INNOVATING NUCLEAR TECHNOLOGY

ANALYSIS AND MEASUREMENT SERVICES CORPORATION

Electromagnetic Shielding

Instrumentation and Control Testing and Troubleshooting Course for TVA

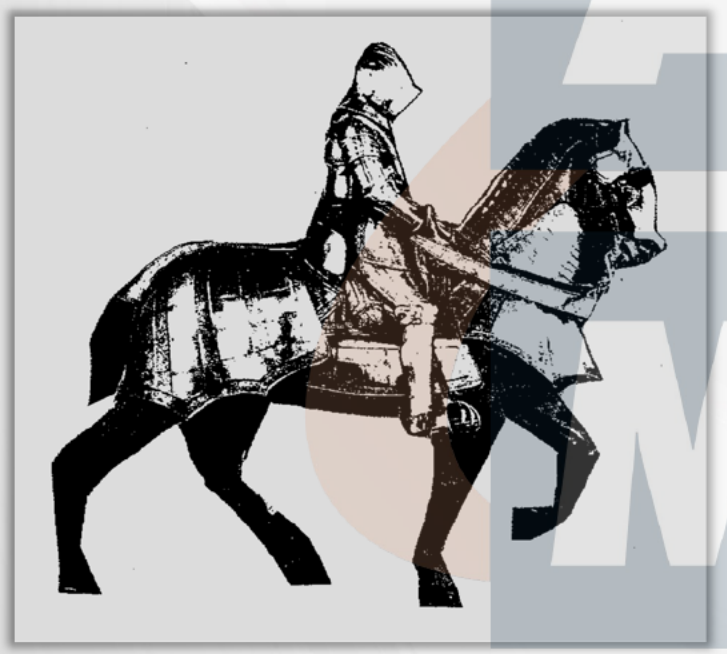
Learning Objectives

Upon completion, the student should be able to:

- Determine the requirements for shielding against near-field electric-field EMI
- Evaluate the benefits of twisted pair wiring versus shielding for near-field magnetic-field EMI
- Construct an ideal shield against far-field electromagnetic wave EMI
- Evaluate the potential for EMI coupling into coaxial cables
- Predict the affects of a pigtail on a high frequency, low signal level instrumentation or control system

