Lightning and Static Electricity

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PDH: 2

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CHAPTER 1
GENERAL

1-1. Purpose. Information and criteria in this course will guide engineering design personnel in deter- mining the adequacy of lightning and static electricity protection systems for all types of facilities. Policy and procedure of design development and tests are also included. Referenced criteria, codes, and standards are intended to include provisions for normal type facilities, which when integrated with criteria included herein, establish complete provisions for these protection systems. The standards and methods of system protection discussed are in- tended as the most practical and economical means of accomplishing protection of real property and avoidance of casualties to personnel. These criteria will not provide suitable protection for construction contractors' personnel.

1-2. Scope

a. General. The scope of this course will include adequacy of engineering design for facilities of Army, Air Force and other agencies in conformance with paragraph 1-3.

b. Limitations. Limitations within continental United States will be subject only to specific provisions of project design directives, deviations included herein or authorized by HQDA (DAEN-ECE-E) WASH DC 20314-1000, for Army projects, and HQUSAF/LEEE WASH DC 20332, for Air Force Projects.

c. Other protection systems. These criteria are not intended to support or implement separate criteria such as furnished for electromagnetic protection or electromagnetic shielding requirements.

1-3. Application. Except as included for facilities of the Army Materiel Development and Readiness Command, criteria contained in this course will ap- ply to new construction of permanent, fixed type facilities conforming to AR 415-15 within the continental United States. Where conflicts arise with criteria or design guidance of different Army or Air Force agencies, or with Federal organizations other than Army or Air Force, the most stringent guidance will govern. Criteria or design guidance will apply to overseas facilities in conformance with AR 415-36.

1-4. General

a. Separate section of a specification. Inasmuch as provisions for lightning protection involve a special type (steeple jack) trade, contract requirements for lightning and static electricity protection will be included as a separate section in project specifications.

b. Environmental considerations. Design consideration will be given to overall appearance to maintain an attractive facility in harmony with area surroundings.

c. System components. Components will conform to applicable NFPA codes, except as otherwise stated or indicated.

d. Penetration of building exterior surfaces. Where roofing, walls, floor, and waterproofing mem- branes are penetrated by components of these systems, adequate waterproofing and caulking of such penetrations will be provided. However, such penetrations will be avoided whenever possible.

1-5. Applicable codes and standards. Codes and standards referenced in this course and listed in Appendix A are to be considered as an integral part of this course,

1-6. Design development

a. Lightning protection system. When contract drawings comprise more than one sheet showing composite roof and architectural elevation, a separate sheet will be provided showing locations of air terminals, routing of roof conductors, down conductors, and grounding system pattern.

b. Static electricity protection system. Where static electricity protection for two or more rooms or areas is indicated on an architectural floor plan and cannot be shown on an appropriate electrical plan, a separate floor plan sheet showing the complete static electricity protection system pattern will be included in the project design.

1-7. Approved type systems

a. Lightning protection. Selection of the type of protective system should be as prescribed in NFPA No. 78 and MIL–HDBR-419.

b. Static electricity protection. Selection of system type should be prescribed in NFPA No. 77, MIL-HDBR 419, and MIL-STD-188-124.

1-8. Materials. Materials will conform to applicable NFPA codes, unless otherwise stated. Normally, copper materials will be specified for use below the finished grade. Stainless steel grounding devices should be used when there is a potential of galvanic corrosion of nearby steel pipes. UL listed compression- type connectors may be used where such connectors are equivalent to the welded type. Special consideration will be given to selection of materials to compensate for the following conditions as encountered at project locations:

(1) Corrosive soils and atmosphere.

(2) Atmospheric and ground contact corrosion.

(3) Electrolytic couples that will accelerate corrosion in the presence of moisture or ground contact corrosion. This must be prevented by use of same type metals, or by providing junctions of dissimilar metals in air that will permanently exclude moisture.

(4) Equal mechanical strength or fusing capability where conductors of different metals are joined.

