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DOD LIGHTNING PROTECTION REQUIREMENTS FOR STRUCTURES HOUSING EXPLOSIVES

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FOREWORD

This report presents the results of the Department of Defense Lightning Protection Working Group when tasked to produce a new chapter to DOD 6055.9-STD (1) on Lightning Protection for DOD Facilities. The Working Group consisted of the following:

NAME	REPRESENTING
Ignacio Cruz, Chairman	Department of Defense Explosives Safety Board (DDESB)
Raymond Vaselich	Naval Sea Systems Command (NAVSEA)
Eric Livingston	Department of Army Readiness Command (DARCOM)
Mike Aimone	Air Force Headquarters (AF/LEEEU)
John Eddy	Defense Nuclear Agency (DNA)
Scott Dow	Defense Logistics Agency (DLA)
Anthony Brown	Naval Facilities Command (NAVFAC)
Howard Stickley	Naval Facilities Command (NAVFAC)
John Gilson	Army Corp of Engineers (ACE)
Mitchell Guthrie	Naval Surface Weapons Center (NSWC)

The author of this paper is Chairman of the National Fire Protection Association Subcommittee on Lightning Protection for Structures Housing Explosives. He will discuss this parallel commercial effort during the presentation; however the text of this paper will be limited to that of DOD 6055.9-STD, Chapter 7.

References 2 through 7 provide some background information utilized in drafting of the Standard. References 2, 6, and 7 are suggested reading for those requiring a greater amount of detail on the subject.

The requirements of this Standard will often be supplemented by additional requirements from each of the services. References 8 through 11 are samples of these additional requirements.

LIGHTNING PROTECTION

A. GENERAL

The National Fire Protection Association Lightning Protection Code (NFPA 78) and the National Electrical Code (NFPA 70), as supplemented by the requirements of this Chapter, provide the minimum criteria for the design of lightning protection systems for facilities involved with development, manufacturing, testing, handling, storage, maintenance, and demilitarization or disposal of ammunition and explosives. Military Handbook 419 provides additional guidelines on surge suppression, bonding, and shielding for incoming power, communication, and instrumentation lines.

B. REQUIRED LIGHTNING PROTECTION

Lightning protection systems identified in section C., below, shall be used to protect all facilities used for development, manufacturing, testing, handling, storage, maintenance, and demilitarization or disposal of explosives in areas with more than 5 thunderstorm days per year. If thunderstorms are severe, DOD Components may determine it necessary to provide lightning protection for such facilities even if the number of thunderstorm days per year is 5 or less. Otherwise, required lightning protection may be omitted for the following:

1. Facilities equipped with an adequate lightning warning system (see section G., below), when operations can be terminated before the incidence of an electrical storm, all personnel can be evacuated, and the expected damage due to a lightning strike will not impact seriously the mission of the installation.

2. Facilities where personnel are not expected to sustain injury and at the same time the resulting economic loss to the structure, its contents, or surrounding facilities is minimal.

3. Earth-covered magazines used for the storage of ammunition and explosives in closed containers or in their approved shipping configuration. The bonding and surge suppression requirements of this Chapter apply for such magazines.

4. Facilities containing ammunition and explosives or items or systems incorporating explosive components that cannot be initiated by lightning as determined by the DOD Component concerned. These facilities and contents must not be subject to fire in the event of a lightning strike. The bonding and surge suppression requirements of this Chapter apply for such facilites.

C. PROTECTION SYSTEM DESIGN

Lightning protection systems designend for explosives facilities shall be based on a 100-foot striking distance arc as shown if Figures 1 and 2. However, for a Faraday cage this striking distance is not a consideration.