The Classic Shield

Evolution

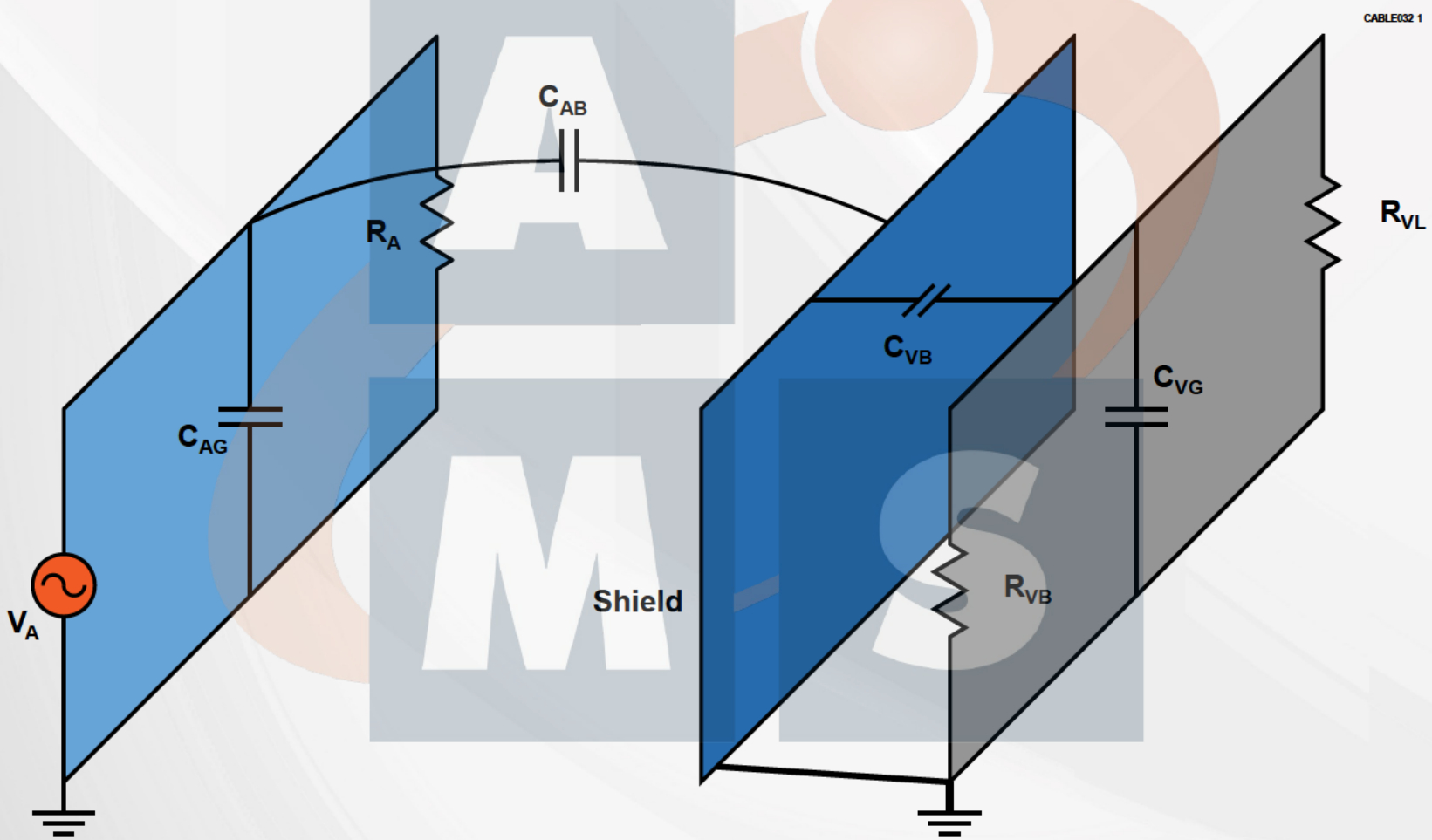


Review of Low Frequency Shields

- **Electric field shield functions as a circuit element**
  - Capacitor (plate) that must be connected to circuit common.

- **Magnetic field shield functions as a preferred path for magnetic flux**
  - Warps magnetic field around the protected circuit.
  - Does not have to be grounded to be effective (is normally grounded for personnel safety reasons).

