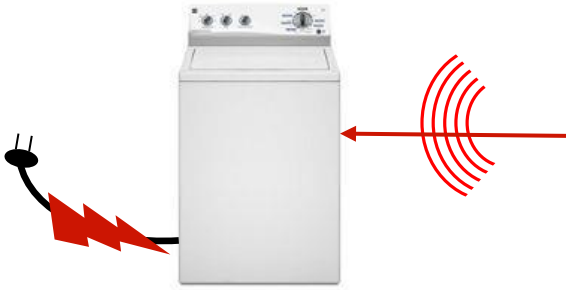
An Overview of EMC Chambers

Donald J Gray
Director of Business Development

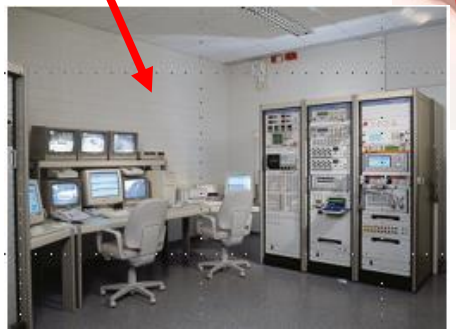
Review of EMC Testing

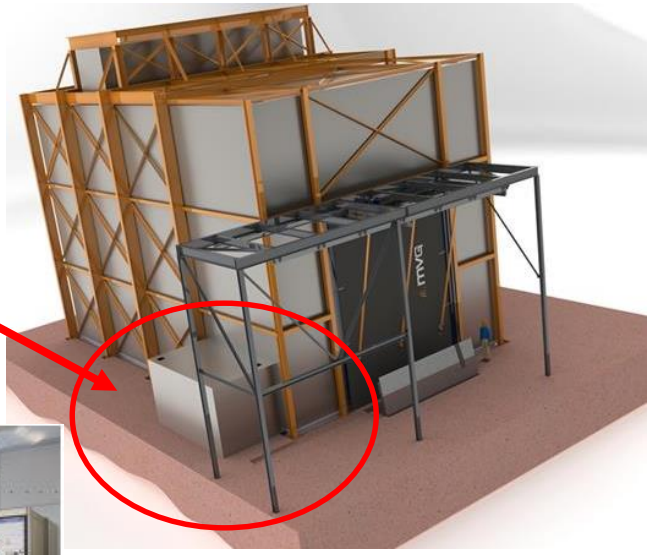
Electromagnetic Compatibility (EMC) Testing		
	Radiated	**Conducted**
Test: How much energy is emitted by the EUT?	**Emission**	**Emission**
Test: Can your device withstand external energy?	**Immunity**	**Immunity**



Shield Rooms

- Conducted EMI
- Conducted EMS
- Includes Transients (e.g., ESD, Surge, Burst)
- Control Rooms & Amplifier Rooms





Radiated Testing

Electromagnetic Compatibility (EMC) Testing		
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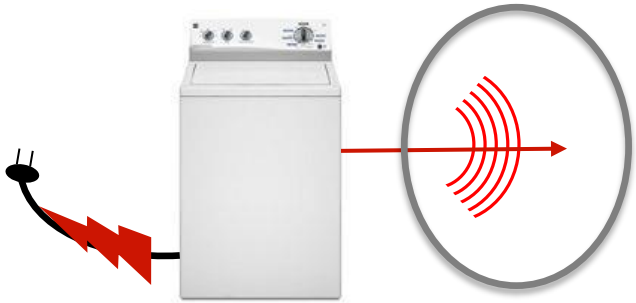
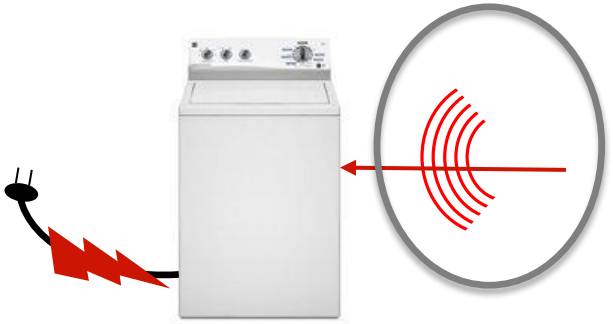




Why Do We Use A Chamber?

- Early Testing Done Outdoors
  - Open-Air Test Sites (OATS) – EMC
  - Outdoor Far-field Ranges – Antenna Measurements
- But Issues Exist Outdoors
- Noisy Environment
  - Ambient Signals
  - Reflections from Nearby Structures
- Creating Unauthorized Signals!
- Protection from Weather
- Security

EMC Anechoic Chamber Types

- 3m CAC
- 3m Chamber
- 5m Chamber
- 10 m Chamber
- MIL-STD-461
- CISPR 25
- ISO 11452-2
- ETSI
- CISPR 12

All Refer to Commercial Testing – CISPR 16, FCC, Etc

- Compliance vs Precompliance
- Partially lined
- Semi-anechoic (conductive floor)
- Fully-anechoic
- Turntables & Towers

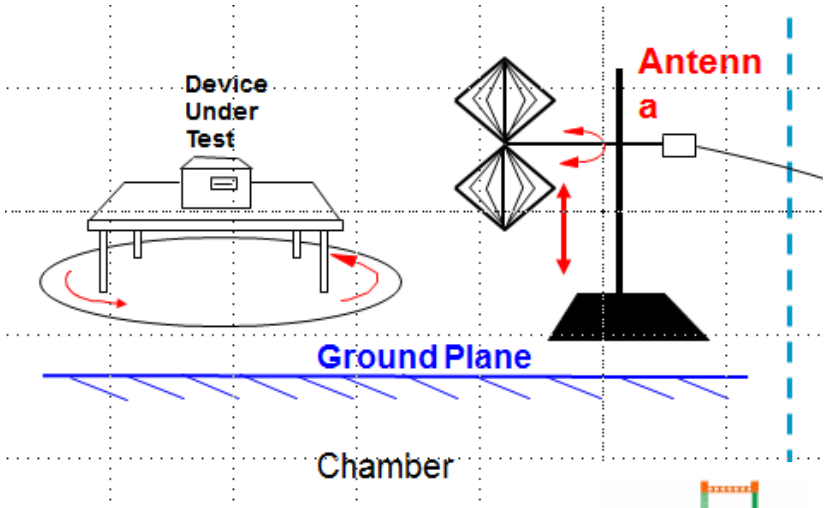
Most common chambers are the compact and full-compliance 3m chambers

