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Lesnická a dřevařská fakulta Mendelova univerzita v Brně

NATURE AND LANDSCAPE MANAGEMENT STANDARDS

ARBORIST STANDARDS	**PROTECTION OF TREES AGAINST LIGHTNING STRIKE**	**SPPK A02 006:2016**
SERIES A		

Protection of trees against lightning strike

Baumschutz gegen Blitzeinschlag

This standard is intended as a definition of material and technical equipment and work procedures for assurance of protection of trees and adjacent structures against lightning strike.

References:

ČSN EN 62 305-1 ed. 2 Protection against lightning - Part 1: General principles 2012
ČSN EN 62 305–2 Protection against lightning - Part 2: Risk management 2013
ČSN EN 62 305-3 ed. 2 Protection against lightning - Part 3: Material damage to structures and life danger 2012
ČSN EN 62 305-4 ed. 2 Protection against lightning - Part 4: Electric and electronic systems in structures 2012
ČSN EN 62 561–1 December 2012 Lightning protection system components - Part 1: Requirements for connecting components
ČSN EN 62 561–2 Lightning protection system components (LPSC) - Part 2: Requirements for conductors and grounding electrodes
ČSN EN 62 561-4 Lightning protection system components (LPSC) - Part 4: Requirements for conductor supports
ČSN EN 50 164–5 Lightning protection components (LPC) - Part 5: Requirements for inspection cabinets and grounding electrode design
ČSN EN 62 561-7 Lightning protection system components (LPSC) - Part 7: Requirements for ground-improving mixtures
BMP – Tree Lightning Protection Systems, International Society of Arboriculture, 2002
ANSI A300 (Part 4) – Lightning Protection Systems, International Society of Arboriculture, 2008
EU Directive 2011/65/EU (RoHS) on the restriction of the use of certain hazardous substances in electrical and electronic equipment

Act no. 114/1992 Coll. on Nature and Landscape Protection, as amended
Act no. 174/1968 Coll. on State Supervision over Occupational Health Protection, as amended
Act no. 183/2006 Coll. Building Act, as amended

MRD Decree no. 499/2009 Coll. on Building Documentation
Decree no. 73/2010 Coll., defining designated electric devices, their classification into classes and categories, and detailed requirements on their safety (Designated Electric Devices Decree)

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Contents

1. Standard purpose and contents

1.1 Standard purpose

1.1.1 The standard "Protection of trees against lightning strike" defines the method for determining risks of property or health damage in connection with lightning strike on a tree and techniques of their potential minimisation using protective procedures.

1.1.2 The standard describes model types of installation and recommends materials and work procedures for installation of protective measures.

1.1.3 The standard is intended for application primarily to trees of great value or trees near buildings or other structures requiring protection.

1.1.4 Implementation of measures on trees defined by this standard must not result to damage to non-forest trees pursuant to Section 7 of Act no. 114/1992 Coll. and Section 2 of Decree no. 189/2013 Coll.

1.2 Qualifications of persons

1.2.1 LPS project designs shall be developed by persons professionally qualified pursuant to legislative requirements in accordance with the wording of this standard.

1.2.2 Persons doing installation, repairs, inspections and testing of LPS have to possess authorisation issued by a state professional supervision organisation pursuant to Act no. 174/1968 Coll. and a valid certificate for inspection of electric equipment pursuant to Section 9 of Decree no. 50/1978 Coll.

1.2.3 The recommended qualification of persons making **assessments** of **tree condition** and detailed designs for installation of LPS on specific woody plants is passing of the certification test Czech Certified Arborist – Consultant.[1]

1.2.4 The recommended qualification for persons doing the **LPS installation** in cooperation with persons qualified pursuant to 1.2.2 above is passing of the certification test Czech Certified Arborist – Specialist for Tree Climbing Technique[1], ISA Certified Tree Worker Climber Specialist®[2] or European Treeworker[3].

[1] Certification scheme provided by the Faculty of Forestry and Wood Technology of the Mendel University in Brno.
[2] Certification scheme provided by the International Society of Arboriculture.
[3] Certification scheme provided by the Czech Landscape and Garden Society.

2 General context

There are no devices or methods that would allow modification of natural atmospheric processes to the extent that they could prevent lightning discharges. It is therefore advisable to consider options for installation of lightning protection by trees of great value and trees growing near buildings and other structures, which would reduce potential consequences.

The need for protection, economic benefits of installation of protective measures, and a selection of measures are defined in this standard. In the case of trees, they include primarily a set of protective measures to reduce material damage and danger.

Installation of lightning protection is intended to minimise the risk of damage to the tree and adjacent structures when struck by lightning. Its purpose is not direct protection of persons against lightning strike or injury by contact or step voltage. Protected trees and their immediate surroundings are not a suitable hiding place during a storm.

The physical parameters of lightning and potential damage caused by a lightning strike on or near a structure or utility network line are defined in the standard series in force ČSN EN 62 305. A lightning strike on a tree may cause:

- direct mechanical damage to the tree (part of crown breaking off, trunk splitting, etc.),
- explosion caused by the passage of the lightning current changing liquids and substances in the tree into vapour,
- tree fire (e.g., a hollow) ignited by a lightning spark,
- personal injury by burning or by falling parts of the tree or step or contact voltage caused by the lightning striking the tree.

In the case of trees of great value, lightning damage may cause loss of irreplaceable cultural heritage.

3 Necessity and economic benefits of LPS

3.1 Choice of trees for LPS installation

3.1.1 A tree should be equipped with lightning protection in case it is an exposed individual or it matches one of the following parameters:

- it is a tree promulgated as a memorial pursuant to Act no. 114/1992 Coll. or otherwise important tree,
- it is a tree of a social/environmental value of more than CZK 1,000,000 according to the NCA CR methodology,
- the tree is located near a building (closer than 3 m) that has lightning protection and is lower than the tree or its branches extend over the building.

3.1.2 The probability of a lightning strike can be increased by the following factors:

- tree growing near a watercourse or water body,
- growth on sites with a significant presence of ores,
- trees penetrating moister soil layers with a deep root system,
- growth on top of a hill or on a slope facing the oncoming storm,
- growth at the edge of a stand, solitary or at ends of avenues,
- trees growing taller in a stand or group of trees,
- growth on sites with historic evidence of lightning strikes.

3.1.3 A tree meeting the above conditions but located in a continuous stand of trees of identical height or taller or surrounded by structures of identical height or taller does not need protection.

3.1.4 Protective measures for buildings near trees are governed by the standard series ČSN EN 62 305.

3.1.5 Buildings in LPL I and II need to consider implementation of protective measures against secondary effects of lightning after a strike on a tree and receive lightning protection in case it does not meet the lightning protection conditions.

3.2 Tree protection levels

3.2.1 Trees that should be protected from lightning according to 3.1.1 above are divided into two groups, namely lower-level and higher-level protective measures.

3.2.2 **Lower-level protective measures.** These area applied to trees near structures and trees that are not memorial. The parameters of the protective measures are identical to those for LPL IV under the standard series ČSN EN 62 305.

3.2.3 **Higher-level protective measures.** Their parameters are identical to those for LPL II under the standard series ČSN EN 62 305.

3.2.4 In the case of higher-level protective measures and if the shape of the tree crown and trunk permit, an isolated conducting system should be built pursuant to ČSN EN 62 305–3 to minimise potential damage to the main tree trunk by a lightning strike.

3.2.5 Lightning protection levels (LPL) pursuant to ČSN EN 62 305–1 are described in detail in Annex 1.

4 LPS design and establishment

4.1 LPS design

4.1.1 LPS are designated technical equipment.

4.1.2 **Assessment of current tree condition** has to be made by a professional arborist (competent person pursuant to SPPK A01 001 – Assessment of tree condition). The tree must not show any principal defects that would significantly limit its outlook or endanger employees installing the LPS.

4.1.3 LPS installation always has to be assessed in the context of the entire area with adjacent trees and buildings in which it is situated. Achievement of the protection objective should not adversely affect the immediate surroundings, including the tree itself. The assessment shall be made in the form of an arborist report.

4.1.4 Before the design, the site for grounding system construction has to be assessed to ensure the tree's root system is not damaged by the installation. Simultaneously, an analysis of the site's pedological and geological conditions has to be made in order to design the depth and type of the grounding system.

4.1.5 The expected annual change in the tree size (increment) has to be determined and reflected in the specification of inspection time and expansion of the conducting system as necessary. In particular, the assessment has to include a specification of the crown increment and an estimate of the rate of ingrowth of supports.

4.1.6 The assessment of tree condition shall also include a quantification of its social/environmental value applying the Nature Conservation Agency of the Czech Republic methodology[4].

4.1.7 **LPS design** shall be developed a person professionally qualified pursuant to legislative requirements. The design shall be made in writing in accordance with the wording of this standard.

4.1.8 The design shall contain:

- a sketch of LPS installation layout in floor plan view and elevation view depicting the grounding system lines and design type,
- delineation of LPS protective zone,
- determination of protection level pursuant to 3.2 above,
- inspection date.

4.1.9 A work procedure has to be developed in order to minimise damage during installation.

4.1.10 The project planning shall include delineation of all underground utility networks in the area.

4.1.11 The grounding system shall be designed primarily:

- outside protective zones of underground utility networks,
- outside main structural roots without damaging them,
- in the direction down the slop below the tree to be protected,
- if possible outside rocky and impermeable surfaces.

[4] Available from www.ocenovanidrevin.nature.cz.

4.1.12 If a tree neighbours on buildings or facilities that have a grounding system, the two grounding systems should be connected by arrangement with their administrator or owner (see Annex 6, Figure 11).

4.1.13 Construction of a conducting system requires determination of earth lead routes so that the direction of grounding system installation follows from them.

