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STEC PAMPHLET - 17

PROTECTION OF EXPLOSIVE BUILDINGS AGAINST LIGHTNING

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PREFACE

As a general rule, lightning protection should be provided during construction of all new facilities to be used for the storage or maintenance of ammunition and explosives. There may be certain situations involving either new construction or existing facilities where the installation of lightning protection systems is unwarranted.

It is hoped that users will find this revised STEC Pamphlet 2025 simpler, easier to understand and implement, thereby promoting the safe storage and transportation of military explosive. This publication supersedes STEC Pamphlet, 2017 on the subject.

ASSESSMENT OF THE NEED FOR LIGHTNING PROTECTION

1. As a general rule, lightning protection should be provided during construction of all new facilities to be used for the storage or maintenance of ammunition and explosives. There may be certain situations involving either new construction or existing facilities where the installation of lightning protection systems is unwarranted. When making a determination as to whether or not lightning protection should be installed, consideration should be given to the following factors :

    (a) Does the structure itself afford sufficient protection without further installation?
    (b) Are the explosive facilities properly sited, so that an explosion will not endanger exposed sites?
    (c) Does the frequency of electrical storm; e.g. five or more per year, justify the installation?
    (d) Are people physically located in the structure with the ammunition and explosives?
    (e) Can the loss of the ammunition and explosives be tolerated?
    (f) In case of an existing structure, does the value of the content, warrant the cost of an installation?

General

2. a) The principle of protection against the effects of lightning discharges is to provide a conducting path between the atmosphere above a structure and the general mass of earth so that the discharge can pass to earth with the minimum risk to the structure, its contents and occupants.

    b) It is essential that any system of protection and the means of fixing it should be effective, simple, rugged, accessible and permanent. This applies particularly to earth termination networks which are hidden from view.

    c) So many factors, such as quantity-distances, terrain, and access roads have to be taken into account when planning an explosives area, the lightning protection may be given little consideration until the type and position of each site are finalized. This may result in difficulty in obtaining a suitable resistance to earth.

Selection of Materials

3. a) The selection of materials for the system should take account of their compatibility and corrosion problems etc. Generally metals should be chosen which are close in the electrochemical series in order to reduce the risk of electrolytic interaction.

b) Where the possibility of significant electrolytic action exists, dry sealed metallic joints should be used to provide adequate protection.

c) Aluminum is generally satisfactory but it should be joined to copper by dry sealed joint and it should not be used in direct contact with soil.

d) Conductors for use as suspended air termination networks should be stranded and of hard drawn aluminum, hard drawn copper, or copper coated steel. The number and nominal diameter of wires in the conductor should not be less than 4/7/4.30 mm for aluminium conductors, 7/3.55 mm for copper conductors, and 7/2.05 mm for copper coated steel conductors.

Component Parts

4. The main component parts of a lightning protection system are:

(a) Air termination network.
(b) Down conductor.
(c) Earth termination network.
(d) Test joint.
(e) Bond

Air termination Network

5. There are three forms of air termination network for a system:

(a) Fixed air termination network
(b) Suspended air termination network
(c) Vertical air termination network

The three basic forms are shown in Figures 1 to 3 and a variation of the fixed air termination network (the integrally mounted system) is shown in Figure 4.

Fixed Air Termination Network

6. (a) The roof conductor should be in the form of a mesh having sides not greater than 7.5m. However, on a concrete roof having reinforcement metal bonded to the lightning protection system, the mesh may be increased to 10m. When unusually sensitive explosives are held at the site, the mesh should be reduced to 5 m.

(b) Each conductor should be supported on "stand-off hold-fasts" or a small concrete block; it should not be fixed directly to the surface of the roof. As the edges are generally the most vulnerable parts of the roof, each conductor should be positioned as close to the edge of the roof as practicable, but in no circumstances more than 0.3 m from the edge.

(c) Each roof conductor should be fixed above the level of any up stand such as a canopy over a doorway.

