Lightning protection
Risk management

Created according to international standard:
IEC 62305-2:2010-12

Considering the country-specific annexes for:
IEC 62305-2:2010-12

Summary of measures for
reducing damage caused by lightning effects,
resulting from the risk management
concerning the following project:

Project / object description:

LODHA ACME Ozone - Tower 1

Customer / principal:

LODHA Group

Risk assessment by:

Contents

1. Abbreviations

2. Normative basics

3. Risk and sources of damage

4. Project data
Selection of risks to be considered
Geographic and building parameters
Division of the structure into lightning protection zones/zones
Supply lines
Risk of fire
Measures to reduce the consequences of a fire
Special hazards in the building for persons

5. Risk assessment
Risk R1, Human life
Selection of protection measures

6. Legal obligation

7. General information

8. Definition

1. Abbreviations

a	Amortisation rate
a_t	Amortisation period
c_a	Value of animals in a zone in currency
c_b	Value of a zone of the structure in currency
c_c	Value of the contents of a zone in currency
c_s	Value of the systems in a zone (including their activities) in currency
c_t	Total value of the structure in currency
C_D;C_{DJ}	Location factor
C_L	Annual costs of the total loss without protection measures
C_{PM}	Annual costs of the selected protection measures
C_{RL}	Annual costs of the residual loss
EB	Lightning equipotential bonding
H	Height of the structure
H_P	Highest point of the structure
i	Interest rate
K_{S1}	Factor relevant to the shielding effectiveness of a structure (external spatial shielding)
K_{S1W}	Mesh size of the shielding of a structure
K_{S2}	Factor relevant to the shielding effectiveness of a structure (external spatial shielding)
K_{S2W}	Mesh size of the shielding within a structure
L1	Loss of human life
L2	Loss of service to the public
L3	Loss of cultural heritage
L4	Loss of economic value
L	Length of the structure
LEMP	Lightning electromagnetic impulse
LP	Lightning protection (consisting of a lightning protection system (LPS) and LEMP protection measures)
LPL	Lightning protection level
LPS	Lightning protection system
LPZ	Lightning protection zone (zone where the lightning electromagnetic environment is defined)
m	Maintenance rates
N_D	Frequency of dangerous events caused by lightning strikes to a structure
N_G	Ground flash density
P_B	Probability that a lightning strike to a structure causes physical damage
P_{EB}	Lightning equipotential bonding
P_{SPD}	Coordinated SPD system
R	Risk
R_1	Risk of loss of human life in a structure
R_2	Risk of loss of service to the public
R_3	Risk of loss of cultural heritage
R_4	Risk of loss of economical value in a structure
R_A	Risk component (injury to living beings - Lightning strike to the structure)
R_B	Risk component (physical damage to a structure - Lightning strike to the structure)
R_C	Risk component (failure of internal systems - Lightning strike to the structure)

R_M	Risk component (failure of internal systems - Lightning strike near the structure)
R_U	Risk component (injury to living beings - Lightning strike to a connected supply line)
R_V	Risk component (physical damage to a structure - Lightning strike to a connected supply line)
R_W	Risk component (failure of internal systems - Lightning strike to a connected supply line)
R_Z	Risk component (failure of internal systems - Lightning strike near the connected supply line)
R_T	Tolerable risk (maximum value of the risk which can be tolerated for the structure to be protected)
r_f	Reduction factor considering the fire risk in a structure
r_p	Reduction factor considering the measures to reduce the consequences of a fire
S_M	Annual savings
SPD	Surge protection device
SPM	LEMP protection measures (measures to reduce the risk of failure of electrical and electronic equipment due to LEMP)
t_{ex}	Duration of the presence of a dangerous explosive atmosphere
W	Width of the structure
Z	Zones of a structure

2. Normative basics

The IEC 62305 standard series consists of the following parts:

- IEC 62305-1:2010-12 - "Protection against lightning - Part 1: General principles“

- IEC 62305-2:2010-12 - "Protection against lightning - Part 2: Risk management"

- IEC 62305-3:2010-12 - "Protection against lightning - Part 3: Physical damage to structures and life hazard“

- IEC 62305-4:2010-12 - "Protection against lightning - Part 4: Electrical and electronic systems within structures“

3. Risk and sources of damage

In order to avoid damage resulting from a lightning strike, specific protection measures must be taken for the objects to be protected. The risk management described in the IEC 62305-2:2010-12 standard includes a risk analysis which allows to determine the lightning protection requirements of a structure. The aim of the risk management is to reduce the risk to an acceptable level by taking protection measures.

