LIGHTNING RISK ASSESSMENT CALCULATIONS (AS PER IEC 62305-2)

Building / Installation :	**ESIC Hospital Main Block (Zone-1 general hospital areas)**
Location	**Thirippur, Tamil Nadu**

ENVIRONMENT AND STRUCTURE CHARACTERISTICS

Lightning Density	N_G=	4		$N_G \approx 0.1\ T_D$ (Eq.A.1)
Length of structure	L=	85	m	
Width of structure	W=	66	m	
Length of perimeter of structure	L=	85	m	
Width of perimeter of structure	W=	66	m	
Height of structure	H=	13	m	$A_{D1} = (L \times W) + 6 \times H \times (L+W) + 9 \times \pi \times H^2$ (Eq.A.2)
Chimney/Tower height	T=		m	$A_{D2} = 9 \times \pi \times T^2$ (Eq.A.3)
Collection area by graphical method	A_{D3}=		m^2	
Location factor of structure	C_D	Isolated structure: no other objects in the vicinity		
LPS	P_B	Structure protected by LPS (Class II)		
Equipotential bonding	P_{EB}	II		
Mesh width of external spatial shield	w_{m1}=	10	m	Use 10 if not provided
Structure location factor	C_D=	1		Table A.1
Probability that a flash to a structure will cause physical damage	P_B=	0.05		Table B.2
Probability as a function of LPL for which SPDs are designed	P_{EB}=	0.02		Table B.7
Screening effectiveness of the structure, LPS or other shields at boundary LPZ 0/1	K_{S1}=	1		$K_{S1} = 0.12 \times w_{m1}$ (Eq.B.5)
Collection area for flashes to structure	A_D=	22166	m^2	$A_D = Max(A_{D1}, A_{D2}, A_{D3})$
Collection area for flashes near structure	A_M=	936398	m^2	$A_M = 2 \times 500 \times (L+W) + \pi \times 500^2$ (Eq.A.7)
Number of dangerous events for flashes to structure	N_D=	0.088665		$N_D = N_G \times A_D \times C_D \times 10^{-6}$ (Eq.A.4)
Number of dangerous events for flashes near structure	N_M=	3.745593		$N_M = N_G \times A_M \times 10^{-6}$ (Eq.A.6)

POWER LINE

Line type		Power lines		
Line installation factor	C_I	Buried		
Line type factor	C_T	LV power, telecommunication or data line		
Line environmental factor	C_E	Suburban		
Shield of line	R_S	Shielded aerial or buried whose shield bonded to the same bonding bar as Equipment (5Ω/km < RS ≤ 20Ω/km)		
Shielding, grounding, isolation	C_{LD},C_{LI}	Shielded buried line (power or TLC) (Shield bonded to the same bonding bar as equipment)		
Withstand voltage of internal system (kV)	U_W	2.5		
Location factor of adjacent structure	C_{DJ}	Isolated structure: no other objects in the vicinity		
Line Length	L_L	150	m	Use 1000m if unknown
Length of adjacent structure	L=		m	
Width of adjacent structure	W=		m	
Height of adjacent structure	H=		m	$A_{D1} = (L \times W) + 6 \times H \times (L+W) + 9 \times \pi \times H^2$ (Eq.A.2)
Chimney/Tower height	T=		m	$A_{D2} = 9 \times \pi \times T^2$ (Eq.A.3)
Collection area by graphical method	A_{DJ3}=		m^2	

Line installation factor	C_I=	0.5	*Table A.2*
Line type factor	C_T=	1	*Table A.3*
Line environmental factor	C_E=	0.5	*Table A.4*
Shielding, grounding, isolation	C_{LD}=	1	*Table B.4*
	C_{LI}=	0	*Table B.4*
Structure location factor	C_{DJ}=	1	*Table A.1*
Factor for impulse withstand voltage of the system to be protected.	K_{S4}=	0.40	$K_{S4} = 1/U_W$ *(Eq.B.7)*
Probability of failure of internal systems due to a flash to the connected line	P_{LD}=	0.95	*Table B.8*
Probability of failure of internal systems due to a flash near the connected line	P_{LI}=	0.3	*Table B.9*
Collection area for flashes to adjacent structure	A_{DJ}=	0 m²	$A_D = Max(A_{DJ1}, A_{DJ2}, A_{DJ3})$
Collection area for flashes to line	A_L=	6000 m²	$A_L = 40 \times L_L$ *(Eq.A.9)*
Collection area for flashes near line	A_I=	600000 m²	$A_I = 4000 \times L_L$ *(Eq.A.11)*
Number of dangerous events for flashes to adjacent structure	N_{DJ}=	0.000000	$N_{DJ} = N_G \times A_{DJ} \times C_{DJ} \times C_T \times 10^{-6}$ *(Eq.A.5)*
Number of dangerous events for flashes to line	N_L=	0.006000	$N_L = N_G \times A_L \times C_I \times C_E \times C_T \times 10^{-6}$ *(Eq.A.8)*
Number of dangerous events for flashes near line	N_I=	0.600000	$N_I = N_G \times A_I \times C_I \times C_E \times C_T \times 10^{-6}$ *(Eq.A.10)*

