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Infrastructure Security Solutions Against Electromagnetic Pulse (EMP) Threats

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What is EMP?

- ElectroMagnetic Pulse (EMP) or High-Altitude ElectroMagnetic Pulse (HEMP)
- Due to the interaction of the nuclear radiation with the upper atmosphere
- Affects both fixed and mobile facilities; this presentation focuses on ground-based fixed facilities

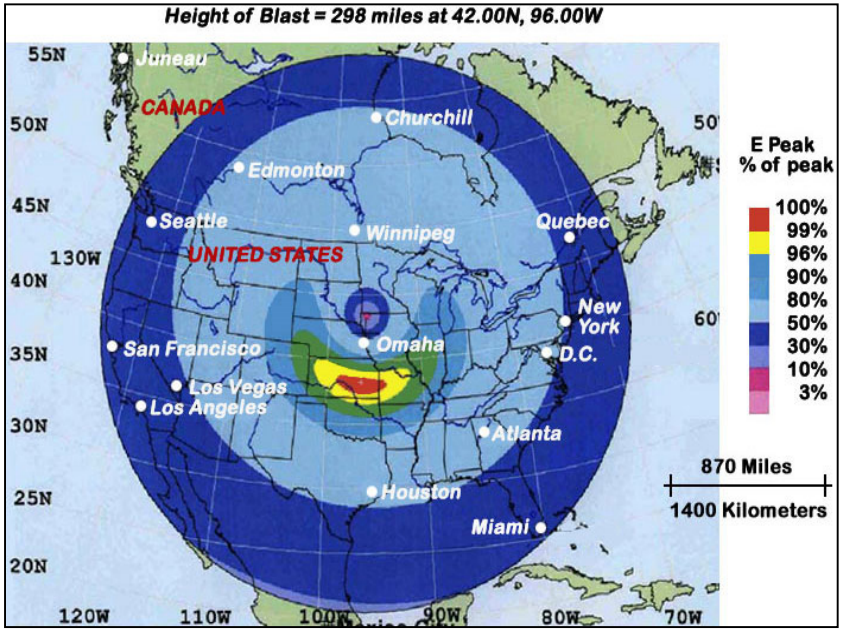
The Threat

- Recognized during weather events - 1859 Carrington Event
- Atmospheric tests by US & Soviets
  - US Tests - Starfish Prime Weapons Test
  - Soviet Tests - Kazakhstan

Flash created by the Starfish Prime explosion as seen through heavy cloud cover in Honolulu

How is HEMP Delivered?

- HEMP
  - Exoatmospheric nuclear detonation – 40 to 400 km above earth's surface
  - Produces intense electromagnetic field



Who has HEMP Capability?

- Countries with nuclear capabilities (even low-yield devices) and launch capabilities
- Don't need to be able to hit the US, just launch above
- Impact of an attack may be asymmetric
  - Protagonists who are not as dependent on modern electronics

September 3, 2017 – North Korea reported that it had developed a hydrogen bomb, adding that it could be used for a "super-powerful" HEMP attack

Who's at Risk?

- Anyone with electrical power systems, electronics, or information systems – EVERYONE
- Potential for cascading failures to electric power – telecom, energy, infrastructure – financial system – food, medical care, trade, production of goods & services

How Does it Work?

- Gamma rays from a high-altitude nuclear detonation interact with the atmosphere to produce radio-frequency waves of varying intensity that covers everything within line-of-sight
- Effects dependent on curvature of earth's surface and height above surface

How Does it Work? (cont'd)

2 types of effects associated with a HEMP event:

- Planar:
  - Radiated fields move across the equipment causing disruption or damage
- Coupling:
  - Planar fields "couple" to conductive pathways (wires) and travel to equipment

How Does it Work? (Cont'd)

3 Major EMP Components:

- E1 component – "Fast Pulse" electromagnetic shock (billionth to few billionths of a sec in duration)
  - Couples to antennae, short cable runs, circuit-based systems
- E2 Component – Similar to lightning and follows a small fraction of a second after E1.
  - Couples to longer lines, vertical antennae
  - E1 often knocks out protective or control features so E2 can pass into system and damage
- E3 Component – Long duration pulse
  - Creates disrupting currents in electrical transmission lines and the systems connected
  - Can be underground and undersea

How Does it Work? (cont'd)

The components couple to ANY lines exposed to the threat field (outside the HEMP barrier)

- Overhead power and telephone lines
- Distribution power lines inside building
- Control lines inside building

What Happens?

Induces current & voltages at the “chip level” in electronics

Long wires “collect” current and bring the current to a concentrated location

- Degradation: Premature aging of components
- Upset or Latch: Requiring manual intervention (reset)
- Damage: Requiring replacement of equipment

What Needs to be Protected?