The following risk analysis according to IEC 62305-2:2010-12 for the project LODHA ACME Ozone - Tower 1 shows the necessity of protection measures. The risk potential for the structure is determined and, if necessary, measures to reduce the risk have to be taken. The result of the risk analysis not only specifies the class of LPS, but also provides a complete protection concept including the necessary LEMP protection measures.

As a result, an economically reasonable selection of protection measures suitable for the properties and use of the structure is ensured.

4. Project data

Selection of risks to be considered

Due to the type and use of the structure, object Lodha Ozone - Tower 1, the following risks were selected and considered:

Risk R_1:	Risk of losses of human life;	R_T: 1.00E-05

The tolerable risks R_T were defined by selecting the risks.

The standard specifies the tolerable risk for the risks R_1, R_2 and R_3 . No tolerable risk is defined for risk R_4. To this end, it is considered whether the protection measures make economical sense with regard to the value of the structure.

The aim of a risk analysis is to reduce the risk to a acceptable level RT by an economically sound selection of protection measures.

Geographic and building parameters

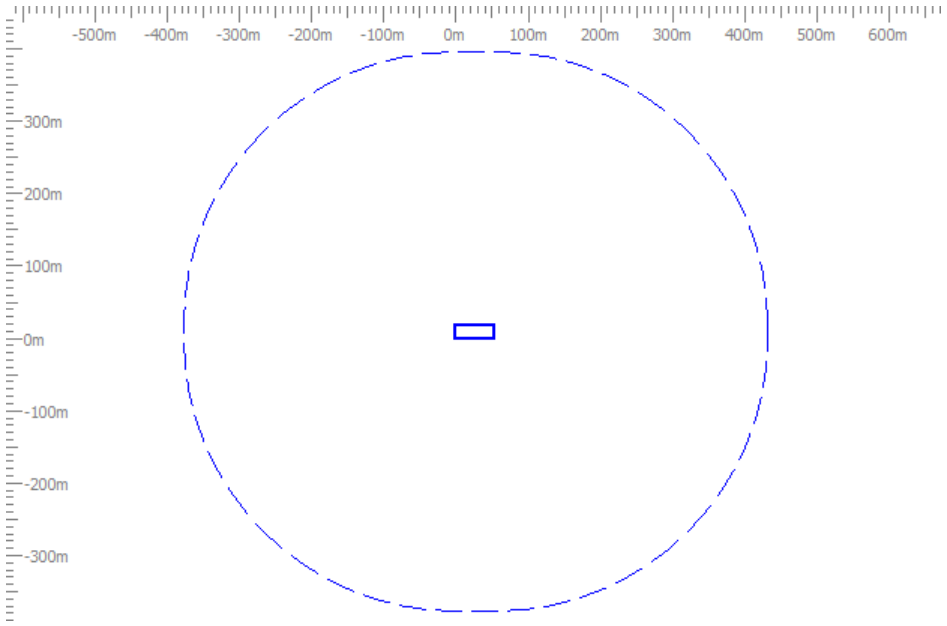
The ground flash density Ng is the basis for a risk analysis according to IEC 62305-2:2010-12. It defines the number of direct lightning strikes in 1 / year / km². A value of 1.60 lightning strikes / year / km² was determined for the location of the structure Lodha Ozone - Tower 1 by means of the ground flash density map. As a result, there is a calculated number 16.00 thunderstorm days per year for the location of the project.

The dimensions of the building are decisive for the risk of a direct strike. The collection areas for direct / indirect lightning strikes are determined based on these dimensions. The structure Lodha Ozone - Tower 1 has the following dimensions:

L_b	Length:	56.00 m
W_b	Width:	19.00 m
H_b	Height:	126.00 m
H_{pb}	Highest point (if applicable):	0.00 m

Based on the dimensions of the structure, there are the following calculated collection areas:

Collection area for direct lightning strikes:	506,647.00 m²
Collection area for indirect lightning strikes: (near the structure)	860,398.00 m²



The environment surrounding the structure is an important factor for determining the number of possible direct / indirect lightning strikes. This is defined as follows for the structure Lodha Ozone - Tower 1:
Relative location C_{db}: 0.50

If the ground flash density is referred to the size and the environment of the structure, a frequency of:

- direct strikes to the structure ND = 0.4053 strikes / year,
- indirect strikes to the structure NM = 1.3766 strikes / year,

is to be expected.

