



CAERI

Electric-Drive Vehicle Testing at CAERI

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China Automotive Engineering Research Institute





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- 1. Overview**
- 2. On-going Work**
- 3. Future Work**
- 4. Conclusion**



Three-year Plan

BEV



Plug-in



REEV



Full Hybrid



Mild Hybrid



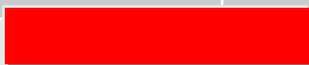
- Three year program in CAERI
- Evaluating the performance of the EV, HEV and PHEV
- Plan to benchmark more than 12 cars in three years



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2011-2012 works

| Milestones | 2011-Q2 | 2011-Q3 | 2011-Q4 | 2012-Q1 | 2012-Q2 | 2012-Q3 | 2012-Q4 |
|---|---|---|---------|---|--|---|---|
| Test Procedures Research and Preparation for cars |  | | | | | | |
| Civic Hybrid Test and Analysis |  |  | |  |  | | |
| Nissan Leaf Test and Analysis |  | | |  |  | | |
| MY2010 Prius Test and Analysis |  | | | |  |  | |
| Fusion Hybrid Test and Analysis |  | | | |  |  | |
| Volt Test and Analysis |  | | | |  |  | |
| Plug-in Prius Test and Analysis |  | | | | |  |  |



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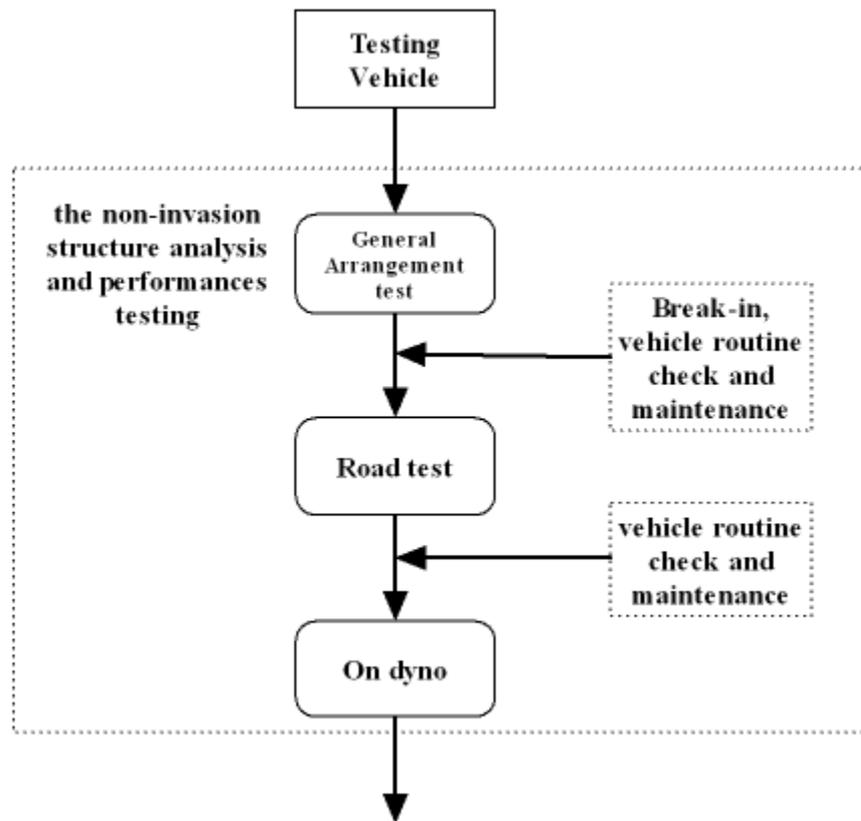
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Testing Approach

■ The vehicle testing activity and analysis approach has been defined:

