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SERIES K: PROTECTION AGAINST INTERFERENCE

**Protection of persons inside a structure using
telecommunication services provided by
metallic conductors against lightning – Risk
management**

Recommendation ITU-T K.89

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Protection of persons inside a structure using telecommunication services provided by metallic conductors against lightning – Risk management

Summary

Recommendation ITU-T K.89 gives the methodology for evaluating the need to protect users of telecommunication equipment in structures and that of building occupants related to the telecommunication installation.

This method is based on a risk assessment: protection measures are necessary when the risk is greater than the tolerable risk. A maximum value of the tolerable risk is suggested.

The risk is evaluated using the lightning risk components which can be a source of injury to telecommunication service users and building occupants (lightning flashes direct to the line or to the structures connected at the ends of the line).

The risk assessment is done according to Edition 2 of IEC 62305-2. A simple risk assessment is provided to enable the telecommunication network operator to decide when to install gas discharge tubes (GDTs) at the point of entry of the telecommunication line into the structure independent of the structure attributes. This Recommendation can be used together with Recommendation ITU-T K.47, which provides a more accurate risk assessment of lightning flashes directly to the telecommunication line, and IEC 62305-2, which provides the risk assessment of lightning flashes to the structure.

History

Edition	Recommendation	Approval	Study Group
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FOREWORD

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Introduction

Lightning flashes to earth may be hazardous to the telecommunication network, the structures at each end of the line and the telecommunication service users.

The hazard can result in:

- injury of people inside the structures connected to the telecommunication line;
- physical damage (e.g., cable destruction) to the telecommunication line or structures;
- failure (e.g., insulation breakdown) of the telecommunication line;
- failure of the associated electrical and electronic equipment inside the structure (i.e., exchange, customer's building, or remote electronic site).

To reduce the loss (due to electric shock, physical injury or failure of internal systems) as a result of lightning flashes, protection measures may be required. Whether they are needed, and to what extent, will be determined by the risk assessment.

The risk, defined in this Recommendation as the probable average annual loss due to injury as the result of lightning flashes, depends on:

- the annual number of lightning flashes influencing the structure;
- the probability of damage by one of the influencing lightning flashes;
- the mean amount of consequential loss.

Lightning flashes influencing the structure may be divided into:

- flashes direct to a structure connected to the telecommunication line;
- flashes terminating on the telecommunication line entering the structure;
- flashes terminating near the telecommunication line;
- flashes terminating near the structure.

Flashes direct to a telecommunication line or a structure connected to the telecommunication line may cause physical damage to the structure and the telecommunication line. More importantly, they may cause injury to telecommunication equipment users, cause a fire in the premises or damage equipment, which could immediately endanger life. Flashes near the telecommunication line or the structure may also cause failure of the telecommunication line and of electrical and electronic systems inside the structures.

The number of lightning flashes influencing the structure depends on the dimensions and the characteristics of the telecommunication network, the characteristics of the structure, on the environment characteristics, as well as on lightning ground flash density in the region where the structure is located.

The probability of lightning damage depends on the telecommunication network, on the structure, on the lightning current characteristics, as well as on the type and efficiency of applied protection measures.

The annual mean amount of the consequential loss depends on the extent of damage and the consequential effects which may occur as result of a lightning flash.

The use of protection will reduce the probability of damage and the amount of consequential loss.

The assessment of risk due to all possible effects of lightning flashes, to the telecommunication network and the structure, are given in this Recommendation.

The decision to provide lightning protection may be taken regardless of the outcome of any risk assessment where there is a desire that there be no avoidable risk.

The boundary between IEC 62305-2 and ITU-T K.89 is that the former deals with the full risk assessment whereas the latter deals with the limitation of dangerous events at the structure from the telecommunication line. The telecommunication network operator can contribute to the customer's protection costs by limiting the number of dangerous events arriving at the customer's structure from the telecommunication line.

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Recommendation ITU-T K.89

Protection of persons inside a structure using telecommunication services provided by metallic conductors against lightning – Risk management

1 Scope

This Recommendation deals with the risk management of lightning protection for occupants of a structure related to a telecommunication service using metallic conductor cables. Where the telecommunication service is provided by CDMA WLL, or similar, refer to [ITU-T K.71].

The risk assessment is limited to injury of occupants where the installation of the telecommunication service increases the risk of injury due to lightning. This Recommendation provides a procedure for the evaluation of such a risk. Once an upper tolerable limit for the risk has been selected, this procedure allows the selection of appropriate protection measures to be adopted to reduce the risk to a level at or below the tolerable limit.