TELECOM LINE

Line type		TLC lines		
Line installation factor	C_I	Buried		
Line type factor	C_T	LV power, telecommunication or data line		
Line environmental factor	C_E	Suburban		
Shield of line	R_S	Shielded aerial or buried whose shield bonded to the same bonding bar as Equipment (5Ω/km < RS ≤ 20Ω/km)		
Shielding, grounding, isolation	C_{LD},C_{LI}	Shielded buried line (power or TLC) (Shield bonded to the same bonding bar as equipment)		
Withstand voltage of internal system (kV)	U_W	1.5		
Location factor of adjacent structure	C_{DJ}	Isolated structure: no other objects in the vicinity		
Line Length	L_L	1000	m	*Use 1000m if unknown*
Length of adjacent structure	L=		m	
Width of adjacent structure	W=		m	
Height of adjacent structure	H=		m	$A_{DJ} = (L \times W) + 6 \times H \times (L+W) + 9 \times \pi \times H^2$ *(Eq.A.2)*
Chimney/Tower height	T=		m	$A_{DJ} = 9 \times \pi \times T^2$ *(Eq.A.3)*
Collection area by graphical method	A_{DJ3}=		m²	

Line installation factor	C_I=	0.5		*Table A.2*
Line type factor	C_T=	1		*Table A.3*
Line environmental factor	C_E=	0.5		*Table A.4*
Shielding, grounding, isolation	C_{LD}=	1		*Table B.4*
	C_{LI}=	0		*Table B.4*
Structure location factor	C_{DJ}=	1		*Table A.1*
Factor for impulse withstand voltage of the system to be protected.	K_{S4}=	0.67		$K_{S4} = 1/U_W$ *(Eq.B.7)*
Probability of failure of internal systems due to a flash to the connected line	P_{LD}=	1		*Table B.8*
Probability of failure of internal systems due to a flash near the connected line	P_{LI}=	0.5		*Table B.9*
Collection area for flashes to adjacent structure	A_{DJ}=	0	m²	$A_D = Max(A_{DJ1}, A_{DJ2}, A_{DJ3})$

Collection area for flashes to line	A_L=	40000	m^2	$A_L = 40 \times L_L$ (Eq.A.9)
Collection area for flashes near line	A_I=	4000000	m^2	$A_I = 4000 \times L_L$ (Eq.A.11)
Number of dangerous events for flashes to adjacent structure	N_{DJ}=	0.000000		$N_{DJ} = N_G \times A_{DJ} \times C_{DJ} \times C_T \times 10^{-6}$ (Eq.A.5)
Number of dangerous events for flashes to line	N_L=	0.040000		$N_L = N_G \times A_L \times C_I \times C_E \times C_T \times 10^{-6}$ (Eq.A.8)
Number of dangerous events for flashes near line	N_I=	4.000000		$N_I = N_G \times A_I \times C_I \times C_E \times C_T \times 10^{-6}$ (Eq.A.10)

