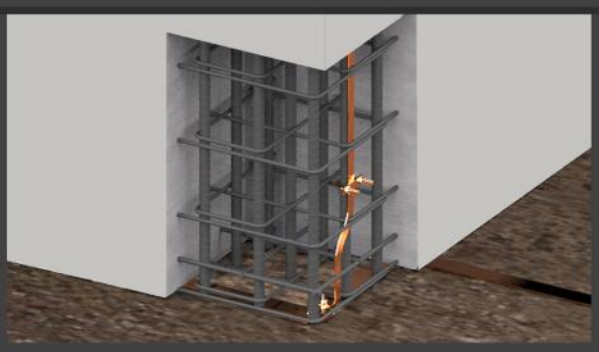
CAPE ELECTRIC

GLOBAL EARTHING SYSTEM
LIGHTNING PROTECTION SYSTEM

Functional Earthing (ISO/IEC 30129)
Global Earthing System (IEC 61936-1)
Lightning Protection System (IS/IEC 62305)
Verification of complete installation (IS 732/NEC 2023)
TN-S system with PME for industrial and commercial installations (IS 3043)



Established in 1997, we have been the market leader in India for 25 years in lightning protection, modern earthing, and building shielding measures.

In the early years, our reactive power compensation panels demonstrated their superiority by operating in challenging climatic conditions within wind turbine towers, where high temperatures, significant harmonic distortions, and frequent fluctuations in reactive power demand existed.

CAPE is well-known in the electrical engineering community for its proficiency in a variety of electrical engineering subjects and its innovative market solutions. CAPE recognises the significance of user-friendly and premium-quality products.

We provide a vast array of products and technical solutions for Lightning Protection, Earthing, and EMP/HEMP protections, owing to our decades of experience in providing cutting-edge solutions. Our expertise includes product development, manufacturing, installation, training, and consulting.

We have organised over a thousand webinars and training programs on the subject of electrical safety throughout Asia and have successfully reached fifty thousand people with our trainings. We at Cape have taken on the mission of eliminating electrical accidents in India and are collaborating with various institutions and NGOs to make this a reality.

Having two manufacturing facilities in Chennai and Kanyakumari, the products have been tested and approved by a number of international laboratories and are compliant with industry standards. The success of CAPE is attributable to a workforce of 250 or more talented Indians.

LPCI

www.lpci.in

SOLVE
Safe Operation of Low Voltage Electricity

www.solvelv.com

LPCI and SOLVE-LV are brand names of CAPE

Our training programs are appreciated across India and aboard.

Dr. Shriram Sharma, Dr. Chandima Gomes, Mr. Gopakumar & participants during 2 days Lightning Protection workshop in Nepal, June 2016 along with former Prime Minister Hon. Shri Jhala Nath Khanal

Dr. Chandima Gomes, Dr. Muralidas, Mr. Varadarajan & Mr. Gopakumar with participants during 2 days seminar at cochin in 2006

A.B. Kottewar Memorial Oration 2022 - Saturday, 19th November, 2022.

2 days Seminar at CPRI in 2016

Training session for engineers from Electrical Inspectorate in at Adani Electricity management training center Mumbai, September 2022

2 days Training programs in Mumbai , Chennai ,Bangalore, Delhi .....August 2017 by world famous specialists

Railway S&T officials at IRISET, Secunderabad during 2 days EMI/EMC program on Railway System 2014

National Electrical Safety week at Engineers India Ltd, New Delhi, June 2022

Lightning

The occurrence of lightning is capricious, random, and unpredictable. Since prehistoric times, the power of lightning has inspired reverence. Since lightning is caused by common meteorological conditions, we are all susceptible to being struck by it. The High Powered Committee on Disaster Management in India, which was established in August 1999 with the objective of adopting a systematic, comprehensive, and holistic approach to disasters, identified thunder and lightning as one of the most severe natural disasters. In India, lightning causes a significant number of fatalities, injuries, and property damage.

Equipment damage is increasing for the last few decades due to wide use of electronics, extension of national pow- er grid into rural areas and the mushrooming communication towers all over the country. Apart from the losses due to direct strike the losses due to the downtime caused by the damage and malfunctioning of equipment and loss of data in the microprocessors is colossal.

Lightning is the visible discharge of static electricity within a cloud, between clouds, or between earth and a cloud. Lightning occurs in all thunderstorms. Each year lightning strikes the Earth 20 million times. A lightning flash is composed of a series of strokes with an average of about four. The length and duration of each lightning stroke vary.

Lightning may ignore every defense man can conceive. A systematic hazard mitigation approach to lightning safety is a prudent course of action In India, many of the engineers involved with lightning protection at present have vague knowledge in this unique field although they may be very competent in general electrical engineering. The field of Lightning Protection is being updated frequently at international level. New concepts, techniques and products are constantly introduced into the market.

Many of the problems could be completely avoided or at least minimized by installing proper lightning protection system, taking some actions to educate the people both general public and those in engineering sector on safety issues.

Throughout early Europe, church bell ringers would make as much noise as possible, hoping to scare away the storms from these holy dwellings which were struck frequently by lightning.

Benjamin Franklin was one of the first lightning scientists. In 1752, he performed his legendary kite experiment. During a thunderstorm, he tied a metal key to the end of a kite string and set his kite flying in the storm's winds. When sparks jumped from the electrified key, he knew that electrical current had traveled from the electrified air above, down to the kite string to his key. He had suspected that lightning was actually a natural form of electricity. With the experiment, he was able to conclude that lightning was an electrical current.

This experiment was successfully performed by Thomas Francois D'Alibard of France in May 1752 when sparks were observed to jump from the iron rod during a thunderstorm. G. W. Richmann, a Swedish physicist working in Russia during July 1753, proved that thunderclouds contain electrical charge, and was killed when lightning struck him.

Lightning: History And Myths

Early Greeks believed that lightning was a weapon of Zeus. Thunderbolts were invented by Minerva the goddess of wisdom. Since lightning was a manifestation of the gods, any spot struck by lightning was regarded as sacred. Greek and Roman temples often were erected at these sites, where Gods were worshipped in an attempt to appease them.

In the Hindu religion, Indra was the God of heaven, lightning, rain, storm and thunder. The Muslim also attributed lightning and thunder to their God. The Quran says "He it is who showed you lightning and launches the thunderbolts."

Scandinavian mythology alludes to Thor, the thunderer, who was the foe of all demons. Thor tossed lightning bolts at his enemies. Thor also gave us Thurs-day.

Impundulu is the lightning Bird - God of the Bantu tribesmen in Africa. Even today their medicine men go out in storms and bid the lightning to strike far away. Indian tribes in North America believed that lightning was due to the flashing feathers of a mystical bird whose flapping wings produced the sound of thunder.

ZEUS – The greek god

Benjamin Franklin

Practical Scenario

Lightning strikes are categorized as

Intra Cloud
Inter Cloud
Cloud to ground

The first two create coupling of surges in power / data /signal lines where as the third creates serious damages such as fire, explosion, touch and step potential, failure of electrical and electronic system

95% lightning strikes between cloud and ground are Negative strikes & less than 5% is positive.

Lightning Protection System (LPS)

The purpose of a Lightning Protection System (LPS) is to intercept all lightning strikes entering a building, redirect them to the ground, and distribute them evenly across the ground. In order to prevent dangerous flashover and lightning-caused fires, all metallic installations in the building must be made at equal potential. A LPS is regarded as the most effective measure for protecting the structure and its contents against physical damage or degradation. The goal is to prevent thermal, mechanical, and electrical effects that can cause damage to the protected structure or to humans via touch or step voltages within the structure.

Main protection measures against injury to living beings due to touch and step voltages are intended to:

1) reduce the dangerous current flowing through bodies by insulating exposed conductive parts, and/or by increasing the surface soil resistivity

2) reduce the occurrence of dangerous touch and step voltages by physical restrictions and/or warning notices

LPS comprises of External LPS and Internal LPS.

An external LPS is intended to

a. Intercept a lightning flash to the structure (with an air-termination system)

b. Conduct the lightning current safely towards earth (using a down- conductor system)

c. Disperse the lightning current into the earth (using an earth- termination system)

An internal LPS

a. Prevents dangerous sparking within the structure using either equipotential bonding or a separation distance between the external LPS components and other electrically conducting elements in the structure

b. Protects against permanent failure of electrical and electronic systems caused by the lightning electromagnetic impulse (LEMP) due to conducted and induced EMI

c. Protects against surges transmitted to equipment via connecting wires and the effects of radiated electromagnetic fields directly into equipment itself

Surges can be originated from sources, external or within the structure itself. The coupling can arise from different mechanisms such as

a. Resistive coupling (e.g. the earth impedance of the earth termination system or the cable shield resistance)

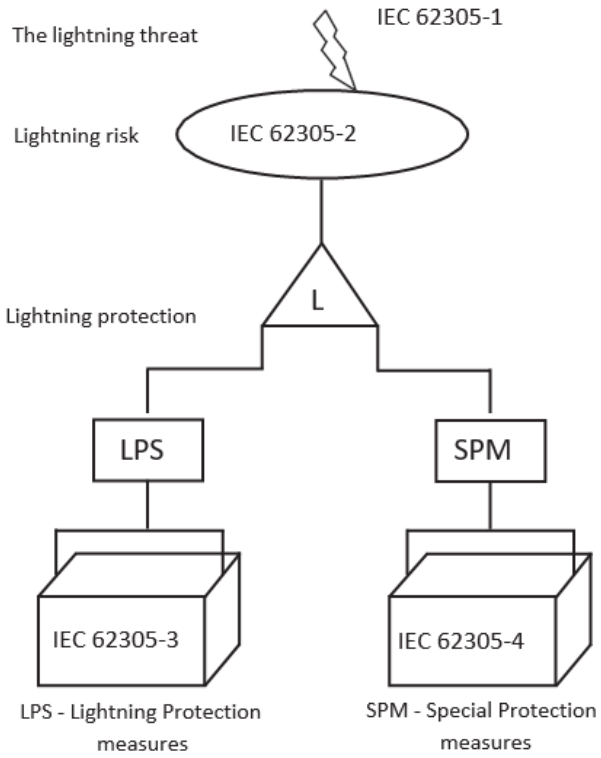
b. Magnetic field coupling (e.g. caused by wiring loops in the electrical and electronic system or by inductance of bonding conductors)

c. Electric field coupling (e.g. caused by rod antenna reception)

The type and location of an LPS should be carefully considered in the initial design of a new structure, thereby enabling maximum advantage to be taken from the electrically conductive parts of the structure.

By doing so, design and construction of an integrated installation is made easier, the overall aesthetic aspects can be improve, and the effectiveness of the LPS can be increased at minimum cost and effort.

Once construction has begun on a site, access to the ground and the proper use of foundation steelwork for forming an effective earth termination may be impossible. Therefore, soil resistivity and earth composition should be considered as early as possible in the design process. This information is crucial to the design of an earth termination system and may impact the foundation design work for the structure.



Standards & Regulation

Lightning protection as per IS/IEC 62305 / NBC / NEC becomes legal requirement under various rules and regulations.

IS/IEC 62305 part 1 to 4 is the Indian Standard for Lightning Protection. The Standard quotes

There are no devices or methods capable of modifying the natural weather phenomena to the extent that they can prevent lightning discharges.

Lightning flashes to, or nearby, structures (or lines connected to the structures) are hazardous to people, to the structures themselves, their contents and installations and to lines. This is why the application of lightning protection measures is essential.

National Building Code of India NBC - 2016 quote

Any other kind of air-terminals like dissipation system / ESE air-terminal / CSE air-terminal shall not be allowed

CEA Safety Regulations insist

Lightning protection as per IEC 62305 for all buildings taller than 15 meters

Applicable Standards

Indian Standards

IS/IEC 62305-1	:	Protection against lightning – Part 1: General principles
IS/IEC 62305-2	:	Protection against lightning – Part 2: Risk management
IS/IEC 62305-3	:	Protection against lightning – Part 3: Physical damage to structures and life hazard
IS/IEC 62305-4	:	Protection against lightning – Part 4: Electrical and electronic systems within structures
NBC: 2016	:	National Building Code of India
IS732: 2019	:	Code of Practice For Electrical Wiring Installations
NEC 2023(SP30)	:	National Electric Code of India
IS 3043: 2018	:	Code Practice of Earthing

International Standards

IEC 62793	:	Thunderstorm Warning system
IEC 62561-1	:	Lightning Protection System Components – Part 1 Requirement for Connection Components
IEC 62561-2	:	Lightning Protection System Components – Part 2 Requirement for Conductors and Earth Electrodes
IEC 62561-3	:	Lightning Protection System Components – Part 3 Requirement for Isolating Spark gaps
IEC 62561-4	:	Lightning Protection System Components – Part 4 Requirement for Conductor Fasteners
IEC 62561-5	:	Lightning Protection System Components – Part 5 Requirement for Earth electrode inspection housing
IEC 62561-6	:	Lightning Protection System Components – Part 6 Requirement for Lightning Strike Counters
IEC 62561-7	:	Lightning Protection System Components – Part 7 Requirement for Earth Enhancing Compounds
IEC TS 62561-8	:	Lightning Protection System Components – Part 8: Requirements for components for isolated LPS
IEC 61643-11 (IS 16463-11)	:	Part 11: SPD connected to low-voltage power systems – Requirements and test methods
IEC 61643-12 (IS16463-12)	:	Part 12: SPD connected to low-voltage power systems – Selection and application principles
IEC 61643-21	:	Part 21: SPD connected to telecom and Signaling Networks – Requirements and test methods
IEC 61643-22	:	Part 22: SPD connected to telecom and Signaling Networks – Selection and application principles
IEC 60364-4-44	:	LV electrical installations - Protection against voltage disturbances and electromagnetic disturbances
IEC 60364-5-53	:	LV electrical installations - Selection and erection - Isolation, switching and control
IEC 60364-5-54	:	LV electrical installations - Selection and erection - Earthing arrangements and protective conductors
IEC 61936-1	:	Power installations exceeding 1 KV common rules
ISO/IEC 30129	:	Information technology – Telecommunications bonding networks for buildings and other structures

American Standards

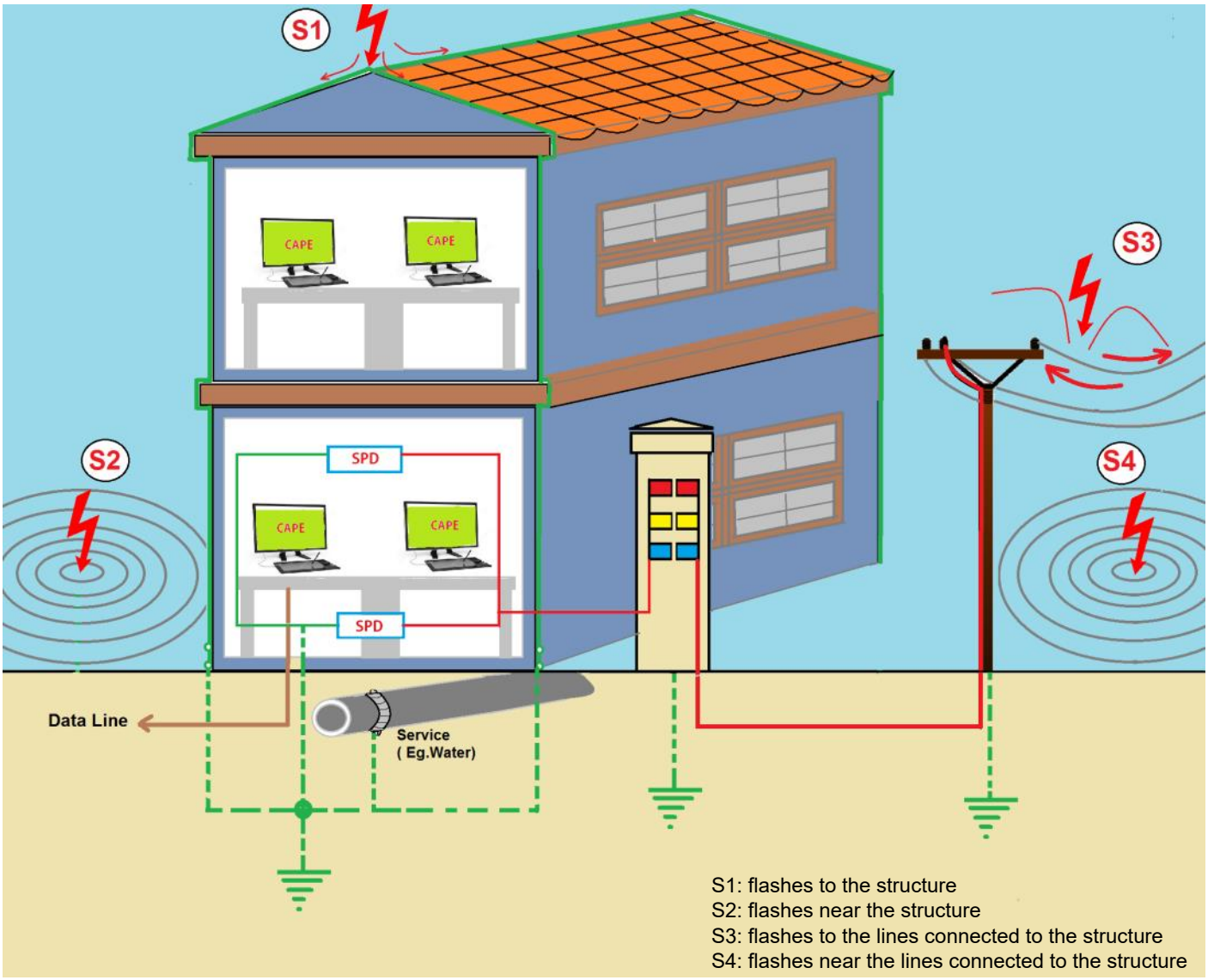
NFPA 780	:	Standard for the Installation of Lightning Protection Systems
UL 96	:	Standard for Installation Requirements for Lightning Protection Systems
UL 96A	:	Lightning Protection Components
UL 467	:	Grounding and Bonding Equipment
UL 1449	:	Standard for Surge Protective Devices
IEEE 80	:	Safety in AC Substation Grounding
IEEE 1100	:	Powering and Grounding Electronic Equipment
IEEE 142	:	Grounding of Industrial and Commercial Power systems
IEEE 837	:	Exothermic welded Connections
IEEE C62.41.1	:	IEEE Guide on the Surge Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	:	IEEE Recommended Practice on Characterization of Surges in LV (1000 V and Less) AC Power Circuits
ANSI/BICSI	:	Bonding and Grounding of IT equipment in commercial buildings

LPS according to IS/IEC 62305

The lightning protection system has been divided into four categories (I, II, III, IV). In accordance with the Lightning Protection Level, the structure's LPS class is chosen (LPL). LPL is determined via a risk assessment in accordance with IEC 62305-2. Minimum and maximum lightning current parameters are fixed for each LPL level (I, II, III, and IV).

Sources and types of damage to a structure

The lightning current is the source of damage. The following situations (S1 to S4) shall be taken into account, depending on the position of the point of strike relative to the structure considered:



S1: flashes to the structure
S2: flashes near the structure
S3: flashes to the lines connected to the structure
S4: flashes near the lines connected to the structure

Risk Assessment

The need for protection, the economic benefits of installing protection measures and the selection of adequate protection measures should be determined in terms of risk assessment. To reduce the loss due to lightning, protection measures may be required. Whether they are needed, and to what extent, should be determined by risk assessment as per IS/IEC 62305-2.

Before proceeding with the detailed design of a lightning protecting system, the following essential steps should be taken by carrying out a risk assessment:

a) Decide whether the structure need protection or not and if so, the special requirements
b) Modern buildings with electronic equipment need protection from radiated effect of lightning. To achieve this, the structural steel of the building should form a part of lightning protection system
c) Include lightning protection measures in the construction drawing including foundation
d) Agree the procedures for testing and future maintenance

The protection measures should ensure that the calculated risk is less than the tolerable risk explained in IS/IEC 62305. Tolerable risk is maximum value of the risk which can be tolerated for the structure to be protected.

Tolerable risk (RT) as per IS/IEC 62305

Type of loss	Tolerable risk
Loss of human life or permanent injuries	10^{-5} (One injury out of 100,000 Strikes)
Loss of service to the public	10^{-3} (One service loss out of 1,000 Strikes)
Loss of cultural heritage	10^{-4} (One damage out of 10,000 Strikes)
Economic Loss	10^{-3} (One failure out of 1,000 Strikes)

Risk Analysis and Lightning Protection Level (LPL)

Risk is analyzed considering the following factors and protection is divided into four protection levels (LPL 1 to 4)

Source of Damage

- Flashes to a structure (S1)
- Flashes near a structure(S2)
- Flashes to a line (S3)
- Flashes near a line (S4)

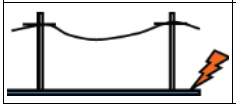
Type of damage

- Injury to living beings by electric shock (D1)
- Physical damage (D2)
- Failure of electrical and electronic systems (D3)

Type of Loss

- Loss of human life (including permanent injury) (L1)
- Loss of service to the public (L2)
- Loss of cultural heritage (L3)
- Loss of economic value (L4) (structure, content, and loss of activity)

Sources of damage, types of damage and types of loss according to the point of strike

Lightning Flash		Structure	
Point of strike	Source of damage	Type of damage	Type of loss
	S1	D1 D2 D3	L1, L4[a] L1, L2, L3, L4 L1[b], L2, L4
	S2	D3	L1[b], L2, L4
	S3	D1 D2 D3	L1, L4[a] L1, L2, L3, L4 L1[b], L2, L4
	S4	D3	L1[b], L2, L4

a. Only for properties where animals may be lost.
b. Only for structures with risk of explosion and for hospitals or other structures where failures of internal systems immediately endangers human life

Risk (R) is the value of a probable average annual loss. For each type of loss which may appear in a structure or in a service, the relevant risk shall be evaluated. The risk to be evaluated are for each source & type of damage

R1 : risk of loss of human life
R2 : risk of loss of service to the public
R3 : risk of loss of cultural heritage
R4 : risk of loss of economic value

Each risk component $Rx = N_x \times P_x \times L_x$ where

- N_x is the number of dangerous events per annum
- P_x is the probability of damage to structure
- L_x is the consequent loss

Total risk R is the sum of various risk components.

If $R \leq R_T$, lightning protection is not necessary.
(RT – Tolerable Risk)

Risk components for a structure due to flashes to the structure

R_A: Component related of injury to living beings caused by electric shock due to touch and step voltages inside the structure and outside in the zones up to 3 m around down conductors. Loss of type L1 and, in the case of structures holding livestock, loss of type L4 with possible loss of animals may also arise. In special structures, people may be endangered by direct strikes (e.g. roof top or stadiums).

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

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

Risk component for a structure due to flashes near the structure

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

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

R_U: Component related to injury of living beings caused by electric shock due to touch voltage inside the structure. Loss of type L1 and, in the case of agricultural properties, loss of type L4 with possible loss of animals could also occur.

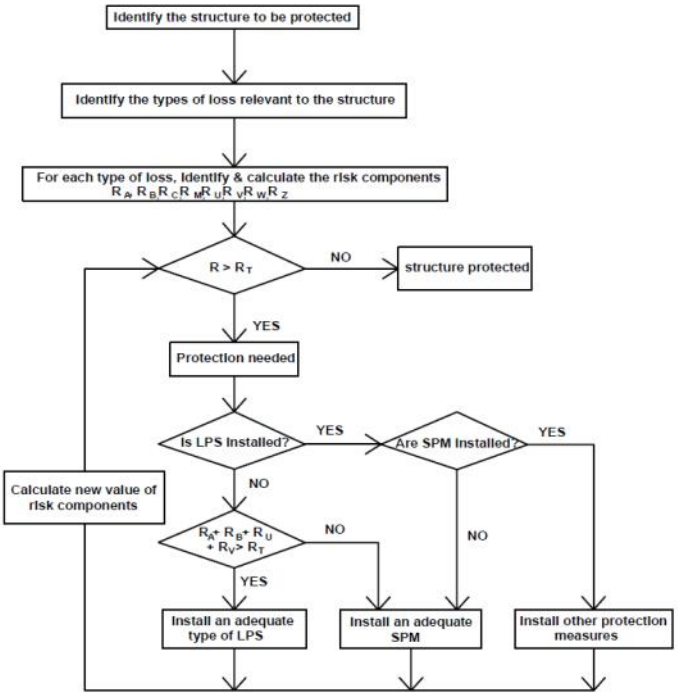
R_V: Component related to physical damage (fire or explosion triggered by dangerous sparking between ex- ternal installation and metallic parts generally at the entrance point of the line into the structure) due to lightning current transmitted through or along incoming lines. All types of loss (L1, L2, L3, L4) may occur.