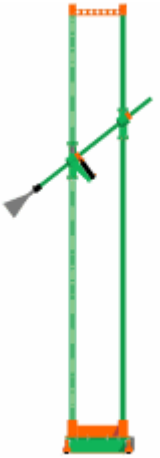
OATS vs. Chamber

Liberty Labs, Kimballton, Iowa

EMI Testing - Data Collection

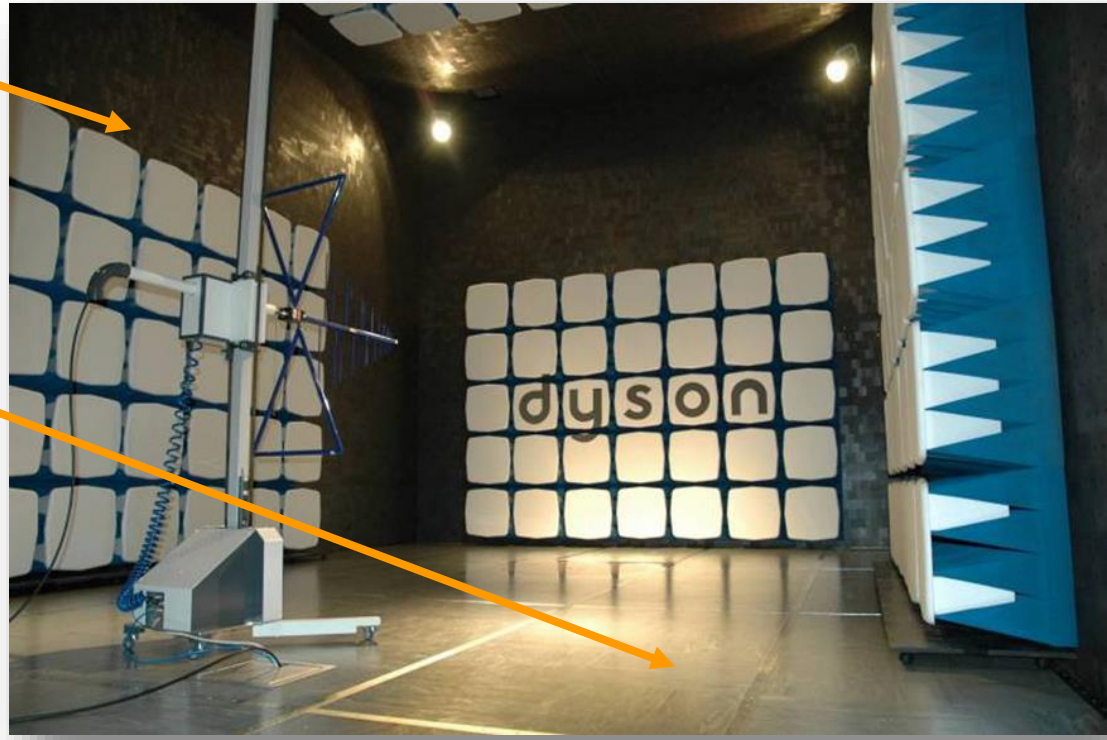
- Full Cylinder of Data
  - Antenna Height: 1- 4 m
  - 360^0
- Antenna Tower
- Turntable





Semi-Anechoic Chamber

- Absorber on Five Sides
- Shielded
- Minimize Reflections
- Ground Plane
- Reflection Like OATS
- Correlation

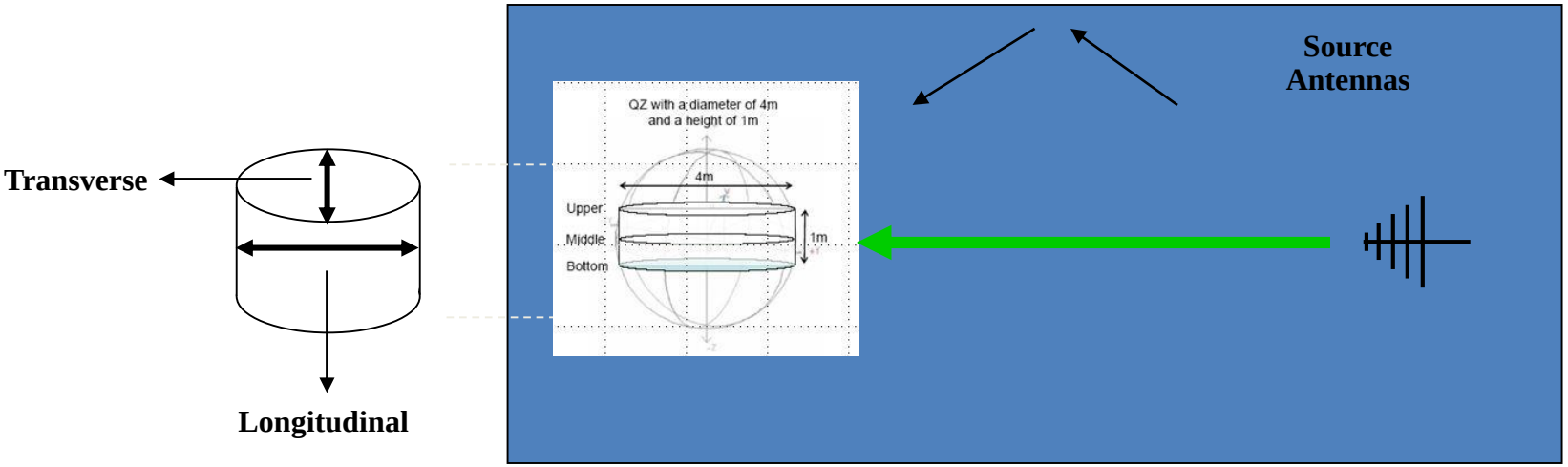


Performance of a Chamber

- Decreases the Reflections – Unwanted Signals
- Allows Measurement of Wanted Signal
- Creates a Quiet Zone for Optimum Testing
- This Creates Better “Performance”

What is a Quiet Zone?

