and which can transfer a significant amount of the lightning current, are shown in Table 14.

Table 14: The smallest dimensions of the conductors which connect the various equipotential bonding busbars or connect the equipotential bonding busbars to the earthing system

LPS class	**Material**	**Cross-section** [mm^2]
I to IV	Copper	16
	Aluminium	25
	Steel	50

(5) The smallest cross-sections of the connections for equipotential bonding between the metal parts or the connections of the metal parts to the equipotential bonding bus bars and which do not conduct a significant amount of the lightning current are shown in Table 15.

Table 15: The smallest dimensions of the conductors that connect the internal metal installations to the equipotential bonding busbars

LPS class	**Material**	**Cross-section** [mm^2]
I to IV	Copper	6
	Aluminium	10
	Steel	16

(6) If insulation inserts are in the gas pipes or plumbing within the building, they are bridged with SPDs that are sized for this specific installation. The same applies to other metal parts which are not usually connected to the integrated earthing system in the building (e.g. parts protected with cathode protection).

5.2.3 Equipotential bonding of external conductive parts

(1) It is necessary to carry out the connection of the external metal parts as close as possible to the entrance of the protected building.

(2) The connecting conductor must have a suitable cross-section and must be able to conduct the estimated lightning current.

(3) If the direct connection cannot be made, it should be established with a correctly sized spark gap.

(4) If it is necessary to create equipotential bonding where there is no external LPS, the earth-termination system of the electrical installation should be used.

5.2.4 Equipotential bonding in the internal LPS

(1) In the internal lightning protection system, installed devices and equipment must be earthed and connected to the same earthing system. Connections must be consistent and direct. SPD devices must be connected to the same earthing system. The earthing system inside the building should be selected according to the requirements of the installed equipment (radial, network or tree system).

(2) Shielding is carried out to minimise the impact of an electromagnetic pulse caused by a lightning strike. Depending on the requirements and the specific characteristics of the building, the equipment and conductors are shielded either locally within individual protection zones or throughout the entire building (density of reinforcement bars in concrete walls). The shielding must be connected to the earthing system of the building.

(3) If the internal conductors are in the form of shielded cables or they are in metal conduits or tubes, it is necessary to connect the shielding and metal conduits and tubes to the earthing system of the building. Prior to this, it is necessary to check cross-sections of individual cable metal coats and to determine their ability to conduct electric current, which will run after the equalisation connection or metal cable coats. In doing so, Tables 14 and 15 should be taken into account. If the cross-section of the metal cable coat is insufficient, the metal coat must be earthed at one end, and at the other end of the cable, appropriate surge arresters or spark gaps must be installed between the metal coat and the cable conductors; alternatively, the coat can be connected at both ends to the building's earthing system, with a galvanic connection of suitable cross-section added in parallel.

(4) Electric cables and other conductors in a building without shielding, which are not laid in metal ducts, must be additionally protected by SPD. In TN earthing electrical installation systems PE and N conductors must be galvanically connected to LPS. In TT earthing electrical installation systems PE conductors must be galvanically connected to LPS.

(5) When implementing overvoltage protection in the building interior, it is necessary to create a coordinated protection with correctly chosen characteristics of the SPD at all boundaries between protection zones.

5.2.5 Equipotential bonding of the supply cables

(1) Equipotential bonding of electrical and telecommunications conductors should be implemented in accordance with item 5.2.4.

(2) All conductors of each supply line should be connected directly to or through spark gaps or the SPD to the earthing system of the building to which they are integrated. Live conductors should be connected to the equipotential bonding busbar through the SPD. The PE and N conductors should be connected directly to the equipotential bonding busbars in TN systems, together with lightning protection installation.

(3) The SPD must be mounted at the entrance of the connecting power lines in the cabinet so that the total length of the individual connections of the SPD does not exceed 50 cm and does not interfere with the other connecting cables of the cabinets. It is advisable to install a lightning arrestor at the first possible point of entrance of the main power supply in the building so that the conductor does not cross or run parallel to the internal installations.

(4) If the integrated lines are shielded or in metal conduits, it is necessary to connect the shields or metal tubes to the earthing system in the building. On the basis of a calculation, the designer decides on the cross-sections of the metal coatings of the shielded cables and on how many, as well as on the possibility of connecting them to both ends of the cable’s metal coatings.

(5) The connection of the cable braids and metal shields should be set up where the connections enter the building. In doing so, the characteristics of the SPD should be in accordance with item 5.2.3 and coordinated in accordance with the third paragraph of item 5.2.4 and the adapted

options for discharging hazardous incoming energy content (the concept of escalating over-voltage protection).

(6) The other side of the spark gaps or SPD must not be bound to the functional earthing circuit of the FE.

(7) When integrating lines or external conductive parts into the building, it is necessary to ensure direct equipotential bonding or a connection through the spark gap or SPD.

(8) In buildings with a continuous connection of metal masses, a connected reinforcement mesh, a metal construction, it is not possible to achieve a separation distance and so a galvanic connection of all metal masses into a united and combined earthing system is required.

6 PROTECTION AGAINST HAZARDS CAUSED BY TOUCH AND STEP VOLTAGE

When lightning current is dissipated into the ground, excessively high touch and step voltages may occur; therefore the appropriate protective measures must be taken.

6.1 PROTECTIVE MEASURES AGAINST TOUCH VOLTAGE

(1) The hazards from contact voltage shall be reduced to an acceptable level if:

- no person is within a distance of 3 m of any down conductors under normal functioning conditions;
- the natural system of metal masses is made up of a number of connected parallel paths and connected with reinforcement and to the construction of the building that has good electrical conductivity (a system of at least 10 down conductors);
- the transitional resistance of the surface layer of the floor within 3 m of the down conductor is not less than 100 kΩ.

(2) If none of the conditions from the preceding paragraph of this item have been fulfilled, it is necessary to do the following to protect people against touch over-voltage:

- insulate the external LPS down conductors;
- install physical barriers and warnings to reduce the possibility of touching the external LPS down conductors.

(3) In the event of unexpected dangers of touch over-voltage and not fulfilling the conditions stated in the first paragraph, the designer should determine the necessary additional measures and, if necessary, the inspection of dangerous differences in potentials.

6.2 PROTECTIVE MEASURES AGAINST STEP VOLTAGE

(1) Too high a step voltage is reduced to an acceptable level, if:

- no person is within a distance of 3 m of any down conductors under normal functioning conditions;
- a system of at least 10 down conductors is installed;
- the transitional resistance of the surface layer of the floor within 3 m of the down conductor is not less than 100 kΩ.

(2) A layer of insulating material, for example 5 cm of asphalt, decreases the danger of step voltages to an acceptable level.

(3) If none of the conditions referred to in the first paragraph of this item is met, the following must be done:

- create equipotential bonding by modifying the density of the grounding earth-termination system meshes and
- install physical barriers and warnings within a three meter radius around the LPS down conductors to reduce the possibility of touching them.

(4) In the event of predicted or determined dangers of excessive step voltages and unfulfilled requirements from the first paragraph of this item, the designer determines the necessary additional measures and, if necessary, the inspection of the origin of dangerous differences in potential.

7 PROTECTION OF ELECTRICAL AND ELECTRONIC SYSTEMS IN BUILDINGS

7.1 GENERAL

(1) Atmospheric discharges at their point of discharge and, indirectly, into the nearby surroundings represent a high-energy occurrence. The discharge releases hundreds of megajoules of energy, which is why it is sensible to install additional protection for some of the more important electric and electronic equipment.

