SLOVENSKI STANDARD
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Protection of structures against lightning - Part 1: General principles

Protection of structures against lightning -- Part 1: General principles

Blitzschutz baulicher Anlagen -- Teil 1: Allgemeine Grundsätze

Protection des structures contre la foudre -- Partie 1: Principes généraux

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Protection of structures against lightning
Part 1: General principles
(IEC 1024-1:1990, modified)

Protection des structures contre la foudre
Première partie: Principes généraux
(CEI 1024-1:1990, modifiée)

Gabäudeblitzschutz
Teil 1: Allgemeine Grundsätze
(IEC 1024-1:1990, modifiziert)

This European Prestandard (ENV) was approved by CENELEC on 1994-10-24 as a prospective standard for provisional application. The period of validity of this ENV is limited initially to three years. After two years the members of CENELEC will be requested to submit their comments, particularly on the question whether the ENV can be converted into a European Standard (EN).

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CENELEC

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

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Foreword

This European Prestandard, which is based on the International Standards IEC 1024-1:1990 and IEC 1024-1-1:1993, has been prepared by Reporting Secretariat SR 81.

The text of the draft was voted and accepted during the meeting of SR 81 on 1994-10-24.

The following date was fixed:

- latest date of announcement of the ENV at national level (doa) 1995-01-04

Annexes designated "normative" are part of the body of the standard.
In this prestandard, all annexes are normative.

Part 1
General principles

Introduction

It should be noted that a lightning protection system cannot prevent the formation of lightning.

To date no devices or methods have been scientifically proven capable of preventing lightning from occurring or preventing lightning from striking structures.

A lightning protection system, designed and installed in accordance with this standard, cannot guarantee absolute protection to structures, persons, or objects; however, application of this standard will significantly reduce risk of damage caused by lightning to the structure protected by it.

The type and location of a lightning protection system should be carefully considered at the design stage of a new structure, thereby enabling maximum advantage to be taken of the electrically conductive parts of the structure. Thus design and construction of an integrated installation is made easier, the overall aesthetic aspects can be improved, and the effectiveness of the lightning protection system can be increased at minimum cost and effort.

Access to ground and proper use of foundation steelwork for the purpose of forming an effective earth termination may well be impossible once construction work on a site has commenced. Therefore, soil resistivity and the nature of the earth should be considered at the earliest possible stage of a project. This information is fundamental to the design of an earth termination system which may influence the foundation design work of architects.

To avoid unnecessary work, regular consultation between lightning protection system designers, architects and builders is essential.

This standard provides information on setting up Lightning Protection Systems (LPS) for common structures.

The design, installation and materials of LPS should fully comply with the provisions of this standard.

1. General

1.1 Scope and object

1.1.1 Scope

This standard provides information for the design, installation, inspection and maintenance of Lightning Protection Systems (LPS) using rods, stretched wires, and mushed conductors as air-termination system for the protection of structures against lightning as indicated in Sub-clause 1.1.2, as well as for persons, installations and contents in or on them.

Note – Air -termination systems other than those considered in this standard such as early streamer emission terminals exist but are outside the scope of this Standard. They are taken into account in the standards issued by National Committees of some countries.

1.1.2 Object

This standard is applicable to the design and installation of Lightning Protection Systems (LPS), as defined in Sub-clause 1.1.1, for common structures up to 60 m high.

The following cases are outside the scope of this standard:

a) railway systems;
b) electrical transmission, distribution and generating systems external to a structure;
c) telecommunication systems external to a structure;
d) vehicles, ships, aircraft, offshore installations.

Note – Usually the systems from a) to d) are under special regulations made by various specific authorities.

Additional requirements to those specified in this standard are necessary in the case such as:

- tall structures (above 60m height);
- structures dangerous to their surroundings due to explosion or to propagation of fire;
- structures dangerous to the environment due to the possible emission of toxic, radioactive, contamined or polluted substances;
- temporary structures and structures under construction;
- tents, camping sites and sports fields;
- installations and electronic equipment sensitive to overvoltages.

Note – Components used for erection of the LPS are covered by EN 50164 "Lightning protection components" (in preparation).

1.2 Terms and definitions

For the purpose of this standard, the following definitions apply.

1.2.1 Lightning to earth

An electrical discharge of atmospheric origin between cloud and earth consisting of one or more strokes.

1.2.2 Lightning stroke

A single electrical discharge in a lightning to earth.

1.2.3 Point of strike

A point where a lightning stroke contacts the earth, a structure or an LPS.

Note – A lightning may have more than one point of strike.

1.2.4 Lightning current (i)

The current flowing at the point of strike.

1.2.5 Peak value (I)

The maximum value of the lightning current.

