

# Protection against lightning —

## Part 1: General principles

ICS 29.020; 91.120.40

# National foreword

This British Standard is the UK implementation of EN 62305-1:2006, incorporating corrigendum November 2006. It is identical with IEC 62305-1:2006. This standard, together with BS EN 62305-2:2006, BS EN 62305-3:2006 and BS EN 62305-4:2006, supersedes BS 6651:1999, which will be withdrawn on 31 August 2008.

The UK participation in its preparation was entrusted to Technical Committee GEL/81, Protection against lightning.

A list of organizations represented on this committee can be obtained on request to its secretary.

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|              |                                                                           |
|              |                                                                           |

English version

**Protection against lightning**  
**Part 1: General principles**  
(IEC 62305-1:2006)

Protection contre la foudre  
Partie 1: Principes généraux  
(CEI 62305-1:2006)

Blitzschutz  
Teil 1: Allgemeine Grundsätze  
(IEC 62305-1:2006)

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**CENELEC**

European Committee for Electrotechnical Standardization  
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Europäisches Komitee für Elektrotechnische Normung

**Central Secretariat: rue de Stassart 35, B - 1050 Brussels**

# BS EN 62305-1:2006

## Foreword

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Annex ZA has been added by CENELEC.

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## Endorsement notice

The text of the International Standard IEC 62305-1:2006 was approved by CENELEC as a European Standard without any modification.

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## INTRODUCTION

There are no devices nor methods capable of modifying the natural weather phenomena to the extent that they can prevent lightning discharges. Lightning flashes to, or nearby, structures (or services connected to the structures) are hazardous to people, to the structures themselves, their contents and installations as well as to services. This is why the application of lightning protection measures is essential.

The need for protection, the economic benefits of installing protection measures and the selection of adequate protection measures should be determined in terms of risk management. Risk management is the subject of IEC 62305-2.

The criteria for design, installation and maintenance of lightning protection measures are considered in three separate groups:

- the first group concerns protection measures to reduce physical damage and life hazard in a structure is given in IEC 62305-3,
- the second group concerns protection measures to reduce failures of electrical and electronic systems in a structure is given in IEC 62305-4,
- the third group concerns protection measures to reduce physical damage and failures of services connected to a structure (mainly electrical and telecommunication lines) is given in IEC 62305-5.

## PROTECTION AGAINST LIGHTNING –

### Part 1: General principles

#### 1 Scope

This part of IEC 62305 provides the general principles to be followed in the protection against lightning of

- structures including their installations and contents as well as persons,
- services connected to a structure.

The following cases are outside the scope of this standard:

- railway systems;
- vehicles, ships, aircraft, offshore installations;
- underground high pressure pipelines;
- pipe, power and telecommunication lines not connected to a structure.

NOTE Usually these systems are under special regulations made by various specific authorities.

#### 2 Normative references

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

IEC 62305-2, *Protection against lightning – Part 2: Risk management*

IEC 62305-3, *Protection against lightning – Part 3: Physical damage to structures and life hazard*

IEC 62305-4, *Protection against lightning – Part 4: Electrical and electronic systems within structures*

IEC 62305-5, *Protection against lightning – Part 5: Services* <sup>1</sup>

#### 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

##### 3.1

##### **lightning flash to earth**

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

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<sup>1</sup> To be published.

### 3.2

#### **downward flash**

lightning flash initiated by a downward leader from cloud to earth

NOTE A downward flash consists of a first short stroke, which can be followed by subsequent short strokes. One or more short strokes may be followed by a long stroke.

### 3.3

#### **upward flash**

lightning flash initiated by an upward leader from an earthed structure to cloud

NOTE An upward flash consists of a first long stroke with or without multiple superimposed short strokes. One or more short strokes may be followed by a long stroke.

### 3.4

#### **lightning stroke**

single electrical discharge in a lightning flash to earth

### 3.5

#### **short stroke**

part of the lightning flash which corresponds to an impulse current

NOTE This current has a time to the half value  $T_2$  typically less than 2 ms (see Figure A.1).