- A Volume of Space (typically a cylinder) in Which the least amount of disturbance from “unwanted” signals is incurred



Inter-relationship between:

- **Size of QZ**
- **Size of Chamber**
- **Size of Absorber**

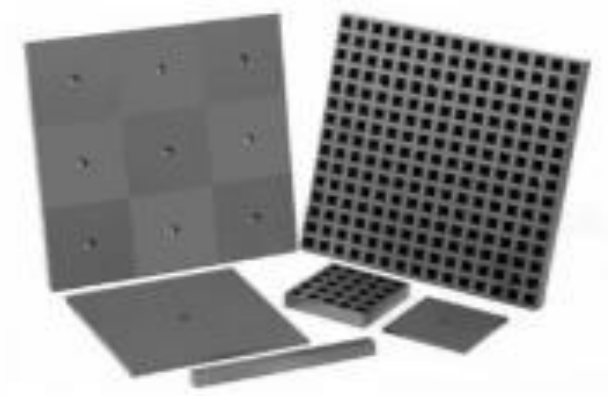
Carbon-Loaded, Polyurethane Material

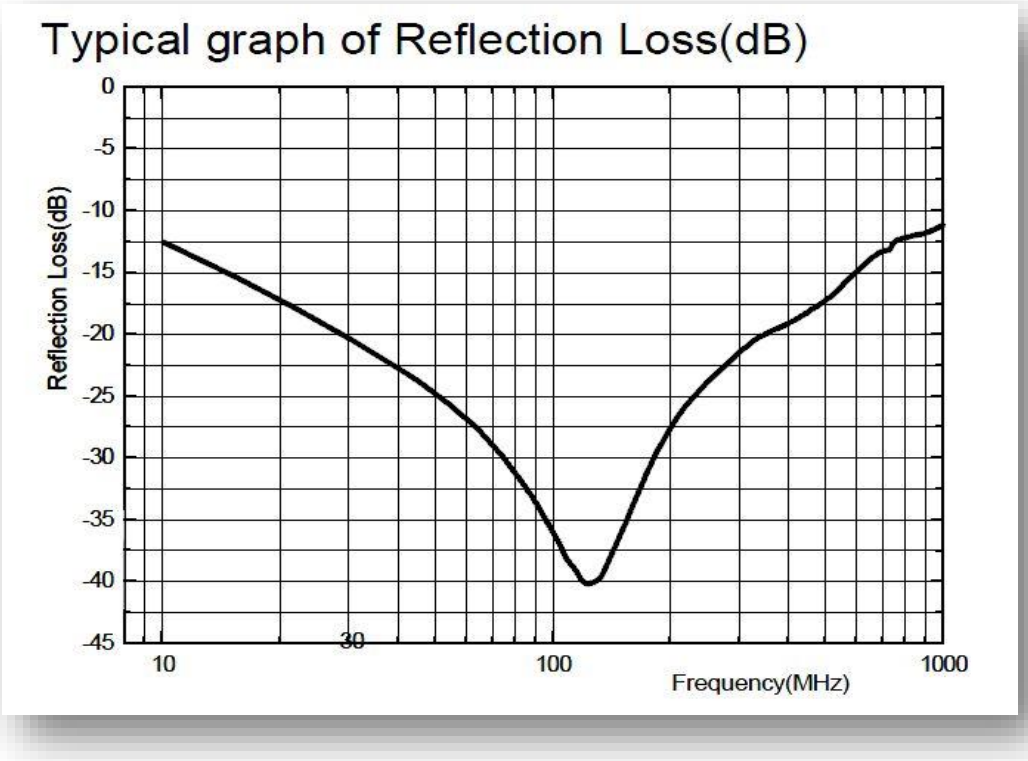
Pyramidal/Wedge-Shaped Absorber

- Carbon Loaded
- Tapered Shape Creates Tapered Resistances
- Creates Transition of Many Tiny Reflections as EM Wave Passes through Absorber
- These Tend to Cancel Each Other Out
- Common Rule of Thumb (EMC): Length Should be Half-Wavelength of Lowest Frequency

Ferrite Tiles

Ferrite Tiles
100 x 100 mm
~ 5.2 – 6.7 mm thick

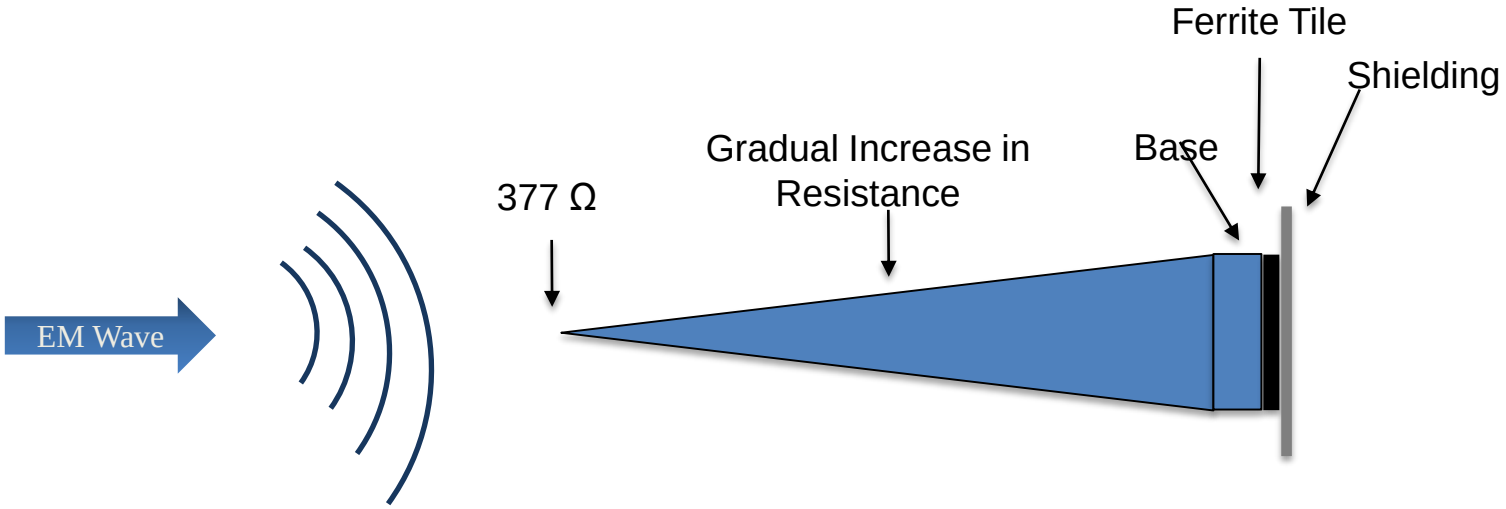




How Does Absorber Work?

Hybrid Absorber

- Combines the Magnetic & Resistive Losses
- Must Create Effective Impedance Match
- If Not, Greater Reflections Created



Compact 3 m Chambers (CAC)

- EMC-MC Mini Compact Chamber
  - 6m x 3m x 2.4m
  - QZ = 0.5 m to 1.0 m (??)
  - Performance Below 300 MHz Not Good (± 6.0 dB below; ± 4.0 dB above)
  - Cannot Fit Antenna Tower!