(2) LEMP poses a constant threat to electrical and electronic equipment, and it works:

- by ohm and induced over-voltage transferred to electrical and electronic devices and their connections;
- with the effects of electromagnetic field propagation on the devices themselves.

(3) The connecting mechanisms can vary as follows:

- galvanic connections (e.g. the galvanic connection of the earth-termination system to various connecting lines);
- connections through the electromagnetic field (e.g. wiring hoops), or
- electromagnetic assemblies (e.g. through transmitters, antennas).

(4) Over-voltage effects can arise outside and inside a building:

- external effects on buildings arise when atmospheric discharges strike connected supply lines or in their vicinity. They can also be transferred through electrical and electronic connecting systems;
- internal induced over-voltages in the building arise when lightning strikes directly into the building or its vicinity.

7.2 PROTECTION ZONES

Protection against LEMP is based on intentionally chosen zones, intended for controlling the electromagnetic effects on buildings when lightning strikes. Individual protection zones are consecutively limiting the electromagnetic effects of a lightning strike. In the area of each zone, the influence of LEMP is reduced to a sufficiently low level, which enables the operation of the devices operating in this zone and designed for it to function smoothly. SPDs and spatial shielding of the protection zone boundaries are installed at the boundaries between individual protection zones. A higher protection zone number means more favourable parameters in the electromagnetic environment.

7.3 EARTHING AND CONNECTION

(1) The success of the earthing and connection is based on the unified earthing system, which importantly consists of:

- a suitable earth electrode system, which distributes the lightning current into the earth, and
- suitable galvanic connections which reduce the differences in potential and simultaneously reduce the influencing magnetic field.

(2) The various methods of earthing and connecting are chosen by the designer using radial earthing methods, loop methods and tree methods.

7.4 MAGNETIC SHIELDING AND TRANSPOSITION

Magnetic shielding reduces the penetration of the electromagnetic field at the boundary between the protection zones, as well as the induced over-voltages in the wiring within the protection zones. Proper routing of individual internal conductors also minimizes the probability of internal loops forming and reduces the amplitude of internal induced over-voltages. Both methods are very effective in reducing the effects of internal damage to devices. Magnetic shielding and routing of conductors are shown in more detail in paragraph 6 of standard SIST EN 62305-4.

7.5 COORDINATED CASCADE SURGE PROTECTION WITH SPDs

Protection of internal electrical and electronic devices requires a systematic approach with coordinated installations of surge protection devices (SPD) for both power and signal connections. Individual characteristics of protective devices depend on the purpose of the device in need of protection (analogue, digital, DC or AC, low or high frequency).

7.6 DESIGNING, CHOOSING AND THE INSPECTION PROCEDURE FOR LEMP PROTECTION

The design and choice of LEMP protection devices must take place at the same time as the design of the whole building and before its construction. In doing so, the natural components of other designed building systems should be used effectively and the most suitable solution for cabling and the location of individual pieces of equipment should be found.

7.7 ELECTRICITY GENERATION EQUIPMENT ON BUILDINGS

Prior to the installation of electricity generation equipment, regardless of the type of building, a risk assessment must be carried out to ensure adequate lightning protection and measures to be taken and verified as specified in other items of this Guideline.

8 INSPECTION OF THE LPS

8.1 GENERAL

Article 12
(First inspection of electrical installation and lightning protection)

(1) The investor must ensure that an inspector is appointed before work commences on those parts of the construction project that relate to the inspection of electrical installations and lightning protection.
(2) As part of the supervision of the construction work, the supervisor shall ensure that the inspector carries out checks on those parts of the construction work that affect the safety of the electrical installation and the lightning protection system. If the inspector identifies any shortcomings in the project documentation or in the execution of the works for a particular phase, they shall notify the supervisor. The inspector shall carry out their work in cooperation with the construction supervisor.
(3) When performing the inspection, the inspector shall check the compliance and safety of the electrical installation and lightning protection in accordance with these Rules and with the project documentation for the execution of the works or the project documentation of the works that have been executed. The conformity check shall also include an assessment of the compatibility of the installed equipment and devices intended for the operation of the building, as well as permanently connected devices. The inspector shall draw up the minutes as defined in Article 14 of these Rules. The minutes are a mandatory annex to the certificate of structural integrity.

Article 15
(Use and maintenance)

(1) In accordance with the provisions of these Rules, the administrator ensures the timely and correct execution of all actions necessary for the safe use and maintenance of electrical installation and lightning protection.
(2) Maintenance of electrical installations and lightning protection may be carried out by an individual with appropriate professional education, with acquired professional and practical knowledge in the field of electrical installations and lightning protection, and knowledge of occupational safety and health.
(3) The administrator of the electrical installation or lightning protection shall keep documentation and records of maintenance and changes to the electrical installation and lightning protection.

(1) Inspection as part of ensuring the safe operation of the lightning protection system includes visual inspection, tests and measurements of the completed unit.
(2) When installing and checking lightning installations, this always represents a complete set: the air-termination system, the down conductor system, the earthing system and the over-voltage protection system.
(3) The lightning installation always represents a completed unit, in case of installation and inspection, and includes the following: the air-termination system, the down conductor system, the earthing system and the over-voltage protection system.
(4) The inspector must verify that the lightning protection earth electrodes are connected to the equipotential bonding bars to which the PE or PEN conductors of the electrical installation are connected.
(5) An external lightning conductor installation (insulated or non-insulated version) must be checked.

Article 13
(Periodic and extraordinary verification)

(1) Periodic and extraordinary verifications of electrical installations and lightning protection are part of the maintenance of the facility.
(2) Periodic verification of complex electrical installations and less complex lightning protection must be carried out at intervals not exceeding four years.
(3) Periodic verification of complex lightning protection must be carried out at intervals not exceeding two years, while periodic visual inspections must be conducted at intervals not exceeding one year.
(4) Notwithstanding the preceding two paragraphs, the periodic verification referred to in the first paragraph of this Article shall be carried out:

- in the part of the building where an explosive atmosphere may occur, or in the part of the building and electrical circuit specified in the explosion risk assessment, inspections must be carried out at intervals not exceeding three years, and periodic visual inspections at intervals not exceeding one year; in parts of the building where a corrosive atmosphere is also present, inspections must be carried out at intervals not exceeding two years, and periodic visual inspections at intervals not exceeding one year;
- within a building for the production and storage of explosives, at intervals not exceeding one year, while periodic visual inspections must be conducted at intervals not exceeding six months.

(5) Periodic verification of less complex electrical installations must be carried out at intervals not exceeding eight years, and periodic verification of electrical installations in single and two-dwelling buildings must be carried out at intervals not exceeding 16 years.
(6) Notwithstanding the preceding paragraph, periodic verification of the electrical installations in single-dwelling buildings with an installed photovoltaic power plant must be carried out at intervals not exceeding 8 years.
(7) An extraordinary verification of the electrical installation and lightning protection system shall be carried out following damage, repairs or other interventions, including refurbishment or minor reconstruction, and following the connection of new installed equipment, built-in devices and permanently connected devices that may affect safety. An extraordinary verification shall be carried out only on those electrically complete sections of the electrical installation or lightning protection system on which work has been carried out. An extraordinary verification of the lightning protection system must also be carried out following any direct lightning strike to the lightning protection system, following any damage to the building caused by a lightning strike, or following any intervention in the lightning protection system. An extraordinary verification shall also be performed in the event of construction interventions on the building envelope, including the installation of equipment, if such interventions affect the lightning protection.
(8) In buildings or electrically completed units in buildings with built-in basic protection against electric shock with automatic disconnection of power supply, in two-wire design (with zeroing), verifications of electrical installations must be carried out within a period not exceeding eight years.
(9) The provisions of this Article shall also apply to buildings with existing electrical installations or lightning protection systems that were constructed and were in regular use prior to the entry into force of these Rules.