Critical Systems

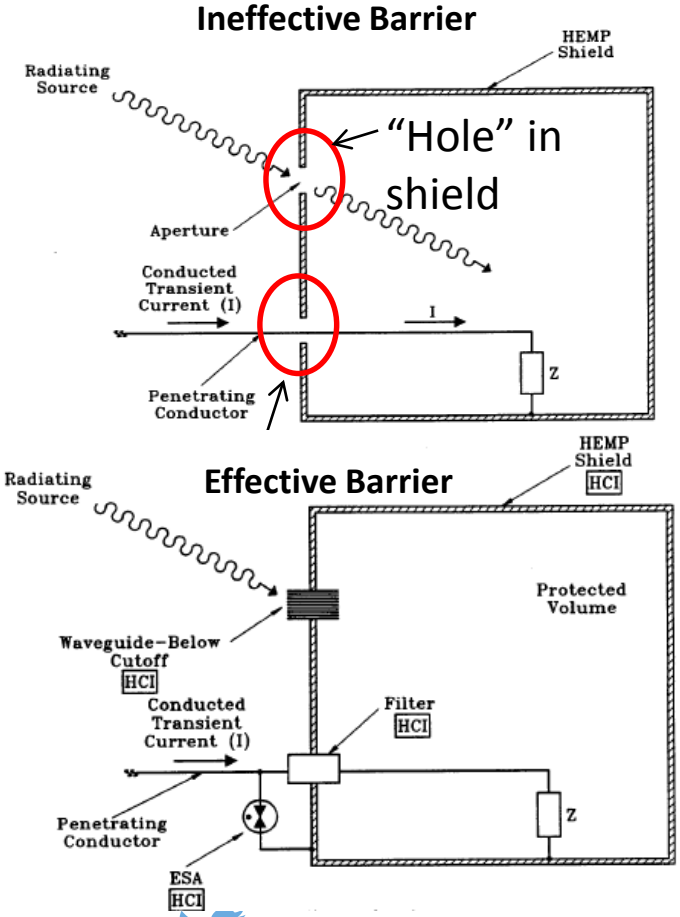
- National Emergency Communication Systems
- Weapons Systems Military and Commercial Communication Systems
- Electrical Grid

What Needs to be Protected? (cont'd)

- Components key to mission
- Equipment that need long time to replace or repair
- Recognize the cascading risks

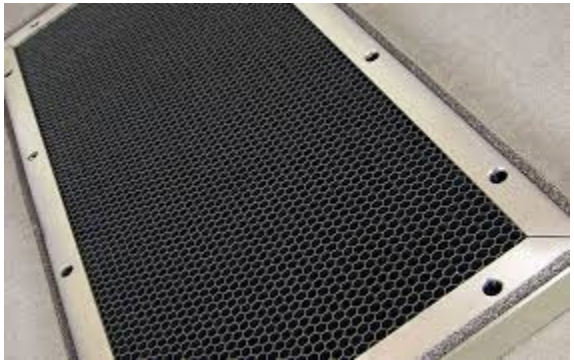
Protection

- Physical security to prevent intrusion
- Electromagnetic barrier with protective devices for all points of entry (POEs)

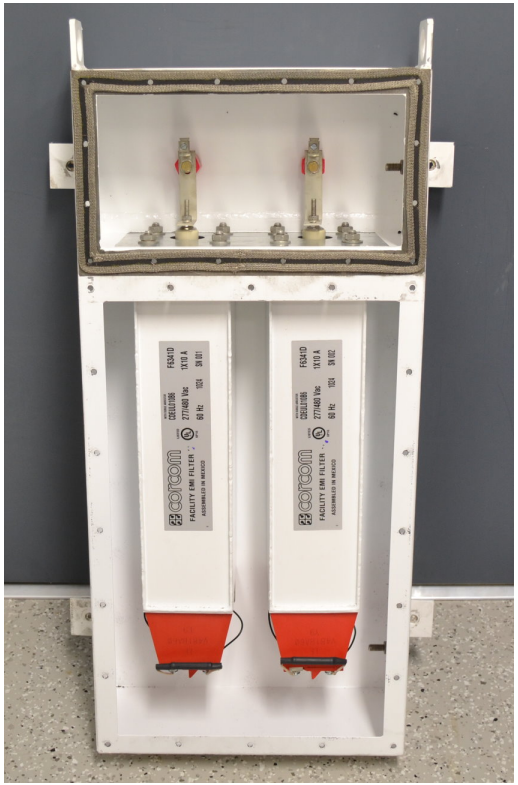


Protection (cont'd)

- Power filters – electrical wires
- RF Filters – communication wires
- Wave guides – air ducts, fuel & water pipes



