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ITU-T

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SERIES K: PROTECTION AGAINST INTERFERENCE

Protection of customer antenna installations

Recommendation ITU-T K.71

ITU-T

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Protection of customer antenna installations

Summary

Recommendation ITU-T K.71 provides information to network operators on when antennas may be installed in, or on, a customer building without performing a building-specific risk assessment.

When a risk assessment is required, the Recommendation provides guidance on the application of IEC 62305-2. It also provides information on the responsibilities of the network operator and the building owner.

This revised version of Recommendation ITU-T K.71 has updated references and added definitions from IEC 60364-5-54 to minimize confusion regarding protective conductors. The section on protecting against contacts between the antenna and feeder cable has been amended. Appendix II has been checked to ensure the generic risk assessments are in line with IEC 62305-2 ed. 2.

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T K.71	2007-07-29	5
2.0	ITU-T K.71	2011-06-13	5

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

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Protection of customer antenna installations

1 Scope

Telephony services delivered via an antenna installation may be subjected to lightning discharges. This Recommendation provides requirements to minimize the risk of injury to users of the service and damage to equipment. It provides requirements to achieve protection of telecommunications and video content antenna systems, including satellite antennas, against lightning discharges and mains contact including contact with aerial power service leads.

When protection against direct lightning discharges is not required, this Recommendation requires protection against mains contact to minimize the risk of injury to users of the service and to network operator personnel.

When protection against direct lightning discharges is required, this Recommendation defines protection measures distinguishing two cases:

1) The antenna is located on the building.
2) The antenna is installed on a mast near to the building at a maximum distance of about ten metres.

This Recommendation does not provide methods to protect the antenna and associated cabling against a direct strike to the antenna mast (see clause 7.2).

Damage to equipment is minimized by providing requirements to achieve protection against lightning.

This Recommendation provides requirements for:

– the resistibility of the equipment;
– how and when to protect the customer's premises from direct strikes;
– how and when to bond the mast or tower to the customer building electrical installation earthing system;
– how and when to protect the services, i.e., the power supply for the service, the telecommunication line and the antenna cable, entering the customer's building.

This Recommendation does not apply to structures where there is the risk of explosion, nor to hospitals with life-saving electrical equipment or structures where failures of internal systems immediately endanger human life.

This Recommendation covers the protection of antennas installed at private buildings ranging in size from small single-storey buildings up to multi-storey buildings. This Recommendation only applies in the case when the antenna is being installed to supply service to the building on which the antenna is being installed. For radio base station installations refer to [ITU-T K.56].

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 (2008), *Resistibility of telecommunication equipment installed in customer premises to overvoltages and overcurrents*.

[ITU-T K.47] Recommendation ITU-T K.47 (2008), *Protection of telecommunication lines using metallic conductors against direct lightning discharges*.

[ITU-T K.56] Recommendation ITU-T K.56 (2010), *Protection of radio base stations against lightning discharges*.

[ITU-T K.66] Recommendation ITU-T K.66 (2004), *Protection of customer premises from overvoltages*.

[ITU-T K.67] Recommendation ITU-T K.67 (2006), *Expected surges on telecommunications and signalling networks due to lightning*.

[IEC 60364-5-54] IEC 60364-5-54 Ed. 2.0 (2002), *Electrical installations of buildings – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements, protective conductors and protective bonding conductors.*

[IEC 60728-11] IEC 60728-11 Ed. 3.0 (2010), *Cable networks for television signals, sound signals and interactive services – Part 11: Safety*.

[IEC 60950-1] IEC 60950-1 Ed. 2.0 (2005), *Information technology equipment – Safety – Part 1: General requirements.*

[IEC 62305-1] IEC 62305-1 Ed. 2 (2010), *Protection against lightning – Part 1: General principles*.

[IEC 62305-2] IEC 62305-2 Ed. 2.0 (2010), *Protection against lightning – Part 2: Risk management*.

[IEC 62305-3] IEC 62305-3 Ed. 2.0 (2010), *Protection against lightning – Part 3: Physical damage to structures and life hazard*.

[IEC 62305-4] IEC 62305-4 Ed. 2.0 (2010), *Protection against lightning – Part 4: Electrical and electronic systems within structures.*

[IEC 62368-1] IEC 62368-1 Ed 1.0 (2010), *Audio/video, information and communication technology equipment – Part 1: Safety requirements*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 earthing conductor [IEC 60364-5-54]: Conductor which provides a conductive path, or part of the conductive path, between a given point in a system or in an installation or in equipment and an earth electrode. [IEV 195-02-03]

NOTE – For the purposes of this Recommendation, an earthing conductor is the conductor which connects the earth electrode to a point in the equipotential bonding system, usually the main earthing terminal.

3.1.2 main earthing terminal (main earthing busbar) [IEC 60364-5-54]: Terminal or busbar which is part of the earthing arrangement of an installation enabling the electric connection of a number of conductors for earthing purposes. [IEV 195-02-33]

NOTE – ITU-T sometimes designates the MET as the main earthing bar (MEB).

3.1.3 protective bonding conductor [IEC 60364-5-54]: Protective conductor provided for protective-equipotential-bonding. [IEV 195-02-10]

3.1.4 protective conductor [IEC 60364-5-54]: Conductor provided for purposes of safety, for example protection against electric shock. [IEV 195-02-09]

NOTE – In some countries this conductor is sometimes referred to as protective earth (PE).

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 antenna system: The antenna connecting cable and terminating equipment.

3.2.2 exposed structure: A structure, e.g., a telecommunications tower or a high building, which needs to be protected against direct lightning strokes.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

BB	Bonding Bar
CDMA WLL	Code Division Multiple Access Wireless Local Loop
GDT	Gas Discharge Tube
LPL	Lightning Protection Level
LPS	Lightning Protection System
MEB	Main Earthing Bar
MET	Main Earth Terminal
R	Risk value
R_1	Risk of loss of human life
R_2	Risk of loss of service
R_{A1}	Risk of loss of human life related to injury of living beings caused by touch and step voltages due to flashes to the structure
R_B	Risk component related to physical damage caused by dangerous sparking inside the building due to flashes to the structure
R_{B1}	Risk of loss of human life related to physical damage caused by dangerous sparking inside the building due to flashes to the structure
R_c	Risk component related to physical damage due to flashes to the building
R_M	Risk component related to physical damage due to flashes near the building
R_T	Tolerable risk value
R_{T1}	Tolerable risk of loss of human life
R_{T2}	Tolerable risk of loss of service
R_U	Risk component related to injury to living beings caused by touch voltage inside the structure due to flashes to the service
R_v	Risk component related to physical damage caused by dangerous sparking inside the building due to flashes to the service
R_w	Risk component related to physical damage due to flashes to the service
R_z	Risk component related to physical damage due to flashes near the service
SPD	Surge Protection Device

5 Reference configuration

Telephony services delivered via an antenna installation have the following two reference configurations:

1) the antenna is located on the building (Figure 1a);

2) the antenna is installed on a mast near to the building (Figure 1b).

In both configurations, the antenna is connected to the associated equipment with shielded symmetrical pair cable or with a coaxial cable. The associated equipment, powered by mains, is connected to the end user equipment, e.g., a personal computer (PC) (for example via a serial or USB cable), and to the external telecommunication line.

Further examples of the reference configurations covered by this Recommendation are shown in Figures 1c to 1e.