8.1.1 Inspector jurisdiction

(1) At the beginning of the construction, an inspector must be present to verify the earthing/grounding installation prior to filling up with concrete. The inspector shall be present in any subsequent construction phase of the building, which could affect the correctness of the low-voltage electrical installation and lightning protection system implementation. Information on the individual construction phases affecting the LPS are an integral part of the record of the first lightning protection system inspection.
(2) Upon completion of the lightning protection system, after modifications, renovations, repairs and occasionally the inspection of the suitability and quality of this system for protection against lightning, its properties, safety, reliability and functionality and the use of the prescribed (construction) products shall be carried out. The lightning protection system is to be inspected as a whole. Following changes, reconstructions and repairs to the lightning protection system, the entire lightning protection system must be inspected.
(3) The inspector should be familiar with and follow the results and recommendations of the preliminary checks.
(4) Inspection of LPS systems constructed in protection zones I and II can only be carried out by individuals who have acquired the vocational qualification NPK to inspect complex electrical installations and lightning protection systems.
(5) Inspection of LPS systems constructed in protection zones III and IV can only be carried out by individuals who have acquired the vocational qualification NPK to inspect complex electrical installations and lightning protection systems.
(6) At first verification, low-voltage electrical installations and lightning protection systems, if installed, are simultaneously checked. If the examined building should have a lightning protection system, but does not have it, it does not pass the verification.
(7) When the building has built-in lightning protection, then the inspection of electrical installations must be performed within the time limits set for the lightning protection inspection and testing, except for the measurement of protection against electric shock, which are included in the checks prescribed by regulations, which are the basis of this Technical Guideline.
(8) Upon completion of the inspection, the inspector may, in a visible place on the lightning installation, affix the number of the certificate of his competency and the date of the inspection carried out, allowing for faster inspection of statutory checks and ensuring the safety of the lightning protection system.

8.1.2 Responsibilities of the inspector

Article 11
(Verification provider)

(1) The tasks related to the verification of electrical installation and lightning protection referred to in Articles 13 and 14 of these Rules may only be performed by a verification provider (hereinafter referred to as ‘an inspector’), i.e. an individual with an acquired national vocational qualification for the verification of complex electrical installations and lightning protection or national vocational qualification for the verification of less complex electrical installations and lightning protection in accordance with the act governing national vocational qualifications. The inspector must possess competences that complement the national vocational qualification obtained in specific areas of electrical installations and lightning protection, and which go beyond the scope of that qualification.

(1) The inspector is responsible for the proper implementation of his/her fields of activity. In order to correctly carry out verifications and ensure electrical safety and quality, they must regularly update and expand their knowledge and experience in line with technological developments across all the areas they cover. In addition to the national vocational qualification, the inspector requires additional knowledge, skills, and experience in certain cases. These are:

- power engineering and industrial electrical installations and workplace responsibility
- low-voltage electrical installations and workplace responsibility

- safe work in areas and environments at risk of explosion
- energy, production, transmission and distribution, industry
- low-voltage electrical and lightning protection installations
- electrical machinery, equipment, distributors and devices
- vehicles with LV electrical installations (LVEI), electric vehicles, converted vehicles with generator sets, emergency vehicles, motorhomes
- equipment and installations in medicine and healthcare.

Details of these competencies and experiences are given in Appendix A to this Guideline.

(2) The inspector with the national vocational qualification for less complex electrical installations and lightning protection installations may not independently carry out checks on complex electrical and lightning installations.

(3) The inspector is liable for inadequate or fraudulent inspection records. The responsibility of the inspector is based on the provisions of the first paragraph of Article 14 of the Rules.

Article 14
(Scope of verification and report)

(1) During the inspections referred to in Articles 12 and 13 of these Rules, the electrical installation and lightning protection shall be inspected, and a report shall be drawn up to the extent and in the manner specified in both technical guidelines. The report must provide a clear and unambiguous assessment of the condition of the inspected electrical installation and lightning protection, stating whether the inspected electrical installation or lightning protection complies with the requirements of these Rules.

(2) If, during the inspection, the inspector finds that the electrical installation and lightning protection pose, or could pose, a hazard, they shall record the irregularities in the report and may also propose the necessary measures to rectify the situation. The report shall be handed over to the building manager. Any irregularities must be rectified within the time limit specified by the inspector in the report. Once the irregularities have been rectified, the inspector shall repeat that part of the inspection which serves to establish whether the irregularities have been rectified, and shall draw up a report to that effect.

(3) The building manager is obliged to keep reports of all verifications.

conductor installation;

7. that there are no weakened LPS parts due to corrosion, particularly not at the points of contact with the earth;
8. that all visible earth electrodes and earthing connections are undamaged;
9. that all visible conductors and integral parts of the system are attached to suitable surfaces and that the mechanical protection parts are not damaged;
10. that the protective measures against the dangers of excessive touch and step voltages are implemented in the areas where people may be present;
11. that no additional changes have been made to the protected building which would require additional protective measures;
12. that there are no signs of damage to the LPS or SPD or fuses which protect the surge protection devices;
13. that the connecting conductors and joints are correctly installed in the building;
14. that the equipotential bonding has been correctly carried out for any new wiring or additions which have been put in since the last inspection and that tests have been carried out to check the continuity of these new additions;
15. that the galvanic connections to the neighbouring buildings have been correctly carried out and that their installations are connected;
16. that the separation distances, dimensions of the air-terminals conductors, down conductors and earthing have been correctly chosen and maintained;
17. that the connecting conductors, joints and shielding devices, the site of the cable laying and the surge protection devices have been correctly installed and correctly connected to the earthing system;

18. that the compatibility of the electrical and lightning conductor installation has been achieved with regard to the earthing system in the electrical installation (TN, TT, IT);
19. that the compatibility of the electrical and lightning conductor installation is achieved and maintained with regard to the designed protection zones of the LPS system;
20. that the passages of the conductor from the foundation to the ground and from the ground into the above-ground part are made of stainless material and with adequate insulation (bitumen strip, insulated conductor, ...);
21. that the foundation earthing is galvanically connected to the building reinforcement with welded joints or corresponding coupling elements.

(2) In the course of periodic inspections as part of maintenance procedures, the acts referred to in items 1, 2, 3, 6 and 19 to 21 of the preceding paragraph may be suspended.

8.3 TESTS

The following tests need to be carried out after the visual inspection:

- to establish whether the distances between the air-terminal meshes and the individual down conductors comply with the chosen protection level of the lightning conductor installation;
- to establish whether the distances between the various metal parts or parts of the other installations comply with the calculated separation distances of the project;
- to test the insulation suitability of the insulation inserts and spark gaps which intentionally separate the various metal installations (gas, installations with cathode protection, etc.);
- to test the operation of surge protection devices;
- to carry out a shut-down test of the earth electrodes in the event of significant effects of corrosion or an unusual increase in the earth resistance of the earth electrode, which showed considerably higher values before the inspection.