This Recommendation is mainly aimed at mitigating the risk associated with a telecommunication service in a private, public or commercial structure. The risks in telecommunication structures are generally mitigated by network operator practices and policies. However, this Recommendation can be used for telecommunication structures if agreed by the telecommunication operator.

This Recommendation shall be used together with [ITU-T K.72], which provides the risk assessment against lightning flashes to the telecommunication line. Recommendation [ITU-T K.85] provides the risk assessment against equipment damage in customer premises.

The protection need for line equipment (such as multiplexers, power amplifiers, optical network units) and line termination equipment is not considered in this Recommendation and it should be evaluated using the risk assessment applied to the structure where the equipment is located (i.e., exchange, customer's building, or remote electronic site).

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

- [ITU-T K.21] Recommendation ITU-T K.21 (2011), *Resistibility of telecommunication equipment installed in customer premises to overvoltages and overcurrents*.
- [ITU-T K.60] Recommendation ITU-T K.60 (2008), *Emission levels and test methods for wireline telecommunication networks to minimize electromagnetic disturbance of radio services*.
- [ITU-T K.66] Recommendation ITU-T K.66 (2011), *Protection of customer premises from overvoltages*.
- [ITU-T K.71] Recommendation ITU-T K.71 (2011), *Protection of customer antenna installations*.
- [ITU-T K.72] Recommendation ITU-T K.72 (2011), *Protection of telecommunication lines using metallic conductors against lightning – Risk management*.

- [ITU-T K.85] Recommendation ITU-T K.85 (2011), *Requirements for the mitigation of lightning effects on home networks installed in customer premises.*
- [IEC 62305-2] IEC 62305-2 (2010), *Protection against lightning – Part 2: Risk management.*
<http://webstore.iec.ch/webstore/webstore.nsf/ArtNum_PK/45856?OpenDocument>
- [IEC 62305-3] IEC 62305-3 (2010), *Protection against lightning – Part 3: Physical damage to structures and life hazard.*
<http://webstore.iec.ch/webstore/webstore.nsf/ArtNum_PK/46595?OpenDocument>
- [IEC 62305-4] IEC 62305-4 (2010), *Protection against lightning – Part 4: Electrical and electronic systems within structures.*
<http://webstore.iec.ch/webstore/webstore.nsf/ArtNum_PK/46590?OpenDocument>

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following term defined elsewhere:

3.1.1 telecommunication network [ITU-T K.60]: Entirety of equipment (comprising any combination of the following: network cable, telecommunication terminal equipment, and telecommunication system or installation) that is indispensable to ensure normal intended operation of the telecommunication network.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 dangerous event: Lightning flash to or near the telecommunication line to be protected which causes a dangerous surge voltage due to lightning.

3.2.2 dangerous surge voltage due to lightning: A surge voltage whose peak value U_p is greater than the equipment resistibility or the conductor insulation surge voltage withstand level of the telecommunication line.

3.2.3 electronic system: System incorporating sensitive electronic components such as communication equipment, computers, control and instrumentation systems, radio systems and power electronic installations.

3.2.4 failure of electrical and electronic systems: Permanent damage of electrical and electronic systems due to surges.

3.2.5 lightning flash near a line: Lightning flash striking close enough to a line to be protected that it may cause dangerous surges.

3.2.6 lightning flash to a structure connected to the line to be protected: Lightning flash striking the structure connected to the line to be protected.

3.2.7 line to be protected: Line connected to a structure for which protection is required against the effects of lightning in accordance with this Recommendation.

3.2.8 loss L_X : Annual mean amount of loss (humans and goods) consequent to a specified type of damage due to a dangerous event, relative to the total value (humans and goods) of the object to be protected.

3.2.9 metallic symmetric conductors: Transmission media consisting of a pair of twisted wires balanced with respect to earth, usually assembled in groups in order to form a telecommunication cable.

3.2.10 node: Point between sections of a telecommunication line.

NOTE – The list of nodes on a telecommunication installation is shown in the reference configuration (clause 5).

3.2.11 physical damage: Damage to a telecommunication line due to mechanical and thermal effects of lightning.

3.2.12 priority service: A priority service is a service where the loss of the telecommunication service may result in loss of life.

3.2.13 protection measures: Measures to be adopted in the telecommunication installation to be protected to reduce the risk.

