SAFETY PRINCIPLES FOR STORAGE OF AMMUNITION AND EXPLOSIVES - PROTECTION OF STACKS AGAINST LIGHTNINGS

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Abstract
All stack buildings and workplaces with ammunition and explosives must be equipped with lightning protection. Lightning rod is intended to protect the object from atmospheric discharges - lightning and its destructive effects. When lightning strikes the protected object, lightning rod conducts its safe discharge directly into the ground. The protection of stacks against lightings and their secondary effects must be carried out in accordance with STN EN 62305, which has replaced STN 341390.

Keywords: lightning rod, zone of protection, discharge, grounded conducting element.

1 Introduction

This publication covers the particularities of lightning protection for ammunition handling installations and facilities. An effective lightning protection is part of the overall safety concept for the handling of ammunition and explosives. Lightning protection systems are to be designed and constructed in a way which ensures an effective and long-term protection of the ammunition against lightning discharges. Lightning protection systems must be constructed by specialist personnel and according to the state-of-the-art of lightning protection technology. As a matter of principle, installations and facilities used for handling ammunition must be equipped with lightning protection systems. Whether such systems can be omitted in individual cases is to be decided by the nations. The hazard of lightning discharges and possible consequences are to be assessed within the scope of a facility-related safety analysis. A distinction must be made between "external" and "internal" lightning protection. External lightning protection forms the basis of an effective lightning protection consisting of

- air termination network,
- down conductors, and
- earth termination network.

For internal lightning protection a lightning protection equipotential bonding must be established between the lightning protection system of a building and the metallic installations and electrical systems of the building.

2 Lightning Protection Systems for Buildings

As a rule, buildings for the handling of ammunition and explosives (explosive workshops, magazines) are equipped with two external lightning protection systems, one lightning protection system which is insulated against the building and one lightning protection system for the building itself. The insulated lightning protection system is designed to intercept high-current lightning discharges inorder to keep them away from the lightning protection system of the building itself. The lightning protection system for buildings designed for ammunition handling is to be arranged in such a way that an electroconductive cage is established. This cage must surround the building on all sides (ceiling, walls, ground). The design of the cage depends on the construction of the building.

2.1 Insulated Lightning Protection System for Buildings

As a rule, fixed air termination networks with a roof conductor in form of a mesh are applied in insulated lightning protection systems.

- The fixed air termination network is to be supported by supporting poles.
- The poles shall be positioned at least 3 m from the building.
- The mesh size must not exceed 10 m.
- Roof edges, projections, etc. shall be located at a maximum distance of 0.3m from the network.
- Even if the network sags, the minimum distance from the roof of the building must be 1.5 m.

If vertical air termination networks are used, their height and zone of protection shall be such as to ensure that the entire surface of the building will be situated within this zone of protection (see Figure 3-V). The vertical air termination networks shall be positioned at least 3 m from the site. In case there should be a barricade, the vertical air termination networks may be mounted thereupon. Instead of vertical air termination networks trees may be used and equipped with air termination networks if they are located in an appropriate position. In buildings with a complete earth of at least 0.5 m, insulated lightning protection can be omitted; this applies also to earth covers with vent pipes.

2.2 Lightning Protection Systems for Buildings

Fixed air termination networks are to be arranged on the building with a mesh size not exceeding 10 m x 10 m. Parts of the building made of nonconductive material which protrude from the network are to be equipped with suspended air termination networks and pointed conductors. Superstructures made of metal are to be bonded to the suspended air termination networks. The air termination networks of the lightning protection system of the building must be installed in the middle between the conductors of the insulated lightning protection system (top view). Each building must have one down conductor for 10 m each of the circumference of the building with four down conductors being the minimum number. Those down conductors should be positioned at least 0.5 m from windows, doors, and other openings. Above ground pipelines leading up to the buildings are to be bonded to the down conductor next to them. In the case of reinforced concrete buildings which have connected reinforcing rods, these can be used as down conductors; these buildings only require air termination networks but not separate down conductors. Reinforced concrete buildings without connected reinforcing rods are to be equipped with air termination networks and down conductors. In any case the reinforcement is to be bonded to the internal ring conductor at intervals not exceeding 10 m. For earth-covered buildings (e.g. igloo) with an earth-cover of at least 0.5 m a fixed air termination network having a mesh size not exceeding 10 m x 10 m and installed within or on the earth-cover is a sufficient lightning protection (see Figure 3-VI). For buildings with a lateral length of less than 10 m two conductors in a diagonal arrangement are sufficient. Those conductors are to be bonded to a ring conductor. Metal venting systems which protrude from the earth-cover are to be equipped with down conductors which must be bonded to air termination networks or the ring conductor. Venting systems made of non-conductive material must be equipped with air termination networks and down conductors. In buildings made of reinforced concrete the connected reinforcement can be used as down conductor; it must be bonded to the ring conductor in at least two opposing locations. Suspended air termination networks are necessary here as well. Instead of a fixed air termination network, a space screen (e.g. as alternative upgrading measure) may be inserted into the building. The space screen consists of a network of band steel having a mesh size not exceeding 2 m x 4 m on which a fine grid (5 cm x 10 cm) is installed. The space screen must surround ceilings, walls, and columns; it is to be connected to the ring conductor.