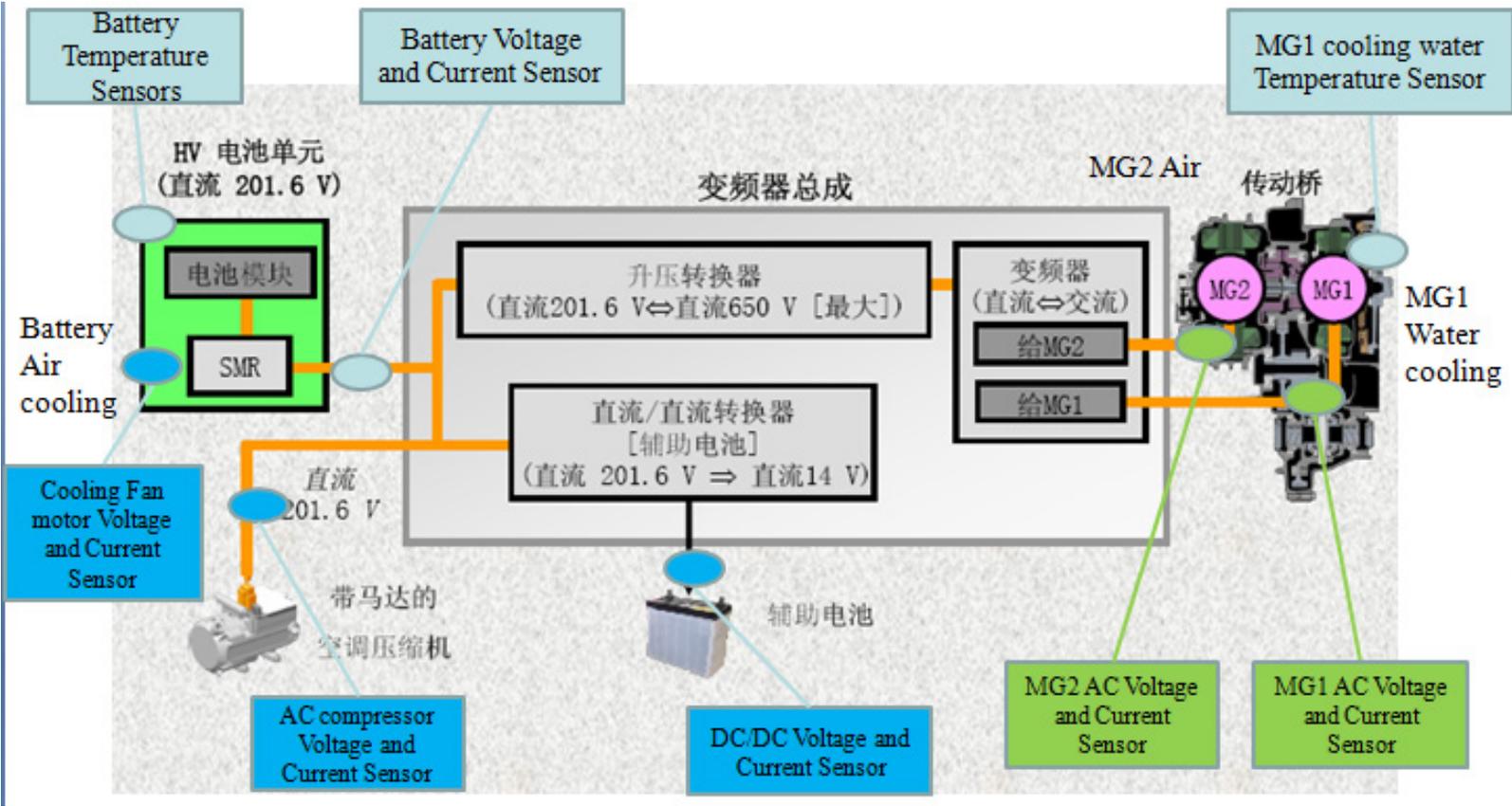
- Advanced instruments and sensors
- Kinds of performances and systems in-situ tests
- Continuous improvement of testing procedures

