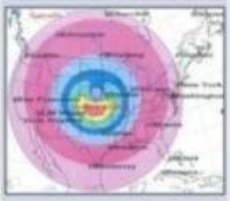
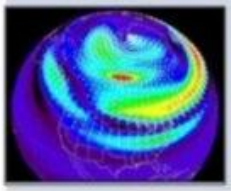
EMPs and Faraday Protection Overview

What:

- Basically, Faraday protection is an enclosure with a continuous covering of conductive material that will block electromagnetic fields

Why:

- Protect equipment
- An EMP, or electromagnetic pulse, is a broadband burst of electromagnetic energy
  - Potential to damage nearly everything electronic over hundreds of miles
- Anything in the vicinity of the burst's origin may be impacted – how much depends on how powerful the EMP is

	THREAT	Environments	Susceptible Systems
	High Altitude EMP	Fast Pulse E1	Long-line and short-line electrical and electronic systems
		Slow Pulse E3	Long-line network systems incl. electric power grid, terrestrial and undersea comm. lines, pipelines
	Solar Super Storms	Geomagnetic Disturbance	Long-line network systems incl. electric power grid, terrestrial and undersea comm. lines, pipelines

Protection:

- Electrical shielding = conductive material blocking/redirecting EMP
  - Ex: aluminum foil, metal, etc.
- Electric current takes the path of least resistance - it will flow around the conductive layer and won't go inside the enclosure (unless there's a gap)
- Equipment is protected because the electrical surge hits the conductive material and flows around it leaving the contents intact
- The intensity of the EMP (electromagnetic pulse) and the range of frequencies, wavelengths, etc. (all electromagnetic radiation) will determine the optimum thickness of the conductive layer
- Conductive layer must NOT have any gaps or holes in it
- Contents of enclosure must NOT be in direct contact with the conductive layer

Causes:

- Source of an EMP can be from:
  - Detonation of a large bomb (nuclear or not) in the atmosphere, miles above land
    - The pulse wave may cover an entire continent and destroy electronic components (ex: computers, engines (inc. cars, planes, etc.), power plants, anything electronic, etc.)
  - The sun, could also do extensive damage in the form of a Coronal Mass Ejection (CME)

Enclosures:

Container	Pros	Cons	Critical
Metal trash can or box 	Wide range of choices/sizes	Gaps between lid/base Equipment contact with metal	Conductive tape to seal gap Line can/box with cardboard/carpet padding, wood, etc.
Microwave 	Most people already have one	Usually a gap between the door and body – enough to allow EMP in	Seal the gap when using to protect equipment
Anti-static bags 	Available in a wide range of sizes	Physical ruggedness is critical – rip or tear allows EMP energy to enter	Use bags certified to MIL-PRF-8170 or MIL-PRF-131 for the greatest protection
Chicken wire 	Readily available	Not as effective as a solid conductive surface	Openings of wire are smaller than EMP wavelengths
Cardboard box  	Inexpensive Readily available supplies in most homes Fast/easy to make	Keep testing to determine the number of layers required to protect equipment	Use multiple layers of heavy duty aluminum foil – ensure no gaps when wrapping
Ammo can 	Sturdy and portable	Lose some volume due to need to line metal interior	Line with foam padding
Bird cage 	Easy to obtain, often at no cost	May have plastic base, holes could be too large to protect against high freq.	Line with foam Cover with foil if holes are too large
Cookie/Popcorn tins 	Usually tight fitting lids Easily portable	Inside must be lined	Line with cardboard or put equipment in an anti-static bag
Original boxes 	Easy and fast	Equip. not used on daily basis	Wrap equipment in its original box with heavy duty aluminum foil
Wood frame & aluminum screen  	Customize to meet needs – can be sized to hold generators, etc.	Skilled at building Gluing preferred to nailing wood frame	Line with wood, cardboard, plastic to avoid contact with aluminum screen
Shield room 	Holds large amounts of equipment – may offer more than 50 dB of shielding up to several hundred MHz	Must cover entire surface – inc. light switches, elec. outlets, etc. Tape with conductive tape	Cover all walls, ceiling, inside door with heavy duty foil – overlap & tape seams – floor with cardboard or wood (walk able surface)

Effectiveness:

