EMP SHIELDING

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1. GENERAL

1.01 This section discusses and provides standards for EMP Shielding. These standards are provided for use in the design of new buildings or building additions that are intended to house telephone equipment that meets the requirements of Bell System Practice 800-610-164, "New Equipment-Building System (NEBS), General Equipment Requirements."

1.02 This practice supersedes Section 8.3 of Specification X-74300, "NEBS Building Engineering Standards (BES)." This issue corrects availability information for the last reference.

DESCRIPTION

1.03 Electronic communication equipment, especially equipment with digital logic circuits, is susceptible to disturbances caused by currents excited by electromagnetic fields. These fields can be generated by either a pulsed or continuous wave source external to the building housing the equipment. The following paragraphs review the nature of electromagnetic-pulse (EMP) sources (Fig. 1 depicts an EMP source region), the test procedures to determine potential interference levels, and recommended practices for shielding against this source of interference. Information about the nature of radio frequency interference (RFI) shielding is included in Section 760-220-100.

2. ELECTROMAGNETIC PULSE

2.01 A nuclear detonation can generate a transient, high-level, electromagnetic field which rises to a peak in tens of nanoseconds and lasts several microseconds. This pulsed field is known as the electromagnetic pulse (EMP). The high-altitude detonation, which potentially can illuminate a geographical area larger than the continental United States, is considered the most serious threat. Some discussion of EMP appears in Section 001-780-201 LL, Issue B, Long Lines Plans for Survivable Communications.

2.02 The high-altitude or exoatmospheric nuclear detonation releases large amounts of energy in the form of gamma ray radiation. Gamma ray radiation travels radially away from the burst point and upon entering the atmosphere scatters electrons. The electrons are deflected by the geomagnetic field, producing nonradial components of current flow which generate radiated fields. These emanate from a saucer-shaped source region between 20 and 40 kilometers above the earth.

2.03 In order to protect against EMP effects, a communications facility must shield equipment from illumination and also from the large currents that may be induced on building penetrations. (See Fig. 2.) These penetrations include commercial power lines, cables, conduits, pipes, and, in the case of microwave stations, waveguide runs. The building can maintain acceptable interior field and current levels by appropriate shield design and treatment of penetrations.

2.04 The shielding from direct illumination is attained by the use of solid sheets or by steel reinforcing bars in the walls, roof, and floor slabs. When reinforcing bars are used for shielding purposes they must be bonded at crosspoints, with a stable nondeteriorating electrical bond to provide

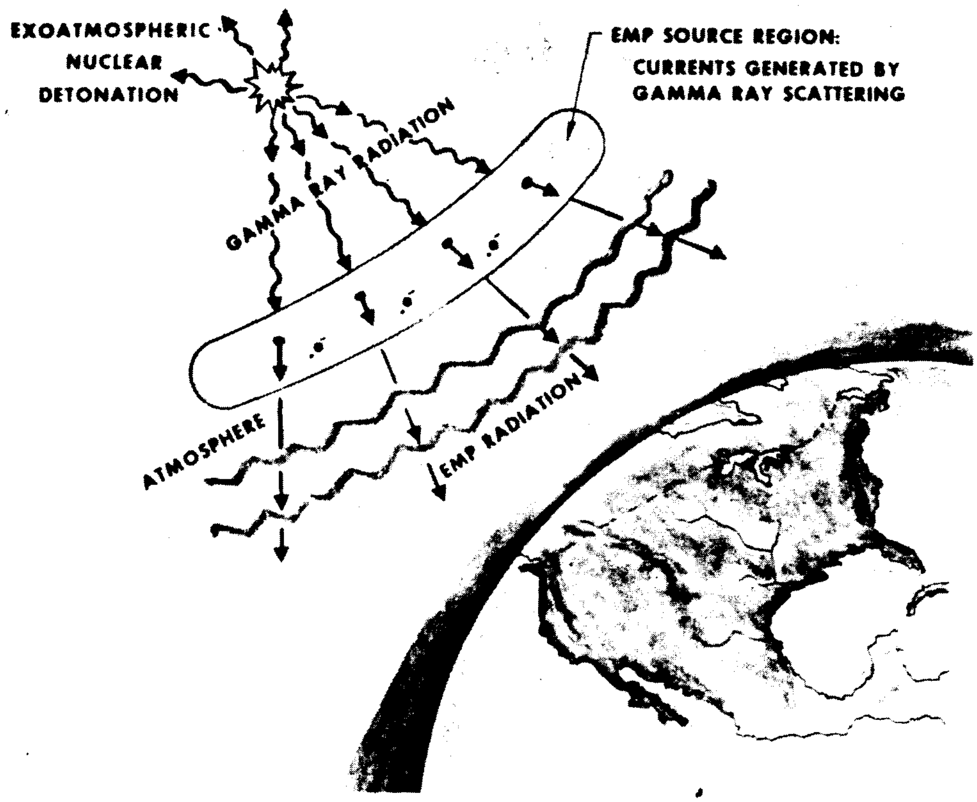

Fig. 1—Illumination of Continental United States by Electromagnetic Pulse (EMP)

an electrically continuous metallic cage around the space enclosed by the building. The shielding results from the incident fields inducing current and charge distributions, which generate secondary fields that tend to cancel the incident fields. To reduce internal building currents, the external grounding system must provide the induced currents with a low-impedance path to earth. Grounding requirements are discussed in Section 802-001-180, Protective Grounding Systems.