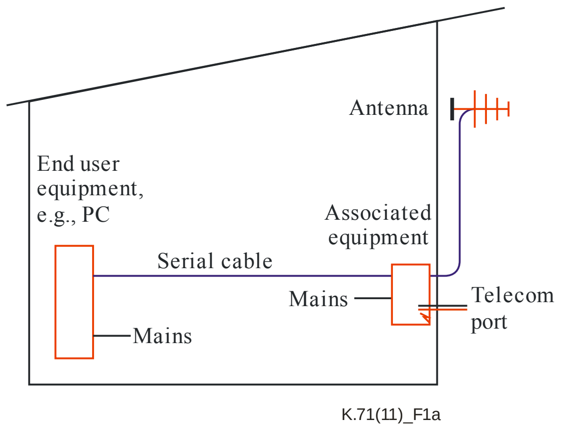


Figure 1a – Antenna attached to structure

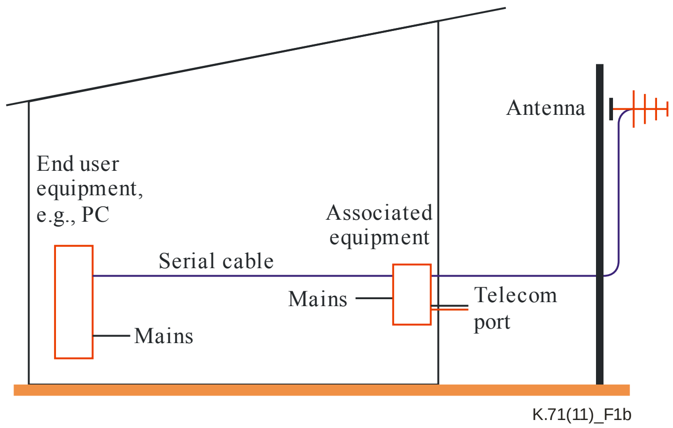


Figure 1b – Antenna installed on a mast

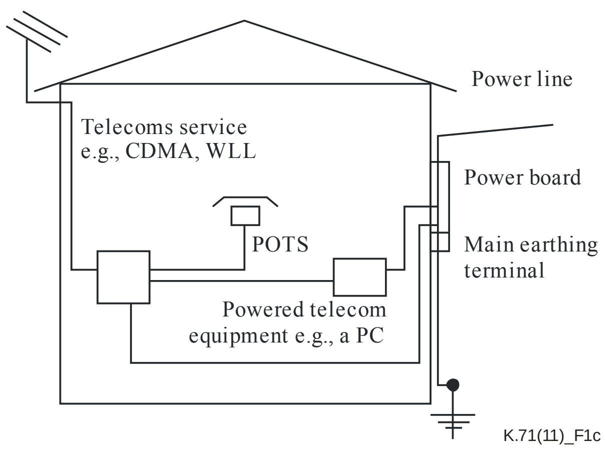


Figure 1c – Basic antenna-provided service

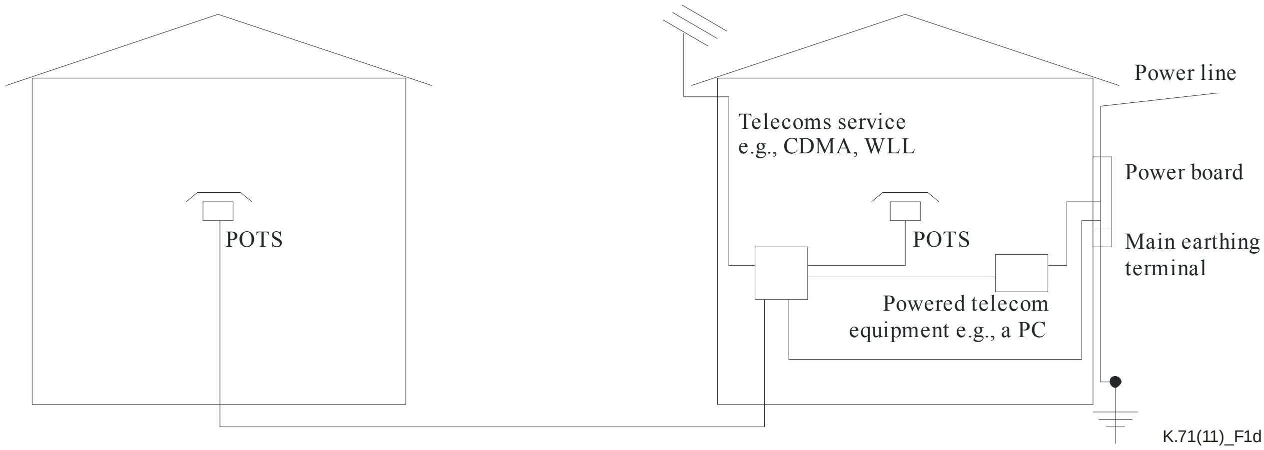


Figure 1d – Basic antenna-provided service with service extended to an out-building

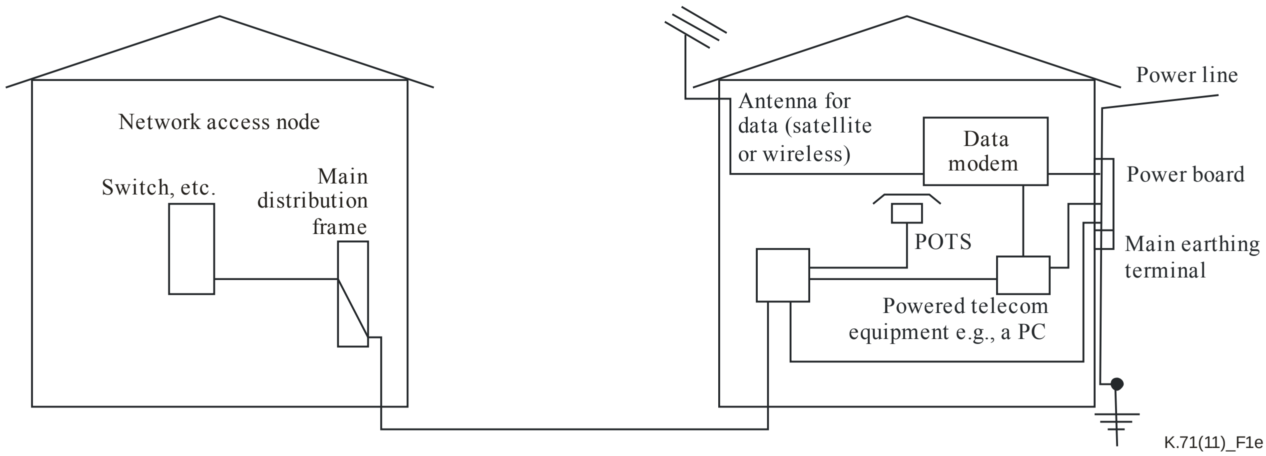


Figure 1e – Telecommunications service plus an antenna for Internet service

6 Protection need against lightning

The need for lightning protection is determined by performing a risk assessment according to [IEC 62305-2 e1], which compares the risk value R, as the sum of all the risk components, with the tolerable risk value R_T.

To minimize the risk of injury to users, the risk of loss of human life (R_1) related to the building shall be evaluated by the building owner and compared with the tolerable risk value (R_{T1}). A maximum value of the tolerable risk of loss of human life equal to 10^{-5} is assumed by this Recommendation.

When the risk R_1 of the building, with the antenna installation, is less than the tolerable risk R_{T1}, the site is considered inherently protected against direct lightning. In this case, the antenna need only be protected against mains contact (clause 8.2).

When $R_1 > R_{T1}$ lightning protection, against the loss of human life in the building, is required. This Recommendation defines the methods of protection (clause 8) and the protection requirements (clause 9).

To minimize the risk of damage to equipment inside the building, the risk of loss of service (R_2) should be evaluated and compared to the tolerable risk of loss of service value $R_{T2} = 10^{-3}$ or a lower value according to the customer's decision. Even when $R_1 < R_{T1}$, the customer should evaluate the risk of loss of service R_2 in accordance with [IEC 62305-2 e1]. When $R_2 > R_{T2}$, protection is recommended and the knowledge of the risk component values guides the protection designer in selecting the most adequate protective measures in order to protect the equipment inside the building. This evaluation and the relevant protective measures are outside the scope of this Recommendation.

The risk assessment of loss of service R'_2 related to the antenna system when the antenna is installed near the building is not necessary because this risk is very low due to both the short length (in general less than 50 m) of the cabling and the presence of the shield (coaxial pair or shielded line).

The protection needs of the antenna cable against physical damage due to a direct lightning strike to the building is considered in the risk assessment against the loss of human life (see clause 9.5).

To assist in the risk assessments, this Recommendation has defined a site classification (clause 7).

7 Site classification

7.1 Antenna installed within, or attached to, the building

The flowchart in Figure 2 determines the need for a risk assessment.

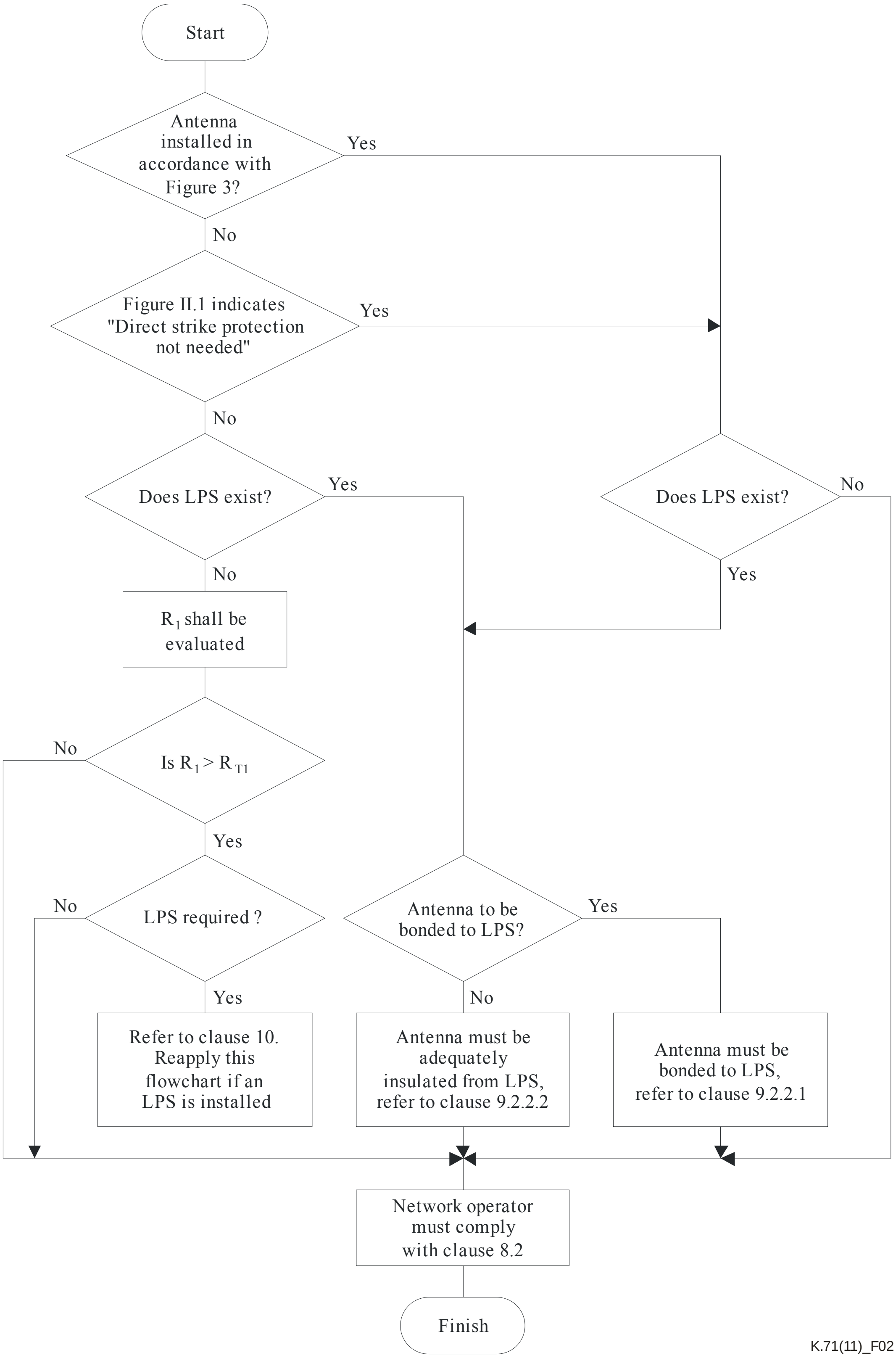


Figure 2 – Process for antennas on or in the structure

7.1.1 Sites inherently protected against direct flashes due to antenna placement

If the antenna is installed within the shaded area of Figure 3, it is considered to be inherently protected from direct lightning strikes. There are two cases to consider (see Figure 2):

1) No LPS exists. In this case refer to clause 9.2.1.