3.2.14 risk component R_X : Partial risk depending on the source and the type of damage.

3.2.15 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.

3.2.16 section of a telecommunication line S_S : Part of a telecommunication line with homogeneous characteristics where only one set of parameters is involved in the assessment of a risk component.

3.2.17 source of damage: The source of damage depends on the position of the point of strike relative to the considered line:

- Source of damage S_1 : Flashes to the structure (the exchange, the customer's building, or remote site) where the telecommunication or the signalling line enters.
- Source of damage S_2 : Flashes near the structure (the exchange, the customer's building, or remote site) where the telecommunication or the signalling line enters.
- Source of damage S_3 : Flashes to the telecommunication line entering the structure (the exchange, the customer's building, or remote site).
- Source of damage S_4 : Flashes near the telecommunication line entering the structure (the exchange, the customer's building, or remote site).

3.2.18 surge: Temporary excessive voltage or current, or both, coupled on a telecommunication line from an external electrical source.

NOTE 1 – Typical electrical sources are lightning and AC/DC power systems.

NOTE 2 – Electrical source coupling can be one or more of the following: electric field (capacitive), magnetic field (inductive), conductive (resistive), electromagnetic field.

3.2.19 surge due to lightning: A surge that is caused by lightning through any type of electromagnetic (conductive, inductive and capacitive) coupling.

NOTE – It is characterized by the following five parameters: peak value; front time, T_1 ; time to half value, T_2 (or time parameters T_1/T_2); steepness; and specific energy.

3.2.20 surge protective device (SPD): Device that restricts the voltage of a designated port or ports, caused by a surge, when it exceeds a predetermined level.

- 1) Secondary functions may be incorporated, such as a current-limiting device to restrict a terminal current.
- 2) Typically, the protective circuit has at least one non-linear voltage-limiting surge protective component.
- 3) An SPD is a combination of a protection circuit and holder.

3.2.21 telecommunication installation: A combination of equipment, systems, finished products and/or components assembled and/or erected by an assembler/installer at a given place to operate together in order to provide telecommunication services.

3.2.22 telecommunication line: Transmission medium intended for communication between equipment that may be located in separate structures, such as a phone line and a data line.

3.2.23 tolerable risk R_T : Maximum value of the risk which can be tolerated for the object to be protected.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

DSLAM	Digital Subscriber Line Access Multiplier
EB	Equipotential Bonding
EBB	Equipotential Bonding Bar
EPR	Earth Potential Rise
GDT	Gas Discharge Tube
LEMP	Lightning Electromagnetic Pulse
LPL	Lightning Protection Level
LPS	Lightning Protection System
MDF	Main Distribution Frame
MET	Main Earthing Terminal
MSPD	Multiservice Surge Protective Device
NT	Network Termination
PE	Protective Earthing
RCCB	Residual Current Circuit Breaker
RCD	Residual Current Device
SELV	Safety Extra Low Voltage
SPD	Surge Protective Device
CDMA WLL	Code Division Multiple Access Wireless Local Loop

5 Reference configuration

The telecommunication network to be considered is the physical connection between:

- the switch telecommunication building and the customer's building; or
- two switch telecommunication buildings; or
- two customer's buildings.

The telecommunication network to be protected using this Recommendation is limited to telecommunication lines (buried or aerial cables, shielded or unshielded cables).

Figure 1 shows the reference configurations for the telecommunication lines using metallic symmetric conductors, where the nodes and the cable sections between them can be seen.

The nodes of Figure 1 have the following description:

- Node E: Entrance of the exchange building, e.g., main distribution frame (MDF).
- Node P: Transition between paper-insulated and plastic-insulated buried cables.
- Node C: Transition between buried and aerial cables.

- Node R: Entrance of remote electronic sites with active equipment, e.g., DSLAM.
- Node D: Transition between shielded and unshielded aerial cables.
- Node S: Entrance of the customer's building.