4.1.14 If LPS installation concerns memorial trees promulgated pursuant to Act no. 114/1992 Coll., the LPS design has to include a statement from an applicable nature protection authority. LPS installation should be subject to decision of an applicable nature protection authority.

4.1.15 A copy of the LPS design for memorial trees shall be submitted to the nature protection authority promulgating the protection.

4.2 Exterior LPS type design

4.2.1 The design for a conducting system has to achieve a situation where the whole tree crown is located within the protective zone of the conducting system (see Annex 3 and Annex 6, Figures 3 and 5).

4.2.2 The rolling ball method or protective angle method pursuant to ČSN EN 62 305–3 are permissible for designing the location of the conducting system (see Annex 3 and Annex 6, Figures 9 and 10).

4.3 Sizing LPS components

4.3.1 Design of LPS components has to conform to minimum product requirements of the standard series ČSN EN 50 164 (ČSN EN 62 561).

4.3.2 Fastening screws of supports should have an M8 thread (see 5.2.5).

4.4 Random components

4.4.1 Random components refer to all elements present in the tree that are electrically conductive. They may include supports, static safety ties, etc.

4.4.2 Random components have to have a conductive connection with the conducting system, and the connections have to conform to parameters of the expected lightning current flowing through the connection.

4.4.3 Random components should be only an auxiliary addition to the protection, conductively connected with the conducting system, and lightning current should only flow through them in extreme cases.

4.5 Model types of conducting systems, earth leads and grounding systems

4.5.1 In the case of **conical, ellipsoid, cylindrical or fusiform crowns,** the conducting system comprises a lightning rod situated as high up as possible so that, if possible, it is higher than the tree crown. If the branch thickness does not permit the fastening of a lightning rod, the conducting system has to be implemented as a rope wound around the tallest branch. In the case of a crown taller than 20 metres, the lightning electrode has to be installed at that height in the shape of a cross to absorb potential sideways strikes (see Annex 6, Figures 1 and 2).

4.5.2 In the case of **spherical, hemispherical or umbrella-shaped crowns,** the conducting system comprises a lightning rod situated as high up the tree trunks as possible so that, if possible, it is higher than the tree crown. If the branch thickness does not permit the fastening of a lightning rod, the conducting system has to be implemented as a rope wound around the tallest branch (see Annex 6, Figure 4).

4.6 Protective measures against contact voltage

4.6.1 Each tree equipped with a conducting system has to be marked with a warning "DO NOT APPROACH CLOSER THAN 3 METRES TO THE TREE AND ITS CONDUCTING SYSTEM DURING A STORM".

4.6.2 Installation of information boards, seating facilities and other elements attracting people's attention on and near trees with LPS installed is prohibited.

4.7 Protective measures against step voltage

4.7.1 Precautions specified in 4.6 above have to be observed.

4.7.2 If the tree's size and position may function as a rain shelter near tourist or hiking routes, presence of people has to be prevented by mechanical barriers or other adequate measures to reduce the risk of step voltage.

4.7.3 Adequate measures include, for example:

- construction of equipotential sills around the tree,
- equalising the potential around the tree with a grid-shaped grounding system with a mesh size that prevents formation of dangerous step voltage,
- covering the area with potential presence of persons with a 100 mm layer of gravel or 50 mm of asphalt.

Details are specified in ČSN EN 62 305–3.

4.7.4 Protective measures have to be designed so that they preserve a sufficient rootable areas for the tree (see SPPK A02 001 – Planting of trees and A02 007 – Modification of woody plant site conditions).

5 Components and materials

5.0.1 An LPS has the following components:

- lightning electrode, lightning rod,
- conductor,
- earth leads, earth lead system,
- test clamp,
- grounding outlet,
- grounding electrode, grounding system.

see Annex 6, Figure 4.

5.0.2 The lightning electrode, lightning rod and conductor comprise the **conducting system**, the grounding outlet and grounding electrode comprise the **grounding system**.

5.0.3 Use of hazardous substances defined by Directive EU 2011/65, as amended, such as lead, when installing LPS is not permitted.

5.1 Conducting system

5.1.1 The conducting system consists of lightning rods, wires and ropes.

5.1.2 The conducting system should be installed on the tree using supports; on branches leading to the edge of the crown, a rope or wire should be wrapped around the branch.

5.1.3 Fastening using threaded rods is possible on branches at least 200 mm thick.

5.1.4 Ends of lightning lines made of rope should form a loop around the branch connected with a terminal clamp.

5.1.5 Lightning rods have to be fastened to the tree so that they withstand swaying of the crown due to wind.

5.1.6 Preferred materials are aluminium and its alloys, stainless steel and plastics conforming to ČSN EN 62 561-1 (ČSN EN 50 164-1).

5.1.7 Use of other materials specified in product standards and the standard series ČSN EN 62 305 is not recommended.

5.2 Earth lead system

5.2.1 Each tree has to have at least one earth lead (see Annex 6, Figure 7); trees with higher-level protective measures (see 3.2.3 above) have to have at least two opposite earth leads, each on one side of the trunk (see Annex 6, Figure 8).

5.2.2 The earth lead material should be a wire made of aluminium or its alloys. Wires with a plastic coating can be used for earth leads as well (see Annex 2).

5.2.3 The earth lead starts at the highest point of the main trunk and may further branch upwards (see Annex 6, Figure 7).

5.2.4 Fastening to the tree trunk has to be made using line supports according to the methodology pursuant to ČSN EN 62305–3 and in qualitative grade pursuant to ČSN EN 50 164–4 (ČSN EN 62 561–4).

5.2.5 Earth leads are fastened to the tree using supports compliant with ČSN EN 50 164–4 (ČSN EN 62 561–4) using stainless steel threaded bars or combi screws driven into the tree. The preferred thread size is M8 in a drilled hole approximately 60 mm deep.

5.2.6 The installation procedure and drill hole locations have to be approved by an

arborist-consultant in order to minimise damage to the tree. Areas with visible symptoms of wood-decaying fungus infection and structural defects have to be excluded.

5.2.7 An earth lead may be allowed to grow into the tree trunk in exceptional cases. Such cases have to be approved by a professional arborist individually. In such cases, wires made of aluminium or its alloys have to be coated with frost-resistant and UV-stabilised insulation.

5.3 Grounding system

5.3.1 The grounding system design has to conform to ČSN EN 62 305–3, the material has to conform to ČSN EN 50 164–2 (ČSN EN 62 561–2); see Annex 2.

5.3.2 Corrosion-resistant steel should be the preferred material to ensure the longest possible lifetime of the grounding electrode in relation to the tree's lifetime.

5.3.3 **Type A grounding system.** The grounding system consists of a supply line made of strip steel or wire. The minimum dimensions and materials are identical to the requirements for grounding electrodes pursuant to ČSN EN 50 164–2 (ČSN EN 62 561–2). The grounding system itself shall be made preferably from grounding rods designed as per ČSN EN 62 305–3. In the case of higher-level protective measures pursuant to 3.2.3 above, a grounding system shall be made for each earth lead. Grounding electrodes have to be connected in the ground with wire or strip made of a material conforming to ČSN EN 50 164–2 (ČSN EN 62 561–2).

5.3.4 **Type B grounding system.** The grounding system consists of a closed grounding electrode circuit made of wire or strip pursuant to ČSN EN 50 164–2 (ČSN EN 62 561–2). Installation of a type B grounding system has to ensure no significant damage to the tree's root system and no effect on rainwater flow.

5.3.5 The grounding electrode or grounding system should be installed outside the tree crown drip zone so that it is in moist ground.

5.3.6 The grounding electrode has to be installed at a depth greater than the freezing depth at that point (see Annex 5).

5.3.7 Only the length below the freezing depth is considered in rod grounding electrodes (see Annex 4).

5.3.8 Installation of type B grounding systems pursuant to 5.3.4 above is preferred on rocky ground.

5.4 Grounding outlet

5.4.1 A grounding outlet begins at the end of an earth lead with a test terminal clamp. On the trunk, it should begin above the expected snow level. Its typical height is 600–2000 mm.

5.4.2 The materials should conform to ČSN EN 50 164–2 (ČSN EN 62 561–2). Use of stainless materials is recommended.

5.4.3 If hot galvanised steel is used, the grounding outlet has to be protected with additional corrosion protection 300–500 mm above and below ground. A coat of PVC is a suitable solution.

6 Installation, inspection and maintenance

6.1. LPS installation

6.1.1 LPS installation can only be done by persons qualified pursuant to 1.2.2 and 1.2.4.

6.1.2 A project design pursuant to 4.1 has to be developed before commencing LPS installation on the tree.

6.1.3 Earth leads shall run down main trunks and main branches. No earth lead should be bent at an acute angle smaller than 90°. The bending radius should not deform the circular cross-section of the wire.

6.1.4 Distances between supports should not be shorter than 1 m. Around the trunk base in particular, shorter distances between supports may reduce the risk of damage to the LPS.

6.1.5 If any random components are connected to the earth lead system (see 4.4 above), their connection shall run through at least one earth lead. Earth leads must not be wrapped around random components.

6.1.6 An **as-built documentation** has to be developed after completion of works and retain it throughout the LPS service life along with the LPS design and tree condition assessment (see 4.1).

6.1.7 The documentation has to be updated for any changes.

6.1.8 The conducting system of the tree has to include a sign specifying the person in charge of its condition. Typically, this is the tree owner.

6.1.9 Each tree equipped with an LPS should be clearly identified to prevent confusion among trees during inspection.

6.1.10 LPS installation must not be done if there is a danger of a storm coming.

6.1.11 LPS installation shall comply with all requirements for occupational safety and area lockout during arborist operations (see notably SPPK A03 001 – Area lockout during arborist operations, A03 002 – Protective equipment for tree climbing and A03 003 – Work procedures for tree climbing).