- EMC-3C Compact Chamber
  - 7m x 3m x 3m
  - QZ = up to 1.5 m
  - Performance Below 300 MHz is Not Good (± 6.0 dB below; ± 4.0 dB above)
  - Use a Reduced Height Ant Tower (2.4 m)
- Still Maintain 3m Test Distance (EMI & EMS)

Full Compliance 3 m Chamber

- Dimensions: 8.9 m x 5.6 m x 5.8 m
- QZ = Up to 2.0
- Excellent Performance – Entire Frequency Range

Dimensions for 3m SAC

• Test Distance to Antenna	• 3m
• Test Volume Size	• 1.5m
• Antenna Footprint	• 1.5m
• Absorber Size (each wall)	• 1m (0.5m x 2)
• Clearance to Absorber	• 2m (1m x 2)
• Total Length	• 9m

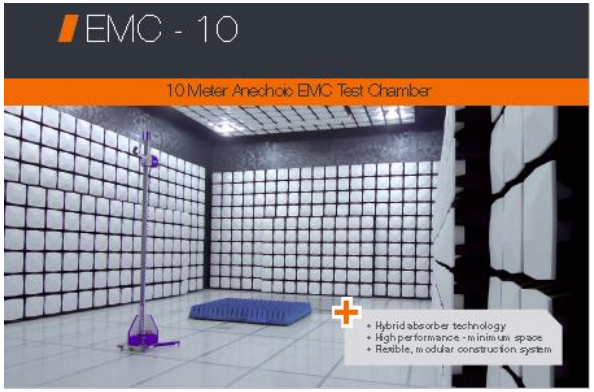
- This is 3x the required test distance!

5 m Chamber

- Actually… Oversized 3 m chambers!!!
- Dimensions: 11.5 m x 7.5 m x 5.8 m
- QZ = 2 to 4 m (can handle larger EUTs!!)
  - NSA Compliance tested to 3 m ONLY!!!
  - SVSWR Compliance tested to 3 m ONLY!!!!
- Excellent Performance – Entire Frequency Range
- Longer & Much Wider (can fit “dual masts”)
- Larger Personnel Door (3.0 m x 3.0 m vs 0.9 m x 2.1 m)

- **Chamber validated at a 3m distance**
- **Can do EMI testing at 5 m -> More easily correlated to the 10 m distance**

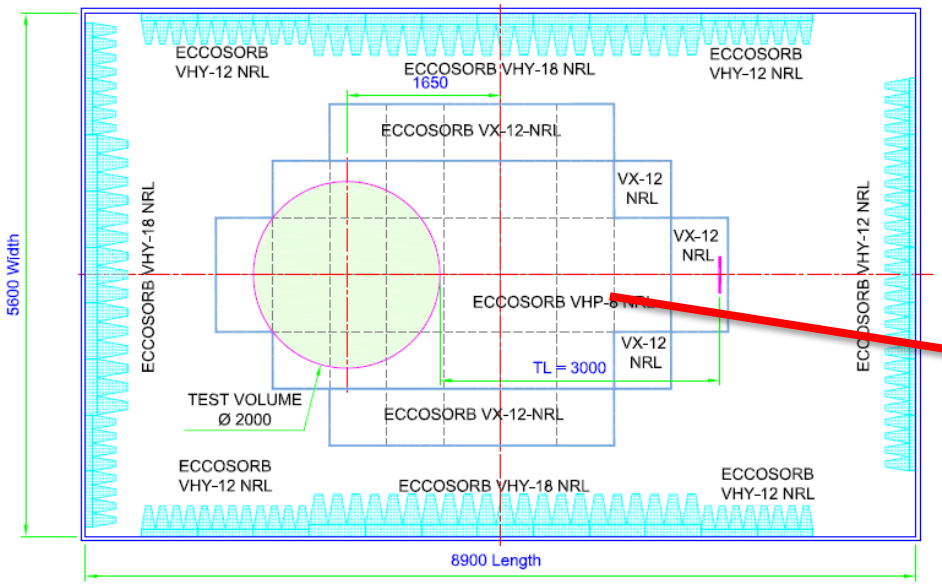
10 m Chamber



- Dimensions: 21 m x 12 m x 8.5 m
- QZ > 4 m (can handle larger EUTs!!)
  - NSA Compliance tested to 10 m
  - SVSWR Compliance tested to 3 m ONLY!!!!
- Excellent Performance – Entire Frequency Range
- Twice as Long as 5 m and wider/higher
- Larger Personnel Door (3.0 m x 3.0 m vs 0.9 m x 2.1 m)
- Very Large EUTs; Full Automotive Testing
- Generally Considered the “Gold Standard”

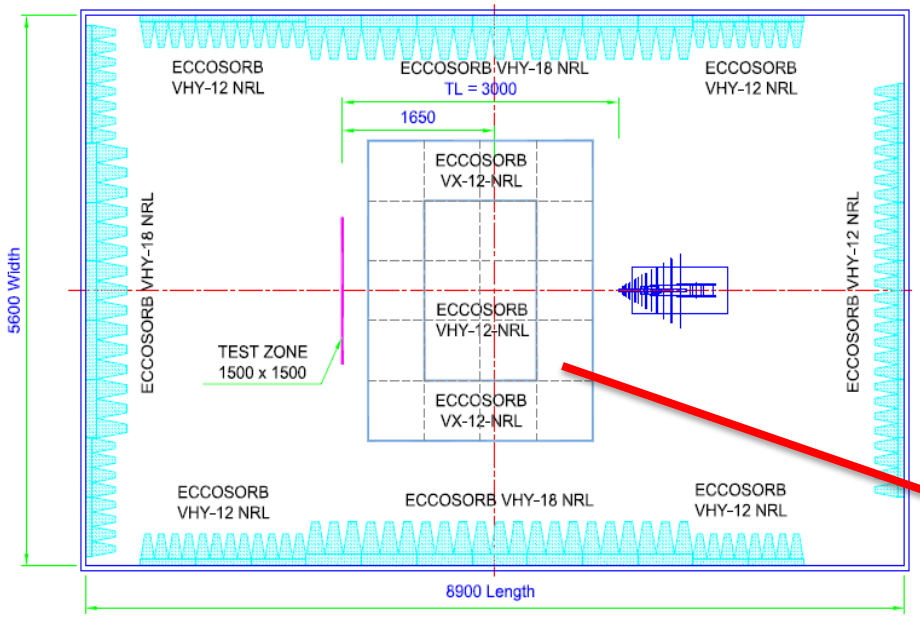
Radiated Emissions Testing > 1 GHz

- SVSWR Method of Verification
- Absorber ≤ 30 cm (assuming EUT/TT flush with the Floor)