### 3.6

#### **long stroke**

part of the lightning flash which corresponds to a continuing current

NOTE The duration time  $T_{\text{long}}$  (time from the 10 % value on the front to the 10 % value on the tail) of this continuing current is typically more than 2 ms and less than 1 s (see Figure A.2)

### 3.7

#### **multiple strokes**

lightning flash consisting on average of 3-4 strokes, with typical time interval between them of about 50 ms

NOTE Events having up to a few dozen strokes with intervals between them ranging from 10 ms to 250 ms have been reported.

### 3.8

#### **point of strike**

point where a lightning flash strikes the earth, or protruding object (e.g. structure, LPS, service, tree, etc.)

NOTE A lightning flash may have more than one point of strike.

### 3.9

#### **lightning current**

$i$

current flowing at the point of strike

### 3.10

#### **peak value**

$I$

maximum value of the lightning current

### 3.11

#### **average steepness of the front of short stroke current**

average rate of change of current within a time interval  $t_2 - t_1$

NOTE It is expressed by the difference  $i(t_2) - i(t_1)$  of the values of the current at the start and at the end of this interval, divided by  $t_2 - t_1$  (see Figure A.1).

**3.12****front time of short stroke current** $T_1$ 

virtual parameter defined as 1,25 times the time interval between the instants when the 10 % and 90 % of the peak value are reached (see Figure A.1)

**3.13****virtual origin of short stroke current** $O_1$ 

point of intersection with time axis of a straight line drawn through the 10 % and the 90 % reference points on the stroke current front (see Figure A.1); it precedes by 0,1  $T_1$  that instant at which the current attains 10 % of its peak value

**3.14****time to half value of short stroke current** $T_2$ 

virtual parameter defined as the time interval between the virtual origin  $O_1$  and the instant at which the current has decreased to half the peak value (see Figure A.1)

**3.15****flash duration** $T$ 

time for which the lightning current flows at the point of strike

**3.16****duration of long stroke current** $T_{\text{long}}$ 

time duration during which the current in a long stroke is between the 10 % of the peak value during the increase of the continuing current and 10 % of the peak value during the decrease of the continuing current (see Figure A.2)

**3.17****flash charge** $Q_{\text{flash}}$ 

time integral of the lightning current for the entire lightning flash duration

**3.18****short stroke charge** $Q_{\text{short}}$ 

time integral of the lightning current in a short stroke

**3.19****long stroke charge** $Q_{\text{long}}$ 

time integral of the lightning current in a long stroke

**3.20****specific energy** $W/R$ 

time integral of the square of the lightning current for the entire flash duration

NOTE It represents the energy dissipated by the lightning current in a unit resistance.

**3.21****specific energy of short stroke current**

time integral of the square of the lightning current for the duration of the short stroke

NOTE The specific energy in a long stroke current is negligible.

**3.22**

**object to be protected**

structure or service to be protected against the effects of lightning

**3.23**

**structure to be protected**

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

NOTE A structure to be protected may be a part of a larger structure.

**3.24**

**service to be protected**

service connected to a structure for which protection is required against the effects of lightning in accordance with this standard

**3.25**

**lightning flash to an object**

lightning flash striking an object to be protected

**3.26**

**lightning flash near an object**

lightning flash striking close enough to an object to be protected that it may cause dangerous overvoltages

**3.27**

**electrical system**

system incorporating low voltage power supply components

**3.28**

**electronic system**

system incorporating sensitive electronic components such as communication equipment, computer, control and instrumentation systems, radio systems, power electronic installations

**3.29**

**internal systems**

electrical and electronic systems within a structure

**3.30**

**physical damage**

damage to a structure (or to its contents) or to a service due to mechanical, thermal, chemical and explosive effects of lightning

**3.31**

**injury of living beings**

injuries, including loss of life, to people or to animals due to touch and step voltages caused by lightning

**3.32**

**failure of electrical and electronic systems**

permanent damage of electrical and electronic systems due to LEMP

**3.33****lightning electromagnetic impulse**

LEMP

electromagnetic effects of lightning current

NOTE It includes conducted surges as well as radiated impulse electromagnetic field effects.