6.1.12 LPS installation must not result in excessive damage to the tree (such as damage to the trunk or branches) and its surroundings (for example, compaction of soil within the crown projection). The choice of equipment for work at heights has to correspond to that.

6.1.13 Installation of the grounding system must not result in damage or severance of roots more than 50 mm in diameter. If excavation work is necessary, it shall respect SPPK A01 002 – Protection of woody plants during development activities.

6.1.14 If LPS installation necessitates tree pruning, it shall respect SPPK A02 002 – Pruning of trees. In that case, the pruning should ideally be made before commencement of LPS installation.

6.1.15 It is recommended to make a complete photo documentation of all the main LPS components during installation. The photo documentation shall constitute one of

the annexes to the as-built documentation.

6.1.16 LPS installation shall be completed by submission of an initial inspection report pursuant to 6.3 below.

6.2. Visual inspection

6.2.1 Visual inspection of the conducting system shall be made at least once a year for **higher-level protective measures** pursuant to 3.2.3 above, as long as possible after the inspection pursuant to 6.3. Visual inspection of **lower-level protective measures** pursuant to 3.2.3 shall be made once every two years, as long as possible after the inspection pursuant to 6.3.

6.2.2 In the event of major weather changes, a special inspection is necessary in the spring and autumn of the given year for either level of protective measures.

6.2.4 The visual inspection shall determine:

- whether the conducting system is coherent, undamaged, not excessively corroded and firmly fastened to the tree,
- whether the joints are strong and not excessively corroded,
- whether the conducting system is damaging the tree anywhere by abrasion or growing into the tree,
- whether the conducting system still reaches outside the tree crown,
- whether the grounding system and grounding outlets are exposed due to soil erosion,
- whether the grounding system area shows any signs of excavation work.

6.2.5 A report on the visual inspection and photo documentation of the situation shall be made. The tree owner shall retain the report as part of the LPS documentation.

6.2.6 A copy of the report for memorial trees shall be submitted to the nature protection authority promulgating the protection.

6.3. Conducting system inspection

6.3.1 Inspection of the conducting system shall be made once every two years for **higher-level protective measures** pursuant to 3.2.3. Inspection of **lower-level protective measures** pursuant to 3.2.3 shall be made once every four years.

6.3.2 More frequent inspections can be prescribed based on:

- local conditions (for example, more frequent inspections should be prescribed in environments with high corrosion aggressiveness),
- material used for LPS construction,
- soil conditions and the related expected degree of corrosion to the grounding system.

6.3.3 The inspection shall include the following operations:

- check of unambiguity of technical documentation (LPS design, as-built documentation),
- periodic measurements,
- check of connection of those LPS components that could not be measured during initial installation and then were inaccessible for visual inspection,
- individual and combined measurements of ground resistance of the grounding system.

6.3.4 Ground resistance shall be measured for each local grounding electrode and, where practical, also for the whole grounding system.

6.3.5 Each local grounding electrode should be measured individually by the test terminal clamp between the earth leads and the grounding electrode in disconnected position (individual measurements).

6.3.6 If the total ground resistance of the grounding system exceeds 10 Ω, it should be checked whether the minimum grounding electrode length complies with Annex 4.

6.3.7 If the ground resistance is significantly lower or higher compared to the previous inspection, additional investigation should be made to determined the cause of the change.

6.3.8 Grounding electrodes in rocky areas should conform to requirements of ČSN EN 62 305–3. In this case, the requirement for 10 Ω cannot be met.

6.3.9 If the grounding system is not built in the standard manner or if a check of requirements is not possible due to lack of information, the grounding system should be improved by installation of additional grounding electrodes or a new grounding system.

6.3.10 The inspection outcome is an LPS inspection report. It shall be retained as part of the LPS documentation.

6.3.11 Each LPS inspection report shall contain the following information:

- overall condition of conducting system and its components,
- overall degree of corrosion and condition of corrosion protection,
- protection of LPS line and component fastening,
- measurement of ground resistance of the grounding system,
- any deviation from requirements of this standard,
- documentation of all changes and extensions to the LPS and all changes in the tree,
- results of checks of all LPS structural identification and design of LPS descriptions,
- inspection results.

6.3.12 A copy of the report for memorial trees shall be submitted to the nature protection authority promulgating the protection.

6.4. Maintenance

6.4.1 The LPS has to be periodically maintained so as to ensure no worsening to its functionality and continued compliance with requirements for which it was designed.

6.4.2 Maximum maintenance and inspection intervals shall be observed (see 6.2.1 and 6.3.1).

6.4.3 Any LPS defects and damage identified have to be resolved without undue delay.

6.4.4 If supports are growing into the tree, it is advisable to extend the threaded rods using a stainless steel connecting nut.

6.4.5 If the tree crown has grown above the originally installed apex earth lead, the lead has to be moved higher or the overgrowing branches reduced.

6.4.6 If the earth lead system is damaged, the interrupted section has to be bridged. If the earth lead system is damaged more extensively, it may be advisable to replace the whole lead.

Annex 1 Lightning protection levels (LPL)

Four lightning protection levels (LPL I to IV) are implemented for the purposes of IEC 62 305. A set of maximum and minimum parameters of lightning current is defined for each LPL.

The maximum parameters of lightning current for the different lightning protection levels are shown in Table 1; they are used for designing lightning protection components (for example, wire cross-section, thickness of metal shielding, current load capacity of the SPD, sufficient distances to prevent dangerous sparking) and for determining parameters simulating effects of lightning on said components.

The minimum apex lightning current values for the different LPL are used for deriving the rolling ball radius for determining the lightning protection zone LPZ 0_B, which must not he hit by a direct strike. The minimum lightning current parameters are shown in Table 2 together with applicable rolling ball radii. They are used locating the conducting system and determining the lightning protection zone LPZ 0_B.

Table 1 – Maximum lightning parameters depending on LPL

First positive discharge			**LPL**			
Current parameters	**Designation**	**Unit**	**I**	**II**	**III**	**IV**
Apex current	I	kA	200	150	100	
Discharge charge	Q_{short}	C	100	75	50	
Specific energy	W/R	MJ/Ω	10	5.6	2.5	
Time parameters	T_1/ T_2	μs/μs	10/350			
First negative discharge[a]			**LPL**			
Current parameters	**Designation**	**Unit**	**I**	**II**	**III**	
Apex current	I	kA	100	75	50	
Median slope	di/dt	kA/μs	100	75	50	
Time parameters	T_1/ T_2	μs/μs	1/200			
Following short discharge			**LPL**			
Current parameters	**Designation**	**Unit**	**I**	**II**	**III**	**IV**
Apex current	I	kA	50	37.5	25	
Median slope	di/dt	kA/μs	200	150	100	
Time parameters	T_1/ T_2	μs/μs	0.25/100			
Long discharge			**LPL**			
Current parameters	**Designation**	**Unit**	**I**	**II**	**III**	**IV**
Long discharge charge	Q_{long}	C	200	150	100	
Time parameters	T_{long}	s	0.5			
Discharge			**LPL**			
Current parameters	**Designation**	**Unit**	**I**	**II**	**III**	**IV**
Discharge charge	Q_{flash}	C	300	225	150	

a. The use of this wave shape only corresponds to calculation, not to testing.

Table 2 – Minimum lightning parameters and applicable rolling ball radii adequate to LPL

Interception criteria			**LPL**			
	Designation	**Unit**	**I**	**II**	**III**	**IV**
Minimum apex current	I	kA	3	5	10	16
Rolling ball radius	$_r$	m	20	30	45	60

Weighted probabilities of lightning current parameters being lower than maximum values and higher than minimum values, respectively, defined for each protection level may be determined (see Table 3).

Table 3 – Probabilities for limit lightning current parameters

Probability of lightning current parameters	**LPL**			
	I	**II**	**III**	**IV**
being lower than maximum values defined in Table 3	0.99	0.98	0.95	0.95
being higher than minimum values defined in Table 4	0.99	0.97	0.91	0.84

Protective measures defined in ČSN 62 305-3 and ČSN 62 305-4 are effective against lightning of parameters within the range defined by the LPL adopted in the project design. The effectiveness of the protective measures is therefore assumed based on the probability of the lightning current parameters being within the range. A residual risk of damage remains for parameters exceeding this range.

NOTE 1: Protection against lightning with maximum and minimum lightning current parameters exceed the parameters applicable to LPL I requires more effective measures, which should be selected and built on an individual basis.

NOTE 2: The probability of lightning of minimum and maximum current parameters outside the range of values defined for LPL I is less than 2%.

Maximum lightning current parameters defined for LPL I will not be exceeded with a 99% probability. Depending on the expected polarity ratio, values gained from positive discharges will have a probability below 10%, while the probability of values from negative discharges will remain below 1%.

Maximum lightning current parameters corresponding to LPL I are limited to 75%, to 50% for LPL II, and to 50% for LPL III and LPL IV (in linear fashion for *I*, *Q*and d*i*/d*t*, but in quadratic fashion for , *W*/*R*). The time parameters do not change.

NOTE 3: Lightning protection levels of maximum lightning current parameters lower than those for LPL IV admit damage probabilities higher than those listed in Annex B to IEC 62 305–2:2010, but are not quantified and are useful for better adjustment of protective measures to prevent unjustified expenditures.