■ Common Testing Flow in CAERI



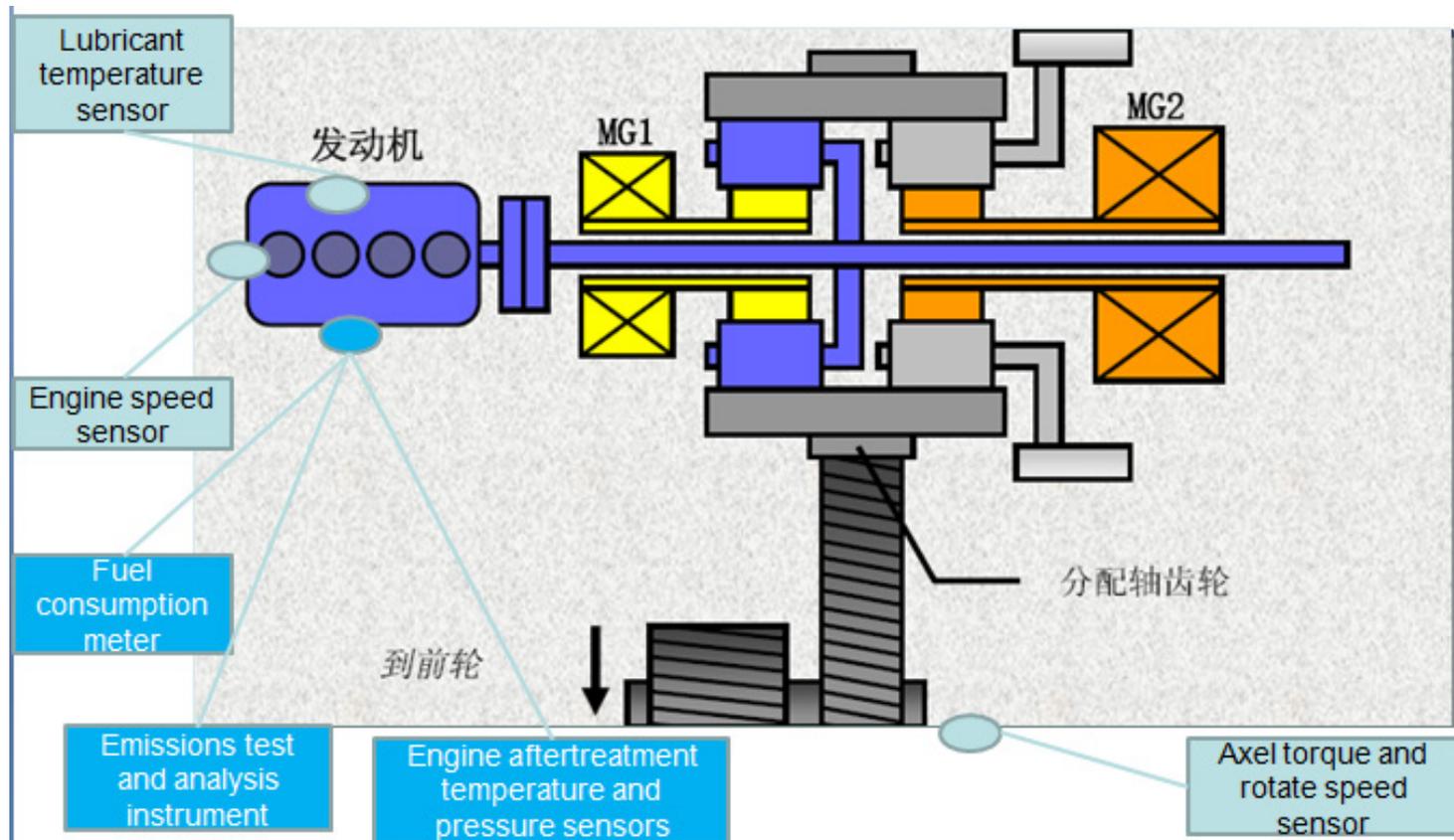
Testing Approach

• Sensors installation diagram for electrical power-flow testing



Testing Approach

- Sensors installation diagram for mechanical power-flow and operating temperature testing





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Vehicle static tests

-HEV



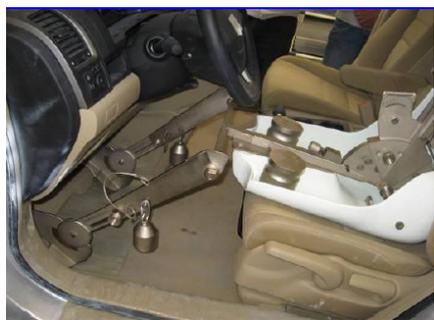
External Dimensions

GB/T 12673 Vehicle Dimensions Measuring method
SAE J1100-2002 Motor Vehicle Dimensions