Division of the structure into lightning protection zones/zones

The structure Lodha Ozone - Tower 1 was not divided into lightning protection zones / zones.

L1tz – Time during which persons are present in the zone.:	8,760 hours/year
L1nz – Number of persons in the zone:	0 persons

Supply lines

All incoming and outgoing supply lines of the structure to be considered must be taken into account in the risk analysis. Conductive pipes do not have to be considered if they are connected to the main earthing busbar of the structure. If this is not the case, the risk of incoming pipes should be considered in the risk analysis (observe that equipotential bonding is required!).

The following supply lines were considered for the structure Lodha Ozone - Tower 1 in the risk analysis:

- Power
- Telecommunication

Parameters such as

- Type of conductor (overhead line / buried conductor)
- Conductor length (outside the building)
- Environment
- Connected structure
- Type of internal wiring (shielded / unshielded)
- Minimum rated impulse withstand voltage (dielectric strength of terminal equipment) were determined for every defined conductor.

On this basis, the risk for the structure and its content resulting from lightning strikes to and near the supply lines was determined and assessed in the risk analysis.

Risk of fire

The risk of fire in a structure is an important factor for determining the required protection measures. The risk of fire for the structure Lodha Ozone - Tower 1 was defined as follows:

- Normal risk of fire

Measures to reduce the consequences of a fire

The following measures were selected to reduce the consequences of a fire:

- Fire extinguishers, manual fire alarm system, hydrants, fire-proof compartments, protected escape routes

Special hazards in the building for persons

Due to the number of persons, the possible risk of panic for the structure Lodha Ozone - Tower 1 was defined as follows:

- Average level of panic (e.g. structures designed for a number of participants between 100 and 1 000 persons)

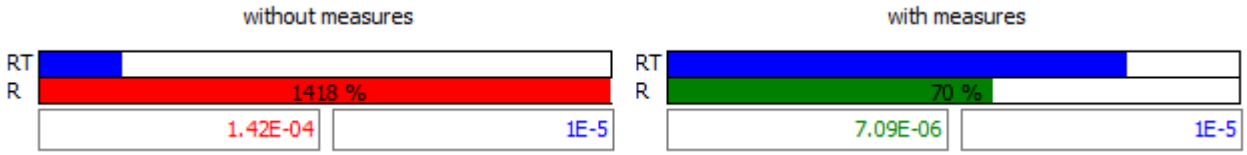
5. Risk assessment

As described in 4.1, the following risks according to 5.were assessed. The blue bar shows the tolerable risk value and the green / red bar shows the risk determined.

Risk R1, Human life

The following risk was determined for persons outside and inside the structure Lodha Ozone - Tower 1:

Tolerable risk R_T:	1.00E-05
Calculated risk R1 (unprotected):	1.42E-04
Calculated risk R1 (protected):	7.09E-06



To reduce the risk, it is necessary to take measures as described in 5.

Selection of protection measures

The risk was reduced to an acceptable level by selecting the following protection measures.

This selection of protection measures is part of the risk management for the object Lodha Ozone - Tower 1 and is only valid in connection with this object.

Measures With protection/target state:

Area		Measures	Factor
	pB:	Lightning protection system (LPS) Class of LPS II	5.000E-02
	pEB:	Lightning equipotential bonding Equipotential bonding for LPL II	2.000E-02

6. Legal obligation

The risk analysis performed refers to the information provided by the operator and/or proprietor of the building or expert which has been assumed, assessed or defined on site. Please note that this information must be verified after assessment.

The procedure of the DEHNsupport software for calculating the risks is based on the IEC 62305-2:2010-12 standard.

Please note that all assumptions, documents, illustrations, drawings, dimensions, parameters and results are not legally binding for the person performing the risk analysis.

Place, date	Stamp, signature

7. General information

Components of the external lightning protection system

Lightning protection components used for the construction of the external lightning protection system must comply with the mechanical and electrical requirements defined in the IEC 62561-x standard series. This standard series is for example divided into following parts:

- IEC 62561-1:2012	Requirements for connection components
- IEC 62561-2:2012	Requirements for conductors and earth electrodes
- IEC 62561-3:2012	Requirements for isolating spark gaps
- IEC 62561-4:2010	Requirements for conductor fasteners
- IEC 62561-5:2011	Requirements for electrode inspection housings and earth electrode seals

IEC 62561-1:2012 Requirements for connection components
The requirements for connection components such as clamps are defined in IEC 62561-1. For the installer of lightning protection systems this means that the connection components are to be selected for the load (H or N) to be expected at the place of installation. Therefore, a clamp for load H (100 kA) is to be used e.g. for an air-termination rod (100% lightning current) and a clamp for load N (50 kA) e.g. for a mesh or an earth entry (lightning current already distributed). The suitability for these applications must be proven by the manufacturer.

