Test Chambers provided by ETS-Lindgren
Photo courtesy of Jacobs Engineering

The Electromagnetic Compatibility Test Chambers at General Motors Proving Ground, Milford, Michigan

The General Motors EMC facility houses four state-of-the-art EMC testing chambers at its Proving Ground in Milford, Michigan. The ten-meter semi-anechoic chambers are used interchangeably for radiated emissions and radiated immunity testing for automotive vehicles including cars, trucks, and busses. The world's first vehicle-sized electronically modulated spherical near-field system (Antenna Test System) is housed in one of the EMC chambers. It is used to measure vehicle and component antenna gain and directionality for cellular, PCS, GPS, and SDARS bands.

Key technical features of the facility include:

Physical Chambers

All chambers are freestanding with an external size of 31m x 22m x 10m high, designed and installed by ETS-Lindgren. The nominal shield-to-shield internal size is 29m x 20m x 9m high; the test area is 5m x 2.5m.

The chambers were built using a welded, 12-gauge all-steel construction on the walls and ceiling and 6.35mm steel plate for the floors. Cable ducts with access ports were arranged on the floor area so cables can be routed below the ground plane for various test configurations.

The RF sliding doors, designed for at least 100,000 operations, provide 120dB attenuation over 10 kHz to 18 GHz. The largest sliding door measures 12'w x 14'h.

A combination of ferrite and FerroSorb™ absorber provide broad frequency performance from 30 MHz to 18 GHz and withstand continuous field intensity of 200 V/m and intermittent field intensity of 500 V/m. The FerroSorb™ absorber design combines ferrite materials with matched, broadband, dielectric polyurethane foam in pyramidal shapes. This foam utilizes a combination of 60cm and 1m sections as required. Removable absorber lined walls and turntable pallets are used for antenna testing.

All four (4) chambers were designed to be compliant with the +/- 4 dB Normalized Site Attenuation (NSA) requirements of ANSI C63.4-1992 from 30-1000 MHz. All four (4) chambers were designed to comply with a field homogeneity requirement of +/- 1 dB from 30-1000 MHz.

The floor and turntable of each chamber can support 40,000 lb of total vehicle weight and 25,000 lb of axle weight.

A high-resolution, closed circuit video system is provided in all four (4) chambers. The system is fiber-optically controlled and includes a high-performance video camera and 14in color monitor with remote pan, focus, tilt and zoom features. The camera and control cabling within the chamber are hardened against interference from electromagnetic fields up to 200V/m from 0.5 MHz to 18 GHz.

The radiated emissions/antenna test chamber is equipped with a video projection system inside of the chamber, which allows for visual confirmation of the measurement data.

Antenna Test System (ATS) Measurements

The Satimo ATS is housed inside of the radiated emissions/antenna test chamber. The chamber can be configured for either radiated emissions or antenna testing in less than two hours. The Satimo ATS uses 103 dual polarized probes, which are electronically modulated, to measure 103 elevation angles at 360 azimuth points in approximately 5 minutes. The operating frequency range is 500 MHz to 6 GHz and is used to test cellular, PCS, GPS, SDARS, and DAB L-band. The minimum sphere diameter (maximum test artifact diameter) ranges from 9m to 1.6m (at 6 GHz), allowing for quick, and accurate, repeatable vehicle antenna gain measurements. The ATS has been XM certified since March 2004.

Dynamometers

- All four (4) chambers include a 9m turntable with adjustable-rate engine cooling air.
- The DC motors of the chassis dynamometers/turntables are bi-directional, with a maximum road-load horsepower of 0-70hp at 55mph.
- The dynamometer system is immune to chamber field strength levels of 200V/m, 100 kHz to 12GHz and 600V/m, 1-12GHz.
- The turntable system is integrated with each dynamometer and flush with each finished chamber floor. The turntables provide a rotation speed of 0.5 rpm maximum with a controlled ramp up and ramp down transition.
- Special filtering elements were incorporated into one chamber's dynamometer motors to allow "at-speed" testing for radiated emissions measurements.

EMC Antenna Systems

0.1-30 MHz

Three (3) of the chambers are fitted with an electric/magnetic field generator (EMCO Model 5503) suspended from the ceiling with non-conductive cables and may be raised or lowered using a hoist system. The system can be switched to generate electric or magnetic fields from 100 kHz to 30 MHz and can accommodate 10 kW of RF power.

30-1000 MHz

The antenna system utilized provides the appropriate patterns at the test sample to assure the field uniformity and field intensity requirements are met. Per the design for radiated immunity, three (3) of the chambers were configured to accommodate a field uniformity design requirement (for 30-1000 MHz) of:

- +0, -3 dB along an axis extending +/- 2.5 meters horizontally from the reference point.
- 3 dB maximum span relative to the reference point (e.g. +3/-0, +1/-2, +0/-3, etc.) along the vertical axis of the reference plane beginning at 0.6 meters and extending to 3 meters above the floor.
- The minimum field intensity design requirement was 100 V/m.

The antennas include:

- 30-100 MHz: Biconical, capable of handling 10 kW
- 100-500 MHz: Log-Periodic Array, capable of handling 2 kW
- 500-1000 MHz: Extended-Range Horn antennas (-H, -V), capable of handling 2 kW

1 – 18 GHz

Three (3) horn antennas, each designed to cover 1-2.5 GHz, 2.7-5.7 GHz, and 9.3-9.57 GHz, respectively. They are intended to produce field levels in excess of 100 V/m at a distance of six meters from the reference point, with corresponding available minimum power of 500 W (CW), 2 kW (pulsed), and 2 kW (pulsed), respectively. Additionally, each radiated immunity chamber is equipped with a high-gain antenna designed for L-Band radar field applications, given an available power of 18 kW (pulsed).

RF Generation

The RF generation systems are located under each of the three radiated immunity chambers to minimize cable/waveguide run length and use of transfer switches. Each RF generation system includes amplifiers, signal generators, power meters, safety-interlock controllers and switches, etc. An airlift palette system facilitates rapid and safe replacement of the RF systems and helps to optimize facility readiness.

Primary Contractor

The facility, including the chambers, shielded doors, absorber, turntables, antennas and other related accessories, was provided by ETS-Lindgren of Cedar Park, Texas.