R_W: Component related to failure of internal systems caused by over voltages induced on incoming lines and transmitted to the structure. Loss of type L2 and L4 could occur in all cases, along with type L1 in the case of structures with risk of explosion, and hospitals or other structures where failure of internal systems immediately endangers human life. The lines taken into account in this assessment are only the lines entering the structure. Lightning flashes to, or near, pipes are not considered as a source of damage, based on the bonding of pipes to an equipotential bonding bar. If an equipotential bonding bar is not provided, such a threat should also be considered.

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

R_Z: Component related to failure of internal systems caused by over voltages induced on incoming lines and transmitted to the structure. Loss of type L2 and L4 could occur in all cases, along with type L1 in the case of structures with risk of explosion, and hospitals or other structures where failure of internal systems immediately endanger human life.

Procedure for deciding the need of protection & selecting protection measures

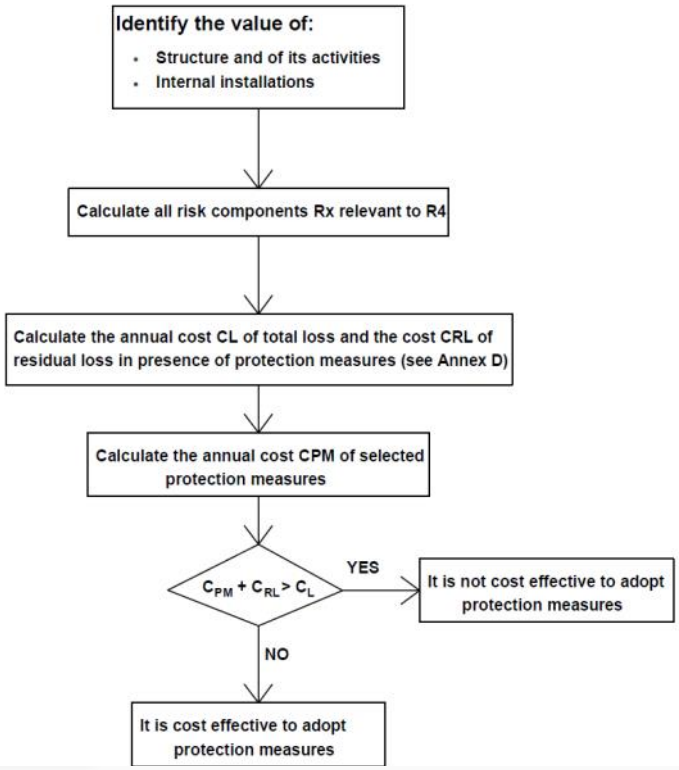


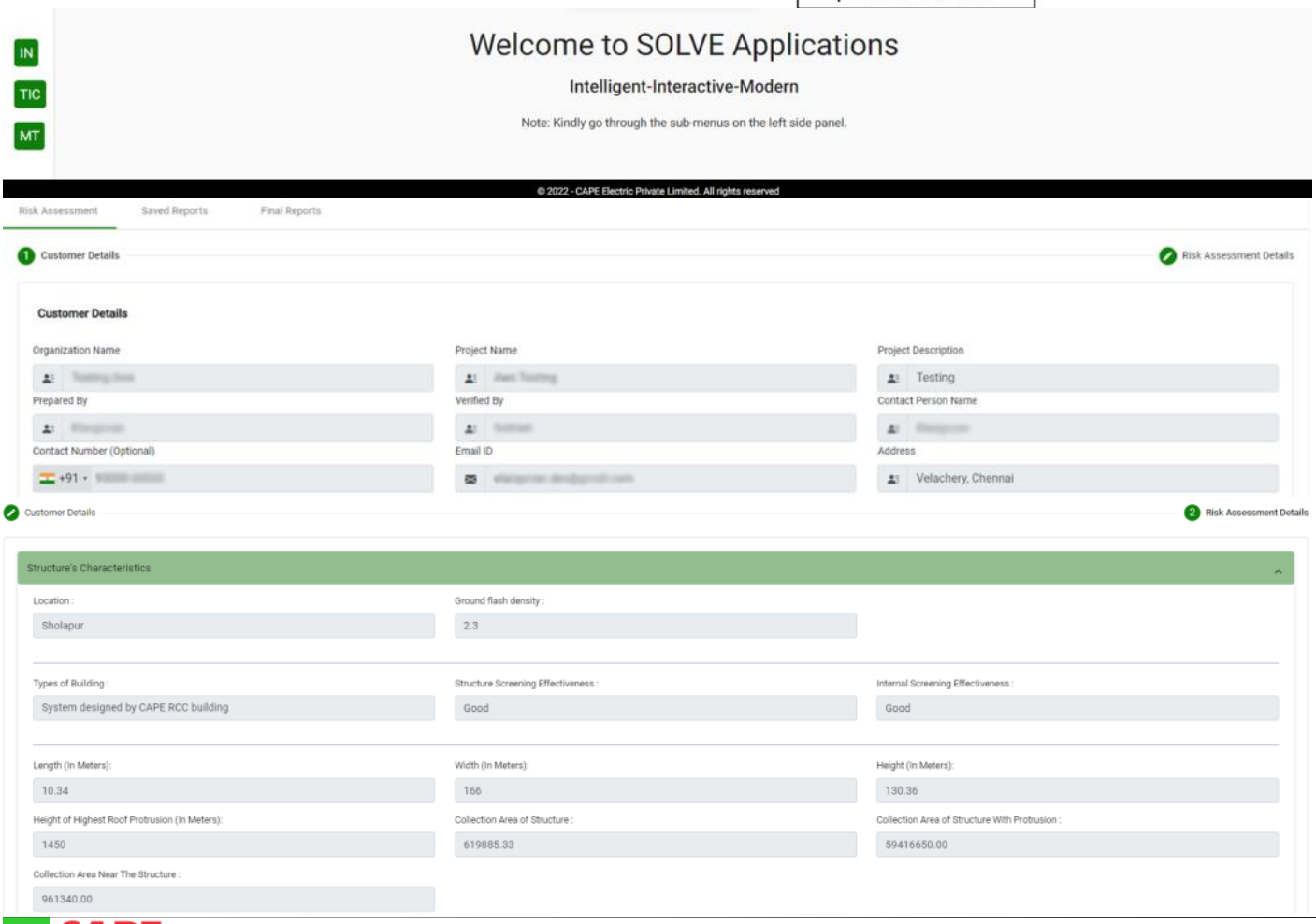
Risk assessment Software

SOLVE risk assessment software is a handy tool for building designers to select economical and appropriate protection measures. For more information visit www.solvelv.com. Annual thunderstorm days all over India are available in the standard make it user friendly.

Procedure for evaluating the cost effectiveness of protection measures

Apart from finding the need of lightning protection for a structure or a service, it is useful to ascertain the economic benefits of installing protection measures in order to reduce the economic loss L4. The assessment of components of risk R4 for a structure allows the user to evaluate the cost of the economic loss with and without the adopted protection measures





Height of Nearby Structure :
Lower than surrounding buildings

Electrical / Telephone Service Line :
LV power, telecommunication or data line

Environment :
Suburban

No of dangerous event on structure :
0.356434064750

No of dangerous event near the structure :
2.2110820000

Protection required for part of building :
Yes

Length (In Meters):
153

Width (In Meters):
156

Height (In Meters):
316

Collection Area :
3431662.56

Structure's Attributes

Type of Floor Surface :
Marble, Ceramic

Additional Protection :
Electrical Insulation

Risk of Fire : Pick the Risk of Fire
Zones 1, 21

Fire Protection Measures :
Manual

Type of Internal Wiring :
Unshielded, proper routing to avoid large loops

Lines:

Total No of Lines :
163.65

Number of Power Lines :
165.5

Type of Power Lines :
Overhead

Length Of Power Line (In Meters) :
5636

Shielding, grounding, isolation :
TN-C-S system with PME

Collection Area Of The Power Lines :
225440

Collection Area Near The Lines :
22544000

No of Dangerous Event Near The Power Lines :
25.92560000

No of Dangerous Event On The Power Lines :
0.25925600

Number of Telecom lines :
5446

Type of Telecom Lines :
Overhead

Length Of Telecom Line (In Meters) :
65.6

Shielding, grounding, isolation :
TN-C-S system with PME

Collection Area Of The Telecom Lines :
2624

Collection Area Near The Telecom Lines :
262400

No of Dangerous Event Near The Telecom Lines :
0.30176000

No of Dangerous Event On The Telecom Lines :
0.00301760

Losses

Loss of Human Life (L1) :

Hazard Classification :
Hospitals,Multi-Storey Buildings

Loss Due To Physical Damage :
Public entertainment,church,museum

Loss Due To Failure Of Internal Systems :
Risk of explosion

Loss Due To Injury To Living Beings By Electric Shock :
0.00208862058080808

Loss Due To Physical Damage L1 :
2.61077572601010122

Loss Due To Failure Of Internal Systems :
20.88620580808080973

Loss Of Service To Public (L2) :

Loss Due To Physical Damage :
TV, telecommunication lines

Loss Due To Failure Of Internal System :
TV, telecommunication lines

Loss Due To Physical Damage :
0.00252

Loss Due To Failure Of Internal Systems :
0.0050

Loss Of Cultural Heritage (L3) :

Loss Due To Physical Damage :
Museums,galleries

Loss Due To Physical Damage :
0.0050

Economic Loss (L4) :

Loss Due To Physical Damage :
Hospitals, industrial, museum, agricultural

Loss Due To Failure Of Internal System :
Risk of explosion

Loss Due To Injury To Living Beings By Electric Shock :
0.0000100

Loss Due To Physical Damage :
0.025

Loss Due To Failure Of Internal Systems:
0.1000

Protection :

Class of LPS :
Class III LPS

Class of SPD :
Protec T1H 300 3+1 R

Calculated Risk

	Tolerable Risk (Rt)		Direct Strike Risk (Rd)		Indirect Strike Risk (Ri)		Calculated Risk (R)
Loss of Human Life	1.00E-05	=>	1.8E+2	+	1.1E+2	=	2.90E+2
Loss of Public service	1.00E-03	=>	5.9E-2	+	2.6E-2	=	8.50E-2
Loss of Cultural Heritage	1.00E-04	=>	3.8E-2	+	0	=	3.78E-2
Economic Loss	1.00E-03	=>	9.8E-1	+	5.2E-1	=	1.50E+0

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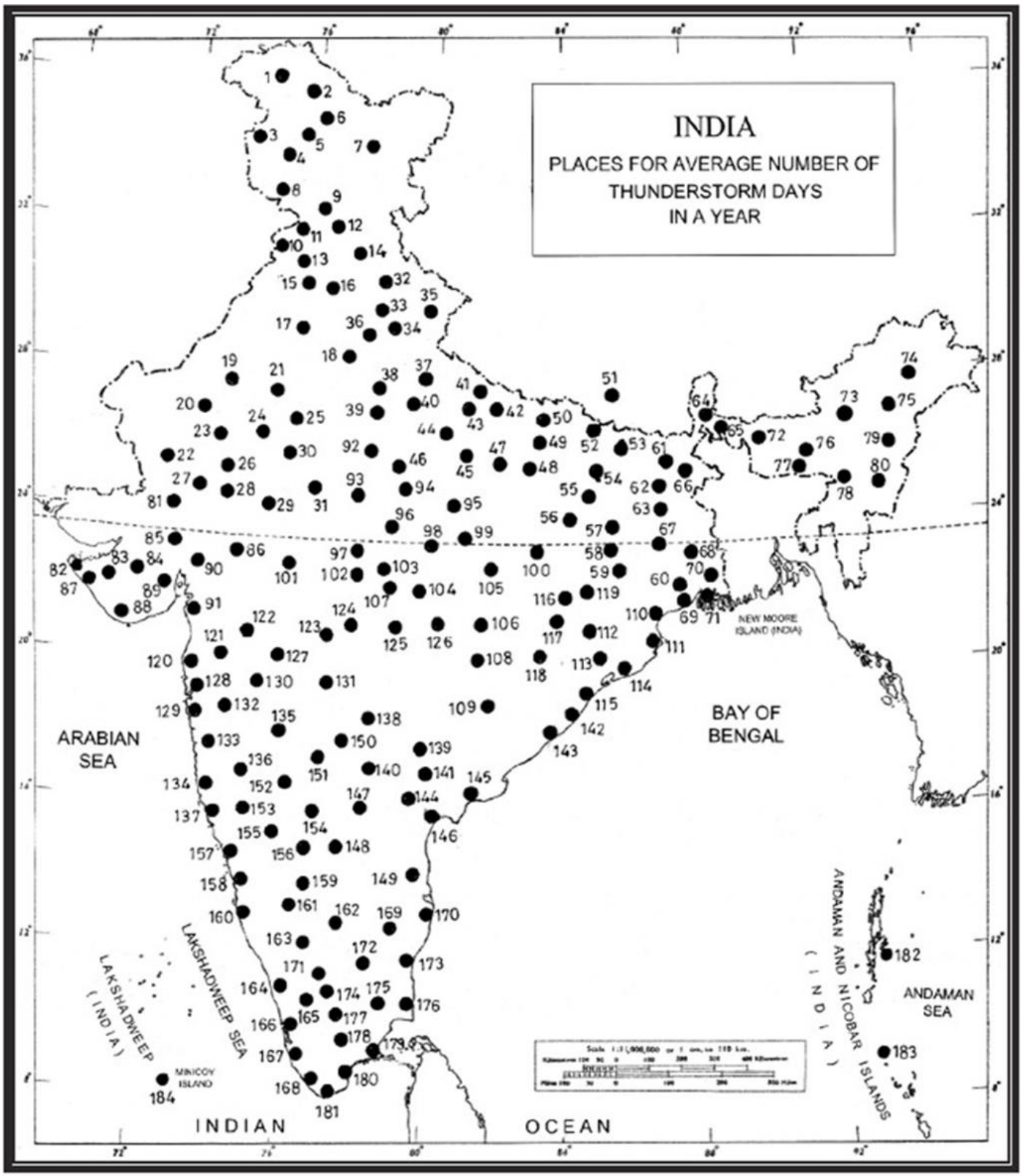
Annual Thunderstorm days in India (To be read along with the name of place in next table)

The average annual number (N) of dangerous events due to lightning flashes influencing a structure to be protected depends on the thunderstorm activity of the region where the structure is located and on the structure's physical characteristics. To calculate the number N, one should multiply the lightning ground flash density N_g by an equivalent collection area of the structure, taking into account correction factors for the structure's physical characteristics.

The lightning ground flash density N_g is the number of lightning flashes per square kilometer per year.



Based upon Survey of India Outline Map printed in 1993.

The territorial waters of India extend into the sea to a distance of twelve miles measured from the appropriate base line.
The boundary of Meghalaya shown on this map is as interpreted from the North-Eastern Areas (Reorganisation) Act. 1971, but has yet to be verified.
Responsibility for correctness of internal details shown on the map rests with the publisher.
The state boundaries between Uttaranchal & Utter Pradesh, Bihar & Jharkhand and Chhatisgarh & Madhya Pradesh have not been verified by Governments concerned.

Name of place, annual thunderstorm days (T_d) and Lightning flash density (N_g)

S.NO	Name of place	T_d	N_g	S.NO	Name of place	T_d	N_g	S.NO	Name of place	T_d	N_g
1	Chloht	7	0.46	63	Dumka	63	7.1	125	Nagpur	45	4.66
2	Skarou	5	0.3	64	Darjeeling	20	1.69	126	Gonda	10	0.71
3	Gulmarg	53	5.72	65	Jalpaiguri	68	7.81	127	Aurangabad	36	3.53
4	Srinagar	54	5.86	66	Malda	50	5.32	128	Bombay	18	1.48
5	Dras	3	0.16	67	Asansol	71	8.24	129	Alibag	12	0.89
6	Kargil	2	0.1	68	Burdwan	33	3.16	130	Ahmednagar	10	0.71
7	Leh	3	0.16	69	Kharagpur	76	8.98	131	Parbhani	32	3.04
8	Jammu	26	2.35	70	Calcutta	70	8.1	132	Pune	22	1.91
9	Dharamsala	13	0.99	71	Sager Island	41	4.15	133	Mahabaleshwar	14	1.08
10	Amritsar	49	5.19	72	Dhubri	8	0.54	134	Ratnagiri	6	0.38
11	Pathankot	4	0.23	73	Tezpur	27	2.46	135	Sholapur	23	2.01
12	Mahoi	46	4.79	74	Dibrugarh	70	8.1	136	Miraj	25	2.24
13	Ludhiana	12	0.89	75	Sibsagar	103	13.13	137	Vengurla	39	3.9
14	Shimla	40	4.02	76	Shillong	75	8.83	138	Nizamabad	36	3.53
15	Patiala	26	2.35	77	Cheerapunji	49	5.19	139	Hanamkonda	43	4.4
16	Ambala	9	0.62	78	Silchar	33	3.16	140	Hyderabad	28	2.58
17	Hissar	27	2.46	79	Kohinia	34	3.28	141	Khammam	26	2.35
18	Delhi	30	2.81	80	Imphal	49	5.19	142	Kalingapatam	26	2.35
19	Bikaner	10	0.71	81	Deesa	7	0.46	143	Vishakapatnam	20	1.69
20	Phalodi	14	1.08	82	Dwarka	5	0.3	144	Rentichintala	47	4.92
21	Sikar	17	1.38	83	Jamnagar	6	0.38	145	Machhilipatam	20	1.69
22	Barmer	12	0.89	84	Rajkot	12	0.89	146	Ongole	25	2.24
23	Jodhpur	23	2.01	85	Ahmedabad	11	0.8	147	Kurnool	29	2.69
24	Ajmer	26	2.35	86	Dohad	17	1.38	148	Anantapur	27	2.46
25	Jaipur	39	3.9	87	Porbandar	3	0.16	149	Nellore	18	1.48
26	Kankroli	36	3.53	88	Verawal	3	0.16	150	Bidar	16	1.28
27	Mount Abu	4	0.23	89	Bhavnagar	11	0.8	151	Gulbarga	34	3.28
28	Udaipur	34	3.28	90	Vadodara	8	0.54	152	Bijapur	9	0.62
29	Neemuch	23	2.01	91	Surat	4	0.23	153	Belgaum	31	2.93
30	Kota	27	2.46	92	Gwalior	53	5.72	154	Raichur	17	1.38
31	Jhalawar	40	4.02	93	Guna	33	3.16	155	Gadag	21	1.8
32	Mussoorie	61	6.82	94	Nowgong	59	6.54	156	Bellari	22	1.91
33	Roorkee	76	8.98	95	Satna	41	4.15	157	Karwar	27	2.46
34	Moradabad	36	3.53	96	Sagar	36	3.53	158	Honawar	5	0.3
35	Mukteshwar	53	5.72	97	Bhopal	44	4.53	159	Chikalthana	24	2.12
36	Meerut	-	-	98	Jabalpur	50	5.32	160	Mangalore	36	3.53
37	Bareilly	34	3.28	99	Umaria	37	3.65	161	Hassan	76	8.98
38	Aligarh	30	2.81	100	Ambikapur	29	2.69	162	Bangalore	45	4.66
39	Agra	24	2.12	101	Indore	34	3.28	163	Mysore	44	4.53
40	Mainpuri	23	2.01	102	Hoshangabad	37	3.65	164	Hozhmoode	39	3.9
41	Bharaich	31	2.93	103	Panchmarhi	30	2.81	165	Palghat	35	3.41
42	Gonda	22	1.91	104	Seoni	51	5.45	166	Cochin	63	7.1
43	Lucknow	10	0.71	105	Penda Dam	56	6.13	167	Allepey	57	6.27
44	Kanpur	26	2.35	106	Raipur	34	3.28	168	Trivandrum	48	5.06
45	Fatehpur	24	2.12	107	Chhindwara	27	2.46	169	Vellore	25	2.24
46	Jhansi	20	1.69	108	Kanker	37	3.65	170	Madras	47	4.92
47	Allahabad	51	5.45	109	Jagdalpur	38	3.77	171	Ooty	24	2.12
48	Varanasi	51	5.45	110	Balasore	81	9.72	172	Salem	65	7.37
49	Azamgarh	1	0.04	111	Chandbali	75	8.83	173	Cuddalore	37	3.65
50	Gorakhpur	11	0.8	112	Angul	81	9.72	174	Coimbatore	40	4.02
51	Kathmandu	74	8.68	113	Bhubaneswar	46	4.79	175	Tiruchirapalli	41	4.15
52	Muthihari	38	3.77	114	Puri	33	3.16	176	Nagappattinam	15	1.18
53	Darbhanga	10	0.71	115	Gopalpur	34	3.28	177	Kodaikanal	82	9.87
54	Patna	33	3.16	116	Sambalpur	67	7.67	178	Madurai	39	3.9
55	Gaya	38	3.77	117	Jharsuguda	85	10.32	179	Pamban	5	0.3
56	Daltonganj	73	8.54	118	Titlagarh	24	2.12	180	Tuticorin	14	1.08
57	Hazaribagh	73	8.54	119	Rajgangpur	1	0.04	181	Kanyakumari	60	6.68
58	Ranchi	34	3.28	120	Damamu	4	0.23	182	Port blair	62	6.96
59	Chaibasa	74	8.68	121	Nasik	17	1.38	183	Car Nicobar I	10	0.71
60	Jamshedpur	66	7.52	122	Malegaon	13	0.99	184	Minicoy	20	1.69
61	Purnea	52	5.59	123	Akola	20	1.69				
62	Sabour	76	8.98	124	Khraoti	32	3.04				

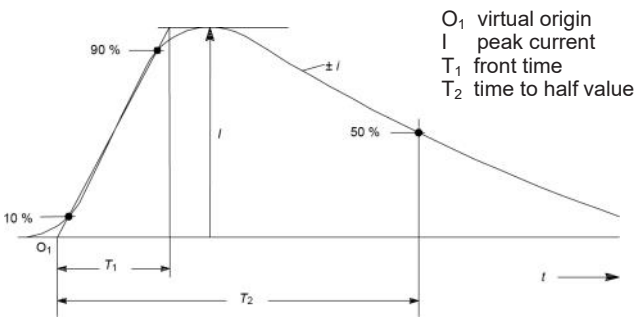
Lightning Protection Level (LPL)

Based on the risk assessment if protection is necessary, Lightning protection is divided into four levels namely LPL 1 to 4, which helps in designing and implementing protection measures for an economical implementation. LPL 1 provides the maximum protection and is expensive where as LPL 4 provides the least protection and less expensive. As a thumb rule the following LPL can be used for typical buildings as recommended in NBC-2016

Application	LPL
Computer datacenter, military application, high rise hotels / hospitals, nuclear power stations, airports, essential service such as telecom	I
Low rise hotels / hospitals, ex-zones in the industry and chemical sector, fuel retail outlets / gas stations / com- pressor stations and similar installations	II
Schools, banks, residential buildings, temples, church-es, mosques, community hall etc	III IV

Impulse current parameters

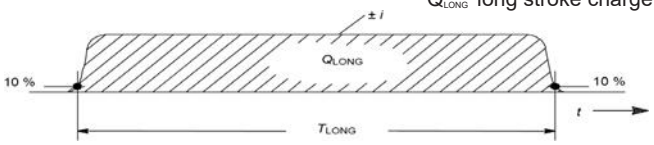
Impulse current (Short Duration high current)
(typically T2 < 2 ms)



O_1 virtual origin
I peak current
T_1 front time
T_2 time to half value

Long duration stroke parameters
(typically 2 ms <TLONG<1 s)

T_{LONG} duration time
Q_{LONG} long stroke charge



Protection measures

An ideal protection for structures would be to enclose the structure within an earthed and perfectly conducting continuous shield of adequate thickness and to provide adequate bonding of the incoming metallic services to the structure.

