Five-Meter Chambers: A Compromise Solution

With recent developments in new absorber materials, 5-meter anechoic chambers emerge as alternative facilities for the new EMC test standards.

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TRADITIONAL CHAMBER SOLUTIONS

As with most areas of technology, anechoic chambers have been improved with design changes and cost efficiencies. One example is traditional urethane pyramidal absorbers, which have given way to ferrite tile grid and ferrite hybrid designs.

A primary driver for the new developments is the more stringent low frequency requirements for both radiated emissions and immunity testing. ANSI C63.4 and the new EN50147 delineate the volumetric test area for emissions testing from 30 MHz to 1 GHz. IEC1000-4-3 and ENV50140 specify the uniform field needed to certify a chamber for radiated immunity to the new European standards with starting frequencies at 26 MHz for some product groups. Constructing chambers with large cone absorbers to meet these new standards has become prohibitive.

Traditional designs for both 3- and 10-m semi-anechoic chambers utilize pyramidal cones from 8 to 10 feet in length. The large cone rooms are marginally suitable to meet the new chamber standards, but have a number of serious drawbacks. Cost and required shielded room size are the primary constraints. Large pyramidal absorbers are heavy, difficult to manufacture with any attenuation performance consistency, and with their large mass, increase the risks associated with fire.

In the late 1980s, ferrite tiles began to find acceptance in the Pacific Rim for small engineering chamber applications. These have evolved into broadband urethane/ferrite hybrids and ferrite grid panels which meet the new test requirements.

CURRENT FACILITY APPROACHES

For the past few years most new chamber construction for commercial applications has considered three basic designs: Compact Anechoic Chambers (CACs) for compliant immunity testing, and 3- and 10-m chambers for compliant emissions and immunity testing. Typical factors in deciding which approach to choose are cost, parent building constraints and product compliance requirements.

COMPACTS

A CAC which is compliant to IEC 1000-4-3 costs between $120,000 to $200,000 depending on final size and options. The typical footprint for a CAC is 10′ W x 23′ L x 10′ H, which provides the 1.5 m x 1.5 m field uniformity specified in IEC 1000-4-3. In many cases these immunity chambers are constructed slightly larger because of EUT size, or more commonly to provide additional scan height to provide better pre-scan emissions measurements. With an overall facility height of 11 to 13 feet, a CAC can easily fit in most industrial buildings.

The market popularity of the CAC is that at a reasonable cost, the owner has an IEC 1000-4-3 compliant facility with good pre-scan emissions capability. The owner can then either obtain final emissions testing at an independent test house, or can further invest in an Open Area Test Site (OATS) to complete the RF test requirements.

THREE-METER CHAMBERS

The cost for a 3-m chamber is substantially more than a CAC, but it provides for compliant FCC/ANSI emissions testing. Prices vary from $350K to $500K depending on options. A 3-m chamber is typically equipped with automated masts and turntables which add to the cost. A separate control room is also quite common.

Three-meter chambers are larger as they must accommodate the 1- to 4-m scan height of the receive antenna and a specified clearance for the ground plane for both FCC (ANSI) and CISPR emissions testing. Their typical footprint is 20′ W x 30′ L x 18′ H. The critical dimension for a 3-m chamber is the height, which, when structural support and high hat lighting is added, is about 18 to 19 feet. Again, this can be accommodated by many existing industrial buildings.

Three-meter anechoic chambers can be used for compliant immunity for IEC and emissions testing for the FCC. As the path length is limited to 3 m, measurement data must be extrapolated to 10 m for the European standards. At the lower frequencies, the lower path length to wave length ratio will cause greater measurement uncertainty. Many companies check critical frequencies on an OATS before signing off on a product, especially below 100 MHz.

TEN-METER CHAMBERS

Ten-meter chambers represent a major step-up in costs over the other chambers. The chambers can range from $1.2 million to over $2.0 million. Ten-meter chambers will meet all the certification requirements for both immunity and emissions testing. Unfortunately, their size can be prohibitive for many parent building facilities. They require a footprint of approximately 60′ L x 45′ W. This varies with the absorber used and also the size of the ANSI test area.

More restrictive is their overall height. For a 10-m chamber, height is not determined by the 1- to 4-m mast scan, but by absorber performance. Typical absorber performance as given by the manufacturers is shown at normal incidence and is the maximum attenuation for that product. At off-angle incidences, all absorbers decrease in effectiveness. With the longer path length of a 10-m chamber, reflected energy on side walls and ceilings are at a low angle of incidence. This forces the 10-m chamber design to an overall height of about 29 to 33 feet. This height is greater than is available in most industrial facilities causing the 10-m chamber to be housed in a dedicated custom constructed building.