Developed based on:
ČSN EN 62 305-1 ed. 2 Protection against lightning - Part 1: General principles

Annex 2 Materials, shapes and minimum cross-sections of conducting system wires, lightning rods, grounding outlets and earth leads[a]

(1) Conducting system wires and lightning rods

Material	Shapes	Cross-section mm^2
Copper, tin-plated copper	Rigid strip	50
	Rigid wire [b]	50
	Rope [b]	50
	Rigid wire [c]	176
Aluminium	Rigid strip	70
	Rigid wire	50
	Rope	50
Aluminium alloy	Rigid strip	50
	Rigid wire	50
	Rope	50
	Rigid wire [c]	176
Copper-plated aluminium alloy	Rigid wire	50
Hot galvanised steel	Rigid strip	50
	Rigid wire	50
	Rope	50
	Rigid wire [c]	176
Copper-plated steel	Rigid wire	50
	Rigid strip	50
Stainless steel	Rigid strip [d]	50
	Rigid wire [d]	50
	Rope	70
	Rigid wire [c]	176

a. The mechanical and electrical characteristics as well as corrosion resistance properties have to conform to requirements of the ČSN 62 561 series.

b. In some applications where mechanical strength is not the primary requirement, the 50 mm^2 (8 mm diameter) can be reduced to 25 mm^2. In that case, attention should be paid to reducing distances between fastening components.

c. This can apply to lightning rods and grounding outlets. Rods 9.5 mm in diameter and 1 m long can be used for lightning rods for which mechanical strain such as wind load is not critical.

d. If mechanical loads have to be considered, then these dimensions should be increased to 75 mm^2.

Developed based on:
ČSN EN 62 305-3 ed. 2 Protection against lightning - Part 3: Material damage to structures and life danger

(2) Grounding electrodes [a, e]

Material	Shapes	Dimensions		
		Grounding rod diameter mm	Grounding wires mm^2	Grounding plate mm
Copper, tin-plated copper	Rope		50	
	Rigid wire	15	50	
	Rigid strip		50	
	Pipe	20		
	Rigid plate			500 × 500
	Grid plate [c]			600 × 600
Hot galvanised steel	Rigid wire	14	78	
	Pipe	25		
	Rigid strip		90	
	Rigid plate			500 × 500
	Grid plate [c]			600 × 600
	Profile	[d]		
Round steel [b]	Finely stranded		70	
	Rigid wire		78	
	Rigid strip		75	
Copper-plated steel	Rigid wire	14[f]	50	
	Rigid strip		90	
Stainless steel	Rigid wire	15[f]	78	
	Rigid strip		100	

a. The mechanical and electrical characteristics as well as corrosion resistance properties have to conform to requirements of the ČSN 62 561 series.

b. Has to be laid in concrete at least 50 mm deep.

c. Grid plate made of wire at least 4.8 m long in total.

d. Various profiles with a cross-section of 290 mm^2 and minimum thickness of 3 mm are permitted, e.g., a transverse profile.

e. For type B foundation grounding electrode, the grounding electrode has to be properly connected with the steel reinforcement every 5 m.

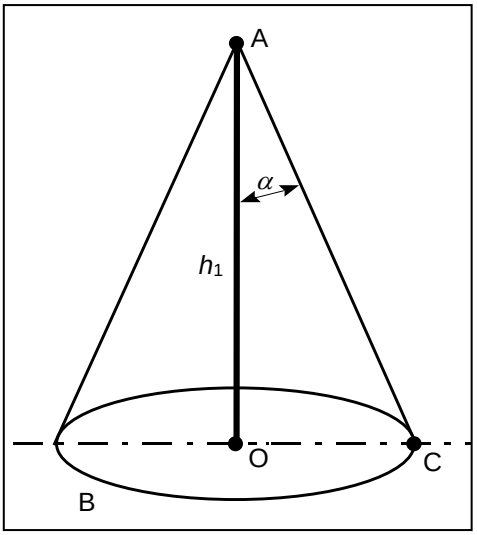
Developed based on:
ČSN EN 62 305-3 ed. 2 Protection against lightning - Part 3: Material damage to structures and life danger

Annex 3 Delineation of protected area

(1) Protective zone for vertical lightning rods

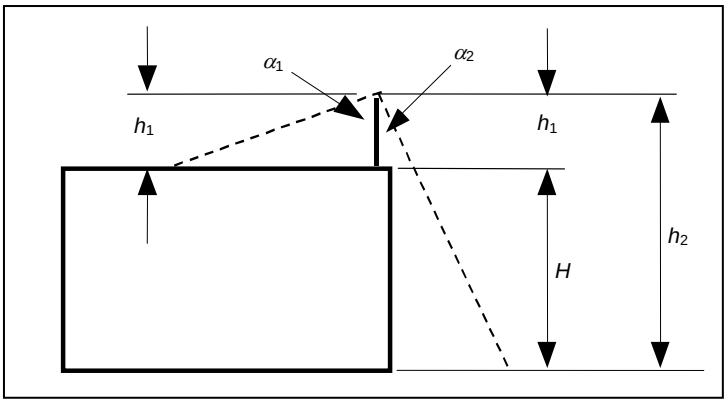
The protective zone for a vertical lightning rod shall consist of an orthogonal cone with its apex situated on the axis of the lightning rod and a half apex angle α depending on the LPS class and the conducting system height (see Diagram 1).

Examples of protective zone for vertical lightning rod:



Explanations

A	Apex of lightning rod
B	Reference plane
OC	Radius of protective zone
h_1	Height of lightning rod above reference plane of protected zone
α	Protective angle according to Diagram 1

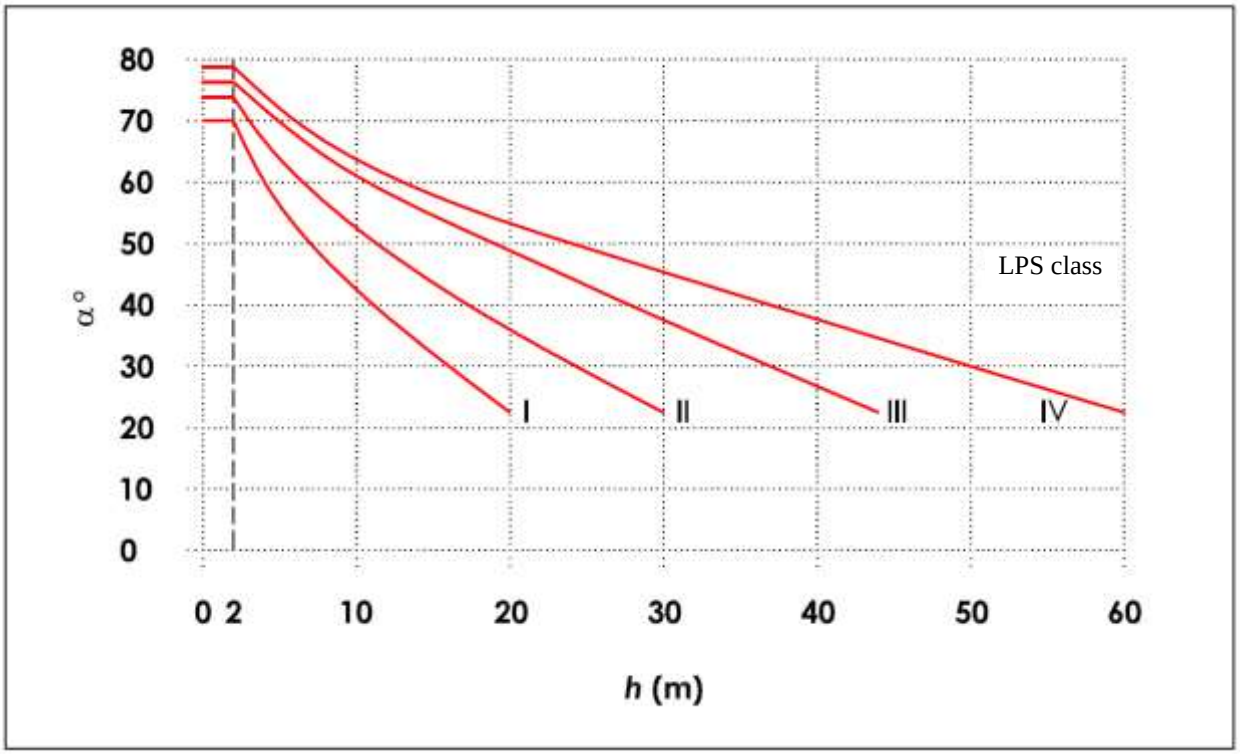


Explanations

h_1	Physical height of lightning rod

NOTE: The protective angle α_1 corresponds to the lightning electrode height h_1, being the height above the protected roof surface; the protective angle α_2 corresponds to the height $h_2 = h_1 + H$, surface of reference plane terrain; α_1 pertains to h_1 and α_2 pertains to h_2.

Diagram 1: Determination of protective angles for different LPS classes



NOTE 1: Not applicable beyond values marked with •. In such cases, only rolling ball and grid system methods shall be used.

NOTE 2: h is the height of the conducting system above the reference plane of the surface to be protected.

NOTE 3: The angle shall not change for *h* below 2 m.

