SLOVENSKI STANDARD

SIST IEC/TR 61662:1998

prva izdaja
september 1998

Assesment of the risk of damages due to the lightning

iTeh STANDARD PREVIEW
(standards.iteh.ai)
SIST IEC/TR 61662:1998
https://standards.iteh.ai/catalog/standards/sist/82729f85-5b87-465e-922b-39c509e5dd3d/sist-iec-tr-61662-1998

ICS 91.120.40

Referenčna številka
SIST IEC/TR 61662:1998(en)

© Standard je založil in izdal Slovenski inštitut za standardizacijo. Razmnoževanje ali kopiranje celote ali delov tega dokumenta ni dovoljeno

iTeh STANDARD PREVIEW
(standards.iteh.ai)
SIST IEC/TR 61662:1998
https://standards.iteh.ai/catalog/standards/sist/82729f85-5b87-465e-922b-39c509e5dd3d/sist-iec-tr-61662-1998

RAPPORT TECHNIQUE – TYPE 2

TECHNICAL REPORT – TYPE 2

CEI
IEC
1662

Première édition
First edition
1995-04

Evaluation des risques de dommages liés à la foudre

Assessment of the risk of damage due to lightning

iTeh STANDARD PREVIEW
(standards.iteh.ai)

SIST IEC/TR 61662:1998
https://standards.iteh.ai/catalog/standards/sist/82729f85-5b87-465e-922b-39c509e5dd3d/sist-iec-tr-61662-1998

© CEI 1995 Droits de reproduction réservés — Copyright – all rights reserved

Aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'éditeur.

No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from the publisher.

Bureau Central de la Commission Electrotechnique Internationale 3, rue de Varembé Genève, Suisse

IEC

Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

CODE PRIX
PRICE CODE XA

Pour prix, voir catalogue en vigueur
For price, see current catalogue

CONTENTS

iTeh STANDARD PREVIEW
(standards.iteh.ai)
SIST IEC/TR 61662:1998
https://standards.iteh.ai/catalog/standards/sist/...85-5b87-465e-922b-
...1662-1998

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ASSESSMENT OF THE RISK OF DAMAGE DUE TO LIGHTNING

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.

iTeh STANDARD PREVIEW
(standards.iteh.ai)

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a technical report of one of the following types:

SIST IEC/TR 61662:1998
https://standards.iteh.ai/catalog/standards/sist/82729185-5087-405e-9226-
39e509a5dd5d/sist-iec-tr-61662-1998

- type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;
- type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;
- type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

Technical reports of types 1 and 2 are subject to review within three years of publication to decide whether they can be transformed into International Standards. Technical reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

IEC 1662, which is a technical report of type 2, has been prepared by IEC technical committee 81: Lightning protection.

The text of this technical report is based on the following documents:

Committee draft	Report on voting
81(SEC)58	81(SEC)61

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

This document is issued in the type 2 technical report series of publications (according to G.4.2.2 of part 1 of the IEC/ISO Directives) as a "prospective standard for provisional application" in the field of the assessment of the risk of damage due to lightning because there is an urgent need for guidance on how standards in this field should be used to meet an identified need.

This document is not to be regarded as an "International Standard". It is proposed for provisional application so that information and experience of its use in practice may be gathered. Comments on the content of this document should be sent to the IEC Central Office.

A review of this type 2 technical report will be carried out not later than three years after its publication, with the options of either extension for a further three years or conversion to an International Standard or withdrawal.

This technical report is connected with IEC 1024-1 and IEC 1024-1-1.

Annexes A and B are for information only.

iTeh STANDARD PREVIEW
(standards.iteh.ai)

SIST IEC/TR 61662:1998
https://standards.iteh.ai/catalog/standards/sist/82729f85-5b87-465e-922b-39c509e5dd3d/sist-iec-tr-61662-1998

INTRODUCTION

The assessment of the risk of damage by direct and nearby lightning flashes to a structure aims to help the lightning protection design engineer in giving his advice whether or not the protection of the structure is required or recommended and if it is, to select the proper measures of protection.