8.4 MEASUREMENT

(1) After completing the visual inspection and tests, the inspection continues with metering. Depending on the findings from both previous parts of the inspection (LPS implementation, surroundings, special requirements), a suitable metering method is chosen that ensures the required level of accuracy of each measurement. The following measurements need to be carried out:

1. Main equipotential bonding, resistance of the protective conductor and connection of conductive parts:
    1. protection against electric shock at all points of the electrical installation, connections to foreign conductive parts within the room;
    2. the connections of the external conductive parts, the continuity of the galvanic connections and joints;
2. insulation resistance of floors and walls:
    5. where a non-conducting location is used as protection against electric shock; floor dissipativity and other protections against static electricity for technological safety reasons;
3. impedance of fault loop and short-circuit loop Z, short-circuit and fault currents, and determination of the correctness of the disconnection time of protective devices; voltage drop on the conductors between the divider and the most distant point of the circuit; correctness of the operation of protective devices on the residual current (RCD):
    4. verification of safety conditions in buildings built before 1985 (zeroing);
4. suitability of protective and operational earthing, touch and step voltages:
    1. touch and step voltages in the vicinity of small objects, buildings, devices and structures;

2. touch and step voltages at the edges of earthing systems and in the earthing of energy installations, industrial facilities, areas and centres where large numbers of people are present,
3. adequacy of integrity for earthing systems of installations and structures in industry, energy and distribution with high fault currents;

5. adequacy of lightning protection ZPS:
    1. the adequacy of the internal lightning protection system ZPS, verification of the surge protective device (SPD) breakdown threshold and no-load current (leakage current); the adequacy of the surge protective device (SPD) earthing,
    2. measurements of external lightning protection systems (ZPS) (air-termination loops and down-conductor networks),

descriptions and requirements for measurements are set out in Appendix B to this document.

(2) The meters for said required measurements must comply with the SIST EN IEC 61557 series standards.

8.5 MAINTENANCE INSPECTION

(1) The maintenance inspection may be carried out by the owner or by an appropriately qualified authorised person. This inspection is usually carried out due to other requirements, during the period of regular checks.
(2) At the maintenance inspection, the following has to be visually checked:

1. that the LPS is in good working condition and does not show signs of damage;
2. that there are no loose joints and random interruptions of the conductors, joints and connections;
3. that the lightning conductor installation (metering joint, metering point, numbered down conductors on the floor plan of the building, the density of the air-terminals and down conductors) is appropriate for the chosen (designed) protection level of the lightning conductor installation;
4. that there are no weakened LPS parts due to corrosion, particularly not at the points of contact with the earth;
5. that all visible earth electrodes and earthing connections are undamaged;
6. that all visible conductors and integral parts of the system are attached to suitable surfaces and that the mechanical protection parts are not damaged;
7. that the indicators of the installed protective devices are correct;
8. that there are no signs of damage to the LPS or SPD or fuses which protect the surge protection devices;
9. that the galvanic connections to the neighbouring buildings have been correctly carried out and that their installations are connected;
10. that the connecting conductors, joints and shielding devices, the site of the cable laying and the surge protection devices have been correctly installed and correctly connected to the earthing system;
11. that the passage of the conductor from the foundation to the ground and from the ground into the above-ground part have adequate insulation (bitumen strip, insulated conductor, ...);
12. that the foundation earthing is galvanically connected to the building reinforcement with welded joints or corresponding coupling elements;
13. perform inspections or interventions in accordance with the manufacturer's instructions for installed or used equipment or contractor.

(3) The owner shall keep records about maintenance inspections.

8.6 SAFETY CHECK PERIODS

(1) When a building combines various demanding electrical installations, power installations and/or lightning protection systems, the period for periodic inspections as well as maintenance inspections shall be determined according to their complexity.
(2) The periods of compulsory visual inspections and checking of the LPS external system should be in line with the periods of mandatory inspections and checks on the most demanding low-voltage electrical installations in the building and are carried out at the same time.
(3) The visual inspection and inspection of internal lightning protection system and electrical installations in the building shall, where this risk assessment does not specify otherwise, take place within the periods required for this type of electrical installation.

8.7 SAFETY CHECK MINUTES

(1) The inspector must compile a report on the completed LPS inspection. The measurement must be carried out taking into account the implementation of the electrical installation in accordance with the combined earthing system on the building.
(2) The minutes must provide an assessment of the adequacy of the lightning protection system for the whole building. Only the assessment which shows the adequacy of all verifications with their results is considered to be positive. A negative assessment must contain an annex in the minutes with a list of detected inadequacies and, optionally, proposals for the necessary corrective measures may also be included.
(3) It should be stated whether it is a self-standing building with an earthing system that is not connected to other buildings or an urban building with connected earthing to other facilities.
(4) The inspection minutes must contain the following information:

- the general state of the air-termination conductors and other key components of the air-termination system;
- the level of corrosion and the effectiveness of the corrosion protection;
- reliability of connections and other components of LPS, metal elements and enclosures of devices;
- measured values of earthing resistance of the earthing system as a whole, resistance of galvanic connections to adjacent objects;
- measured values of the earth resistance of the earth electrodes of the individual down conductors and the connections through the air-termination system and earth electrodes. The individual lightning conductors must be labelled (in the floor plan, design) so that the measurements carried out are identically repeated. In the case of other installations, they must be shown in a common drawing;
- measured values of the resistance of the lightning conductor installation’s galvanic connections with other metal parts and metal parts of other installations with regard to the connection to the LPS (electrical installation, plumbing, central heating, etc.);
- the results of all the measurements performed, all the required inspection values and a comparison with the permissible or limit values for each part of the lightning protection system, must be given unambiguously, and it must be possible to determine from the minutes which part is questionable, where it is located, and to repeat the inspection in the same way;
- the deficiencies identified must be demonstrated in a visual manner;
- data showing that the inspections, tests and measurements referred to in items 7.2, 7.3 and 7.4 have been carried out, as well as data on the inspectors, instruments and actual measurement methods used;
- the minutes must indicate the mark, the number and the date of the valid certificate attesting the calibration data of the measuring instruments used;
- at the first check the minutes must also state that the implementation of the internal and external protection against lightning is in accordance with the project design of works executed or other comparable documentation.

(5) In the event of a negative assessment or inadequate lightning protection system, it is necessary to eliminate the discovered inadequacies and to check the results by means of examination or tests and measurements. This should be repeated until all inadequacies are eliminated and the check gives a positive assessment.
(6) The owner/operator shall be informed in writing of possible dangers arising from the discovery of inadequacies. Written information is an attachment to the minutes.
(7) If the negative assessment of the established condition is the result of a possible inappropriate electrical installation project or written and graphic information describing the condition of electrical installations, the inspector must warn the building owner and suggest that he requests the designer to coordinate the project or information in such a way that it will correspond to the actual purpose of the lightning protection system.
(8) In the event the assessment of the situation is negative due to the possible incorrect implementation of the lightning protection system project, the inspector must warn the building owner of this and suggest that he request the contractor to arrange the condition as specified in the project.
(9) Based on the trend in the measurement results, when compared with the results of previous inspections, as well as the actual condition of the lightning protection system as determined during the inspection, the inspector may, in the interests of the safety of people and property, recommend a shorter interval until the next inspection, regardless of a positive inspection result. The building manager must agree to this.

A Appendix A: Knowledge and experience competencies

A.1 Knowledge and experience competencies of the inspector for performing specific fields of activity

Below is a list of recommended knowledge and experience competencies, broken down by area. With the development of technology and expertise, new competencies and experience can be developed.

A.2 Power engineering and industrial electrical installations and workplace responsibility

Understanding the procedures and rules for working on live equipment and in the vicinity of live parts, and the safe execution of work, maintenance, installation and assembly.