Mass Parameters

GB/T 12674 Vehicle Quality (Weight) Parameter Determination Method



Ergonomics Dimensions

SAE J833 Human Physical Dimensions
SAE J826 H-Point Machine and Design Tool Procedures and Specifications



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Dynamic Performance test

-HEV



■ Coast Down Test

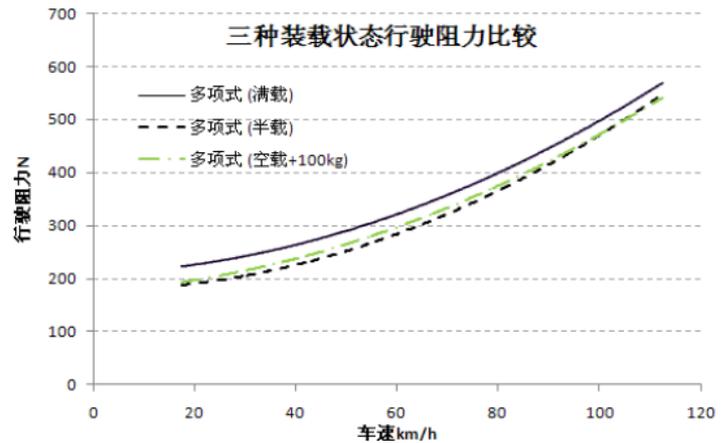
➤ *TYPEV_BZ0004-2012 for coast down test*

■ Objective:

➤ Check testing vehicle state consistency

➤ Determine vehicle target coefficient A, B, C and coast down distance

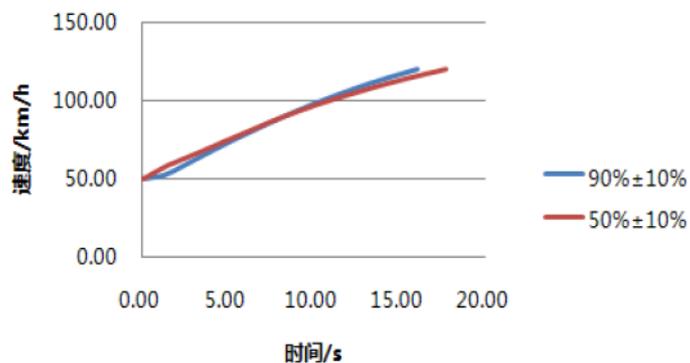
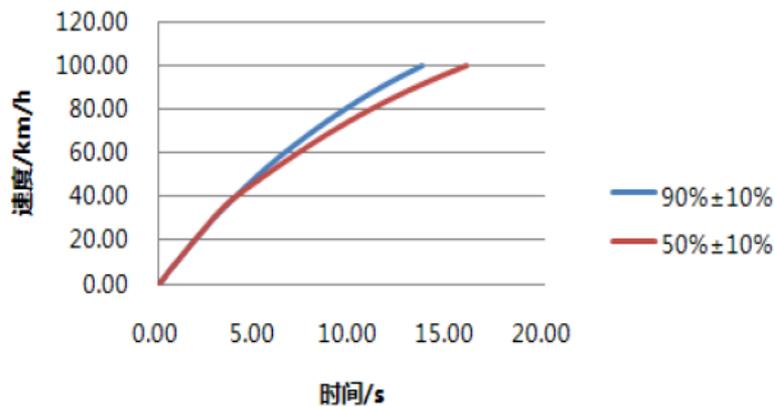
➤ Research the influence of vehicle load state on resistance coefficient



Dynamic Performance test

-HEV

D档 不同SOC速度时间关系



■ Max Acceleration Testing

TYPEV_BZ0005-2012 Hybrid Electric Vehicle Acceleration Test Procedure

■ Objective:

1. Determine 0-100km/h acceleration time under different vehicle condition;
2. Determine 50-120km/h acceleration time under different vehicle condition;
3. Research the influence of SOC, pattern, battery temperature on hybrid electric vehicle acceleration performance;