Wave Guide



Electrical Filter

Protection (cont'd)

- Faraday cages/shields
- Component-level hardening
- Configure components so that they shut down in a controlled manner
- Configure components to reset
- Spare stocks

Standards & Directives

MIL-STD-188-125-1

- Sets standards for facilities and identifies performance criteria for systems to have confidence for survival

MIL-HDBK-423

- Design and construction guidance on hardening & testing to meet MIL-STD-188-125-1

MIL-HBK-419

- Grounding, Bonding, and Shielding for Electronic Equipment and Facilities

HEMP Program

- Identify Critical Infrastructure
  - Cannot protect/harden everything
  - Recognize cascading consequences
- Prioritize
  - Base on system-wide evaluation of threats and vulnerabilities
  - Risk assessment to identify and select hardening investments

HEMP Program (cont'd)

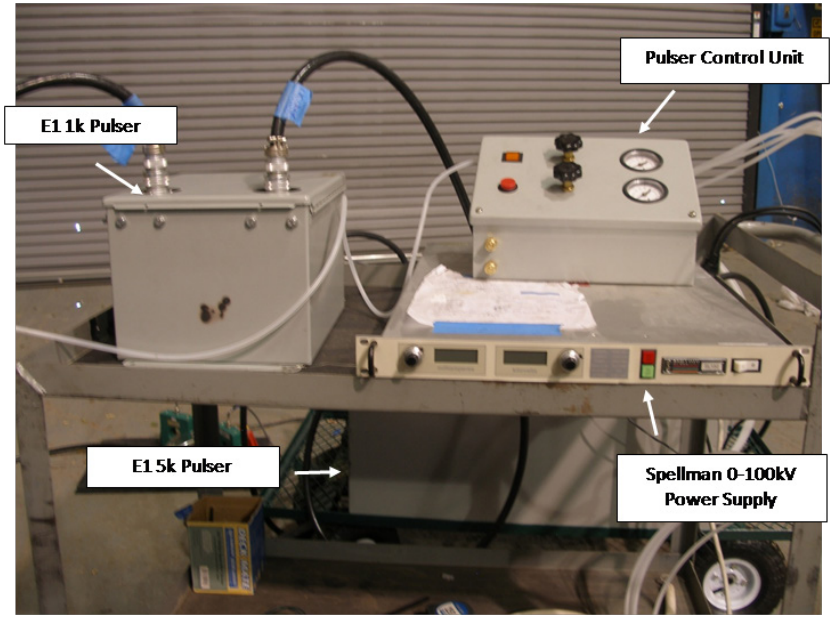
Hardening – reduce HEMP-induced stress that can reach mission-critical equipment

- Global shield/electromagnetic barrier
- POE protection
- Special protective measures

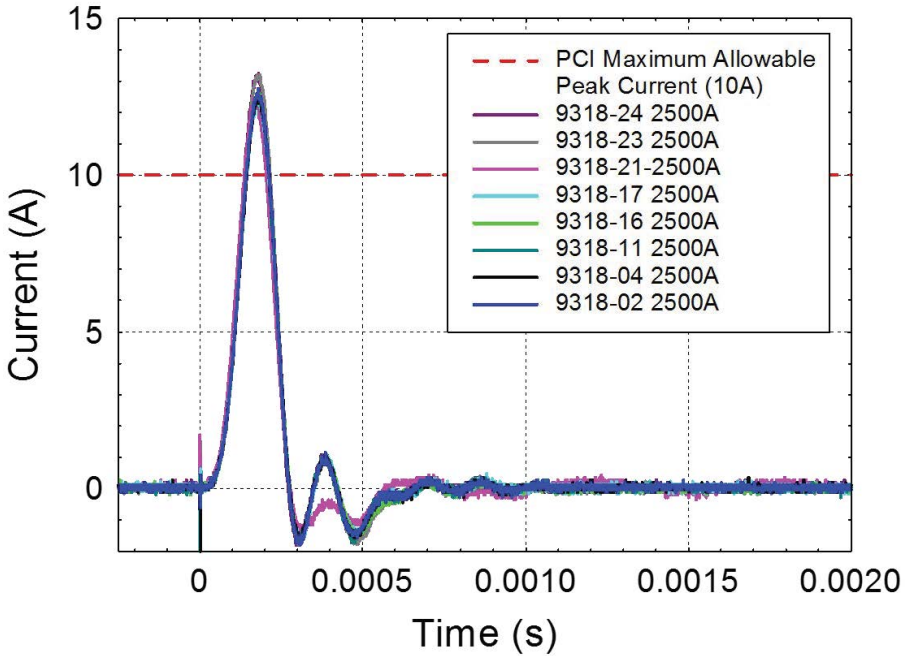
HEMP Program (cont'd)