Reference designation	Competence abbreviation	Description	Reference documents
ZRZ: D-5/009	**BPN eeELI**	Expert for Low-Voltage Electrical Installations qualified to carry out work in a de-energized state and in the vicinity of live parts	Rules on protection at work against the danger of electric current (Official Gazette of the Republic of Slovenia Nos. 29/92, 56/99 – ZVZD and 43/11 – ZVZD-1)

A.3 Low-voltage electrical installations and workplace responsibility

Understanding the procedures and rules for working on live equipment and in the vicinity of live parts, and the safe execution of work, maintenance, installation and assembly.

Reference designation	Competence abbreviation	Description	Reference documents
ZRZ: D-5/007	**BPN nnELI**	Expert for Low-Voltage Electrical Installations qualified to carry out work in a de-energized state and in the vicinity of live parts	Rules on protection at work against the danger of electric current (Official Gazette of the Republic of Slovenia Nos. 29/92, 56/99 – ZVZD and 43/11 – ZVZD-1)

A.4 Safe work in areas and environments at risk of explosion

Reference designation	Competence abbreviation	Description	Reference documents
EZS: D-5 /917	**EXP**	Qualified custodian of complex installations in buildings with explosion-hazard areas.	Explosion Protection Rules

A.5 Energy, production, transmission and distribution, industry

Reference designation	Competence abbreviation	Description	Reference documents
ZRZ: D-5/922	**EES**	Qualified administrator of earthing in electrical power systems and networks	IEEE 81, SIST EN IEC 62305, SIST EN 50522
ZRZ: D-5/712	**PVV**	The qualified administrator of photovoltaic solar power plants, associated installations and devices	SIST EN 60364-7-712, SIST EN 62446

A.6 Low-voltage electrical and lightning protection installations

Reference designation	Competence abbreviation	Description	Reference documents
ZRZ: D-5/105	**LPSinsp**	Inspector for protection against lightning system	SIST EN IEC 62305 Common rules TSG N 003
ZRZ: D-5/104	**LPSc**	Qualified lightning protection manager / contractor / maintenance technician	SIST EN IEC 62305 Common rules TSG N 003

B Appendix B: Measurement procedures and methods

B.1 Measurements of main equipotential bonding, resistance of the protective conductor and connection of conductive parts

In order to ensure safety and to prevent dangerous voltage differences between the metal parts, the quality of the connections in the equipotential bonding system must be verified.

- The minimum requirement is to carry out the following measurements: **using AC or DC current** by reversing the measurement polarity **in the + and – directions** to detect connections made with different materials that form unauthorised combinations. The current generator must be capable of supplying a test current of at least **200 mA**.
- The limit value of the connection resistance between metal parts should not exceed **0.1 Ω.**
- The measurement may exceed the minimum expected measured values if this is permitted by additional measures taken when implementing automatic disconnection within the permissible time limit, in accordance with the requirements of **SIST EN 60364.4.41**, taking into account the appropriate configuration of the TN, TT or IT electrical installation system.

  $R < U_c / I_k$ **faults** or $R < U_c / I_{dn}$ **RCD**

- When connecting the conductive parts of an individual switchboard, the protection implemented in the upstream switchboard shall be taken into account.
- Measurements shall be carried out on all accessible joints and metal structures that are part of the equipotential bonding system.

B.1.1 Measurements of shock protection at all points of the electrical installation, connections 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 verify their connection to the equipotential system or appropriate insulation.

- The resistance of the connection between the foreign conductive part and the equipotential conductor should not exceed **0.1 Ω**. The resistance of connections may be higher if the following items are taken into account.
- If the part is insulated, double insulation or physical separation must be provided, with adequate distance and clearances.

B.1.2 Measurements of external conductive parts, measurements of galvanic connections and joints

External conductive parts, galvanic connections and joints (e.g. rolled metal, conductive structures, metal fences, pipework, metal façades) may carry dangerous potentials in the event of a lightning strike or a fault in the mains supply, thereby increasing touch voltages. The measurements shall be aimed at assessing the safety of **the contact voltage** and the scheduling **of the voltage gradient**.

- The resistance of the connection between the external conductive part and the equipotential conductor should not exceed **0.1 Ω**. The resistance of connections may be higher if the following items are taken into account.
- If the part is insulated, double insulation or physical separation must be provided, with adequate distance and clearances.

B.2 Measurement of the insulation resistance of circuits, installations, isolating transformers

Measuring insulation resistance is crucial for preventing electric shocks, preventing leakage currents from finding a path, and protecting against conditions that could lead to a fire. It is carried out between active conductors and earthed 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 equipment in buildings.
- The insulation resistance must be **≥ 1 MΩ** for each circuit.
- Measurement shall be carried out between live conductors and the protective conductor (PE) with consumers switched off. When the customers are connected, we reduce the test voltage to **250 V DC** so that the measurements are carried out within the range below the operating threshold of the SPD and the varistor protection.

Insulation measurements on transformers and cables in outdoor installations, as well as in areas subject to high- and low-frequency electromagnetic interference, must be carried out using specialised measuring instruments that allow for a higher generator current and ensure adequate immunity to environmental interference.

B.2.5 Insulation resistance of floors and walls

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 an earthed part** (e.g. a metal pipe or PE conductor). The contact surface of the measuring probe shall be 625 cm^2, which shall be lined with a wet cloth during measurement. During the measurement, apply a load of at least 750 N to the probe for floor measurements and at least 250 N for wall measurements.
- Test voltage: **500 V DC**.
- Threshold value:
  - **≥ 1 MΩ** for dry surfaces,
  - **≥ 0.5 MΩ** s for damp or wet surfaces.

Floor dissipatedness and other protections against static electricity
Protection against static electricity is important in rooms with sensitive electronics, explosive atmospheres or medical equipment. Measurements shall be carried out between the floor surface and the earthed part (e.g. PE conductor or metal structure).

B.3 Measurements of impedance Z, short-circuit currents and fault currents for testing the earthing system

Impedance measurements and calculation of short-circuit and fault currents shall be carried out.

- 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 an RCD** – the ZPE method is equivalent to the ZL measurement; the results are comparable, and the values are lower than the permissible limits, **depending on the characteristics** of the circuit breaker or fuse.

- **TN system with RCD** – ZPE method with a lower measurement current ZS, taking into account RCD I_{dn}, U_c**, which must not exceed the permissible value**, shall be calculated.
- **TT system with RCD** – ZPE method with a lower measurement current ZS, taking into account RCD I_{dn}, U_c**, which must not exceed the permissible value**, shall be calculated.

B.3.4 Verification methods for safety in buildings constructed before 1985 (zeroing)

In accordance with SIST EN 60364-4-41, the resistance of the local earthing system must be low enough to enable the rapid operation of the protective devices in the event of failure, but must be high enough not to cause a division of currents during operation that could endanger safety.

- The current flowing into the earthing system passes into the ground at certain points, carrying away conductive metal material with it; over time, the earth electrodes deteriorate, resistances increase, and consequently the ratios within the earthing resistance system and the conditions for permissible zeroing also change.
- When currents flow into the system and pass into the ground, dangerous current paths form in the surrounding area, causing hazardous touch voltages.

For both reasons, it is necessary to ensure that the leakage of current into the ground is minimal!