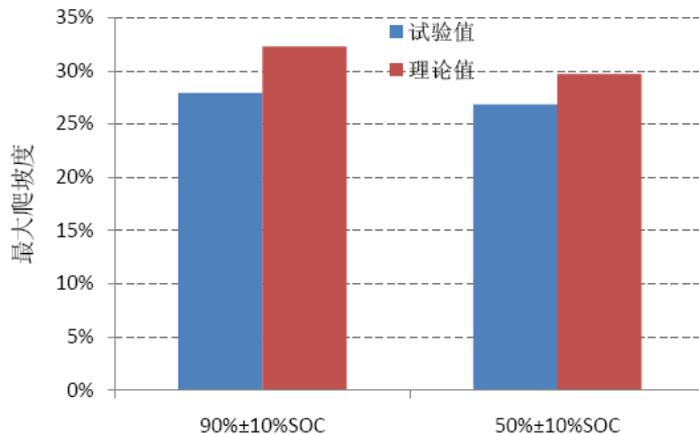


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Dynamic Performance test

-HEV



■ Grade ability Limit Test

TYPEV_BZ0006-2012 Hybrid Electric Vehicle Grade ability Test Procedure

■ Objective:

1. Determine max Grade ability under different vehicle condition;
2. Determine Start ability under different vehicle condition;
3. Research the influence of SOC, pattern, battery temperature on hybrid electric vehicle Grade ability performance.



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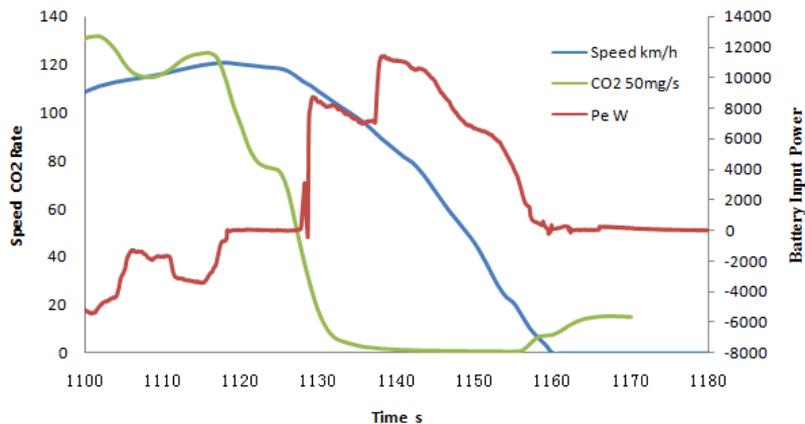
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Regenerative braking energy reclaiming ratio test-EV/HEV

■ Developing the regenerative braking energy reclaiming ratio test method right now

■ Objective:

1. Research the contribution rate of the braking energy regeneration to fuel-saving and emissions-reduction
2. Check the energy reclaiming ratio of regenerative braking;
3. Research on the influence of braking cycle, initial speed, accelerator pedal position, brake pedal position to regenerative braking energy reclaiming ratio.