1.2.6 Average steepness of the lightning current ($\Delta i/\Delta t$)

The average rate of change of current calculated over the 30% to 90% of peak amplitude on the wave front.

$$\Delta i/\Delta t = \frac{I_{90} - I_{30}}{t_{90} - t_{30}}$$

1.2.7 Flash duration (T)

Time for which the lightning current flows at the point of strike.

1.2.8 Total charge (Q_{total})

The time integral of the lightning current for the entire lightning duration.

1.2.9 Impulse charge ($Q_{impulse}$)

The time integral of the lightning current for the impulse part of the lightning duration.

1.2.10 Specific energy (SE)

The energy dissipated by the lightning current in a unit resistance. It is the time integral of the square of the lightning current for the duration of the lightning.

1.2.11 Direct lightning

A lightning which strikes directly the structure or its LPS.

1.2.12 Indirect lightning

A lightning which strikes the earth in the vicinity of the structure, or the services entering the structure.

1.2.13 Direct lightning frequency (N_d)

The expected average annual number of direct lightnings to the structure.

1.2.14 Common structures

Common structures are structures used for ordinary purposes whether commercial, industrial, farm, institutional or residential.

1.2.15 Structure to be protected

The structure for which protection against the effects of lightning in accordance with this standard is required.

1.2.16 Protected volume

The volume that is assumed not to be directly struck by the lightning.

1.2.17 Tolerable lightning frequency (N_c)

The maximum accepted average annual number of lightnings which can cause damage to the structure.

1.2.18 Risk of damage (R_d)

The probable annual losses (humans and goods) in a structure due to lightnings.

1.2.19 Lightning protection system (LPS)

The complete system used to protect a volume against the effects of lightning. It consists of both external and internal lightning protection installations (LPI).

Note – In particular cases, an LPS may consist of an external or an internal installation only.

1.2.20 Efficiency of LPS (E)

The ratio of the average annual number of direct lightnings which cannot cause damage to the structure protected by an LPS, to the direct lightning number to the structure.

1.2.21 Protection level

A term denoting the classification of an LPS according to its efficiency.

Note – It expresses the probability with which an LPS protects a volume against the effects of lightning.

1.2.22 External lightning protection installation

Consists of an air-termination system, a down-conductor system and an earth termination system.

1.2.23 Internal lightning protection installation

All measures additional to those given in Sub-clause 1.2.22 which would reduce the electromagnetic effects of lightning current within the volume to be protected.

1.2.24 Lightning equipotential bonding (EB)

That part of an internal LPI which reduces potential differences caused by lightning current.

1.2.25 Air-termination system

That part of an external LPI which is intended to intercept lightnings.

1.2.26 Down-conductor

That part of an external LPI which is intended to conduct lightning current from the air-termination system to the earth-termination system.

1.2.27 Ring conductor

Conductor forming a loop around the structure and interconnecting the down-conductors for an equal distribution of lightning current among them.

1.2.28 Earth-termination system

That part of an external LPI which is intended to conduct and disperse lightning current to the earth.

Note – The earth-termination system may intercept lightning currents which flow through the soil due to lightnings to the earth in the neighbourhood.

1.2.29 Earth electrode

A part or group of parts of the earth-termination system which provides direct electrical contact with and disperses the lightning current to the earth.

1.2.30 Ring earth electrode

An earth electrode forming a closed loop around the structure below or on the surface of the earth.

1.2.31 Foundation earth electrode

An earth electrode embedded in the concrete foundation of a structure.

1.2.32 Equivalent earth resistance

The ratio of the peak values of the earth-termination voltage and the earth-termination current which, in general, do not occur simultaneously. It is used conventionally to indicate the efficiency of the earth-termination system.

1.2.33 Earth-termination voltage

The potential difference between the earth-termination system and the remote earth.

1.2.34 "Natural" component of an LPS

A component not installed specifically for lightning protection which can be used in addition to the LPS or in some cases could provide the function of one or more parts of the LPS.

Note – Some examples of the use of this term are as follows:
- "natural" air-termination;
- "natural" down-conductor;
- "natural" earth electrode

1.2.35 Metal installations

Extended metal items in the structure to be protected which may form a path for lightning current, such as pipe-work, staircases, elevator guide rails, ventilation, heating and air conditioning ducts, and interconnected reinforcing steel.

1.2.36 External conductive parts

Extended metal items entering or leaving the structure to be protected such as: pipe works, cable screens, metal ducts, etc. which may carry a part of the lightning current.

1.2.37 Bonding bar

A bar on which metal installations, external conductive parts, electrical power and telecommunication lines, and other cables can be bonded to an LPS.

1.2.38 Bonding conductor

Conductor for equalization of potentials.

1.2.39 Interconnected reinforcing steel

Steelwork within a concrete structure which is considered electrically continuous.

1.2.40 Dangerous sparking

An unacceptable electrical discharge caused by lightning current inside the structure to be protected.