Certainly, cost in recent years has dominated many companies' decisions on what type of facility to build. CACs are the most common choice for those firms who are trying to limit work with outside test facilities. Three-meter chambers are good choices for firms that need to certify with the FCC or have large EUTs that require more space for testing than is available in a CAC. Each year a few 10-m chambers are constructed by larger companies, but the $1.2 million-plus cost and large parent building requirements make this a very limited choice.

THE FIVE-METER SOLUTION

In the past year some companies have been opting for a compromise solution in their choice of anechoic facilities: 5-m semi-anechoic chambers. Once again the decision drivers for a 5-m chamber are cost/size and compliance requirements. Any company considering a 5-m chamber would be testing to FCC and CISPR emissions requirements, and to IEC 1000-4-3 for radiated immunity.

With the new advances in hybrid, especially the new ferrite grid absorbers, the relative size of a 5-m chamber is only marginally larger than a 3-m chamber. The typical dimensions for the 5-m chamber is 38′ L x 22′ W x 20′ H (Table 1). This allows installation in most industrial buildings as with the 3-m chamber.

In many companies, available floor space can be an issue, but most structures have both the bay size and the height for either a 5-m or 3-m chamber. This is normally not the case for a 10-m chamber.

The primary cost factor in any anechoic chamber is the absorber material, which typically comprises more than 50 percent of the construction cost. Since a 5-m chamber is only marginally larger than a 3-m chamber, the relative price increase is not as extreme as it is in the case of a 10-meter chamber. Only about 30 percent more absorber material is required. The major cost elements (doors, filters, etc.) of the RF shielding are common to both 3-m and 5-m constructions so that incremental increase also is minimal (Table 2).

Although a 5-m path length is not specified by any current U.S. or international standard, it does provide certain technical advantages over a 3-m chamber. For all absorber materials, the ANSI or quiet zone size of a chamber increases with chamber size. For larger EUTs or systems with multiple components, the larger 5-m chamber accommodates larger diameter areas. The chamber shown in Figures 1 and 2 provides a five-point ANSI diameter of 3 m at a 3-m path length. Figures 3 and 4 show performance of an existing 5-m chamber. The data shown is the worst case of the 20 necessary scans for ANSI. This is normally for vertical polarization at a 1-m transmit height. In this ferrite grid chamber, all ANSI scans were within a +/-3.0 dB range for the 3-m diameter with the 3-m path length.

Chamber	3 m	5 m	10 m
Length	30 feet	38 feet	60 feet
Width	20 feet	22 feet	40 feet
Height	19 feet	20 feet	30 feet