- The first step in reducing the current flowing into the ground is to reduce the current in the PEN conductor. This is **ensured in a three-phase system by careful planning of the symmetric load**.
- When implementing zeroing in single-phase systems, a part of the current always passes from the PEN conductor into the strip electrodes and into the ground.
- **Zeroing is only permitted** if the resistance of the PEN conductor (RPEN) is significantly less than the local earthing resistance (RL). The recommended **ratio is 1 : 10.**
- We must use a TRMS clamp meter with a suitable measuring range and appropriate interference shielding. **The current in the zeroing connection must be at least 10 times smaller than the current in the PEN conductor.**
- For zeroing to be permitted, both ratios must be taken into account.

B.4 Measurements of earthing resistance, protective and operational earthing , touch and step voltage

Effective earthing is essential for the safety of people, animals, installations, buildings and equipment. Measurements are carried out using various methods, depending on the accessibility and size of the building. 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)

- The U-I method, using two-wire, three-wire or four-wire, with a test current of **≥ 25 mA**, suitable for stand-alone installation systems **, TT, IT or stand-alone isolated installations**, and earthing.
- Alternative method using **two-clamp measurement** of closed loops – **SIST HD 60364-6**, suitable for lightning protection systems, roof down-conductors, equipotential bonding connections, suitable, in particular, for measuring earthing resistance on **TN in urban areas** installation systems, where measurement is carried out on the incoming PE or PEN conductor.
- The earthing resistance shall be sufficiently low to permit operation caused by a fault current that ensures the successful automatic disconnection of the power supply.
- If earthing resistance is too high, RCD and ELR devices can be used to ensure the power supply is disconnected before the touch voltage rises above the permissible limit. The most common limits with regard to 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 device, the measured value shall not exceed **10 Ω or 4 % of the specific resistance of the ground in the area.**

B.4.1 Measurements of touch and step voltages in the vicinity of small structures, buildings, devices and constructions

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 protection system.

B.4.2 Measurements of touch and step voltages at the edges of earthing systems and in the vicinity of the earthing systems of power installations, areas and centres where large numbers of people are present

We carry out earthing measurements on large complexes and buildings using the U/I method, which involves injecting high currents into the system under test and using a synchronised, high-precision voltage drop meter whilst applying 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)

B.4.3 High-current integrity testing for earthing systems in installations and structures within industry, the energy sector and distribution

To ensure adequate safety and protection against hazardous step and touch voltages, earthing systems comprising earthing rods and conductive meshes may be installed in the ground in the vicinity of large-scale systems. Buildings, facilities, devices, structures, pipe systems, lightning installations, bases and rails shall be connected to earthing in several places.

B.4.4 Permissible touch and step voltages

The earth resistance must ensure appropriately low permissible touch voltages with respect to the expected fault current and fault duration for cases of faults in the low-voltage network, medium-voltage network, or during a lightning strike.

Calculation of touch voltage (U_{Tp})

$$U_{Tp} = I_B \times HF \times Z_T(U_T) \times BF$$

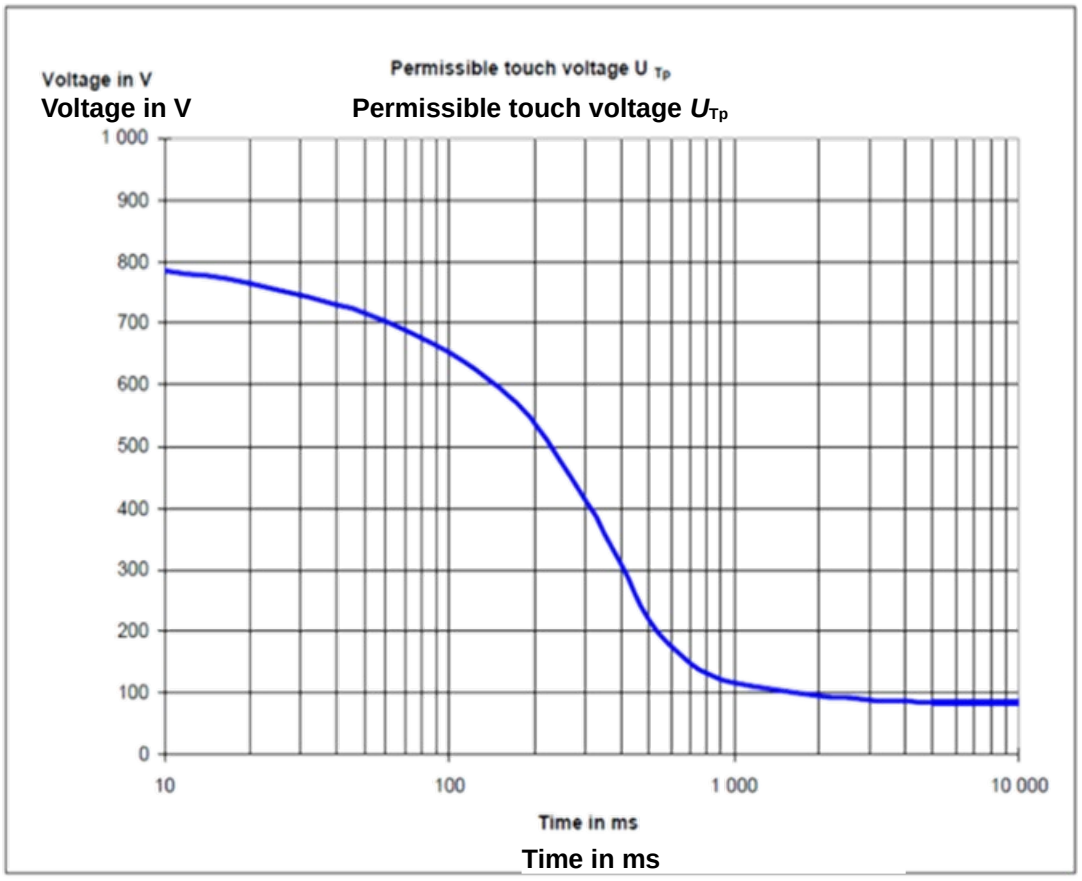
The significance of individual factors:

Factor	Description
I_B	Permissible body current with respect to fault duration (SIST EN 50522)
HF	Heart current factor, 1.0 for the left arm-leg
$Z_T(U_T)$	Body impedance, dependent on contact voltage (e.g. 1000 Ω)
BF	Body factor, e.g. 0.75 for one arm–both legs

The relationship between the duration of a fault or the duration of voltage surges in relation to the current through the human body I_B and the calculated permissible touch and step voltages is

presented in graphical and tabular form in the following figure, in accordance with the safety curves from **IEC/TS 60479-1.**