ZONE 1: BUILDING GENERAL

	Type of floor	r_t	Marble, ceramic		
	Protection against shock (flash to structure)	P_{TA}	No protection measures		
	Protection against shock (flash to line)	P_{TU}	No protection measures		
	Risk of fire	r_f	Ordinary		
	Fire protection	r_p	One of the following provisions: fixed automatic ally operated extinguishing installations; automatic a alarm installations		
Power Line	Internal wiring	K_{S3}	Unshielded cable – routing precaution in order to avoid large loops (loop area of the order of 10m2)		
	Coordinated SPDs	P_{SPD}	II		
Telecom Line	Internal wiring	K_{S3}	Unshielded cable – routing precaution in order to avoid loops (loop area < 10m2)		
	Coordinated SPDs	P_{SPD}	II		
	Special hazard	h_z	Difficulty of evacuation (e.g. structures with immobile persons, hospitals)		
L1: Loss of human life	D1: due to touch and step voltage	L_T	All types		
	D2: due to physical damage	L_F	Hospital, hotel, school, civic building		
	D3: due to failure of internal systems	L_O	Other parts of hospital		
L2: Unacceptable loss of service	D2: due to physical damage, D3: due to failure of internal systems	L_{F2},L_{O2}	No loss of service		
L3: Loss of irreplaceable cultural heritage	D2: due to physical damage	L_{F3}	Others		
L4: Economic loss	D1: due to touch and step voltage	L_{T4}	All types where only animals are present		
	D2: due to physical damage	L_{F4}	Hospital, industrial, museum, agricultural		
	D3: due to failure of internal systems	L_{O4}	Hospital, industrial, office, hotel, commercial		
	Number of persons in the zone	n_z	470		
	Total number of persons in the structure	n_t	500		
	Time per year for which the persons are present in the zone	t_Z	4380	hrs	
	Value of cultural heritage in the zone	c_z	0	$	
	Total value of building and content of the structure (sum over all zones)	c_t	1	$	
	Mesh width of internal spatial shield	w_{m1}=	10	m	*Use 10 if not provided*
Reduction factor as a function of the type of surface of soil or floor		r_t=	0.001		*Table C.3*
Probability that a flash to a structure will cause shock to living beings due to dangerous touch and step voltages		P_{TA}=	1		*Table B.1*
Probability that a flash to an entering line will cause shock to living beings due to dangerous touch voltages		P_{TU}=	1		*Table B.6*
Reduction factor as a function of risk of fire or explosion of structure		r_f=	0.01		*Table C.5*

	Reduction factor as a function of provisions taken to reduce the consequences of fire	r_p=	0.2	*Table C.4*
	Screening effectiveness of shields internal to the structure at boundary LPZ X/Y (X>0, Y>1)	K_{S2}	1	$K_{S2} = 0.12 \times w_{m2}$ *(Eq.B.6)*
Power	Internal wiring	K_{S3}	0.2	*Table B.5*
	Probability as a function of LPL for which SPDs are designed	P_{SPD}	0.02	*Table B.3*
Telecom	Factor for internal wiring	K_{S3}	0.01	*Table B.5*
	Probability as a function of LPL for which SPDs are designed	P_{SPD}	0.02	*Table B.3*
	Factor for increasing the relative amount of loss in presence of a special hazard	h_z	5	*Table C.6*
L1: Loss of human life	D1 - Injury to living beings by electric shock	L_{T1}	0.01	*Table C.2*
	D2 – Physical damage	L_{F1}	0.1	*Table C.2*
	D3 – Failure of electrical and electronic systems	L_{O1}	0.001	*Table C.2*
L2: Unacceptable loss of service	D2 – Physical damage	L_{F2}	0	*Table C.8*
	D3 – Failure of electrical and electronic systems	L_{O2}	0	*Table C.8*
L3: Loss of irreplaceable cultural heritage	D2 – Physical damage	L_{F3}	0	*Table C.10*
L4: Economic loss	D1 - Injury to living beings by electric shock	L_{T4}	0.01	*Table C.12*
	D2 – Physical damage	L_{F4}	0.5	*Table C.12*
	D3 – Failure of electrical and electronic systems	L_{O4}	0.01	*Table C.12*
	PROBABILITY OF DAMAGE			
D1 Injury to living beings by electric shock	S1 - Lightning flash to a structure	P_A=	0.0500	$P_A = P_{TA} \times P_B$ *(Eq.B.1)*
	S3 - Lightning flash to an incoming line	$P_{U/P}$=	0.0190	$P_U = P_{TU} \times P_{EB} \times P_{LD} \times C_{LD}$ *(Eq.B.8)*
	S3 - Lightning flash to an incoming line	$P_{U/T}$=	0.0200	$P_U = P_{TU} \times P_{EB} \times P_{LD} \times C_{LD}$ *(Eq.B.8)*
D2 Physical Damage	S1 - Lightning flash to a structure	P_B=	0.0500	*Table B.2*
	S3 - Lightning flash to an incoming line	$P_{V/P}$=	0.0190	$P_V = P_{EB} \times P_{LD} \times C_{LD}$ *(Eq.B.9)*
	S3 - Lightning flash to an incoming line	$P_{V/T}$=	0.0200	$P_V = P_{EB} \times P_{LD} \times C_{LD}$ *(Eq.B.9)*
	S1 - Lightning flash to a structure	$P_{C/P}$=	0.0200	$P_C = P_{SPD} \times C_{LD}$ *(Eq.B.2)*
	S1 - Lightning flash to a structure	$P_{C/T}$=	0.0200	$P_C = P_{SPD} \times C_{LD}$ *(Eq.B.2)*
	S1 - Lightning flash to a structure	P_C=	0.0396	$P_C = 1 - (1 - P_{C/P}) \times (1 - P_{C/T})$ *(Eq.14)*
D3 Failure of electrical and electronic systems	S2 - Lightning flash near a structure	$P_{M/P}$=	0.0001	$P_{MS} = P_{SPD} \times (K_{S1} \times K_{S2} \times K_{S3} \times K_{S4})^2$ *(Eq.B.3)*
	S2 - Lightning flash near a structure	$P_{M/T}$=	0.0000	$P_{MS} = P_{SPD} \times (K_{S1} \times K_{S2} \times K_{S3} \times K_{S4})^2$ *(Eq.B.3)*
	S2 - Lightning flash near a structure	P_M=	0.0001	$P_M = 1 - (1 - P_{M/P}) \times (1 - P_{M/T})$ *(Eq.15)*
	S3 - Lightning flash to an incoming line	$P_{W/P}$=	0.0190	$P_W = P_{SPD} \times P_{LD} \times C_{LD}$ *(Eq.B.10)*
	S3 - Lightning flash to an incoming line	$P_{W/T}$=	0.0200	$P_W = P_{SPD} \times P_{LD} \times C_{LD}$ *(Eq.B.10)*
	S4 - Lightning flash near a line	$P_{Z/P}$=	0.0000	$P_Z = P_{SPD} \times P_{LI} \times C_{LI}$ *(Eq.B.11)*
	S4 - Lightning flash near a line	$P_{Z/T}$=	0.0000	$P_Z = P_{SPD} \times P_{LI} \times C_{LI}$ *(Eq.B.11)*
	CONSEQUENT LOSS			
	Factor for persons in zone	k_1	0.47	$n_Z / n_t \times t_z / 8\,760$
	D1 - Injury to living beings by electric shock	L_{A1}	4.700E-06	$r_t \times L_{T1} \times k_1$ *(Eq.C.1)*
L1: Loss of human life	D1 - Injury to living beings by electric shock	L_{U1}	4.700E-06	$r_t \times L_{T1} \times k_1$ *(Eq.C.2)*
	D2 – Physical damage	L_{B1},L_{V1}	4.700E-04	$r_p \times r_f \times h_z \times L_{F1} \times k_1$ *(Eq.C.3)*