**3.34****surge**

transient wave appearing as overvoltage and /or overcurrent caused by LEMP

NOTE Surges caused by LEMP can arise from (partial) lightning currents, from induction effects in installation loops and as remaining threat downstream of SPD.

**3.35****lightning protection zone**

LPZ

zone where the lightning electromagnetic environment is defined

NOTE The zone boundaries of an LPZ are not necessarily physical boundaries (e.g. walls, floor and ceiling).

**3.36****risk** $R$ 

value of probable average annual loss (humans and goods) due to lightning, relative to the total value (humans and goods) of the object to be protected

**3.37****tolerable risk** $R_T$ 

maximum value of the risk which can be tolerated for the object to be protected

**3.38****lightning protection level**

LPL

number related to a set of lightning current parameters values relevant to the probability that the associated maximum and minimum design values will not be exceeded in naturally occurring lightning

NOTE Lightning protection level is used to design protection measures according to the relevant set of lightning current parameters.

**3.39****protection measures**

measures to be adopted in the object to be protected to reduce the risk

**3.40****lightning protection system**

LPS

complete system used to reduce physical damage due to lightning flashes to a structure

NOTE It consists of both external and internal lightning protection systems.

**3.41****external lightning protection system**

part of the LPS consisting of an air-termination system, a down-conductor system and an earth-termination system

**3.42**

**internal lightning protection system**

part of the LPS consisting of lightning equipotential bonding and/or electrical insulation of external LPS

**3.43**

**air-termination system**

part of an external LPS using metallic elements such as rods, mesh conductors or catenary wires intended to intercept lightning flashes

**3.44**

**down-conductor system**

part of an external LPS intended to conduct lightning current from the air-termination system to the earth-termination system

**3.45**

**earth-termination system**

part of an external LPS which is intended to conduct and disperse lightning current into the earth

**3.46**

**external conductive parts**

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

**3.47**

**lightning equipotential bonding**

bonding to LPS of separated metallic parts, by direct conductive connections or via surge protective devices, to reduce potential differences caused by lightning current

**3.48**

**shielding wire**

metallic wire used to reduce physical damage due to lightning flashes to a service

**3.49**

**LEMP protection measures system**

LPMS

complete system of protection measures for internal systems against LEMP

**3.50**

**magnetic shield**

closed, metallic, grid-like or continuous screen enveloping the object to be protected, or part of it, used to reduce failures of electrical and electronic systems

**3.51**

**surge protective device**

SPD

device intended to limit transient overvoltages and divert surge currents. It contains at least one non linear component

**3.52**

**coordinated SPD protection**

set of SPD properly selected, coordinated and erected to reduce failures of electrical and electronic systems

**3.53****rated impulse withstand voltage** $U_w$ 

impulse withstand voltage assigned by the manufacturer to the equipment or to a part of it, characterizing the specified withstand capability of its insulation against overvoltages

NOTE For the purposes of this standard, only withstand voltage between live conductors and earth is considered. (IEC 60664-1:2002) <sup>[1]2</sup>

**3.54****conventional earthing impedance**

ratio of the peak values of the earth-termination voltage and the earth-termination current which, in general, do not occur simultaneously

**4 Lightning current parameters**

The lightning current parameters used in the IEC 62305 series are given in Annex A.

The time function of the lightning current to be used for analysis purposes is given in Annex B.

Information for simulation of lightning current for test purposes is given in Annex C.

The basic parameters to be used in laboratory to simulate the effects of lightning on LPS components are given in Annex D.

Information on surges due to lightning at different installation points is given in Annex E.

