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Consulting
Engineers

EMI Shielding Effectiveness
In Conductively Coated Plastics

Analyzing the performance of vacuum metallized plastics with minor voids present in the coating

Prepared for

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Shielding Effectiveness of Vacuum Metallizing

Conductively coated plastics are becoming increasingly popular for EMI shielding. Vacuum metallizing is a cost effective way to get fast turnaround in small quantities. Commonly, shapes can be complex, making it impossible to get absolutely uniform coatings.

VTI Vacuum Technologies, Inc. tasked us to do some comparative shielding effectiveness (SE) tests on various configurations, primarily to assess the impact of selected voids in the coating.

Testing was performed at Environ Labs, based in Bloomington, MN, using accepted shielding effectiveness methods. We used a ten inch square coated panel, configured as described in the individual tests. The panels were grounded at the perimeter using good quality EMI gasketing. An aluminum panel was first tested, and is used as a baseline; therefore, the SE of all coated panels are shown relative to the aluminum panel.

Our findings were that small voids in the samples had little impact on the shielding effectiveness. Additional small holes, as might be placed in an array for ventilation purposes, also had minimal impact. Larger holes showed shielding degradation especially at higher frequencies.

This validates our position that SE is primarily driven by larger openings created by seams and by wires (data and power) penetrating the shield.

We'll start with a comparison of four samples and continue with a wrap-up.

Tests Performed:

The first test compares the SE of a fully coated screen (with no voids) with the aluminum plate (figure 1). The SE of the coated screen is normalized to the aluminum plate, so that SE of the Al plate is shown as "0 dB". As can be seen, SE of the coated screen is nearly as good as that of the Al plate. In practice, since Al plate is a very good shield, we conclude that the coated screen is adequate for almost all applications, including demanding military applications.

Note that SE variations with frequency occur to test variations, and are not to be taken as real variations - you need to look at the overall picture.

The second test examines the SE of a coated screen with one small void, a deliberately placed 1/8 inch diameter hole in the center of the sample (figure 2), and compared with the fully coated sample. This is intended to represent the effect of a small (perhaps unintentional) void in the coating. As can be seen, the presence of the small void has little adverse impact on the SE.

The third test places a 10x10 array of 1/8 inch diameter voids and compares with the fully coated sample (figure 3). Such a condition might exist if there were a need for ventilation holes. As can be seen, the SE of the array is not significantly less than that of the uniform panel.

The fourth test places a 10x10 array of 1/4 inch diameter voids and compares with the similar array of 1/8 inch voids (figure 4). This shows that the SE degrading with larger holes, especially at higher frequencies.

It should be noted that SE degradation due to an opening is a function of the longest dimension of the opening, not the area of the opening. Thus, a 1/4 inch seam performs approximately the same as a 1/4 inch round hole.

Summary of Results:

Shielding effectiveness of the coatings are very good for all samples other than the one with large holes. While this test doesn't test for absolute SE, we note that SE for aluminum sample is very good, so we are comfortable in saying the Al coating SE should be at least 60 dB even at the highest frequency tested (2 GHz). As a general guideline, SE of 30 dB is reasonably adequate for most commercial applications, and 60 dB or more is generally adequate for harsh military environments. Thus, vacuum metallizing can be considered for most shielding needs.

Small holes do not tangibly degrade SE at frequencies up to 2 GHz. Thus, there is no reason to be concerned about small voids that may occur during the metallizing process.

An array of small holes do not significantly degrade SE; therefore, if we need a number of small holes for ventilation, this would not create an SE problem.

Finally, larger holes will start to degrade SE, especially at the higher frequencies.

Design Guides:

In most cases, SE of coating is adequate for even fairly demanding shielding needs. The principle reason for inadequate SE is the wire penetrations and the openings. Without full attention to these factors, the shield will be ineffective.

SE of an opening is given by $SE = 20*\log(2*\pi*\lambda/L)$, where L is the longest dimension of the opening (i.e.gap in seam or round opening) and λ is the wavelength.

