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Protection of structure against lightning - Part 1: General principles - Section 1: Guide A: Selection of protection levels for lightning protection systems

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Section 1: Guide A - Choix des niveaux de protection pour les installations de protection contre la foudre

Protection of structures against lightning

Part 1:
General principles
Section 1: Guide A - Selection of protection levels for lightning protection systems

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

PROTECTION OF STRUCTURES AGAINST LIGHTNING

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FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international cooperation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.

2) The formal decisions or agreements of the IEC on technical matters, prepared by technical committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.

3) They have the form of recommendations for international use published in the form of standards, technical reports or guides and they are accepted by the National Committees in that sense.

4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.

International Standard IEC 1024-1-1 has been prepared by IEC technical committee 81: Lightning protection.

The text of this standard is based on the following documents:

DIS	Report on Voting	Amendment to DIS	Report on Voting
81(CO)14	81(CO)16	81(CO)18	81(CO)20

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

IEC 1024 consists of the following parts, under the general title: Protection of structures against lightning.

– Part 1: General principles.

Annex A forms an integral part of this standard.

INTRODUCTION

The Part 1, General principles, establishes the fundamental definitions and general principles of lightning protection, as well as providing the necessary information concerning design, construction and materials to facilitate the basic installation of external and internal lightning protection systems (LPS) of common structures. The Part 1, also gives the basic requirements for good maintenance and inspection practice.

Guide A contains information on assignment of protection levels to structures to be protected. It gives guide-lines for the selection of LPS and represents the consensus view of many countries' experts as to the best general practice based on the present state of the art.

However it should be kept in mind that the matter is so complicated, due to the involved parameters, that only a thorough risk analysis can give the correct evaluation of the required protection level.

Where the selection of protection levels for structures is based on the assessment of the risk of damage due to lightning, a Technical Report (future IEC 1024-1-2) will assist the national authorities concerned.

This guide is used in conjunction with Part 1, when the particular aspects of protection assessment and physical design and construction of an LPS are considered.

PROTECTION OF STRUCTURES AGAINST LIGHTNING

Part 1: General principles
Section 1: Guide A – Selection of protection levels for lightning protection systems

1 General

1.1 *Scope and object*

This guide is applicable to the selection of protection levels for LPS covered by IEC 1024-1.

It provides information on the classification of structures according to the consequential effects of a lightning stroke and on procedures for selection of an LPS giving an adequate level of protection.

1.2 *Terms and definitions*

For the purpose of this guide, the following definitions apply:

1.2.1 **lightning current** (i): The current flowing at the point of strike.

1.2.2 **peak value** (I): The maximum value of the lightning current in a flash.

1.2.3 **average steepness of lightning current** (di/dt): The difference between the lightning current values at the start and at the end of a specified time interval $[i(t_2) - i(t_1)]$ divided by the specified time interval $[t_2 - t_1]$.

1.2.4 **flash duration** (T): Time for which the lightning current flows at the point of strike.

1.2.5 **total charge** (Q_{total}): The time integral of the lightning current for entire lightning flash duration.

1.2.6 **impulse charge** ($Q_{impulse}$): The time integral of the lightning current for the impulse part of the lightning flash duration.

1.2.7 **specific energy** (W/R): 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 flash.

1.2.8 **probability of damage** (p): Probability of a lightning flash causing damage to the structure.

1.2.9 **risk of damage:** Probable average annual losses (humans and goods) in a structure due to lightning flashes.

1.2.10 **direct lightning flash frequency to a structure** (N_d): Expected average annual number of direct lightning flashes to the structure.

1.2.11 **frequency of damage by direct lightning flash:** Average annual number of direct lightning flashes which cause damage to the structure.

1.2.12 **accepted lightning flash frequency** (N_c): The maximum accepted average annual frequency of lightning flashes which can cause damage to the structure.

1.2.13 **efficiency of an LPS** (E): The ratio of the average annual number of direct lightning flashes which cannot cause damage to the structure to the direct lightning flash number to the structure.

2 Classification of structures

The classification of structures can be made according to consequential effects of lightning strokes which may be dangerous to structures, their contents or their surroundings.

The direct effects of lightning which may be dangerous, are: fires, mechanical damage, injuries to people and animals, and damage to electric and electronic equipment. The effects of lightning may be responsible for panic and moreover cause explosions, and emissions of dangerous substances such as radioactive materials, chemical agents, toxic substances, biochemical contaminators, bacteria and viruses.