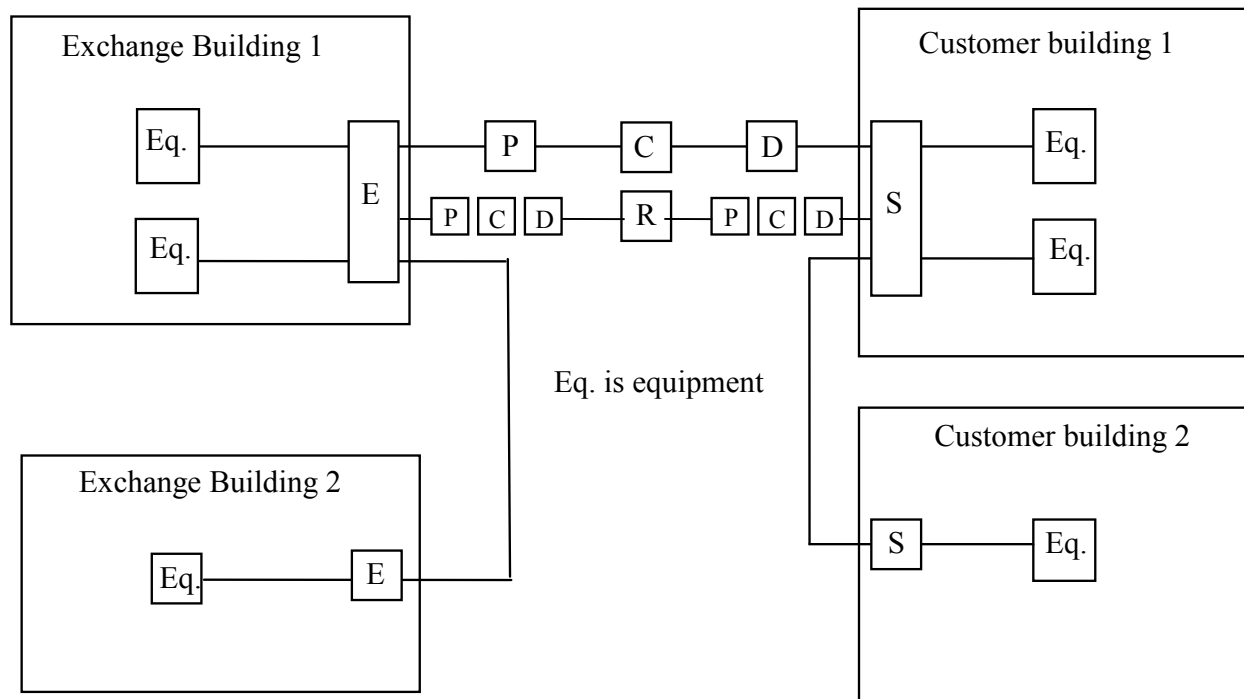


Figure 1 – Reference configuration

6 Explanation of terms

6.1 Damage and loss

6.1.1 Source of damage

The lightning current is the primary source of damage.

In general, the following sources are distinguished by the strike attachment point (Figure 2):

- S₁: Flashes to a structure.
- S₂: Flashes near a structure.
- S₃: Flashes to a service (which includes a telecommunication line).
- S₄: Flashes near a service (which includes a telecommunication line).

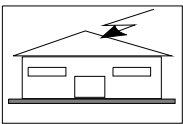
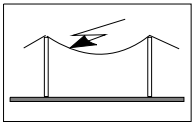
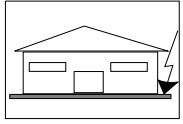
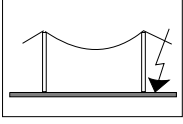
Source of damage	Striking point
S1	
S3	
S2	
S4	

Figure 2 – Lightning as source of damage

6.1.2 Types of damage to persons

A lightning flash may cause injury depending upon the characteristics of the telecommunication network and the structure. Some of the most important characteristics are:

- type of structure construction, e.g., timber, brick or reinforced concrete;
- type of telecommunication cable, e.g., shielded or unshielded;
- whether or not protection measures have been used at the structure or on the network cable.

In general, for practical applications of the risk assessment, it is useful to distinguish between three basic types of damage which can appear as the consequence of lightning flashes. They are as follows.

D1: Injury to living beings by electric shock.

D2: Physical damage (may cause a fire or gas explosion).

D3: Failure of electrical and electronic systems (only where a person has a medical dependency on the telecommunication service).

Lightning striking the telecommunication network can cause:

- a step and touch potential between the equipment, connected to the telecommunication service, and the structure earth environment;
- a flashover within the structure causing a fire or a gas explosion;
- an outage of the telecommunication service due to damage to the physical line itself (both in the network or the structure) and to the telecommunication equipment (both in the network and in the structure).

