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Pantex Lightning Study Recommendations Report

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Abstract

A brief history of lightning protection at Pantex nuclear explosive areas (NEAs) is given. An assessment of current Pantex lightning protection at NEAs is summarized. Recommendations for further improvements in lightning protection are described.

Contents

Acronyms

AWE	Atomic Weapon Establishment
DOE	Department of Energy
EED	electroexplosive device
ESD	electrostatic discharge
LLNL	Lawrence Livermore National Laboratory
LPC	Lightning Protection Corporation
NEA	nuclear explosive assembly
NESS	Nuclear Explosive Safety Study
MOV	metal oxide varistor
SNL	Sandia National Laboratories
TDR	time-domain reflectometer

Pantex Lightning Study
Recommendations Report

1. Introduction

Early approaches to prevent lightning threats to nuclear explosive areas (NEAs) relied on the protection provided by air terminals as specified in the lightning codes required by both the National Fire Protection Association and the U. S. Army Corps of Ordnance. Although in 1976 inspectors from Sandia National Laboratories (SNL) and Lawrence Livermore National Laboratory (LLNL) confirmed that the lightning protection systems strictly complied with the lightning code, R. D. Jones, SNL, was concerned that partially assembled weapons—those with exposed detonator cables connected to partially assembled weapons—could be exposed to magnetic fields during the period in which the weapons were moved on the ramp. He estimated the close-in magnetic field could be as high as 300 A/m[1] with the probability given as once every ten years. Jones's analysis is included in the *Nuclear Explosive Abnormal Environments Reports at Pantex Plant* for the issues printed February 1978 and February 1993.

In 1989, after the incident in Building 12-44, bonding and grounding at the NEA received special attention. Following advice from M. E. Morris of SNL, Pantex requires that production technicians who work on electrical systems of partially assembled weapons should be bonded to the weapon cases and to the accessory equipment in order to prevent inadvertent initiation of electroexplosive devices (EEDs) by ESD. However, to prevent unnecessary exposure to the possible electrical stress of a lightning strike, the technician should not electrically connect the case of the nuclear assembly to the ground loop. The incident in Building 12-44 also precipitated the formation of the Pantex Tester Review Committee (chaired by Dave Dean and convened December 1989 through July 1990). The committee's final report evaluated the arrestors on the power distribution lines, determined that their responses were too slow, and recommended proper installation of fast-response surge-protection arrestors.

On October 11, 1991 use of AC testers in the W76, W78, W87, B83, and W88 assembly areas was prohibited at Pantex by the Nuclear Explosive Safety Study (NESS) until the fast response AC surge arrestors were installed. Around this time, a Dynatech model MB-400/600A, 3-Phase 120-Volt AC surge protection box was installed in the Electrical room in Building 12-84.

In a letter to Ken Pierce (Mason & Hanger - Silas Mason, Inc.) on October 21, 1991, M. E. Morris and K. C. Chen (SNL) recommended that in the absence of fast response surge arrestors, use of AC testers in assembly areas should proceed with a prudent administrative control, (e.g., suspending the use of AC testers when national lightning network indicated direct-strike lightning within ten miles of Pantex or when the electric field reading from a field mill exceeded the static field intensity of 2 kV/m). Furthermore, proper installation procedures were given and a less bulky Lightning Protection Corporation (LPC) arrestor, LPC23618, was recommended instead of the Dynatech surge arrestor. Shortly afterward, the SNL/Pantex Tester Group recommended installation of small metal oxide varistors (MOVs) at the front end of AC testers.

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[1] This is the Stockpile-to-Target Sequence (STS) level for fully assembled weapons.

The surge arrestors limit the voltages between the power distribution lines (hot legs, neutral, and ground). It was further recommended in the letter that a review of all conductors and associated grounding should be conducted by Pantex and SNL. The Electromagnetic Analysis and Test Department would provide the necessary analytical and computer modeling of lighting strikes to the exterior metallic structures, and demonstrate that the recommended LPC arrestors function adequately by testing. In May 1992, Mason and Hanger awarded a contract to SNL to perform these tasks and to provide further recommendations to enhance Pantex safety to the lightning threat. This report fulfills this task.

2. Summary of Analysis and Test Report

Laboratory testing was performed of the LPC arrestors in a configuration electrically equivalent to that in NEAs (with MOVs simulating the front end of an AC tester and an LPC arrestor in the electrical room). When the power distribution lines on the secondary of the transformer in the electrical room were subjected to typical 8-kV and 25-kV lightning waveforms, the input voltages at the AC testers were limited to a few hundred volts [J. E. Solberg and P. Holmes, *Pulse Tests on Pantex Surge Suppressors*, Sandia report, February 1993]. This clearly demonstrated the efficacy of the surge protection.