IEC 61000-4-3 Radiated Immunity Testing

- Compliant 3m Radiated Immunity
- Add Ferrite Tiles Plus Absorber
- Achieve Field Uniformity



MIL-STD-461/RTCA DO 160

RTCA DO 160

TABLE 20-3 RF ABSORPTION AT NORMAL INCIDENCE

Frequency	Minimum Absorption
100 to 250 MHz	6 dB
Above 250 MHz	10 dB

(1)

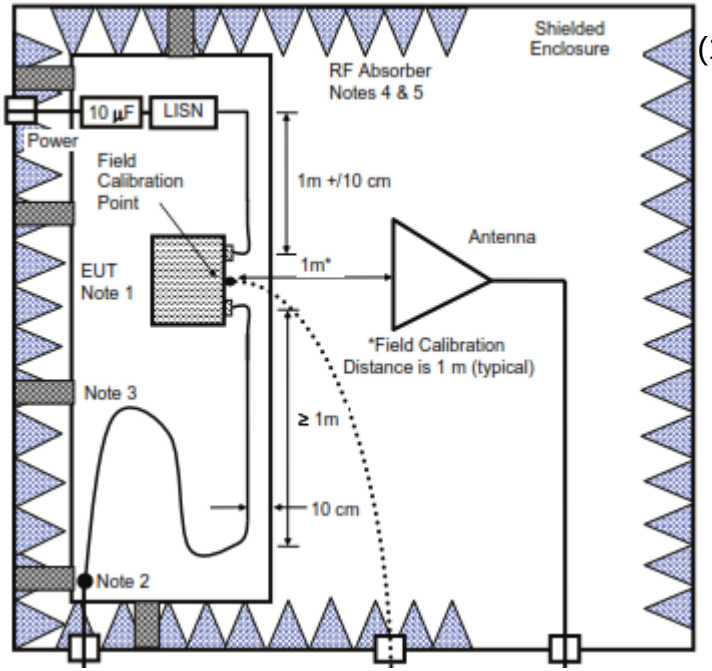
MIL-STD-461

TABLE I. Absorption at normal incidence.

Frequency	Minimum absorption
80 MHz - 250 MHz	6 dB
above 250 MHz	10 dB

(2)

Reference MIL-STD-461F, 10 December 2007



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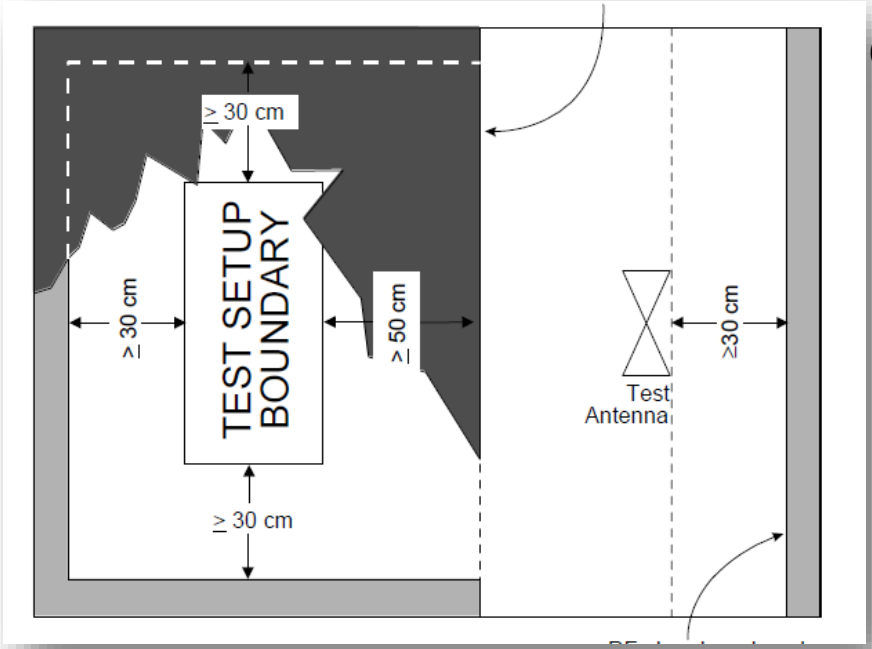

(2)

(1) Reference RTCA DO 160F, December 6, 2007
(2) Reference MIL-STD-461F, 10 December 2007

MIL-STD-461/RTCA DO 160

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MIL-STD-461

TABLE I. Absorption at normal incidence.

Frequency	Minimum absorption
80 MHz - 250 MHz	6 dB
above 250 MHz	10 dB

(2)

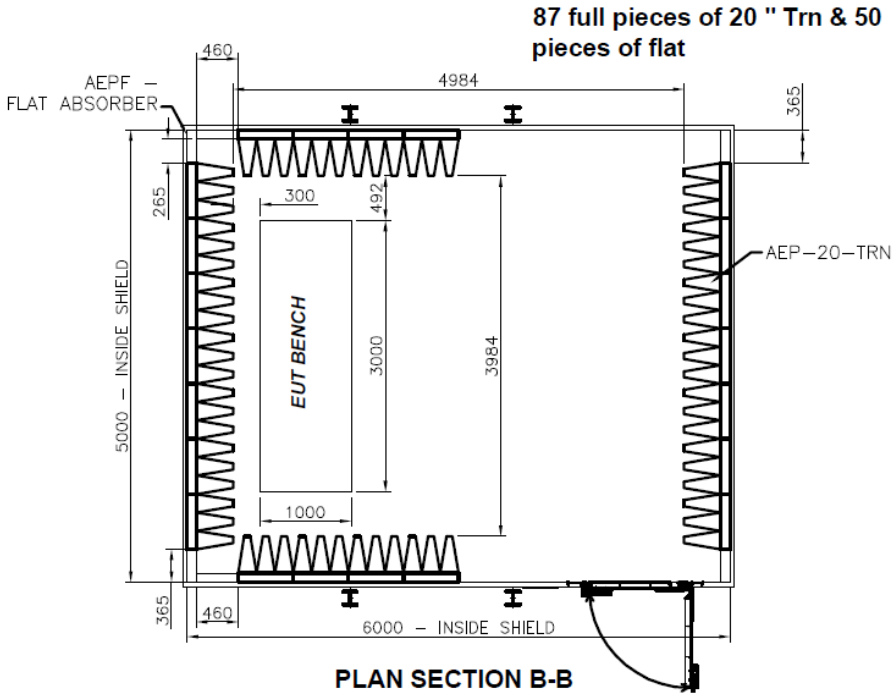
Reference MIL-STD-461F, 10 December 2007