A lightning flash can cause damage depending on the characteristics of the structure among which the most important are:

- nature of the construction material;
- contents and destination;
- services entering the structure;
- measures for damage limitation.

Moreover, the damage itself may be limited to a part of the structure or may be extended to the whole structure and may even involve the surroundings or the environment.

The damage caused by lightning may be of different types:

- injury or loss of human life;
- unacceptable loss of services to the public;
- loss of irreplaceable cultural heritage;
- losses not involving human, cultural and social values.

iTeh STANDARD PREVIEW
(standards.iteh.ai)
SIST IEC/TR 61662:1998

If one of the first three types of damage appears in the structure, the decision whether or not to provide protective measures should be taken by a comparison of the actual value of frequency of damage to the structure with the limit value fixed by National Committees or responsible authorities.

If damage does not involve human, cultural and environmental values, the decision whether or not to provide protective measures may be taken by the designer on the basis of purely economical convenience by comparing the annual cost of the protective measures to the probable amount of annual cost of expected losses due to lightning.

ASSESSMENT OF THE RISK OF DAMAGE DUE TO LIGHTNING

1 General

1.1 *Scope and object*

This report is applicable to the assessment of the risk of damage caused by lightning flashes to earth.

The object of this report is to give the procedure for evaluation of the risk of damage to a structure caused by direct and indirect lightning flashes, and to permit the bodies concerned to fix an acceptable value for the frequency of damage to structures.

Once an upper limit for the frequency of damage has been fixed, the procedure given allows for the selection of appropriate protective measures for the structure.

NOTE – Damage to the equipment due to direct magnetic coupling with lightning current which strikes the earth nearby the structure may be usually disregarded.
Where sensitive electronic equipment are installed in the structure, this damage should be also taken into account in the assessment of the risk.

1.2 *Normative references*

iTeh STANDARD PREVIEW
(standards.iteh.ai)
SIST IEC/TR 61662:1998
https://standards.iteh.ai/catalog/standards/sist/82729f85-5b87-465e-922b-39c509e5dd3d/sist-iec-tr-61662-1998

The following normative documents contain provisions which, through reference in this text, constitute provisions of this technical report. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this technical report are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 364: *Electrical installations of buildings*

IEC 479: *Effects of current on human beings and livestock*

IEC 1024-1: 1990, *Protection of structures against lightning – Part 1: General principles*

IEC 1024-1-1: 1993, *Protection of structures against lightning – Part 1: General principles – Section 1: Guide A – Selection of protection levels for lightning protection systems*

1.3 *Terms and definitions*

For the purpose of this technical report, the following definitions apply.

1.3.1 **direct lightning flash:** Lightning flash which strikes directly the structure or its lightning protection system (LPS).

1.3.2 **indirect lightning flash:** Lightning flash which strikes the earth nearby the structure, or the services entering the structure.

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

1.3.4 **indirect lightning flash frequency (N_i):** Expected annual number of indirect lightning flashes.

1.3.5 **lightning flash frequency to the structure (N):** Expected average annual number of direct and indirect lightning flashes.

1.3.6 **accepted lightning frequency of flashes (N_c):** Maximum accepted average annual number of lightning flashes which can cause damage to the structure.

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

1.3.8 **frequency of damage (Np):** Average annual number of flashes which cause damage to the structure. Can refer to direct, to indirect or to all flashes.

1.3.9 **accepted frequency of damage to the structure (F_a):** Maximum value of expected frequency of damage which can be tolerated by the structure.

iTeh STANDARD PREVIEW
(standards.iteh.ai)

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

SIST IEC/TR 61662:1998
https://standards.iteh.ai/catalog/standards/sist/82729f85-5b87-465e-922b-
93e5095d8d3d/sist-iec-tr-61662-1998

1.3.11 **lightning protection system (LPS):** Complete system used to protect a space under consideration against the effects of direct lightning. It consists of both external and internal lightning protection systems.

1.3.12 **efficiency of LPS (E):** Ratio of the number of direct lightning flashes which cannot cause damage to the structure, to the number of direct lightning flashes to the structure.