(d) Where a building has roofs at different levels (i.e. where there is a tank room on the main roof) each one should be protected. Where the fixed air termination network of a roof at one level affords complete protection to a roof at a lower level, a separate conductor on this roof is not necessary. Where the fixed air termination network of a roof at one level, afford partial protection to a roof at a lower level, then only the unprotected part of the lower roof needs a separate conductor.

(e) There is no requirement to provide pointed conductors or vertical finials on a fixed air termination network.

(f) A variation of the fixed air termination system is the integrally mounted system. The important differences in this variation from the system described above are the requirements for metallic pointed conductors and the spacing of the conductors. This system is an acceptable alternate for the fixed air termination system.

DIMENSION 'A'

EXTREME CONDITION	5.0 m
NORMAL	7.5 m
METAL BONDED ROOF	10.0m

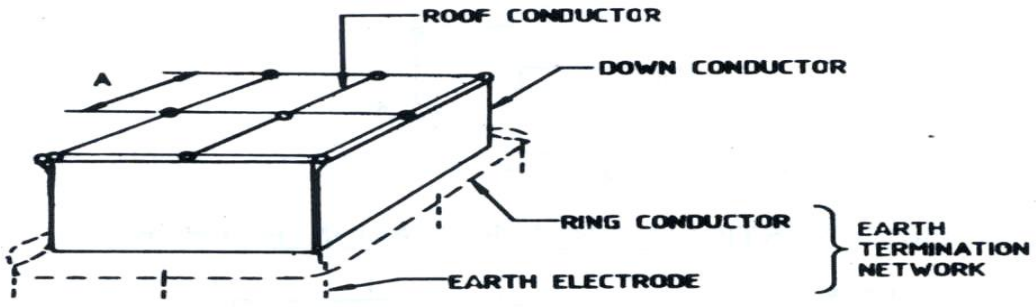

Fig 1 FIXED AIR TERMINATION NETWORK

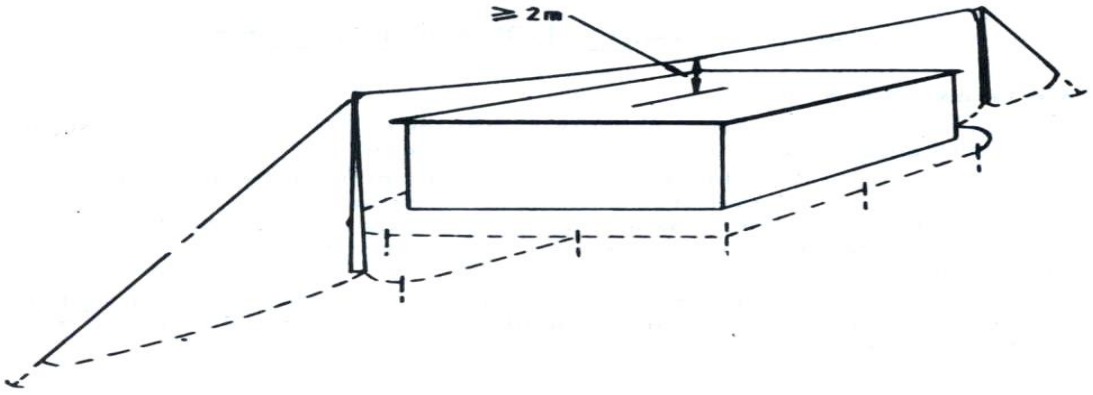

Fig 2 SUSPENDED AIR TERMINATION NETWORK

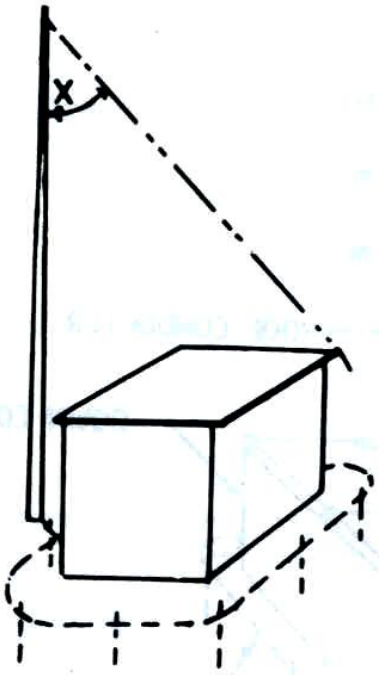

Fig 3 VERTICAL AIR TERMINATION NETWORK

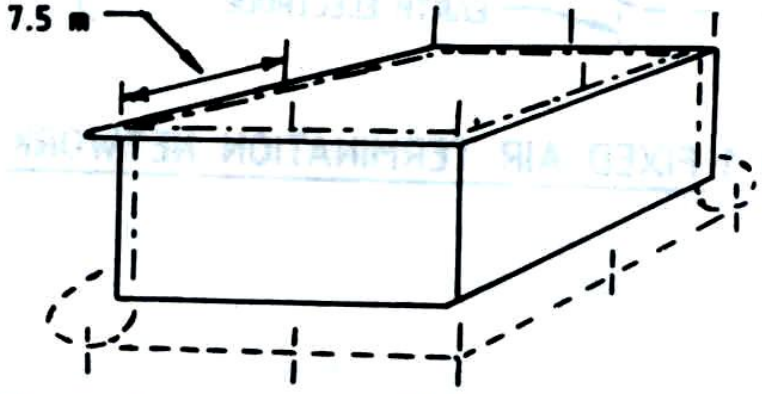

Fig 4 INTEGRALLY MOUNTED SYSTEM

Suspended Air Termination Network

7. (a) A suspended air termination network comprises of two or more poles supporting and bonded to an aerial conductor or several conductors.

(b) A supporting pole should be positioned at least 2 m from the site. When a pole consists of a non-conducting material, a conducting tape should be provided to bond the aerial conductor to the earth termination network and any stay wire should be bonded to both ends of this tape. In the case of a metal pole, any stay wire should be bonded to both ends of this pole.

(c) To prevent flash-over, the minimum clearance between the lowest part of an aerial conductor and the site it protects, should not be less than 7 m in the maximum sag condition, i.e. snow and ice.

Vertical Air Termination Network

8. A vertical air termination network comprises a single, metallic pole positioned at least 2m from the site. Any stay wire should be bonded to both ends of the pole. The height of the pole should be such as to ensure a zone of protection of at least 30° or 60°.