- Test the effectiveness of any Faraday enclosure by inserting a battery powered radio and sealing the enclosure - if you can hear the radio after sealing, radio waves are getting in – protection compromised
- Using a mobile phone is one way to test effectiveness, but it's not as effective as a radio
    - Phones operate on a specific set of frequencies and may not be the same frequency as an EMP – phone frequencies are a bit higher in frequency than EMP
- The conductive layer covering a Faraday enclosure can be very thin due to something known as the *skin effect* (the tendency of current to flow primarily on the skin of a conductor)
    - As long as the conducting layer is greater than the skin depth, it provides excellent shielding because the absorption loss will be large
    - The skin depth is a function of the frequency of the wave and the conductor material
        - Ex: for a frequency of 200 MHz, the skin depth of aluminum is only about 21 microns - EMP pulses can have frequency content that ranges up to 1,000 MHz
        - Wrapping a box in a couple of layers of heavy duty aluminum foil (typically about 24 microns thick) provides the necessary conductor thickness to protect against high-frequency radiated fields
- Conductive mesh may be used long as the holes are small with respect to the wavelength of the electromagnetic wave
    - Ex: a 1 GHz wave has a wavelength of 0.3 meters in free space - as long as the holes are significantly smaller than that dimension (a few millimeters), they won't let in much of the incident wave
    - Generally, the enclosure's lid or door causes the most leakage - taping the seam with conductive tape helps to reduce this leakage
- The most accurate effectiveness assessment is to test with a variety of devices that operate over a wide range of frequencies (AM radio, amateur radio, Wi-Fi router, GPS, mobile phone, etc.)
- While grounding isn't required for effectiveness, consider grounding Faraday enclosure so the electrical energy captured by the metal is directed away and into the Earth
    - If not grounded during an EMP strike, the cage may build up a charge strong enough to give the person opening the enclosure a shock
    - If not grounding, the equipment remains safe, just be aware of the potential of a shock and open accordingly

Things to consider storing in a Faraday Enclosure:

- Earphones and chargers
- Spare laptop computer with stored personal information
- Digital camera
- Walkie-talkies that run on rechargeable batteries
- Solar battery chargers
- Kindle, iPad, or e-reader containing reference and survival books and other relevant books
- Digital watches and clocks
- Any and all digital photos stored on a DVD and/or a thumb drive
- Scanned documents stored on a DVD and/or thumb
- Computer hard drives
- Ham radio equipment
- A small generator
- LED flashlights
- Shortwave radio
- Inverters
- Electronic medical equipment
- Calculators
- DC/AC inverters

Useful suggestions:

- Avoid storing like items (ex: two cameras, multiple chargers, etc.) in the same Faraday enclosure – if one enclosure fails, you'll have a chance that the other location won't
- Layer Faraday containers – pack small filled Faraday containers into larger Faraday containers for additional protection
- Don't store frequently used items in a Faraday enclosure – store items that are duplicates of things frequently used
- Don't waste the space storing batteries (they won't be affected by an EMP), store the chargers for batteries instead

CME:

- Coronal Mass Ejection is different than an EMP
    - CME is a storm of charged particles from the sun and is a threat to our power grid vs. electronics
        - The solar storm flips the Earth's magnetic field lines back and forth which generates currents in anything long, thin and metallic (ex: our electrical grid)
    - Our power grid is like a giant antenna – huge currents build up along the long transmission lines and surge through the grid
        - One by one the transformers overheat and trip or blow up – like a domino effect leading to blackouts
    - Electronics may be affected if they are connected to grid power
    - Ham radio antennas should be disconnected during the solar storm
- Unless your electronics are connected to grid power or a long conductor such as an antenna, they will likely be unaffected by a CME
- Ex: 1989, Quebec, Canada lost its electrical grid
    - Toronto Stock Exchange trading stopped
    - Space Shuttle Discovery's in-flight sensor malfunctioned
    - Likely caused the demise of the Solar Maximum Mission satellite

Personal preparedness:

- Consider the everyday items you need and plan ahead – adjust for the seasons
    - Ensure adequate emergency supplies of food and water
    - Try to start every motorized vehicle you have
    - Consider having bicycles in good working order (back up transportation)
    - Have a well stocked medical supply kit
    - Have a supply of cash – credit cards/ATMs won't work
    - Paper products
    - Flashlights
    - Batteries