Acceptance Testing

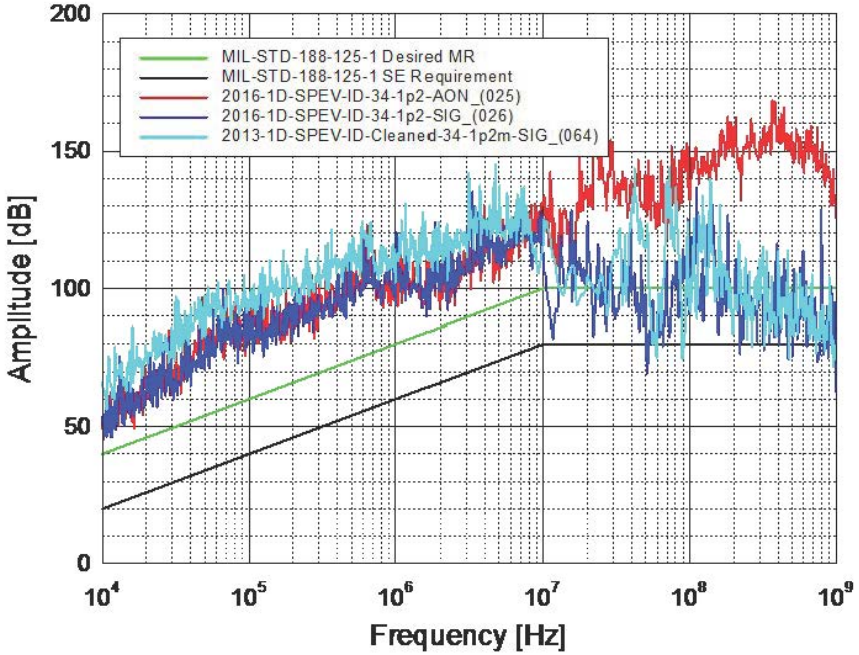
- Testing to ensure HEMP performance characteristics met after construction
- Compliant with MIL-STD-188-125-1



PCI test kit for testing electrical filters during acceptance & verification



Failed Electrical Filter PCI Test



Shielding Effectiveness Test

HEMP Program (cont'd)

Verification

- Test of operational equipment in simulated HEMP excitations to ensure it does not suffer

HM/HS

- Preventive maintenance, inspection, testing, and repair
- Performed between verification cycles

Figure 15. (U) Amplifier Research CL-105/CL-106 SELDS Test System

Figure 16. (U) ETS-Lindgren Euroshield test set

HEMP Program (cont'd)

- Preventive Maintenance & Inspection
  - Periodic to ensure protective measures are performing
  - Adjustments, cleaning, limited testing
  - Identification of potential problems in advance

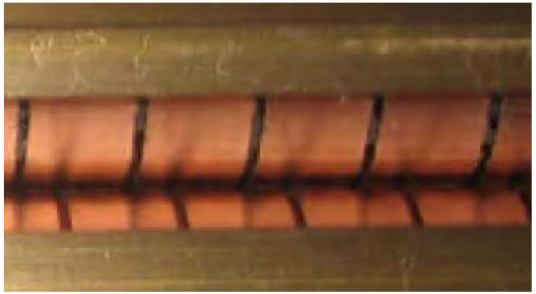


Figure 9. (U) Clean properly aligned finger-stock

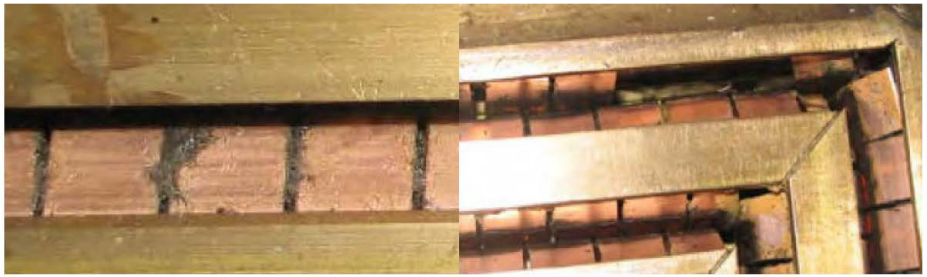


Figure 10. (U) Dirty finger-stock (left) and damaged finger-stock (right)

Implementation

- Identify critical systems
- Determine mitigating measures
- Design and construct volume to meet mission requirements
- Perform acceptance testing following construction
- Perform verification testing following systems installation and commissioning
- Certify, including a written HM/HS program
- Structured adherence to the HM/HS program
- Re-verify and continue HM/HS program performance

Conclusion

- HEMP 101
- Who and what are vulnerable?
- How will your Organization prepare?