Low Frequency Electric Field (Capacitive) Shield

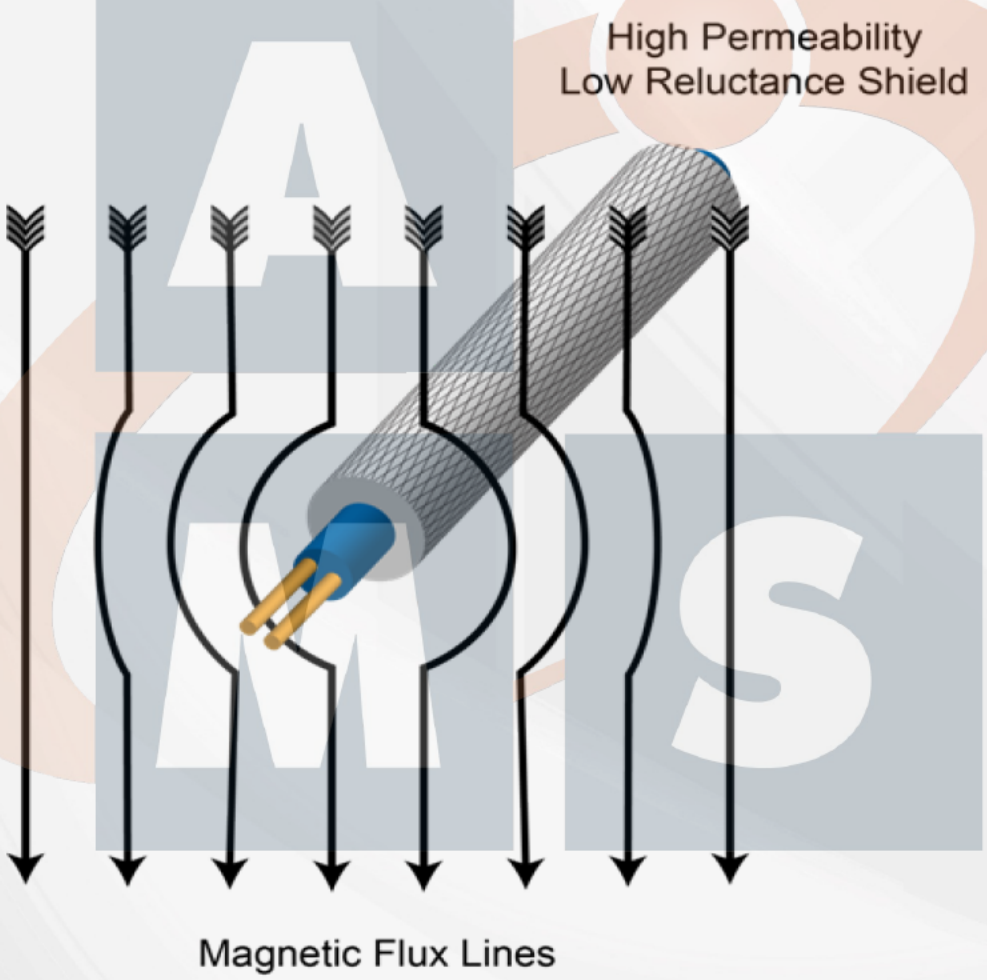


Electric Field Coupling Intensity

- Electric field from straight wire will fall off inversely with distance from reference.

- Electric field from dipole antenna will fall off in the far field inversely with distance and will fall off in the near field inversely with distance cubed.

Low Frequency H-Field (Magnetic) Shield



Magnetic Shield Effectiveness is Based on Permeability

Material	Relative Permeability
• Air, silver, copper	1
• Aluminum, etc.	1
• (Non-ferrous)	1
• Iron, stainless steel	1,000 – 5,000
• Permalloy	8,000
• Mu-Metal	20,000 – 50,000

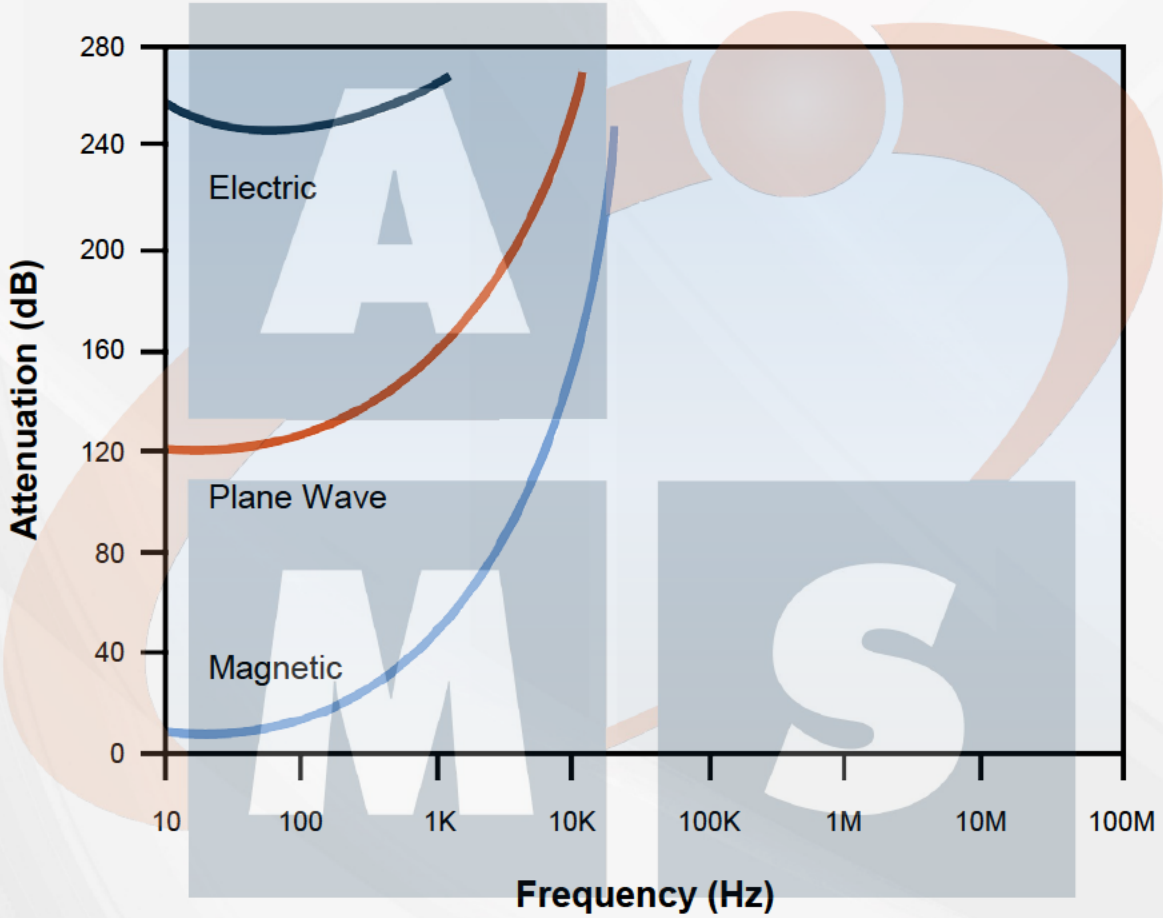
Note: permeability may change with frequency and magnetic field saturation.