But the biggest problem is the wire penetrations, namely the power entry and data entry. Where high speed data lines require shielded cable, mating the cable shield to the enclosure shield is absolutely critical. Fully circumferential closure is mandatory with no pigtail terminations allowed. Similarly where filtering is used (power or low speed data), filter mounting must be directly to the enclosure with no pigtails allowed.

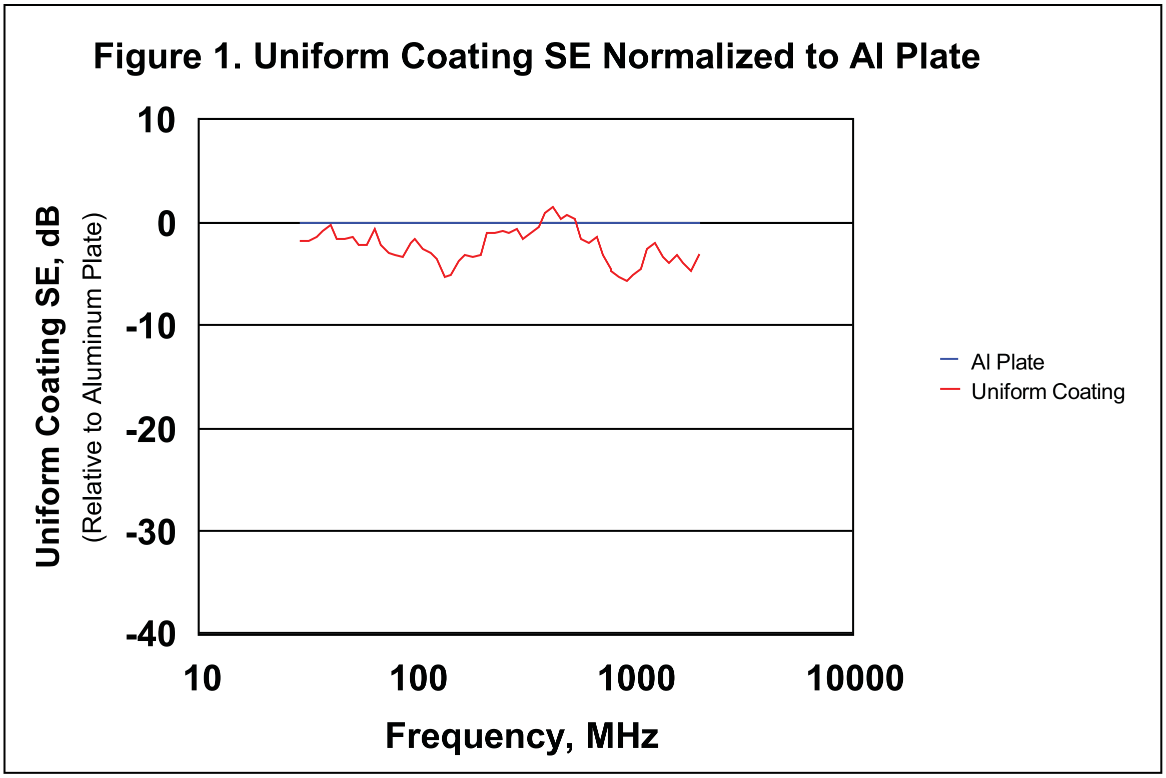
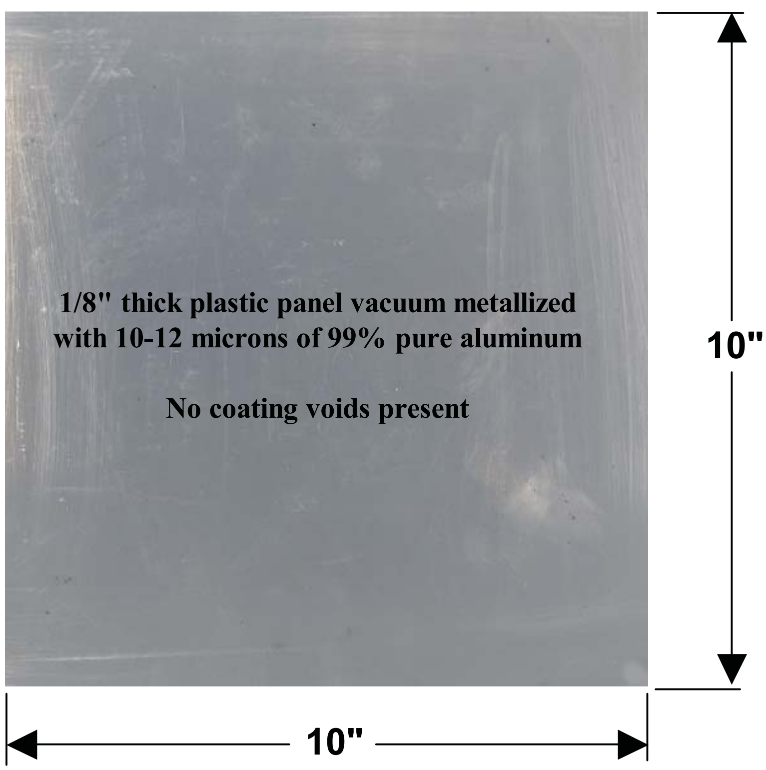