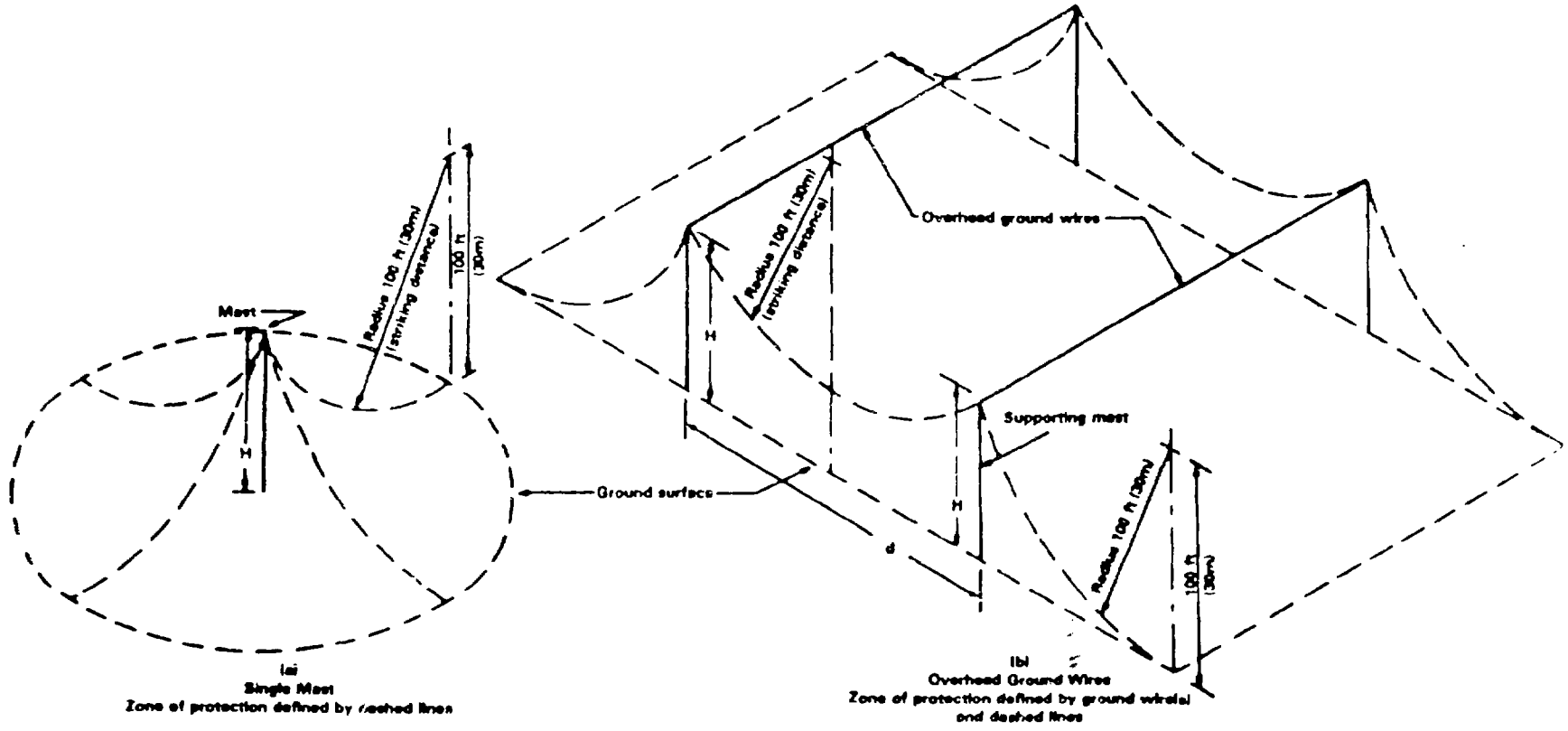

Figure 1 — Zone of Protection for Mast Height "H" Exceeding 50 Feet (15m)