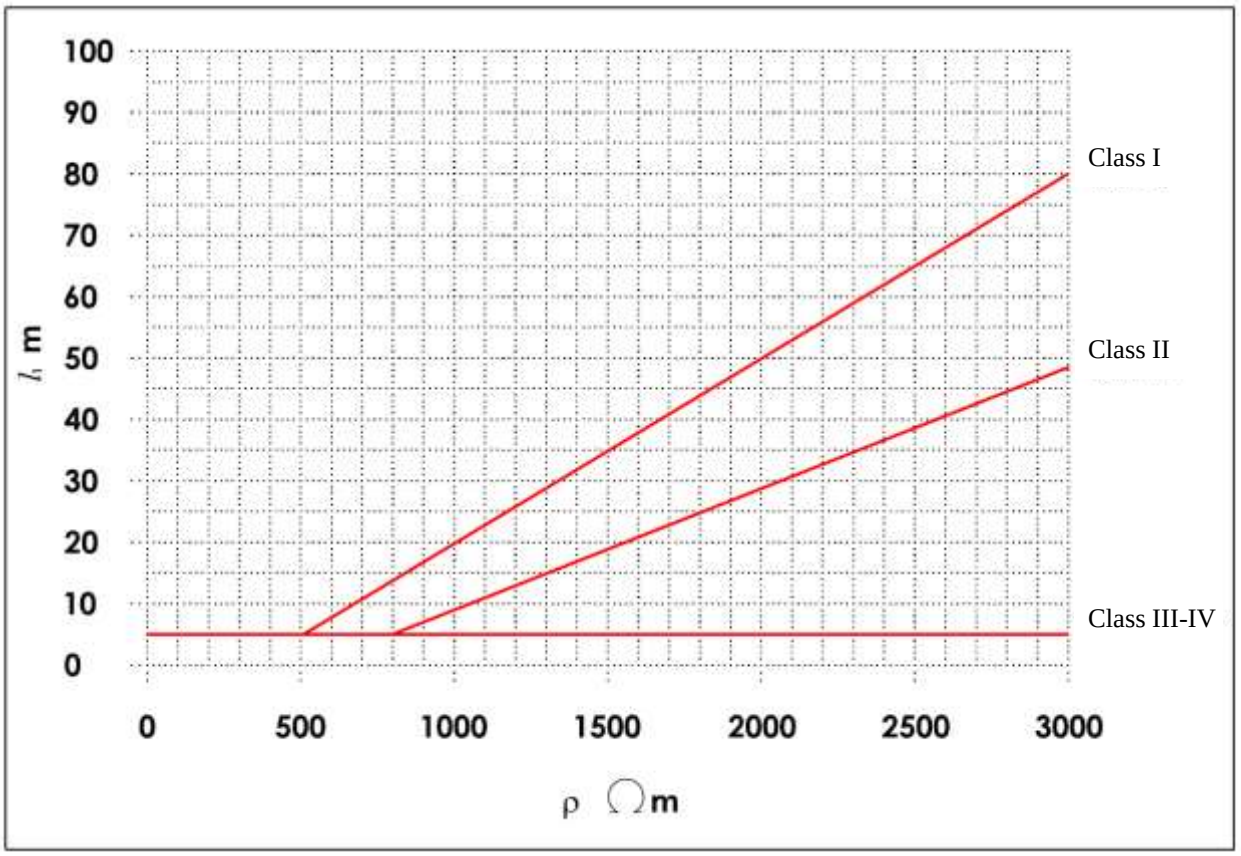
(2) Determination of protective zone using rolling ball method

This method is suitable for conducting system location if no point of the protected structure is in contact with a ball with a radius *r*, which depends on the LPS class (see Annex 1, Table 2), that rolls around the protected structure and over its top in all possible directions. In this manner, the ball only touches the conducting system (see Annex 6, Figure 9).

All structures higher than the rolling ball radius *r* may receive lightning strikes from the side. The greater part of all strikes will hit the top of the structure, and horizontal front edges and corners of structures. Only a small percentage of the total number of strikes will hit the sides of the structure.

Developed based on:
ČSN EN 62 305-3 ed. 2 Protection against lightning - Part 3: Material damage to structures and life danger

Annex 4 Minimum length l_1 of each grounding electrode depending on LPS class



Explanations

l_1 minimum length of horizontal grounding electrodes

ρ ground resistance

The minimum length of each grounding electrode by the foot of each earth lead is:

l_1 for horizontal grounding electrodes

0.5 l_1 for vertical (or inclined grounding electrodes)

NOTE 1: Classes III and IV are independent of soil resistance.

NOTE 2: The total length of grounding electrodes has to be reflected in combined grounding electrode (vertical and horizontal).

NOTE 3: The ground resistance can be reduced virtually only be extending the grounding electrode length up to 60 m.

Developed based on:

ČSN EN 62 305-3 ed. 2 Protection against lightning - Part 3: Material damage to structures and life danger

Annex 5 Determination of freezing depth

Soil type	Minimum freezing depth
Standard freezing depth for ordinary loam-sandy to sand-loamy soils	0.8 m
Fine-grained cohesive (clay-loamy) soils	1.0 m
Shrinking clays and marls	1.4 m
Cases of high water table (higher than 2 m below ground)	1.2 m

Developed based on:

Hájek, P., Fiala, C. (2011): Konstrukce pozemních staveb, CTU Prague

Annex 6 Illustrations

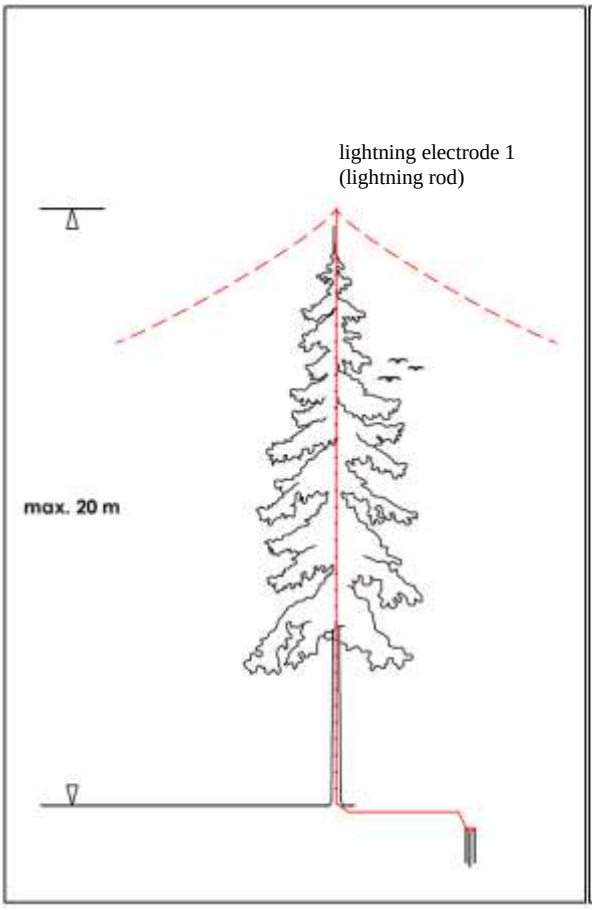


Fig. 1: Model example of LPS installation showing protective zone for vertical lightning rod for conical tree crowns (4.5.1)

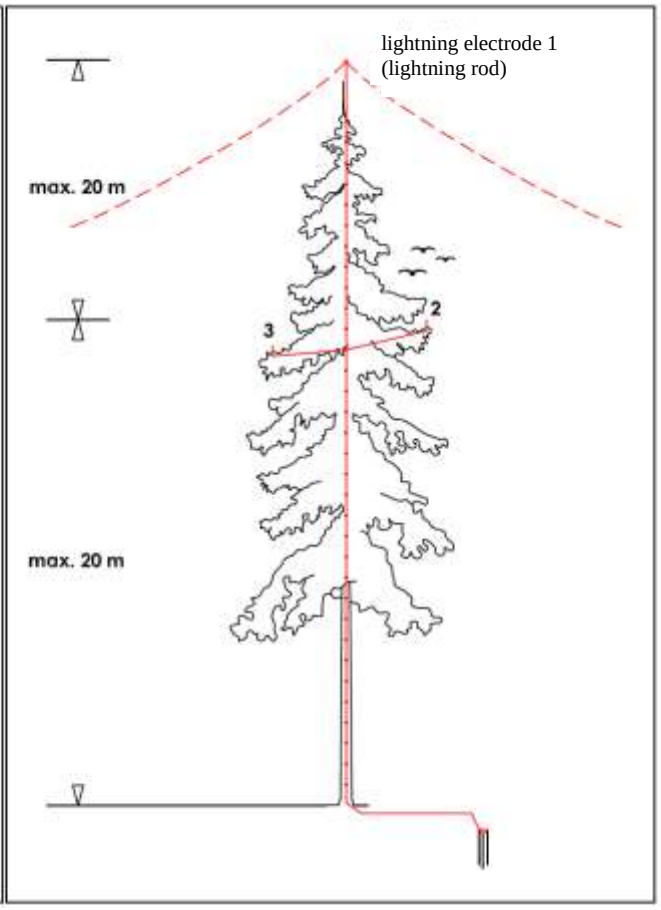


Fig. 2: Model example of LPS installation showing protective zone for vertical lightning rod for conical tree crowns and trees taller than 20 m (4.5.1)