Integrally Mounted System

9. (a) The integrally mounted system consists of metallic pointed conductors, at least 0.6 m in height, which should be securely mounted on roof ridges, parapets and around the perimeter on flat roofs, spaced not more than 7.5 m apart. Where it is necessary to exceed this spacing, the height of pointed conductors should be increased 5 cm for each 0.3 m increase over 7.5 m. On large flat or gently sloping roofs, pointed conductors should be placed at the points of the intersection of imaginary lines dividing the surface into rectangles having sides not exceeding 15 m in length. Pointed conductors should be provided with at least two paths to earth.

(b) There should be no less than two down conductors on every building.

(c) Where an electrically continuous path can be assured by bonding or manner of construction, then metal roofs, metal walls, steel framework, and reinforcing rods (in concrete structures) may serve in lieu of all or portions of normally required down conductors.

(d) Earth-covered magazines may be protected with an integrally mounted system by mounting one pointed conductor on the top of the front wall and one on the ventilator in the rear.

Faraday Cage

10. The optimum scheme for protecting extremely sensitive operations from all form of electromagnetic radiation is to enclose the operations or facility inside a Faraday cage. However, the Faraday cage is difficult to construct and economically justified only for "one of a kind" facilities that are essential or when extremely sensitive operations warrant the level of protection it provides. The Faraday cage affords excellent protection from lightning. Effective lightning protection is provided in a similar manner by metallic enclosures such as formed by the steel arch and reinforcing bars of concrete end walls and floors of steel arch magazines and the reinforcing steel of earth-covered magazines constructed of reinforced concrete.

Down Conductors

11. Where a system of fixed air termination network is adopted, at least two down conductors should be provided around the perimeter of the site, equally spaced so far as is possible, at intervals, not exceeding 15 m. Each down conductor should be connected to an earth termination network via a test joint.