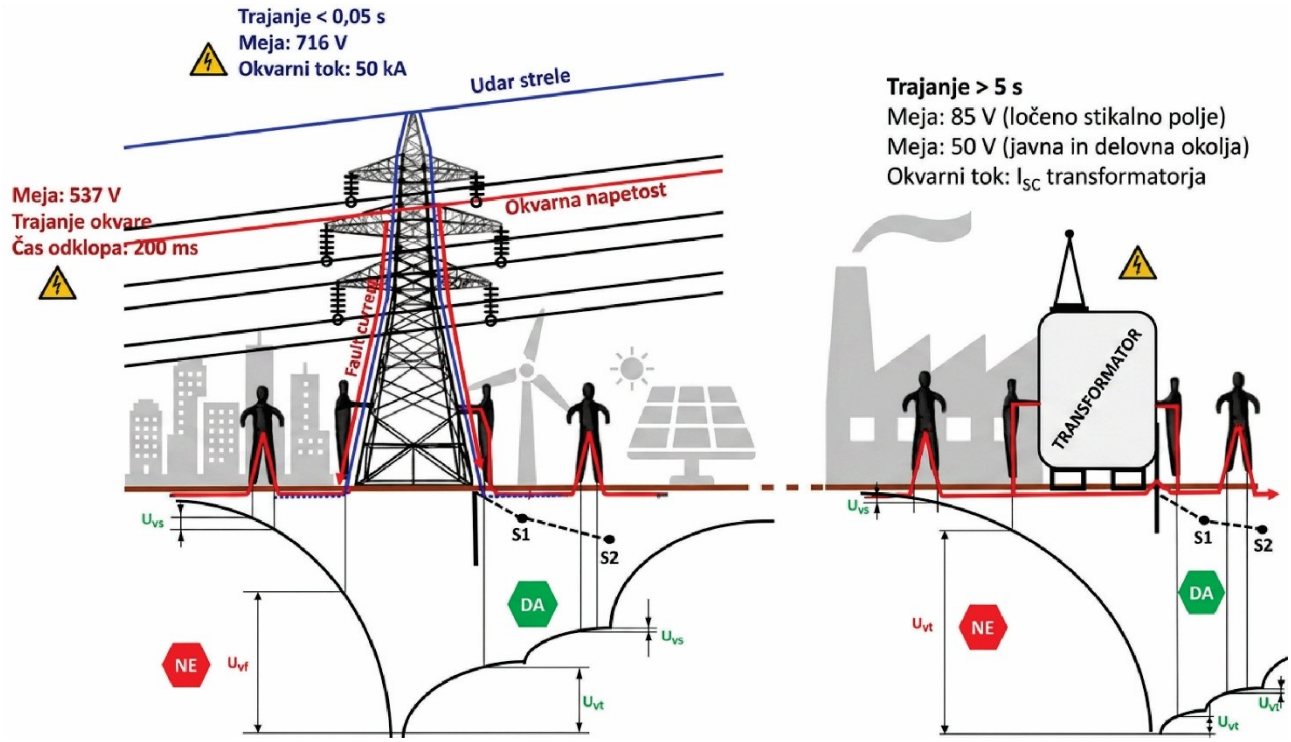
Duration of the fault [s]	**Permissible current I_B [mA]**	**Permissible voltage U_{Tp} [V]**
0.01	1000	800
0.05	900	716
0.10	750	654
0.20	600	537
0.30	180	410
0.50	200	220
0.80	70	130
1.00	80	117
2.00	60	96
5.00	51	86
10.00	50	85



The following figure illustrates three examples of hazards; the worst-case scenario must always be taken into account:

- **lightning strike; a minimum of 50 kA shall be taken into account:** (<0.05 s), permissible current through the body 900 mA, permissible **touch voltage U_{Tp}: 716 V**
- **disconnection time of the MV line conductor, taking into account the fault current of the line conductor to earthing, e.g., 100 A:** (<0.2 s), permissible current through the body 600 mA, permissible **touch voltage U_{Tp}: 537 V**
- **permanent fault on the LV side; taking into account the fault current, e.g. 5 kA** (> 5 s); permissible current through the body 50 mA, permissible touch voltage **U_{Tp}: 85 V for operation within a protected substation area**

- **permanent fault on the LV side; taking into account the fault current, e.g. 5 kA** (> 5 s); permissible current through the body 50 mA, permissible touch voltage **U_{Tp}: 50 V for a more accessible environment**



Meja: 537 V
Trajanje okvare
Čas odklopa: 200 ms

Trajanje < 0,05 s
Meja: 716 V
Okvarni tok: 50 kA

Udar strele
Okvarna napetost

Ne
Da

Trajanje > 5 s
Meja: 85 V (ločeno stikalno polje)
Meja: 50 V (javna in delovna okolja)
Okvarnitok: I_{sc} transformatorja

Transformator

Border: 537 V
Failure duration
Time of disconnection: 200 ms

Duration < 0.05 s
Border: 716 V
Fault current: 50 kA

Lightning strike
Fault voltage

No
Yes

Duration > 5 s
Border: 85 V (separate switch field)
Border: 50 V (public and work environments)
Fault current: I_{sc} of the transformer

Transformer

B.5 Lightning protection measurements ZPS

In order to check the lightning protection, an inspection of the internal and external lightning protection shall be carried out. Measurements must be carried out on the lightning protection system as a whole, which includes all conductive parts within the building, as well as conductive parts, equipment and structures on the exterior of the building, in the immediate vicinity of the building and within the area of influence. The area of influence is defined by the distance over

which potential transfer effects occur in the surroundings and by the type of protective measures applied against touch and step voltages. Normally, the effects of a direct strike are largely confined to an area of 6 m × 6 m around the point of impact, provided there are good connections to a low earthing resistance in the ground. For the area affected by a lightning strike, a distance of 20 m from each individual structure or building is taken into account.
For internal lightning protection, the **verification methods set out in Chapters B.1 and B.2 of this Annex and Chapter B.5.1 below** shall be used.

B.5.1 Measurements of internal lightning protection ZPS and surge protection SPD

Surge arresters must operate reliably in the event of a lightning strike or a power surge. Co-ordinated protection from the same manufacturer must be installed, with the following ratings: T_1 and T_2 (B and C).
The verification method involves inspecting and measuring the connection configuration in accordance with the TT (3 + 1), TNC (3-0), TNS (4-0) and IT (3+1 or 4-0) installation systems, and checking the operating threshold.

- The surge arrester test shall be performed with a high voltage generator with a DC ramp output that raises the voltage above the threshold level of the SPD. It is recommended to use a meter that allows voltage to be raised above 2.5 kV.
- The measured operating threshold must correspond to the manufacturer's information. The measured value of the DC voltage ramp shall be situated within the range between:

  1.41 x U_{AC} of rated voltage SPD > ***U* measured** < U_P SPD protection level
  U_P, SPD protection level < 1.5 kV – for electronic equipment
  U_P, SPD protection level < 2.5 kV – for passive loads, heaters and motors without control systems

For external lightning protection, the **verification methods from Chapters 11.1, 11.2, and 11.4 of this Annex and Chapter B.5.2 below** shall be used.

B.5.2 Measurements of external lightning protection (air-termination loops and down-conductor networks)

In order to verify the continuity and efficiency of the lightning conductor system, the measurement method of two measuring clamps shall be used.