**5 Damage due to lightning****5.1 Damage to a structure**

Lightning affecting a structure can cause damage to the structure itself and to its occupants and contents, including failure of internal systems. The damages and failures may also extend to the surroundings of the structure and even involve the local environment. The scale of this extension depends on the characteristics of the structure and on the characteristics of the lightning flash.

**5.1.1 Effects of lightning on a structure**

The main characteristics of structures relevant to lightning effects include:

- construction (e.g. wood, brick, concrete, reinforced concrete, steel frame construction);
- function (dwelling house, office, farm, theatre, hotel, school, hospital, museum, church, prison, department store, bank, factory, industry plant, sports area);
- occupants and contents (persons and animals, presence of combustible or non-combustible materials, explosive or non-explosive materials, electrical and electronic systems with low or high withstand voltage);

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<sup>2</sup> References in square brackets refer to the bibliography.

- connected services (power lines, telecommunication lines, pipelines);
- existing or provided protection measures (e.g. protection measures to reduce physical damage and life hazard, protection measures to reduce failure of internal systems);
- scale of the extension of danger (structure with difficulty of evacuation or structure where panic may be created, structure dangerous to the surroundings, structure dangerous to the environment).

Table 1 reports the effects of lightning on various types of structures.

**Table 1 – Effects of lightning on typical structures**

| Type of structure according to function and/or contents                            | Effects of lightning                                                                                                                                                                                                                                                                             |
|------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Dwelling-house                                                                     | Puncture of electrical installations, fire and material damage<br>Damage normally limited to objects exposed to the point of strike or to the lightning current path<br>Failure of electrical and electronic equipment and systems installed (e.g. TV sets, computers, modems, telephones, etc.) |
| Farm building                                                                      | Primary risk of fire and hazardous step voltages as well as material damage<br>Secondary risk due to loss of electric power, and life hazard to livestock due to failure of electronic control of ventilation and food supply systems, etc.                                                      |
| Theatre,<br>Hotel,<br>School<br>Department store<br>Sports area                    | Damage to the electrical installations (e.g. electric lighting) likely to cause panic<br>Failure of fire alarms resulting in delayed fire fighting measures                                                                                                                                      |
| Bank<br>Insurance company<br>Commercial company, etc.                              | As above, plus problems resulting from loss of communication, failure of computers and loss of data                                                                                                                                                                                              |
| Hospital<br>Nursing home<br>Prison                                                 | As above, plus problems of people in intensive care, and the difficulties of rescuing immobile people                                                                                                                                                                                            |
| Industry                                                                           | Additional effects depending on the contents of factories, ranging from minor to unacceptable damage and loss of production                                                                                                                                                                      |
| Museums and archeological sites<br>Church                                          | Loss of irreplaceable cultural heritage                                                                                                                                                                                                                                                          |
| Telecommunications<br>Power plants                                                 | Unacceptable loss of services to the public                                                                                                                                                                                                                                                      |
| Firework factory<br>Munition works                                                 | Consequences of fire and explosion to the plant and its surroundings                                                                                                                                                                                                                             |
| Chemical plant<br>Refinery<br>Nuclear plant<br>Biochemical laboratories and plants | Fire and malfunction of the plant with detrimental consequences to the local and global environment                                                                                                                                                                                              |

### 5.1.2 Sources and types of damage to a structure

The lightning current is the source of damage. The following situations shall be taken into account, depending on the position of the point of strike relative to the structure considered:

- S1: flashes to the structure;
- S2: flashes near the structure;
- S3: flashes to the services connected to the structure;
- S4: flashes near the services connected to the structure.

**Flashes to the structure** can cause:

- immediate mechanical damage, fire and/or explosion due to the hot lightning plasma arc itself, due to the current resulting in ohmic heating of conductors (over-heated conductors), or due to the charge resulting in arc erosion (melted metal);
- fire and/or explosion triggered by sparks caused by overvoltages resulting from resistive and inductive coupling and to passage of part of the lightning currents;
- injury to people by step and touch voltages resulting from resistive and inductive coupling;
- failure or malfunction of internal systems due to LEMP.

