Testing the Effects of a Door Opening on the AC ELF Attenuation Performance of a Six-Sided Seam Welded ¼" Thick Aluminum Shield

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Any penetration in a six-sided magnetic shield compromises the effectiveness of the shielding to some degree. For a highly conductive lossy magnetic shield, holes in the shield create not only voids without shielding, but also reduce the conductivity of the shield both locally and globally. Less conductivity reduces the eddy currents and back EMF generated.

The door penetration is usually the largest and most difficult penetration into a shielded room. Penetrations can be modeled with BEM software such as ANSYS Maxwell, but sometimes it is more productive to do real world testing. Vitatech used a ten-foot square ¼" thick seam welded 1100 aluminum enclosure set up for testing and calibration. Three configurations of a 7 foot by 4 foot door and one configuration without a door were tested. The table #1 below shows the results.

The first (baseline) measurement is the enclosure wall without a door. We were able to show an expected -35dB reduction in field strength in the center of the shield. The enclosure has an aluminum door that overlaps the opening by about 4". With this door closed and secured, the shielding effectiveness in front of the door is reduced by about half to -30dB. The enclosure with the door wide open reduces the shielding effectiveness in front of the door by about 80% (-20dB). The enclosure with the door shielded by a plate comprising 65% of the opening reduced the shielding compared to a solid wall by about 77% (-23dB). This is 6% better than the bare opening but 30% less effective than an overlapped door.

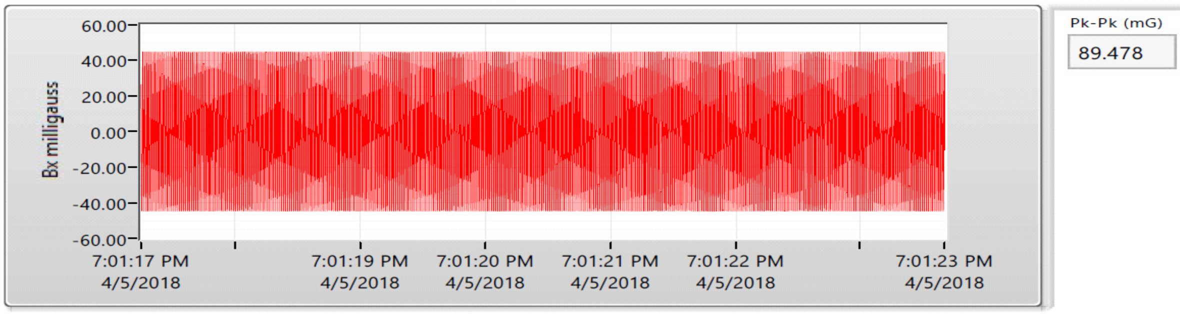
It should be noted that these figures are worst case. In most situations, the door shield covers about 80% of the door opening. Also, sources of fields are normally kept away from the door and not placed directly in front.

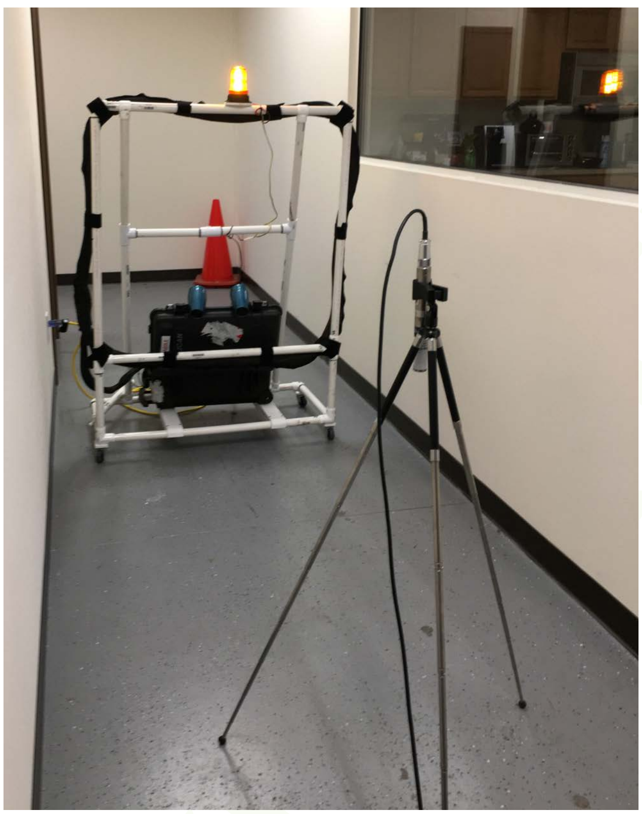
It is clear from these tests that, in any critical EMI environment, the door area should be kept to a minimum. Removable panels with overlapping aluminum are far more effective than a electrically isolated ¼" door shield.