- Can Easily Uses Truncated 24” Absorber
- Or.. Can Use Shorter Hybrid Material
- Both Meet: DO 160 and MIL-STD specs
- Chamber Size Usually Small – but depends on EUT size

(1) Reference RTCA DO 160F, December 6, 2007
(2) Reference MIL-STD-461F, 10 December 2007

MIL-STD Requirements

Example Chamber Config for MIL-STD-461

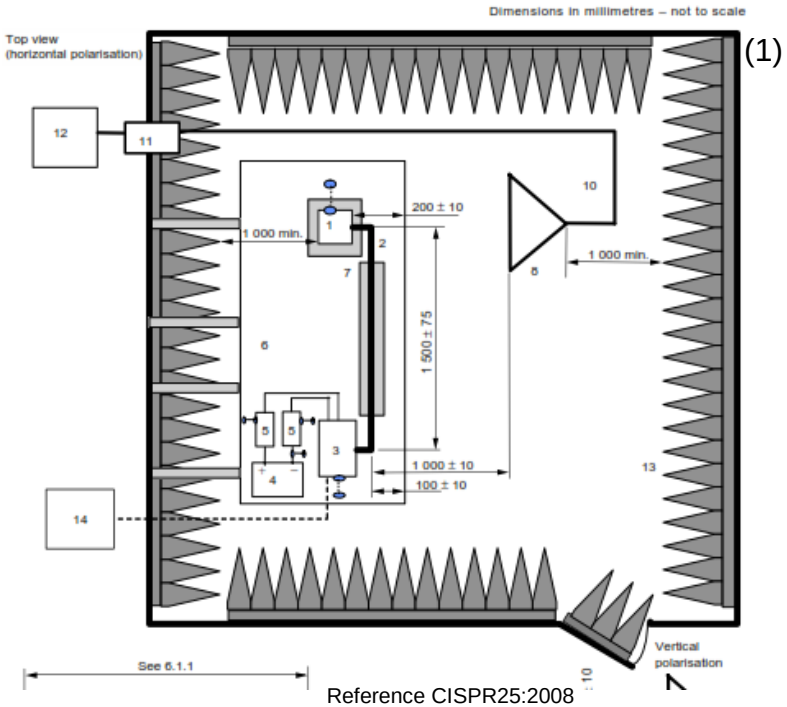


CISPR 25 Requirements

4.3.1 Reflection characteristics

Performance of the absorption material shall be greater than or equal to 6 dB in the 70 MHz to 2 500 MHz frequency range. (1)

- Requirement is for absorber coverage on walls/ceiling
- Performance is based purely on absorber reflectivity
- Can be smaller chambers
- Difficult at lower frequencies or for Immunity testing



Reference CISPR25:2008

(1) Reference CISPR25:2008

Chamber Performance

4.3.1 Reflection characteristics

Performance of the absorption material shall be greater than or equal to 6 dB in the 70 MHz to 2 500 MHz frequency range. (1)

- Don't need hybrid if absorber is about 1 m long
- Typical hybrid absorber with 30 cm absorber will work

Specifications

			AEPH-12 TRN	AEPH-18 TRN	AEPH-30 TRN
Height		cm	33.02	48.26	78.74
Absorption @ Normal Incidence	@ 30 MHz	dB	14	15	16
	@ 125 MHz	dB	25	25	25
	@ 250 MHz	dB	20	22	25
	@ 500 MHz	dB	24	24	24
	@ 1 GHz	dB	16	17	21
	@ 3 GHz	dB	15	20	25
	@ 10 GHz	dB	25	30	40
	@ 18 GHz	dB	> 35	> 40	> 45
Power		kW/m²	1.5	1.5	1.5
Weight		kg	3.1	3.7	4.6
Fire retardancy			NRL 8093 Test, 1,2 and 3, ISO 11925-2, DIN 4102 Class B2		

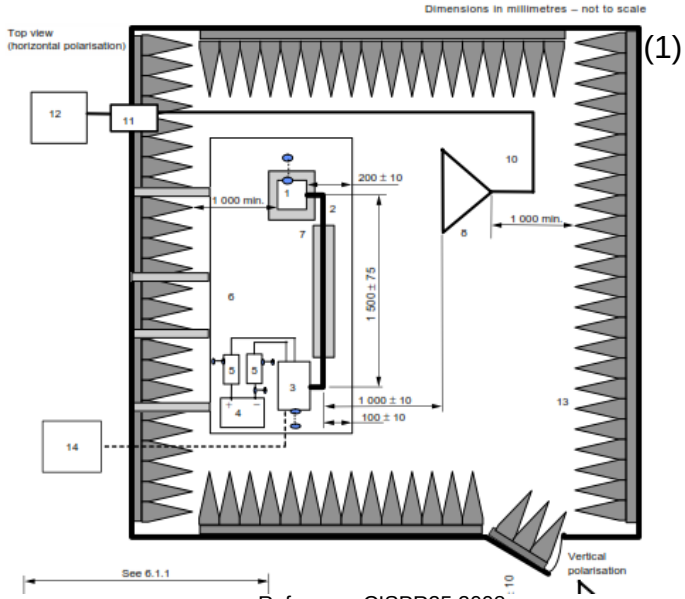
(1) Reference CISPR25:2008

CISPR 25 Requirements

4.3.2 Size

For radiated emissions tests, the shielded enclosure shall be of sufficient size to ensure that neither the vehicle/EUT nor the test antenna shall be closer than 1 m from the walls or ceiling, or to the nearest surface of the absorber material used thereon. (1)

For radiated emissions tests, the shielded enclosure shall be of sufficient size to ensure that neither the EUT nor the test antenna shall be closer than 1 m from the walls or ceiling, or to the nearest surface of the absorber material used thereon. No part of any antenna radiating element shall be closer than 250 mm to the floor. (1)