**Flashes near the structure** can cause:

- failure or malfunction of internal systems due to LEMP.

**Flashes to a service connected to the structure** can cause:

- fire and/or explosion triggered by sparks due to overvoltages and lightning currents transmitted through the connected service;
- injury to people due to touch voltages inside the structure caused by lightning currents transmitted through the connected service;
- failure or malfunction of internal systems due to overvoltages appearing on connected lines and transmitted to the structure.

**Flashes near a service connected to the structure** can cause:

- failure or malfunction of internal systems due to overvoltages induced on connected lines and transmitted to the structure.

NOTE 1 Malfunctioning of internal systems is not covered by the IEC 62305 series. Reference should be made to IEC 61000-4-5 [2].

NOTE 2 Only the sparks carrying lightning current (total or partial) are regarded as able to trigger fire.

NOTE 3 Lightning flashes, direct to or near the incoming pipelines, do not cause damages to the structure, provided that they are bonded to the equipotential bar of the structure (see IEC 62305-3).

As result, the lightning can cause three basic type of damages:

- D1: injury of living beings due to touch and step voltages;
- D2: physical damage (fire, explosion, mechanical destruction, chemical release) due to lightning current effects including sparking;
- D3: failure of internal systems due to LEMP.

## 5.2 Damage to a service

Lightning affecting a service can cause damage to the physical means itself (line or pipe) used to provide the service, as well as to connected electrical and electronic equipment.

NOTE The service to be considered is the physical connection between

- the switch telecommunication building and the user's building or two switch telecommunication buildings or two users' buildings, for the telecommunication (TLC) lines,
- the switch telecommunication building or the user's building and a distribution node, or two distribution nodes for the telecommunication (TLC) lines,
- the high voltage (HV) substation and the user's building, for the power lines,
- the main distribution station and the user's building, for pipes.

The scale of this extension depends on the characteristics of the service, on the type and extension of the electrical and electronic systems and on the characteristics of the lightning flash.

### 5.2.1 Effects of lightning on a service

The main characteristics of services relevant to lightning effects include:

- construction (line: overhead, underground, screened, unscreened, fibre optic; pipe: above ground, buried, metallic, plastic);
- function (telecommunication line, power line, pipeline);
- structure supplied (construction, contents, dimensions, location);
- existing or provided protection measures (e.g. shielding wire, SPD, route redundancy, fluid storage systems, generating sets, uninterruptible power systems).

Table 2 reports the effects of lightning on various types of services.

**Table 2 – Effects of lightning on typical services**

| Type of service         | Effects of lightning                                                                                                                                                                                                                                                                |
|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Telecommunication line  | Mechanical damage to line, melting of screens and conductors, breakdown of insulation of cable and equipment leading to a primary failure with immediate loss of service<br><br>Secondary failures on the optical fibre cables with damage of the cable but without loss of service |
| Power lines             | Damages to insulators of low voltage overhead line, puncturing of insulation of cable line, breakdown of insulation of line equipment and of transformers, with consequential loss of service                                                                                       |
| Water pipes             | Damages to electrical and electronic control equipments likely to cause loss of service                                                                                                                                                                                             |
| Gas pipes<br>Fuel pipes | Puncturing of non-metallic flange gaskets likely to cause fire and/or explosion.<br><br>Damage to electrical and electronic control equipments likely to cause loss of service                                                                                                      |

### 5.2.2 Sources and types of damage to a service

The lightning current is the source of damage. The following situations shall be taken into account, depending on the position of the point of strike relative to the service considered:

- S1: flashes to the supplied structure;
- S3: flashes to the service connected to the structure;
- S4: flashes near the service connected to the structure.

