



UNDERSTANDING EMP TESTING

***Presented By:
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Advanced Fusion Systems LLC***



EMP Yield

For a 1 megaton explosion at high altitude,
the total energy release radiated as EMP is
roughly 10^{11} joules (hundred's of GigaJoules).

1977 DoD/DoE Report



EMP Testing Considerations (1)

- Accurate testing for EMP susceptibility is a non-trivial activity
- Indoor vs Outdoor Testing:
 - Size of test cell (must be large enough to avoid echo problems)
 - Legality of outdoor testing
 - A radiated E Field is limited to 0.5 Volts / meter at edge of property. Difficult to achieve with true EMP pulse as near field extends for 10's to 100's of km
 - Significant Hazard to passing aircraft and satellites
 - Interference with government radio services
 - “Never been a problem”, then they probably aren't testing at power.
 - **ALL USG outdoor EMP ranges have aircraft and satellite deconfliction**



EMP Testing Considerations (2)

- Instrumentation: D Dot, B Dot, Free Field, Rogowski, Wideband Current Shunt, etc.
- Sensor Calibration
- Elimination of Noise,
- Synchronization of signals
- Simultaneous testing of parameters
- Is hard x-ray produced by generator?
 - Any system running over 23KV will produce x-rays
- If you can pick up the source, it isn't big enough, no matter what the manufacturer says. A real EMP source weighs tons.



E-6B During EMP Testing at Pax River



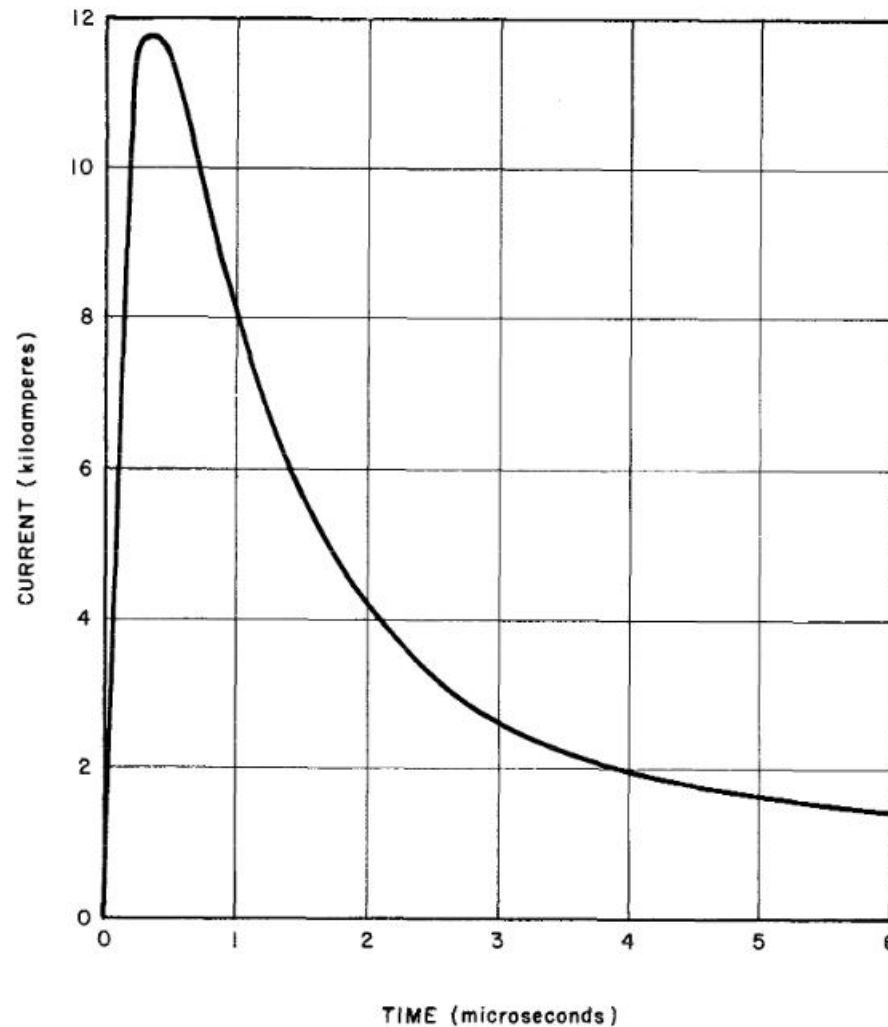
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Where There's an E Field, There's a B Field

- The fundamental physics governing the generation of EM pulses says that an E Field is always accompanied by a B Field orthogonally disposed to it.
- At frequencies below 100 MHz, the ratio of energy distributed between the E field and the B field shifts to be heavily weighted towards the B field
- The bulk of the energy in an EMP pulse falls well below 100 MHz and thus the B field portion of the pulse is extremely important and cannot be ignored.
- Conventional Faraday shielding is ineffective against B fields
- Most labs ignore testing for B field and focus solely on the E field, yet a glance at the magnitude of the current pulse associated with NEMP shows why this is a fallacious approach to testing.