1.3.13 **surge protective device (SPD):** Device designed to suppress line conducted overvoltages and currents, such as surge suppressors defined in IEC 1024-1, including also gaps, varistors, diodes, filters, etc.

2 Assessment of the risk of damage

2.1 *General expression*

For the purpose of this technical report, the risk of damage to the structure may be assessed [1]*, [2] by:

$$R_d = (1 - e^{-Npt})\,\delta \qquad (1)$$

* Figures in square brackets refer to clause 5, bibliography.

where

N is the expected average annual number of lightning flashes to the structure;

p is the probability of damage to the structure;

δ is a measure of the amount of possible losses of the structure or of its contents.

The product $F = Np$ is the expected average annual number of damages to the structure (frequency of damage) [3].

If the time of observation is $t = 1$ year, in the case of $Np \ll 1$, the preceeding formula may be simplified as follows:

$$R_d = Np\,\delta \qquad (2)$$

If a lightning protection system (LPS), as a measure of damage limitation, is applied, the risk of damage is reduced according to its efficiency.

2.2 *Frequency of lightning flashes*

2.2.1 *Direct lightning flash frequency*

The average annual frequency N_d of direct flashes to the structure can be assessed by the product of the annual ground flash density N_g and the effective collection area of the structure A_e (see 4.2 of IEC 1024-1-1):

iTeh STANDARD PREVIEW

$$N_d = N_g\,A_e \qquad (3)$$

(standards.iteh.ai)

The effective collection area of the structure is defined as the measure of the ground surface which has the same annual frequency of direct lightning flashes as the structure. It is a function of the structure dimensions and depends on ground topography and surrounding objects.

SIST IEC/TR 61662:1998
https://standards.iteh.ai/catalog/standards/sist/8d50d5b1-b87...-4...
39c509e5dd3d/sist-iec-tr-61662-1998

For isolated structures, the effective collection area A_e is the area enclosed within the border line (b1) obtained from the intersection between the ground surface and a straight line with 1:3 slope which passes from upper parts of the structure, where it touches the structure, and rotating around it (see figure 1 for flat terrain, and figures 2A and 2B for uneven terrain).

In the case of complicated topography (see figures 2C and 2D) the construction can be simplified taking in account some characteristic parts of the border line and replacing them with straight lines or sections of a circle.

Surrounding objects significantly influence the effective area if their distances from the structure are less than

$$3\,(h + h_s)$$

where

h is the height of the structure under consideration; and

h_s is the height of the surrounding object.

In this case, the effective areas of structure and object overlap each other; the effective area A_e is reduced and it extends up to a distance:

$$X_s = \frac{d + 3\,(h_s - h)}{2} \qquad (4)$$

where

d is the horizontal distance between the structure and the object (see figure 3).

Only those objects which have permanent durability and adequate resistance against lightning stresses shall be taken into account.

In any case a minimum value of the effective collection area is to be assumed equal to the horizontal projection of the structure itself.

2.2.2 *Indirect lightning flash frequency*

It involves lightning flashes nearby the structure and lightning flashes affecting the incoming services [6], [7].

2.2.2.1 *Nearby lightning flash frequency*

The average annual frequency N_n of flashes striking to ground nearby the structure can be assessed by the product of the annual ground flash density N_g times the collection area A_g of the ground surrounding the structure

iTeh STANDARD PREVIEW
(standards.iteh.ai)

$$N_n = N_g A_g \qquad (5)$$

The collection area of the surrounding ground, A_g, is the area surrounding the structure where a stroke to ground causes a localized increase in the ground potential which may influence the structure or the services entering to the structure.

SIST IEC/TR 61662:1998
https://standards.iteh.ai/catalog/standards/sist/82729185-5087-469e-9226-59e509e5dd5d/sist-iec-tr-61662-1998

It extends up to the border line at distance d_s away from the structure, d_s in metres, being numerically equal to the soil resistivity value (in ohms x metres) up to a maximum value of 500 m.