2) An LPS exists. In this case refer to clause 9.2.2.

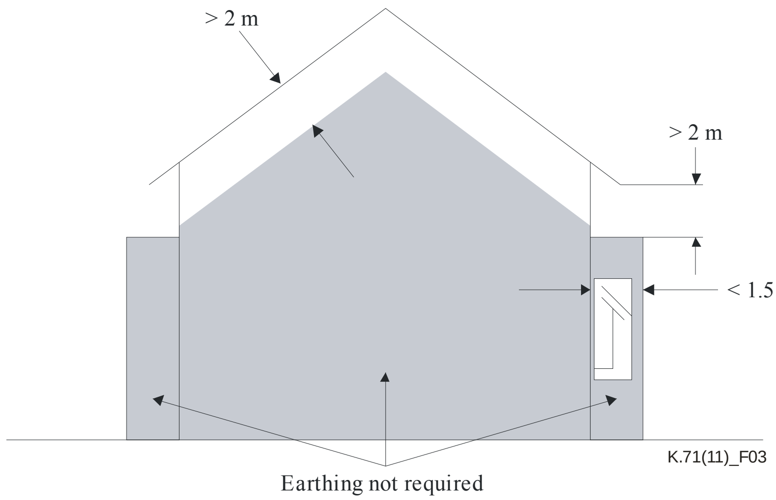


Figure 3 – Example of outdoor antenna mounting on buildings where earthing is not required but is recommended (Figure 9 of [IEC 60728-11])

7.1.2 Sites determined to have a low risk of loss of human life from strikes to the structure

To eliminate the need for the network operator to have to perform a risk assessment for every installation not covered by clause 7.1.1, a range of installations have been considered to determine cases where the risk of a direct lightning strike is less than the tolerable risk using the software provided with [IEC 62305-2]; see Appendix II. If the Flowchart in Figure II.1 indicates "Specific risk assessment required", refer to clauses 6 and 7.1.3.

NOTE – This risk assessment assumes no external services are connected to the building. This risk assessment is only to determine if an LPS is required on the building when the network operator installs the antenna.

There are two cases to consider and these are:

1) No LPS exists. In this case refer to clause 9.2.1.

2) An LPS exists. In this case refer to clause 9.2.2.

7.1.3 Sites requiring individual risk assessment

A risk assessment is not required if an LPS already exists. Where an LPS exists, refer to clause 9.2.2.

If the installation is not covered in clause 7.1.1 or the structure is not covered by the generic risk assessments of clause 7.1.2, the risk of loss of life (R_1) should be calculated in accordance with [IEC 62305-2].

When $R_1 \leq R_{T1}$, lightning protection against loss of life is not required. In this case, protection is only required against mains contact; see clause 8.2.

When $R_1 > R_{T1}$ the methods of protection should be as determined in clauses 8 and 9.

These situations are also shown in Figure 2.

7.2 Antenna installed near the building

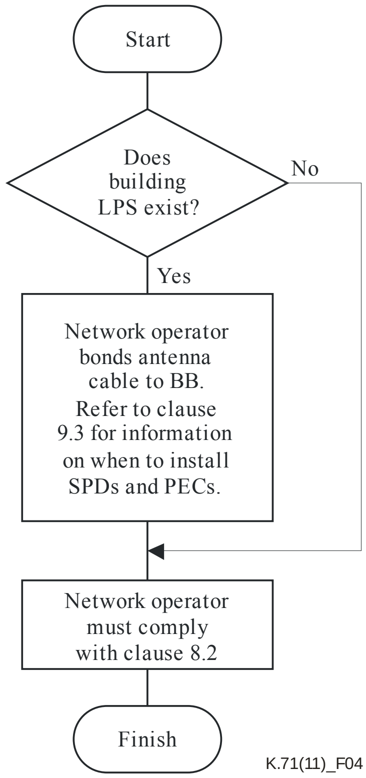


Figure 4 – Process for an antenna on a separate tower

If the structure is not covered by the generic risk assessments of clause 7.1.2, the risk of loss of life (R_1) should be calculated in accordance with [IEC 62305-2]. The individual risk assessment should be evaluated referring to the building, because the antenna mast is considered separate from the building installation.

When $R_1 \leq R_{T1}$, lightning protection against loss of life is not required and only protection against contact with the mains is required, see clause 8.2.

When $R_1 > R_{T1}$, an LPS on the building could be required to achieve the required protection level ($R_1 \leq R_{T1}$), see clause 8. In this case, the method of protection is given in clauses 8 and 9.

To determine the need for protection against direct strikes to the antenna mast, refer to [ITU-T K.56] where some protection measures are also given.

8 Methods of protection

8.1 General

The type of the protection measure depends on which risk components need to be reduced.

If the risk component R_B (related to physical damage caused by dangerous sparking inside the building due to flashes to the structure) is the major contributor, an LPS on the building could be required to achieve the required protection level ($R_1 \leq R_{T1}$).

If the risk components R_U (related to injury to living beings caused by touch voltage inside the structure due to flashes to the service) and R_V (related to physical damage caused by dangerous sparking inside the building due to flashes to the service) are the major contributors, SPDs and equipotential bonding could be enough to achieve the required protection level.

8.2 Contact with an aerial line phase conductor or a subcircuit phase conductor

Contact between the antenna or associated cabling and a phase conductor can cause serious problems, e.g., a fire due to overheating or electric shock. Protection can be provided by either bonding the antenna system to the MEB or by providing adequate isolation.

8.2.1 Bonding

Refer to clause 9.4.1.3.

8.2.2 Isolation

Measures include:

– Maintaining suitable clearance distances of the antenna installation (and associated lead-in cable) from aerial line conductors. A minimum 3 m horizontal clearance would be considered conservative. Additional spacing may be required to ensure safety of personnel during the installation or if the antenna is attached to a long arm. The antenna lead-in cable should not cross over or under overhead mains power service lines.

– Ensuring that there are no live conductors associated with the electrical installation within the vicinity of the proposed antenna location (e.g., within 3 m). This may need to involve suitable inspection and testing as part of the installation procedure.

Where it is not possible to maintain adequate isolation, the installation should be bonded to the building earthing system, see clause 8.2.1.

8.3 Direct lightning strike protection

The installation of the lightning protection system (LPS) against direct lightning strike is a complex subject and reference should be made to [IEC 62305-3] or to a national standard. Some information taken from this IEC standard is reported in Appendix I.

The requirements for bonding of the antenna system to, or insulating from, an LPS are described in clause 9.2.2.

9 Protection requirements

9.1 General

All parts of the outer antenna system shall be so designed that they will withstand a lightning discharge without danger of fire or separation of the components of the antenna system.

Antennas shall not be installed on buildings having roofs covered with highly flammable materials (for example, thatch, reed-like material, etc.).

Antenna cables and earthing conductors shall not be laid in areas used for the storage of easily ignitable materials, such as hay, straw and similar substances, or in areas in which explosive gases can develop or collect.

An antenna installation may need to be protected against mains contact and lightning discharges. As a minimum, the following applies to all sites:

– The associated equipment shall comply with the safety requirements of [IEC 62368-1] or [IEC 60950-1].

– The associated equipment shall comply with the resistibility requirements requested by [ITU-T K.21] for ports connected to:
  - external symmetric pair cables;
  - mains;
  - internal cable.

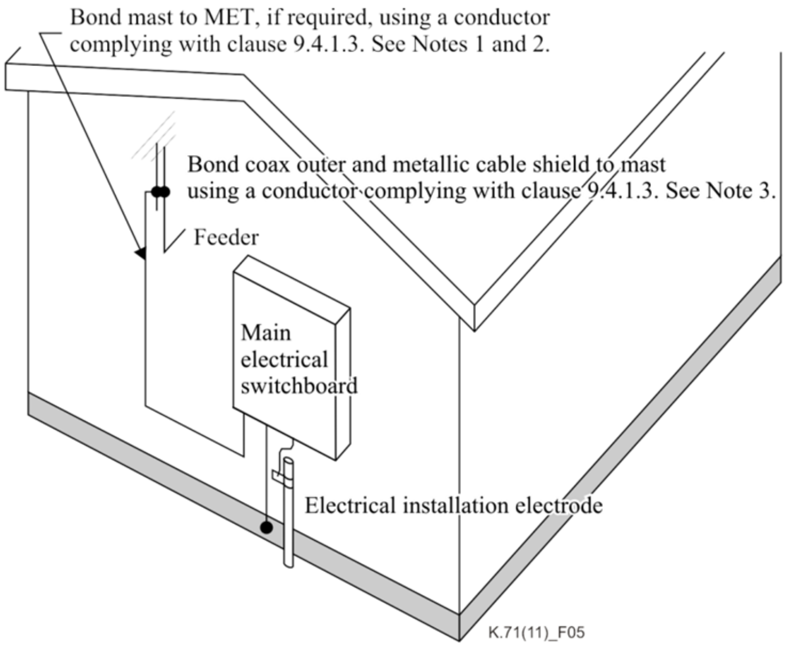
– Protection is required for both the installation and people against mains contacts. Protection against power contact can be achieved by earthing, coordinated with protection fuses or residual current devices on the mains power, or adequate isolation (see clause 8.2).