This would prevent the penetration of lightning current and related electromagnetic field into the structure to be protected, prevent dangerous thermal and electrodynamics effects of current, dangerous sparking, overvoltages for internal systems. In practice, it is often neither possible nor cost effective to go to such measures to provide full protection.

Protection measures are adopted in order to reduce the risk according to the type of damage. Protection measures to reduce injury of living beings by electric shock are

- Adequate insulation of exposed conductive parts
- Equipotentialisation by means of a meshed earthing system
- Physical restrictions and warning notices
- Lightning equipotential bonding (EB)

Equipotentialisation and an increase in the contact resistance of the ground surface inside and outside the structure reduce life hazards. Protection measures are effective only in structures protected by an LPS. Use of storm detectors and associated provisions may reduce the life hazard.

Protection measures to reduce physical damage are achieved by installing a lightning protection system (LPS) which includes the following:

- Air-termination system
- Down-conductor system
- Earth-termination system
- Lightning equipotential bonding (EB)
- Electrical insulation (and hence separation distance) from the external LPS.

Protection measures to reduce the failure of electrical and electronic systems are achieved by installing Special Protection Measures (SPM) which includes

- Earthing and bonding measures
- Magnetic shielding
- Line routing
- Isolating interfaces
- Coordinated SPD system

An LPS consists of both external and internal lightning LPS. These protection measures are to be done based on lightning protection zones (LPZ).

For each LPL, a set of maximum and minimum lightning current parameters relevant to LPL 1 are reduced to 75% for LPL II and to 50% for LPL III and IV.

Protection measures are separate for external (to the structure) & Internal (electrical/electronic equipment). Both protection measures should complement each other

Parameters and effects of Lightning

Peak current, Charge, Specific Energy & Average steepness are the lightning current parameters contributing to failures. Each parameter contribute to some part in a failure. Eg

- The mechanical effects of lightning are related to the peak value of the current (I) , and to the specific energy (W/R)
- The thermal effects are related to the specific energy (W/R) when resistive coupling is involved and to the charge (Q) when arcs develop to the installation
- Over voltages and dangerous sparking caused by inductive coupling are related to the average steepness (di /dt) of the lightning current front

Each of the single parameters (I, Q, W/R , di /dt) tend to dominate each failure mechanism.

Lightning current parameters defined in IS/IEC 62305 for different Lightning Protection Levels (LPL).

First positive impulse			LPL				Effect
Current parameters	Symbol	Unit	I	II	III	IV	
Peak current	*I*	kA	200	150	100		M
Impulse charge	Q_{SHORT}	C	100	75	50		T Arc)
Specific energy	W/R	MJ/Ω	10	5.6	2.5		M and T
Time parameters	T_1 / T_2	µs / µs	10 / 350				
First negative impulse			LPL				Effect
Current parameters	Symbol	Unit	I	II	III	IV	
Peak current	*I*	kA	100	75	50		M
Average steepness	d*i*/*dt*	kA/µs	100	75	50		S and T
Time parameters	T_1 / T_2	µs / µs	1 / 200				
Subsequent impulse			LPL				Effect
Current parameters	Symbol	Unit	I	II	III	IV	
Peak current	*I*	kA	50	37.5	25		M
Average steepness	d*i*/*dt*	kA/µs	200	150	100		S and F
Time parameters	T_1 / T_2	µs / µs	0.25 / 100				
Long stroke			LPL				Effect
Current parameters	Symbol	Unit	I	II	III	IV	
Long stroke charge	Q_{LONG}	C	200	150	100		T Arc)
Time parameter	T_{LONG}	s	0.5				

M Mechanical Failures
T Thermal failures due to arching
M and T Mechanical and Thermal
S and T Surges and Thermal

The maximum values of lightning current parameters are used to design lightning protection components (e.g. cross-section of conductors, thickness of metal sheets, current capability of SPDs, separation distance against dangerous sparking) and to test the devices.

The minimum values of lightning current parameters are used to derive the rolling sphere radius and for positioning of the air-termination system.

Selection and installation of SPD's shall be done considering the average steepness of lightning current rather than providing more importance to surge current capacity.

Lightning Protection expert shall verify applicable parameters of lightning in a typical building and make design and installation capable of withstanding that parameter.

Example: Calculation of specific energy

Specific energy is the equivalent energy dissipated in a resistance of 1 ohm through which lightning current flows

Consider specific energy of first positive strike = 5.6×10^6 j

$$\frac{W}{R} = \int i^2 \, dt$$

For a good conductor
(e.g. CAPE aluminium alloy conductor, 8 mm diameter)

Resistance / meter = 10^{-7} ohm
Specific Energy positive strike in LPL 2 = 5.6×10^6
Energy dissipated in one meter conductor (as heat)
= $5.6 \times 10^6 \times 10^{-7}$
= 0.56 joules
(Negligible heat)

For a bad conductor
(eg. a rusted joint)

Resistance / meter = 1 ohm
Specific Energy positive strike in LPL 2 = $5.6 \times 10^6 \times 1$
= 5.6×10^6 joules

(equal to the total heat produced by a 1.5 kW heater for one hour is dissipated in few micro seconds)

One Joule – is the energy dissipated as heat when an electric current of one ampere passes through a resistance of one ohm for one second. Also called as one "watt-second" (W-s)

One kWh (kilowatt-hour) = 3.6 mega joules

Result

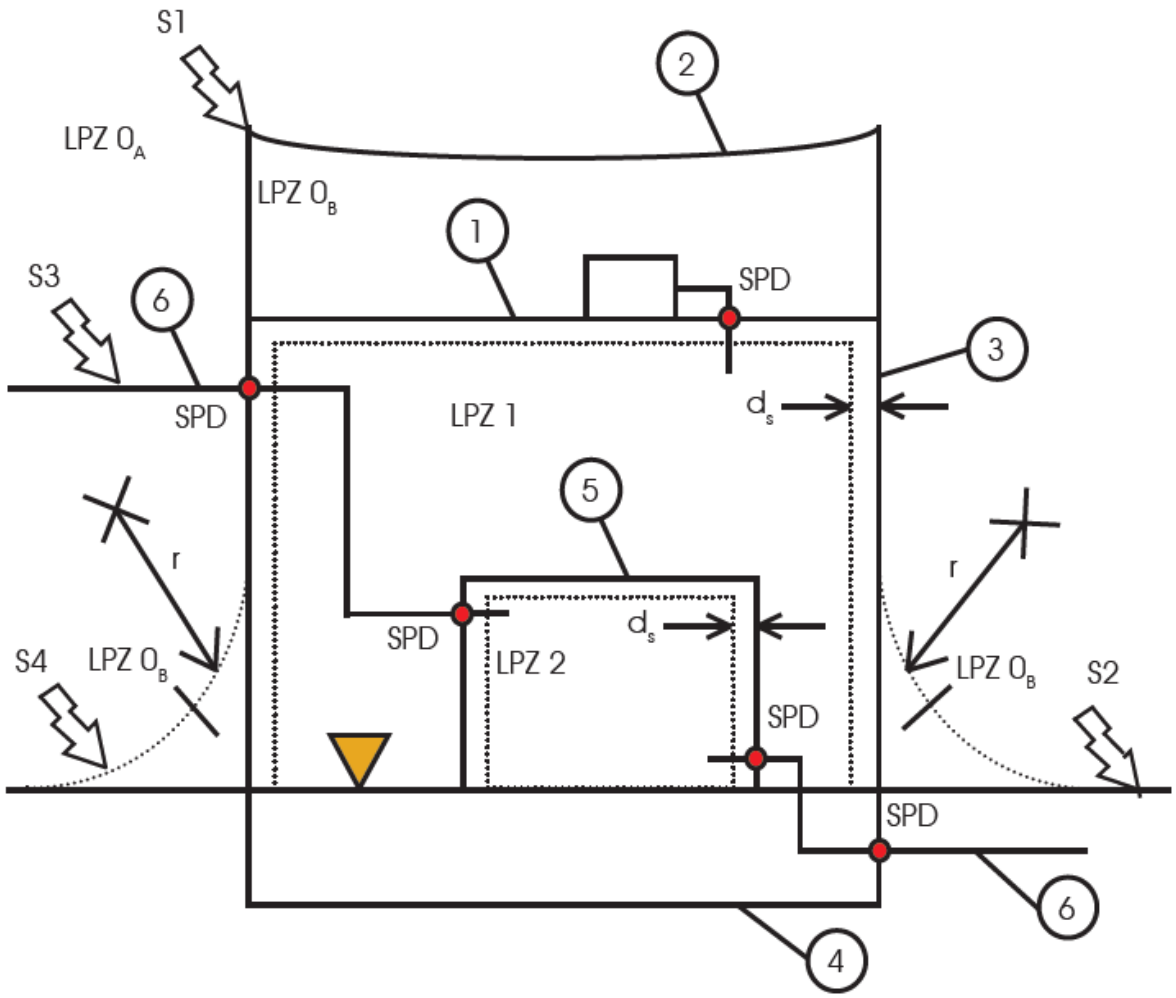
Thermal effects are negligible for good conductors and extremely high for bad conductors during a lightning current flow.

Temperature rise in CAPE Air terminal / Down conductor (eg art no 400 008 or 400 410) is approx. 28°C. After a cross joint the temperature rise will be about 12°C

Lightning Protection Zone (LPZ)

LPZ 0_A	Zones where the threat is due to the lightning flash and the full lightning electromagnetic field. The internal system may be subjected to full or partial lightning current.
LPZ 0_B	Zone protected against direct lightning flash but where the threat is the full lightning electromagnetic field. The internal system may be subjected to partial lightning current.
LPZ 1	Zone where the surge current is limited by current sharing and by isolating interfaces and SPD's at the boundary. Special shielding may attenuate the lightning electromagnetic field.
LPZ 2 to n	Zones where the surge current may be further limited by current sharing and by isolating interfaces or additional SPD's at the boundary. Additional special shielding may be used to further attenuate the lightning electromagnetic field.

In general, the higher the number of an individual zone, the lower the electromagnetic environment parameters



1	structure (shield of LPZ 1)
2	air-termination system
3	down-conductor system
4	earth-termination system
5	room (shield of LPZ 2)
6	lines connected to the structure
S1	flash to the structure
S2	flash near to the structure
S3	flash to a line connected to the structure
S4	flash near a line connected to the structure
r	rolling sphere radius

ds	safety distance against too high magnetic field
LPZ 0_A	Direct flash, full lightning current, full magnetic field
LPZ 0_B	No direct flash, partial lightning or induced current, full magnetic field
LPZ 1	No direct flash, limited lightning or induced current, damped magnetic field
LPZ 2	No direct flash, induced current, further damped magnetic field Protected volumes inside LPZ 1and LPZ 2 must respect safety distance "s"
▽	Ground level
●	Lightning equipotential bonding by means of SPD

Note: Buildings with critical electronics can adopt Protection Zones as a safety measure for electronics against other EMP's such as HEMP / NEMP (High Altitude Electromagnetic Pulse / Nuclear Electromagnetic Pulse). CAPE designed and implemented protective measures as per IEC 61000 in critical buildings.

External Lightning Protection

The external LPS is designed to intercept direct lightning flashes to the structure, including side flashes, and conduct the lightning current from the strike point to ground. The external LPS is also designed to disperse this current into the earth without causing thermal or mechanical damage, or sparking that could result in fires or explosions. External LPS consists of :

- Air termination system
- Down conductor system
- Earth termination system

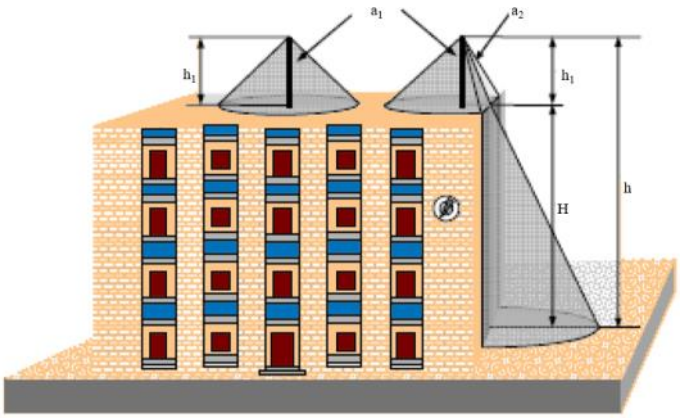
All electrical and electronic equipment should maintain safety distance from parts of LPS to avoid flashover.

Air Termination System

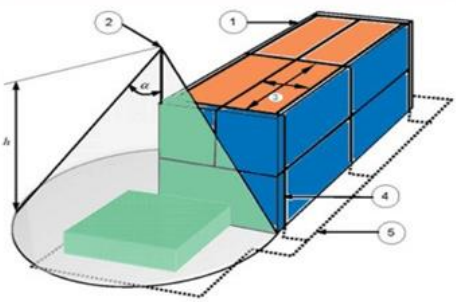
The probability of penetration by a lightning current on a structure is considerably decreased by the presence of a properly designed air termination system. Air termination systems can be composed of any combination of the following elements:

- Vertical Rods (offers certain angle of protection)
- Catenary wires
- Meshed / Grid conductors

Class of LPS	Mesh Size (m)	height of Air termination (m)				
		10	20	30	45	60
		Protection angle w.r.t height (deg)				
I	5 x 5	45.0	22.5	N.A		
II	10 x 10	53.9	37.1	22.5	N.A	
III	15 x 15	60.8	47.8	37.1	27.3	N.A
IV	20 x 20	64.8	53.9	45.0	37.1	22.5



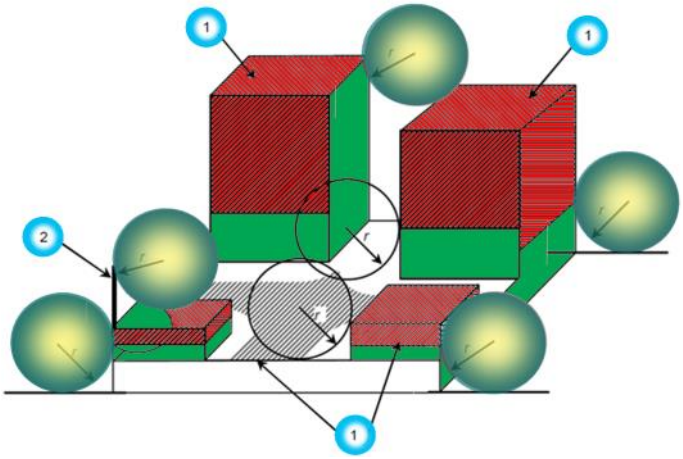
H Height of the building over the ground reference plane
h_1 Physical height of an air termination rod
h h_1 + H = Height of the air termination rod over the ground
a_1 The protection angle corresponding to the air termination height h1
a_2 The protection angle corresponding to the height h



Rolling Sphere Method

Positioning of air termination system can be accurately done by Rolling Sphere Method. Rolling Sphere uses the principle of Electro Geometric design Methods (EGM) which explains attractive effect of the shielding device as a function of amplitude of the current of the lightning stroke.

This method rolls an imaginary sphere of radius “S” over the surface of a building. Chance of direct lightning strike is more wherever the sphere touches. These points need protection from a direct lightning strike.



1 Areas exposed to lightning interception and need protection according below table
2 Mast on the structure
r Radius of rolling sphere according to below table

LPL	Probabilities for the limits of the lightning current parameters		Radius of Rolling Sphere	Minimum peak value of current
	> Minimum values	< Maximum values	r in m	in kA
IV	0.84	0.95	60	16
III	0.91	0.95	45	10
II	0.97	0.98	30	5
I	0.99	0.99	20	3

Lightning - probable place of strike

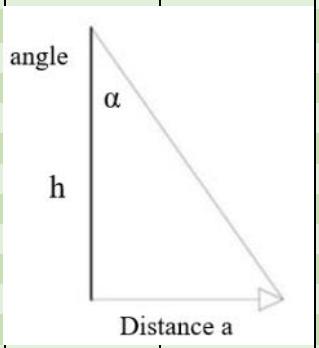
Lightning generally intercept the corners and edges of a building. Corners are more vulnerable. This is due to the increased accumulation of charges in these places (called as point effect). Research also shows that the probability of low amplitude strikes to the vertical side of a structure of less than 60 m in height are low, that they need not be considered where as chances exist and increases for structures more than 60 meter height.

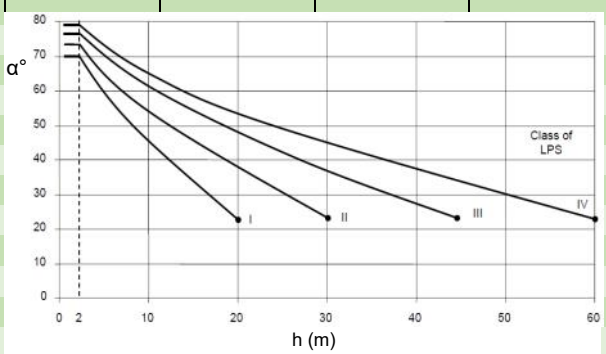
The CAPE Corner Protectors (Pro-CORNER) and Edge Protectors (Pro-EDGE) are useful for protecting the corners and edges of a modern RCC structure. Whereas (Pro-STUD) is beneficial for utilising metal handrails and metal building installations as natural air terminals. This design not only saves money, but is also reliable, aesthetically neutral, and resistant to corrosion.

Note: These products are not included in the catalogue.

Angle of protection chart

Height h (m)	Class I		Class II		Class III		Class IV	
	Angle α (deg)	distance a (m)	angle α (deg)	distance a (m)	angle α (deg)	distance a (m)	Angle α (deg)	distance a (m)
1	71.0	2.90	74.0	3.49	77.0	4.33	79.0	5.15
2	71.0	5.81	74.0	6.98	77.0	8.66	79.0	10.29
3	66.2	6.80	70.6	8.52	74.2	10.60	76.4	12.40
4	62.3	7.62	67.6	9.71	71.7	12.10	74.2	14.14
5	58.9	8.29	64.8	10.63	69.6	13.45	72.3	15.67
6	55.8	8.83	62.3	11.43	67.6	14.56	70.6	17.04
7	52.9	9.26	60.0	12.12	65.7	15.50	69.0	18.24
8	50.2	9.60	57.9	12.75	64.0	16.40	67.6	19.41
9	47.5	9.82	55.8	13.24	62.3	17.14	66.2	20.41
10	45.0	10.00	53.9	13.71	60.8	17.89	64.8	21.25
11	42.6	10.12	52.0	14.08	59.3	18.53	63.6	22.16
12	40.2	10.14	50.2	14.40	57.9	19.13	62.3	22.86
13	37.9	10.12	48.4	14.64	56.5	19.64	61.2	23.65
14	35.6	10.02	46.7	14.86	55.2	20.14	60.0	24.25
15	33.4	9.89	45.0	15.00	53.9	20.57	58.9	24.87
16	31.2	9.69	43.4	15.13	52.6	20.93	57.9	25.51
17	29.0	9.42	41.8	15.20	51.4	21.30	56.8	25.98
18	26.8	9.09	40.2	15.21	50.2	21.60	55.8	26.49
19	24.6	8.70	38.6	15.17	49.0	21.86	54.8	26.93
20	22.5	8.28	37.1	15.13	47.8	22.06	53.9	27.43
21			35.6	15.04	46.7	22.29	52.9	27.77
22			34.1	14.90	45.6	22.47	52.0	28.16
23			32.6	14.71	44.5	22.60	51.1	28.50
24			31.2	14.54	43.4	22.70	50.2	28.81
25			29.7	14.26	42.3	22.75	49.3	29.07
26			28.2	13.94	41.2	22.76	48.4	29.29
27			26.8	13.64	40.2	22.82	47.5	29.47
28			25.4	13.30	39.1	22.76	46.7	29.71
29			23.9	12.85	38.1	22.74	45.8	29.82
30			22.5	12.43	37.1	22.69	45.0	30.00
31					36.1	22.61	44.2	30.15
32					35.1	22.49	43.4	30.26
33					34.1	22.34	42.6	30.35
34					33.1	22.16	41.8	30.40
35					32.1	21.96	41.0	30.43
36					31.2	21.80	40.2	30.42
37					30.2	21.54	39.4	30.39
38					29.2	21.24	38.6	30.34
39					28.2	20.91	37.9	30.36
40					27.3	20.65	37.1	30.25
41					26.3	20.26	36.3	30.12
42					25.4	19.94	35.6	30.07
43					24.4	19.51	34.8	29.89
44					23.5	19.13	34.1	29.79
45					22.5	18.64	33.4	29.67
46							32.6	29.42
47							31.9	29.26
48							31.2	29.07
49							30.4	28.75
50							29.7	28.52
51							29.0	28.27
52							28.2	27.88
53							27.5	27.59
54							26.8	27.28
55							26.1	26.94
56							25.4	26.59
57							24.6	26.10
58							23.9	25.70
59							23.2	25.29
60							22.5	24.85





Down conductor systems

Selection and installation of down conductors plays a major role in protecting electrical and electronic installations in a building. The number of down conductors to a typical building depends upon the class of LPS.

Class of LPS	Maximum distance between down conductors (m)
I	10
II	10
III	15
IV	20

To reduce damage caused by lightning current, the down conductors are arranged so that the current path around the building's perimeter is parallel and at equal distances. The length of the down conductor is minimised, ensuring the shortest and most direct route to earth. Avoiding the formation of bends and loops is required.

Down conductors are installed at each exposed corner of the structure. Lateral connection of down conductors as a ring is a good practice to protection electrical and electronic installations.

Even if encased in insulating material, down conductors must not be installed in service shafts, gutters, or downspouts, as doing so invites severe damage during a lightning strike.

Insulation / Separation of LPS parts

Electrical insulation between LPS components and other metallic installation in the building are necessary to avoid flashover between different metal parts. Bends on down conductors also need special considerations to avoid flashover.

This can be achieved by providing a separation distance

$$S = \frac{k_i}{k_m} \times k_C \times l \quad \text{(m)}$$

Where

ki depends on the selected class of LPS

km depends on the electrical insulation material

kc depends on the lightning current flowing on the air termination and the down conductor

l is the length, in meter, along the air termination and the down conductor from the point, where the separation distance is to be considered, to the nearest equipotential bonding point

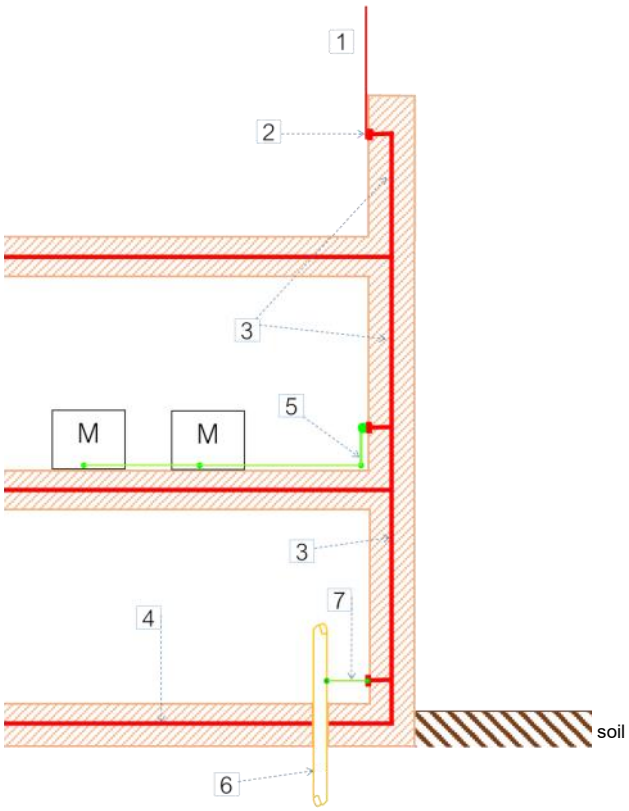
Down conductors integrated into structural steel is the best and practical solution for new and upcoming high raise buildings in India. In this integrated approach high safety is offered with no maintenance, long life, no influence in aesthetics. Separation distance need not be considered in this case.