The collection area of the surrounding ground A_g may be evaluated by the difference of the area enclosed by such border line and the effective collection area of the structure.

NOTE – When direct magnetic coupling with lightning current is to be taken into account, a further collection area A_m is to be considered, being d_s = 500 m.

2.2.2.2 *Frequency of lightning flashes affecting an incoming service*

The average annual number N_k of the flashes affecting an incoming service can be assessed by the product of the annual ground flash density N_g times the area of influence A_k of the service incoming to the structure:

$$N_k = N_g A_k \qquad (6)$$

where

A_k is the area of influence of the service.

The area of influence of the service A_k includes:

A_{sk} the collection area of the incoming service (mains, communication or signal lines);

A_{ak} the effective collection area of adjacent structure connected to the structure under consideration through the service.

$$A_k = A_{sk} + A_{ak} \qquad (7)$$

Collection area of incoming service: A_{sk}

The value of the collection area of an incoming service is related to the characteristics of the service [8] and may be calculated by the expressions reported in table 1 and table 2.

Table 1 – Effective collection area of mains services

Type of mains service	Effective collection (notes 1 and 2) area m^2
Low voltage overhead cable	$2\,000 \times L$
High voltage overhead cable (to on-site substation)	$500 \times L$
Low voltage underground cable	$2 \times d_s \times L$
High voltage underground cable (to on-site transformer)	$0{,}1 \times d_s \times L$

NOTES

1 L is the length in metres of the line from the structure under consideration to the first branch point of the network or to the adjacent structure, with a maximum value of 1 000 m. When the value of L is unknown a value of 1 000 m should be assumed.

2 d_s in metres, being numerically equal to the soil resistivity value (ohms x metres) up to a maximum value of 500 m.

iTeh STANDARD PREVIEW
(standards.iteh.ai)
SIST IEC/TR 61662:1998
59c509c5dd3d/sist-iec-tr-61662-1998

Table 2 – Effective collection area of communication lines

Type of data line	Effective collection (notes 1 and 2) area m^2
Overhead signal line	$2\,000 \times L$
Underground signal line	$2 \times d_s \times L$
Fibre optic cable without a metallic shield or core	0

NOTES

1 L is the length in metres of the line from the structure under consideration to the first branch point of the network or to the adjacent structure, with a maximum value of 1 000 m. When the value of L is unknown a value of 1 000 m should be assumed.

2 d_s in metres, being numerically equal to the soil resistivity value (ohms x metres) up to a maximum value of 500 m.

The collection area of adjacent associated structure A_{ak}

The effective collection area of adjacent associated structure is the collection area of the structure which have direct or indirect connection to the electrical or electronic equipment in the main structure.

Typical examples are external lighting towers supplied from the main building electrical installation, other buildings with computer terminals, control and instrumentation equipment and transmission towers.

NOTES

1 It should be assumed $A_{sk} = 0$ if the service entering to the structure is a no metallic line.

2 It should be assumed $A_{sk} = 0$ when $L < 3$ h (h being the height of the structure).

3 In the case of multicore cables, the cable is considered as a single cable and not as individual circuits.

2.3 *Probability of damage*

Lightning to the structure or to the surroundings can cause damages depending on several factors which are functions of the structure itself and its internal installation, and of the protection measures selected by the lighting protection designer. Probability values p are used for inherent factors in the installation and building and coefficients k, reducing the probability values, are used for protection measures which the lighting protection designer can apply.

iTeh STANDARD PREVIEW
(standards.iteh.ai)

2.3.1 *Types and sources of damages*

The following types of damage are to be taken into account:

SIST IEC/TR 61662:1998
https://standards.iteh.ai/catalog/standards/sist/82729f85-5b87-465e-922b-39c509e5dd3d/sist-iec-tr-61662-1998

1 injury or loss of human life;

2 unacceptable loss of service to the public;

3 loss of irreplaceable cultural heritage;

4 losses not involving human, cultural and social values;

5 as type 4 but not involving sensitive equipment.

In a structure, one or more types of damage can occur due to different sources.