Figure 1. Uniform Coating SE Normalized to Al Plate
Uniform Coating SE, dB
(Relative to Aluminum Plate)
10
0
-10
-20
-30
-40
10
100
1000
10000
Frequency, MHz
Al Plate
Uniform Coating


1/8" thick plastic panel vacuum metallized
with 10-12 microns of 99% pure aluminum
No coating voids present
10"
10"

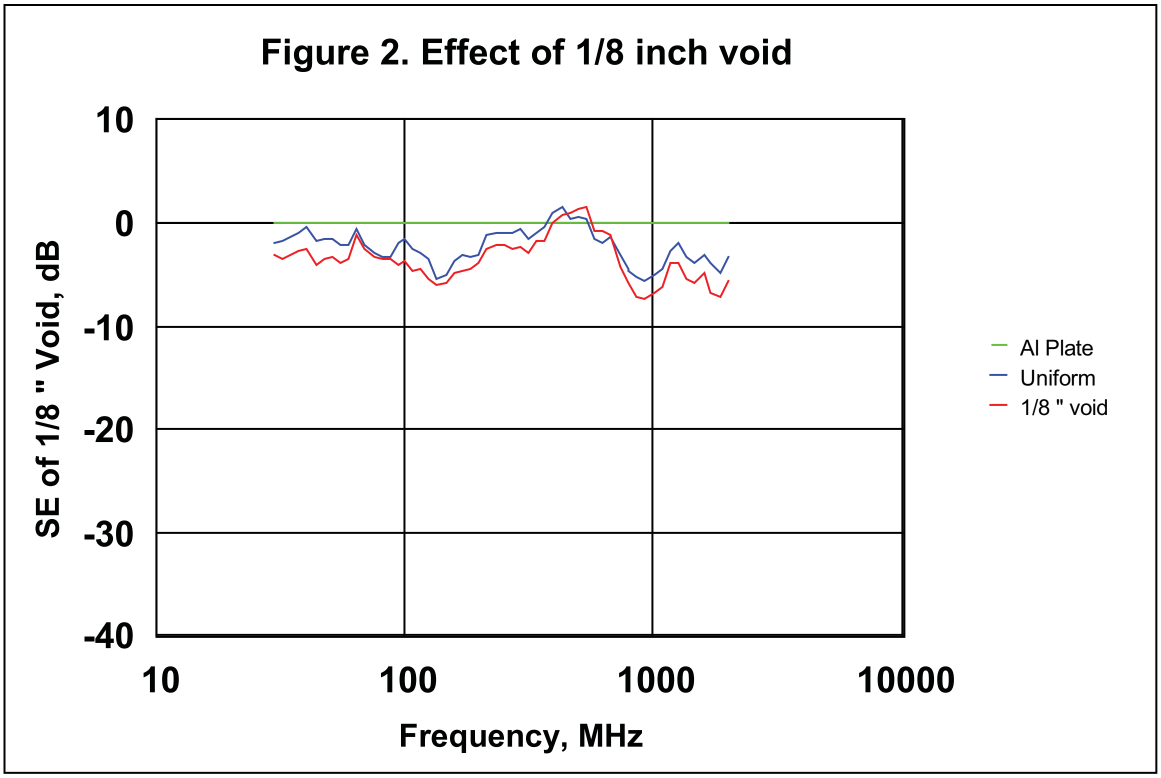
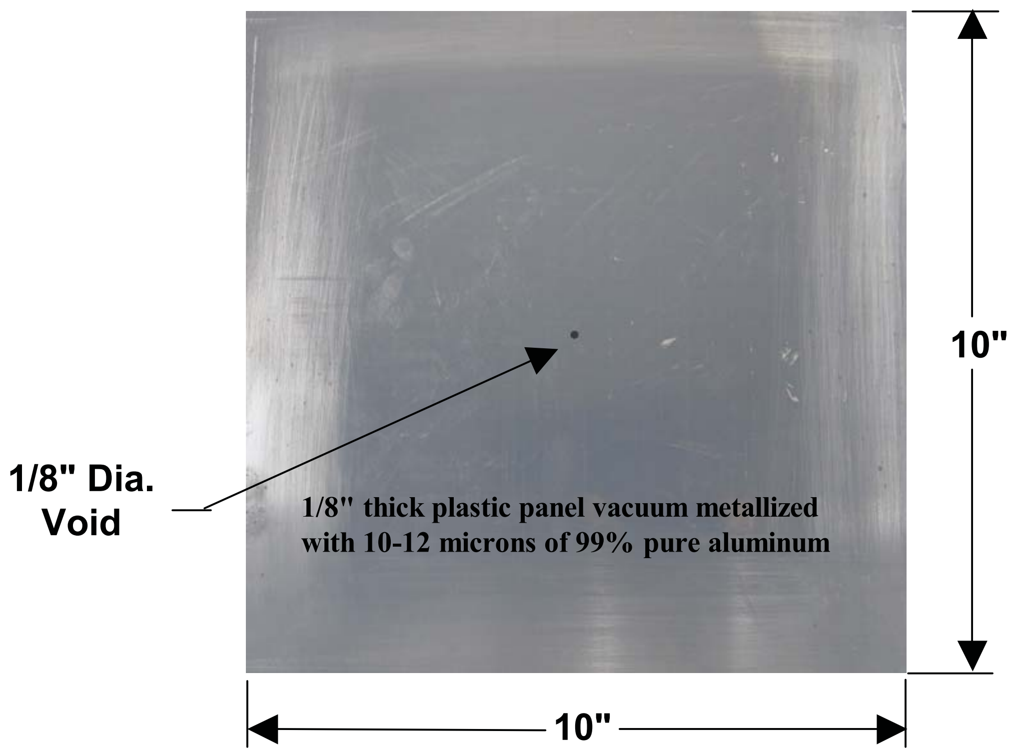


Figure 2. Effect of 1/8 inch void
10
0
-10
-20
-30
-40
SE of 1/8 " Void, dB
10
100
1000
10000
Frequency, MHz
Al Plate
Uniform
1/8 " void


1/8" Dia.
Void
1/8" thick plastic panel vacuum metallized
with 10-12 microns of 99% pure aluminum
10"
10"