	D3 – Failure of electrical and electronic systems	L_{C1},L_{M1},L_{W1},L_{Z1}	4.700E-04	$L_{O1} \times k_1$ (Eq.C.4)
L2: Unacceptable loss of service	D2 – Physical damage	L_{B1},L_{V1}	0.000E+00	$r_p \times r_f \times L_{F2} \times n_z / n_t$ (Eq.C.8)
	D3 – Failure of electrical and electronic systems	L_{C1},L_{M1},L_{W1},L_{Z1}	0.000E+00	$L_{O2} \times n_z / n_t$ (Eq.C.8)
L3: Loss of irreplaceable cultural heritage	D2 – Physical damage	L_{B2},L_{V2}	0.000E+00	$r_p \times r_f \times L_{F3} \times c_z / c_t$ (Eq.C.9)
	D1 - Injury to living beings by electric shock	L_{A4}	1.000E-05	$r_t \times L_{T4} \times c_a / c_t$ (Eq.C.10)
L4: Economic loss	D1 - Injury to living beings by electric shock	L_{U4}	1.000E-05	$r_t \times L_{T4} \times c_a / c_t$ (Eq.C.12)
	D2 – Physical damage	L_{B4},L_{V4}	1.000E-03	$r_p \times r_f \times L_{F4} \times (c_a + c_b + c_c + c_s) / c_t$ (Eq.C.13)
	D3 – Failure of electrical and electronic systems	L_{C4},L_{M4},L_{W4},L_{Z4}	1.000E-02	$L_{O4} \times c_s / c_t$ (Eq.C.14)

RISK OF LOSS OF HUMAN LIFE

D1 Injury to living beings by electric shock	S1 - Lightning flash to a structure	R_{A1}=	0.0021 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{U1/P}$=	0.0001 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{U1/T}$=	0.0004 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
D2 Physical Damage	S1 - Lightning flash to a structure	R_{B1}=	0.2084 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{V1/P}$=	0.0054 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{V1/T}$=	0.0376 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
D3 Failure of electrical and electronic systems	S1 - Lightning flash to a structure	R_{C1}=	0.1650 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S2 - Lightning flash near a structure	R_{M1}=	0.0227 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{W1/P}$=	0.0054 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{W1/T}$=	0.0376 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S4 - Lightning flash near a line	$R_{Z1/P}$=	0.0000 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S4 - Lightning flash near a line	$R_{Z1/T}$=	0.0000 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
		R_1=	**0.48 ×10^{-5}**	**$R_1 = \Sigma R_{X1}$**