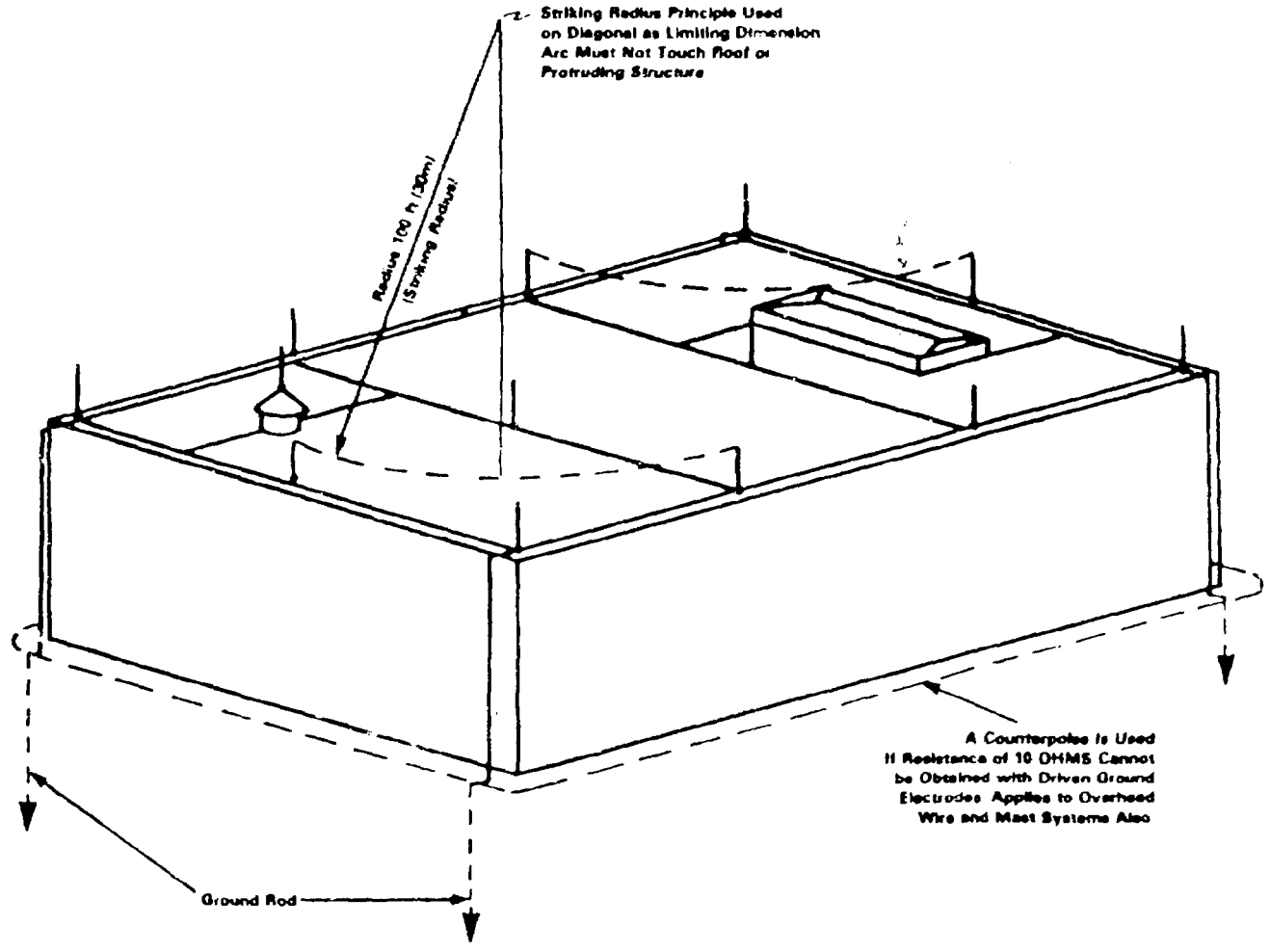

Figure 2 — Zone of Protection for Integral Systems
(100 foot striking distance)

D. TYPES OF SYSTEMS

There are four types of lightning protection systems acceptable for the protection of structures housing ammunition and explosives. They are overhead wires, masts, integral, and Faraday cage lightning protection systems.

1. Overhead Wire System

a. An overhead wire lightning protection system consists of grounded, elevated horizontal metallic wires stretched between masts surrounding a structure. Each wire shall be a continuous run of not less than No. 1/0 AWG copper or copper-coated steel cable suspended above the protected structure and connected to ground rods at each end or to a buried ground ring. The ground ring is required only if 10 ohms maximum resistance to ground is not readily attainable with ground rods. The overhead cable shall be supported by masts to ensure a minimum separation distance of 6 feet from the protected structure (including any projections), increased by 1 foot for every 10 feet of horizontal cable run parallel to the structure greater than 50 feet. The supporting mast shall be separated at least 6 feet from the structure, increased by 1 foot for every 10 feet of structure height above 50 feet.

b. An overhead wire lightning protection system will minimize hazardous side flashes and reduce otherwise necessary bonding when compared to integral and Faraday type systems. A system of this type is often recommended especially for structure with perimeters greater than 300 feet.

2. Mast Systems. A mast-type lightning protection system uses masts that are remote from the structure to provide the primary attachment point of a lightning discharge. The height of the mast shall ensure that the entire structure is enclosed in a zone of protection. Each mast shall be separated at least 6 feet from the structure, increased by 1 foot for every 10 feet of structure height above 50 feet.