Integrated LPS using "natural components"

Natural components such as interconnected steel reinforcement, metal framework of structure, steel roof, metal façade, hand rails etc can be used as parts of an LPS such as air termination, down conductor and earthing.

Down conductors can be embedded in RCC columns. In this case, bonding different metallic installations in the building is simple, thereby eliminating potential differences. This integrated method is not only cost-effective, but has no negative effect on the building's aesthetics. It also reduces the failure of electronic equipment inside the building from radiated lightning effects.

Test joints are not required and earth resistance measurements are not necessary in location where the natural down conductors are terminated to foundation earthing. *(ref. NBC-2016 for more information about the rules for design and installation).*

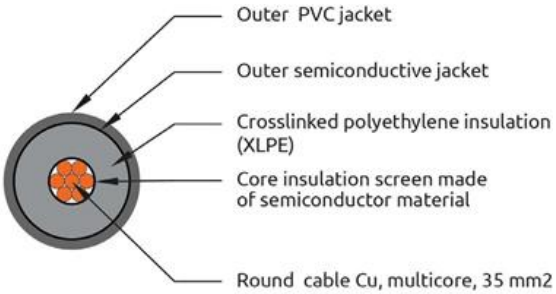


1. Air termination rod
2. Connection of air termination rod to natural down conductor
3. Dedicated down conductor superimposed in RCC column
4. Dedicated foundation earth electrode for LPS superimposed in RCC foundation
5. Protective conductor for exposed conductive parts
6. All incoming services entry
7. Main protective bonding conductor

M. Exposed conductive part

High Voltage Insulated Cable

High voltage cable is utilised in locations where it is impossible to maintain an insulation gap (separation distance) between the protected elements and the cable, or near routes where lightning current poses a risk of electric shock.



High-voltage insulated cable	
Colour	Black
The outer diameter	23.4 mm
Cross section of the cable core	35 mm²
Maximum conductor resistance at 20ºC	0.524 Ω/km
Equivalent of separation distance for air	750 mm
Equivalent of separation distance for regular building materials	1500 mm
Cable weight	0.735 kg/m
Operating temperature range	from -30°C to 70°C
Assembly temperature range Minimum bending radius	from -5°C to 40°C
Minimum bending radius	About 280 mm
Cable Flammability	not spreading flame

Separation distance

To properly use the high-voltage cable a minimum separation distance for the object should be checked in accordance with IS/IEC 62305-3. Separation distance which high voltage cable provides in air is 75 cm, and the total length of the cable should not be more than the value indicated in the table below. In case where an separation distance is greater than s = 75 cm, use additional cables to reduce it.

	Lightning Protection class		
No Of Arresters	I	II	III & IV
1	-	12.50 m	18.75 m
2	14.20 m	18.94 m	28.40 m
3 & More	21.30 m	28.40 m	42.61 m

To minimise the interaction of magnetic fields on the cables, the reduction of the separation distance when additional conductors are included occurs only when the distance between the wires is at least 20 cm. The separation distance and maximum cable length are unaffected by the close proximity of the wires.

Cable preparation and installation tips

1. At a distance of 28mm all the layers of insulation should be cut with scissors, without damaging the cable cores. Then use pliers to remove the layers by rotational move in the direction of core link twist

2. Use wire debarking machine to remove the two outer cable sheath at a distance of 120 mm. Wire debarking machine should be properly set to avoid damage to cross-linked polyethylene insulation film

3. Put the High voltage cable end onto the core of the cable. Make sure that the screws will have access to a vein when tightening

4. Apply a layer of glue in to the holes for the Allen screws

5. Tighten the screws with an Allen wrench

6. Push the heat shrinkable tube onto the cable end to obscure the screw. Then, using a hot air blower or a propane-butane burner shrink the tube

7. Properly shrunk the tube. It should be smooth, without any defects. After shrinking leave the insulated element to cool completely

8. Use a grounding strap at a distance of 1.5 m from every end of the high-voltage cable and attach it to the equipotential bonding rail

Earth termination system

Two basic types of earth electrode arrangements are recommended in IS/IEC 62305 and NBC-2016 such as vertical /horizontal **(Type A)** earthing or ring/foundation **(Type B)** earthing.

Recommendations: Type A is recommended for small buildings. Type B is recommended for buildings with electrical and electronic installations and buildings in high soil resistivity.

When dealing with the dispersion of the lightning current of high frequency behavior into the ground, the shape and the dimension of the earth termination system are important. This is to minimize dangerous over voltage due to lightning.

Type A earthing consists of earth electrodes installed outside the structure. Type A earthing system depends upon the soil resistivity and class of LPS. Each down conductor shall have a vertical earth electrode with a minimum length as per the table. In case of horizontal electrode the length shall be double. The earth electrodes shall be installed at a depth of upper end at least 0.5 m in soil if an earth chamber is not used.

In general, a low earthing resistance (if possible lower than 10 Ω when measured at low frequency) is recommended for type A earthing if the specific length can not be ensured.

Class of LPS	Typical Length (l_1) of each Type A Vertical earth electrode (m) (based on soil resistivity)			
	<500 Ωm	<1000 Ωm	<2000 Ωm	<3000 Ωm
I	2.5	10	25	40
II	2.5	5	15	25
III	2.5	2.5	2.5	2.5
IV	2.5	2.5	2.5	2.5

Type B Earthing consists of either a ring conductor external to the structure to be protected, in contact with the soil for at least 80% of its total length, or a foundation earth electrode forming closed loop.

For ring earth electrode (or foundation earth electrode), the mean radius of the area enclosed by the ring earth electrode (or foundation earth electrode) shall be not less than the double the value l_1.

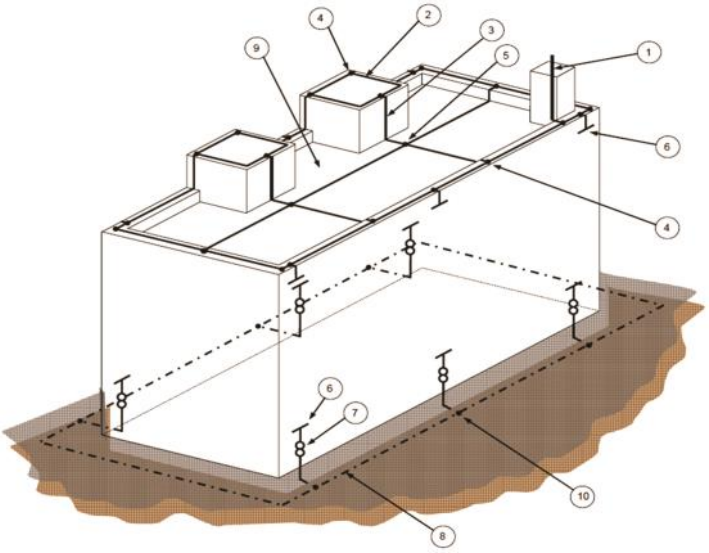
The ring earth electrode (type B arrangement) should preferably be buried at a depth of at least 0.5 m and at a distance of about 1 m away from the external walls.

Foundation Earthing (Type B earthing)

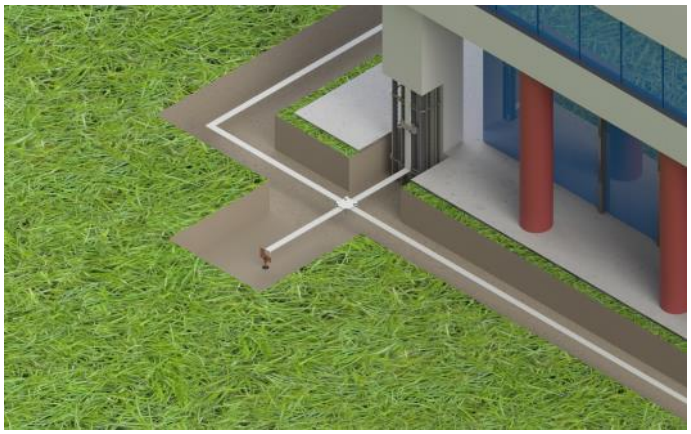
Foundation earthing is done using conductors embedded in foundation of the building. Foundation earthing also serves as protective and functional earthing. This is the most efficient earthing system to protect electronic equipment. Materials used and construction techniques availed must fulfil various mechanical, electrical and chemical requirements to provide long life for the installation.

Bonding of different metallic installations in the building avoid dangerous potential differences and flashover.

Design and support from CAPE helps builder / civil engineer to make a perfect foundation earthing satisfying the requirements of safety, fault loop impedance reduction, fault current dissipation, lightning current dissipation, equipotentialisation, signal reference etc.



1. Air-termination rod
2. Horizontal air-termination conductor (mesh)
3. Down conductor
4. T-type joint
5. Cross type joint
6. Connection of steel reinforcing rods
7. Test joint
8. Earth electrode type B ring earth electrode
9. Flat roof with roof fixtures
10. T-type joint - corrosion resistant



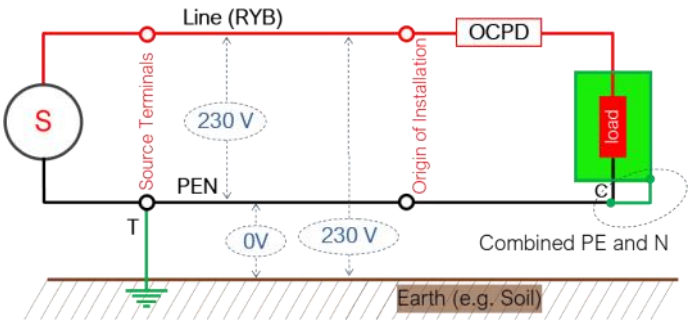
Earthing for Safety

Earthing for "Safety" or "Earth fault protection" is achieved by "Protective equipotential Bonding and Automatic Disconnection of supply". LV networks are categorized into various "System Earthing"

L.V System: The first letter T in the network denotes the source earthing. "T" Terra is a French word meaning "direct connection to earth (soil)". In a 3 phase 4 wire network, star point of the transformer is earthed (Neutral).

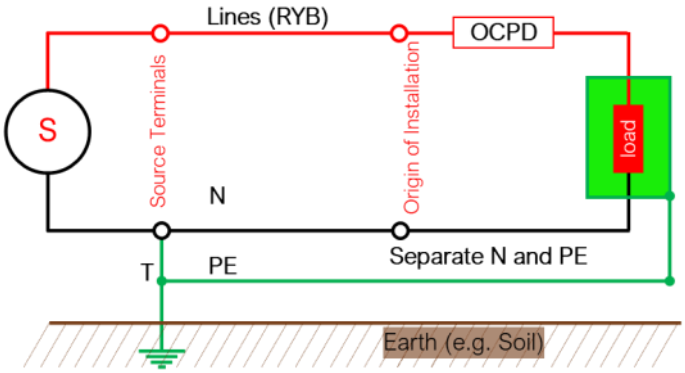
Various system earthing are TN-C, TN-S, TN-C-S, TT, IT.

TN-C System: OCPD is the primary protective device. Connection between the exposed conductive part and neutral in the installation ensure low impedance fault return path through PEN conductor. Neutral conductor does functions of Protective Earth (PE) + Neutral. Hence this conductor is called as PEN. In TN-C the last letter C stands for "Combined" N and PE.



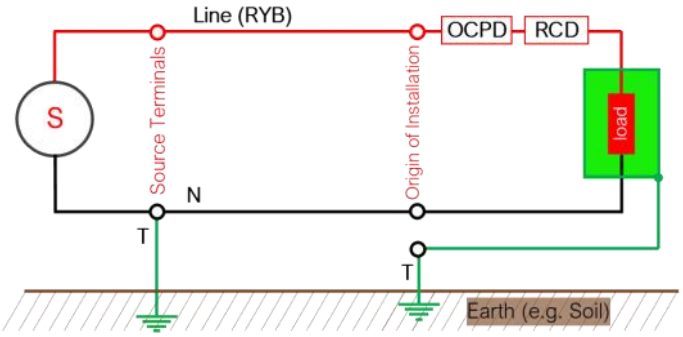
TN-C network with primary protector "OCPD"

TNS System: Exposed conductive parts (body) is connected back to the earthed terminal of the source through a separate conductor. In TNS network OCPD is the primary protector for earth fault. To increase safety during, RCD's / ELCB's can be used as additional protective device.



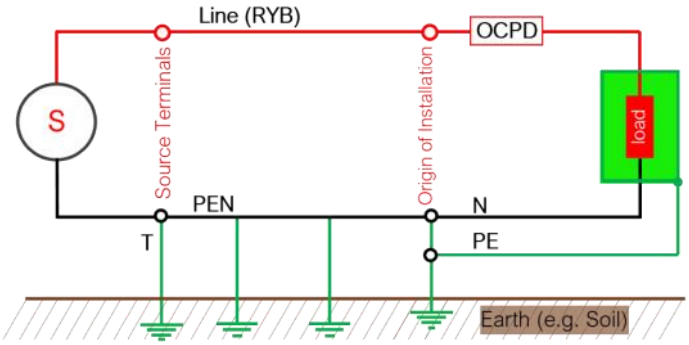
TN-S network with primary protector "OCPD"

TT System: PE conductor at the installation is locally earthed. Earthing "T" at the source and earthing "T" at the installation are electrically independent. An RCD with a maximum disconnection current of 30 mA is recommended in IS732 for TT network as a fault protective measure. Earth fault current in TT network will be of the order of milli Amps to few Amps.



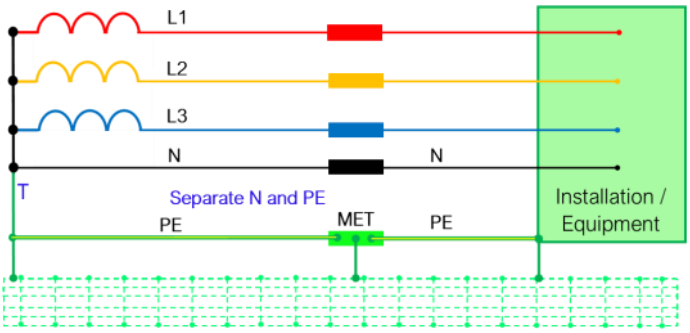
TT network with primary protector "OCPD & RCD"

TN-C-S System: Similar to TN-C, from the source there is one conductor (PEN) which does both protective function and neutral function. At the origin of installation (or anywhere in the distribution) the Neutral and PE are separated. In this network, the primary protector is OCPD. PEN conductor must be earthed at the distribution to increase safety and is called as Protected Multiple Earthing (PME) and is recommended in Indian regulations and standards for public distribution.



TN-C-S with earthed PEN conductor (called as PME). OCPD is the primary protector & RCD is an additional protector

TN-S with PME system for Industrial and commercial premise: IS 3043 recommend TN-S network with PME (also called as Indian TN-S) for industrial and commercial establishments. PME reduces fault loop impedance, touch voltage and create equipotentialisation. TN-S with PME is an efficient way to ensure operation of OCPD during earth fault.

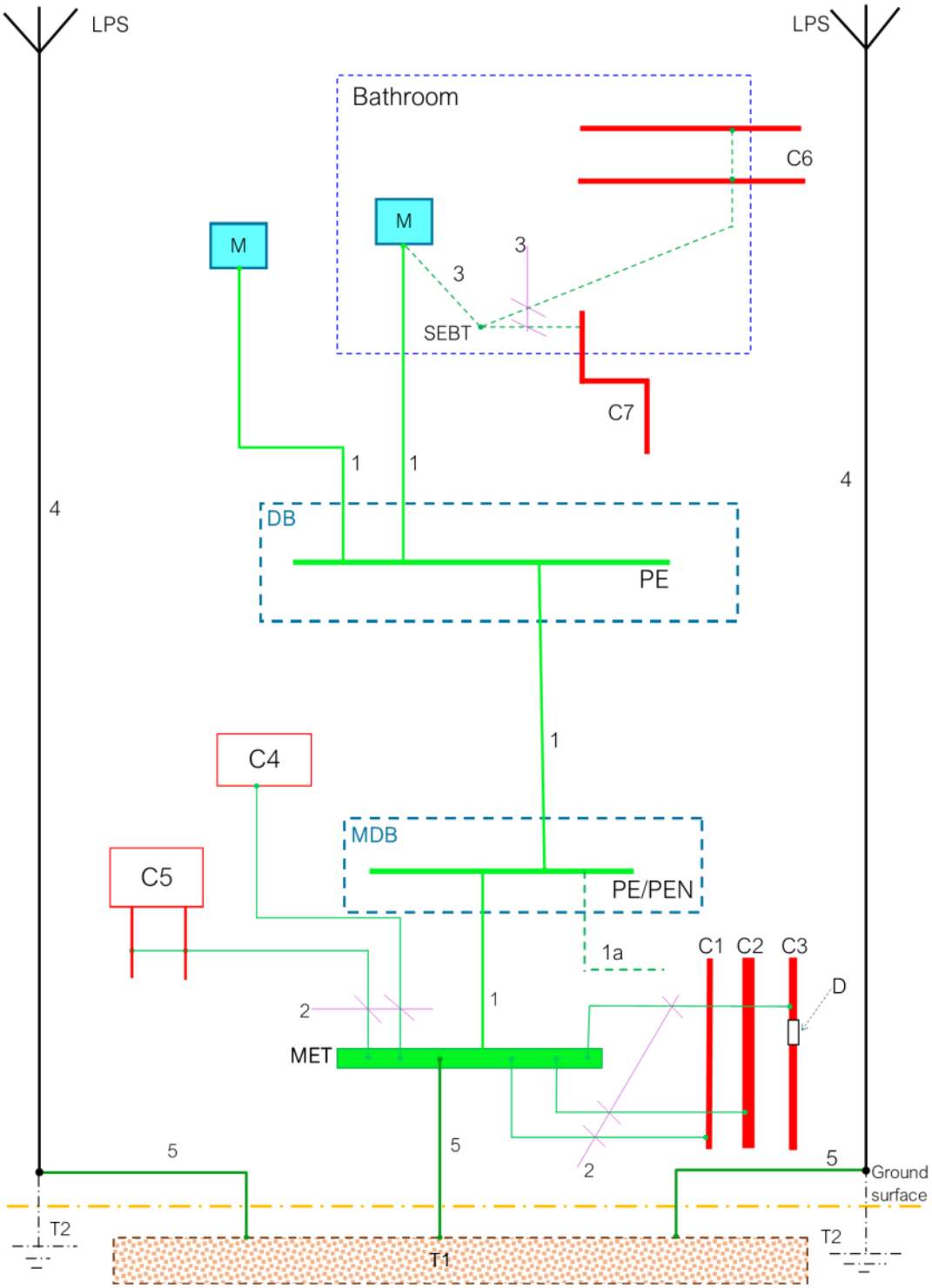


CAPE design, install & commission Global Earthing System as per IS/IEC 61936-1 in modern buildings where EHV/ HV/LV/ELV equipment operate in close proximity. Safety in these installations are ensured by verification by all relevant IS/ IEC standards.

Global Earthing System
Earthing for safety and functionality,
No Maintenance, Long life,
No more fire due to short-circuit.

Note:
OCPD - Over Current Protective Device
RCD - Residual Current Device

Example of protective equipotential bonding (earthing) in a residential building



#	Name
C	Extraneous-Conductive-part
C1	Water pipe, metal from outside
C2	Waste water pipe, metal from outside
C3	Gas pipe with insulating insert, metal from outside
C4	Air-conditioning
C5	Heating system
C6	Water pipe, metal eg in a bathroom
C7	Waste water pipe, metal eg in a room
MDB	Main Distribution Board
DB	Distribution Board
MET	Main Earth Terminal
SEBT	Supplementary Equipotential Bonding terminal

#	Name
T1	Concrete-embedded foundation earth electrode or soil-embedded foundation earth electrode
T2	Earth electrode for LPS if necessary
LPS	Lightning Protection system (if any)
PE	PE terminal(s) in the distribution board
PE/PEN	PE/PEN terminal(s) in the main distribution board
M	Exposed-conductive part
1	Protective Earthing conductor (PE)
1a	Protective Conductor, or PEN conductor, if any, from supplying network
2	Protective bonding conductor for connection to the main earthing terminal
3	Protective bonding conductor for supplementary bonding
4	Down conductor of a lightning protection system (LPS) if any

Earthing for protective, functional and LPS for EHV/HV/LV/ELV application in close proximity.

Equipment at different voltage operate in close proximity in large industrial and commercial buildings. Each of these systems need an efficient earthing for its protective and functional purposes. A single integrated earth termination system is recommended in the standards, and shall be designed, installed and tested, suitable for all protective and functional purposes for the different voltages working in close proximity.

Reinforcing steel in concrete foundations or metal structures can be used in the common bonding network. When the metallic reinforcement in concrete is used as an earth electrode, care shall be taken to prevent mechanical splitting of concrete, corrosion of steel, weakening of RCC etc.

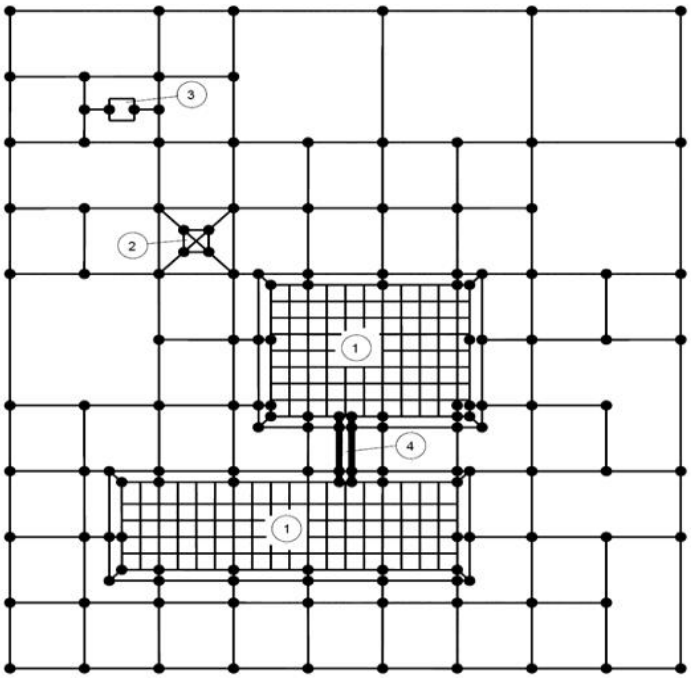
Integrated earthing electrodes in a factory

An Industrial plant typically comprises of number of associated structures, between which a large number of power and signal cables are installed. Earth terminations systems of such structures are very important for the protection of the electrical and electronic systems.

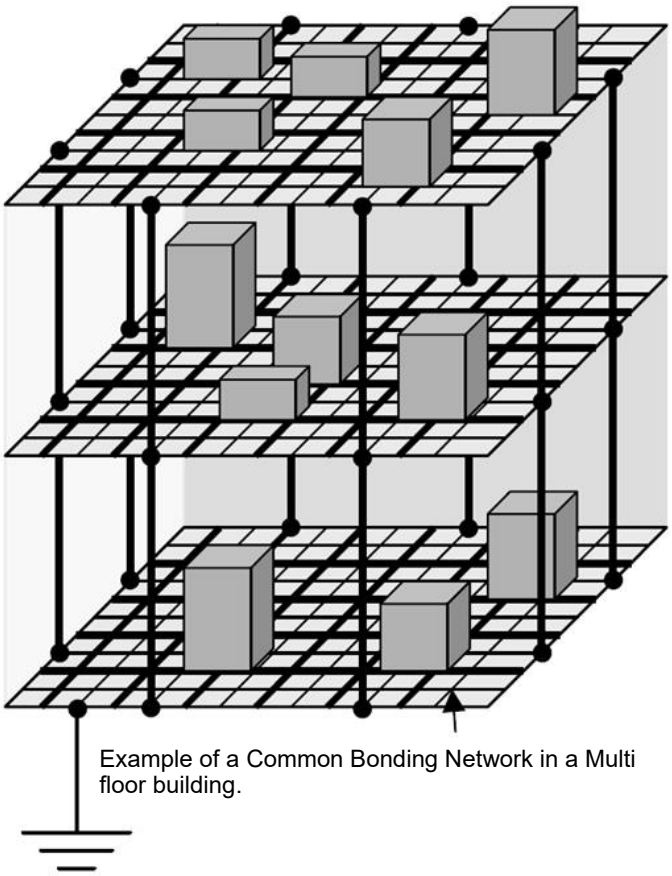
A low impedance earthing system reduces the potential difference between the structures and so reduces the interference injected into the electrical and electronic system. If designed and installed properly, the reinforcing rods of the foundation and in the region below the soil of structures form an excellent foundation earth electrode. The magnetic field generated by the current in the reinforcing steel mesh is weak due to the low current density and the parallel current paths opposing electromagnetic fields. Also, interference with neighboring internal electrical conductors is correspondingly reduced.