- Measurement method with **two-clamp measurement** of closed loops – **SIST HD 60364-6**, suitable for lightning protection systems, roof down-conductors, equipotential bonding connections, suitable, in particular, for measuring earthing resistance on installation systems. The double clamp method allows measurement without breaking the connections.
- Measurements shall be carried out on all accessible parts and all closed loops of the air-termination mesh.
- There must be no gap between the measuring clamps; both measuring clamps must grip the same loop on which the measurement is being taken.
- The measured values should not exceed the loop resistance limit of **0.2 Ω; the recommended value is 0.1 Ω**.
- When measuring newer buildings constructed after 2009, the expected measured values are **0.2 Ω (recommended 0.1 Ω)** at the building's down conductors prior to their termination in the ground, where a rolled metal ring is to be installed in the ground at a distance of 1 m from the building, at a depth of 0.2 m, which connects all the down conductors to one another.
- When measuring older buildings constructed before 2009, the expected measured values of an individual down conductor are up to **20 Ω, or 8 % of the specific resistance of the soil in the area**, measured at the down conductors from the building prior to termination

into the ground, where an unconnected rod earthing is allowed into the ring around the building.

c Appendix C: Example of a lightning protection system inspection report

THE LIGHTNING PROTECTION SYSTEM INSPECTION REPORT

Protection level	☐	I	☐	II	☐	III	☐	IV	☐
Internal Lightning Protection System	☐		External Lightning Protection System						☐

RESULT OF THE INSPECTION						
The inspected lightning protection system	☐	**Suitable**	☐	**Not suitable**	☐	Attached is a list of shortcomings

SIGNATURE AND STAMP	
	Date of the next inspection:

	Attached inspector's sticker:	O YES	O NO
Customer:	**Measurer:**		
Location:	Location:		
Date:	Date:		
Signature:	Signature:		

Notes:

Visual inspection ☐ **Suitable** ☐ **Not suitable**	**U**-Appropriate **N**-Inappropriate	
Lightning installation	**U**	**N**
The design and plans of the lightning installation meet the requirements of the applicable technical regulations	☐	☐
There are documents on conformity (declarations of conformity, certificates) of selected materials	☐	☐
The implemented lightning protection is insulated or non-insulated	☐	☐
The lightning protection system is in good condition and has no visible damage	☐	☐
There are no loose joints and accidental interruptions of conductors, joints and connections in the lightning protection system	☐	☐
Lightning conductor installation (metering joint, metering point, numbered down conductors on the floor plan of the building, the density of the air-terminals and down conductors) is appropriate for the designed protection level	☐	☐
There are no weakened parts of the lightning protection system due to corrosion	☐	☐
All visible earthing connections are undamaged	☐	☐
All visible conductors and components of the system are attached to suitable bases and parts of the mechanical protection are not damaged	☐	☐
There are no additional changes to the protected building which would require additional protective measures	☐	☐
Connecting conductors and joints are correctly installed in the building	☐	☐
Equipotential bonding is correctly performed for any new wiring or additions that have been carried out in the building since the last inspection and that continuity tests have been performed for these new additions	☐	☐
Galvanic connections to the neighbouring buildings and the connection of their installations have been correctly carried out	☐	☐
Separation distances are appropriately selected and maintained	☐	☐
Connecting conductors, joints and shielding devices, cable laying location and surge protection devices are correctly installed, correctly connected to the earthing system:	☐	☐
The distances between various metal parts or parts of other installations correspond to the separation distance calculated in the project	☐	☐
Surge protection	**U**	**N**
Surge arresters are properly installed and connected	☐	☐
Surge protection, according to the coordination of protection elements is properly implemented	☐	☐
Connecting conductors and joints in buildings that form a unified system are appropriately installed	☐	☐
Operation of surge protection devices, which are checked by pressing a button	☐	☐
There are no signs of damage to the LPS or SPD or fuses which protect the surge protection devices:	☐	☐

The zonal principle of surge protection is applied in the building	☐	☐
Step and touch voltage	**U**	**N**
The protective measures against the dangers of excessive touch and step voltages are implemented in the areas where people may be present	☐	☐
Other	**U**	**N**
The compatibility of the electrical and lightning conductor installation has been achieved with regard to the earthing system in the electrical installation (TN, TT, IT)	☐	☐
The compatibility of the electrical and lightning conductor installation is achieved and maintained with regard to the designed protection zones of the LPS system	☐	☐
Connecting conductors and joints are correctly installed in the building	☐	☐
The distances between the air-terminal meshes and the individual down conductors comply with the chosen protection level of the lightning conductor installation:	☐	☐
Insulation suitability of the insulation inserts and spark gaps which intentionally separate the various metal installations (gas, installations with cathode protection, etc.):	☐	☐
A shut-down test of the earth electrodes in the event of significant effects of corrosion or an unusual increase in the earth resistance of the earth electrode, which showed considerably higher values before the inspection	☐	☐
The dimensions of the air-termination system, down conductors and earth-termination system are suitable	☐	☐
	☐	☐
	☐	☐

MEASUREMENTS OF THE CONTINUITY OF EARTHING CONDUCTORS, EQUALIZATION OF CONNECTIONS AND EARTHING

Earthing conductor continuity of equalising connections and earthing ☐ **Suitable** ☐ **Not suitable**	**U**-Appropriate **N**-Inappropriate	
	U	**N**
Measuring the continuity or the connectivity of the metal parts so that it is a unified earthing system – suitable	☐	☐
Measuring of the earthing resistance of the integrated earthing system (the reference point outside the potential impact of the lightning installation of the building must be taken into account (measuring contact – reference ground)) – Measuring Sheet A	☐	☐
Measuring the earth resistance of individual earth electrodes (separate measurements) – Measuring Sheet B	☐	☐
Measuring the resistance of equalising connections (if the measurement is not performed as part of a building inspection) – Measuring Sheet C	☐	☐
Measuring the continuity of the galvanic connection and joints (proof of low electrical resistance between connection points) – Measuring Sheet D	☐	☐
Measuring the voltage of the reaction of the surge protection devices or the idle current (leakage current) of the protection device – Measuring Sheet E	☐	☐
Measurement of the touch and step voltage at particularly exposed places where dangerous differences in potentials are to be expected	☐	☐
	☐	☐

MEASURING SHEET A – External LPS

Annex: sketch of measuring points

MS	Description	Z [Ω]	Z_L [Ω]	Z_o [Ω]	Suitable
1	Main supply				
2	…				
…					
IP	Ground contact				

Legend:
Z (Ω) the measured transient impedance in the loop via the earth electrode and the air termination system
ZL(Ω) the measured transient impedance in the loop through the air termination system
ZO(Ω) the measured transient impedance in the loop through the earth electrode

MEASURING SHEET B – External LPS – individual earthing device
(Measurement if applicable)

MS	Description			Z_o [Ω]	Suitable
1					
2					
…					

Legend:
Z_O(Ω) the measured transient impedance through the earth electrode

MEASURING SHEET C – INTERNAL LPS – connections for equipotential bonding

Equipotential bonding data:

Reference	Description of the conductive part	R_g[Ω]	Suitable

bus bars equipotential bonding	Distributors		
	Cable trays		
	Parapet channels		
	Floor switchboards		
	Pipe installations		
	Ventilation and air conditioning ducts		
	Elevator construction		
	Metal door and window frames		
	Metal fences		

Legend:
$R_g(\Omega)$ maximum measured electrical resistance of galvanic connections

Notes and special features (weather and environmental conditions at the time of inspection, persons present, spatial limitations of inspection, other special features):

MEASURING SHEET D – continuity of galvanic connections and joints

No.	Description	$R_S[\Omega]$	Suitable
1	Plumbing pipes		
2	Heating system pipes		
…	…		

Legend:
$Z_S(\Omega)$ measured coupling impedance

MEASURING SHEET E – SPD control

Measurement method used:	

Notes and special features:

Electrical distributor: En1

Pos.	Phase	Manufacturer	Type	U_n[V]	$U_{C\sim}$[V]	U_c=[V]	I_{PE}[mA]	Indicator
	L1							
	L2							
	L3							
	N							

Electrical distributor: En2

Pos.	Phase	Manufacturer	Type	U_n[V]	$U_{C\sim}$[V]	U_c=[V]	I_{PE}[mA]	Indicator
	L1							
	L2							
	L3							
	N							

Legend:
U_n() rated voltage of the protected line
U_c~ maximum continuous operating voltage OVP
U_c= measured knee value of OVP
I_{PE} down conductor current at knee measurements U_c
Indication optical indication of the state of protection of the OVP