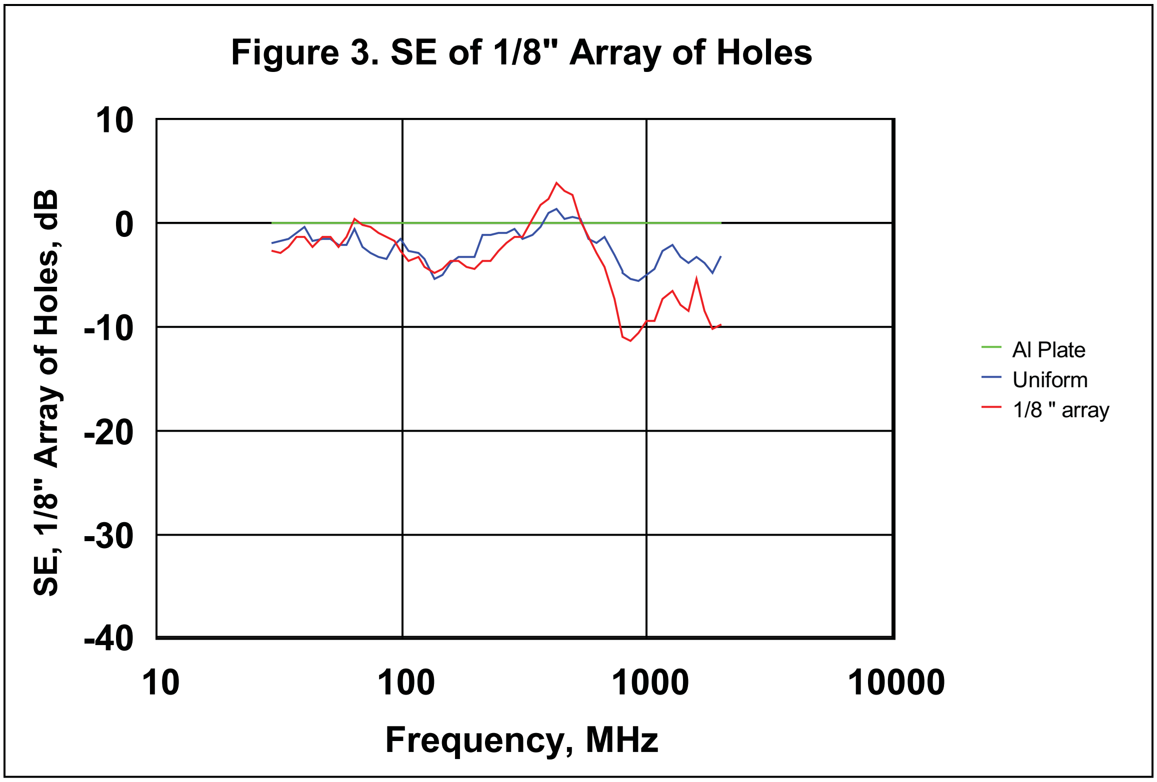
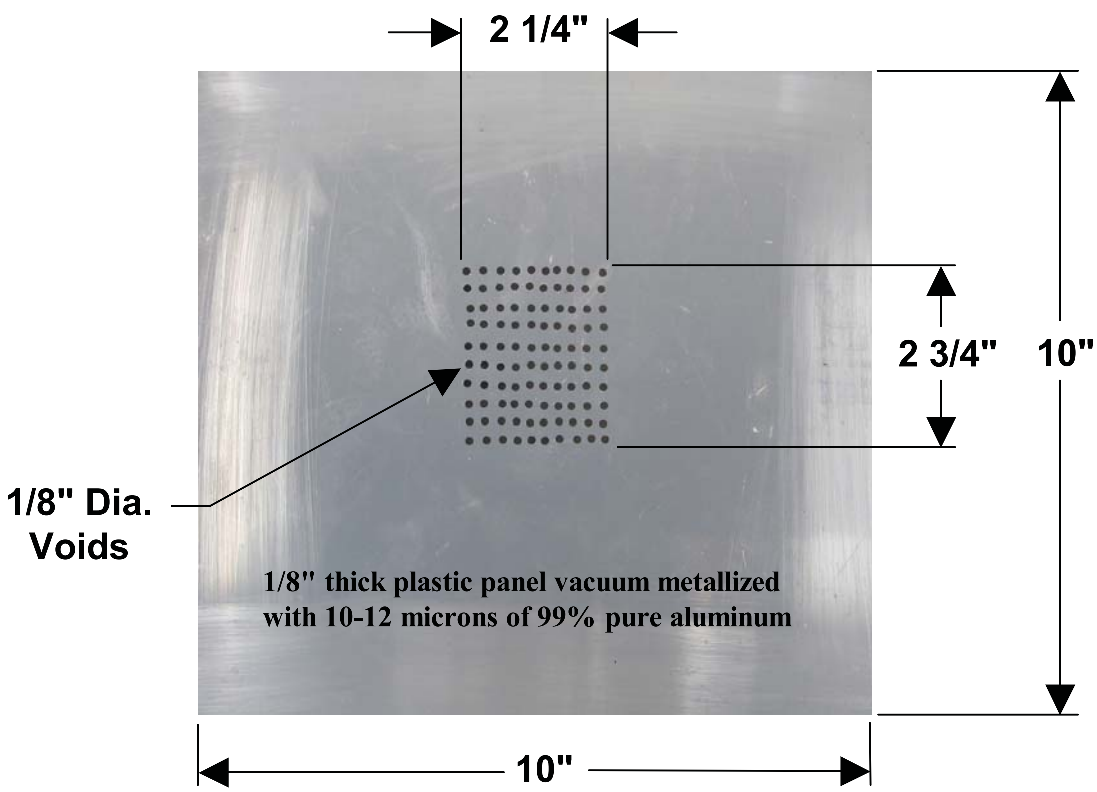