CHAPTER 2
LIGHTNING PROTECTION

2-1. Discussion

a. Lightning phenomena. The planet earth is similar to a huge battery continuously losing electrons to the atmosphere. These electrons could be lost in less than an hour unless the supply is continually replenished. It is widely agreed among physicists and scientists that thunderstorms occurring thousands of times daily around the earth return electrons to earth to maintain normal magnitude of electrons at or near the surface of- the earth. The rate of electron loss from earth, called the “air-earth ionic current”, has been calculated to be 9 microamperes for every square mile of earth’s surface. Thunderstorms supply electrons back to earth with an opposite electron potential gradient of perhaps 10 kilovolts per meter within a thundercloud. This feedback forms a potential difference of from 10 to 100 megavolts in a single dis- charge between the center of a cloud and earth. These lightning discharges carry currents varying from 10 to 345 kiloamperes to earth at an average rate of 100 times per second with duration of less than ½ second per flash. Each flash consists of up to 40 separate strokes, each stroke of lightning lasting for these brief instant releases about 250 kilowatt- hours of energy-enough to operate a 100-watt light bulb continuously for more than three months at the rated voltage of the lamp. Lightning discharges do not always bring electrons to earth, because so-called positive ground-to-cloud strokes consist of low power energy transmissions from earth to small negative charge pockets in a thunder cloud. However, magni- tudes of discharge voltages and currents are approximately the same from cloud to earth, and all occur within the same discharge timeframes. Just before the lightning flash, the ground within a radius of several miles below the cloud becomes deficient in electrons. Repelled by the army of electrons in the cloud base, many of the free electrons on the ground are pushed away. The result is that the ground beneath the cloud base becomes more positively charged. As the cloud moves, the positive charge region below moves like its shadow. As the cloud charge balloons, the pressure becomes so great that a chain reaction of ionized air occurs. Ionization is the process of separating air molecules into positive ions and negative electrons. This air which is normally a good electrical insulator becomes a good conductor and allows the cloud electrons to pierce the faulted insulation and descend this newly created ionized air path be- tween cloud and earth. The lightning flash starts when a quantity of electrons from the cloud heads toward earth in a succession of steps, pulsing forward with an additional step every 50 microseconds creating a faintly luminous trail called the initial or stepped leader. As the leader nears the ground, its effects create an ionized streamer which rises to meet the advancing leader. When the two join, the ionized air path between cloud and earth is completed, and the leader blazes a faint trail to earth. Immediately a deluge of electrons pours from this lightning discharge channel creating the brilliant main or return stroke that produces most of the light we see, the motions of the leader and the main or return stroke appear to move in opposite directions, but lightning is not an alternating current, since the transferred electrical recharge current moves back to earth.

b. Nonconventional systems. Nonconventional and unacceptable systems include the so-called dissipation array, and those using radioactive lightning rods, Radioactive lightning rods have been proven less effective than passive air terminals in storm situations. These systems have not been recognized by NFPA or UL. Use of these systems will not be permitted unless specifically approved by the appropriate using agency. Dissipation arrays consist of two types:

(1) A high tower with top-mounted dissipation suppressor, and radial guy wire array. This type is used on isolated high towers, antenna structures and offshore facilities.

(2) A series of high towers located beyond a given area to be protected and supported by several sharp pointed strands of barbed wire for the protection array.

c. Code applicability. NFPA No. 78 is intended to apply to the protection of ordinary buildings, special occupancies, stacks, and facilities housing flammable liquids and gases. The lightning protection code will be utilized where lightning damage to buildings and structures would cause large economic loss or would prevent activities essential to the Department of Defense. NFPA No, 78 does not relate to the protection of explosives manufacturing or storage facilities. Protection for these facilities will be in accordance with paragraph 2–9. Since NFPA No. 78 does not pre- scribe a comprehensive coverage pattern for each type of facility required by the military departments of the government, additional guidance is given in this chapter. Temporary DOD storage facilities and structure housing operations not regularly conducted at a fixed location and other facilities specifically exempted by the responsible using agency are not governed by the lightning protection code.

d. Effects of lightning discharges.