**Flashes to the supplied structure can cause:**

- melting of metallic wires and of cable screens due to parts of the lightning current flowing into the services (resulting from resistive heating);
- breakdown of insulation of lines and of the connected equipments (due to the resistive coupling);
- puncturing of non-metallic gaskets in flanges of pipes, as well as gaskets in insulating joints.

NOTE 1 Optical fibre cable without metallic conductor are not affected by lightning flashes striking the supplied structure.

**Flashes to a service connected to the structure can cause:**

- immediate mechanical damage of metallic wires or piping due to electrodynamic stress or heating effects caused by lightning current (breaking and/or melting of metallic wires, screens or piping), and due to the heat of the lightning plasma arc itself (puncturing of plastic protective cover);
- immediate electrical damage of lines (breakdown of insulation) and of connected equipment;
- puncturing of thin overhead metallic pipes and of non-metallic gaskets in flanges, where consequences may extend to fire and explosion depending on the nature of conveyed fluids.

**Flashes near a service connected to the structure can cause:**

- breakdown of insulation of lines and of the connected equipments due to inductive coupling (induced overvoltages).

NOTE 2 Optical fibre cable without metallic conductors are not affected by lightning flashes striking the ground.

As a result, the lightning can cause two basic type of damage:

- D2: physical damage (fire, explosion, mechanical destruction, chemical release) due to thermal effects of lightning current
- D3: failure of electrical and electronic systems due to overvoltages.

### 5.3 Types of loss

Each type of damage, alone or in combination with others, may produce different consequential loss in the object to be protected. The type of loss that may appear depends on the characteristics of the object itself.

For the purposes of this standard the following types of loss are considered:

- L1: loss of human life;
- L2: loss of service to the public;
- L3: loss of cultural heritage;
- L4: loss of economical value (structure and its content, service and loss of activity).

Loss of type L1, L2 and L3 may be considered as loss of social values, whereas loss of type L4 may be considered as purely economical loss.

Losses which may appear in a structure are as follows:

- L1: loss of human life;
- L2: loss of service to the public;

- L3: loss of cultural heritage
- L4: loss of economic value (structure and its content).

Losses which may appear in a service are as follows:

- L2: loss of service to the public;
- L4: loss of economic value (service and loss of activity).

NOTE In a service, loss of human life is not considered in this standard.

The relationship between source of damage, type of damage and loss is reported in Table 3 for structures and in Table 4 for services.

