Progress in the Development of HEMP Protection Standards for C3I Facilities

George H Baker, James Madison University
Clinton R Gordon

Available at: https://works.bepress.com/george_h_baker/13/
DOE is involved in DEMP standards development efforts which culminate 25 years of research. This paper provides an ERM protection standard for fixed, ground-based communication facilities. The standard uses a low-risk hardening approach which depends on an electromagnetic barrier (composed of a conducting shield with protective devices for points of entry through shield) to prevent harmful transients from reaching communication equipment. The standard is the first of its kind and is being instituted as part of the MIL-STD-188 series.

The existence of an electromagnetic pulse from a high-altitude nuclear detonation (more appropriately referred to as DEMP) is well established within the Department of Defense (DoD). DEMP constitutes a potential threat to the operation of electronic systems. DEMP can be expected to induce large electrical transients (up to 1000's of amps) on the wiring leading to electronic subsystems in unhardened systems. As a result, both unacceptable upsets and mission-shortening damage to electronic components are possible. Thus, DoD tasked the services and agencies to develop guidelines to reduce the possible vulnerability of critical systems.

This paper will briefly describe DoD efforts to standardize a hardening approach for critical fixed, ground-based command, control, and communication (C3) facilities.

The overall goal for a DEMP hardening program is to establish, with acceptable confidence, that DEMP will not produce unacceptable effects on system performance. To support this goal, the DEMP hardening design must be both effective and verifiable. The basis with which hardness can be verified depends on the harden approach that is adopted. The approach adopted by both C3 hardening (FGEO) facilities is called the low-risk hardening approach.

The low-risk hardening approach relies principally upon an electromagnetic barrier to prevent unacceptable electrical transients from reaching potentially susceptible system components. The barrier consists of (1) an electromagnetic shield (steel or copper) which fully encloses all mission critical components, and (2) treatment of each electrical penetration of the shield and each aperture in the shield to adequately attenuate the transmission of conducted transients. The number of shield penetrations and apertures is strictly controlled to facilitate validation testing. Figure 1 illustrates the low-risk hardening approach. The hardening approach will be promulgated in MIL-STD-188-125 in early 1990.

Even though MIL-STD-188-125 is in draft, some requirements are firm enough to provide advance information to industry. These requirements are:

a. The shield will be of welded steel or brazed copper to provide 1000B of attenuation.

b. A modified version of MIL-STD-285 will be used to determine shielding effectiveness (SE). Figure 2 details proposed SE testing requirements.

c. Fiber optics for telephone circuits will be mandatory.

d. A two-step testing will be required: (1) Testing for construction acceptance to include both shielding effectiveness testing and pulse current injection (PCI) testing to ensure points of entry (POE’s) protective devices meet specifications. (2) Validation testing to ensure completed facility (all equipment installed) will function when stressed with simulated DEMP induced transients. The exact methodology for acceptance and validation testing has not been finalized; however, major elements of a methodology have been incorporated into the draft MIL-STD-188-125.

The testing methodology that is presently in the draft standard consists of:

1. Verification that
the electromagnetic energy only enters at the deliberate POE's, (2) estimation of the HEMP threat-induced stresses at the "interface" defined by the HEMP protection barrier, (3) imposition of threat-equivalent stresses on the system at this interface, (4) observation of the functional response of the system, (5) assignment of the observed response to a pass or fail category, and (6) inference of system hardness based on the results of repetition of steps (1) - (5).

The test techniques employed in the methodology are local illumination (MIL-STD-285), continuous wave (CW) field illumination, and pulsed current injection (PCI). The CW field illumination tests consist of exposure of the system to radiated fields and measurement of stresses inside the system barrier shield. The CW tests establish the adequacy of shielding and provide a check on the hypothesis that electrical penetrations (e.g., power and signal cable penetrations) are the dominant source of HEMP-induced stresses inside the system. The PCI tests consist of driving expected HEMP-induced stresses (plus any desired margin) on electrical penetrations of the shield and observing the functional response of the system and electrical stresses inside the system. The functional responses and interior stresses observed during PCI testing form the basis for determining system hardness. Test equipment for PCI testing is identified in Table 1.

The MIL-STD-188-125 will establish pass/fail criteria for hardness assessment. Presently, SE is set at 106dB at frequencies as shown in Figure 2. A set of norm attributes (action, peak current, peak rate of rise, and rectified impulse) will be used to characterize the residual internal transient stresses.

Some technology development must occur to facilitate implementation of MIL-STD-188-125 requirements. For example, a need exists for EMIs doors capable of maintaining 106dB shielding effectiveness during extended use. Current injectors must be developed to simulate transients induced by a HEMP. There is also room for improvement in terminal protection designs, particularly isolation filters and transformers.

MIL-STD-188-125 is an important milestone in that it institutes enforceable protection requirements. The requirements are performance related for the most part to encourage innovative HEMP protection designs.

References