Earth Termination Network and Earth Electrodes

12. (a) Earth termination networks are to be provided as close as practicable to the building being protected, but no closer than 0.6 m from the wall footings. An earth termination network is to consist of earth electrodes, of rods, tapes or other means of providing a connection with the general mass of earth.

(b) Where rod electrodes are used they are to be driven to the depths necessary to give the desired earth resistance; the minimum depth being at which the rod penetrates into soil of constant dampness. Where more than one rod is necessary to obtain the required resistance, the spacing between the rods is to be at least equal to the driven depth.

(c) In difficult ground conditions where rod electrodes prove ineffective, e.g. in areas of deep gravel or areas having little soil cover, the use of radial type of electrodes should be considered. These comprise copper tapes laid in a trench 0.5 m deep, one tape per trench, and the trench back filled with sifted earth. The length of the radial electrodes is that, which gives the required resistance.

(d) When a building is sited on bare rock, a satisfactory earth electrode can usually be obtained by rock drilling and back filling the hole with sifted earth or a mixture of carbon powder and copper dust before driving the earth rods. Any diameter of hole, 75 mm or

greater, will usually be sufficient. Coke or fly ash must not be used as back fill, owing to their corrosive effect on copper.

(e) Water pipes or other services should not be used as part of the earth termination network system, or as the earth electrode.

(f) To allow for the isolation of the electrode during testing, the upper end of the electrode must terminate in a small pit.

(g) All earth electrodes of a system must be interconnected by a ring conductor. This ring conductor is to be buried at a nominal depth of 0.5 m below ground, unless conditions such as the need for bonding metal forming part of the building make it desirable to have the ring exposed. The earth systems of adjacent structures should be interconnected where reasonably practicable and where the ground conditions make the achievement of the required earth resistance difficult.

(h) When exposed, the ring conductor is to be attached to and encircle the building at a nominal height of 0.5 m above ground level. It is to pass through and be connected to each test joint of the system. The ring conductor, when attached to the building, is to be visible through its entire length, except that where paths and roadways make it necessary for the conductor to go underground, it may be drawn into a non-metallic pipe. (The ring conductor should not go over the top of a door opening, but should go underground as described).

Test Joint

13. (a) A multi-way, clamp type test joint should be properly constructed on each down conductor and each supporting pole, at about 0.5 m above ground level. Only the earth termination networks should be permitted below a test joint.

(b) A test joint on a supporting pole should be connected to an earth termination network, and any stay wire at points as near as practicable to the pole.

Bonding of Structural Metal

14. (a) All major items of metal on, or forming part of, a building or structure should be bonded to the lightning protection system. The welding of metal reinforcement bars to form part of the lightning protection system is not required, since the stirrup tie wires provide adequate bonding between bars. The roof reinforcement should be brought out, in at least two diagonally opposite places, and at each down conductor position, in order to be bonded to the fixed air termination network and appropriate down conductor. Where a down conductor is attached to a reinforced concrete column or a concrete-reinforced steel column, the steel work should be connected to the down conductor above the test

joint. Where the reinforcement or steel work of the column is not contiguous with the reinforcement of the roof, an additional connection to the down conductor should be made at the top of the column. It is not necessary to bond reinforcement or steel work columns other than those described neither above; nor for lengths of metal less than 2 m (i.e. metal window frames), metal ventilators and metal fittings provided they are not within 0.3 m from a conductor.

Bonding of Services

(b) The metal sheath or armour of the incoming electrical supply cable should be bonded to the lightning protection system at the point of entry to the main switch, which should itself be bonded. Additionally, the metal sheath or conduit of each circuit leaving the main switch or distribution board should be bonded to the lightning protection system. All other metal service pipes and alarm system cables connected to building should be bonded to the lightning protection system at the point of entry. All straight runs of metallic conduit, pipe work or metallic cable sheathing in excess of 15m should be bonded at both ends to the lightning protection system.