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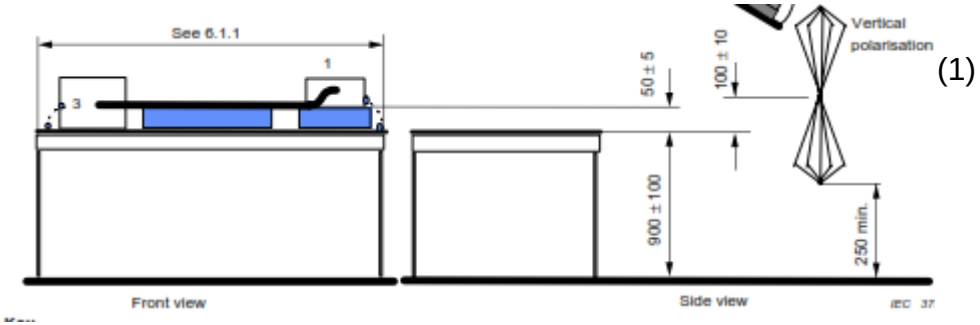
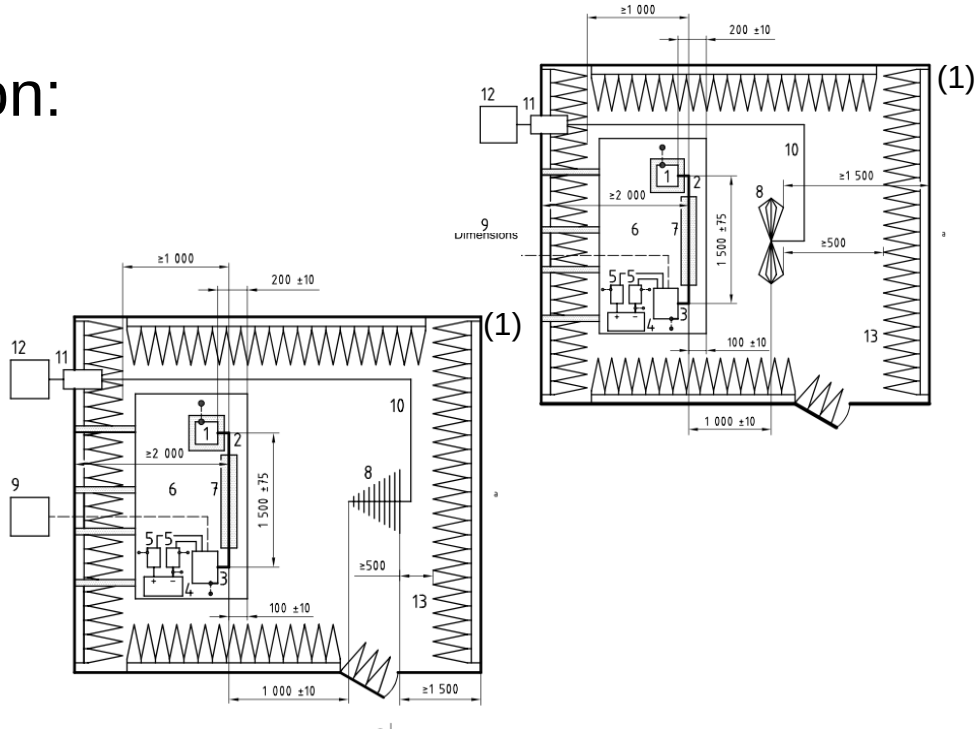


(1)

Reference CISPR25:2008

ISO 11452-2

- Very Similar to CISPR25 Chamber
- Full Absorber on Walls/Ceiling
- Often Combined w/ CISPR25
- Bigger Antennas to Handle Higher Power – Affects Chamber Size
- Dimensions – Depend on:
  - Absorber Size
  - EUT & Test Bench Size
  - Antenna Dimensions



(1) Reference ISO 11452-2:2004

Chamber Performance

5 Test location

The tests shall be performed in an absorber-lined shielded enclosure.

The purpose of such an enclosure is to create an isolated electromagnetic compatibility test facility which simulates open field testing. Basically, an absorber-lined shielded enclosure consists of a shielded room with absorbing material on its internal reflective surfaces, optionally excluding the floor. The design objective is to attenuate the reflected energy in the test area by at least 10 dB compared to the direct energy. (1)

- Don’t need hybrid if absorber is about 1 m long
- Typical 30 cm, hybrid material will work

Specifications

			AEPH-12 TRN	AEPH-18 TRN	AEPH-30 TRN
Height		cm	33.02	48.26	78.74
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	@ 3 GHz	dB	15	20	25
	@ 10 GHz	dB	25	30	40
	@ 18 GHz	dB	> 35	> 40	> 45
Power		kW/m²	1.5	1.5	1.5
Weight		kg	3.1	3.7	4.6
Fire retardancy			NRL 8093 Test, 1,2 and 3, ISO 11925-2, DIN 4102 Class B2		

(1) Reference ISO 11452-2:2004

ISO 11452-2 – Antenna Selection

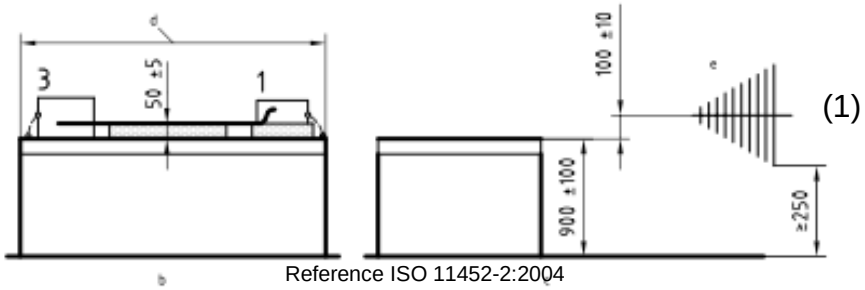
7.6 Location of field generating device (antenna)

The height of the phase centre of the antenna shall be (100 ± 10) mm above the ground plane.

No part of any antenna radiating element shall be closer than 250 mm to the floor. The radiating elements of the antenna shall not be closer than 500 mm to any absorber material, and shall not be closer than 1 500 mm to the walls or ceiling of the shielded enclosure.