Table 1. *Comparison of Typical Chamber Sizes.*

Chamber	3 m	5 m	10 m
Cost	$450,000	$580,000	$1,500,000

Table 2. *Average Costs of Three Types of Emissions Chambers.*

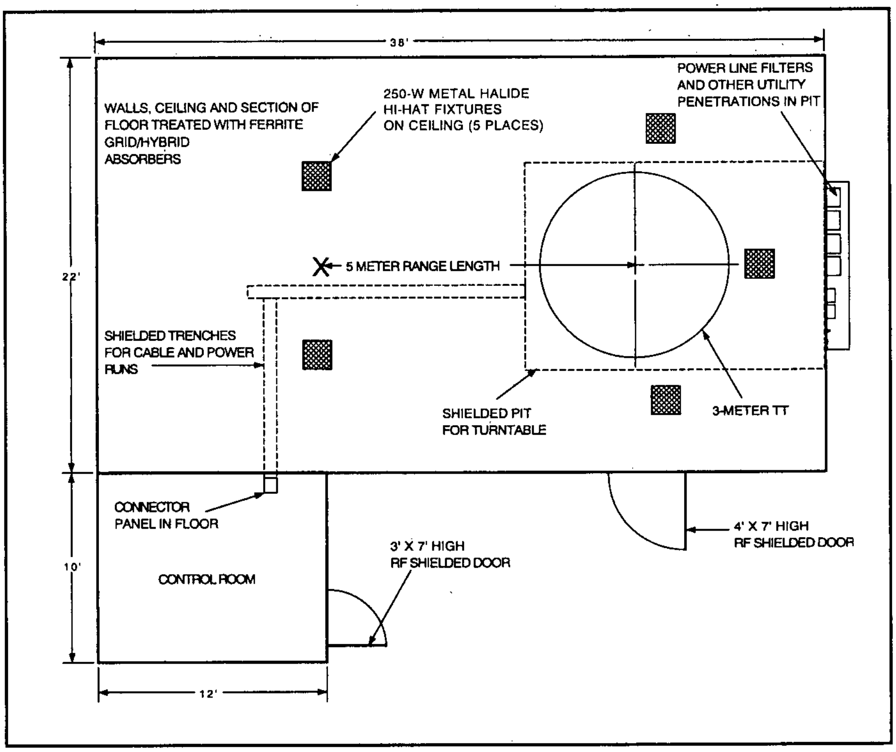

Figure 1. *Plan View of 5-m Semi-Anechoic Chamber.*

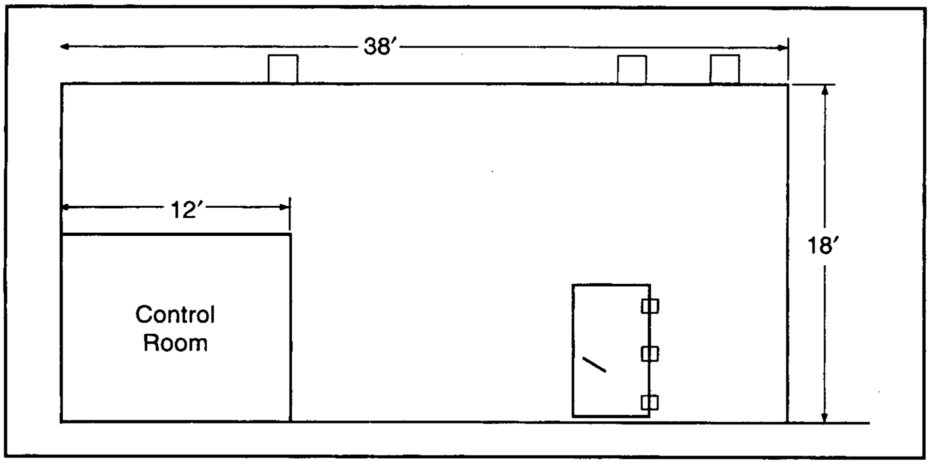

Figure 2. Elevation View of 5-m Semi-Anechoic Chamber.

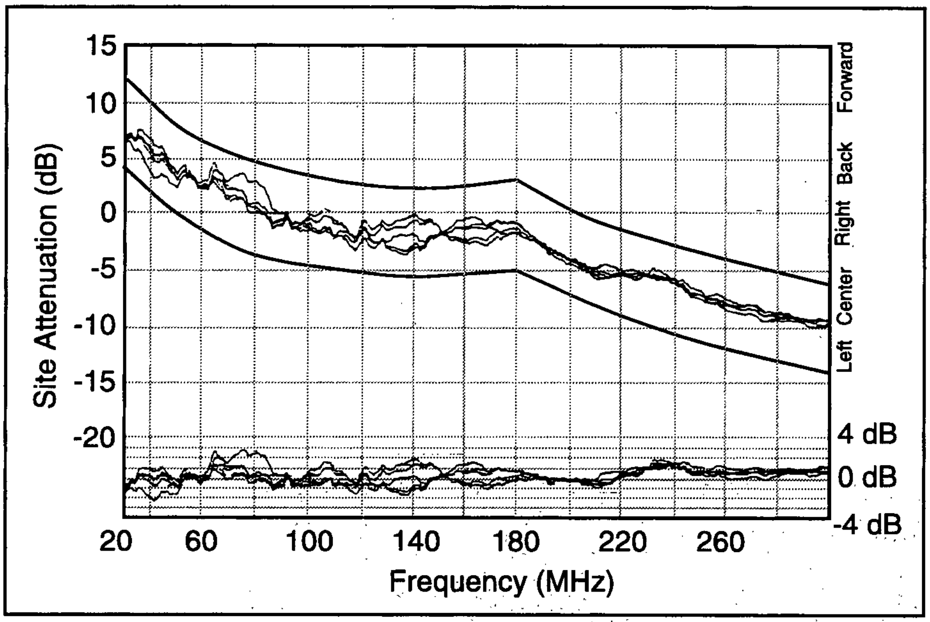

Figure 3. Performance of Existing 5-m Chamber in 20 to 300 MHz Range.