2.05 The requirements for maximum spacing for reinforcing bars and guidelines for tying them are included in the hardened building specifications:

Specification X-76084—Design Criteria for 2 PSI Hardened Buildings

Specification X-76071—Design Criteria for 10 PSI Hardened Buildings

Specification X-76091—Design Criteria for 50 PSI Hardened Buildings

Further descriptive material on recommended building practices appears in the EMP designers handbook.

2.06 Penetration shielding is accomplished by partially reflecting the penetration current and by diverting the remaining current from the interior of the building to ground. For pipes, conduits, and cables, grounding is accomplished by welding sleeves into a steel plate and bonding the outer metallic jackets of the penetration to these sleeves. The steel plate is then appropriately grounded to the building's reinforcing steel and the earth. The steel plate shields are designed to (1) avoid current concentrations that could generate locally high electromagnetic fields, and (2) avoid alternate paths for the current to enter the building. A description of the penetration shield appears in the hardened building specification X-76071.

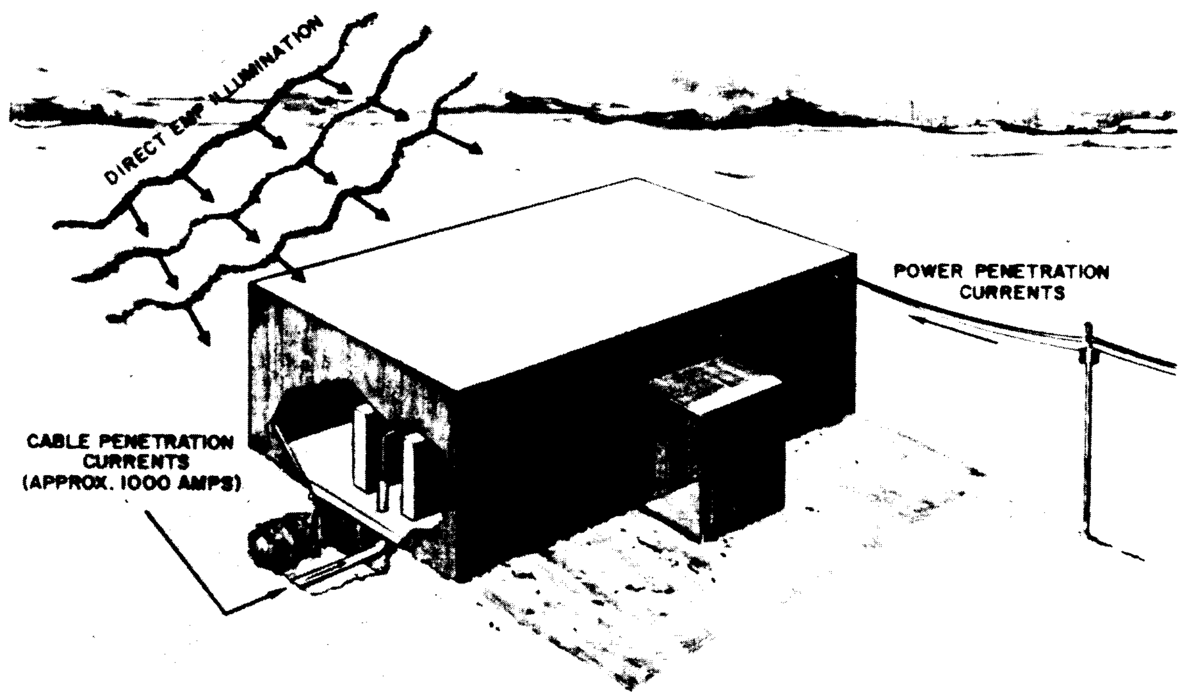

Fig. 2—Modes of EMP Interaction Direct Illumination and EMP—Induced Penetration Currents

2.07 Filters must be put on the lines to prevent transients on power lines and signaling cables from entering the buildings. These filters must provide the transient currents with a low-impedance path to the penetration shield plate.

2.08 A test procedure to determine if a building provides sufficient shielding from an EMP is described in Section 760-150-001, EMP Shielding Test Procedure. The test layout consists of a horizontal loop placed around the facility and excited by a continuous wave source in the frequency range of 1 of 50 kHz. Magnetic field levels are measured on the interior of the building using small loop sensors. It is recommended that prototype hardened buildings be tested.