Door Opening Type	Resultant Field	Reference Field	Shielding Factor (SF)	dB Reduction	Ratio
No opening	1.55 mG p-p	89.5 mG p-p	0.200	-35 dB	1
84" x 48" opening with overlapped door	2.96 mG p-p	89.5 mG p-p	0.033	-30 dB	0.53 (53%)
Exposed 84" x 48" opening	8.93 mG p-p	89.5 mG p-p	0.100	-20 dB	0.17 (17%)
84" x 48" opening with 75" x 35" door shield	6.67 mG p-p	89.5 mG p-p	0.075	-23 dB	0.23 (23%)

Table #1

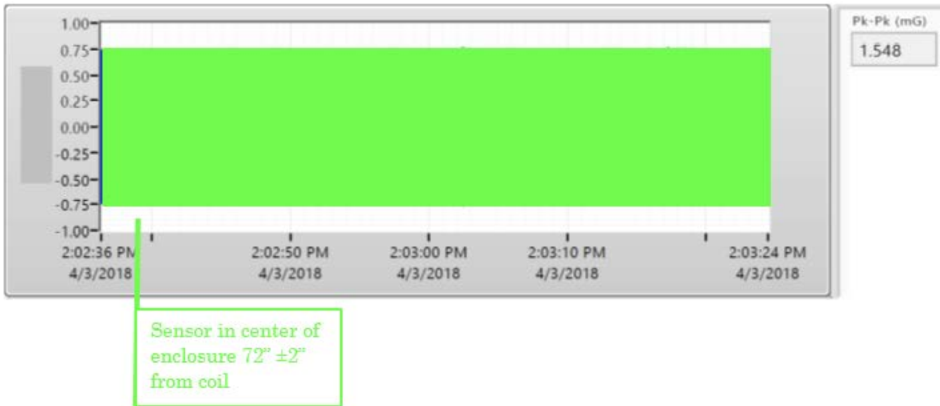
Magnetic Flux Density at 72” from Coil in Milligauss Peak to Peak - Reference Measurement





This measurement is the free space (no shielding) AC magnetic flux density level of the coil generated at 72” from the center of the coil at the center elevation of the coil. This flux density will be used as the unshielded AC flux density reference for calculation of the Shielding Factor (SF) and decibel (dB) flux density reduction. Measurements from the outside of the shield are modified by the eddy current induced back EMF from the aluminum shield will not be used for the shielding calculations.

Magnetic Flux Density at 72" through 6-Sided ¼" Welded Aluminum Box - No Opening



Shielding Factor (SF) = $B_{\text{with shield}}$ / $B_{\text{no shield}}$

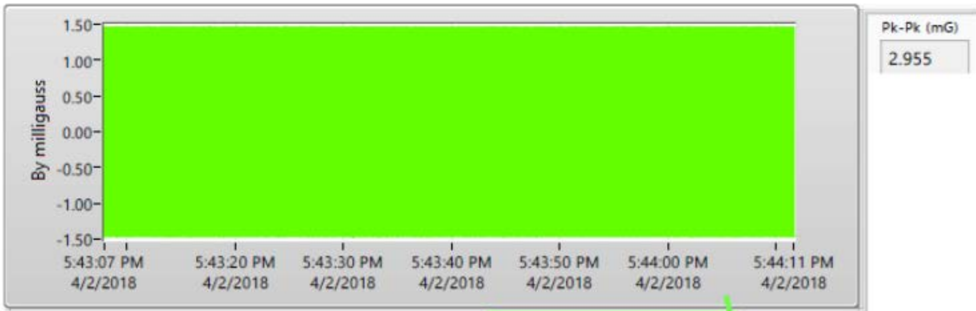
SF = 1.55 / 89.5 = 0.200

dB reduction (r) = $20 \log_{10} (B_{ws} / B_{ns})$

$dB_r = 20 \log_{10} (1.55 / 89.5)$

dB_r = -35 dB attenuation for 6 sided ¼" aluminum plate shield with no opening

Magnetic Flux Density at 72” through 6-Sided ¼” Welded Aluminum Box-Overlap Door



Sensor in center of enclosure 72” ±0.5” from coil.