Extending the ANSI certification path length to 5 m decreases the ANSI diameter. This smaller size varies depending on absorber type. For this chamber, the ANSI diameter at the 5-m path was 2 m.

The main technical advantage of the 5-m path is in reduced measurement uncertainty over data taken in a 3-m chamber. All anechoic chambers provide a clean RF ambient compared to measurements taken on OATS, but measurement uncertainties still exist in a proper chamber. Instrumentation, cabling and connectors are factors in this uncertainty. The most significant errors are always associated with the broadband antennas which are used for both chamber certification and equipment testing. Even with antennas that are carefully calibrated (see sidebar), difficulties arise with calibration/measurement distances at 3 m at the lower frequency test requirements of both CISPR and ANSI.

Ideally, antennas should be calibrated in a "free space" configuration. For frequencies at or near 30 MHz, the low path length to wave length ratio causes this increased uncertainty. Additional measurement error can also be generated by the coupling of the antennas to the chamber walls, and beam width limitations which add to uncertainty with the 4-m scan height at the short 3-m path. Any measurement data taken at 3 or 5 m must be extrapolated to 10 m for acceptance by the Euro-

Broadband Antennas for Site Certification

Between 25 and 50 percent of the +/- 4 dB site uncertainty allowed by ANSI C63.4 and EN50147 can be attributed to the antenna pairs used in certification. Typically, most 3-, 5- and 10-m chamber programs include the certification of the final room by the contractor. Some chamber packages include the antennas used to certify the chambers, bundled with the facility. These antennas are given additional calibration beyond that normally provided by the antenna manufacturer.

This is not simply a clever ruse to sell a few new antennas buried in the chamber program. It eliminates the problems created when the greatest source of measurement uncertainty leave with the independent testing contractor. These specially calibrated pairs antennas can be used for product certification, correlation to other sites, and periodic chamber checks. Of course, all antennas are not suitable. Care should be taken to select an antenna vendor with the appropriate calibration procedures and site facilities.

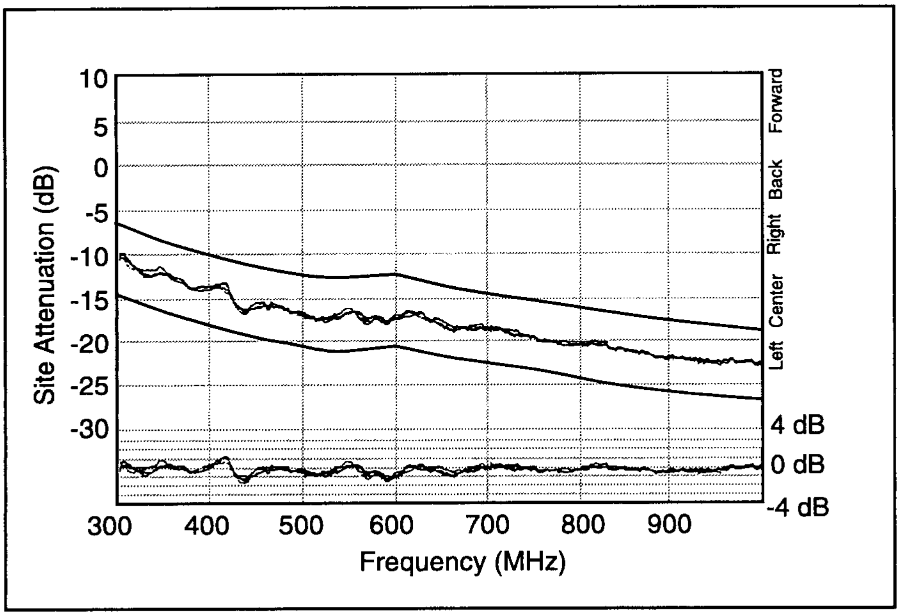

Figure 4. *Performance of Existing 5-m Chamber in 300 to 1,000 MHz Range.*

pean standards. The increased accuracy of the 5-m data over 3-m data provides a greater margin of safety in final product certification.

SUMMARY

Certainly the new European Directives have increased the construction of anechoic chambers both in Europe and the U.S. Compacts are cost-effective for immunity and pre-scan emissions with the second most common choice being 3-m chambers. Ten-m chambers are costly and require special facilities to meet their height requirements. With the recent improvements in absorber materials, the 5-m chamber has become a new alternative. They are moderately more expensive than 3-m chambers. They can be housed in most standard industrial buildings. They also provide significant technical improvements over the standard 3-m chamber with increased test zone size, and improvement in measurement uncertainty.

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