In addition, where the antenna is exposed to direct lightning, the requirements requested by this Recommendation apply.

9.2 Antenna installed within, or attached to, the building

9.2.1 Inherently protected sites (LPS not existing and not required)

When an LPS does not exist and is not required, it is only necessary to provide protection against contact with mains conductors (see clause 8.2). In addition, refer to Figure 5 when the antenna is installed on an outside wall.



NOTE 1 – The above bond may not necessary; see clause 8.2.
NOTE 2 – The bond to MET may be via a BB or a connection to the electrical installation electrode.
NOTE 3 – In a normal installation a bond will already exist between the coax outer/metallic cable shield and the mast.

Figure 5 – Protection requirements when antenna installed within inherently protected sites (protected from direct strikes)

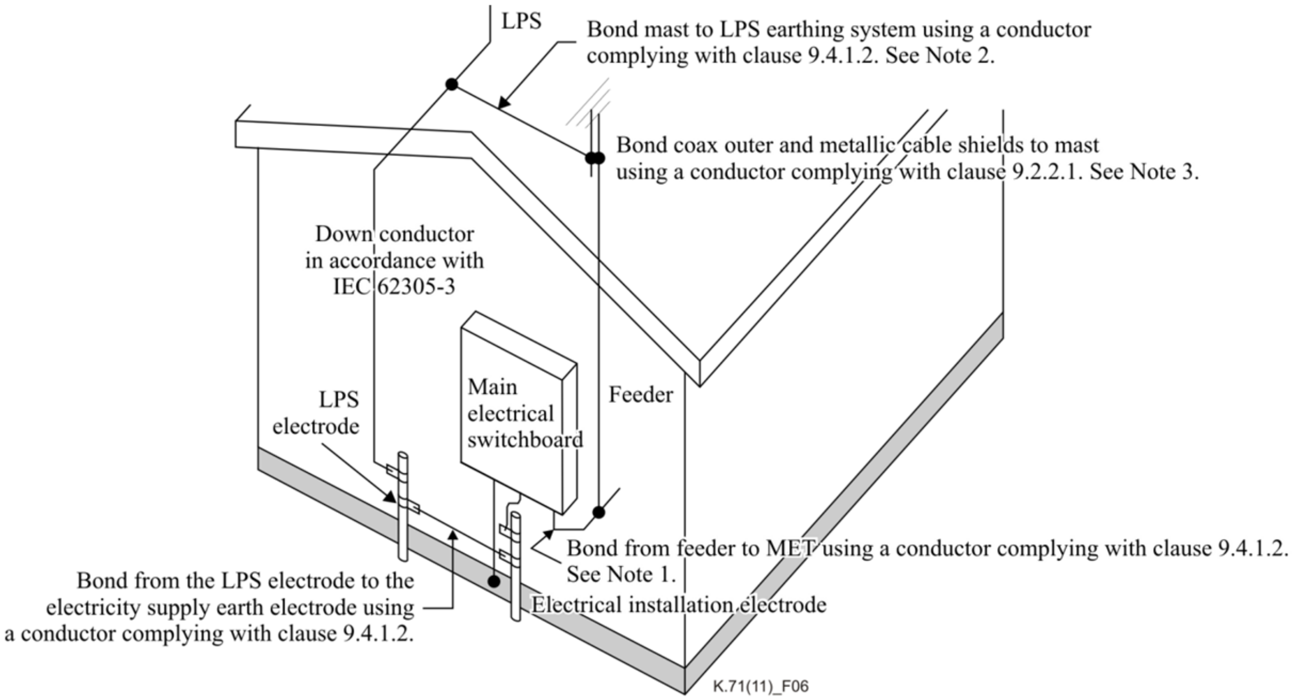
9.2.2 Buildings with existing LPS

When there is an LPS, the antenna system must either be bonded to the LPS or be adequately isolated or insulated from the LPS.

9.2.2.1 Antenna bonded to LPS

Bond the antenna mast to the building's LPS and electrical safety earthing system as shown in Figure 6. Refer to clause 8.2 regarding contact with aerial line conductors and live conductors and to clause 9.4 for general earthing and bonding requirements. If possible, install the antenna in a location where it will be protected from direct lightning strikes by the air termination system.

If the antenna is not protected from direct lightning strikes by the air termination system, it must be able to withstand a direct strike. Refer to [IEC 62305-3] for the design requirements. In this case, the bonding conductor connecting the antenna to the antenna mast and the antenna mast to the LPS shall be in accordance with Table 6 of [IEC 62305-3].



NOTE 1 – The bond to MET may be via a BB or a connection to the electrical installation electrode.
NOTE 2 – If antenna is adequately isolated from the LPS, bonding is not required. See [IEC 62305-3] for the required clearances.
NOTE 3 – In a normal installation a bond will already exist between the coax outer/metallic cable shield and the mast.

Figure 6 – Protection requirements when building is protected by an LPS

9.2.2.2 Antenna not bonded to the LPS

If the antenna is not bonded to the LPS, it is necessary to ensure adequate separation between the antenna installation and the LPS components, including the down conductors. For buildings of one or two storeys, a 2 m clearance should be adequate. See clause 6.3 of [IEC 62305-3] for further information on the required clearance or separation distance and for buildings of more than two storeys in height.

The antenna must be installed in a location where it will be protected from direct lightning strikes by the air termination system.

The installation must comply with clause 8.2.

9.2.3 Buildings without an existing LPS

When an LPS is required to be installed, the antenna mast could be used as an air termination to protect the building. Refer to clause 8.3.

Appendix I, taken from [IEC 62305-3], shows the volume protected by the antenna mast acting as vertical air-termination rod.

9.3 Antenna installed near to the building

There are two situations to be considered.

a) $\mathbf{R_1 \leq R_{T1}}$

In this situation, lightning protection is not required, and protection may only be required for electrical safety, see clause 8.2. In this case, it is not necessary to bond the tower earth electrode system to the building electrical installation earth.

b) $R_1 > R_{T1}$

In this situation, an LPS may need to be installed on the building to achieve the required protection level ($R_1 \leq R_{T1}$). The following protection measures are also required:

– the outer conductor of the coaxial cable is bonded to the BB at the entrance of the building (see Figure 7);

– The SPD is installed between the outer and the inner conductor of the coaxial cable when the cross sectional area (S_c) of the outer conductor is less than the S_{cmin} value reported in Annex A (see Figure 8). The lightning current flowing into the SPD could be greater than the maximum GDT impulse current (actually 4 kA, 10/350 µs). In this case, the current entering the antenna cable shall be reduced. Possible protection measures could be as follows:

  • installing one or two parallel earthing conductors (PEC). The resistance value of the PEC shall reduce the lightning current flowing into the SPD to the required value. In general, the PEC, or other protective measure, should be connected to the mast and building earthing systems;

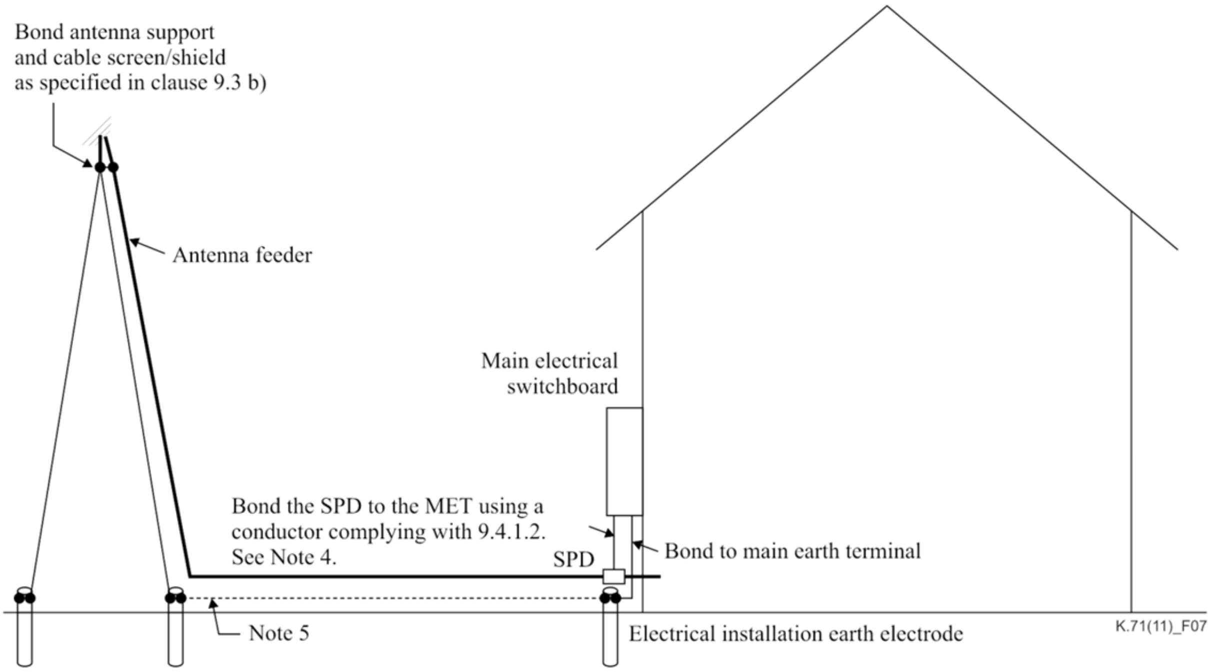
  • using a coaxial cable with a lower resistance outer conductor.