Braking Performance test

-HEV



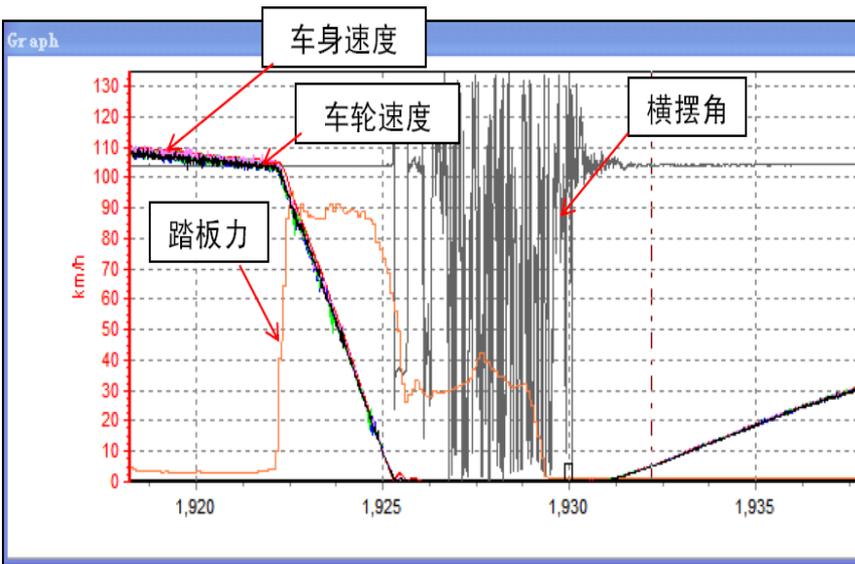
■ Type-0 braking Test

TYPEV_BZ0068-2012 Electric Vehicle

Type-0 braking Test Procedure

■ Objective:

1. Check the brake basic performance;
2. Loaded and non-loaded, driving system, test braking distance, brake maximum control force, whether vehicle happens lock when speed is greater than 15 km/h, horizontal pendulum Angle, etc.



Emissions Performance test

-HEV

■ Emissions Test

TYPEV_BZ0055-2012 Hybrid Electric Vehicle Consumption and Emissions Test Procedure

■ Objective:

1. Measurement energy consumption, emissions factor (HC, CO and NOx) under US06, UDDS, NEDC, Jan10-15 and so on
2. Linear correction method using a correction coefficient as ECE R101



| | US06 | UDDS | NEDC | 10-15 |
|-------------------|-------------|---------|----------|----------|
| NO _x | 0.011666667 | 0.0145 | 0.01525 | 0.003333 |
| HC | 0.059333333 | 0.023 | 0.06275 | 0.002333 |
| CO | 3.437666667 | 0.089 | 0.25375 | 0.033333 |
| CO ₂ | 160.6963333 | 140.285 | 142.2485 | 171.7 |
| K _{fuel} | 0.0027 | -5.3241 | 0.7435 | -1.715 |
| 燃料消耗量 燃料消耗量 | 6.9 | 5.48 | 5.59 | 6.8 |

$$K_{fuel} = (n \cdot \sum \Delta E_{storage_i} C_i - \sum \Delta E_{storage_i} \cdot \sum C_i) / (n \cdot \sum \Delta E_{storage_i}^2 - (\sum \Delta E_{storage_i})^2)$$

$$C_0 = C - K_{fuel} \cdot Q$$



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Facilities

Emission Labs



Range and consuming test-EV



■ Range and Economy Test

TYPEV_BZ00XX-2012, Battery Electric Vehicle Consumption and Range Test Procedure

■ Objective:

1. Research the shortcut testing method of Energy Consumption and Range
2. Research the influence of environmental temperature on performance
3. Research the influence of driving cycles (likes NEDC, UDDS and so on) on performance



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Range and Economy test- PHEV



■ Range and Economy Test:

**TYPEV_BZ00XX-2012 and ECE R101
Plug-in Electric Vehicle Energy
Consumption and Emissions Test
Procedure**

■ Objective:

1. Research the appropriate plug-in electric vehicle energy consumption and emission test methods;
2. Carry out plug-in electric vehicle energy consumption and emission characteristics of research



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Facilities

Proving Ground



NVH test - HEV



副驾驶员左右耳麦克风位置

驾驶员左右耳麦克风位置



后排右侧麦克风位置

后排中部麦克风位置

后排左侧麦克风位置



方向盘处加速度传感器

换挡杆处加速度传感器



仪表盘处加速度传感器

座椅导轨处加速度传感器

■ NVH Test

TYPEV_BZ0016-2011 Electric Vehicle
NVH Test Procedure at road
procedure

■ Objective:

1. Vehicle Idle Interior Noise/Vibration
2. Vehicle Pass-by Noise
3. Vehicle Run Up/down Interior Noise
4. Vehicle Run Up/down Interior Vibration

<GB 1495 Limits and measurement methods for noise emitted by accelerating motor vehicles>

<GB/T 14365 Acoustics-Measurement of noise emitted by stationary road vehicles>

NVH test-EV/HEV



■ NVH Test

Test EV/PHEV NVH characters and develop test method at semi-anechoic room

■ Focus:

1. Compare testing at semi-anechoic room and at testing road, analyze difference and its reason;
2. Consider battery initial SOC, battery temperature, etc;
3. Determine the test conditions and sensors arrangement

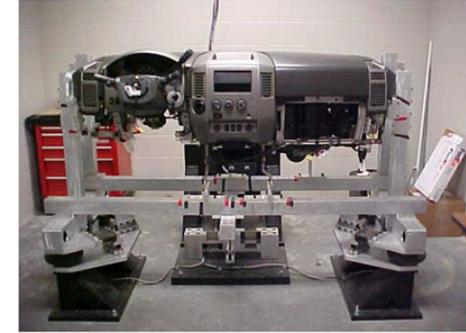
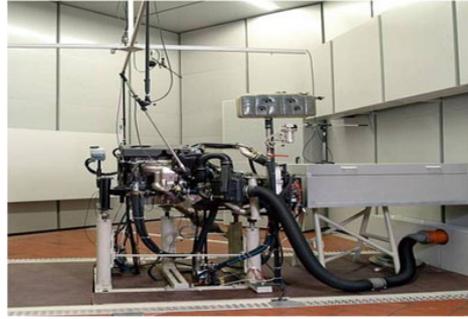


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Facilities

NVH Labs



• 整车半消声室

• (4驱、2电机、5.5吨)
Vehicle semi-anechoic chamber
4 WD , 2 motor , 5.5 tons

• 全消声发动机试验室

Full anechoic engine test chamber

• 整车振动实验室

Vehicle Vibration Lab

• 零部件异响室

Parts abnormal sound room



• 部件振动疲劳

Parts vibration fatigue



• 模态试验室

Modal Lab



• 全消/混响室

All consumers / reverberation
chamber



• 声品质分析室

Sound Quality
Analysis Laboratory



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Crash Safety test –EV/PHEV



■ Crash Safety Test

Battery safety test and evaluation method under crash situation

■ Focus:

1. Compared with the conventional vehicle, electric car collision safety should be more focus on the battery system requirements
2. Consider mechanical requirements, electrical requirements, chemical requirements and function requirements, etc;
3. Consider the battery initial SOC, flip test and the long time stalling test after collision test samples and so on

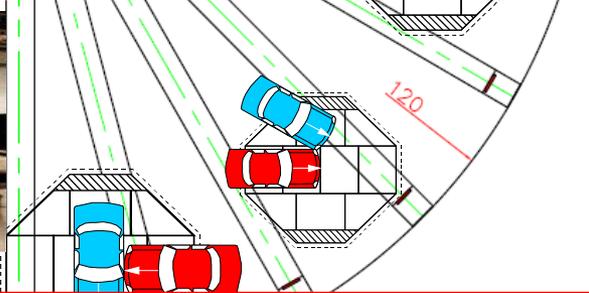
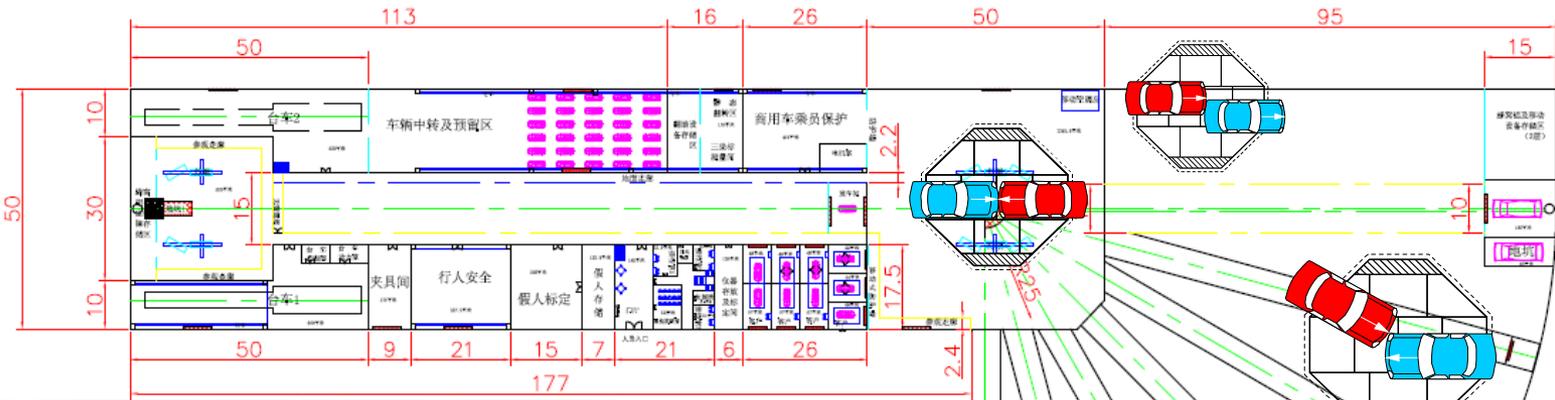