2.09 At all prototype L4 and L5 power feed and main stations, in addition to the horizontal loop, a vertical conducting loop must be installed around the building at time of construction. This loop, which is also excited by continuous wave signals, is described in Specifications X-76071 and X-76091. The loop orientations used for testing below-grade buildings is shown in Fig. 3. If any serious shielding degradation (as defined in Section 760-150-001) is observed, the cognizant plant engineer should determine the proper procedure for correcting the problem.

3. REFERENCES

Section 001-780-201 LL, "Engineering Planning—Long Lines Plans for Survivable Communications"

Section 760-150-001, "EMP Shielding Test Procedures"

Specification X-76071, "Design Criteria for 10 PSI Hardened Buildings"

Specification X-76084, "Design Criteria for 2 PSI Hardened Buildings"

Specification X-76091, "Design Criteria for 50 PSI Hardened Buildings"

MIL STD-442, "Measurement of Electromagnetic Interface Characteristics"

MIL STD-463, "Definitions and Systems of Units, Electromagnetic Interface Technology"

"EM Shielding of Building Materials," AD 667 546, U.S. Dept of Commerce, Feb 1968

"EMP Engineering and Design Principles," Bell Telephone Laboratories, 1975. (Available from W. E. Co. Inc., Indiana Publication Center, P. O. 26205, Indianapolis, Indiana, 46226

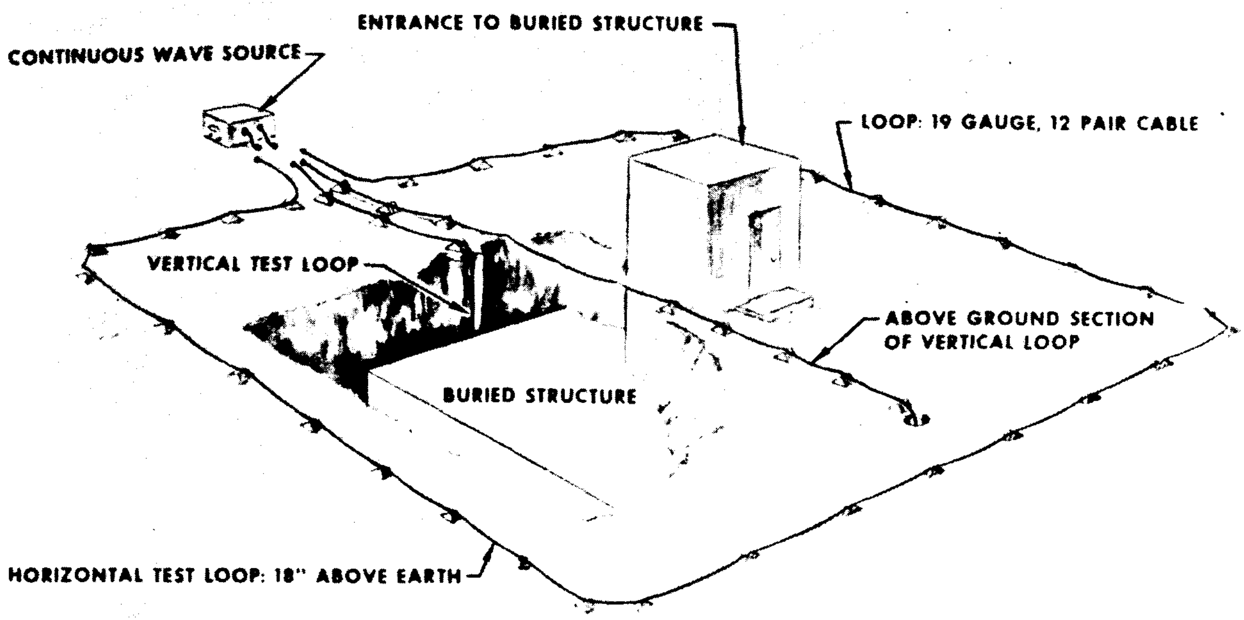

Fig. 3—Two Loop Configurations for Test of Buried Building Shielding Effectiveness

4. EMP SHIELDING STANDARDS

1. Consider effects of exoatmospheric nuclear detonations on hardened communication facilities.

2. Provide solid sheets or steel reinforcing bars in walls, roof, and slab to shield against direct illumination.

3. Specially design the building and all metallic elements that penetrate the shield to meet the appropriate Bell Laboratories design criteria.

4. Provide filters on power lines and signaling cables that enter building.

5. Provide a vertically oriented conducting test loop around each prototype building at time of construction.

6. Measure magnetic field levels in equipment room during excitation of test loops by a 1- to 50-kHz continuous wave source.