In addition the equipotential bonding bar connected to the steel reinforcement of the structure offers good potential references to the power, telecommunication and electronic installations of the structure. However, this design and installation must be performed by a professional.

By interconnecting earths of a number of structures, a meshed earthing system can be created. This system gives low impedance between buildings and has significant EMC advantages. The size of the mesh close to large equipment are based on expected fault levels and signal reference requirements.



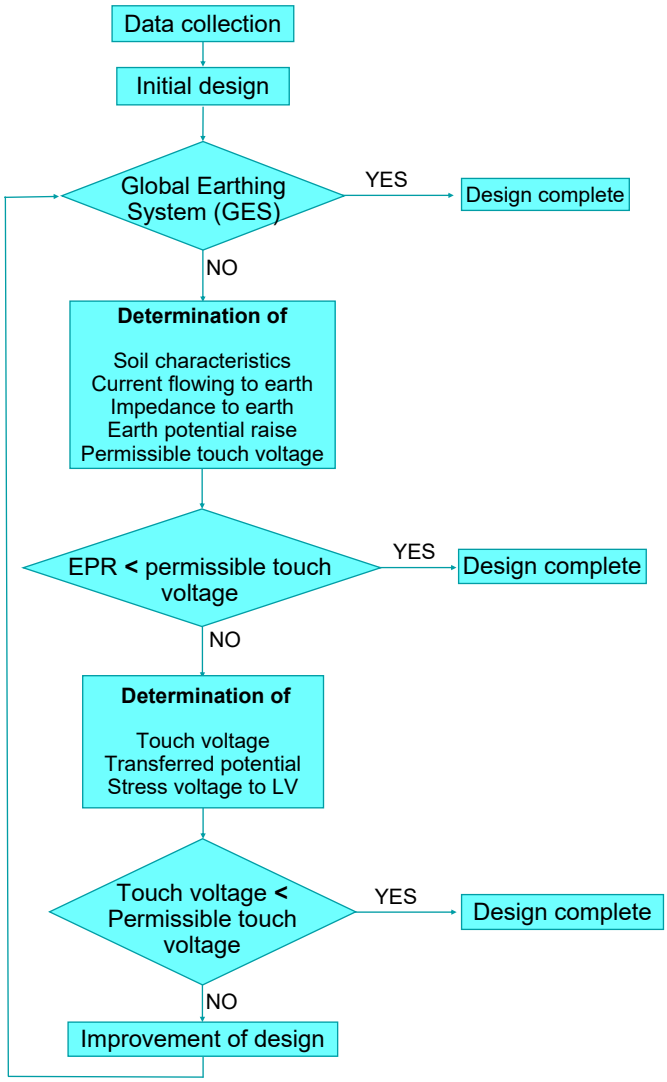
1. Building with meshed network of reinforcement
2. Tower inside the plant
3. Stand-alone equipment
4. Cable trenches



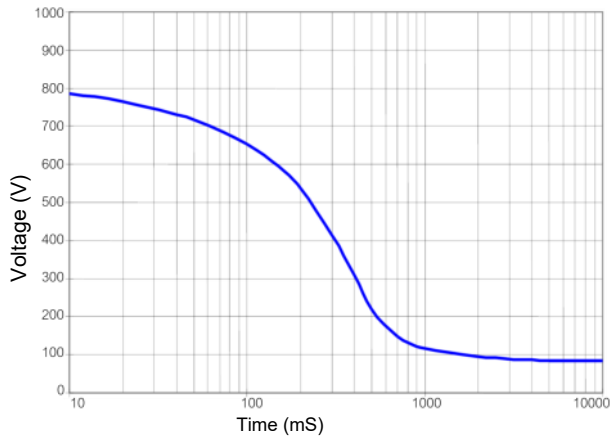
Example of a Common Bonding Network in a Multi floor building.

Global Earthing System (GES) for application where (EHV/HV/LV/ELV systems working in close proximity)

(IEC 61936-1 / EN 50522 / IS3043 / IS732)



GES is an earthing system created by interconnecting local earthing systems to minimise dangerous touch voltages. GES permits the division of the earth fault current in a way that reduces the earth potential rise at the local earthing system. Such system could be said to form a quasi-equipotential surface. Exposed and extraneous conductive parts are bonded together with a sufficiently dense interconnection (following the rules of main and supplementary bonding) that the rise in potential "together" ensuring NIL/MINIMUM potential difference between each item under fault conditions. No true earth reference exists and therefore safety voltages are limited.



Permissible touch voltage recommended in IEC standards

The existence of a GES is determined by sample measurements and calculation. Typical applications of GES are

- Substation surrounded by buildings with foundation earth electrode and earthing system inter connected by low voltage protective earth conductors
- Substation feeding densely built up areas
- Substation feeding suburban area with many distributed earth electrodes interconnected by low voltage protective earth conductors
- Substation with given number of nearby substations,
- Substations connected via cables with earth electrode effect
- Substation feeding extended industrial area
- Substations that are part of system with multi earthed high voltage neural conductors

For installations where high-voltage equipment is not located in closed electrical operating areas, e.g. in an industrial environment, GES prevent touch voltages resulting from HV faults in a LV system.

GES ensure high degree of safety. A well designed and installed GES system in commercial and industrial premise ensure maintenance free operation until the life of the building.

Measurements and calculations are the key part in GES design & Selection of materials are important in execution.

The conventional concepts and calculations followed for decades in India are of little importance. Measurement does not mean soil resistivity measurement, calculation does not mean the amount of earth electrode in soil to dissipate the current to soil, but the methods to limit the touch voltage within the tolerable limit.

The existence of a GES is determined by sample measurements and calculation.

CAPE and GES

Cape has not only introduced but also implemented GES installations in India. Additionally, we have designed projects for multiple countries. In order to fulfil the complete requirements of GES, the service provided by CAPE include

- Design support for the fulfilment of technical requirements as per the standard
- Training for all engineers including management, operations, maintenance etc.
- Verification of basic electrical drawings
- Support during erection
- Complete testing and commissioning
- Long term contract for periodical verification
- Record maintenance for future reference

Selection and erection of GES.

GES consists of interconnection of exposed and extraneous conductive parts of EHV, HV, LV and ELV system. These extraneous parts include steel in concrete foundations and conductors and other metallic parts in soil, in air and under foundation. GES becomes a permanent part of the building. Once installed it shall provide a life equal to the life of the building.

Earth electrodes and corrosion

Corrosion, is a major factor to be considered, which will occur at a rate depending on the type of metal and the nature of its environment. Environmental factors such as moisture, dissolved salts, degree of aeration, temperature, extent of movement of electrolyte, local conditions with different natural or industrial contaminants, etc, make this complex condition. The electrolyte for this reaction may be groundwater, soil with some moisture content or even moisture condensate in above ground structures.

Corrosion problems requires special attention

- Avoid the use of unsuitable metals in an aggressive environment
- Avoid contact of dissimilar metals, of substantially different electrochemical or galvanic activity
- Use an adequate cross-section of conductors, bonding straps and conducting terminals and clamps to ensure life of service
- Provide appropriate filling in conductor joints so as to eliminate moisture in joints (Eg cover with PROCEM-Protective and Conductive Cement Concrete Aggregate)
- Consider the galvanic effects of other metallic items to which the earth electrode is to be bonded
- Avoid designs where natural corrosion products from a cathodic metal (e.g. copper) could contact and erode an anodic metal (e.g. steel or aluminium)

Electrochemical influence between earth electrodes are also due to DC Leakage current in the soil, chemical components and their concentration in soil or water and galvanic cells formed by interconnected earth electrodes of different metals.

Potential (cathodic) Index of few commonly used earth electrodes	**Index (Volt)**
Gold, solid and plated & Gold-platinum alloy	0.00
Silver, solid or plated, nickel-copper alloys	- 0.15
Nickel, solid or plated, titanium and alloys	- (0.20 to 0.25)
Copper, solid or plated,	- (0.2 to 0.30)
Brass and bronzes	0.40
Steel (Fe) in air and in soil.	0.85
Hot-dip-galvanized steel	1.20
Steel (Fe) in concrete	- (0.25 to 0.30)

Electrochemical potential difference
Copper and GI = 1 volt
Steel in concrete and GI in soil = 1 volt

GI in soil could not be connected to rebar or other metals inside concrete: If they are connected, GI in soil will experience accelerated corrosion from rebar/steel inside concrete.

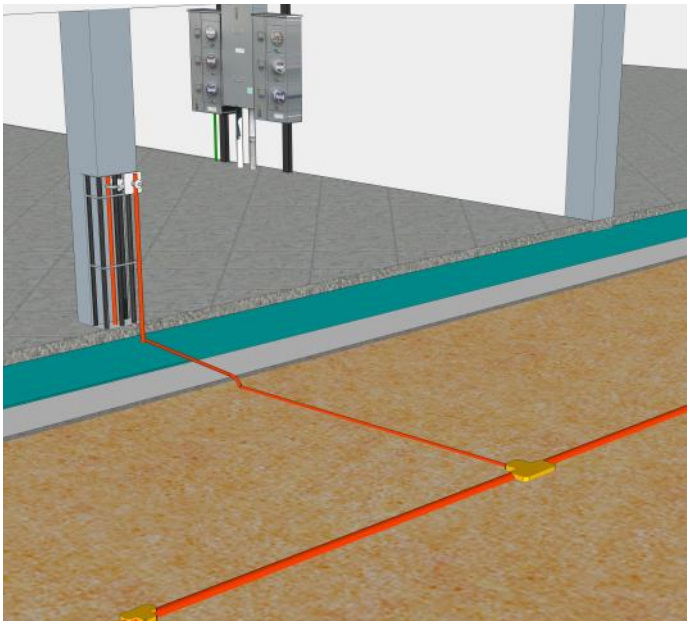
IS and IEC standards recommend to use isolating spark gap in between to avoid direct connection between these metals.

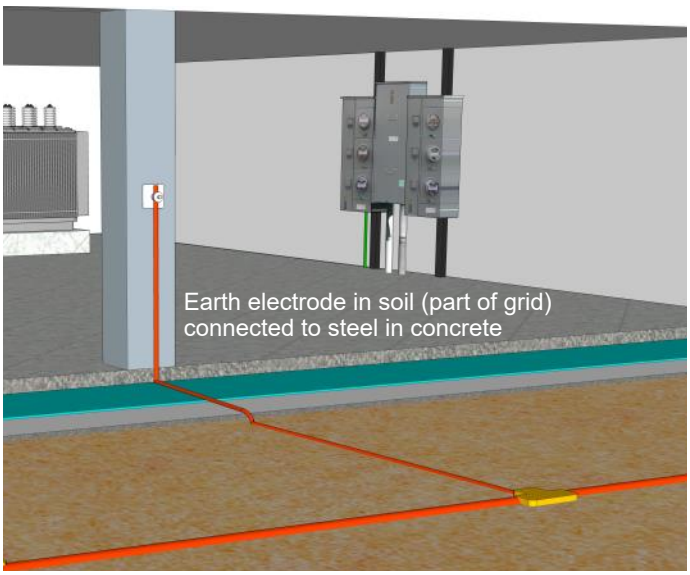
Metal inside concrete connected to metal in soil - GI could not be used

Chance of corrosion due to galvanic action between different metal parts are a major concern in GES for eg.

a. Steel in concrete has approximately the same galvanic potential as copper in soil

b. Steel and galvanised steel in soil is anodic to steel in concrete





GI is not recommended to use inside concrete

IEC standards explain, "the behaviour of a galvanized layer on steel in concrete is very complicated, particularly in concrete with chlorides, the zinc will corrode quickly on contact with the reinforcement, and can under certain conditions cause damage to the concrete". As the use of galvanized steel in concrete requires evaluation of many external factors, it is recommended not to use GI inside concrete. The alternate is to use copper or copper bonded steel.

Copper bonded steel conductors and strips is an economical and efficient alternate for copper for use in soil connected to concrete and in concrete itself.

Material selection

Aluminium, Copper, Stainless Steel, Copper Bonded Steel, Galvanized Steel are the commonly used materials for Lightning Protection and Earthing. These metals in solid / stranded types in different shapes can be used. The mechanical strength, ease of use, corrosion resistance behaviors and cost plays major role in selecting the material.

Aluminium alloys are resistant to corrosion in most environments and are easy to install for exposed application such as air-terminals and down-conductors. Aluminium can not be used inside concrete and soil.

Copper is the best material for several application, but cost, low mechanical endurance and chance of theft makes it unsuitable in many places.

Galvanized steel can be used in all application and is economical, but the zinc coating in galvanized steel can create damage to concrete if used in areas with high chlorine and salt in ground water. Due to its complicated behavior with structural steel, better is to avoid galvanized steel inside structural application. Steel if used as earthing in soil connected to structural steel, will corrode due to galvanic potential of structural steel, hence galvanised steel cannot be used in soil, if connected to structural steel. (refer IS/IEC 62305-3 E.4.3.4)

Copper bonded steel is an alternate material which is economical and corrosion resistant in most applications. Copper, Stainless steel and Copper bonded steel are recommended as earth conductors in soil when these are connected to steel in concrete.

For Indian conditions the recommended materials are

- Aluminium Alloys – As air terminals and down conductors in exposed places
- Copper Bonded Steel – for application inside structural concrete and in soil

CAPE copper bonded steel conductors are made from virgin steel material molecularly bonded with electrolytic grade copper. Copper coatings are 250 microns for vertical electrodes or 100 microns for horizontal electrodes tested and confirming to IEC 62561-2. The conductors are available in round and in strip form with a length up to 100 meters. Several models of vertical electrodes are UL listed.

CAPE Earth Electrodes and Connections

CAPE Earth electrodes are steel with electro deposited copper coating (copper bonded steel). It has highly resistance to corrosion and have high mechanical strength. These rods can be mechanically driven deep in soil.

- ***IS 34043 and NBC-2016 recommend copper bonded steel electrodes for long life***
- ***IS/IEC 62305 recommend copper bonded rod instead of GI for application in steel and in concrete***

Connections of earthing conductor and earth electrode is exothermically welded to provide durable, corrosion resistant, low resistance connection.

Earth Electrodes

Vertical Rods

CAPE CBR earthing rods are made of high tensile strength low carbon solid steel rod, molecularly bonded with electrolytic grade copper. The rods are tested as per IEC 62561 for its mechanical and corrosion resistance behavior. In addition all 8 feet and 10 feet rods are UL listed.

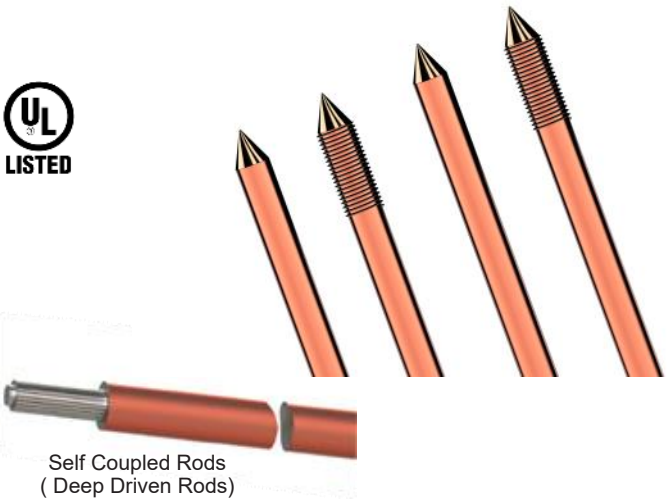
These highly corrosion resistant rods can be used in Industrial, commercial and residential applications to make maintenance free earthing system. CAPE CBR are available in various sizes with 250 micron copper coating. The rods offer tensile strength above 600 N/mm². Compared to solid copper rods, CAPE CBE rods are much more stronger with a corrosion resistance almost equal to copper

Test Confirmations -

- Tensile Strength: higher than 600 N/mm^2
- Accelerated corrosion resistance test
- Salt mist test as per IEC 60068-2-52:1996
- Humid sulphureous atmosphere test as per ISO 6988:1985

Available in both threaded and non-threaded type

All 8 feet and 10 feet rods of 14.2, 17.2, 20 and 25 mm are UL listed

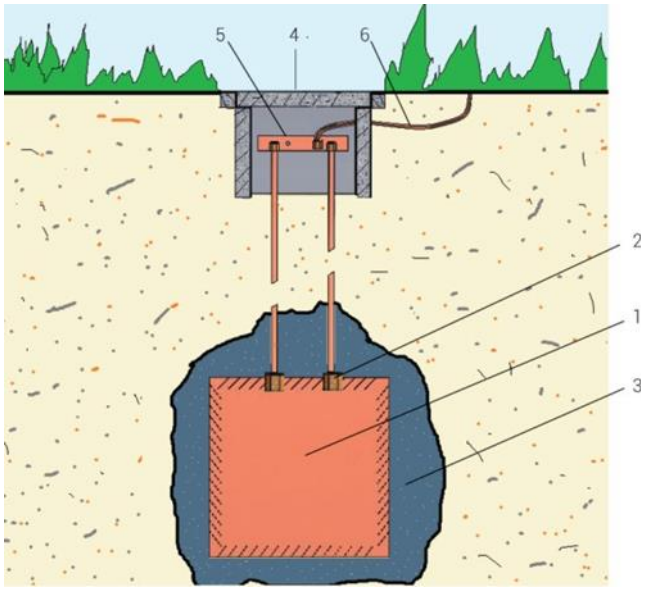


Self Coupled Rods
(Deep Driven Rods)

Copper Bonded Stripes

Copper Bonded Plates

Copper Plate Electrodes with connecting wires confirming to NBC-2016, UL and several national / international standards. These maintenance free plate electrodes offers long life. Electrode and conductors are made of high conductivity, non corrosive copper, exothermically welded to copper conductor in order to offer maximum life. Two meter long, two runs of connecting wires ensure deep burying of the plates in soil. Plate Electrodes of other sizes are available on request.



1. 600 * 600 * 1.5 mm copper plate
2. Exothermic welding
3. Earth enhancement material
4. Earth chamber
5. Busbar
6. 70 sq.mm stranded copper wire

Artificial treatment of soil

Multiple electrodes even in large number, may some time fail to produce an adequately low resistance to earth, especially in soil with high resistivity (e.g >3000 Ωm). The alternative is to reduce the resistivity of the soil, immediately surrounding the earthing electrode.

The selection and construction of earth-enhancing compounds must be such that, in normal use, their performance is reliable and they pose no risk to people or the environment. Earth enhancing compound material must be chemically inert to the subsoil and must not pollute the environment. It must provide a physically and chemically stable environment and have a low resistance. The earth enhancing compound must not be corrosive to the utilised earth electrodes. Earth enhancing compounds must be evaluated in accordance with IEC 62561-7.

Maintenance Free Earthing as per NBC-2016:

National Building Code of India (NBC-2016) explain maintenance free earth electrodes and its installation. Primary requirement of earth electrode is its capability to withstand corrosion and adequate mechanical strength for the intended lifetime.

Maintenance free earth electrode is an installation where the electrodes are tested as per IEC62561-2, exothermically welded to coper flat installed in an augured hole including Earth enhancing material tested as per IEC 62561-7.

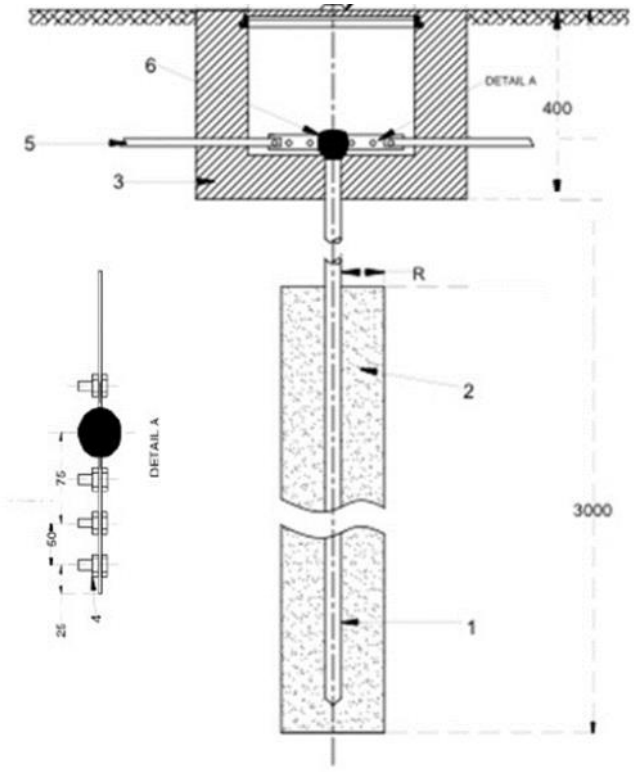
Maintenance free earthing Installation as per NBC-2016 need high quality earth electrodes with copper coated steel rods, exothermic welding and earth enhancement material. This installation primarily increase the life of installation and reduce electrochemical and galvanic corrosion.

Corrosion due to Bi-Metallic effects of earth electrodes are known for years where as information on corrosion due to galvanic effects are relatively new. Use of copper bonded material over GI / CI is recommended in IS/IEC 62305 to overcome corrosion due to galvanic effect. Maintenance free earthing as per NBC-2016 will provide long life in almost every environment.

Resistance of earth electrode to soil depends mainly on the soil resistivity of the place where it is installed. Compounds used as earth enhancing materials can improve this value to some extend. For getting low resistance value, increase the length of rod vertically or install more electrodes interconnected in parallel.

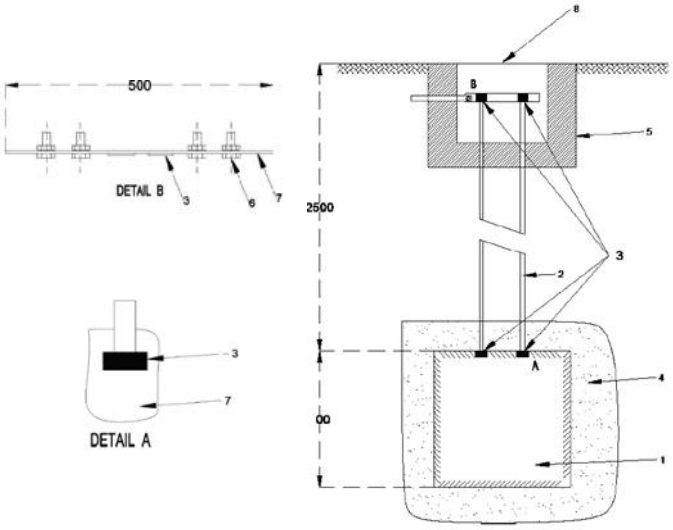
No electrical requirement need vertical earth electrode with a resistance near to 1 ohm. Minimum requirement of 10 ohms as per IS/IEC62305-3 can be disregarded with the recommended length of electrode confirming the above standards.

Maintenance free earthing as per NBC-2016
(copper / copper bonded rod with exothermic welding)



1. Copper / Copper bonded steel rod tested to IEC 62561
2. Earth Enhancement Material confirming to IEC 62561
3. Inspection Chamber
4. M10 Bolts and Nuts All dimensions are in mm
5. Copper Strip – 25*6 mm or higher
6. Exothermic Welding

Maintenance free earthing as per NBC-2016
(copper plate electrode with exothermic welding)



1. 600 x 600 x 1.5 mm copper plate
2. 30 x 6 mm copper strip
3. Exothermic welding
4. Earth enhancement material tested as per IEC 62561-7
5. Inspection Chamber

Earth Enhancing Compound

PRO-CEM is a conductive cement based soil conductivity improvement compound, which hardens and become permanent conductive layer after installation. The minerals used offers non corrosive behavior and is tested in accordance with IEC 62561.