The effects of lightning may be particularly hazardous to computer systems, control systems, regulation systems, and power supplies thereby causing loss of service to the public, loss of data production and business. Sensitive electronic equipment is installed in all types of structures and may require special protection.

Examples of four classifications of different types of structures are given in table 1, but only common structures are considered in Part 1 and in this Guide.

2.1 *Common structures*

Common structures are structures used for ordinary purposes, whether commercial, industrial, farming, institutional or residential. Structures higher than 60 m are not considered in Part 1.

2.2 *Special structures*

Descriptions of four types of special structures are given below.

2.2.1 *Structures with confined danger*

Structures whose construction materials, contents or occupants make the whole volume of the structure vulnerable to the consequential effects of lightning.

2.2.2 *Structures dangerous to their surroundings*

Structures whose contents can be dangerous to the surroundings if struck by lightning.

2.2.3 *Structures dangerous to social and physical environments*

Structures which may cause biological, chemical and radioactive emissions as a consequence of being struck by lightning.

2.2.4 *Miscellaneous structures*

Structures for which an LPS of special design might be considered.

Typical cases are as follows:

- tall structures (above 60 m in height);
- tents, camping sites and sports fields;
- temporary installations;
- structures under construction.

Table 1 - Examples of structure classification

Classification of structures	Type of structure	Effects of lightning
Common structures (see note)	Dwelling-house	Puncture of electrical installations, fire and material damage Damage normally limited to objects exposed to the point of strike or to the lightning path
	Farm	Primary risk of fire and hazardous step voltages 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 School Department store Sports area	Damage to the electrical installations (e.g. electric lighting) likely to cause panic Failure of fire alarms resulting in delayed fire fighting measures
	Bank Insurance Company Commercial company, etc.	As above, plus problems resulting from loss of communication, failure of computers and loss of data
	Hospital Nursing home 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 archaeological sites	Loss of irreplaceable cultural heritage
Structures with confined danger	Telecommunications Power plants Industries with fire hazards	Unacceptable loss of services to the public Consequential hazards to the immediate surroundings caused by fire, etc.
Structures dangerous to their surroundings	Refinery Service station Firework factory Munition works	Consequences of fire and explosion to the plant and its surroundings
Structures dangerous to the environment	Chemical plant Nuclear plant Biochemical laboratories and plants	Fire and malfunction of the plant with detrimental consequences to the local and global environment

NOTES

1 Sensitive electronic equipment might be installed in all kinds of structures, including all kinds of common structures, which can be easily damaged by overvoltages due to lightning.

2 The loss of service is the product of the time for which a single user cannot make use of the service by the number of users involved, in one year.

3 Lightning parameters

Lightning parameters are usually obtained from measurements taken on high objects. The data given in this guide relates to both downward and upward flashes.

The statistical distribution of the recorded lightning parameters can be assumed to have a logarithmic normal distribution. On this basis, the probability of occurrence of any value of each parameter can be calculated from the values given in annex A.

The polarity ratio of lightning strokes depends on the nature of the territory. If no local information is available, 10 % positive and 90 % negative should be assumed.

The values reported in this guide are based on polarity ratio 10 % positive and 90 % negative.

3.1 *Lightning current parameters used for dimensioning Lightning Protection Systems (LPS)*

The mechanical and thermal effects of lightning are related to the peak value of the current (I), the total charge (Q_{total}), the impulse charge ($Q_{impulse}$) and specific energy (W/R). The highest values of these parameters occur in positive flashes.

The damaging effects caused by induced voltage are related to the steepness of the lightning current front. In this guide the average steepness between 30 % and 90 % values of the peak current is used for design purposes. The highest value of this parameter occurs in subsequent negative strokes. Such negative strokes occur in almost all negative flashes to a structure.

Provided that 10 % of positive strokes and 90 % of negative flashes is assumed, the values of lightning parameters related to the protection levels are given in table 2.

3.2 *Lightning ground flash density*

The lightning ground flash density expressed in terms of ground strokes per square kilometre per year should be determined by measurement.

If lightning ground stroke density (N_g) is not available, it may be estimated by using the following relationship:

$$N_g = 0{,}04 \cdot T_d^{1{,}25} \text{ per km}^2 \text{ per year}$$

where

T_d is the number of thunderstorm days per year obtained from isoceraunic maps

NOTE - This relationship varies with changes in climatic conditions.