IEC 62561-2:2012 Requirements for conductors and earth electrodes
The IEC 62561-2 specifies concrete requirements for conductors, such as air-termination and down conductors as well as earth electrodes. These are defined as follows:

- Mechanical properties (minimum tensile strength and elongation),
- Electrical properties (maximum resistivity) and
- Corrosion protection properties (artificial aging).

The IEC 62561-2 standard also specifies the requirements for earth electrodes and earth rods. In this context, the material, geometry, minimum dimensions as well as the mechanical and electrical properties are important. These normative requirements are relevant product features, which must be documented in the manufacturers' documents and product datasheets.

IEC 62561-3:2012 Requirements for isolating spark gaps
Isolating spark gaps can be used to galvanically isolate an earth-termination system.IEC 62561-3 specifies that isolating spark gaps must be dimensioned in such a way that the components, if installed according to the manufacturer's instructions, are reliable, durable and safe for persons and nearby installations.

IEC 62561-4:2010 Requirements for conductor fasteners
The IEC 62561-4 standard specifies the requirements and tests for metal and non-metal conductor fasteners used with air-termination and down conductors.

IEC 62561-5:2011 Requirements for electrode inspection housings and earth electrode seals All earth electrode inspection housings and earth electrode seals must be designed in such a way that they are reliable and safe for persons and the environment when used as intended. IEC 62561-5 specifiesthe requirements and tests for earth electrode inspection housings (e.g. pressure load) and for earth electrode seals (e.g. leak test).

8. Definition

Coordinated SPD system
SPDs properly selected, coordinated and installed to form a system intended to reduce failures of

electrical and electronic systems.

Isolating interfaces
Devices which are capable of reducing conducted surges on lines entering the LPZ. These include isolation transformers with earthed screen between windings, metal-free fibre optic cables and opto-isolators. Insulation withstand characteristics of these devices are suitable for this application intrinsically or via SPD.

LEMP (lightning electromagnetic impulse)
All electromagnetic effects of lightning current via resistive, inductive and capacitive coupling, which create surges and electromagnetic fields.

LP (lightning protection)
Complete system for protection of structures against lightning, including their internal systems and contents, as well as persons, in general consisting of an LPS and SPM.

LPL (lightning protection level)
Number related to a set of lightning current parameters values relevant to the probability that the associated maximum and minimum design values will not be exceeded in naturally occurring lightning.

LPS (lightning protection system)
Complete system used to reduce physical damage due to lightning flashes to a structure.

EB (lightning equipotential bonding)
Bonding to LPS of separated metallic parts, by direct conductive connections or via surge protective devices, to reduce potential differences caused by lightning current.

SPD (surge protection device)
Device intended to limit transient overvoltages and divert surge currents; contains at least one non-linear component.

Node
Point on a line from which onward surge propagation can be assumed to be neglected. Examples of nodes are a point on a power line branch distribution at an HV / LV transformer or on a power substation, a telecommunication exchange or an equipment (e.g. multiplexer or xDSL equipment) on a telecommunication line.

Physical damage
Damage to a structure (or to its contents) due to mechanical, thermal, chemical or explosive effects of lightning.

Injury to living beings
Permanent injuries, including loss of life, to people or to animals by electric shock due to touch and step voltages caused by lightning.

Risk R
Value of probable average annual loss (humans and goods) due to lightning, relative to the total value (humans and goods) of the structure to be protected.

Zone of a structure ZS
Part of a structure with homogeneous characteristics where only one set of parameters is involved in assessment of a risk component.

LPZ (lightning protection zone)

Zone where the lightning electromagnetic environment is defined. The zone boundaries of an LPZ are not necessarily physical boundaries (e.g. walls, floor and ceiling).

Magnetic shield
Closed, metallic, grid-like or continuous screen enveloping the structure to be protected, or part of it, used to reduce failures of electrical and electronic systems.

Lightning protective cable
Special cable with increased dielectric strength and whose metallic sheath is in continuous contact with the soil either directly or by use of conducting plastic covering.

Lightning protective cable duct
Cable duct of low resistivity in contact with the soil (concrete with interconnected structural steel reinforcements or metallic duct).