- **PRO-CEM** is a concentration of minerals combined with the elements that improves earthing effectiveness, especially in areas of poor conductivity (rocky ground areas of moisture variation, sandy soils etc.)
- It improves the contact area between earth electrode and soil and thus improves the conductivity
- Protects the electrode from corrosion permanently and NO Maintenance

Applications: **PRO-CEM** is acceptable in all types of groundings especially the one which should always have low resistance and NO Maintenance

PRO-CEM

- PRO-CEM is a compound based on mixture of minerals in a suitable proportion
- PRO-CEM can be used directly by mixing with the soil in 'dry' / 'slurry' form
- PRO-CEM does not need watering and is maintenance free for years
- PRO-CEM is stable at 10 ° C to + 60 ° C
- PRO-CEM is environmental friendly, not explosive, not harmful to eyes, skins etc.
- PRO-CEM is non Corrosive

Earth Chamber

Available in Polypropylene (PP) and concrete. PP chamber are heavy duty and can handle heavy truck loads.

Corrosion of buried metals in soil

In application such as metallic pipes in soil, earthing of high-voltage direct current (DC) equipment etc., some external leakage current is always the driving force for the corrosion. Prevention of this form of corrosion involves devices that providing an alternate low-resistance path to connect the leakage current directly to the ground.

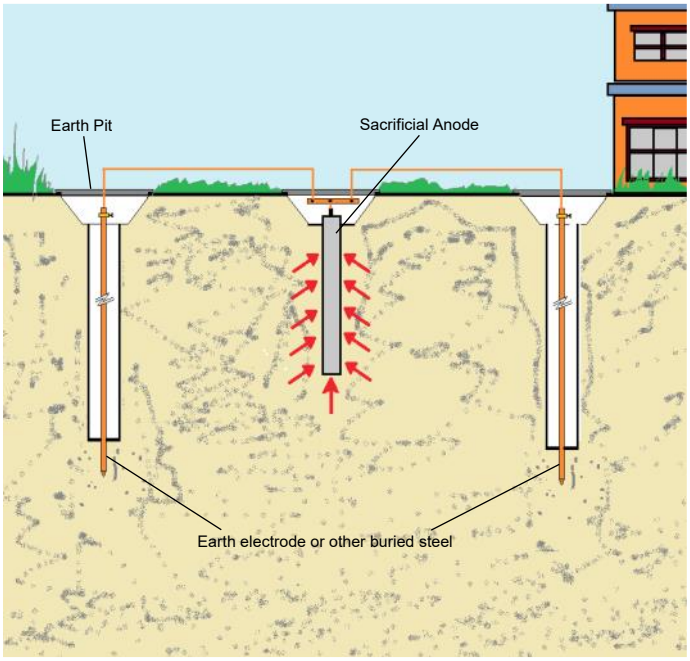
PRO-GAL Sacrificial Earthing

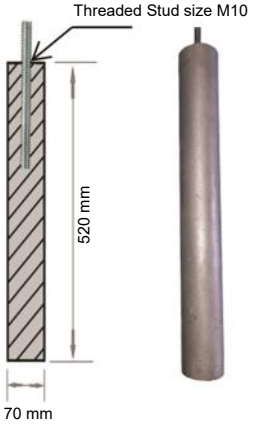
Sacrificial electrodes are active metals with high electrochemical potential that are used to protect a less active material surface from corrosion. Sacrificial anodes are created from a metal alloy with a higher electrochemical potential than the other metals, which need protection. The sacrificial electrode will be consumed in place of the metal it is protecting, which is why it is referred to as a "sacrificial" electrode, sacrificial anode, or galvanic anode.

Due to the difference in potential between the two metals, the galvanic anode oxidises more quickly than the metal it is protecting, being consumed completely before the other metal reacts with the electrolytes. In simple terms, the anode material is consumed in preference to the structure. The loss of the anode material gives rise to the alternate name "sacrificial electrode."

PRO-GAL is a sacrificial electrode-based corrosion protection system that protects metals in soil from corrosion. Engineering and application of PRO-GAL depend on various parameters, and it is necessary to calculate the quantity of anode material required to protect the structure considering factors such as type and mass of the structure, resistivity of the soil, and service life.

This system requires no external power and requires no maintenance throughout its design life. CAPE engineers are trained to test the system components after installation.



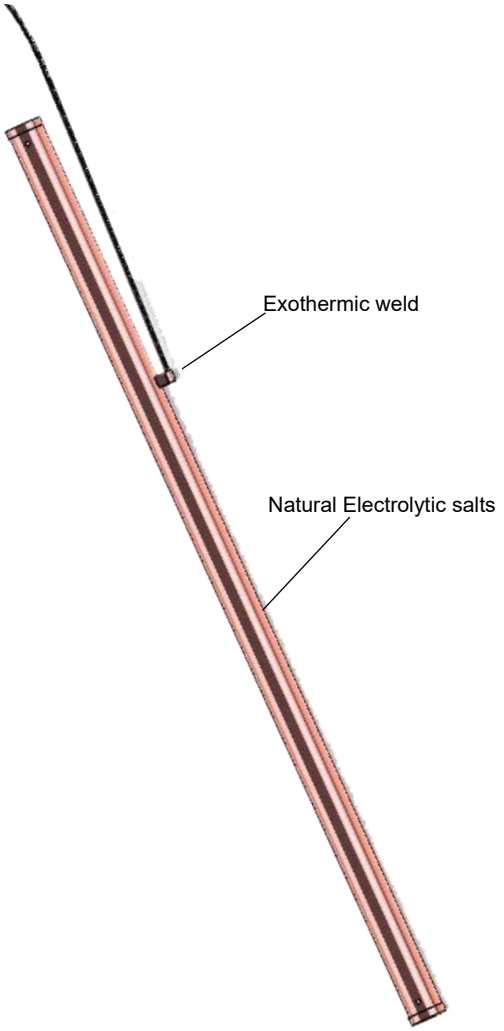


PRO-CHEM ROD®

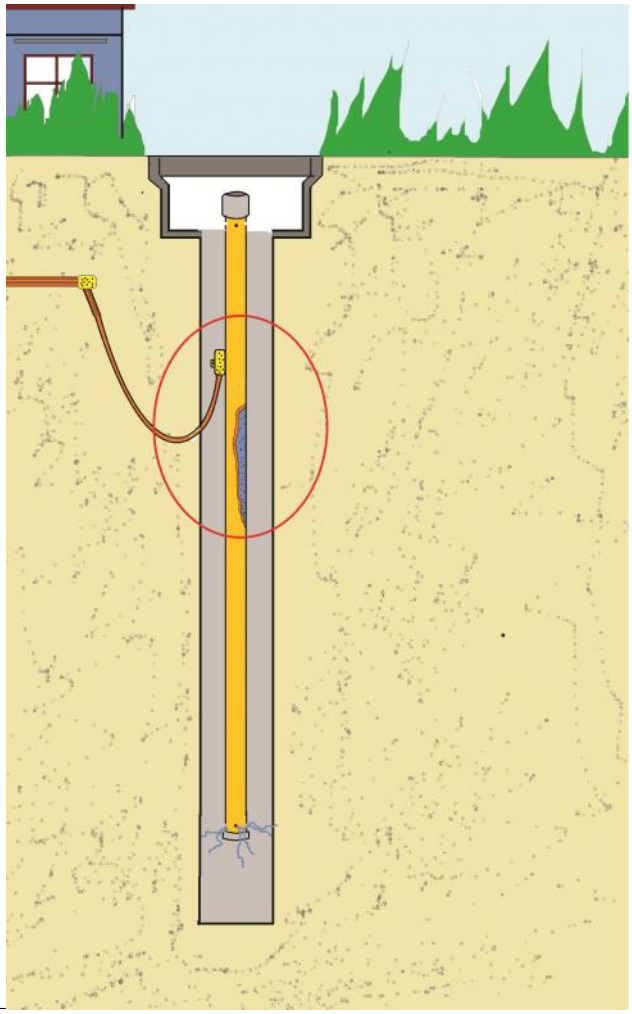
PRO-CHEM rods provide low resistance in locations of high soil resistivity and dry soil conditions. PRO-CHEM rod is made of 99.9% electrolytic copper pipe filled with hygroscopic eco-friendly salts, tested, and listed to UL0467. This electrode can replace multiple conventional earth rods, so it is space saving. PRO-CHEM rod maintains a low earth resistance, is maintenance-free, and is capable of dissipating lightning and other fault currents in high soil resistance areas.

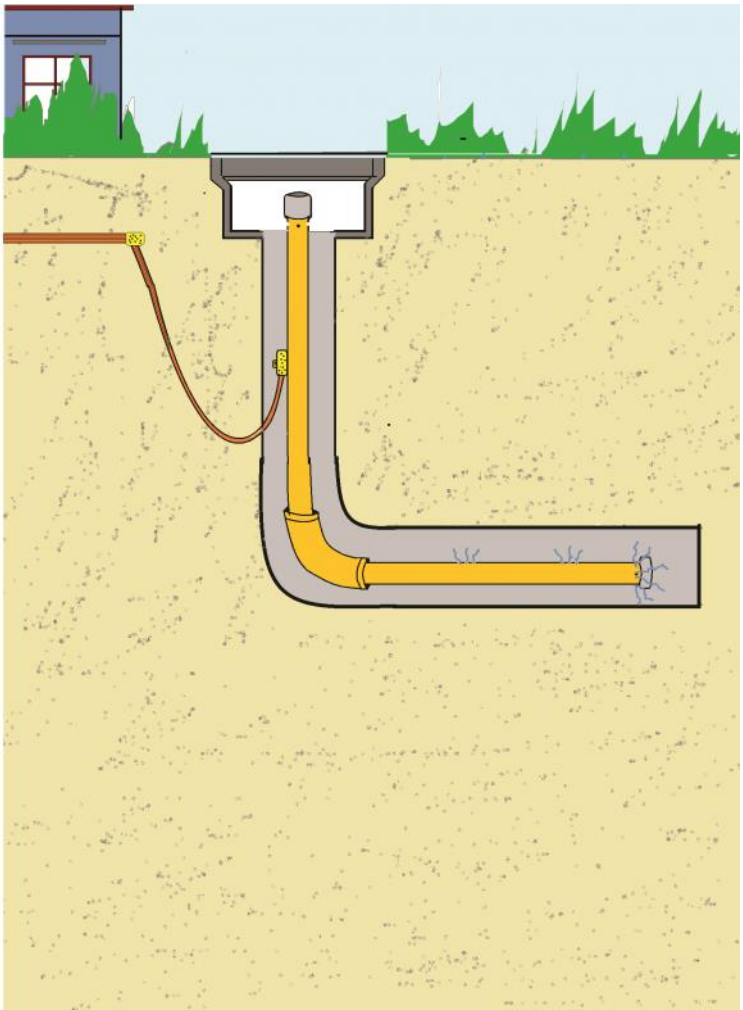
PRO-CHEM rod finds application in various industrial, commercial, and defence applications. The system is more efficient with PRO-CEM as a backfill compound. The rods can be installed either vertically or horizontally. It contains natural electrolytic and hygroscopic salts, which absorb moisture from the surrounding air and react with the salts to create an electrolytic solution. This electrolytic solution leaches into the surrounding soil and increases its conductivity.

Provides decades of reliable service due to rugged construction and high quality thick copper pipe, 3 meters long with aluminothermically welded multi stranded copper flexible connector



Maintenance free
Earth Chamber



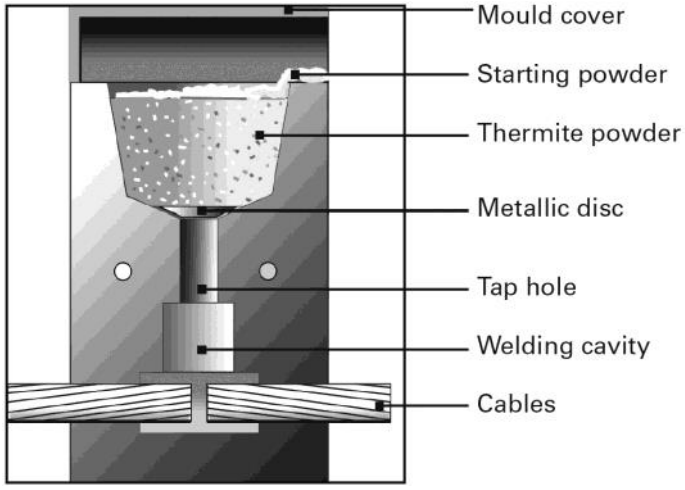


Exothermic weld - A perfect molecular weld

Exothermic welding connections are used widely in earthing, equipotential bonding, and railway applications. This welding process utilises the high temperature of the reaction between copper oxide and aluminium. The reaction happens in a graphite-mold crucible, into which the pieces to be welded have been inserted. The molten metal from the exothermic reaction flows over the piece, causing it to melt and fuse into a solid, homogeneous mass.

The reaction in weld point is so quick that the pieces to be welded get lower temperature on the zone around. The WELD connection is a perfect molecular weld and not just a mechanical contact.

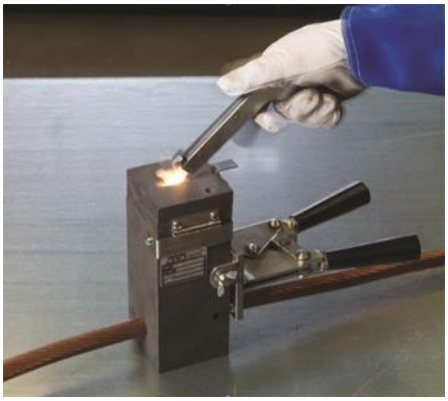
Connections are not affected by high current surges. Tests have shown that the electrical conductors will melt before the connection when subjected to high short-circuit current. Connection conductivity is at least equal or greater than the conductors welded. There is no possibility of corrosion at the point of the weld, since conductors become an integral part of the connection.



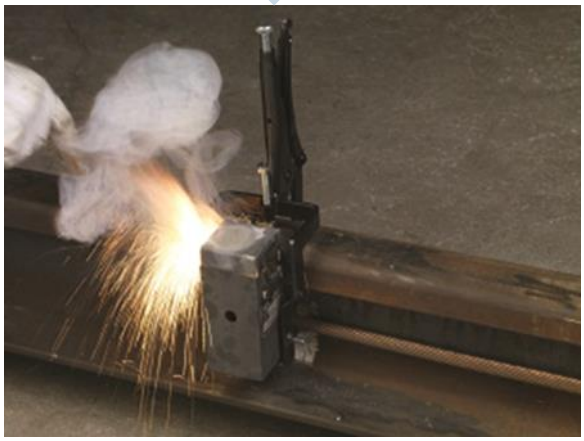
Exothermic Welding is possible between different metals

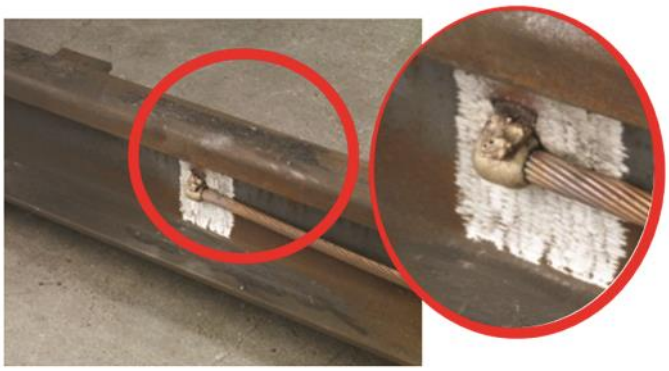
Main Advantages:

- Negligible contact resistance. Conductivity is equal or greater than welded conductors. Double cross section than welded material
- Highly Corrosion Resistant
- Withstand short-circuit and overload currents without affecting the connection. Conductors melts before the connection itself (Short-circuit current tests at CESI Lab. Italy)
- Conductors become an integral part of the welded material



- **Copper-Copper**
- **Steel-Copper**
- **Steel-Steel**



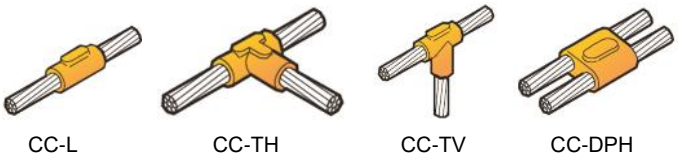


Exothermic Welding Models

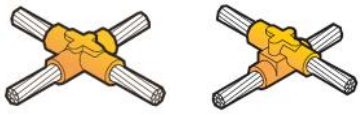
Every model of exothermic welding need a graphite mould designed according to the Type of connection, conductor size and the surface area in which the bonding need to be done. The mould varies according to

- Position of the welding parts
- Number of Conductors to be bonding.
- Material type

Cable to Cable

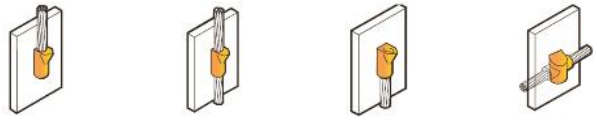


CC-L CC-TH CC-TV CC-DPH

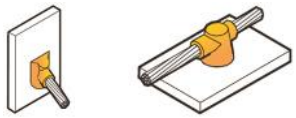


CC-X CC-XS

Cable / Steel Surface

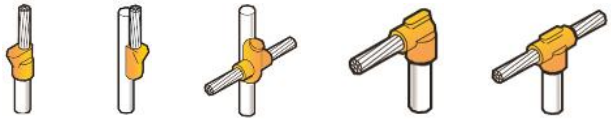


CH-VS CH-PVV CH-VI CH-TVD CH-TVI



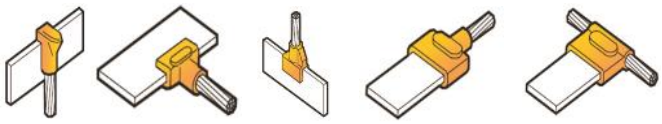
CH-TF CH-PHH

Cable to Earth Rod



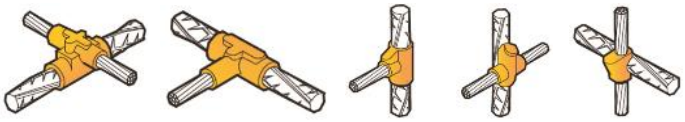
CP-V CP-VS CP-TS CP-AR CP-T

Cable / Busbar



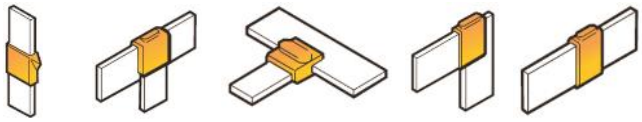
CPL-VI CPL-H CPL-VS CPL-L CPL-T

Cable / Steel Rebar

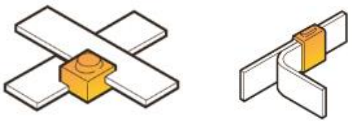


CR-XS CR-TH CR-TL CR-PH CR-PV

Busbar to Busbar



PL-V PL-TV PL-TH PL-ARI PL-LV



PL-X PL-DP

Earth Rod to Earth Rod

PP-V

Internal Lightning Protection

SPD and Lightning Equipotential Bonding for the protection of Electrical / Electronic equipment from Surges

Internal LPS (also called as LPMS or SPM) shall avoid the occurrence of dangerous sparking within the structure during lightning. Dangerous sparking between different parts can be avoided by means of equipotential bonding or electrical insulation between the parts.

Permanent failure of electrical and electronic systems can be caused by the lightning electromagnetic impulse (LEMP) through conducted and induced surges transmitted to equipment via connected wiring.

Surges to the structure can originate from sources external to the structure such as lightning or within the structure due to switching actions.

Surges which originate externally from the structure are created by lightning flashes striking incoming lines or the nearby ground, and are transmitted to electrical and electronic systems within the structure via these lines

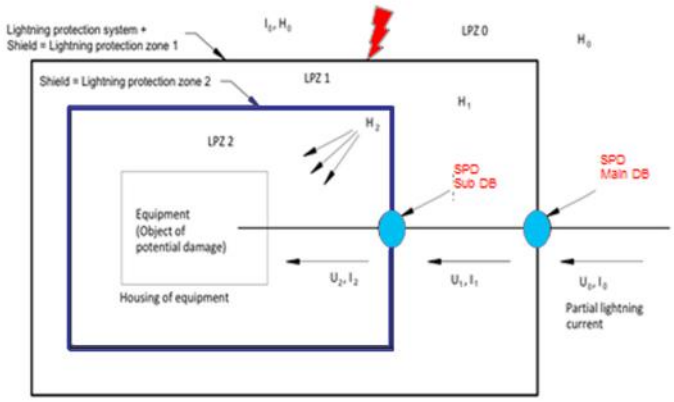
Surges which originate internally within the structure are created by lightning flashes striking the structure itself or nearby ground. Surges can also originate internally within the structure from switching effects (e.g. switching of inductive loads).

Coupling can arise from different mechanisms such as resistive coupling (e.g. the earth impedance of the earth-termination system or the cable shield resistance) and magnetic field coupling (e.g. caused by wiring loops in the electrical and electronic system or by inductance of bonding conductors).

In general electrical and electronic systems are subjected to damage from a Lightning Electromagnetic impulse (LEMP). Therefore Special Protection Measures (SPM) need to be provided to avoid failure of internal systems.

LEMP protection based on the Lightning Protection Zone (LPZ) concept:

Zone containing electrical and electronic systems are divided into LPZ's. These LPZ's are theoretically assigned part of space (or of an internal system) where the LEMP severity is compatible with the withstand level of the internal system. Successive zones are characterized by significant changes in the LEMP severity. The boundary of an LPZ is defined by the protection measures employed.



LPZ – Lightning Protection Zone ($U_2 << U_1 << U_0$)
U – Conducted Surge Voltage ($I_2 << I_1 << I_0$)
I – Conducted Surge Current ($H_2 << H_1 << H_0$)
H – Radiated Magnetic field

Intensity of conducted and radiated surges are reduced inside every LPZ

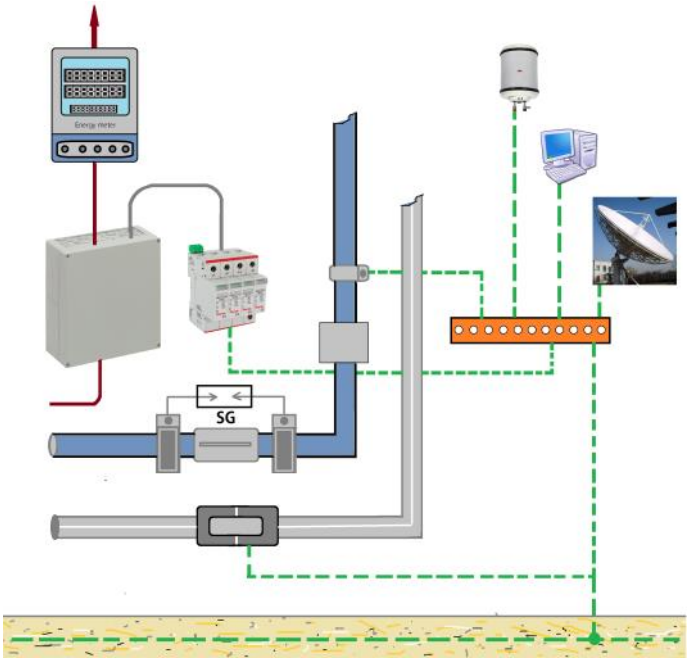
For protection against the effects of conducted and induced surges in the line coordinated SPD system should be used.

For protection against the effects of radiated electromagnetic fields impinging directly onto the equipment, SPM consisting of spatial shields and/or shielded lines, combined with shielded equipment enclosures should be used.

Equipotentialisation of Services to LPS

Equipotentialisation is achieved by interconnecting the LPS with structural metal parts, metal installations, internal systems, external conductive parts and lines connected to the structure.

Interconnection can be done with bonding conductors or using Surge Protective Devices (SPD's). SPD is a device intended to limit transient over voltages and divert surge currents. It contains at least one non-linear component. All SPD's at the service entrance to an installation should be tested for 10/350 µS Impulse current.