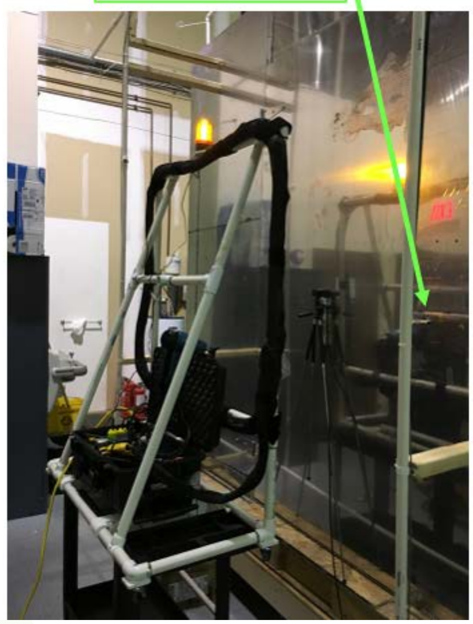
Shielding Factor (SF) $= B_{\text{no shield}} / B_{\text{with shield}}$

$SF = 2.96 / 89.5 = 0.033$

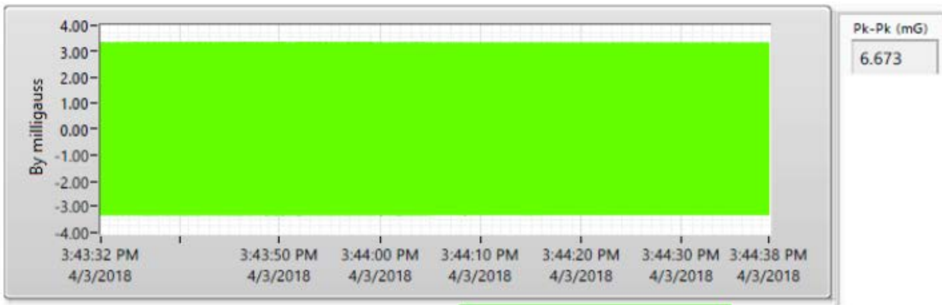
$dB_{\text{reduction (r)}} = 20 \log_{10} (B_{ws}/B_{ns})$

$dB_r = 20 \log_{10} (2.96 / 89.5)$

$dB_r = -30$ dB attenuation for 6 sided ¼” aluminum plate shield with overlapped door opening



Magnetic Flux Density at 72" through 6-Sided ¼" Welded Aluminum Box - Open Door



Shielding Factor (SF)
= B with shield / B no shield

SF = 6.67 / 89.5 = 0.075

dB reduction (r) = 20 $\log_{10}$ (B_{WS}/B_{NS})

dB_r = 20 $\log_{10}$ (6.67 / 89.5)

dB_r = -23 dB attenuation for 6 sided ¼" aluminum plate shield with a 75" x 35" door shield in an 84" x 48" door opening. The shield covers 65% of the door opening.

This is worst case scenario with source directly in front of opening and with a large door frame. Unshielded door perimeter area is larger than in a normal installation.

Test Procedure

AC ELF fields were generated by a custom apparatus consisting 1 meter square coil #4 AWG wire driven from a 120VAC 60Hz source which was current limited by two air-cooled series load resistors. The apparatus can generate over 1000mG (100uT) of AC ELF flux density at one foot in front of the coil center. The magnetic flux density levels were measured with a Bartington flux gate magnetometer and recorded with a National Instruments NI DAQ - 4431 digitizer controlled by custom NI LabView software. The test enclosure is a 10' cube seam welded aluminum box used for experiments and instrument calibration.