Top 10 Considerations for Automotive EMC Chamber Design and Testing

ETS-LINDGREN®
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TOP 10 CONSIDERATIONS FOR AUTOMOTIVE EMC CHAMBER DESIGN AND TESTING

Following is our Top 10 list of the most important things you need to consider when developing or refining an automotive EMC chamber and test design. This resource will help you avoid the most common mistakes, and what you should consider to ensure a more successful project. This quick and concise guide covers standards, DUT considerations, automotive industry trends – including autonomous vehicles - and more!

1. Know your automotive EMC standards – what standards do you want to test in accordance with to attract customers/meet your company's requirements?

The major automotive EMC standards are issued by the Society of Automotive Engineers (SAE), the International Electrotechnical Committee (IEC), the International Standards Organization (ISO), the European Community (EC) and the United Nations Economic Commission for Europe (UNECE). The most commonly referenced standards for full vehicle and electronic subassemblies (ESA) are the CISPR standards issued by the IEC, such as CISPR 25 and CISPR 12, followed closely by the ISO standards 11451 and 11452. These standards apply to traditional, hybrid and electric vehicles and specify the test distances and methods required to validate a product's performance. This dictates the size of the test range required, placement of anechoic absorber (if needed) and test apparatus needed to perform various tests. Each standard has its own requirements so research them carefully to ensure your chamber will comply with your standards of interest. The table below summarizes the most commonly referenced EMC standards that cover vehicles in their scope. In addition to the commercial EMC standards noted above, there are also military standards, such as MIL-STD-461, which also applies to automotive subsystems and vehicles.

Standard	Issuing Bodies	Applicability		Test Covered
		Vehicle	ESA	
ISO 11451	ISO	Yes	No	RS
ISO 11452	ISO	No	Yes	RS
CISPR-12	IEC	Yes	No	RE
CISPR-25	IEC	Yes	Yes	RE
SAE J551	SAE	Yes	No	RE & RS
SAE J1113	SAE	No	Yes	RE & RS
95/54/EC	EC	Yes	Yes	RE & RS
2004/104/EC	EC	Yes	Yes	RE & RS
ECE Reg. 105	UNECE	Yes	Yes	RE & RS
MIL-STD-461	DoD	Yes	Yes	RE & RS

Be aware that manufacturers also issue company specific standards, such as those published by General Motors, Ford, and Fiat Chrysler Automobiles (FCA), etc. These company specific standards each have their own nuances that should be addressed if they are a targeted customer of your test chamber.

2. Consider the size of the device under test (DUT) as full vehicle DUTs vs component level DUTs influence the chamber size and cost.

This may be stating the obvious, but within full vehicles, there are many sizes. Some chambers are sized to test 56 seat passenger busses, while others are sized to test “smart cars” which seat two passengers. Some vehicles are heavier than others which impacts floor loading requirements. The radiating elements used can also have an impact on the chamber size, especially those used for low frequency high field strength testing. Components likewise can vary in size. Every square yard/meter of a chamber adds to the overall cost so careful consideration of the size of your DUT, antennas and test range will result in the most cost effective chamber.

3. Consider the frequency range when looking at test chambers for ADS, V2X, and OTA applications.

Another cost driver of a chamber size is a factor of the frequency range. Advanced Driver Assistance Systems (ADAS), Connected Vehicles including vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and Vehicle-to-Cloud (V2C) as well as Over-the-Air (OTA) operational frequencies all feature different frequencies. Automotive test chambers need to address various frequency ranges, currently including:

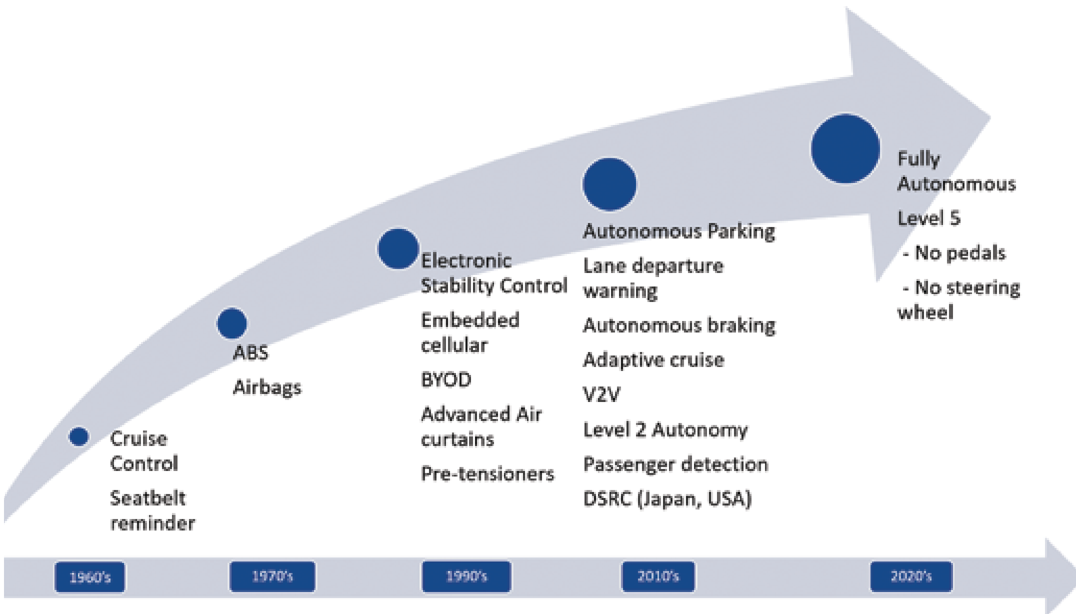
- **FM Radio from 70 MHz**
- **HD radio**
- **Cellular from 700 MHz to 60 GHz (3G, 4G,LTE, 5G)**
- **Satellite from 1.6 GHz**
- **WiFi from 2.4/5.8 GHz**
- **DSRC 5.9 GHz**
- **RADAR 24 GHz/79 GHz**

Research the features of your DUT to specify the desired frequency range testing needed. The overall scope of vehicle testing is expected to experience ongoing development so consider the upgrade potential of the chamber and system design.

Images courtesy of the U.S. Department of Transportation

4. Become familiar with and follow the automotive industry trends to be prepared for future test requirements.

Automobiles have changed considerably over the years as shown below. From the early 1960s when cruise control was introduced to the current trend towards autonomous vehicles, the test environment for automotive vehicles and components has changed, and continues to change!



The rapid development of advanced automotive features and the trend toward autonomy is driving the need for more sophisticated automotive EMC design and test scenarios. Vehicle platforms continue to become increasingly more complex with propulsion, entertainment and safety related systems all having to function reliably without impacting safety or the legacy communications infrastructure. The safety and reliability requirements for autonomous vehicles will rival, and in some cases surpass, the requirements for aerospace and military systems. Plan your chamber design to take into account the capabilities needed for future automotive test requirements, especially those related to communications.

Image by Dllu - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=63450446

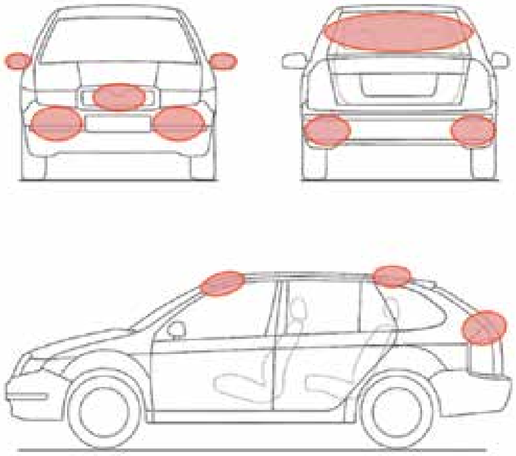
5. Consider a retrofit/upgrade of an existing chamber.