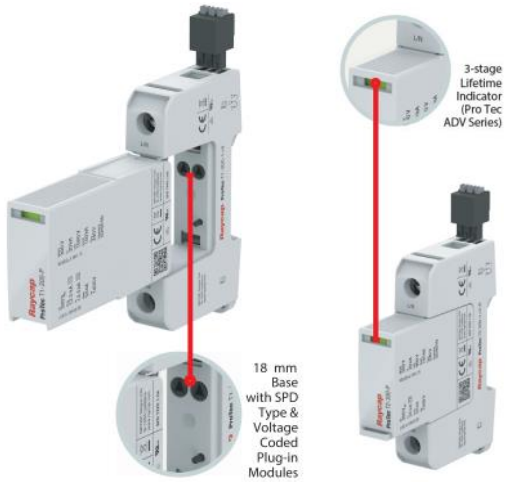


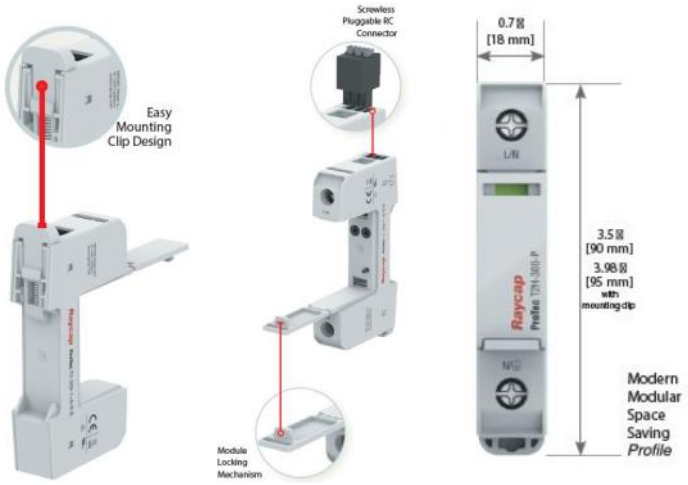
Surge Protection devices (SPD's)

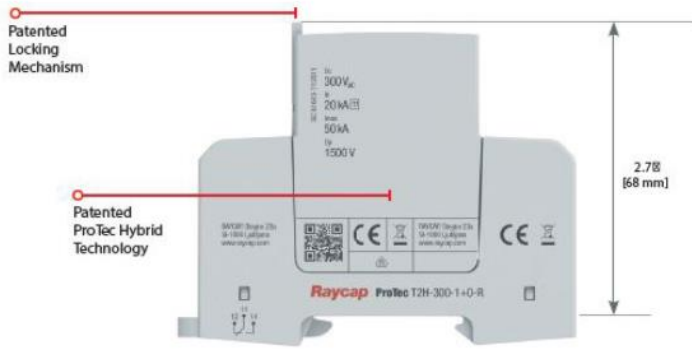
Failure of electrical and electronic systems are due to insulation breakdown or when over voltages exceed the equipment's insulation withstand level. Equipment is protected if its rated impulse withstand voltage U_W at its terminals is greater than the surge overvoltage.

Coordinated SPD's installed in the electrical system provide protection against conducted surges. Shielding and Routing of power and data lines, Bonding of Services at various Lightning Protection Zones (LPZ) & Earthing plays major role in protecting electrical and electronic equipment from radiated surges

SPD shall be selected according to their environmental conditions and the acceptable failure rates of the equipment and the SPD"s

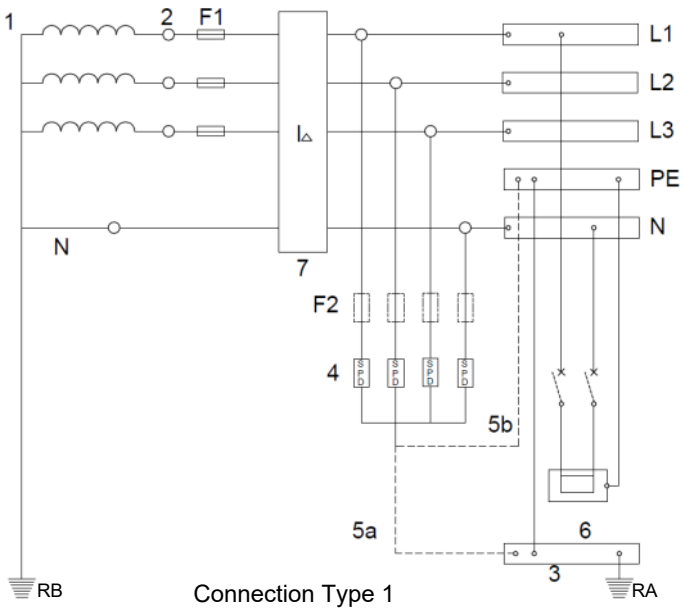




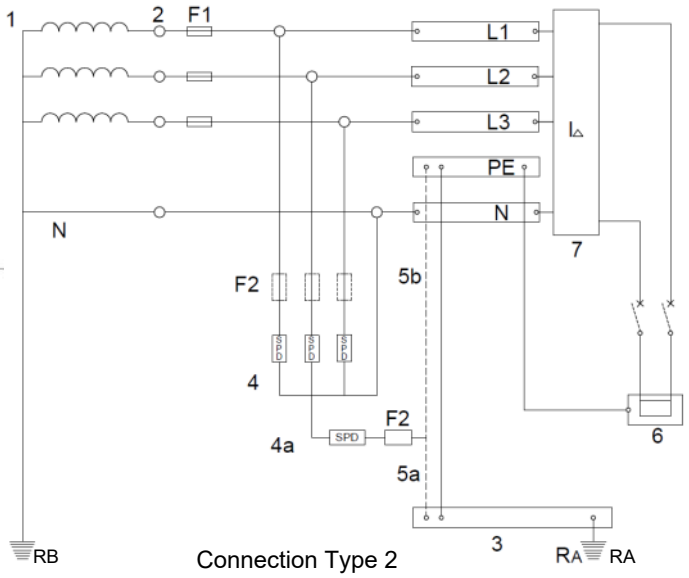


SPD for Power Lines

SPD's for power line need to be installed according to the type of Service such as TN, TT, IT etc. Two type of connections are recommended which need to be selected based on type of network, place of installation, Temporary over voltage conditions etc



Connection Type 1



Connection Type 2

1. System Earthing
2. Origin of installation
3. Main Earthing terminal or Bar
4. Surge Protection Device for Sub DB
5. Earthing Connection of SPD
6. Equipment to be protected
7. Residual current Protective Device (RCCB)

F1 Protective Device at the origin of installation
F2 Protective Device required by the SPD manufacturer
RA Earthing Electrode of the installation
RB Earthing Electrode of the supply system

Impulse Current and Discharge Current of SPD's

SPD's at Main DB (origin of installation): Partial lightning current is diverted through connected metallic services at the origin of installation (Between LPZ 0 and LPZ 1). Approximately 50% of total lightning current during a direct lightning strike in a building need to be diverted through services. Selection of Impulse current for SPD's can be made based on the following selection chart.

Application / Building / Installation	Total I_{imp} through each service in kA	I_{imp} (10/350µS) Rating of SPD in kA			
		Type -1		Type -2	
		L-N	N-PE	L-N	N-PE
No risk assessment - eg General Buildings, Residential, shops, Small scale units	50	12.5	12.5	12.5	50
Multiple Electricity supply eg Apartments / commercial	50	12.5	12.5	12.5	50
Large buildings with only one L.V Electricity supply with LPL 1	100	25	25	25	100
Telecom	100	25	25	25	100
Buildings with in-house transformer	50	12.5	12.5	12.5	50

Note:

Type -1 means Connection type 1
Type - 2 means connection type 2
All ratings are I_{imp} (10/350 µS)

Type 1 connection is preferable for large installations with OCPD's of high capacity, where high fault currents are expected

SPD's tested and approved by International Laboratories are generally tested for one life cycle test which guarantees life around 20 years in a general Lightning situation. However SPD's may fail due to various other reasons such as TOV's

SPD's tested with Impulse Current of 10/350 µS are called as Type - 1 SPD's.

Current through the SPD having wave shape of 8/20 µS is nominal discharge current. This is used for the classification of Type -2 SPD's. The recommended minimum nominal discharge current are 10 kA for all applications and 20 kA for connection type 2 between N and PE.

Important Parameters to be considered for 230/400 (240/415) volt SPD

Maximum Continuous operating voltage

This is the maximum voltage at which an SPD can be stressed. Continuous voltage more than this limit may cause an SPD to fail depending upon its internal component.

Temporary Over Voltage (TOV) - 120 minutes with- stand

TOV's are the abnormal voltage situation arise due to a fault in the HV system or due to an isolation of Neutral. SPD's can withstand this TOV or can fail. In case if it fails due to a TOV. Failure of SPD create discontinuity of protection. It can also affect the electrical network due to short circuit, follow current etc. For this purpose all SPDs are used with back up fuse. SPD's which can withstand TOV up to 440 volts are best suited for Indian condition due to erratic supply voltage from electricity boards / utilities.

Voltage Protection Level of SPD

SPD's are intended to limit the transient over voltage in the installation and hence its Voltage protection level is one of the major parameter. SPD with lower protection level is always better. Protection level need to be selected based on the impulse withstand voltage of equipment.

Response time

More than 95% of lightning strikes are of negative current with an average steepness of 100 KA / µS. Steepness of subsequent strikes are much higher than this level. Raise time of lightning current is responsible for induced surges. Spark Gap SPD's have a response time of 100 nS, whereas SPD's with better discharge devices have response time up to 1 nS.

Strikesorb - Busbar Mounted SPD

High performance BUSBAR mounted SPD's with 1 ηS response time

Type 1 SPD ProTec T1SF

A type 1 Spd with integrated fuse

Type 1 SPD ProTec T1S

Compact Type 1 Spd (100 kA, 10/350 µS)

Type 2 SPD ProTec T2F

With integrated Fuse

Type 2 SPD ProTec T2H

With TOV withstand 120 minutes 440 volt

Type 2 SPD ProTec T2-ADV

With 3 stage status indication

Type 2 SPD ProTec T2-CM-E

Compact SPD

CAPE

Product Quality and Protection Strategy

With over two decades of knowledge and experience in the field, CAPE collaborated with multiple laboratories to develop testing methods for our India-made components based on the most recent IEC standards. This allowed us to offer customised solutions in a short amount of time, tested in accordance with IEC 62561 standards, and altered the situation regarding the use of products of foreign origin designed for construction practises in other countries. Authentic "Made in India"

Lightning Protection components supplied by CAPE conform to the most recent IEC 62561 requirements, have been tested and certified in Indian laboratories, and are suited to our local conditions.

Our Assurance

With more than 20 years experience in the field of Lightning Protection, EMI/EMC and Earthing, we assures our installations.

2 years against Failures.
5 years for components.
5 years corrosion resistance.

“NO FAILURE” Guarantee for equipment from Lightning, Transient surges, HV faults and other EM related issues where we design, install and inspect

- External and internal Lightning Protection
- Equipotential Bonding & Shielding
- Signal Reference Earthing
- Protection of UPS / Drives and other semiconductor operated equipment in the building
- Bonding of Control and Security System, Fire and Safety System etc.

Our certified installations Guarantee use of electrical and electronic equipment during thunderstorm days without disconnection.

CAPE Certified Installations are safe during lightning




International Co-operations:

SURGE PROTECTION DEVICES

Headquartered in Munich - Germany, Raycap is a leading, award-winning company offering innovative technological solutions and services on Surge Protection to industrial clients across telecoms, energy, industrial, defence and transportation markets. The company is a world leader in surge protection.

- Global presence
- Number one global supplier for new generation wireless networks & connectivity solutions with installations in approx. 400,000 cellular sites worldwide
- Exclusive supplier to the largest telecom operators in the world
- Exclusive supplier to the largest renewable energy and Industrial systems manufacturers in the world
- State-of-the-art fully owned manufacturing, R&D laboratories and testing facilities in multiple locations
- Subsidiaries Iskra Zaščite & AC DATA are leaders in their own markets in surge protection products

EXOTHERMIC WELDING AND EARTHING

Headquartered in Gijón (Asturias) – Spain, KLK weld is founded during 1965 which is now a subsidiary of RAILTECH – France. RAILTECH Welding & Equipment (RW&E) is the railway division of the DELACHAUX Group specialized in Thermit - Welding Techniques, Flash - Butt Welding Systems, Track Equipment and Electrification Systems. RAILTECH Welding & Equipment is a leading player on the world railway industrial stage, not only for its expertise, but the quality of products, its technical solutions and the services provided to customers always.

The KLK-WELD connection is a perfect molecular weld and not a mere mechanical contact. The alloy used has a melting point nearly equal to that of copper and generally has a section of about twice that of the conductors to be welded, so that:

- Overloads or short circuit currents do not affect the connection and tests have shown that the conductors melt before the weld does
- The conductivity of the connection is at least equal to or greater than that of the conductors that are joined
- There is no possibility of galvanic corrosion, since the conductors are integrated into the connection

Abbreviations:

Al: Aluminium
Cu: Copper
SS: Stainless steel
PC: Polycarbonate
PPGF: Polypropylene Glass filled
CuB: Copper bonded steel
HDG: Hot dip galvanized steel
TM: Tek Matt coated steel
VAT: Vertical air terminal
LPS: Lightning protection system

Solid Round Conductor

- Used for horizontal air termination and down conductor in the LPS
- Meets the requirement of IS/IEC 62305 and tested as per IEC 62561-2
- Coil length: 35 m (Al. Alloy), 100 m (SS304)

Type	Nominal diameter (mm)	CSA (mm^2)	Material	Weight (kg/m)	Article Number
SRC 8 Al	8	50	Al. Alloy	0.136	400 008
SRC 10 Al	10	78	Al. Alloy	0.213	400 009
SRC 10 SS	10	78	SS304	0.630	400 025

Solid Flat Conductor

- Used for horizontal air termination and down conductor in the LPS
- Meets the requirement of IS/IEC 62305 and tested as per IEC 62561-2
- Coil length : 100 m

Type	Nominal size Width x Thick (mm)	CSA (mm^2)	Material	Weight (kg/m)	Article Number
SFC 203 Al	20 x 3	60	Al. Alloy	0.16	400 047
SFC 243 Al	24 x 3	72	Al. Alloy	0.19	400 048
SFC 253 SS	25 x 3	75	SS304	0.58	400 041
SFC 30 SS	30 x 4	120	SS304	0.90	400 046

Stranded Conductor

- Used for earth termination, equipotential bonding and structural earthing system.
- Meets the requirement of IS/IEC 62305 and tested as per IEC 62561-2
- Coil length : 100 m

Type	Nominal diameter (mm)	CSA (mm^2)	Material	Weight (kg/m)	Article Number
BCSC 50	8.0	50	Cu	0.43	401 018
BCSC 70	9.5	70	Cu	0.60	400 018
BCSC 100	11.3	100	Cu	0.90	402 018
SSSC 50	8.0	50	SS304	0.30	403 018

Copper Bonded Steel Solid Round Conductor

- Used for earth termination, equipotential bonding and structural earthing system.
- Meets the requirement of IS/IEC 62305 and tested as per IEC 62561-2
- Available in coil and rod form
- Material: CuB Steel
- Copper bonding thickness: 100 µm

Type	Nominal diameter (mm)	CSA (mm^2)	Length (m)	Weight (kg/m)	Article Number
SRC 10 Cu	10	78	100	0.61	400 010
SRC 16 Cu	16	201		1.57	400 015
SRC 18 Cu	18	254		1.99	400 020
CBSR 10	10	78	5	0.61	400 012
CBSR 18	18	254		1.99	400 021
CBSR 14	14.2	158		1.24	400 062
CBSR 16	16	201		1.57	400 065
CBSR 17	17.2	232		1.82	400 061
CBSR 20	20	314		2.46	400 071
CBSR 25	25	490		3.85	400 081
CBSR 32	32	804		6.31	400 091

Copper Bonded Steel Flat Conductor

- Used for earth termination, equipotential bonding and structural earthing system
- Meets the requirement of IS/IEC 62305 and tested as per IEC 62561-2
- SS fasteners / rivets are included for inter-connection.
- Copper bonding thickness: min. 100 µm
- Length: 5 m

Type	Nominal size Width x Thick (mm)	CSA (mm^2)	Weight (kg/m)	Article Number
SFC 2545 CuB 100	25 x 4	100	0.78	400 104
SFC 2565 CuB 100	25 x 6	150	1.18	403 134
SFC 5065 CuB 100	50 x 6	300	2.35	400 129
SFC 5085 CuB 100	50 x 8	400	3.13	400 134
SFC 50105 CuB 100	50 x 10	500	3.92	400 135

Insulated Copper Conductor

- Serve as a down conductor for protection against touch voltage
- Meets the requirement of IS/IEC 62305 and IEC 62561-2
- Insulation material : Cross linked polyethylene (XLPE)
- Tested for impulse withstand voltage (1.2/50 µs) = 100 kV

Type	Nominal OD (mm)	CSA (mm^2)	Length (m)	Weight (kg/unit)	Article Number
ISRC 8 Cu L-3.5	24.3	50	3.5	3.4	400 026

Customized length available upon request

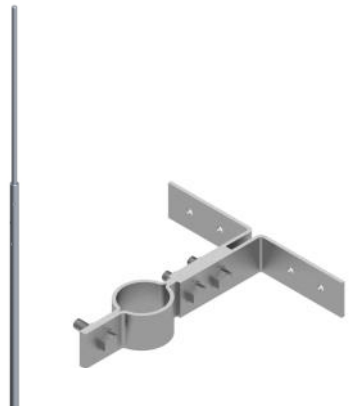
Vertical Air Terminal with accessories on a flat surface

- Serve as a Vertical air terminal in the LPS
- Meets the requirement of IS/IEC 62305 and tested as per IEC 62561-2
- Material: VAT- Aluminium alloy, Tristand- SS304, Stone- Concrete

Type	VAT Tapered diameter (mm)	Mounting base	VAT Height (mm)	Article Number
VAT F2	16/10	Stone	2000	401 420
TSVAT2	16/10	Tristand	2000	400 407
VAT F3	16/10	Stone	3000	401 430
TSVAT3	16/10	Tristand	3000	400 414
VAT F4	16/10	Stone	4000	401 440
TSVAT4	16/10	Tristand	4000	400 415
VAT F5	40/16/10	Tristand	5000	401 450
VAT F6	40/16/10	Tristand	6000	401 470
VAT F8	40/22/16/10	Tristand	8000	401 480

VAT material: SS / Cu / CuB – available upon request.

Vertical Air Terminal with accessories on wall



- Serve as a Vertical air terminal in the LPS
- Meets the requirement of IS/IEC 62305 and tested as per IEC 62561-2
- Material: VAT- Aluminium alloy, VAT clamp- SS304
- VAT tapered diameter: 16/10

Type	VAT Height (mm)	Article Number
VAT W1	1000	402 411
VAT W2	2000	404 420
VAT W3	3000	405 420
VAT W4	4000	406 440

VAT material: SS / Cu / CuB – available upon request.

Vertical Air Terminal with accessories on PEB metal roof sheets

- Serve as a Vertical air terminal in the LPS
- Meets the requirement of IS/IEC 62305 and tested as per IEC 62561-2
- Material: VAT- Aluminium alloy, VAT holder- SS304
- VAT tapered diameter: 16/10

Type	Roof sheet type	Roof sheet pitch (mm)	VAT Height (mm)	Article Number
VAT FBM1 200	Trapezoidal	108-268	1000	403 413
VAT M1 200	Standing seam	108-268		403 414
VAT FBM1 400	Trapezoidal	308-468		403 411
VAT M1 400	Standing seam	308-468		403 415
VAT FBM1 500	Trapezoidal	408-568		403 416
VAT M1 500	Standing seam	408-568		403 417
VAT FBM1 600	Trapezoidal	558-718		403 418
VAT M1 600	Standing seam	558-718		403 419
VAT FBM2 200	Trapezoidal	108-268	2000	403 424
VAT M2 200	Standing seam	108-268		403 421
VAT FBM2 400	Trapezoidal	308-468		403 425
VAT M2 400	Standing seam	308-468		403 422
VAT FBM2 500	Trapezoidal	408-568		403 427
VAT M2 500	Standing seam	408-568		403 426
VAT FBM2 600	Trapezoidal	558-718		403 428
VAT M2 600	Standing seam	558-718		403 423

VAT material: SS / Cu / CuB – available upon request.

Vertical Air Terminal with accessories on Parapet

- Serve as a Vertical air terminal in the LPS
- Meets the requirement of IS/IEC 62305 and tested as per IEC 62561-2
- Material: VAT- Aluminium alloy, VAT holder- SS304
- VAT tapered diameter: 16/10

Type	VAT Height (mm)	Article Number
VAT P1	1000	402 410

VAT material: SS / Cu / CuB – available upon request.