The antenna support and the antenna cable screen/shield, at the top of the tower, shall be bonded to the tower earth electrode system using the applicable method below:

1) If the tower is metallic, the antenna support and cable screen/shield may be directly connected to the tower with a conductor complying with clause 9.4.1.2.

2) If the tower is non-metallic, the antenna support and cable screen/shield are connected to the tower earth using a conductor complying with clause 9.4.1.2.

Refer to clause 9.4 for detailed requirements on earthing conductors. Refer to Figure 7 for earthing and bonding requirements. Refer to Figure 8 for installing the SPD.



NOTE 1 – To be effective, the bond wire length from the SPD to the MET must be less than 1.5 m long.
NOTE 2 – Refer to Figure 8 for installation of SPD.
NOTE 3 – The installation of an SPD, and hence bonding to the BB, is not required at sites assessed as low risk.
NOTE 4 – The bond to MET may be via a BB or a connection to the electrical installation electrode.
NOTE 5 – A PEC may be required to prevent cable damage; refer to Annex A.
NOTE 6 – In accordance with [ITU-T K.56], bonding of the feeder at the base of the tower is not recommended. This is under study.

Figure 7 – Protection requirements for antenna mast away from the building

9.4 Bonding

9.4.1 Bonding conductors

When required, the antenna mast shall be connected to earth via a bonding conductor. The bonding conductor shall be installed straight and vertical such that it can provide the shortest, most direct path to the LPS or building earthing system. The outer conductors of all coaxial cables coming from the antenna shall be connected to the antenna mast or to the building earthing system via an equipotential bonding conductor having a minimum cross-section as specified below.

The formation of loops shall be avoided.

Only materials which do not show corrosive behaviour towards each other shall be used.

Examples of components which may be employed are:

– LPS down conductors;

– the metal framework of the structure;

– the interconnected steel of the structure;

– facade elements, profiled rails and sub-constructions of metal facades, provided that:

  • their dimensions comply with the requirements for down conductors and their thickness is not less than 0.5 mm;

  • their electrical continuity in a vertical direction is assured (joints shall be made secure by such means as brazing, welding, crimping, screwing or bolting) or the distance between the metal parts does not exceed 1 mm and the overlap between two elements is at least 100 cm^2. The overall electrical resistance shall not be greater than 0.2 **Ω**, using test equipment suitable for this purpose.

The above components should only be used when:

- local regulations allow it;
- the electrical continuity between the various parts is considered durable;
- their dimensions are at least equal to those specified for standard earthing conductors.

NOTE – According to [IEC 60364-5-54], metallic water pipes do not generally meet the requirements for use as a protective conductor or as protective bonding conductors.

The following shall not be used as a bonding conductor, i.e., a specific bonding conductor shall be used:

– protective earth and/or neutral conductors of the electricity supply;

– the outer conductor of any coaxial cable.

Bonding may be required for the reasons defined in clauses 9.4.1.1 to 9.4.1.3.

9.4.1.1 Bonding to safely discharge to ground the full lightning current

In this case, a suitable bare conductor would have a minimum cross-sectional area of not less than 14 mm^2 Cu, 22 mm^2 Al or 50 mm^2 Fe. If this conductor is insulated, enclosed (e.g., by concrete) or close to flammable material, a minimum cross-sectional area of not less than 35 mm^2 Cu, 55 mm^2 Al or 125 mm^2 Fe would be required.

9.4.1.2 Bonding to safely discharge to ground a partial lightning current

In this case a suitable bonding conductor would have a minimum cross-sectional area of not less than 5 mm^2 Cu, 8 mm^2 Al or 16 mm^2 Fe.

9.4.1.3 Bonding to protect against contact with an aerial line phase conductor or subcircuit phase conductor

Protection against contact with an aerial line phase (active) conductor: If it is necessary to protect the antenna system by the method of bonding, install a protective conductor from the antenna mast, or from the coaxial cable outer conductor, to the MET to facilitate disconnection of supply. The cross sectional area of the protective conductor shall comply with clause 543 of [IEC 60364-5-54].

Protection against contact with subcircuit phase (active) conductors: If it is necessary to protect the antenna system by the method of bonding, install a protective conductor from the antenna mast, or from the coaxial cable outer conductor, to the MET to facilitate disconnection of supply. The cross sectional area of the protective conductor shall comply with clause 543 of [IEC 60364-5-54].

NOTE – In most cases, compliance with [IEC 60364-5-54] can be achieved by using a protective conductor with a cross-sectional area not less than:

- 2.5 mm^2 Cu or 16 mm^2 Al, if protection against mechanical damage is provided;
- 4 mm^2 Cu or 16 mm^2 Al, if protection against mechanical damage is not provided.

9.4.2 Earthing arrangements

The earthing arrangements shall comply with:

– [IEC 60364-5-54] when an LPS is not required;

– [IEC 62305-3] when an LPS is required. In this case, the information on the necessary earth electrode dimension is reported in Figure 2 of [IEC 62305-3] wherein:

- a minimum of two horizontal earth electrodes of at least 2.5 m length buried in an angle larger than 60°, at least 0.5 m deep and not closer than 1 m to the foundation; or

- a vertical or inclined earth electrode of at least 2.5 m length or two vertical earth electrodes of at least 1.5 m length with a spacing of 3 m and not closer than 1 m to the foundation.

The minimum cross-sectional area of each earth electrode is 50 mm^2 Cu or 90 mm^2 Fe. More detailed information is reported in Table 7 of [IEC 62305-3]. The choice of material may depend on the material of the structure and/or the soil type.

"Natural" components such as interconnected concrete reinforcing steel or other suitable underground metal structures, incorporated in the building's foundation and whose dimensions comply with the above-mentioned limits, can also be employed.

Other earth termination systems according to [IEC 62305-3] are also allowed.

9.5 Selection and dimensioning of the surge protection devices (SPDs)

9.5.1 General

The selection of the SPDs has to take into account the expected overcurrent values in the installation point as indicated in Annex E of [IEC 62305-1] or in [ITU-T K.67]:

– the lightning current entering each service due to a lightning strike hitting the building when a LPS on the building is required to reduce the risk of loss of human life R_1 (see clause E.1 of [IEC 62305-1] or clause 7.1 of [ITU-T K.67]);

– the current due to direct flashes to the services to reduce the risk of loss of human life R_1 (see Table E.2 [IEC 62305-1] or clause 7.3 of [ITU-T K.67]);

– the current due to flashes to the building or to services, and near the building or near the services (see Table E.2 of [IEC 62305-1] or clause 7.4 of [ITU-T K.67]) to reduce the risk of loss of service R_2.

NOTE – The values of the expected overcurrent, coming from the telecommunication network or induced by flashes near the building and reported in Table E.1 of [IEC 62305-1], are not identical to those given by [ITU-T K.67]. Coordination work between IEC TC 81 and ITU-T SG 5 is necessary in order to align the expected overcurrent values on telecommunication points.

9.5.2 Flashes to the building

These SPDs are SPDs tested with the I_{imp} (10/350 µs) current flowing through the SPD and the I_{imp} value should be evaluated as follows in agreement with Annex E of [IEC 62305-1] and [ITU-T K.67] for unshielded service:

$$I_{imp} = \frac{0.5 \times I_p}{n \times m} \qquad (1)$$

where:

n: is the number of services entering the structure

m: is the number of conductors of the service

I_p: is the peak current value, in kA, as a function of the selected LPL.

For shielded service, e.g., a coaxial pair or a shielded cable pair, the value of the I_{imp} (10/350 µs) current flowing through the SPD should be evaluated as shown in Annex A (see clause 7.1 of [ITU-T K.67] for more information on shielded service).

9.5.3 Flashes to the service

These SPDs have been SPDs tested with the I_{imp} (10/350 µs) current flowing through the SPD and the I_{imp} value is reported in Table E.2 of [IEC 62305-1] or clause 7.3 of [ITU-T K.67].

NOTE – These overcurrent values, reported in Table E.1 of [IEC 62305-1] for the telecommunication network, are not identical to those given by [ITU-T K.67]. Coordination work between IEC TC 81 and ITU-T SG 5 is necessary in order to align the expected overcurrent values on telecommunication points.

9.5.4 Protection of equipment

The SPDs tested with the I_{imp} (10/350 μs) can reduce all of the risk components related to damage to the equipment inside the building.

They are due to flashes (see [IEC 62305-2 e1]):

– to the building (R_C);

– near the building (R_M);

– to the service (R_W);

– near the service (R_Z).

SPDs tested with I_n (8/20 μs) can reduce only the risk components due to induction (R_Z and R_M).

The expected overcurrent values are reported in Table E.2 of [IEC 62305-1] or in [ITU-T K.67].