In a worst case, when a direct lightning strikes air terminals or some protrusions (e.g., vents), the maximum voltages between different points of the building conducting structure are calculated to be 3 kV for a bay, 10 kV for a cell, and 100 kV for the ramp [K. O. Merewether and K. C. Chen, *Evaluation of the Electromagnetic Effects due to Direct Lightning to Nuclear Explosive Areas at Pantex, Final Report*, SAND93-2517, November 1993]. It is unlikely that these voltages in the bays and cells will cause safety concerns; and because the partially assembled weapons are enclosed in shipping containers, the higher voltage value in the ramp does not cause safety concerns, either. Of greater concern are the power lines entering the bay and cell interior if these lines are not bonded to the wall rebar at the penetration points. This issue is addressed in the recommendations.

3. Recommendations

The present analysis and tests demonstrated that direct lightning strikes to air terminals or overhead ground wires do not cause significant voltages on conductor loops inside the NEAs. By avoiding connecting the weapon assembly electrically to the static ground bus, the potentially large voltage (a few kVs) induced on the rebar cannot directly couple to weapon subsystems. Nuclear weapon assembly at Pantex is extremely safe from the abnormal lightning environments. The following recommendations are compiled not because we have found any safety problems but rather to enhance further the safety of these operations.

Operational. With proper installation of the LPC arrestors and tester MOVs, AC testers are no longer a safety threat during a lightning storm. It is recommended that during static alert and lightning storm alert, use of AC testers at the NEAs be allowed.

Test and Analysis. Although blueprints of cells and bays were reviewed to determine the quality of the electrical bondings to the wall rebar at the metallic penetrations to the building interior, it cannot be ascertained whether these bondings will divert the lightning current to the wall. Contact resistance of typical rebar joints are in the range of 3 to 10 ohms [G. A. Seely and P.

Holmes, *Rebar Junction Contact Resistance*, Sandia National Laboratories, Electromagnetic Test Report, May 1993]. If there is no electrical bonding between the metallic penetrants and the wall rebar, voltages that occur in the ramp can be transferred to the cell and bay interiors. These high voltages are a safety concern.

It is recommended that Pantex and SNL jointly develop a penetration tester using the concept of a time-domain reflectometer (TDR). A TDR with appropriate current source can determine the quality of the junction of the line penetration and the wall rebar. When such a test indicates the junction is well bonded, the large voltage in the ramp will not appear inside the cell and bay.

A low-current MOV characteristics tester can be helpful in determining whether the MOVs in the testers and the lightning arrestors are still functional. When this tester is properly designed, it can be used as part of routine maintenance.

To ensure that a large voltage does not occur at the intersection of the reinforced concrete floor and wall at magazines in Zone 4, it is necessary to develop an RF attenuation tester on a TDR joint tester.

Because older sections of the NEAs are not protected by overhead ground wire lightning protection systems, it is recommended that Pantex and SNL jointly design an overhead ground wire system for optimum protection against lightning. A poorly designed overhead ground wire protection system may not provide an improvement over an air terminal system. A very well designed overhead ground wire protection system can reduce the voltage coupling to the interiors of bays and cells by as much as a factor of ten.

Proper Installation of Overhead Ground Wire. When a design is available for erecting an overhead wire protection system, Pantex should proceed with the installation of such a system over the older section of NEAs. The enhanced safety to the NEA operation during a lightning storm is well worth the minimal cost for such an installation.

Related Lightning and ESD Study. Lightning protection systems used in the U.K. and in the U.S. DOE complex were compared during a joint conference held June 21 through 25, 1993, at Pantex and which involved representatives of SNL, Pantex, and the Atomic Weapon Establishment (AWE), Burghfield, England.

At the AWE, all conducting structures are connected. The counterpoise buried ground wires of the overhead lightning protection system are connected at many locations to the building rebar, which are in turn connected through the conducting floor to the technicians and the partially assembled weapon. At Pantex, the counterpoise buried ground wires are connected to bays and cells indirectly through the static grounding grid. The technicians are bonded only to the local conducting object; because Pantex floors are not conducting, there is no direct conducting path from the counterpoise ground wire to the technicians or the partially assembled weapon.

Although both Pantex and the AWE practices are sound, a joint investigation by Pantex (with SNL) and the AWE to document the technical justification for the practices is recommended. Furthermore, this investigation can enhance the electromagnetic safety (including lightning and ESD safety) at Pantex and the AWE.

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