**Table 3 – Damages and loss in a structure according to different points of strike of lightning**

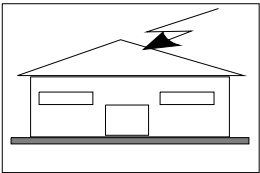
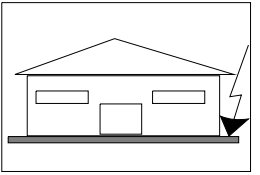
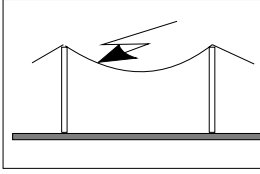
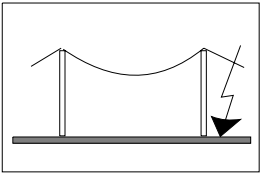
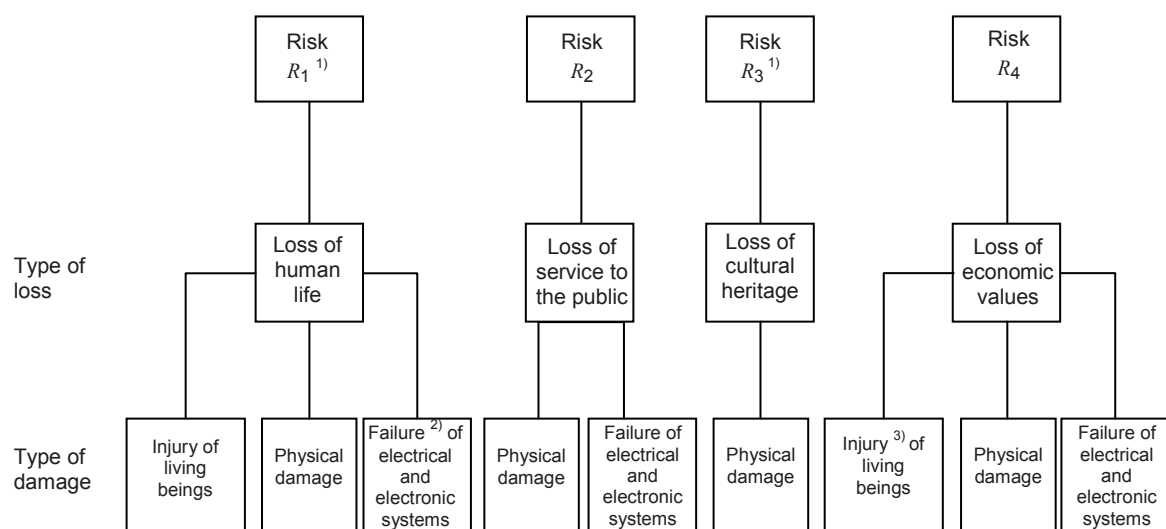
| Point of strike                                                                                                                                        |                                                                                     | Source of damage | Type of damage | Type of loss                              |
|--------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|------------------|----------------|-------------------------------------------|
| Structure                                                                                                                                              |    | S1               | D1<br>D2<br>D3 | L1, L4**<br>L1, L2, L3, L4<br>L1*, L2, L4 |
| Near a structure                                                                                                                                       |  | S2               | D3             | L1*, L2, L4                               |
| Service connected to the structure                                                                                                                     |  | S3               | D1<br>D2<br>D3 | L1, L4**<br>L1, L2, L3, L4<br>L1*, L2, L4 |
| Near a service                                                                                                                                         |  | S4               | D3             | L1*, L2, L4                               |
| * Only for structures with risk of explosion and for hospitals or other structures where failure of internal systems immediately endangers human life. |                                                                                     |                  |                |                                           |
| ** Only for properties where animals may be lost.                                                                                                      |                                                                                     |                  |                |                                           |

**Table 4 – Damages and loss in a service according to different points of strike of lightning**

| Point of strike    | Source of damage | Type of damage | Type of loss |
|--------------------|------------------|----------------|--------------|
| Service            | S3               | D2<br>D3       | L2, L4       |
| Near the service   | S4               | D3             |              |
| Supplied structure | S1               | D2<br>D3       |              |

Types of loss resulting from types of damage and the corresponding risks are reported in Figure 1.



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<sup>1)</sup> Only for structures.

<sup>2)</sup> Only for hospitals or other structures where failure on internal systems immediately endanger human life.

<sup>3)</sup> Only for properties where animals may be lost.

**Figure 1 – Types of loss and corresponding risks resulting from different types of damage**

## 6 Need and economic convenience for lightning protection

### 6.1 Need for lightning protection

The need for lightning protection of an object to be protected in order to reduce the loss of social values L1, L2 and L3 shall be evaluated.

In order to evaluate whether or not lightning protection of an object is needed, a risk assessment in accordance with the procedures contained in IEC 62305-2 shall be made. The following risks shall be taken into account, corresponding to the types of loss reported in 5.3:

- $R_1$ : risk of loss of human life;
- $R_2$ : risk of loss of services to the public;
- $R_3$ : risk of loss of cultural heritage.

Protection against lightning is needed if the risk  $R$  ( $R_1$  to  $R_3$ ) is higher than the tolerable level  $R_T$

$$R > R_T$$

In this case, protection measures shall be adopted in order reduce the risk  $R$  ( $R_1$  to  $R_3$ ) to the tolerable level  $R_T$

$$R \leq R_T$$