(REF: FAA-RD-75-215, 1, pp. 5-7)

Magnetic Field Coupling Intensity

- Magnetic field from loop antenna will fall off in the far field inversely with distance and will fall off in the near field inversely with distance cubed.
- Magnetic field due to a paired signal and return cable will fall off inversely with distance squared.
- Magnetic field from straight wire will fall off inversely with distance.

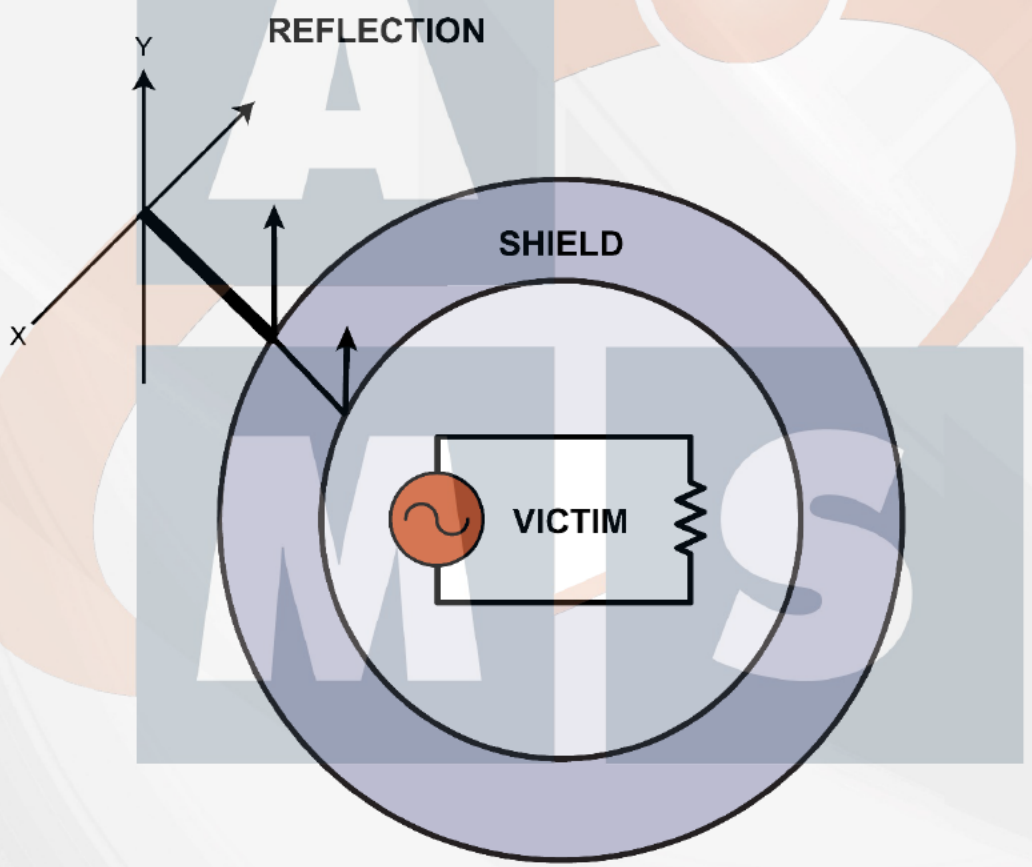
Thin Iron Sheet EM Attenuation



(REF: FAA-RD-75-215, I, pp. 5-29.)