12 KA EMP Current Pulse in Overhead Power Line



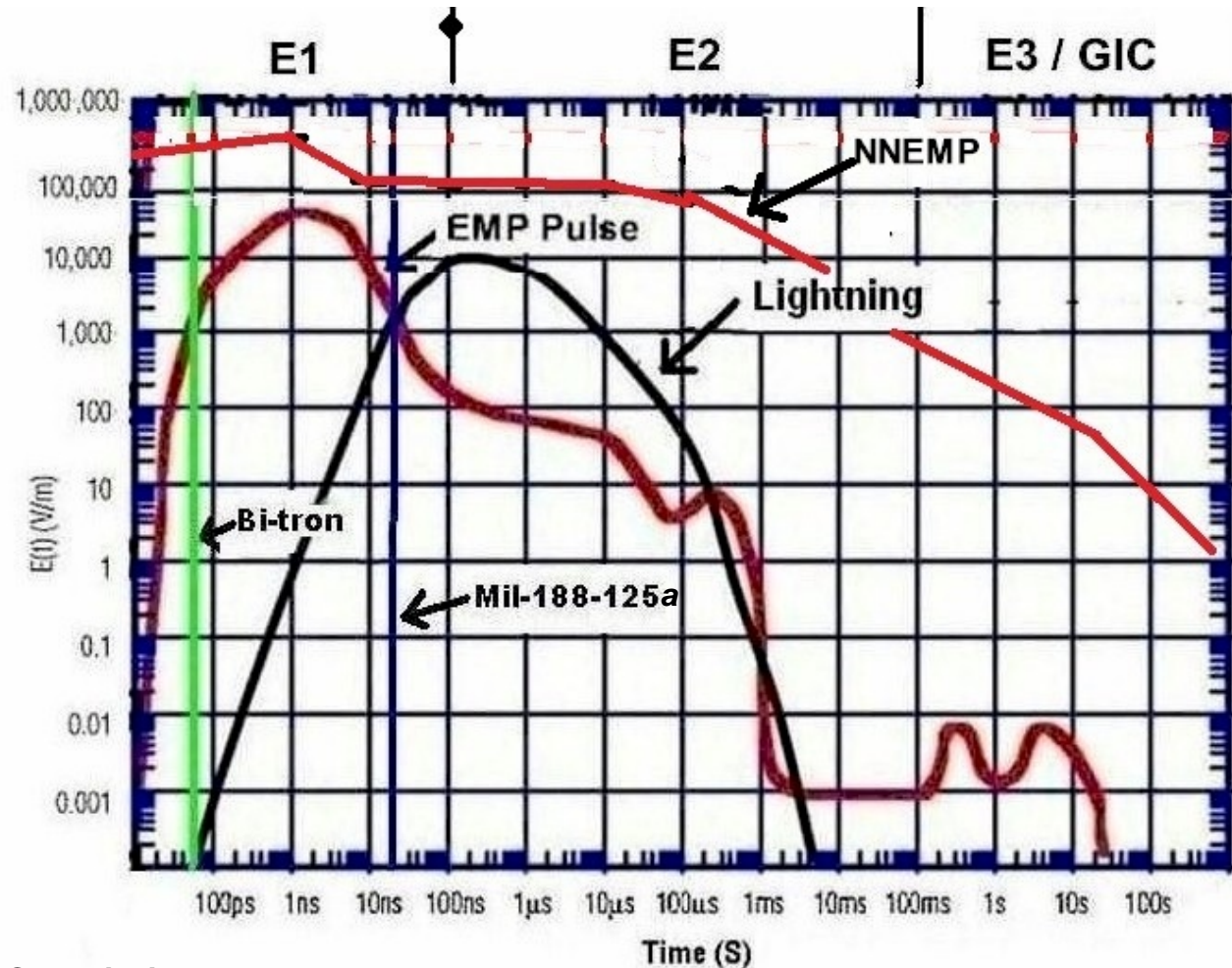
**Source:
DoD & DoE
1977**

EM Waveforms

**NNEMP &
Super EMP
Regime >>>>**

**Green line shows
when AFS
protection occurs
>>>>>**

**Blue line shows
when Mil-188-125a
protection occurs
>>>>>**



Derived from 2008 EMP Commission Report

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Non-Nuclear EMP

- The non-nuclear EMP threat (NNEMP) arises from the ability to build extremely powerful radio transmitters that can duplicate the waveforms and intensities of the EMP portion of a nuclear explosion.
- The technology exists to build transmitters of this nature that can be portable and still produce effects many times that of a large nuclear EMP pulse.
- Shown is a 35KV/m systems built in a collaborative program with the US Army.