NOTE – These overcurrent values, reported in Table E.1 of [IEC 62305-1] for the telecommunication network, are not identical to those given by [ITU-T K.67]. Coordination work between IEC and ITU is necessary in order to align the expected overcurrent values on telecommunication points.

The equipment protection is achieved when the effective protection level $U_{p/f}$ is less than or equal to the equipment withstand voltage U_w. $U_{p/f}$ depends on the selected protection level U_p and on the inductive voltage drop ΔU of the connecting conductors, in accordance with Annex D of [IEC 62305-4]:

$$U_{p/f} \geq U_p + \Delta U \quad \text{for voltage limiting type SPD} \tag{2}$$

$$U_{p/f} = \max\left(U_p, \Delta U\right) \quad \text{for voltage switching type SPD} \tag{3}$$

The voltage drop ΔU can be assumed equal to 1 kV/m when the I_{imp} current is flowing through the bonding conductors, whereas it can be neglected when only the I_n current is considered.

If the distance between the SPDs and the equipment to be protected is greater than the protection distances (reflection and induction protection distances), it is necessary to install, closer to the equipment, other SPDs coordinated with the upstream SPDs. These protection distances are calculated with equations given in Annex D of [IEC 62305-4].

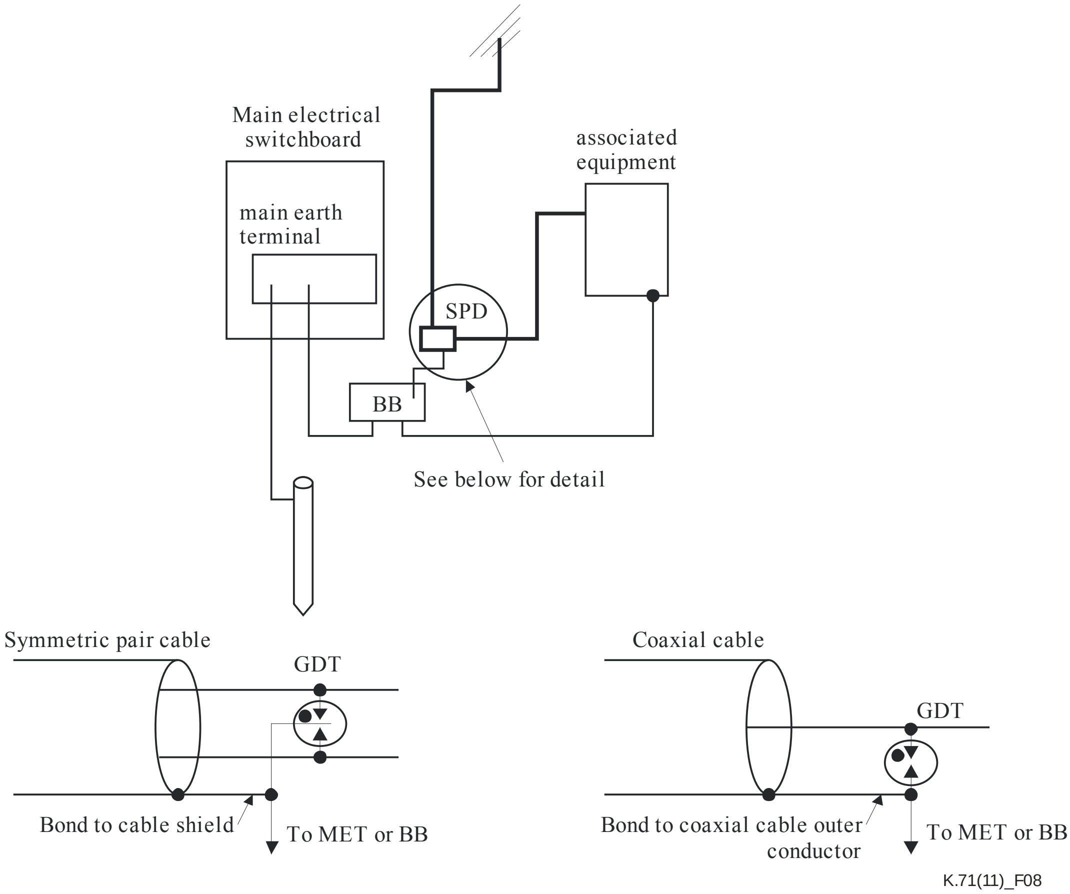
9.5.5 Installation of SPDs

The SPDs on mains and telecommunication conductors shall be located at their entrance into the building, e.g., at the main electrical board, between the conductors and the BB.

These SPDs are tested with I_{imp} (10/350 μs) current whose peak value should be greater than or equal to the value resulting from direct flashes to the structure (see equation 1 in clause 9.5.2) and from direct flashes to the services (see clause 9.5.3).

Refer to Figure 8 to see how to protect coaxial and shielded symmetric pair installations.

Refer to Annex A of [ITU-T K.66] for the installation of mains SPDs for different power systems.



NOTE 1 – Equipment may be earthed by a hard-wired earth connection or via the mains plug.
NOTE 2 – To be effective, the length of the bond wire from the cable screen and SPD to the MET must be < 1.5 m.
NOTE 3 – If required, the cable shield or coaxial cable outer may be bonded to the MET or BB via a GDT.
NOTE 4 – Refer to [ITU-T K.66] for further bonding information.

Figure 8 – Installation of effective overvoltage protection between the antenna and the associated equipment at the point of entry

10 Responsibilities

It may be necessary to provide guidance on responsibility between the network operator and the building owner. The network operator is responsible for the costs associated with bonding of the antenna system to existing bonding bars and an LPS, if it exists.

If an LPS is required, prior to the installation of the antenna, this is obviously the responsibility of the building owner.

If the installation of the antenna increases the risk such that an LPS is required, the network operator is responsible for the costs of the LPS. This could lead to the following possibilities:

– it is not economic to install the antenna on the building;
– the building owner pays for the installation of the LPS;
– the antenna may be installed away from the building, see clause 7.2;
– it is not economic to install this type of service.

Annex A

Direct lightning to the structure: equipotential bonding of a shielded cable at the entrance of the structure

(This annex forms an integral part of this Recommendation.)

The overvoltages between the active conductors and the screen of a cable may cause failure of the internal system due to the lightning current carried by the screen. The overvoltages depend on the material, the dimensions of the screen, and the length and positioning of the cable.

The minimum value S_{cmin} (in mm^2) of the cross-sectional area of the screen, to avoid failure of the internal system, is given by:

$$S_{cmin} = \frac{I_f \times \rho_c \times l_c \times 10^6}{U_w} \qquad \text{(A.1)}$$

where:

I_f: is the current flowing on the screen, in kA (evaluated as indicated by [ITU-T K.67])

ρ_c: is the resistivity of the screen, in Ωm

l_c: is the cable length, in m

U_w: is the impulse withstand voltage (or resistibility voltage) of the electrical/electronic system fed by the cable, in kV.

When the cross section area S_c of the outer conductor of the coaxial pair is less than S_{cmin}, an SPD shall be installed between the inner and outer conductors of the coaxial pair. The current I_{imp} flowing through the SPD is given by:

$$I_{imp} = \frac{0.5 \times I_p \times R_s}{n \times (R_s + R_c)} \qquad \text{(A.2)}$$

where:

n: is the number of services entering the structure

I_p: is the peak current value, in kA, as a function of the selected LPL

R_c: is the ohmic resistance for unit length of the inner conductor of the coaxial pair

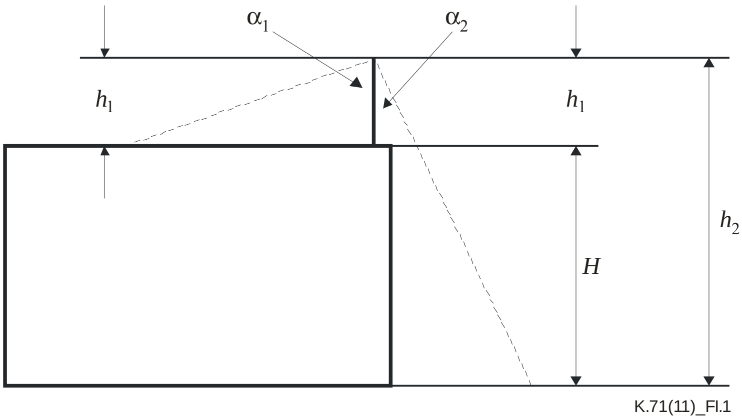
R_s: is the ohmic resistance for unit length of the outer conductor of the coaxial pair.

Appendix I

Antenna on buildings used as air termination of the LPS

(This appendix does not form an integral part of this Recommendation.)

When the LPS is installed, the antenna mast could be used as air termination to protect the building. Figure I.1, taken from [IEC 62305-3], shows the volume protected by the antenna mast acting as vertical air-termination rod.



h_1 – Physical height of an air-termination rod.

NOTE – The protective angle α_2 corresponds to the air-termination height h_1, being the height above the roof surface to be protected; the protective angle α_2 corresponds to the height $h_2 = h_1 + H$, the ground being the reference plane; α_1 is related to h_1 and α_2 is related to h_2. The α value is reported in figure I.2, taken from [IEC 62305-3], as a function of the height (H) of the air-termination above the reference plane of the area to be protected for each class of LPS.