6.1.3 Types of loss

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

In general, the following types of loss shall be taken into account:

- 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 contents, service and loss of activity)

The type of loss considered in this Recommendation is:

- L₁: Loss of human life

This Recommendation will also consider the risk of injury.

6.2 Risk and risk components

6.2.1 Risk

The risk R is the value of a probable average annual loss.

To evaluate risk, R , the relevant risk components (partial risks depending on the source and type of damage) shall be defined and calculated.

The risk, R , is the sum of the risk components.

The risk components, as defined in [IEC 62305-2], which can cause all types of loss, are listed in clauses 6.2.2 to 6.2.5.

6.2.2 Risk components for a structure due to flashes to the structure

Direct lightning flashes to the structure to which the telecommunication network is connected can cause the following risk component:

- R_A : Component related to injury to living beings caused by electric shock due to touch and step voltages inside the structure and in the zones up to 3 m outside the structure. Loss of type L₁ and, in the case of structures holding livestock, loss of type L₄ with possible loss of animals may also arise.

NOTE – In special structures, people may be endangered by direct strikes (e.g., top level of garage parking or stadiums). These cases may also be considered using the principles of this standard.

- R_B : Component related to physical damage caused by dangerous sparking inside the structure triggering fire or explosion, which may also endanger the environment. All types of loss (L₁, L₂, L₃ and L₄) may arise.

- R_C : Component related to failure of internal systems caused by LEMP. Loss of type L₂ and L₄ could occur in all cases along with type L₁ in the case of structures with risk of explosion and hospitals or other structures where failure of internal systems immediately endangers human life.

6.2.3 Risk component for a structure due to flashes near the structure

- R_M : Component related to failure of internal systems caused by LEMP. Loss of type L₂ and L₄ could occur in all cases, along with type L₁ in the case of structures with risk of explosion and hospitals or other structures where failure of internal systems immediately endangers human life.

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6.2.4 Risk components for a structure due to flashes to a line connected to the structure

- R_U : Component related to injury to living beings caused by electric shock due to touch voltage inside the structure. Loss of type L_1 and, in the case of agricultural properties, losses of type L_4 with possible loss of animals could also occur.
- R_V : Component related to physical damage (fire or explosion triggered by dangerous sparking between external installation and metallic parts generally at the entrance point of the line into the structure) due to lightning current transmitted through or along incoming lines. All types of loss (L_1 , L_2 , L_3 , L_4) may occur.
- R_W : Component related to failure of internal systems caused by overvoltages induced on incoming lines and transmitted to the structure. Loss of type L_2 and L_4 could occur in all cases, along with type L_1 in the case of structures with risk of explosion and hospitals or other structures where failure of internal systems immediately endangers human life.

NOTE 1 – The lines taken into account in this assessment are only the lines entering the structure.

NOTE 2 – Lightning flashes to or near pipes are not considered as a source of damage based on the bonding of pipes to an equipotential bonding bar. If an equipotential bonding bar is not provided, such a threat must also be considered.

6.2.5 Risk component for a structure due to flashes near a line connected to the structure

- R_Z : Component related to failure of internal systems caused by overvoltages induced on incoming lines and transmitted to the structure. Loss of type L_2 and L_4 could occur in all cases, along with type L_1 in the case of structures with risk of explosion and hospitals or other structures where failure of internal systems immediately endanger human life.

NOTE 1 – The lines taken into account in this assessment are only the lines entering the structure.

NOTE 2 – Lightning flashes to or near pipes are not considered as a source of damage based on the bonding of pipes to an equipotential bonding bar. If an equipotential bonding bar is not provided, such a threat must also be considered.

6.3 Composition of risk components related to a structure

Risk components to be considered for each type of loss in a structure are listed below:

- R_1 : Risk of loss of human life:

$$R_1 = R_{A1} + R_{B1} + R_{C1}^{1)} + R_{M1}^{1)} + R_{U1} + R_{V1} + R_{W1}^{1)} + R_{Z1}^{1)}$$

¹⁾ Only for structures with risk of explosion and for hospitals with life-saving electrical equipment or other structures when failure of internal systems immediately endangers human life.

The above formula determines the general risk R_1 for a person inside or outside the structure. The purpose of this Recommendation is to determine the risks of injury associated with the telecommunication service provided over metallic conductors.

It should be understood that the metallic telecommunication service brings a remote earth into the structure. As well as the surges entering the structure from the telecommunication line a lightning strike to the structure or to the power service can cause a touch potential between the telecommunication remote earth and the structure earth.