Sources of damage taken into consideration in this technical report include:

S_1 touch and step voltages by direct lightning flashes (see annex A);

S_2 fire, explosion, mechanical and chemical effects by direct lightning flashes;

S_3 overvoltages on equipment by direct lightning flashes;

S_4 overvoltages on equipment by indirect lightning flashes;

S_5 fire, explosion, mechanical and chemical effects by indirect lightning flashes.

Each type of damage can be caused by different sources of damage according to the example shown in table 3.

Table 3 – Types and sources of damage

Type of damage	Source of damage				
	By direct lightning			By indirect lightning	
	S_1	S_2	S_3	S_4	S_5
1	X	X			X
2		X	X	X	X
3		X			X
4		X	X	X	X
5		X			X

2.3.2 *Damage probability due to step and touch voltages*

Only the step and touch voltages outside the structure due to direct lightning flash are considered, the damage probability being negligible in other cases (inside the structure, due to nearby lightning flashes, due to lightning flashes affecting the incoming services).

Damage probability due to step and touch voltages by direct lightning flashes to the structure is given by:

iTeh STANDARD PREVIEW
(standards.iteh.ai)

$$p_h = k_h \, p'_h \tag{8}$$

where

p'_h is the probability of damage due to step and touch voltages by direct flashes to the structure without protection measures;

SIST IEC/TR 61662:1998
https://standards.iteh.ai/catalog/standards/sist/82729f85-5b87-465e-922b-20c509a5dd3d/sist-iec-tr-61662-1998

k_h is the reducing factor relevant to the protective measures provided in the structure to mitigate the consequential effects of the lightning.

The values of probability p'_h and of the reducing factor k_h are given in table 4.

Table 4 – Values of damage probability p'_h due to step or touch voltages by direct lightning and values of k_h relevant to protective measures

Type of surface outside the structure	R_c [1] kΩ	p'_h [2]	Protective measure	k_h
Humus, concrete	<1	10^{-2}	Without LPS	1
Marble	1–10	10^{-3}	With LPS	$1-E$[3]
Gravel	10–100	10^{-4}	With LPS and 3 mm PVC insulated down conductor	0,5 $(1-E)$
Asphalt	>100	10^{-5}		

1) The values are obtained as results of measurements between one electrode of 400 cm^2 pressed with a force of 500 N and a far-away point.

2) See annex A.

3) E = efficiency of LPS.

NOTES

1 If people are usually not present outside the structure $p'_h = 0$ is to be assumed.

2 If more than one surface is present in the dangerous place the highest value of p'_h is to be assumed.

3 If more than one protective measure is provided, the resulting reducing factor is the product of the relevant reducing factors.

iTeh STANDARD PREVIEW
(standards.iteh.ai)

2.3.3 *Damage probability due to fire, explosion, mechanical and chemical effects*

SIST IEC/TR 61662:1998
https://standards.iteh.ai/catalog/standards/sist/82729f85-5b87-465e-922b-39c509e5dd3d/sist-iec-tr-61662-1998

Damage may be caused by direct lightning flashes to the structure (source S_2) or by indirect lightning flashes (source S_5).

The partial probabilities of damage involved are:

- p_t probability of a dangerous sparking triggering fire or explosion;
- p_1 probability of dangerous sparking on metal installations;
- p_2 probability of dangerous sparking on electrical installations internal to the structure;
- p_3 probability of dangerous sparking on incoming services; and
- p_4 probability of dangerous sparking on incoming external conductive parts (ECP).

The probabilities p_1, p_2 and p_4 are relevant to direct lightning flashes only; the probability p_3 is relevant to both direct and indirect flashes.

In the case of direct flashes the probability of damage due to fire, explosion, mechanical or chemical effects is:

$$p_{fd} = 1 - [(1 - p_t\,p_1)\,(1 - p_t\,p_2)\,(1 - p_t\,p_3)\,(1 - p_t\,p_4)\,] \approx p_t\,(p_1 + p_2 + p_3 + p_4) \qquad (9)$$