Figure 3. SE of 1/8" Array of Holes
10
0
-10
-20
-30
-40
SE, 1/8" Array of Holes, dB
10
100
1000
10000
Frequency, MHz
Al Plate
Uniform
1/8 " array


2 1/4"
2 3/4"
10"
1/8" Dia.
Voids
1/8" thick plastic panel vacuum metallized
with 10-12 microns of 99% pure aluminum
10"

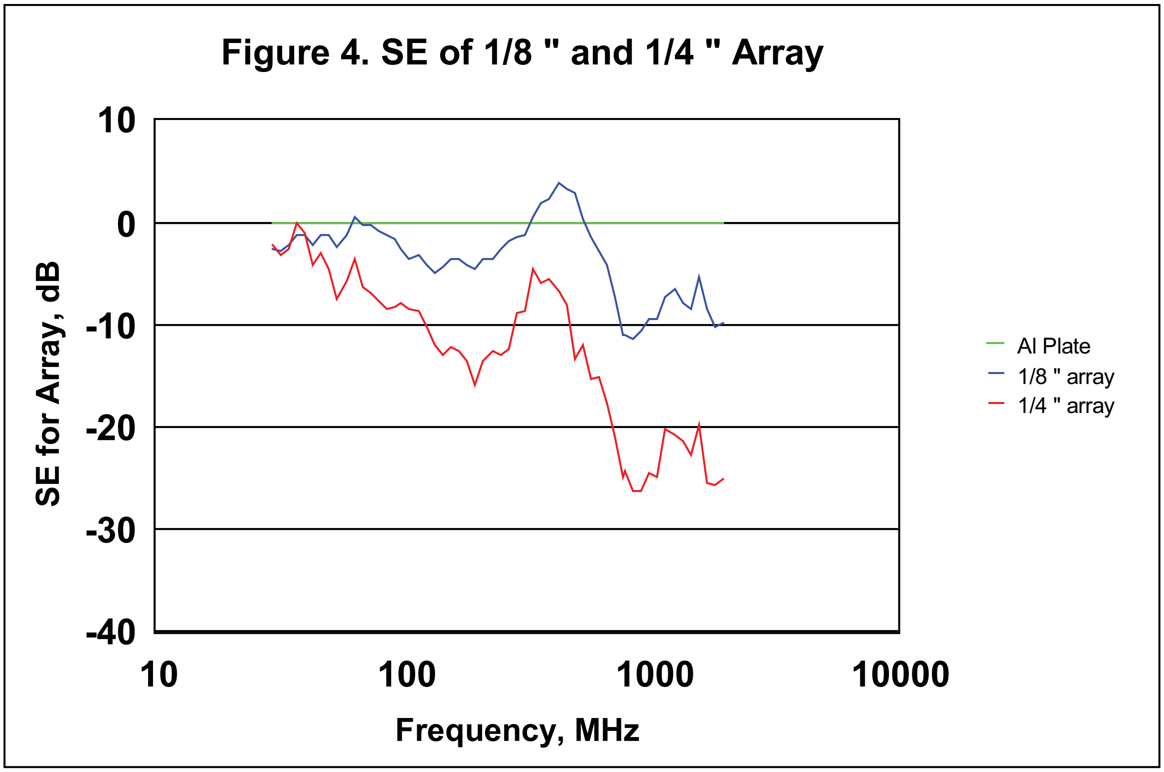