Electromagnetic Wave Shield Causes Reflections

Shield must completely enclose victim

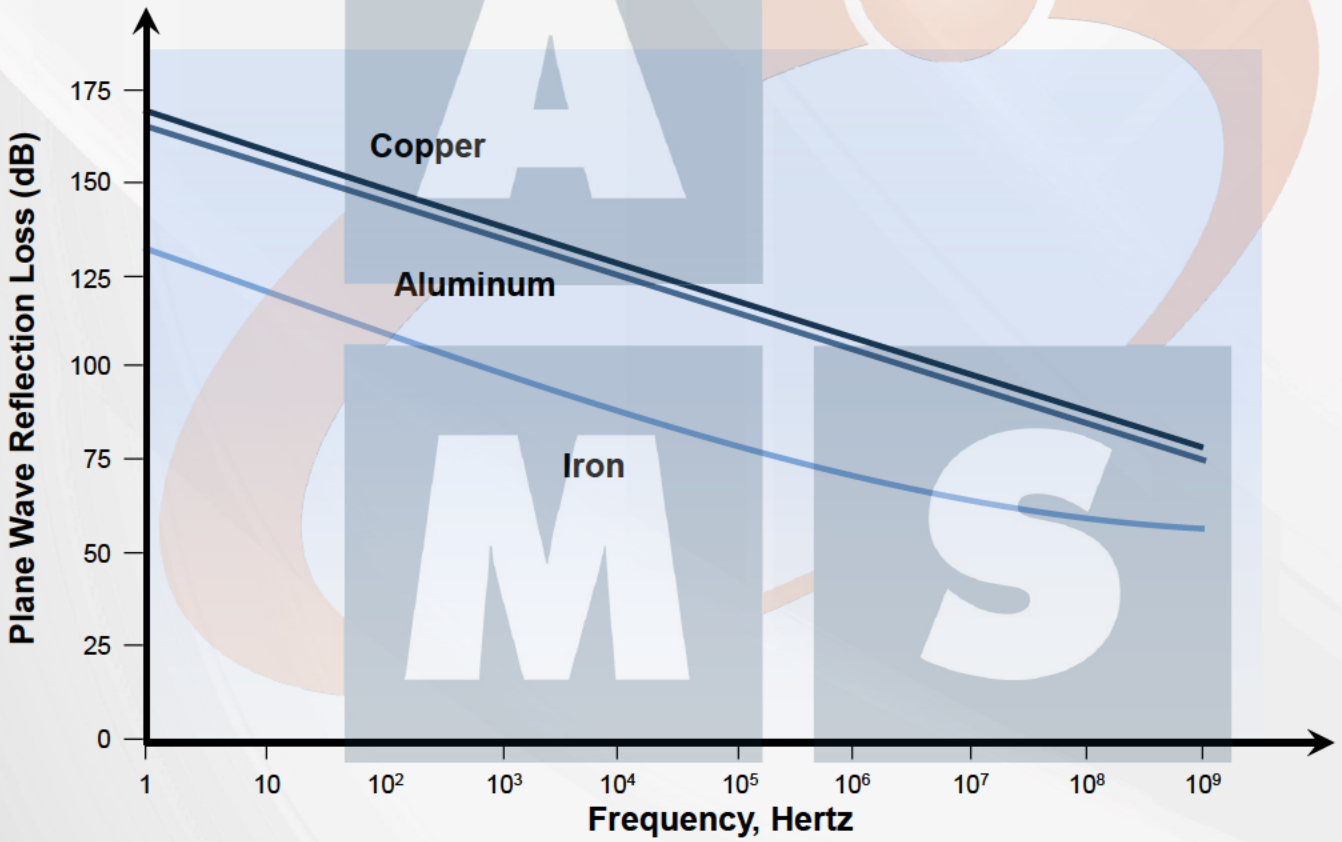


Requirements for Plane Wave Shield

- Holes must be small relative to wavelength of excluded frequency
- Antennas cannot penetrate boundary (antenna is any insulated, unfiltered conductor)
- Current must flow freely on all planes to cancel magnetic fields