3. Integral System. An integral system consists of sharp or blunt grounded air terminals of 2-feet minimum height configured on the structure. Down conductors shall be as nearly vertical as possible without unnecessary bends. Any bend shall be as gradual as possible, have a minimum radius of 8 inches, and not exceed 90 degrees. Air terminal spacings shall be designed on the 100-foot striking distance as stated in section C. above, as opposed to the 150-foot design used in Chapter 3, NFPA 78 (see Figure 2). Adequate bonding is critical to ensure that side flashes are eliminated. An integral system that is removed (for example, to permit roofing repair) shall be retested after reinstallaton.

4. Faraday Cage and Faraday Shield. The optimum scheme for protecting extremely sensitive operations from all forms 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 DOD-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.

E. GROUNDING, BONDING, AND SURGE PROTECTION

1. Grounding. Resistance of 10 ohms or less to ground for a lightning protection system is the desirred optimum. If 10 ohms resistance cannot be achieved with ground rods alone, a buried ground ring system is acceptable even if its resistance exceeds 10 ohms.

2. Bonding. The bonding of metallic bodies is required to ensure that voltage potentials due to lightning are equal everywhere in the facility. The resistance of any metal object bonded to the lightning protection system may not exceed 1 ohm to the grounding system. The material used shall be compatible with the metallic mass and down conductor to minimize corrosion. NFPA 78 shall be used as minimum acceptable bonding requirements for DOD facilities. Wires and connectors on lightning protection systems shall not be painted. Earth-covered magazines shall have their metal ventilators (if used), steel doors, metal door frames, and steel reinforcing bars bonded to the structure's grounding system. Fences shall have bonds across gates and other discontinuities and shall be bonded to the lightning protection system if they come within 6 feet of the system. Railroad tracks run within 6 feet of a structure shall be bonded to the structure's lightning protection system or its grounding system. The lightning protection system shall be bonded to all grounding systems of the protected facility.

3. Surge Protection. A lightning protectiton system for structures housing sensitive materials shall be designed for surge protection as well as lightning stroke interception. Nearby flashes will produce electromagnetic pulses that can b coupled into internal and external power, communication, and instrumentation lines. Consequently, one or more of the following shall be provided on all incoming metallic power, communication, and instrumentation lines to reduce transient voltages to a harmless level: lightning arrestors, surge arrestors, surge protectors, surge suppressors, transient power suppressors, fiber optic data lines, and isolation transformers. These power and communication lines shall enter the facility in shielded cables or in metallic conduits run underground for at least 50 feet from the structure. In addition, intrusion detection systems, utility lines (such as water, steam, and air conditioning) and other metallic lines shall run underground for at least 50 feet from the structure. The use of low-pass filters shall be considered for added protection on specific critical electronic loads as determined by the user.

F. TESTING

1. Seven-Month Test. The lightning protection system shall be inspected visually every 7 months for evidence of corrosion or broken wires or connections. All necessary repairs shall be made immediately. Transient suppression networks also shall be inspected visually at 7-month intervals.

2. Fourteen-Month Test. The lightning protection system shall be tested electrically every 14 months to afford testing of the system during all seasons. The test shall be conducted in accordance with the appropriate instrument manufacturer's instructions, by personnel thoroughly familiar with lightning protection systems.

3. Test equipment. Only those instruments designed specifically for earth-ground system testing are acceptable. The instrument must be able to

measure 10 ohms, plus or minus 10 percent, for ground resistance testing and 1 ohm, plus or minus 10 percent, for bonding testing.

4. Records. The most recent test results will be kept on file.

G. LIGHTNING WARNING SYSTEMS

1. Lightning warning systems provide a positive, reliable means of continuously monitorirng and recording atmospheric voltage gradients and can detect atmospheric conditions that may produce lightning in the vicinity. Lightning warning systems that are installed and maintained properly can detect thunderstorms up to 200 miles away and indicate the direction of approach. This may mean several hours of warning of an approaching thunderstorm.

2. Installations with lightning warning systems shall establish a specific criteria for terminating ammunition and explosives operations at the approach of a thunderstorm. This criteria shall be based on the sensitivity of the operation involved and the amount of time required to safely terminate the operations.

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