RISK OF UNACCEPTABLE LOSS OF SERVICE TO THE PUBLIC

D2 Physical Damage	S1 - Lightning flash to a structure	R_{B2}=	0.0000 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{V2/P}$=	0.0000 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{V2/T}$=	0.0000 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
D3 Failure of electrical and electronic systems	S1 - Lightning flash to a structure	R_{C2}=	0.0000 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S2 - Lightning flash near a structure	R_{M2}=	0.0000 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{W2/P}$=	0.0000 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{W2/T}$=	0.0000 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S4 - Lightning flash near a line	$R_{Z2/P}$=	0.0000 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S4 - Lightning flash near a line	$R_{Z2/T}$=	0.0000 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
		R_2=	**0.00 ×10^{-5}**	**$R_2 = \Sigma R_{X2}$**

LOSS OF IRREPLACEABLE CULTURAL HERITAGE

D2 Physical Damage	S1 - Lightning flash to a structure	R_{B3}=	0.0000 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{V3/P}$=	0.0000 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{V3/T}$=	0.0000 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
		R_3=	**0.00 ×10^{-5}**	**$R_3 = \Sigma R_{X3}$**

ECONOMIC LOSS

D1	S1 - Lightning flash to a structure	R_{A4}=	0.0044 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)

Injury to living beings by electric shock	S3 - Lightning flash to an incoming line	$R_{U4/P}$=	0.0001 $\times 10^{-5}$	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{U4/T}$=	0.0008 $\times 10^{-5}$	$R_X = N_X \times P_X \times L_X$ (Eq.5)
D2 Physical Damage	S1 - Lightning flash to a structure	R_{B4}=	0.4433 $\times 10^{-5}$	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{V4/P}$=	0.0114 $\times 10^{-5}$	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{V4/T}$=	0.0800 $\times 10^{-5}$	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S1 - Lightning flash to a structure	R_{C4}=	3.5112 $\times 10^{-5}$	$R_X = N_X \times P_X \times L_X$ (Eq.5)
D3 Failure of electrical and electronic systems	S2 - Lightning flash near a structure	R_{M4}=	0.4828 $\times 10^{-5}$	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{W4/P}$=	0.1140 $\times 10^{-5}$	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{W4/T}$=	0.8000 $\times 10^{-5}$	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S4 - Lightning flash near a line	$R_{Z4/P}$=	0.0000 $\times 10^{-5}$	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S4 - Lightning flash near a line	$R_{Z4/T}$=	0.0000 $\times 10^{-5}$	$R_X = N_X \times P_X \times L_X$ (Eq.5)
		R_4=	**5.45 $\times 10^{-5}$**	$R_1 = \Sigma R_{X1}$

ZONE 2: HIGH DEPENDENCY AREAS

	Type of floor	r_t	Marble, ceramic	
	Protection against shock (flash to structure)	P_{TA}	No protection measures	
	Protection against shock (flash to line)	P_{TU}	No protection measures	
	Risk of fire	r_f	Low	
	Fire protection	r_p	One of the following provisions: fixed automatic ally operated extinguishing installations; automatic a alarm installations	
Power Line	Internal wiring	K_{S3}	Unshielded cable – routing precaution in order to avoid large loops (loop area of the order of 10m2)	
	Coordinated SPDs	P_{SPD}	II	
Telecom Line	Internal wiring	K_{S3}	Unshielded cable – routing precaution in order to avoid loops (loop area < 10m2)	
	Coordinated SPDs	P_{SPD}	II	
	Special hazard	h_z	Difficulty of evacuation (e.g. structures with immobile persons, hospitals)	
L1: Loss of human life	D1: due to touch and step voltage	L_T	All types	
	D2: due to physical damage	L_F	Hospital, hotel, school, civic building	
	D3: due to failure of internal systems	L_O	Intensive care unit and operation block of hospital	
L2: Unacceptable loss of service	D2: due to physical damage, D3: due to failure of internal systems	L_{F2},L_{O2}	No loss of service	
L3: Loss of irreplaceable cultural heritage	D2: due to physical damage	L_{F3}	Others	
L4: Economic loss	D1: due to touch and step voltage	L_{T4}	All types where only animals are present	
	D2: due to physical damage	L_{F4}	Hospital, industrial, museum, agricultural	
	D3: due to failure of internal systems	L_{O4}	Hospital, industrial, office, hotel, commercial	