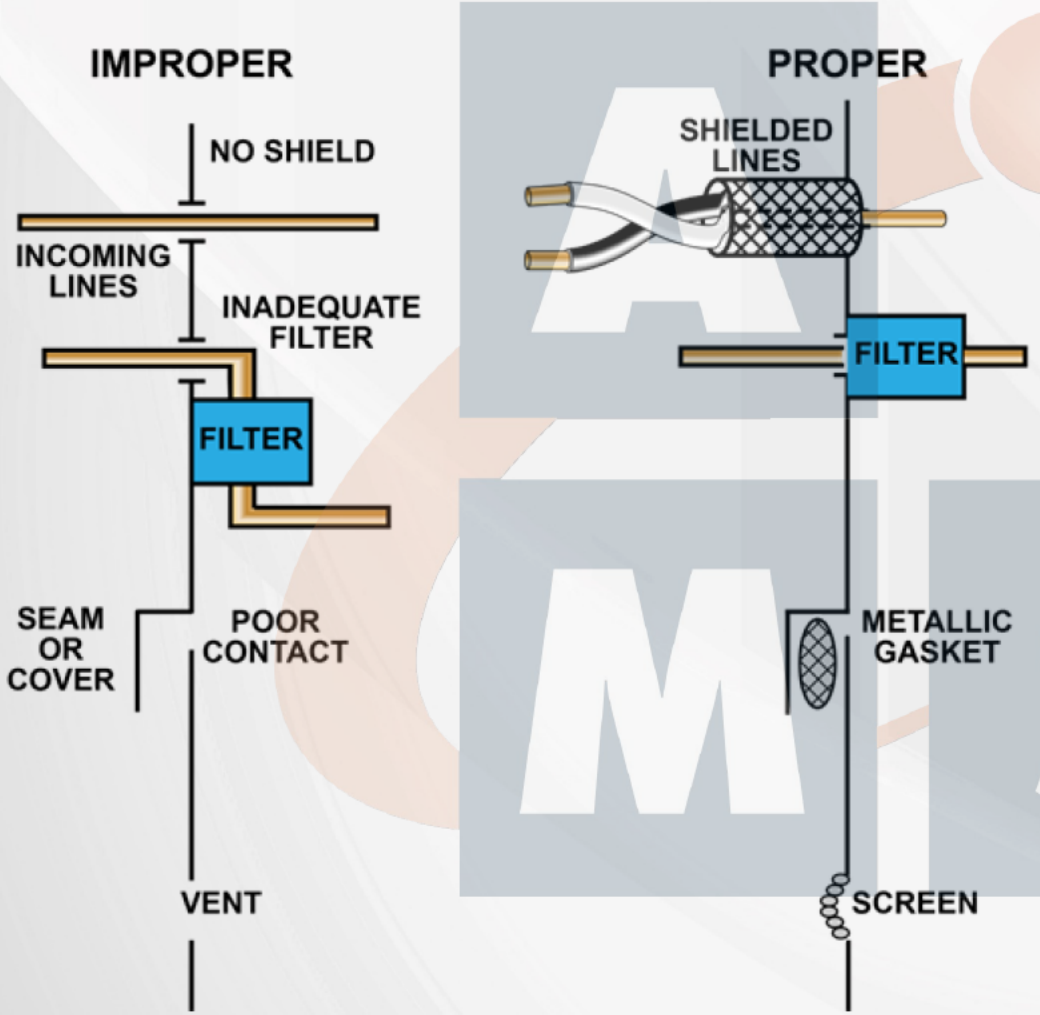
Plane Wave Reflection Loss

Plane wave reflection loss for iron, copper, and aluminum



(REF: FAA-RD-75-215, 1, pp. 5-15.)

Shield Penetrations are Greatest Problem



COMMENT

ALL IN COMING LINES SHOULD BE SHIELDED WITH SHIELD SOLIDLY CONNECTED AT PENETRATION - OR FILTERED.

FILTERS SHOULD BE PART OF SHIELD WALL SO THAT UNFILLTERED LINES DO NOT ENTER SHIELDED ENCLOSURE.

METALLIC GASKETS SHOULD BE USED ON SEAMS, DOORS, OR COVERS.

METALIC HONEYCOMB SCREENS SHOULD BE USED ON VENTS

Preventing EMI Coupling to Coaxial Cables

- Terminate with 360° bonding
- Prevent damage such as tight bends
- Do not use pigtails before shield termination
- Prevent moisture/contamination to maintain shield integrity
- Use Ferrite beads for poor/degraded connectors

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Thank You

Questions?