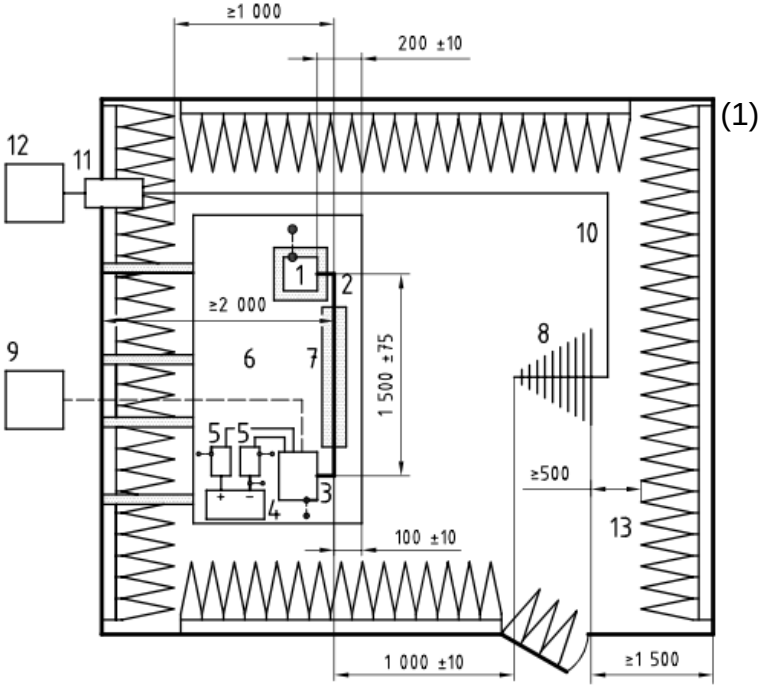
The distance between the wiring harness and the antenna shall be (1 000 ± 10) mm. This distance is measured from

- the phase centre (mid-point) of the biconical antenna, or
- the nearest part of the log-periodic antenna, or
- the nearest part of the horn antenna.



(1)

Reference ISO 11452-2:2004



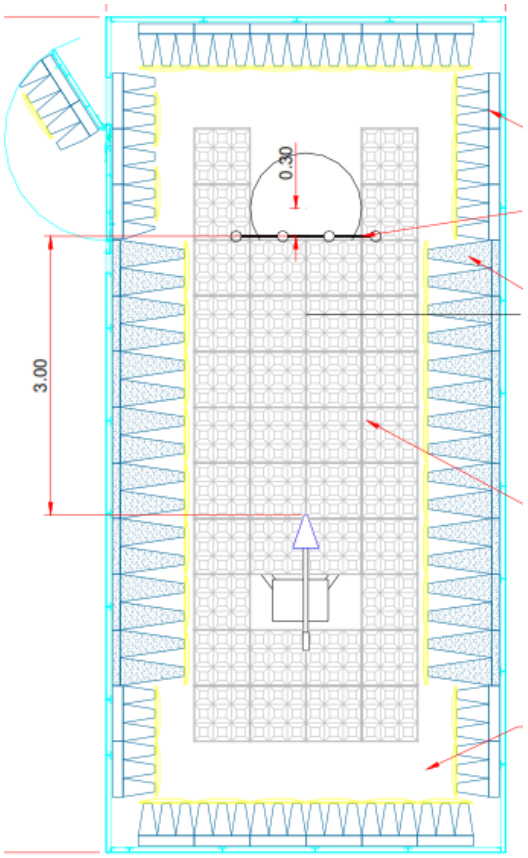
(1)

Reference ISO 11452-2:2004

(1) Reference ISO 11452-2:2004

Fully Anechoic Rooms (FARs)

- Alternative to SAC
- CISPR16 (FSNSA)
- ETSI Standards
- Performance Specs:
  Similar to CISPR25
  (Specs Reflectivity of Absorber)



ETSI (FAR) Absorber Performance Requirements

- 10dB 30-100MHz
- 20dB 100-300MHz
- 30dB 300MHz-10GHz

Full Vehicle Testing

- Testing at 10 m Distances
- Chamber Sizes are Customized
- Need to Accommodate Full Vehicles
  - Dynomometers
  - Specialized Facilities
  - Specialized, Extremely Large Antennas
  - Much Higher Power

Turntable & Dynomometer Considerations

Large TT, No Dyno

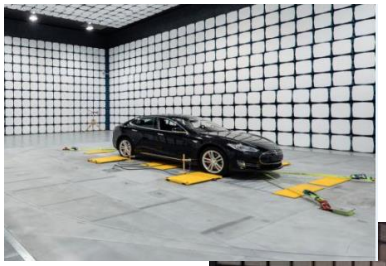
Extremely Large TT, No Dyno

- Budget
- Flexibility
- Features

Portable Dyno, on top of TT

Portable Dyno, no TT

Built-in Dyno, no TT



TT with integrated Dyno

Specialized Facility Considerations

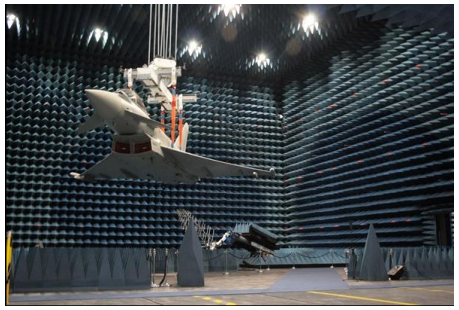
- Large Doors & TT's
- Fire Suppresson
- HVAC
- Hoists
- Increased Costs

Automatic and Semi-Automatic Doors & Ramps

High Capacity Turntables

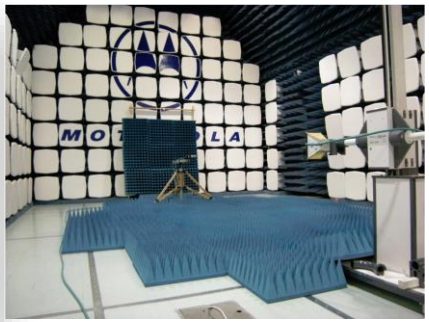
Fire Suppression

HVAC Systems



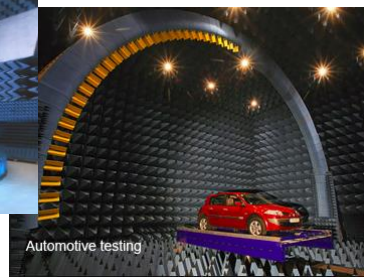
Lift Mechanisms

Large Chambers & Customized Shapes

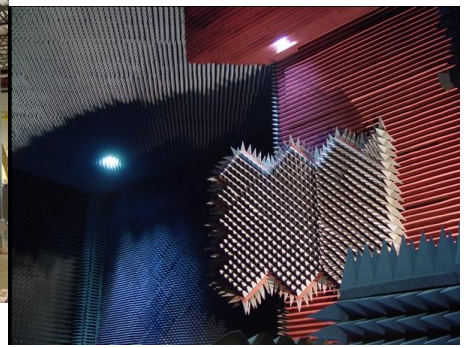


Customized “Domed” Shapes

Large Dual-Purpose Chambers



Tapered Chambers



Customized Absorber Topologies:

- Varying shapes
- Varying Heights and directions
- “Baffled” Absorbers

Extremely Large Rectangular Chambers

Thanks for attending!

Mark your calendars for EMC LIVE 2016
April 26-28, 2016