Number of persons in the zone	n_z	30		
Total number of persons in the structure	n_t	500		
Time per year for which the persons are present in the zone	t_Z	6132	hrs	
Value of cultural heritage in the zone	c_z	0	$	
Total value of building and content of the structure (sum over all zones)	c_t	1	$	
Mesh width of internal spatial shield	w_{m1}=	10	m	*Use 10 if not provided*
Reduction factor as a function of the type of surface of soil or floor	r_t=	0.001		*Table C.3*

	Probability that a flash to a structure will cause shock to living beings due to dangerous touch and step voltages	P_{TA}=	1	*Table B.1*
	Probability that a flash to an entering line will cause shock to living beings due to dangerous touch voltages	P_{TU}=	1	*Table B.6*
	Reduction factor as a function of risk of fire or explosion of structure	r_f=	0.001	*Table C.5*
	Reduction factor as a function of provisions taken to reduce the consequences of fire	r_p=	0.2	*Table C.4*
	Screening effectiveness of shields internal to the structure at boundary LPZ X/Y (X>0, Y>1)	K_{S2}	1	$K_{S2} = 0.12 \times w_{m2}$ *(Eq.B.6)*
Power	Internal wiring	K_{S3}	0.2	*Table B.5*
	Probability as a function of LPL for which SPDs are designed	P_{SPD}	0.02	*Table B.3*
Telecom	Factor for internal wiring	K_{S3}	0.01	*Table B.5*
	Probability as a function of LPL for which SPDs are designed	P_{SPD}	0.02	*Table B.3*
	Factor for increasing the relative amount of loss in presence of a special hazard	h_z	5	*Table C.6*
L1: Loss of human life	D1 - Injury to living beings by electric shock	L_{T1}	0.01	*Table C.2*
	D2 – Physical damage	L_{F1}	0.1	*Table C.2*
	D3 – Failure of electrical and electronic systems	L_{O1}	0.01	*Table C.2*
L2: Unacceptable loss of service	D2 – Physical damage	L_{F2}	0	*Table C.8*
	D3 – Failure of electrical and electronic systems	L_{O2}	0	*Table C.8*
L3: Loss of irreplaceable cultural heritage	D2 – Physical damage	L_{F3}	0	*Table C.10*
L4: Economic loss	D1 - Injury to living beings by electric shock	L_{T4}	0.01	*Table C.12*
	D2 – Physical damage	L_{F4}	0.5	*Table C.12*
	D3 – Failure of electrical and electronic systems	L_{O4}	0.01	*Table C.12*
	PROBABILITY OF DAMAGE			
D1 Injury to living beings by electric shock	S1 - Lightning flash to a structure	P_A=	0.0500	$P_A = P_{TA} \times P_B$ *(Eq.B.1)*
	S3 - Lightning flash to an incoming line	$P_{U/P}$=	0.0190	$P_U = P_{TU} \times P_{EB} \times P_{LD} \times C_{LD}$ *(Eq.B.8)*
	S3 - Lightning flash to an incoming line	$P_{U/T}$=	0.0200	$P_U = P_{TU} \times P_{EB} \times P_{LD} \times C_{LD}$ *(Eq.B.8)*
D2 Physical Damage	S1 - Lightning flash to a structure	P_B=	0.0500	*Table B.2*
	S3 - Lightning flash to an incoming line	$P_{V/P}$=	0.0190	$P_V = P_{EB} \times P_{LD} \times C_{LD}$ *(Eq.B.9)*
	S3 - Lightning flash to an incoming line	$P_{V/T}$=	0.0200	$P_V = P_{EB} \times P_{LD} \times C_{LD}$ *(Eq.B.9)*
	S1 - Lightning flash to a structure	$P_{C/P}$=	0.0200	$P_C = P_{SPD} \times C_{LD}$ *(Eq.B.2)*
	S1 - Lightning flash to a structure	$P_{C/T}$=	0.0200	$P_C = P_{SPD} \times C_{LD}$ *(Eq.B.2)*
	S1 - Lightning flash to a structure	P_C=	0.0396	$P_C = 1 - (1 - P_{C/P}) \times (1 - P_{C/T})$ *(Eq.14)*
D3 Failure of electrical and electronic systems	S2 - Lightning flash near a structure	$P_{M/P}$=	0.0001	$P_{MS} = P_{SPD} \times (K_{S1} \times K_{S2} \times K_{S3} \times K_{S4})^2$ *(Eq.B.3)*
	S2 - Lightning flash near a structure	$P_{M/T}$=	0.0000	$P_{MS} = P_{SPD} \times (K_{S1} \times K_{S2} \times K_{S3} \times K_{S4})^2$ *(Eq.B.3)*
	S2 - Lightning flash near a structure	P_M=	0.0001	$P_M = 1 - (1 - P_{M/P}) \times (1 - P_{M/T})$ *(Eq.15)*
	S3 - Lightning flash to an incoming line	$P_{W/P}$=	0.0190	$P_W = P_{SPD} \times P_{LD} \times C_{LD}$ *(Eq.B.10)*
	S3 - Lightning flash to an incoming line	$P_{W/T}$=	0.0200	$P_W = P_{SPD} \times P_{LD} \times C_{LD}$ *(Eq.B.10)*
	S4 - Lightning flash near a line	$P_{Z/P}$=	0.0000	$P_Z = P_{SPD} \times P_{LI} \times C_{LI}$ *(Eq.B.11)*
	S4 - Lightning flash near a line	$P_{Z/T}$=	0.0000	$P_Z = P_{SPD} \times P_{LI} \times C_{LI}$ *(Eq.B.11)*