Figure I.1 – Volume protected by a vertical air-termination rod

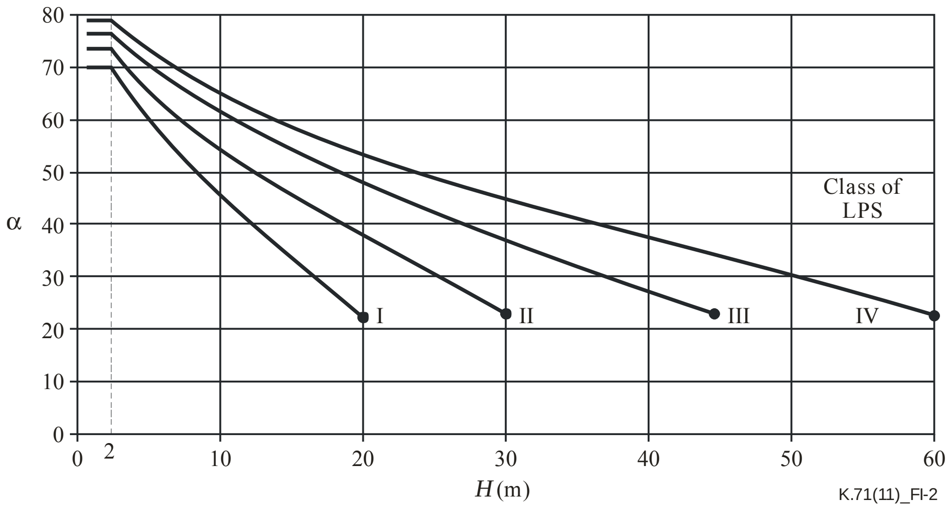


Figure I.2 – Protection angles

The earthing conductor (the down conductor) and the earthing system shall comply with the requirements related to the LPS class requested by the risk assessment. The outer conductor of the coaxial cable shall be bonded to the antenna mast at one end and to the main earthing terminal at the other end.

Appendix II

Generic risk assessment

(This appendix does not form an integral part of this Recommendation.)

The following generic risk assessments have been according to [IEC 62305-2].

II.1 Site with a roof antenna deemed to be low risk

In this case, the antenna need only be protected against mains contact, see clause 8.2.

Installations considered in this analysis for the need for direct lightning strike protection were assumed to be on buildings meeting all of the following prerequisites:

– Domestic dwelling, small business premises or similar low-occupancy building.
– Moderate size (ground floor area nominally < 600 m^2).
– Height less than 12 m (typically 2 storeys or less).
– Not located on a mountain top which is greater than 1000 m above sea level.
– Permanent structure constructed from standard building materials (timber, masonry, concrete, metal, etc.).
– The top of the antenna is attached to the outside of the building, is less than 2.5 m above the gutter line and below the peak of the roof.

A lightning risk assessment decision flowchart is provided in Figure II.1.

If the site is low risk, according to Figure II.1, the antenna can be protected from direct lightning strikes. In this case, the antenna needs only to be protected against static atmospheric overvoltages and mains contact, see clauses 7.1 and 7.2. If the site requires a specific risk assessment, see clauses 6 and 7.1.3.

Buildings which do not comply with all of these prerequisites are outside of the scope of this analysis and require a specific risk assessment (see [IEC 62305-2 e1]).

Case 1 – Installations in areas with up to 15 thunder days per year

Buildings in these areas, for which specific direct strike lightning protection considerations are not needed, include:

– Any building which meets the above prerequisites.

Case 2 – Installations in areas with up to 30 thunder days per year

Buildings in these areas, for which specific direct strike lightning protection considerations are not needed, include:

– Any building which meets the above prerequisites which is less than 6 m high (typically one storey), or is located on the flat, or has a metallic roof.

NOTE – Buildings located on the flat are those not located on a hill, mountain or ridge line.

Case 3 – Installations in areas with up to 60 thunder days per year

Buildings in these areas, for which specific direct strike lightning protection considerations are not needed, include:

– Any building which meets the above prerequisites which is less than 6 m high (typically one storey); or
– Any building which meets the above prerequisites which has a metallic roof and is located on the flat.

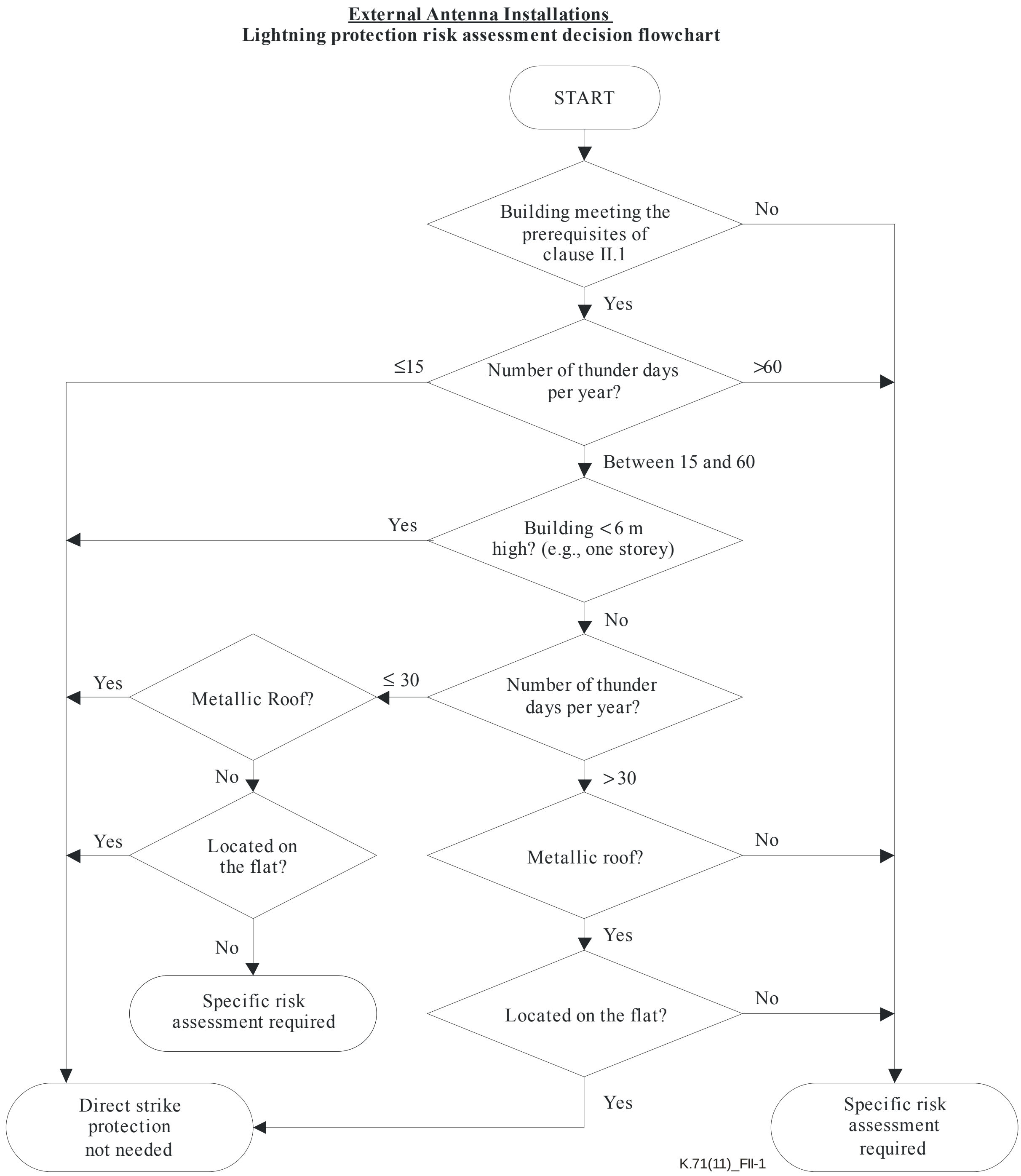


Figure II.1 – Generic risk analysis flowchart

II.2 Risk calculations

Case 1 – Thunder days up to 15/year

Ground floor area < 600 m^2.

Height < 12 m.

Located on a hillside ≤ 1000 m.

Permanent structure from standard building materials.

The risk components related to a direct strike are R_A and R_B (R_C is only needed if human life is put at risk by failure of electronic equipment).

$R_1 = R_{A1} + R_{B1}$

$R_{A1} = N_D \times P_A \times L_A$

$N_D = N_G \times A_D \times C_D \times 10^{-6}$

$N_G = 1.5$

$A_D = 8272$ m^2

$C_D = 2$

Therefore $N_D = 0.025$

$P_A = 1$ (No protection measures and no LPS)

$$L_A = r_t \times L_T \times \frac{n_z}{n_t} \times \frac{t_z}{8760}$$

$r_t = 10^{-2}$ (linoleum or wooden floors)

$L_T = 10^{-2}$ (Table C.2 of [IEC 62305-2])

$n_z = 1$

$n_t = 1$

$t_z = 8760$

$L_A = 10^{-4}$

Therefore $R_{A1} = 2.5 \times 10^{-6}$

$R_{B1} = N_D \times P_B \times L_B$

Now $N_D = 0.025$

$P_B = 1$ (No LPS)

$$L_B = r_p \times r_f \times h_z \times L_F \times \frac{n_z}{n_t} \times \frac{t_z}{8760}$$

$r_p = 1$ (No provisions)

$r_f = 0.01$ (Ordinary)

$h_z = 1$ (No special hazard)

$L_F = 10^{-2}$ (Table C.2 of [IEC 62305-2]

$n_z = 1$

$n_t = 1$

$t_z = 8760$

$L_B = 10^{-4}$

Therefore $R_{B1} = 2.5 \times 10^{-6}$

Direct strike risk to structure $R_1 = 5.0 \times 10^{-6}$ (components $R_{A1} + R_{B1}$ only).