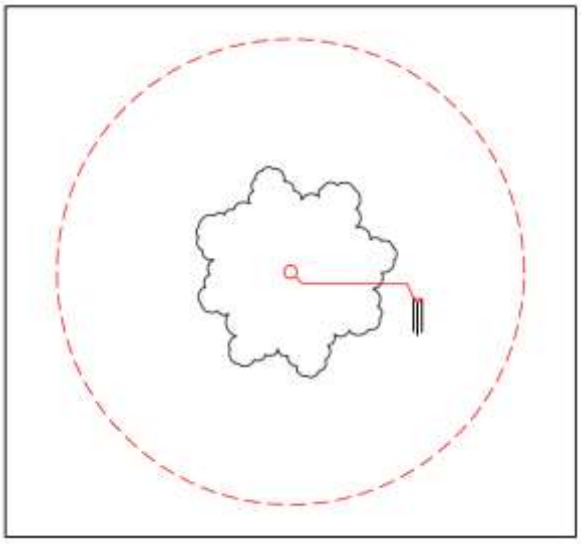


Fig. 3: Protective zone for vertical lightning rod for conical tree crowns

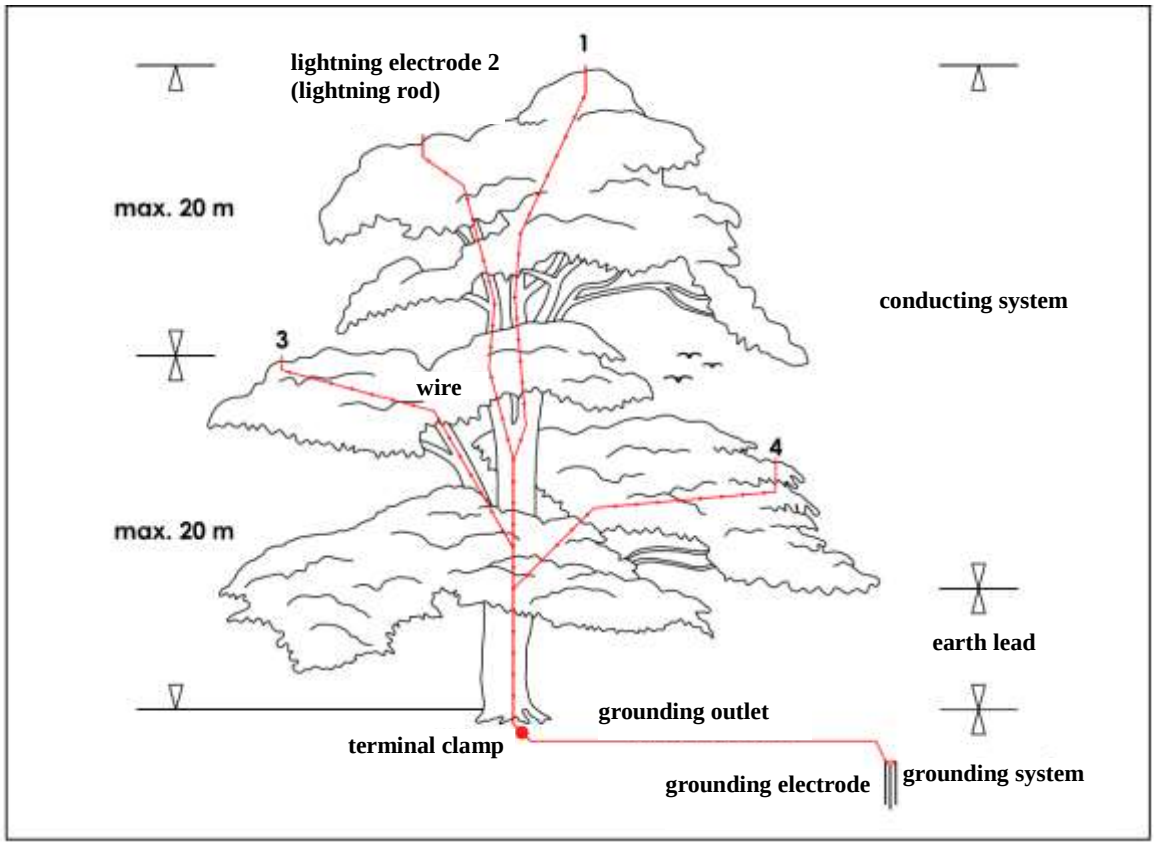


Fig. 4: Model example of LPS installation showing protective zone for vertical lightning rod for umbrella-shaped tree crowns (4.5.2)

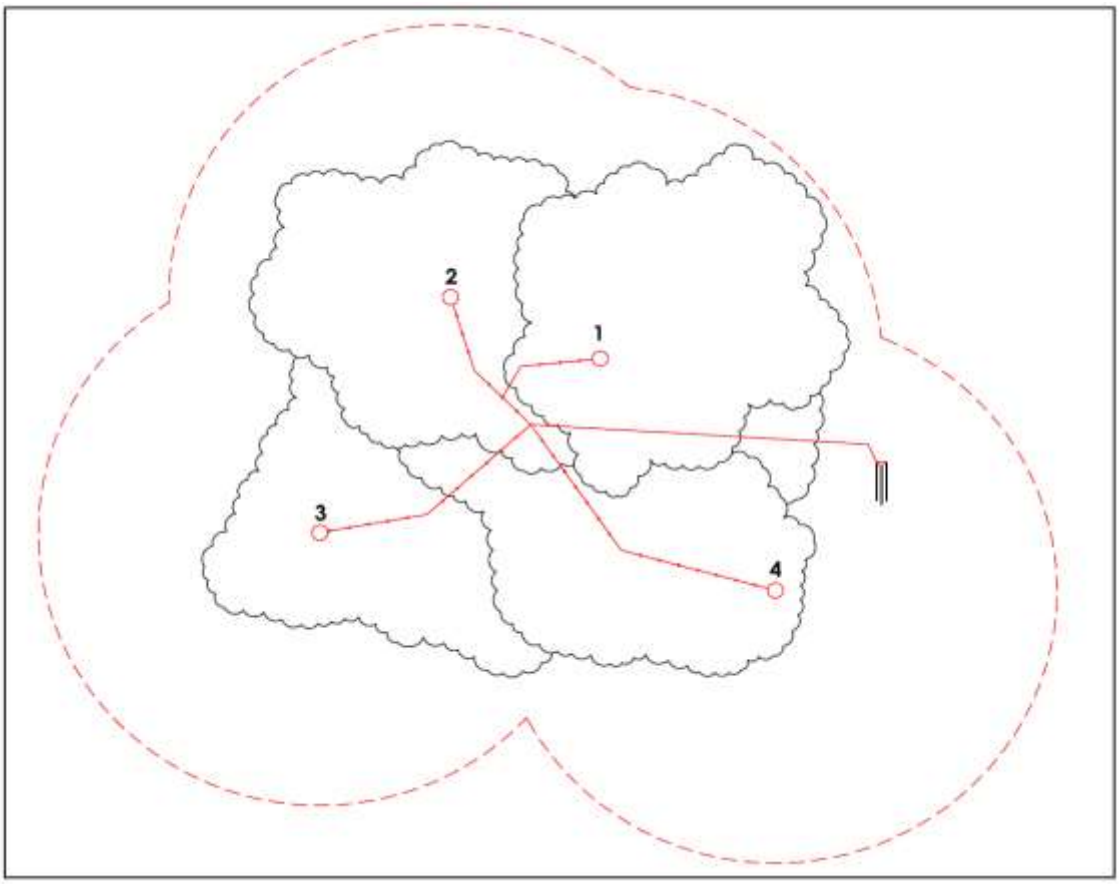


Fig. 5: Protective zone for vertical lightning rod for umbrella-shaped tree crowns (4.5.2)

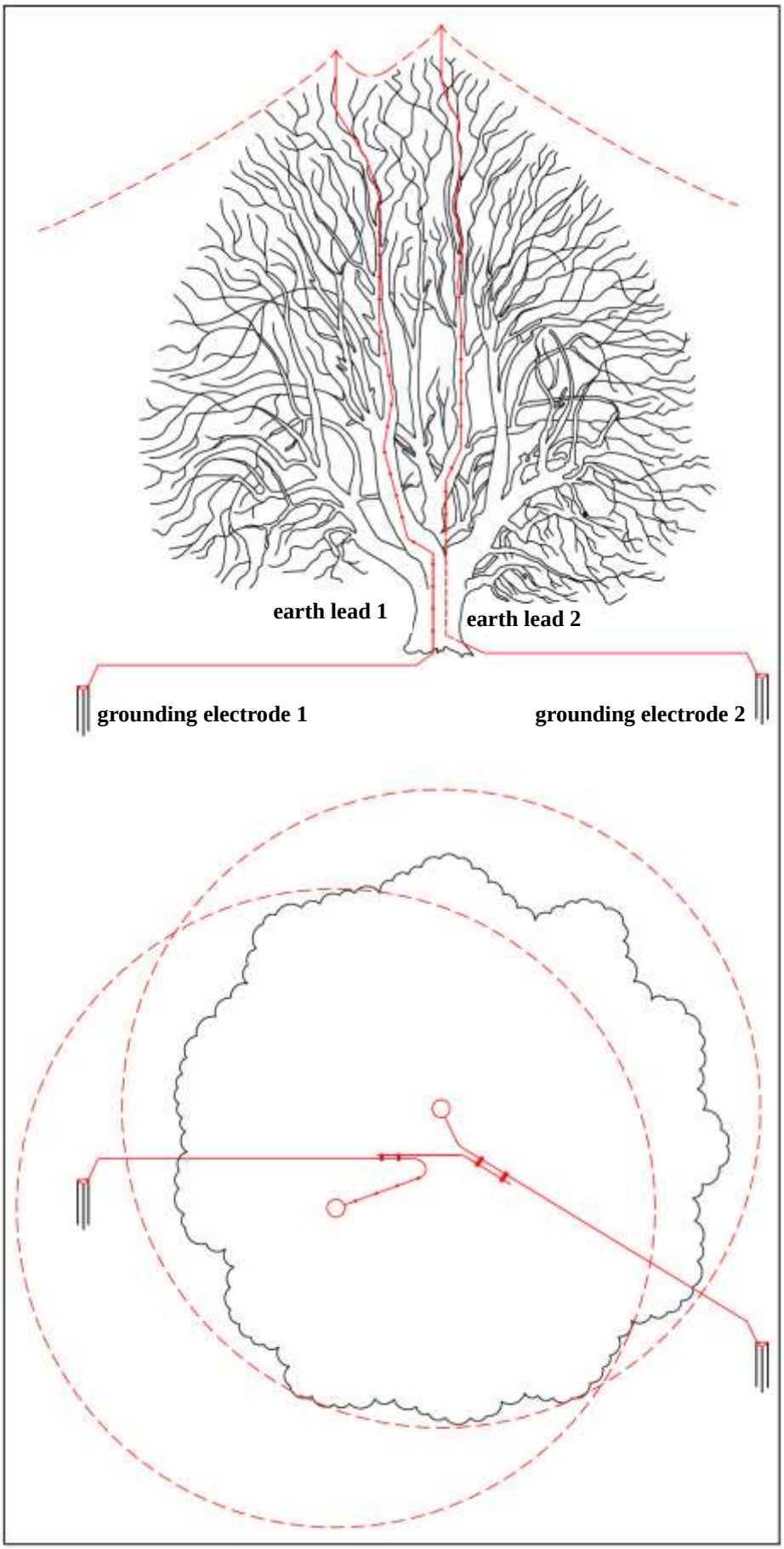


Fig. 6: Model example of LPS installation showing protective zone for vertical lightning rod if two earth leads are used