CONSEQUENT LOSS

	Factor for persons in zone	k_1	0.04	$n_Z / n_t \times t_z / 8\,760$
L1: Loss of human life	D1 - Injury to living beings by electric shock	L_{A1}	4.200E-07	$r_t \times L_{T1} \times k_1$ (Eq.C.1)
	D1 - Injury to living beings by electric shock	L_{U1}	4.200E-07	$r_t \times L_{T1} \times k_1$ (Eq.C.2)
	D2 – Physical damage	L_{B1},L_{V1}	4.200E-06	$r_p \times r_f \times h_z \times L_{F1} \times k_1$ (Eq.C.3)
	D3 – Failure of electrical and electronic systems	L_{C1},L_{M1},L_{W1},L_{Z1}	4.200E-04	$L_{O1} \times k_1$ (Eq.C.4)
L2: Unacceptable loss of service	D2 – Physical damage	L_{B1},L_{V1}	0.000E+00	$r_p \times r_f \times L_{F2} \times n_Z / n_t$ (Eq.C.8)
	D3 – Failure of electrical and electronic systems	L_{C1},L_{M1},L_{W1},L_{Z1}	0.000E+00	$L_{O2} \times n_Z / n_t$ (Eq.C.8)
L3: Loss of irreplaceable cultural heritage	D2 – Physical damage	L_{B2},L_{V2}	0.000E+00	$r_p \times r_f \times L_{F3} \times c_Z / c_t$ (Eq.C.9)
L4: Economic loss	D1 - Injury to living beings by electric shock	L_{A4}	1.000E-05	$r_t \times L_{T4} \times c_a / c_t$ (Eq.C.10)
	D1 - Injury to living beings by electric shock	L_{U4}	1.000E-05	$r_t \times L_{T4} \times c_a / c_t$ (Eq.C.12)
	D2 – Physical damage	L_{B4},L_{V4}	1.000E-04	$r_p \times r_f \times L_{F4} \times (c_a + c_b + c_c + c_s) / c_t$ (Eq.C.13)
	D3 – Failure of electrical and electronic systems	L_{C4},L_{M4},L_{W4},L_{Z4}	1.000E-02	$L_{O4} \times c_S / c_t$ (Eq.C.14)

RISK OF LOSS OF HUMAN LIFE

D1 Injury to living beings by electric shock	S1 - Lightning flash to a structure	R_{A1}=	0.0002 $\times 10^{-5}$	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{U1/P}$=	0.0000 $\times 10^{-5}$	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{U1/T}$=	0.0000 $\times 10^{-5}$	$R_X = N_X \times P_X \times L_X$ (Eq.5)
D2 Physical Damage	S1 - Lightning flash to a structure	R_{B1}=	0.0019 $\times 10^{-5}$	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{V1/P}$=	0.0000 $\times 10^{-5}$	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{V1/T}$=	0.0003 $\times 10^{-5}$	$R_X = N_X \times P_X \times L_X$ (Eq.5)
D3 Failure of electrical and electronic systems	S1 - Lightning flash to a structure	R_{C1}=	0.1475 $\times 10^{-5}$	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S2 - Lightning flash near a structure	R_{M1}=	0.0203 $\times 10^{-5}$	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{W1/P}$=	0.0048 $\times 10^{-5}$	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{W1/T}$=	0.0336 $\times 10^{-5}$	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S4 - Lightning flash near a line	$R_{Z1/P}$=	0.0000 $\times 10^{-5}$	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S4 - Lightning flash near a line	$R_{Z1/T}$=	0.0000 $\times 10^{-5}$	$R_X = N_X \times P_X \times L_X$ (Eq.5)
		R_1=	**0.21 $\times 10^{-5}$**	***$R_1 = \Sigma R_{X1}$***