2.3 Earth Termination Networks

Each lightning protection system must be grounded with an earth termination network. In most cases closed ring conductors or grounding circuits are used for that purpose.

- The total earth resistance of the earth termination network shall not exceed 10 Ω for buildings or groups of buildings.
- The earth termination network and the lightning protection system are to be appropriately connected.
- Earth termination networks of adjoining buildings within a radius of 20 m are to be connected underground.
- Ammunition and packagings containing ammunition are usually not grounded.
- Test joints are to be integrated into the lightning protection system between down conductor and earth termination network for test and measuring purposes. They are to be situated approximately 0.5 m above ground; below the test joint only parts of the earth termination network are permissible.

All essential conductive elements of a building such as machines, equipment, heaters, and pipelines as well as large metal items (metal doors and windows, conductive floors) are to be bonded to the lightning protection system via lines.

3 Lightning Protection Systems for Open-air Stacks of Ammunition

Ammunition stacks endangered by lightning, especially those containing mass detonating ammunition are to be protected by a lightning protection system. Ammunition stacks are particularly endangered by lightning discharge if they are situated

- on mountain tops, hills,
- at the edges of woods,
- under isolated trees.

In general, four horizontal aerial conductors of a rectangular shape (e.g. zinc-coated steel rope with a cross section of 50 mm2) mounted on insulated supports (e.g. made of wood) at least 0.5 m above the upper edges of the ammunition stack are sufficient to provide lightning protection. On each of the four corners one down conductor which is to be bonded to the ring conductor shall be installed at least 0.5 m from the stack. The ring conductor is to be buried at least 0.5 m below ground with a minimum lateral distance of 1 m round the perimeter of the stack (see Fig 3 - VII). If the stacks are positioned on floor plates the latter are to be connected with the ring conductor on the four corners of the stack.

3.1 Lightning Protection Systems for Ammunition Bins

a) In ammunition bins made of concrete the reinforcement forms a conductive cage which is to be grounded using two earth electrodes (50 cm deep into the ground).

b) If ammunition bins made of wood are to be equipped with a lightning protection system, they must be provided with suitable suspended air termination networks and the conductive roof decks are to be included in the lightning protection system.

4 Minimum Distances of Ammunition from Lightning Protection Systems

Ammunition and packaging containing ammunition are to be stored so as to prevent flash over the lightning stroke from the lightning protection system to the ammunition or the packaging. Ammunition stacks in a magazine or an explosives workshop are to be positioned at a distance to walls, support, ceilings, beams, metal parts, and electrical installations which shall be:

- 10 cm at least if the lightning protection system is properly designed and meets the requirements of this chapter,

- 50 cm at least if the lightning protection system does not meet the requirements of this chapter.

5 Testing of Lightning Protection Systems

a) Each lightning protection system is to be tested upon completion. The result shall be recorded. The established values for the earth resistance are to be used as comparative values for future tests.

b) The proper condition of the lightning protection system is to be ensured by regular inspections and measurements.

References

[1] STN EN 62305 Protection against lightning. Part 3: Physical damage to structures and life hazard, 2012, p. 31-33.
[2] L. Kučera: Pokyny pro skladování, údržbu a přepravu munice v rámci rozvinutých sil nebo při operacích, Úřad pro obrannou standardizaci, katalogizaci a státní ověřování jakosti, Praha, 2010, p. 22-23.
[3] L. Kučera: Bezpečná likvidace munice – Konstrukční principy a požadavky, hodnocení bezpečnosti, Úřad pro obrannou standardizaci, katalogizaci a státní ověřování jakosti, Praha, 2005, p. 6.
[4] P. Viceník: Zásady bezpečnosti pro přepravu vojenské munice a výbušnin, Úřad pro obrannou standardizaci, katalogizaci a státní ověřování jakosti, Praha, 2007, p. 32.
[5] Standard: NATO - Stanag 4657, NATO guidelines for the storage, maintenance and transport of ammunition on deployed missions or operations, 2009, p. 14.
[6] Standard: NATO – AASTP-1, Manual of NATO safety principles for the storage of military ammunition and explosives, 2009, p. 287.
[7] Standard: NATO - Stanag 4442, ed. 1 application of risk analysis to the storage and transport of military ammunition and explosives, 2010, p. 53.
[8] Standard: NATO - Stanag 4397, NATO catalogue of explosives, 2009.
[9] Standard: NATO - Stanag 4540, explosives, procedures for dynamic mechanical analysis (DMA) and determination of glass transition temperature, 2013, p.27.