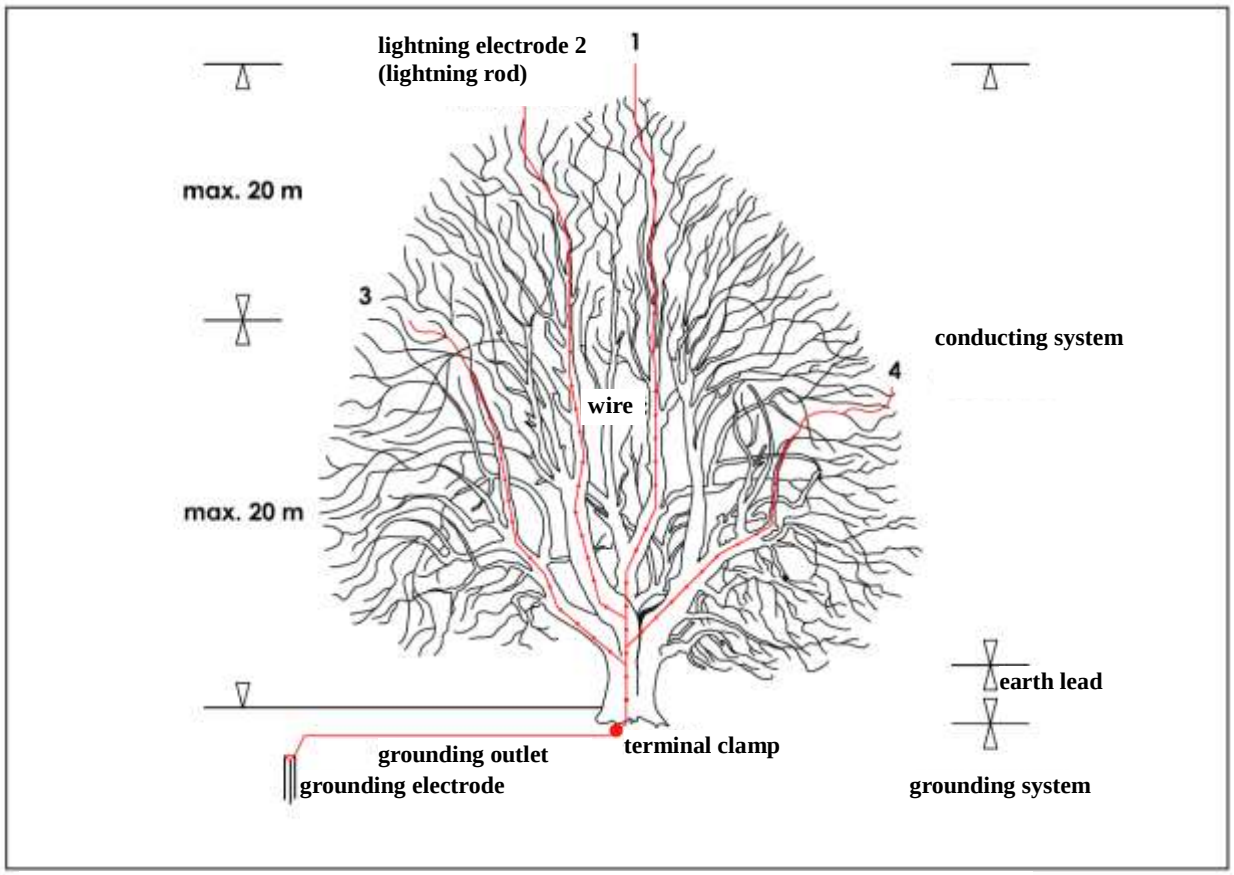


Fig. 7: LPS installation diagram if a single earth lead is used (5.2.1)

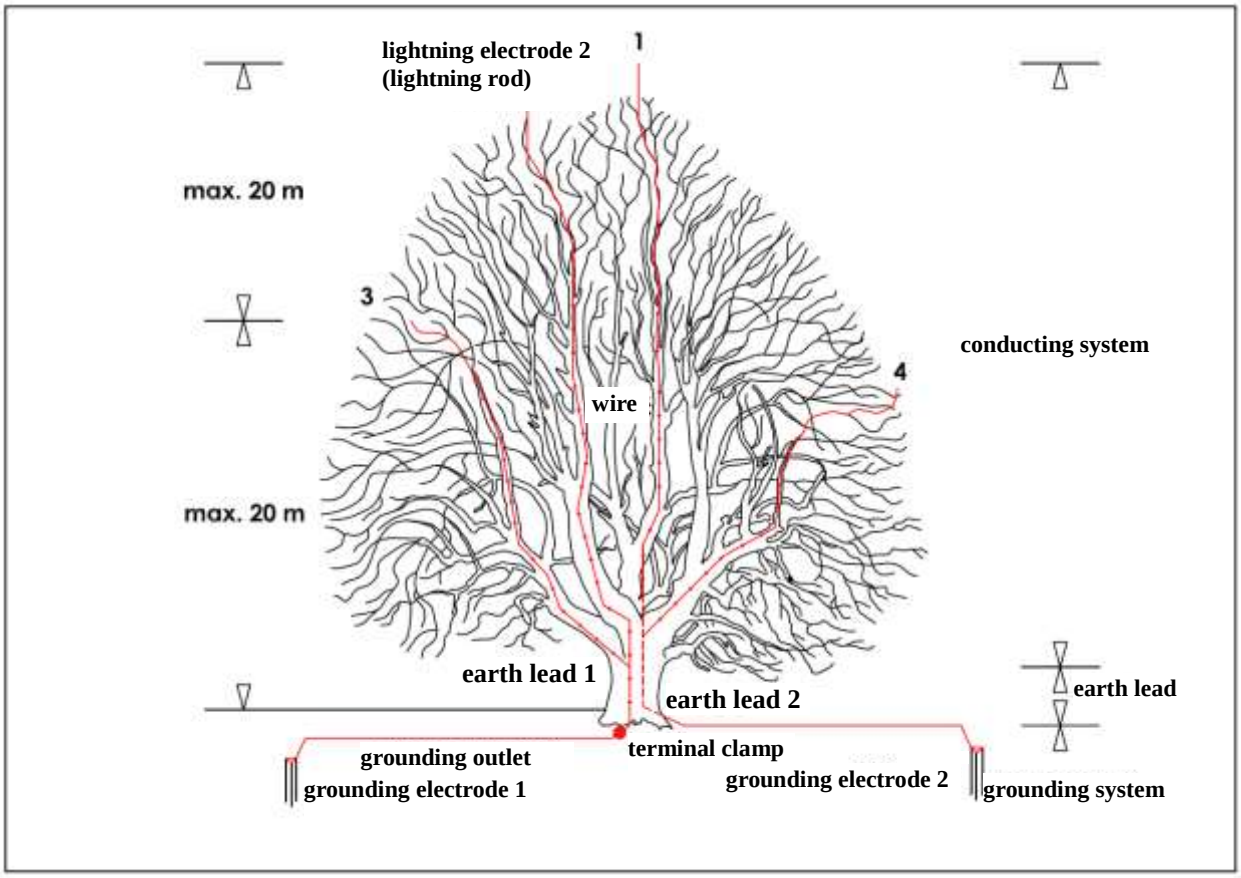


Fig. 8: LPS installation diagram if two earth leads are used (5.2.1)