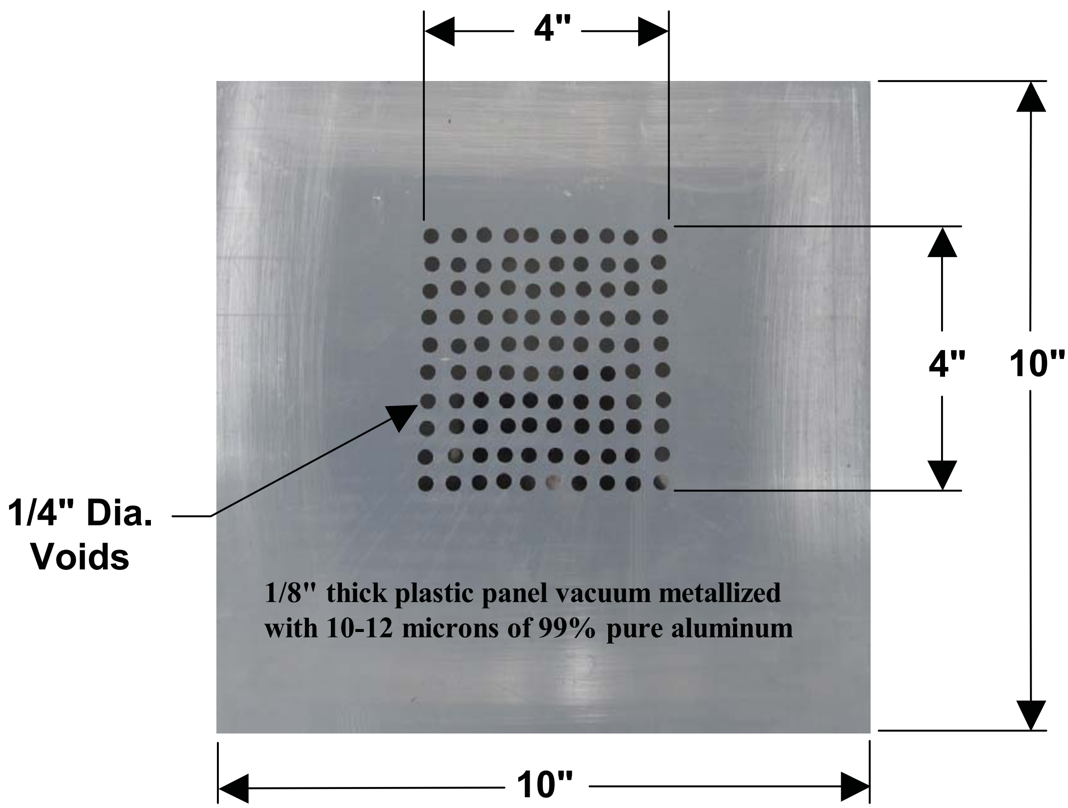


Figure 4. SE of 1/8 " and 1/4 " Array
SE for Array, dB
10
0
-10
-20
-30
-40
10
100
1000
10000
Frequency, MHz
Al Plate
1/8 " array
1/4 " array


4"
4"
10"
10"
1/4" Dia. Voids
1/8" thick plastic panel vacuum metallized with 10-12 microns of 99% pure aluminum