Bonding of Rails for Cranes

(c) The rails of all cranes within a building should be bonded at each end to the lightning protection system. The resistance when measured between the crane and the crane rails must not exceed 1 ohm under worst conditions of crane loading. Furthermore rails which extend beyond the building should be bonded to the lightning protection system at the point of entry.

Electrical Conductance

15. Lightning protection systems should conform to the following requirements:

(a) With all connections removed, the resistance to earth of each earth termination network should not exceed 10 ohms multiplied by the number of earth electrodes comprising the system.

(b) Exceptionally, where a buried ring conductor is provided to improve the earth resistance, this ring conductor may be considered as part of the earth termination network. In such circumstances, with all earth electrodes connected to the ring conductor, the resistance to earth should not exceed 10 ohms.

(c) With all earth electrodes connected to the system and all extraneous bonding removed, the resistance to earth of a system when measured at each point approximately equidistant between earth electrodes should not exceed 10 ohms.

(The removal of all extraneous bonding should be undertaken only for acceptance testing).

Steel framed Structure

16. A steel framed structure with cladding such as asbestos sheet may be regarded as self-protecting provided that the resistance to earth of each stanchion does not exceed 10 ohms. This measurement should be made before the electricity supply cable or any metallic service pipe is attached to the structure. Where these conditions of resistance are not met, a ring conductor, bonded to each stanchion and with earth electrodes at each end of the structure, should be provided.

Earth-Covered Building

17. An earth covered building should be protected against lightning in accordance with the above principles subject to the following requirements:

(a) Any roof conductor may be fixed directly to the roof of the building without the use of "stand-off hold-fasts" or concrete blocks.

(b) The ring conductor should run underground at a distance of 1 m from the toe of the earth-cover. It may however be taken across the head-wall, or other wall not covered with earth, at about 0.5 m above ground level.

(c) A down conductor should pass through the earth-cover at a distance of about 0.5 m from the structure. It should however be taken down the head-wall, or other wall not covered with earth, and similarly run down the top of any wing-wall.

(d) The joint between a down conductor and either a roof conductor or an earth termination network should be readily accessible for inspection pit with a cover.

Risk Assessment and Recommendations for the Selection of Lightning Protection Systems

18. The decisions whether or not to provide lightening protection and what type of system should be used for a particular building have to be based on many factors and on personal judgment table I shows factors to be considered under three headings. Select the appropriate index number for each factor; the sum of these indices indicates whether or not lightning protection is required and, if so the type of system recommended. Requirements for flexibility of use during the lifetime of buildings should be considered when indices are selected.

Relevant Documents

19. In addition to the guidance provided in this pamphlet, for other aspects like engineering design, material selection, construction, fabrication and code of practice for laying the system, BIS standard No. IS 62305: Part 1 to Part 4 Protection against lightning on the subject should be consulted.

Annexure

TERMINOLOGY

1. The following definitions are used in connection with protection against lightning:

(a) Air termination Network

The part of a lightning protection system that is intended to intercept lightning discharges.

(b) Bond

A conductor intended to provide electrical connection between the protective system and other metal work.

(c) Cone of Protection

The space coverage provided by a vertical conductor.

(d) Down Conductor

A conductor which connects the air termination network with the earth termination network.

(e) Earth Electrode

The portion of the earth termination network which is designed to provide direct electrical contact with the general mass of earth.

(f) Earth Termination Network

The part of the lightning protection system which is intended to discharge lightning currents into the general mass of earth. All parts below the lowest test joint in a down conductor are included in this term.

(g) Joint

The junction between portions of the lightning protection system.

(h) Ring conductor

The ring conductor is that part of the earth termination network which connects the earth electrodes to each other or to the down conductors.

(j) Test Joint

A joint designed and situated to enable resistance or continuity measurements to be made.

(k) Zone of Protection

The zone considered to be protected by a complete air termination network.