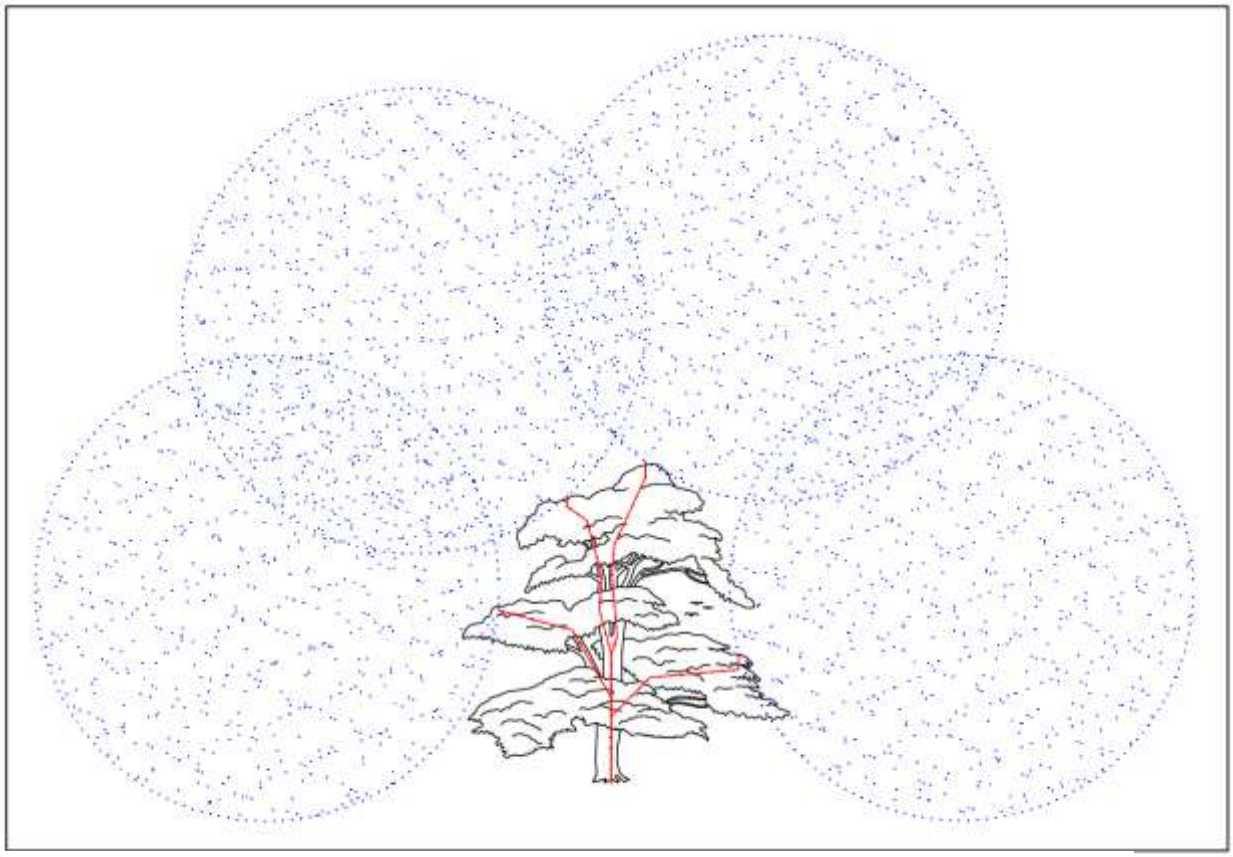


Fig. 9: Protective zone for conducting system calculated using rolling ball method (4.2.2)

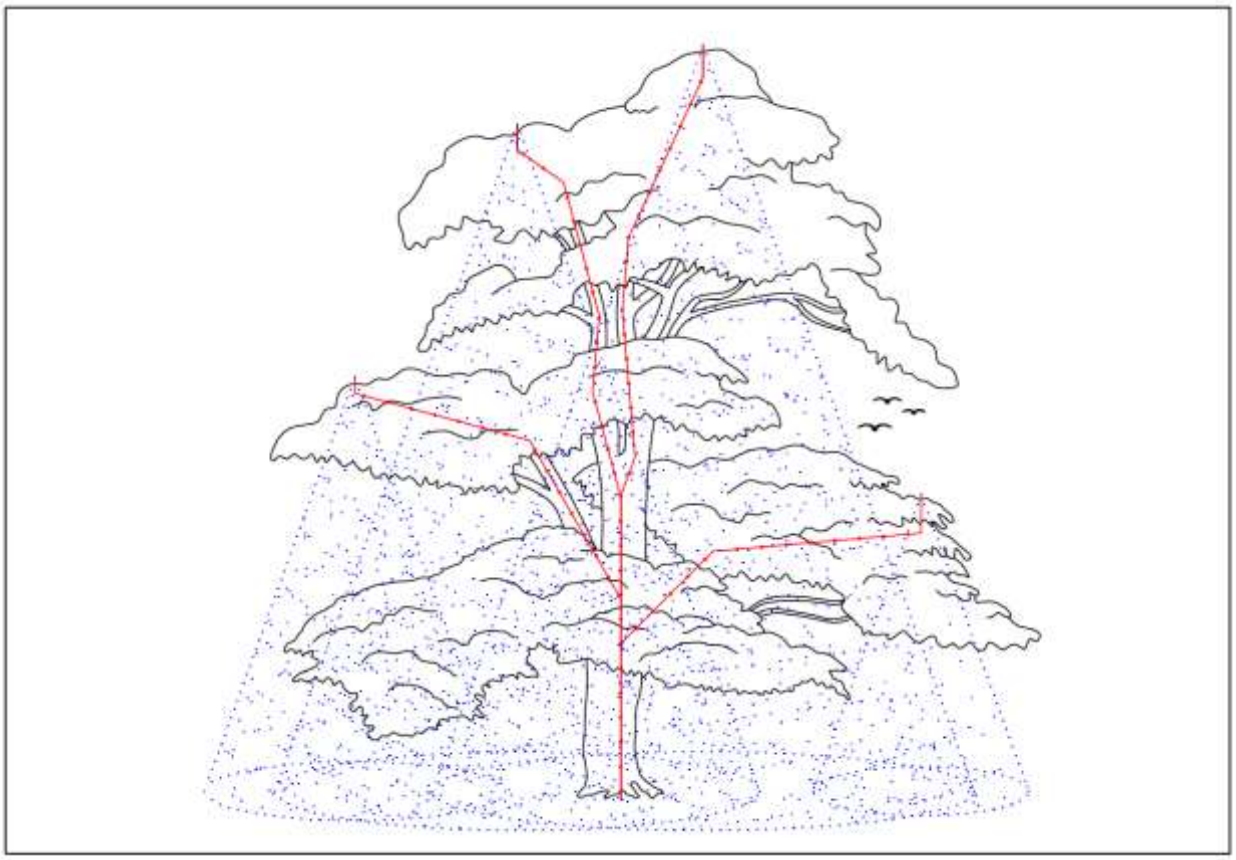


Fig. 10: Protective zone for vertical lightning rod using protective angle method (4.2.2)

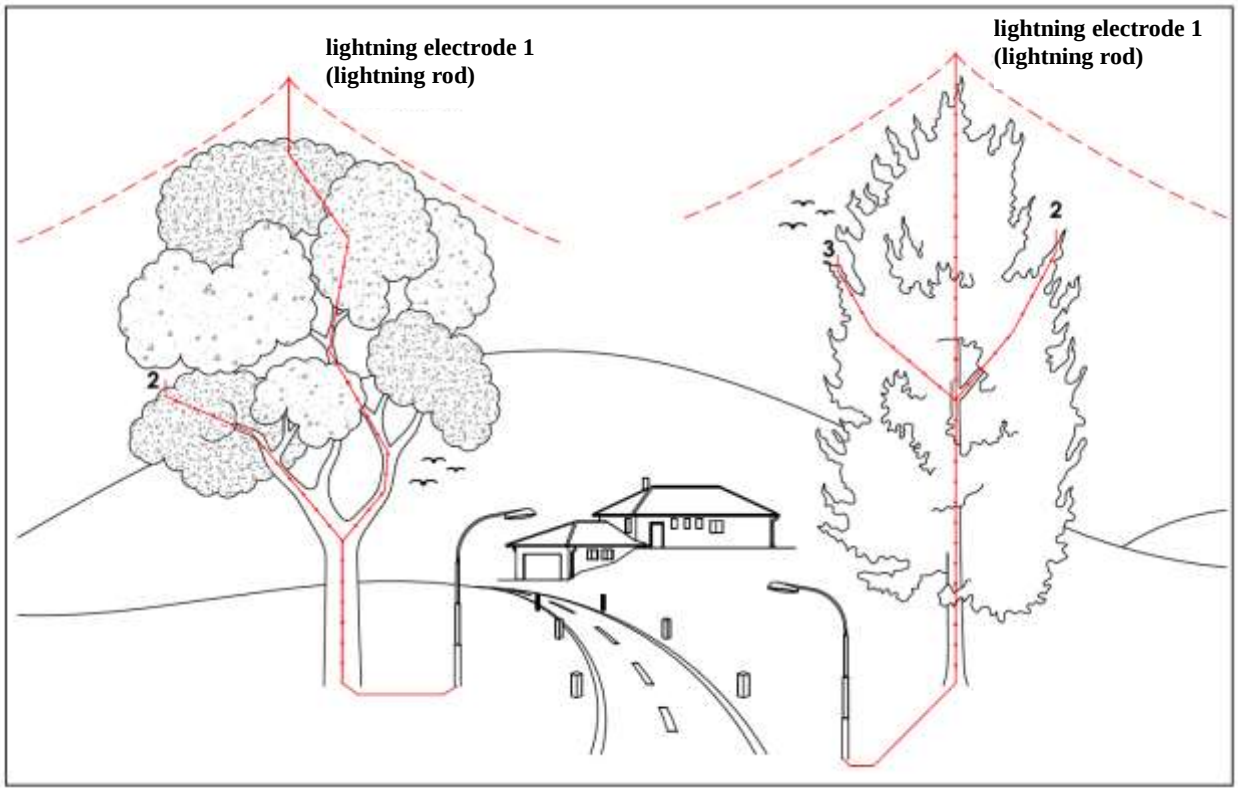


Fig. 11: Model example of connection of grounding system **to an adjacent grounded structure** (4.1.9)

Annex 7 List of Nature and Landscape Management Standards (Arborist Standards) developed

00	**General**
00 001	Terminology
01	**Inspection, assessment, planning**
01 001	Assessment of tree condition
01 002	Protection of woody plants during development activities
02	**Work procedures**
02 001	Planting of trees
02 002	Pruning of trees
02 003	Planting and pruning of shrubs and climbing plants
02 004	Safety bonds and other stabilisation systems
02 005	Cutting of trees
02 006	Protection of trees against lightning strike
02 007	Modification of woody plant site conditions
02 008	Woody plant stand establishment and management
02 009	Special interventions in trees
02 010	Management of woody plants along public transport infrastructures
02 011	Management of woody plants along public technical infrastructures

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