Case 2a – Thunder days up to 30/year

Ground floor area < 600 m^2.

Height < 6 m.

Located on a hillside ≤ 1000 m.

Permanent structure from standard building materials.

The risk components related to a direct strike are R_A and R_B (R_C is only needed if human life is put at risk by failure of electronic equipment)

$R_1 = R_{A1} + R_{B1}$

$R_{A1} = N_D \times P_A \times L_A$

$N_D = N_G \times A_D \times C_D \times 10^{-6}$

$N_G = 3$

$A_D = 3418\ \text{m}^2$

$C_D = 2$

Therefore $N_D = 0.02$

$P_A = 1$ (No protection measures and no LPS)

$$L_A = r_t \times L_T \times \frac{n_z}{n_t} \times \frac{t_z}{8760}$$

$r_t = 10^{-2}$ (linoleum or wooden floors)

$L_T = 10^{-2}$ (Table C.2 of [IEC 62305-2])

$n_z = 1$

$n_t = 1$

$t_z = 8760$

$L_A = 10^{-4}$

Therefore $R_{A1} = 2.05 \times 10^{-6}$

$R_{B1} = N_D \times P_B \times L_B$

Now $N_D = 0.02$

$P_B = 1$ (No LPS)

$$L_B = r_p \times r_f \times h_z \times L_F \times \frac{n_z}{n_t} \times \frac{t_z}{8760}$$

$r_p = 1$ (No provisions)

$r_f = 0.01$ (Ordinary)

$h_z = 1$ (No special hazard)

$L_F = 10^{-2}$ (Table C.2 of [IEC 62305-2]

$n_z = 1$

$n_t = 1$

$t_z = 8760$

$L_B = 10^{-4}$

Therefore $R_{B1} = 2.05 \times 10^{-6}$

Direct strike risk to structure $R_1 = 4.1 \times 10^{-6}$ (components $R_{A1} + R_{B1}$ only).

Case 2b – Thunder days up to 30/year

Ground floor area < 600 m^2.

Height < 12 m.

Located on the flat.

Permanent structure from standard building materials.

The risk components related to a direct strike are R_A and R_B (R_C is only needed if human life is put at risk by failure of electronic equipment)

$R_1 = R_{A1} + R_{B1}$

$R_{A1} = N_D \times P_A \times L_A$

$N_D = N_G \times A_D \times C_D \times 10^{-6}$

$N_G = 3$

$A_D = 8272\ m^2$

$C_D = 1$

Therefore $N_D = 0.025$

$P_A = 1$ (No protection measures and no LPS)

$$L_A = r_t \times L_T \times \frac{n_z}{n_t} \times \frac{t_z}{8760}$$

$r_t = 10^{-2}$ (linoleum or wooden floors)

$L_T = 10^{-2}$ (Table C.2 of [IEC 62305-2])

$n_z = 1$

$n_t = 1$

$t_z = 8760$

$L_A = 10^{-4}$

Therefore $R_{A1} = 2.48 \times 10^{-6}$

$R_{B1} = N_D \times P_B \times L_B$

Now $N_D = 0.025$

$P_B = 1$ (No LPS)

$$L_B = r_p \times r_f \times h_z \times L_F \times \frac{n_z}{n_t} \times \frac{t_z}{8760}$$

$r_p = 1$ (No provisions)

$r_f = 0.01$ (Ordinary)

$h_z = 1$ (No special hazard)

$L_F = 10^{-2}$ (Table C.2 of [IEC 62305-2]

$n_z = 1$

$n_t = 1$

$t_z = 8760$

$L_B = 10^{-4}$

Therefore $R_{B1} = 2.48 \times 10^{-6}$

Direct strike risk to structure $R_1 = 4.96 \times 10^{-6}$ (components $R_{A1} + R_{B1}$ only).

Case 2c – Thunder days up to 30/year

Ground floor area < 600 m^2.

Height < 12 m.

Located on a hillside ≤ 1000 m.

Permanent structure from standard building materials.

Metallic roof (assumed to be equivalent to a class IV LPS).

The risk components related to a direct strike are R_A and R_B (R_C is only needed if human life is put at risk by failure of electronic equipment)

$R_1 = R_{A1} + R_{B1}$

$R_{A1} = N_D \times P_A \times L_A$

$N_D = N_G \times A_D \times C_D \times 10^{-6}$

$N_G = 3$

$A_D = 8272$ m^2

$C_D = 2$

Therefore $N_D = 0.05$

$P_A = 0.2$ ($P_{TA} = 1$ and $P_B = 0.2$ (Class IV LPS))

$$L_A = r_t \times L_T \times \frac{n_z}{n_t} \times \frac{t_z}{8760}$$

$r_t = 10^{-2}$ (linoleum or wooden floors)

$L_T = 10^{-2}$ (Table C.2 of [IEC 62305-2])

$n_z = 1$

$n_t = 1$

$t_z = 8760$

$L_A = 10^{-4}$

Therefore $R_{A1} = 0.99 \times 10^{-6}$

$R_{B1} = N_D \times P_B \times L_B$

Now $N_D = 0.05$

$P_B = 0.2$ (Class IV LPS)

$$L_B = r_p \times r_f \times h_z \times L_F \times \frac{n_z}{n_t} \times \frac{t_z}{8760}$$

$r_p = 1$ (No provisions)

$r_f = 0.01$ (Ordinary)

$h_z = 1$ (No special hazard)

$L_F = 10^{-2}$ (Table C.2 of [IEC 62305-2]

$n_z = 1$

$n_t = 1$

$t_z = 8760$

$L_B = 10^{-4}$

Therefore $R_{B1} = 0.99 \times 10^{-6}$

Direct strike risk to structure $R_1 = 1.99 \times 10^{-6}$ (components $R_{A1} + R_{B1}$ only).

Case 3a – Thunder days up to 60/year

Ground floor area < 600 m^2.

Height < 6 m.

Located on a hillside ≤ 1000 m.

Permanent structure from standard building materials.

The risk components related to a direct strike are R_A and R_B (R_C is only needed if human life is put at risk by failure of electronic equipment)

$R_1 = R_{A1} + R_{B1}$

$R_{A1} = N_D \times P_A \times L_A$

$N_D = N_G \times A_D \times C_D \times 10^{-6}$

$N_G = 6$

$A_D = 3418$ m^2

$C_D = 2$

Therefore $N_D = 0.041$

$P_A = 1$ (No protection measures and no LPS)

$$L_A = r_t \times L_T \times \frac{n_z}{n_t} \times \frac{t_z}{8760}$$

$r_t = 10^{-2}$ (linoleum or wooden floors)

$L_T = 10^{-2}$ (Table C.2 of [IEC 62305-2])

$n_z = 1$

$n_t = 1$

$t_z = 8760$

$L_A = 10^{-4}$

Therefore $R_{A1} = 4.1 \times 10^{-6}$

$R_{B1} = N_D \times P_B \times L_B$

Now $N_D = 0.041$

$P_B = 1$ (No LPS)

$$L_B = r_p \times r_f \times h_z \times L_F \times \frac{n_z}{n_t} \times \frac{t_z}{8760}$$

$r_p = 1$ (No provisions)

$r_f = 0.01$ (Ordinary)

$h_z = 1$ (No special hazard)

$L_F = 10^{-2}$ (Table C.2 of [IEC 62305-2]

$n_z = 1$

$n_t = 1$

$t_z = 8760$

$L_B = 10^{-4}$

Therefore $R_{B1} = 4.1 \times 10^{-6}$

Direct strike risk to structure $R_1 = 8.2 \times 10^{-6}$ (components $R_{A1} + R_{B1}$ only).

Case 3b – Thunder days up to 60/year

Ground floor area < 600 m^2.

Height < 12 m.

Located on the flat.

Permanent structure from standard building materials.

Metallic roof (assumed to be equivalent to a class IV LPS).

The risk components related to a direct strike are R_A and R_B (R_C is only needed if human life is put at risk by failure of electronic equipment)

$R_1 = R_{A1} + R_{B1}$

$R_{A1} = N_D \times P_A \times L_A$

$N_D = N_G \times A_D \times C_D \times 10^{-6}$

$N_G = 6$

$A_D = 8272$ m^2

$C_D = 1$

Therefore $N_D = 0.05$

$P_A = 0.2$ ($P_{TA} = 1$ and $P_B = 0.2$ (Class IV LPS))

$$L_A = r_t \times L_T \times \frac{n_z}{n_t} \times \frac{t_z}{8760}$$

$r_t = 10^{-2}$ (linoleum or wooden floors)

$L_T = 10^{-2}$ (Table C.2 of [IEC 62305-2])

$n_z = 1$

$n_t = 1$

$t_z = 8760$

$L_A = 10^{-4}$

Therefore $R_{A1} = 0.99 \times 10^{-6}$

$R_{B1} = N_D \times P_B \times L_B$

Now $N_D = 0.05$

$P_B = 0.2$ (Class IV LPS)

$$L_B = r_p \times r_f \times h_z \times L_F \times \frac{n_z}{n_t} \times \frac{t_z}{8760}$$

r_p = 1 (No provisions)

r_f = 0.01 (Ordinary)

h_z = 1 (No special hazard)

$L_F = 10^{-2}$ (Table C.2 of [IEC 62305-2]

n_z = 1

n_t = 1

t_z = 8760

$L_B = 10^{-4}$

Therefore $R_{B1} = 0.99 \times 10^{-6}$

Direct strike risk to structure R_1 = 1.99 × 10^{-6} (components $R_{A1} + R_{B1}$ only).

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