TABLE I
GUIDANCE FOR THE SELECTION OF LIGHTNING PROTECTION SYSTEMS

A SITE	
FACTORS	**INDEX**
1. PROXIMITY OF PERSONNEL	
None	0
Up to 5 inside building	1
Up to 10 inside building	2
10 or more inside building	3
2. PROBABILITY OF BUILDING BEING STRUCK	
Collection area (sq.m.)x Flashes/sq.km/year x 10^{-6} (See BS 6651 clause9.2)	
Less than 1 in 100,000(10^{-5})	0
1in 10,000 to 1 in10,000(10-5 to 10^{-4})	1
1 in 10,00 to 1in 1,000 (10^{-4} to 10^{-3})	3
Less than 1 in 1,000 (10^{-3})	6
3. FREQUENCY OF STRIKES ON SITE	
Nil recorded	0
One per 30 or more years.	1
One per 10 to 30 year.	2
One per 10 or less years.	3
4. LOCATION OF BUILDING	
Among buildings or trees of similar height	1
In area with few buildings or trees of similar height	2
Isolated by at least twice the height of adjacent Buildings or trees	3
5. NATURE OF TERRAIN	
Flat, at any elevation	1
Hilly	2
Mountainous, 300 to 1,000 m	3
Mountainous over 1,000 m	4

B. BUILDING AND ITS CONTENTS

	FACTORS	INDEX
6.	IMPORTANCE OF BUILDINGS	
	Very low	0
	Low	2
	Medium	4
	High	8
7.	EXPLOSION HAZARD CLASSIFICATION OF BUILDINGS CONTENTS (includes both articles & substances)	
	1.5	1
	1.4	1
	1.3 (not mass fire risk)	6
	1.3 (mass fire risk)	10
	1.2	6
	1.1	30
8.	SENSITIVITY OF SUBSTANCES IN BUILDING CONTENTS (for boxed items deduct 10)	
	RDX/Water more than 30%	0
	Picrite, TATB, etc.	1
	TNT, RDX/TNT, RDX/Water 10%	2
	RDX/Wax etc.	6
	RDX dry, HMX dry etc.	20
	Gunpowder, Lead Azide.	40
	Lead Styphnate	40
	Sensitive Pyrotechnics.	0
9.	NET QUANTITY OF EXPLOSIVE (Q)	
	All hazard divisions	
	Less than 100g	-6
	More than 100g upto 1kg	-4
	More than 1kg upto 10 kg	-2
	More than 10 kg upto 100 kg	0
	HD 1.1 Less than 1000 kg	1
	For 100 kg or more HD 1.1, Index $Q^{1/3}/10$ (Rounded up) (Q in kg)	
	HD 1.3 (mass fire risk) as for HD 1.1	
	Minus 3. (= or O)	
	HD 1.2, HD 1.3 (not mass fire risk), HD 1.4, HD 1.5	0

10	MILITARY IMPORTANCE OR BUILDING CONTENTS	
	Very low	0
	Low	4
	Medium	14
	High	70
11.	TYPE OF BUILDING STRUCTURE	
	Steel frame, non-metallic roof	1
	Reinforced concrete, non-metallic roof	2
	Brick, Concrete, Masonry, metallic roof	3
	Steel frame, encased, Metallic roof	4
	Other	5
12.	BUILDING REPLACEMENT COST	
	Less than Rs. 2.0 Lakhs	0
	2.0 Lakhs to 5 Lakhs	1
	5.0 Lakhs to 10 Lakhs	3
	Over 10 Lakhs	4
13.	RATIO OF COST CONTENTS TO COST OF LPS	
	Less than 1:1	0
	1:1 to 5:1	1
	5:1 to 10:1	2
	Greater than 10:1	3

C. LIGHTNING PROTECTION SYSTEM RECOMMENDED

SUM OF INDICES	SYSTEM RECOMMENDED
9 OR LESS	None.
9 to 22	Fixed air termination, 10 metre mesh or integrally mounted system.
18 to 35	Fixed air termination, 7.5 metre mesh
30 to 60	Fixed air termination, 5 metre mesh
55 to 85	Fixed air termination, 3.5 metre mesh or vertical or suspended aerial termination, 45degree cone of protection.
70 to 110	Vertical or suspended aerial termination, 30degree cone of protection.
90 to130	Vertical or suspended aerial termination, 15degree cone of protection.
More then 110	Suspended mesh. (special case)