(1) General. When any building or structure is located within a radius of several hundred feet from the point where a lightning discharge will enter the surface of the earth, the lightning discharge current becomes so high that any building or structure within this radius becomes vulnerable to immediate damage.

(2) Nature of damage. Damage may range from minor defacement to the building to serious foundation upheaval, fire and personnel casualties. Damage control can be effective dependent on extent of fire- proofing and lightning protection incorporated into the project design. Although lightning strokes generate static discharges in the form of radio noise, it is generally accepted that this cause only an instant of interference to manmade electronic systems. Increased heating effects are also a factor since a lightning bolt increases the temperature of the lightning channel to about 15,000 degrees C. This sudden in- crease in temperature and pressure causes such an abrupt expansion of air that any hazard type of atmosphere which comes within the ionized air path of the lightning bolt becomes explosive. The explosive nature of the air expansion of bolt channels can cause physical disruption of structures located near the lightning stroke. Lightning discharges below the earth surface sometimes fuse sand into fulgurates which appear like glass tubes. Trees of 40 feet or more in height are especially vulnerable targets for attraction of lightning discharges, and are susceptible to being totally destroyed.

e. Effective resistance to ground.

(1) The lightning protection system will be designed to provide an electrical path to ground from any point in the system, and that point will be of considerably lower resistance than that otherwise available by use of the unprotected facility.

(2) Low resistance to ground is desirable for any lightning protection system but not essential. This is in conformance with NFPA No. 78 and MI L–HDBK–419. Where low resistance to ground is mandatory, grounding electrode patterns as described herein and MIL-HDBK-419 will furnish ample length of electrical path in contact with earth to dissipate each lightning discharge without damage to the protected facility.

2–2. Limitations in use of lightning protection

a. General. Lightning protection will be installed as part of the initial construction project, particularly in view of long replacement time and high cost of structures. Installation cost of lightning protection systems during project construction is small when compared to the cost of the installation as a whole. Economic and operational considerations will be made in determining the need for a lightning protection system, unless otherwise directed by the using agency. Unless lightning frequency at the project site averages five or less thunderstorms per year, as indicated in figure 2-1, lightning protection will be provided for buildings and structures as follows:

(1) Buildings of four floors having elevator or stairwell penthouses or other similar projections above roof.

(2) Buildings of five floors or more with or without projections above roof.

(3) Structures such as steel towers, aluminum and reinforced concrete towers, and flagpoles without inherent grounding, and smokestacks and steeples of 50-foot elevation or more above lowest point of contact with finished grade.

b. Other applications. Special consideration will be given in determining need for lightning protection as follows:

(1) Whether building is manned, and there is inherent hazard to personnel.

(2) Whether building contains explosive or hazardous areas or rooms, weapons systems technical equipment, or security communication equipment.

(3) If an unprotected building is destroyed by lightning, the length of outage which can be tolerated until replacement is made. This includes the restoration of high priority facilities such as water supply, weapons systems, police and security intelligence communications, strategic communication system operating components.

(4) Replacement of building contents and value thereof.

2–3. Air terminals. The purpose of air terminals is to intercept lightning discharges above facilities. Air terminals will be in accordance with UL 96, and 96A, NFPA No. 78 or MIL–HDB-419. Where building roof is not metal and building construction includes steel framing, air terminal connection assemblies will conform generally to figure 2-2.

2-4. Grounding

a. General. Grounding generally should conform to NFPA No. 78, except as required by the using agency. Guidance for grounding for purposes, such as electromagnetic pulse (EMP), electro- magnetic interference shielding, NASA and HQDCA electronic facility grounding, are subjects of other engineering manuals which govern grounding requirements. Those grounding systems will also serve as grounding of the lightning protection system. Where separate systems are installed such systems will be bonded below grade to any other independently in- stalled exterior grounding system such as for electro-

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