If you have an existing full vehicle test chamber, depending on the size of the chamber, desired DUT size and applicable test standards, you may be able to upgrade your chamber. This may involve replacing current anechoic absorber with new or different absorber, adding a test apparatus to the interior of your chamber to cover an extended range of measurements as shown above, or possibly increasing the size of the chamber door. It is worth exploring if a chamber upgrade/retrofit will expand your automotive test capabilities while also saving time and money.

6. If a new chamber, evaluate design options for various component or full vehicle test needs.

This presents the best opportunity to design for your current and future testing needs. Available budget is always a limitation but avoid making this the limiting factor in the initial discussions on overall scope. The intended use of the chamber can drive several design elements. A commercial test lab's need for customer throughput and flexibility is different to a manufacturer's R&D needs. Addressing and incorporating the new chamber design with the parent building design and construction also has many cost and schedule advantages. These and the other items listed in this "Top 10" could drive subtle differences in overall chamber design which could be considered for a new chamber.

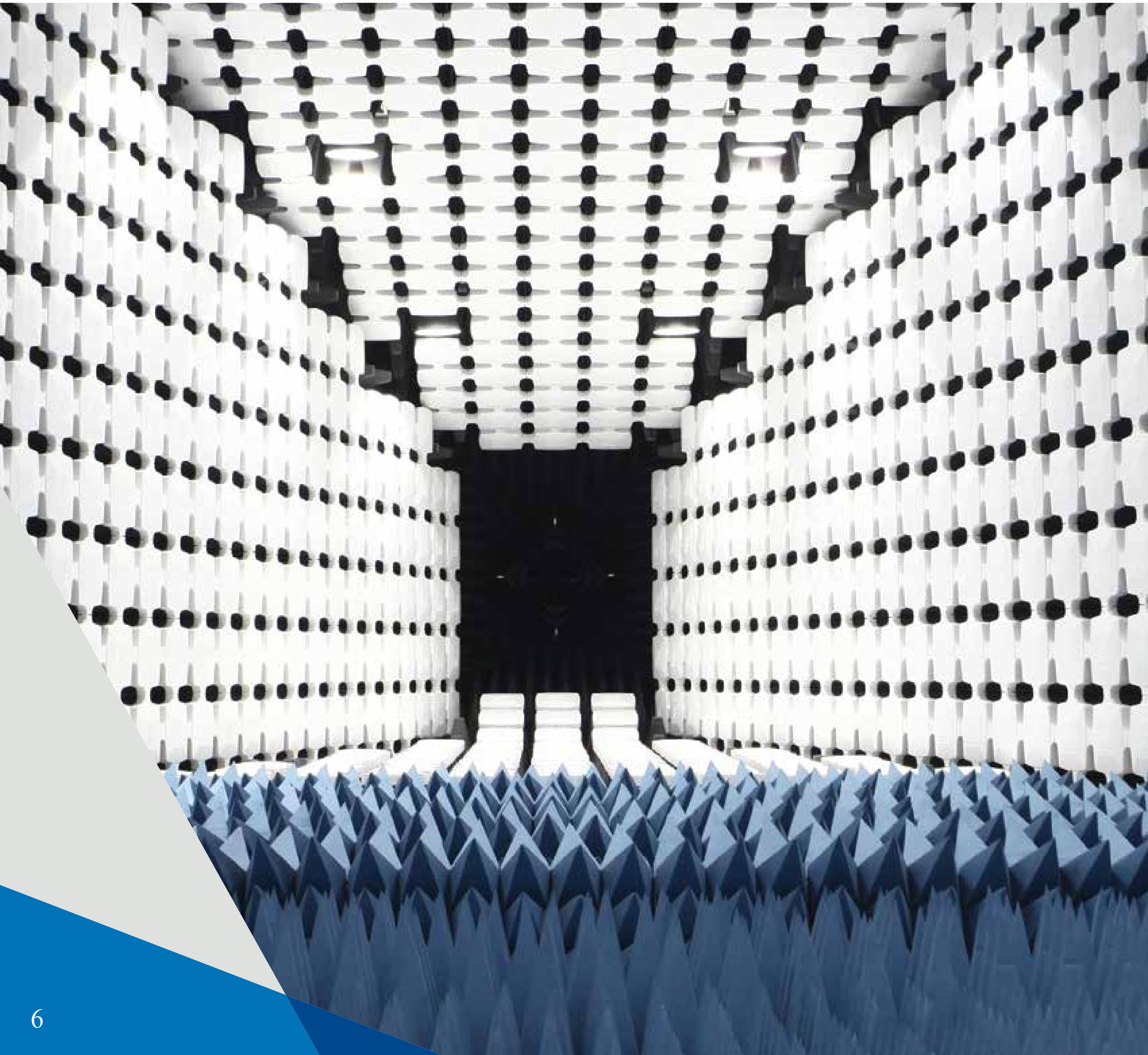
7. Be aware of the challenges associated with current and quickly developing sensor and antenna technologies extending traditional automotive EMC testing.