RISK OF UNACCEPTABLE LOSS OF SERVICE TO THE PUBLIC

D2 Physical Damage	S1 - Lightning flash to a structure	R_{B2}=	0.0000 $\times 10^{-5}$	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{V2/P}$=	0.0000 $\times 10^{-5}$	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{V2/T}$=	0.0000 $\times 10^{-5}$	$R_X = N_X \times P_X \times L_X$ (Eq.5)
D3 Failure of electrical and electronic systems	S1 - Lightning flash to a structure	R_{C2}=	0.0000 $\times 10^{-5}$	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S2 - Lightning flash near a structure	R_{M2}=	0.0000 $\times 10^{-5}$	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{W2/P}$=	0.0000 $\times 10^{-5}$	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{W2/T}$=	0.0000 $\times 10^{-5}$	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S4 - Lightning flash near a line	$R_{Z2/P}$=	0.0000 $\times 10^{-5}$	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S4 - Lightning flash near a line	$R_{Z2/T}$=	0.0000 $\times 10^{-5}$	$R_X = N_X \times P_X \times L_X$ (Eq.5)
		R_2=	**0.00 $\times 10^{-5}$**	***$R_2 = \Sigma R_{X2}$***

LOSS OF IRREPLACEABLE CULTURAL HERITAGE

D2 Physical Damage	S1 - Lightning flash to a structure	R_{B3}=	0.0000 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{V3/P}$=	0.0000 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{V3/T}$=	0.0000 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
		R_3=	**0.00 ×10^{-5}**	$R_3 = \Sigma R_{X3}$

ECONOMIC LOSS

D1 Injury to living beings by electric shock	S1 - Lightning flash to a structure	R_{A4}=	0.0044 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{U4/P}$=	0.0001 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{U4/T}$=	0.0008 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
D2 Physical Damage	S1 - Lightning flash to a structure	R_{B4}=	0.0443 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{V4/P}$=	0.0011 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{V4/T}$=	0.0080 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S1 - Lightning flash to a structure	R_{C4}=	3.5112 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
D3 Failure of electrical and electronic systems	S2 - Lightning flash near a structure	R_{M4}=	0.4828 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{W4/P}$=	0.1140 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S3 - Lightning flash to an incoming line	$R_{W4/T}$=	0.8000 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S4 - Lightning flash near a line	$R_{Z4/P}$=	0.0000 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
	S4 - Lightning flash near a line	$R_{Z4/T}$=	0.0000 ×10^{-5}	$R_X = N_X \times P_X \times L_X$ (Eq.5)
		R_4=	**4.97 ×10^{-5}**	$R_1 = \Sigma R_{X1}$

RISK ASSESMENT SUMMARY

1. RISK OF LOSS OF HUMAN LIFE

ZONE 1: Building general	R_1=	0.48 ×10^{-5}	
ZONE 2: High Dependancy Units	R_1=	0.21 ×10^{-5}	
	ΣR_1=	**0.69 ×10^{-5}**	**TOLERABLE**
Tolerable risk	R_{T1}=	*1E-05*	

2. RISK OF UNACCEPTABLE LOSS OF SERVICE TO THE PUBLIC

ZONE 1: Building general		0.00 ×10^{-5}	
ZONE 2: High Dependancy Units	R_1=	0.00 ×10^{-5}	
	ΣR_2=	**0.00 ×10^{-5}**	**TOLERABLE**
Tolerable risk	R_{T2}=	*1E-03*	

3. LOSS OF IRREPLACEABLE CULTURAL HERITAGE

ZONE 1: Building general		0.00 ×10^{-5}	
ZONE 2: High Dependancy Units	R_1=	0.00 ×10^{-5}	
	ΣR_3=	**0.00 ×10^{-5}**	**TOLERABLE**
Tolerable risk	R_{T3}=	*1E-04*	

3. ECONOMIC LOSS

ZONE 1: Building general		5.45 ×10^{-5}	
ZONE 2: High Dependancy Units	R_4=	4.97 ×10^{-5}	
	ΣR_4=	**10.41 ×10^{-5}**	**TOLERABLE**
Tolerable risk	R_{T4}=	*1E-03*	

Notes:
Following provisions required to keep risk level within permissible limits.
1. LPS Level II.
2. Coordinated SPD system Level II.
3. Automated fire protection and alarm system.
4. Equipotential bonding for external services (Electrical cable armour, Telecome cable armour/shield, Medical gas line and LPG lines).