Vertical Air Terminal for Parapet

- Serve as a air terminal on building corners in the LPS
- Meets the requirement of IS/IEC 62305
- Material: VAT- CuB Steel, VAT holder- SS304

Type	VAT nominal diameter (mm)	VAT Height (mm)	Article Number
VAT CR 14.2 CuB	14.2	500	401 170

Wall Clamp for Vertical Air Terminal

- Used to mount a Vertical air terminal on parapet and side walls
- Meets the requirement of IS/IEC 62305
- Material: SS304

Type	VAT clamping range (mm)	VAT centre distance from wall (mm)	Article Number
WC 40 SS	Ø38-40	100	400 408
WC 16 SS	Ø14-16	100	401 408
WC 18 SS	Ø14-16	300	403 408

Hand Rail Clamp for Vertical Air Terminal

- Used to mount a Vertical air terminal on hand rails (round sections)
- Meets the requirement of IS/IEC 62305
- Material: SS304

Type	VAT clamping range (mm)	Handrail pipe range (mm)	Article Number
HRC 6040	Ø38-40	Ø50-60	400 495
HRC 8016	Ø14-16	Ø65-80	404 407
HRC 5016	Ø14-16	Ø40-50	407 408
HRC 254516	Ø14-16	Ø25-45	408 408
HRC 254510	Ø8-10	Ø25-45	409 408

Air Terminal Conductor Joining Clamp

- Used to interconnect vertical air terminal and round conductor
- Meets the requirement of IS/IEC 62305 and IEC 62561-1
- Material: SS304

Type	VAT diameter (mm)	Conductor diameter (mm)	Article Number
ATCJC 16	16	8	400 403

Air Terminal Conductor Clamp

- Used to interconnect vertical air terminal and flat conductor
- Meets the requirement of IS/IEC 62305 and IEC 62561-1
- Material: SS304

Type	VAT diameter (mm)	Conductor size Upto (mm)	Article Number
VATFC	16	25 x 3	401 403

Conductor Holder for Round Conductor

- Used as conductor holder in horizontal air termination and down conductors
- Meets the requirement of IS/IEC 62305 and IEC 62561-4

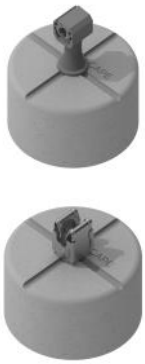
Type	Conductor diameter (mm)	Material	Article Number
PCH 8	8	Plastic	400 202
CH 8-10	8/10	SS304	400 213
MCH 8-10	8/10	SS304	400 230
CHC 8	8	SS304	400 552
CHC 10	10	SS304	400 553
CH 20-25	20-25	SS304	400 381

Conductor Holder for Metal Roof Sheet for Round Conductor

- Used as conductor holder in horizontal air termination
- Meets the requirement of IS/IEC 62305 and IEC 62561-4

Type	Conductor diameter (mm)	Material (Holder & Base)	Article Number
PRCH 8	8	Plastic & SS304	401 204
MRMCH 8-10	8/10	SS304 & SS304	402 230

Conductor Holder for Flat Roof for Round Conductor



- Used as conductor holder in horizontal air termination
- Meets the requirement of IS/IEC 62305 and IEC 62561-4

Type	Conductor diameter (mm)	Material (Holder & Base)	Article Number
MBPCH 8	8	Plastic & Concrete	403 201
MBCH 8-10	8/10	SS304 & Concrete	403 202
MBMCH 8-10	8/10	SS304 & Concrete	401 230

Conductor Holder for Metal Roof Mechanical/Clipped Standing Seam for Round Conductor

- Used as conductor holder in horizontal air termination
- Meets the requirement of IS/IEC 62305 and IEC 62561-4
- Material: SS304
- Clamping range on seam: 2-20 mm

Type	Conductor diameter (mm)	Article Number
FC 19	8/10	404 409
FC 3208 SS	8	404 410
FC 32010 SS	10	404 411
FC MCH 8-10	8/10	403 230

Conductor Holder for Metal Roof Zip lock round Seam for Round Conductor

- Used as conductor holder in horizontal air termination
- Meets the requirement of IS/IEC 62305 and IEC 62561-4
- Material: SS304
- Clamping range on seam: 18-28 mm

Type	Conductor diameter (mm)	Article Number
SSC 20	8	407 409
SSC 20/8-10	8/10	404 230

Conductor Holder for Ridge / Hip Tile for Round Conductor

- Used as conductor holder in ridge or hip tile roof
- Meets the requirement of IS/IEC 62305 and IEC 62561-4
- Material: SS304

Type	Conductor diameter (mm)	Clamping range (mm)	Article Number
CHC RT3-08	8	280-360	401 552
MCH RT2-10	8/10	180-280	405 230

Conductor Holder for Roof Tile for Round Conductor

- Used as conductor holder in tile roof
- Meets the requirement of IS/IEC 62305 and IEC 62561-4
- Material: SS304

Type	Conductor diameter (mm)	Article Number
MCHT 150	8/10	406 230

Clamping Connector for Metal Structure

- Used to interconnect metal installations and round conductor
- Meets the requirement of IS/IEC 62305 and tested as per IEC 62561-1
- Material: SS304

Type	Conductor diameter (mm)	Article Number
CS 8-10	8-10	400 207

Cross Connector for Round Conductor

- Meets the requirement of IS/IEC 62305 and tested as per IEC 62561-1

Type	Conductor diameter (mm)	Material / Coating	Article Number
CCMS 8-10	8-10	Steel / Trivalent	400 205
CC 8-10 TM	8-10	Steel / Tek Matt	404 205
CC 8-10 HDG	8-10	Steel / Galvanized	403 205
CCSS 8-10	8-10	SS304	400 206
CCMS 16-18	16-18	Steel / Trivalent	403 206
CC 16-18 TM	16-18	Steel / Tek Matt	406 206
CC 16-18 HDG	16-18	Steel / Galvanized	407 206
CCSS 16-18	16-18	SS304	402 206

Expansion Piece with connector for round conductor

- Compensate the expansion and contraction due to thermal effect in conductor
- Meets the requirement of IS/IEC 62305 and tested as per IEC 62561-1&2
- Material: Aluminium alloy

Type	Nominal diameter (mm)	CSA (mm^2)	Article Number
EPC 8	8	50	401 209
EPC 10	10	78	402 209

Straight, Cross & T Connector for Aluminium Round Conductor

- Used as connection component
- Meets the requirement of IS/IEC 62305 and IEC 62561-1
- Connection made by permanent crimping.
- Material: Aluminium alloy

Type	Conductor diameter (mm)	Article Number
CJ8	8	401 211
CJX 8	8	402 211
CJT 8	8	403 211
CJ10	10	404 211

Straight Connector for Steel Round Conductor

- Used as connection component
- Meets the requirement of IS/IEC 62305 and IEC 62561-1

Type	Conductor diameter (mm)	Material / Coating	Article Number
SC 8-10	8-10	SS304	400 210
SC 8-10 CuB	8-10	Steel / CuB	404 210
SC 8-10 TRZ	8-10	Steel / Trivalent	405 210
SC 16-18	16-18	SS304	402 210

Conductor Holder for Flat Conductor

- Used as conductor holder in horizontal air termination and down conductors
- Meets the requirement of IS/IEC 62305 and IEC 62561-4
- Material: SS304

Type	Conductor size (mm)	Article Number
FCH 30 SS	30 x 4	401 213
FCH 40 SS	40 x 4	403 213
FCH 20 SS	20 x 3	400 235
FCH 25 SS	25 x 3	400 240

Conductor Holder for Flat Roof for Flat Conductor

- Used as conductor holder in horizontal air termination on flat roof
- Meets the requirement of IS/IEC 62305 and IEC 62561-4
- Material (Holder & Base): SS304 & Concrete

Type	Conductor size (mm)	Article Number
MBFCH 30	30 x 4	404 202
MBFCH 20	20 x 3	401 235
MBFCH 25	25 x 3	401 240

Conductor Holder for Metal Roof Sheet for Flat Conductor

- Used as conductor holder in horizontal air termination
- Meets the requirement of IS/IEC 62305 and IEC 62561-4
- Material: SS304

Type	Conductor size (mm)	Article Number
MRFCH 30	30 x 4	406 203
MRFCH 20	20 x 3	402 235
MRFCH 25	25 x 3	402 240

Conductor Holder for Metal Roof Mechanical/Clipped Standing Seam for Flat Conductor

- Used as conductor holder in horizontal air termination
- Meets the requirement of IS/IEC 62305 and IEC 62561-4
- Material: SS304
- Clamping range on seam: 2-20 mm

Type	Conductor size (mm)	Article Number
FC 1940	40 x 4	404 412
FC 1930	30 x 4	405 412
FC 1920	20 x 3	403 235
FC 1925	25 x 3	403 240

Expansion Piece for Flat conductor

- Compensate the expansion and contraction due to thermal effect in conductor
- Meets the requirement of IS/IEC 62305 and IEC 62561-2
- Material: Aluminium alloy

Type	Nominal size (mm)	CSA (mm^2)	Article Number
EPF 70	32 x 6	70	403 209

Cross Connector for Flat Conductor

- Meets the requirement of IS/IEC 62305 and IEC 62561-1
- Material: SS304

Type	Conductor size (mm)	Article Number
FC 3035 SS	30 x 4	401 501
FCC 2030 SS	20 x 3	406 501
FCC 2530 SS	25 x 3	407 501

Bridging Cable

- Used to interconnect metal installations with the LPS
- Meets the requirement of IS/IEC 62305 and tested as per IEC 62561-1&2
- Conductor material: Cu
- Ozone resistant

Type	Length (mm)	CSA (mm^2)	Article Number
BC 500	500	16	400 211
BC 1000	1000	16	402 212

Customized length available upon request

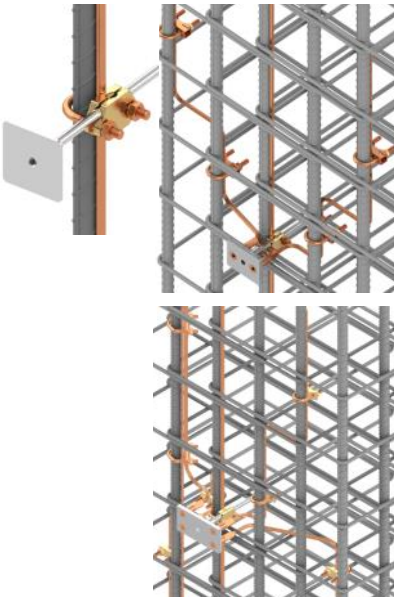
Test Joints with enclosure

- Test joint facilitate electrical testing and measurement of LPS components
- TJRR used to link round conductor and round conductor
- TJRF used to link round conductor and flat conductor
- TJFF used to link flat conductor and flat conductor
- Meets the requirement of IS/IEC 62305 and IEC 62561-1
- Material: Test joint-SS304, Enclosure- PC

Type	Conductor size End 1 (mm)	Conductor size End 2 (mm)	Article Number
TJRRE	Ø8-10	Ø8-10	404 214
TJRFE	Ø8-10	20 x 3 - 30 x 4	405 214
TJFFE	20 x 3 - 30 x 4	20 x 3 - 30 x 4	406 214

Earth Stud with connecting accessories

- Earthing points for structural earthing system
- Meets the requirement of IS/IEC 62305 and tested



Type	Thread size	No. of Earthing Point	Stud material	Riser / conductor type	Riser / conductor size (mm)	Article Number
ES1-RA1	M10	01	SS304	Round	Ø10-18	401 510
ES1P-RA1	M10	01	SS304			401 540
ES3-RA1	M12	03	SS304			401 520
ES5-RA1	M12	05	SS304			401 530
ES3Cu-RA1	M12	03	Cu/SS304			406 520
ES5Cu-RA1	M12	05	Cu/SS304			406 530
ES1-FA1	M10	01	SS304	Flat	Width 25 - 50	402 510
ES3-FA1	M12	03	SS304			405 520
ES5-FA1	M12	05	SS304			405 530
ES3Cu-FA1	M12	03	Cu/SS304			406 540
ES5Cu-FA1	M12	05	Cu/SS304			406 550

Multi Purpose Bonding Clamp for Round / Flat Conductor

- Interconnects between conductor, earth stud and / or reinforcement bar inside the concrete in structural earthing system
- Meets the requirement of IS/IEC 62305 and IEC 62561-1

Type	Rebar size (mm)	Conductor size (mm)	Material / Coating	Article Number
MPBC 162810	Ø16-28	Ø10/Ø10-12	Brass / Steel / CuB	403 506
MPBC 1628	Ø16-28	Ø10-12	Brass / Steel/CuB	404 506
MCBC 101832 CuB	Ø16-32	Ø10-18	Steel / CuB	410 506
MCBC 101832 TM	Ø16-32		Steel / Tek Matt	412 506
MFBC 150 CuB	Ø16-40	Width 25-50	Steel / CuB	400 509
MFBC 250 CuB	Ø16-40		Steel / CuB	401 509
MFBC 150 TM	Ø16-40		Steel / Tek Matt	402 509
MFBC 250 TM	Ø16-40		Steel / Tek Matt	403 509

Diagonal Clamp

- Interconnects between conductor and reinforcement bar inside the concrete in structural earthing system
- Meets the requirement of IS/IEC 62305 and IEC 62561-1

Type	Rebar size (mm)	Conductor size (mm)	Material / Coating	Article Number
DCSS	Ø16-32	Ø6-18	SS304	400 507
DCMS	Ø16-32	Ø6-18	Steel / Trivalent	401 507
DCTM	Ø16-32	Ø6-18	Steel / Tek Matt	402 507

Connecting point for Earth Stud

- Interconnects between round conductor and earth points in structural earthing system
- Interconnects between air terminal rod and round conductor in LPS
- Meets the requirement of IS/IEC 62305 and tested as per IEC 62561-1
- Material: SS304

Type	Thread size	Conductor size (mm)	Article Number
CPES 8	M8	Ø8-10	401 504
CPES 10	M10	Ø8-10	400 504
CPES 12	M12	Ø8-10	400 505

Earthing Clamp with Tensioning strap for Metal Pipe

- Used to make an earth connection on steel pipe
- Meets the requirement of IS/IEC 62305
- Material: SS304

Type	Conductor dia range (mm)	Pipe range (mm)	Article Number
PEC 20-170	Ø6-10	Ø20-170	400 220
PEC 50-300	Ø6-10	Ø50-300	401 220

Customized pipe clamping range available upon request

Equipotential Bonding Stud

- Interconnects LPS and structural steel work to maintain an equipotential
- Meets the requirement of IS/IEC 62305
- Material: SS316

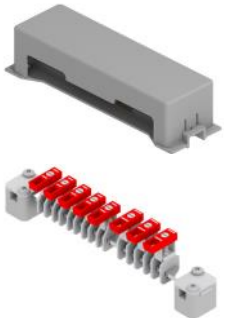
Type	Stud size x Length (mm)	Article Number
EBS 8-85	M8 x 85	400 503

Earth Boss

- Used to interconnect metal structures to maintain an equipotential
- Meets the requirement of IS/IEC 62305
- Material: Low carbon steel

Type	Size (Dia x Length) (mm)	Article Number
EB 3050 MS	Ø30 x 50	400 830
EB 4050 MS	Ø40 x 50	401 830
EB 5050 MS	Ø50 x 50	402 830

Equipotential Bonding Rail Light duty



- Interconnects all electrical earthing system to maintain an equipotential
- Meets the requirement of IS/IEC 62305

Type	Busbar size L x B x T (mm)	CSA (mm^2)	Material	Article Number
EBRL	130 x 14 x 9	120	Brass	400 701
EBRL 100	100 x 10 x 3	30	Tinned Cu	400 691
EBRL 170	170 x 10 x 3	30		400 696

Equipotential Bonding Rail Heavy duty

- Interconnects all electrical earthing system to maintain an equal potential
- Meets the requirement of IS/IEC 62305 and TIA-607-B

Type	Busbar size L x B x T (mm)	CSA (mm^2)	Material	Article Number
EBRH 5306	300 x 50 x 6	300	SS304	400 702
EBRH 5506	500 x 50 x 6	300		400 750
EBRH 55010	500 x 50 x 10	500		400 751
EBRH 10506	500 x 100 x 6	600		400 752
EBRH 105010	500 x 100 x 10	1000		400 753
EBRHCu 5306	300 x 50 x 6	300	Tinned Cu	400 754
EBRHCu 5506	500 x 50 x 6	300		400 755
EBRHCu 55010	500 x 50 x 10	500		400 756
EBRHCu 10506	500 x 100 x 6	600		400 757
EBRHCu 105010	500 x 100 x 10	1000		400 758

Lightning Event Recorder

- LCD screen shows the number of lightning strikes, date and time of lightning events
- Buttons enable TIME/DATE setting and log viewing
- Replaceable battery
- Contactless sensor makes install of product easily with no change to existing installation
- Meets the requirement of IS/IEC 62305 and tested IEC 62561-6

Type	Threshold Current (8/20 µs)	Maximum withstand Current (10/350 µs)	Maximum Counts	Enclosure Material	Article Number
PRO-LER	1kA	100 kA	999	PC	400 999

Copper Bonded Earth Electrode

- Vertical earth electrode
- Copper bonding thickness of minimum 254 µm
- Meets the requirement of IS 3043, IS/IEC 62305, IEC 60364-5-54, UL 467
- Tested as per IEC 62561-2

	Type	Nominal diameter (mm)	CSA (mm^2)	Length (mm)	Weight (kg/Unit)	Article Number
UL Listed Electrodes	CBR 1410	14.2	158	3000	3.70	300 010
	CBR 1408	14.2	158	2500	3.10	300 020
	CBR 1406	14.2	158	2000	2.40	300 030
	CBR 1710	17.2	232	3000	5.40	300 060
	CBR 1708	17.2	232	2500	4.50	300 070
	CBR 2010	20	314	3000	7.40	300 110
	CBR 2008	20	314	2500	6.10	300 120
	CBR 2510	25	490	3000	11.50	300 150
	CBR 2508	25	490	2500	9.60	300 160
	CBR 1405	14.2	158	1500	1.80	300 040
	CBR 1403	14.2	158	1000	1.20	300 050
	CBR 1706	17.2	232	2000	3.60	300 080
	CBR 1705	17.2	232	1500	2.70	300 090
	CBR 1703	17.2	232	1000	1.80	300 100
	CBR 2005	20	314	1500	3.70	300 130
	CBR 2505	25	490	1500	5.70	300 170

Copper Bonded Earth Electrode (Threaded type coupled)

- Vertical earth electrode
- Copper bonding thickness of minimum 254 µm
- Meets the requirement of IS 3043, IS/IEC 62305, IEC 60364-5-54

Type	Nominal diameter (mm)	CSA (mm^2)	Length (mm)	Weight (kg/Unit)	Article Number
CBR 1420	14.2	158	6000	7.4	300 011
CBR 1720	17.2	232	6000	10.9	300 071
CBR 1730	17.2	232	9000	16.4	300 069
CBR 2020	20	314	6000	14.8	300 112
CBR 2520	25	490	6000	23.0	300 158

Copper Bonded Earth Electrode (Knurling type coupled)

- Vertical earth electrode
- Specially designed for deep driving
- Copper bonding thickness of minimum 254 µm
- Meets the requirement of IS 3043, IS/IEC 62305, IEC 60364-5-54

Type	Nominal diameter (mm)	CSA (mm^2)	Length (mm)	Weight (kg/Unit)	Article Number
CBR 2003	20	314	1000	2.4	300 180
CBR 2503	25	490	1000	3.8	300 190

Impact point & driving head need to be ordered separately.

Earth Electrode (Stud type coupled)

- Vertical earth electrode
- Specially designed for deep driving
- Meets the requirement of IS 3043, IS/IEC 62305, IEC 60364-5-54, IEC 62561-2
- Material: SS316L

Type	Electrode Nominal diameter (mm)	CSA (mm^2)	Length (mm)	Weight (kg/Unit)	Article Number
ERSC 2010 316	20	314	1000	2.50	300 230
ERSC 2030 316	20	314	3000	7.60	300 231
ERSC 2050 316	20	314	5000	12.70	300 232

Copper Bonded Earth Electrode with Copper Busbar Exothermically welded

- Vertical earth electrode
- Copper bonding thickness of minimum 254 µm
- Busbar material: Cu
- Meets the requirement of IS 3043, IS/IEC 62305, IEC 60364-5-54

Type	Electrode Nominal diameter (mm)	CSA (mm^2)	Length (mm)	Busbar Size (mm)	Weight (kg/Unit)	Article Number
CBREX 1410	14.2	158	3000	300x25x6	4.10	300 045
CBREX 1710	17.2	232	3000	300x25x6	5.80	300 065
CBREX 2010	20	314	3000	300x25x6	7.80	300 114
CBREX 2510	25	490	3000	300x25x6	11.90	300 155

Copper Bonded Earth Electrode with pre welded clamp

- Vertical earth electrode.
- Meets the requirement of IS 3043, IS/IEC 62305, IEC 60364-5-54
- Copper bonding thickness of minimum 254 µm on rod and 70 µm on bar

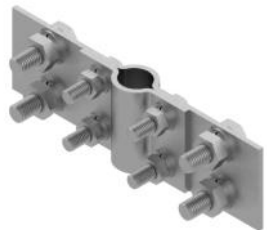
Type	Electrode Nominal diameter (mm)	CSA (mm^2)	Length (mm)	weight (kg/Unit)	Article Number
CBRPW6G 1410	14.2	158	3000	4.30	300 013
CBRPW 1410	14.2	158	3000	4.30	300 014
CBRPW 1710	17.2	232	3000	6.00	300 062
CBRPW6G 1710	17.2	232	3000	6.00	300 063
CBRPW6G 2010	20	314	3000	8.00	300 113
CBRPW6G 2510	25	490	3000	12.15	300 153

Tripod Earth Rod

- Vertical earth electrode
- Copper bonding thickness of minimum 254 µm
- Core material: low carbon steel
- Meets the requirement of IS 3043, IS/IEC 62305, IEC 60364-5-54

Type	Nominal diameter (mm)	OD (mm)	CSA of each rod (mm^2)	Length of each rod (mm)	Weight (kg/Unit)	Article Number
TER 1403	14.2	200	158	3000	11.90	300 012
TER 1703	17.2	200	232	3000	17.00	301 012

Universal Clamp



- Used for earth termination of round / flat conductors
- Meets the requirement of IS/IEC 62305 and tested as per IEC 62561-1
- Recommended for heavy duty application
- Material: SS304

Type	Earth rod dia (mm)	Article Number
SSUC 14	14.2	300 570
SSUC 17	17.2	300 580
SSUC 20	20	300 590
SSUC 25	Ø25	300 600

Earth Rod Clamp

- Used for earth termination of round / flat conductor
- Meets the requirement of IS/IEC 62305 and tested as per IEC 62561-1

Type	Earth rod dia (mm)	Material / Coating	Article Number
ERC 1417 CuB	14.2-17.2	Steel / CuB	300 462
ERC 1417 SS	14.2-17.2	SS304	300 463
ERC 2025 CuB	20-25	Steel / CuB	300 466
ERC 2025 SS	20-25	SS304	300 464

Copper bonded steel Plate Electrode with connecting wires

- Stranded conductors are made of high conductive copper
- Exothermically welded in order to offer maximum life
- Meets the requirement of IS/IEC 62305

Type	CuB plate size (mm)	No. of wire X length (mm)	Wire CSA (mm^2)	Article Number
CPE 600	600 x 600 x 1.5	02 X 2000	70	300 741

Customized materials and wire length available upon request

PRO-CEM : Earth Enhancing Mineral Compound

- Conductive concrete with SET properties
- Used in areas with high soil resistance and rocky areas
- Meets the requirement of IS 3043, IS/IEC 62305 and tested as per IEC 62561-7

Type	Weight (kg)	Article Number
PRO-CEM 5	5.0	300 784
PRO-CEM 10	10.0	300 785
PRO-CEM 12.5	12.5	300 790

PRO-SAN

- Used in areas with high soil resistance and rocky areas
- Meets the requirement of IS 3043, IS/IEC 62305 and tested as per IEC 62561-7

Type	Weight (kg)	Article Number
PRO-SAN 2.5	2.5	300 833
PRO-SAN 5	5.0	300 831
PRO-SAN 12.5	12.5	300 830

Earth Electrode Inspection Housing

- Used for maintenance free earthing inspection
- Meets the requirement of IS/IEC 62305 and tested as per IEC 62561-5
- Classification: Heavy duty usage slow moving vehicular traffic, multi-axle, etc

Type	OD L x W x H (mm)	ID L X W X H (mm)	Load test (kN)	Weight (kg)	Material	Article Number
EC 290	290 x 290 x 209	212 x 212 x 153	60	2.2	PPGF	300 852
CEC 320	320 x 320 x 190	195 x 195 x 110	30	30	Concrete	300 855

PRO-GAL : Sacrificial Earthing

- Protects metal in soil from corrosion

Type	Application	Size Dia x Length (mm)	Article Number
PRO-GAL Z70520	Low resistive areas, corrosive soil, steel in foundation	Ø70 x 520	300 860
PRO-GAL M70520	Very low resistive areas, high corrosive soil, buried steel such as steel pipes	Ø70 x 520	300 870

PRO-CHEM Rod

- Low earth resistance, maintenance free and capable of dissipating lightning and other fault current in high soil resistive areas
- Meets the requirement of UL 467
- UL listed
- Includes earth chamber and its accessories

Type	Length (mm)	Article Number
PRO-CHEM	3000	300 880

Installation Images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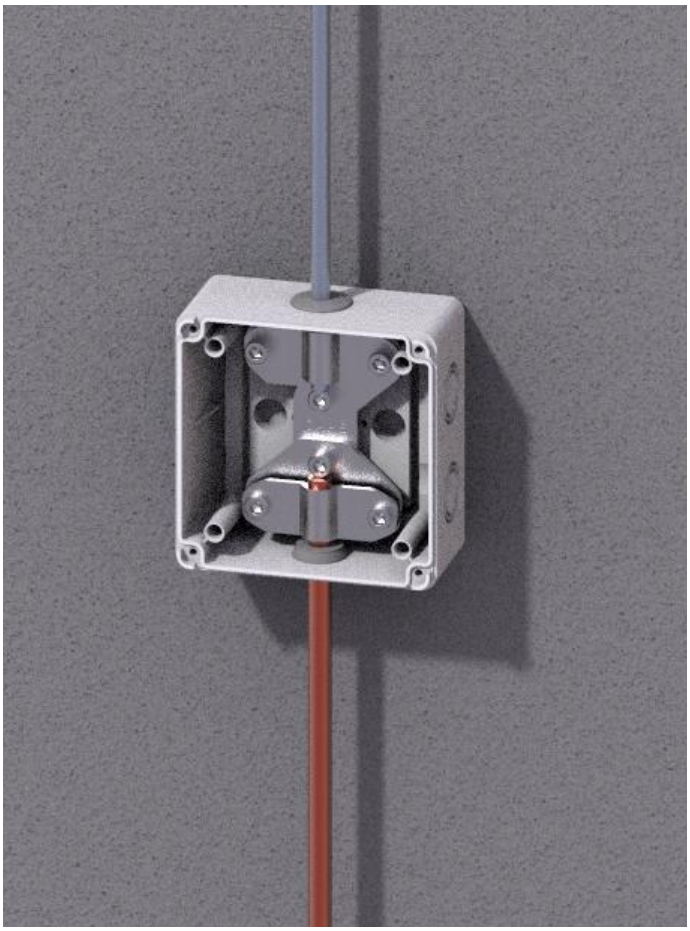

Air Termination System

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