1.2.41 Safety distance

The minimum distance between two conductive parts within the structure to be protected between which no dangerous sparking can occur.

1.2.42 Surge Protective Device (SPD)

A device designed to limit the surge voltages between two parts such as a spark gap, surge diverter, semiconductor device, etc.

1.2.43 Test joint

A joint which is designed and situated to facilitate electrical testing and measurement of LPS components.

1.2.44 External LPI isolated from the structure to be protected

An LPI whose air-termination system and down-conductor system are positioned in such a way that the path of the lightning current has no contact with the structure to be protected.

1.2.45 External LPI not isolated from the structure to be protected

An LPI whose air-termination system and down-conductor system are positioned in such a way that the path of the lightning current can be in contact with the structure to be protected.

1.3 Reinforced concrete structures

Steelwork within reinforced concrete structures is considered to be electrically continuous provided that it fulfils the following conditions:

a) approximately 50% of interconnections of vertical and horizontal bars are welded or are securely tied;

b) vertical bars are welded or are overlapped a minimum of 20 times their diameters and securely tied;

c) electrical continuity of the reinforcing steel is established between individual precast concrete units and other adjacent precast concrete units.

1.4 Protection levels

The characteristics of required LPS depend on the characteristics of the structure to be protected and on the protection level to be achieved.

Four different protection levels are considered in this standard.

The efficiency of LPS decreases from protection level I to protection level IV. The relation between protection levels and efficiency is given in Table 1 for selection of protection level purposes.

The appropriate protection level shall be selected on the basis of the risk of damage evaluation.

A guidance for selection of the LPS is given in Annex F.

1.5 Lightning current parameters

The values of lightning parameters corresponding to protection levels are given in Table 2.

Statistical distribution of lightning current parameters and their effects on LPS are reported in Annex A.

1.6 Design of the LPS

A technically and economically optimized design of an LPS is only possible if the steps in the design of the LPS are correlated with the steps in the design and construction of the structure to be protected. In particular, the possible utilization of metal parts of a structure as parts of the LPS should be foreseen in the design of the structure itself.

2. External lightning protection installation

2.0 General

The external LPI is intended to intercept direct lightnings, to conduct lightning current from the point of strike to the earth and to disperse it to the earth without causing thermal and mechanical damages to the structure to be protected, and overvoltages dangerous for persons.

2.0.1 Choice of type of external LPI

In most cases, the external LPI may be attached to the protected structure.

An isolated external LPI should be used when the thermal effects on the point of strike or on conductors carrying the lightning current may cause damage to the structure or to the content of the volume to be protected.

Notes: 1 – Typical cases are:
- structures with combustible covering
- structures with combustible walls
- areas with danger of explosion and fire

2 – The use of an isolated LPI may be convenient where it is predicted that changes in structure, contents or use of the volume to be protected may cause modifications to the LPI.

Dangerous sparking shall be avoided:

– in isolated external LPI by insulation or separation according to Clause 3.2;

– in non isolated external LPI by bonding, according to Clause 3.1, or by insulation or separation according to Clause 3.2.

2.0.2 Use of natural components

Natural components which will always remain in the structure, which will not be modified and whose conductivity is measurable (e.g.: interconnected reinforced steel, metal framework of the structure, etc.) can be used as part of LPS.

Other natural components should be used only in addition to LPS.

Note – Natural components should only be used as parts of the LPS with the agreement of the structural engineer for the building or the property owner.
In this case, connection points should be provided during construction.

2.1 Air-termination systems

2.1.1 General

The probability of a lightning stroke penetrating the structure to be protected is considerably decreased by the presence of a properly designed air-termination system.

The air-termination systems can be composed of any combination of the following elements:

1) rods;
2) stretched wires;
3) meshed conductors.

2.1.2 Positioning

In determining the position of the air-termination system, two methods are generally used. These are the "protection angle" method and the "rolling sphere" method.

For most simple shape buildings, the protection angle method is suitable, but the rolling sphere method is suggested for complicated cases.

Where plane surfaces are to be protected, a third method, "the mesh method", is a suitable form of protection.

The values for protection angle, rolling sphere radius and mesh size are given in Table 3 according to the protection level chosen; the positioning of the air-termination system is given in Annex B.

2.1.3 "Natural" components

The following parts of a structure may be considered as "natural" air-termination components:

a) metal sheets covering the structure to be protected providing that:
   – the electrical continuity between the various parts is made durable (e.g. by means of brazing, welding, crimping, screwing or bolting);
   – the thickness of the metal sheet is not less than the value *t* given in Table 4 if it is necessary to take precautions against puncture or to consider hot spot problems;
   – the thickness of the metal sheet is not less than:
     - 0,5 mm for galvanized steel;
     - 0,4 mm for stainless steel;
     - 0,3 mm for copper;