Automotive EMC test chambers may be designed for more complex test capabilities, such as those involving elements of Advanced Driver Assistance Systems (ADAS), Radio Detection and Ranging (RADAR) and Light Detection and Ranging (LIDAR). Antenna arrays, as well as signal and protocol simulators, may be installed in the chamber to test the performance of these capabilities. This results in a combination chamber for both EMC and antenna (wireless) measurements, commonly referred to as a hybrid chamber. Today's modern vehicles include many antennas that are mounted in various locations inside and outside of the vehicle. These antennas are highly integrated with the automotive body for aesthetic, practical and performance reasons. Performance must be verified as an integral part of the vehicle. A hybrid chamber facilitates these measurements by enabling EMC, wireless Over-the-Air (OTA), and antenna pattern measurements.

8. Don't overlook anechoic absorber – consider options for optimal performance, durability, and cost effectiveness.

Traditional EMC chambers have been designed over the years with RF absorber optimized to provide a cost effective level of performance over the 28 MHz to 2.5 GHz frequency range. Dedicated antenna measurement and RADAR cross section (RCS) chambers which typically cover frequencies from 100 MHz to over 100 GHz use a different type of RF absorber, with different performance and in some cases, different RF power dissipation requirements. Hybrid chambers (those capable of EMC and antenna pattern measurements) are increasingly utilized since their dual purpose drives some test efficiencies. The RF absorber treatment must be based on the overall frequency range of the chamber and in the case of the tapered shape chamber, where different test zones are employed with the benefit of a reduced footprint, the absorber layout could be critical. An example of a full vehicle hybrid chamber is shown below.



9. Don't underestimate the importance of a dynamometer.

Dynamometers are an essential component of a full vehicle test chamber. They are expensive, have a long lead time, and require careful integration with the chamber to ensure the chamber performance is not compromised. There are two major types of dynamometers:

1. **A chassis 'Dyno' which is full size vehicle dyno to simulate road driving load.**
2. **A motor 'Dyno' which is a smaller device connected directly to a motor during component testing to provide a representative load to the motor assembly. It is typically capable of measuring the torque at various speeds while applying drive or a breaking or drag resistance.**

A typical test set up for a motor dynamometer is shown above.

There are many types of dynamometers available with advantages and disadvantages for specific test types. Selection is based on a number of parameters and features:

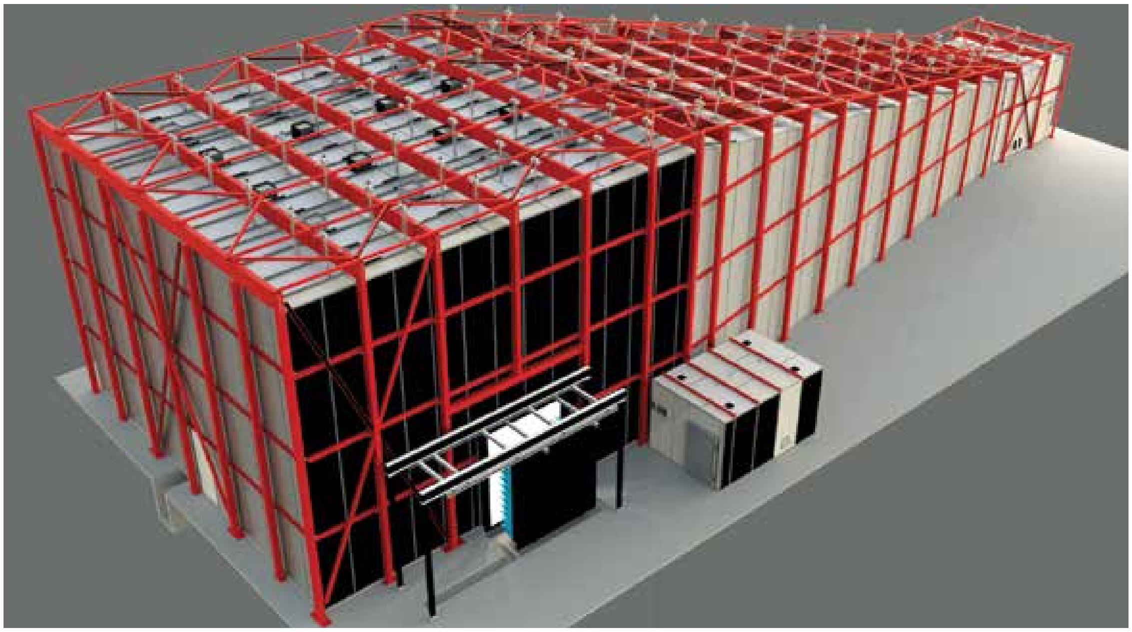
- **Available torque range**
- **Maximum speed**
- **Minimum speed**
- **Maximum power dissipation**
- **Response time**
- **Inertia profile**
- **Test scenario**

In addition, dynamometers used for E-motor testing need more operating options, such as higher maximum speed rating than combustion engines, the ability to operate in both directions, and the ability to drive and brake. Installing a dynamometer also requires planning to accommodate the support equipment. Consider and select your dynamometer at the beginning of your chamber design planning.

10. Use BIM to facilitate design and construction, stay on budget, and meet schedule deadlines.

Building Information Modeling (BIM) is recommended for significant projects involving the design and installation of a large RF shielded enclosure or anechoic chamber. BIM is a process that enables better insight and predictability of the physical and functional characteristics of a facility - before it is built. It includes the generation of 3D digital representations of the structure's architecture as well as the mechanical, electrical and plumbing (MEP) so users can see how the RF shielded enclosure or anechoic chamber will interface with their parent building. BIM becomes a resource of shared knowledge, facilitating collaboration between users, architects and general contractors. Large test chambers are a considerable investment. By using BIM, users can have a better understanding of the entire project and how to address any potential problems up-front, during the design phase. Ideal BIM files are provided in a 3D solid object format; no wire frame objects are used in any of the families. The chamber is modeled to overall final dimensions. Design software should be compatible for direct importation across responsibilities. All elevations of shielding objects should be true and accurate per plans and specs; all MEP connections and penetrations into the chamber should be modeled to size in their required locations. A series of walk through or drive through videos can be created to give a realistic simulation of movement through the designed space. This can be very beneficial in understanding vehicle access routes, for example.

Projects using BIM result in lower expense and risk through reduced construction delays, rework, and/or on site problems. Consider chamber manufacturers who have an in-house Autodesk Certified Professional design team that is proficient in BIM to minimize the inherent risk in your construction project. An example of a BIM image of a semi-tapered anechoic chamber is shown below.



Need additional assistance in choosing a chamber? ETS-Lindgren can help! Contact your local ETS-Lindgren representative, phone us at +1.512.531.6400, or visit our website at www.ets-lindgren.com.