35 KV/m NNEMP Source



Where There's E3, There's E1

- The fundamental physics governing the generation of nuclear EMP pulses demands that if an E3 pulse is present, then an E1 pulse (and E2) must also be present.
- The reverse is not necessarily true. One can generate a non-nuclear EMP pulse that only has an E1 component and/or just an E3 signal.
- Caution is advised when designing protective systems and these rules must be kept in mind. There is little sense in just protecting for E3 in an environment where E1 is anticipated as some are suggesting.
- It is noted that the E3 portion of any EMP waveform is essentially identical to a Geomagnetically Induced Current (GIC) that is created during a solar storm.



EMP/GIC Test Facility

- It is essential that all devices be tested under realistic conditions. As part of our commitment to the EMP protection arena, AFS has constructed a world-class EMP test facility.
- This facility can create $>350\text{KV/m}$ electric fields with sub-nanosecond risetimes
- This facility can inject arbitrary simulated GIC fault signals.
- This facility will be capable of testing devices at line voltages up to 1.2 million VAC or VDC (currently 250VAC) under load conditions of up to 10MW.
- While the facility is primarily for AFS production use, AFS the fully staffed and instrumented facility to outside users under appropriate circumstances.
- This facility will test in excess of the Mil-188-125D standard so as to provide realistic HEMP, NNEMP, and GIC conditions.
- This facility can successfully create SGEMP pulses.



Control Room Console





Patch Panel, Host Computer, Safety Scope, Auxiliary Equipment



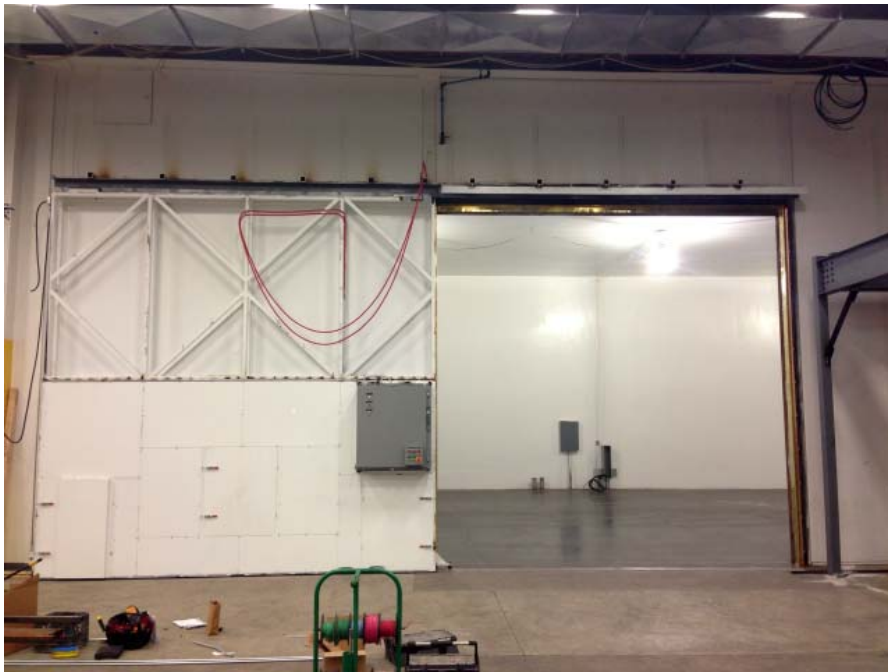


EMP Test Cells

- AFS Has 2 dedicated EMP Test cells
 - EMP 1: 80' x 40' x 20'
 - EMP 2: 94' x 34' x 20'
- Onsite sources can test to >350KV/M
- Test cell can duplicate magnetic field conditions of the largest transmission lines.
- Digital instrumentation:
 - >25 GS/sec/channel (8) simultaneous channels;
 - <20 picosecond resolution.



AFS EMP Test Cell #1



Test Cell = 80' x 40' x 20' Door = 16' x 16'
(8) 25 GHz Instantaneous Bandwidth Instrumentation Channels

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LAT350 Pulser





ABOUT AFS



***11 Edmond Road,
Newtown CT***



- ***250,000 sq ft***
- ***80' x 40' x 20'***
EMP Test Cell
- ***94' x 34' x 23'***
Radiation Lab
- ***EM, Circuit, &***
Mechanical
Simulation
- ***Precision***
Manufacturing
- ***60,000 sq ft***
EM Test Dept.



Senior Management

- ***Dr. William H. Joyce:*** Chairman of the Board, CEO: Dr. Joyce is formerly Chairman and CEO of Union Carbide, Hercules Chemical, and Nalco. He has started 7 other businesses, some of which have grown to billion dollar size. He was awarded the National Medal of Technology from President Clinton in 1993. He sits on a number of Boards including the University Research Association.

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- ***Curtis Birnbach:*** President, CTO: Mr. Birnbach is the inventor of the entire AFS technology suite. He is an expert in electromagnetics, electron tubes, pulse power systems, materials science, manufacturing methods, intellectual property development, registered export agent.

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