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Facilities

Safety Labs

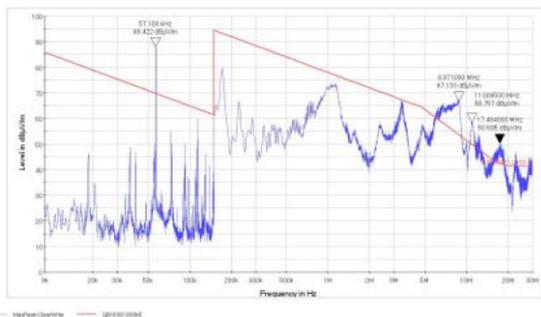


| | | | | |
|------|----|---------|-----|--------|
| 实车碰撞 | 5t | 120Km/h | 25t | 80km/h |
| 车车碰撞 | 5t | 80Km/h | 25t | 50km/h |

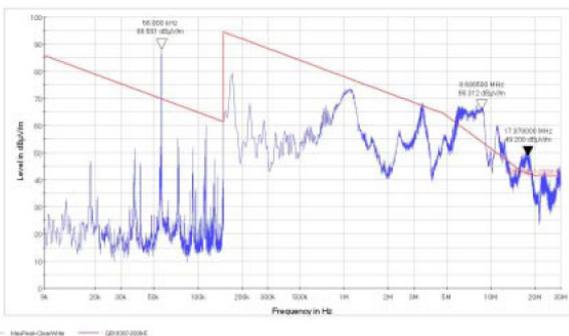


EMC test-EV/HEV

A.1.1 车头前面电场垂直极化峰值扫描曲线（车辆以16km/h稳定车速运行）：



A.1.2 车头前面电场垂直极化峰值扫描曲线（车辆以64km/h稳定车速运行）：



<GB/T 18387 Limits and test method of Magnetic and Electric Field Strength from Electric Vehicles, Broadband, 9 kHz To 30 MHz>

■ EMC Test

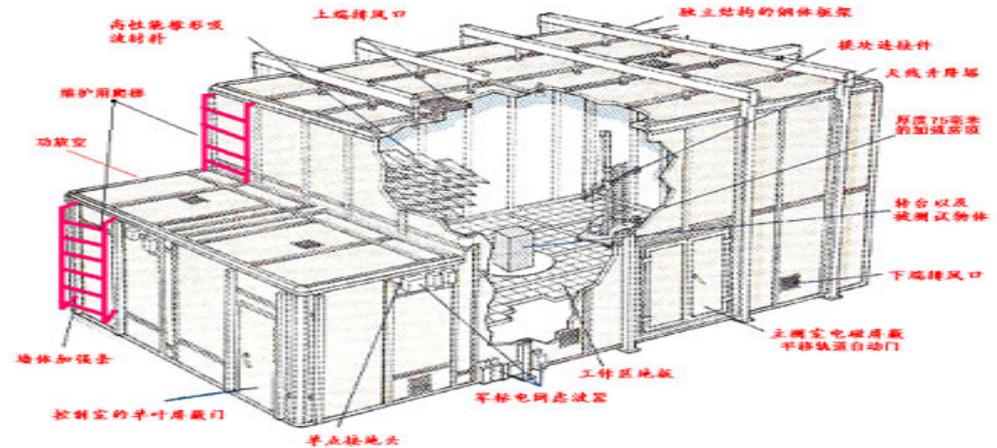
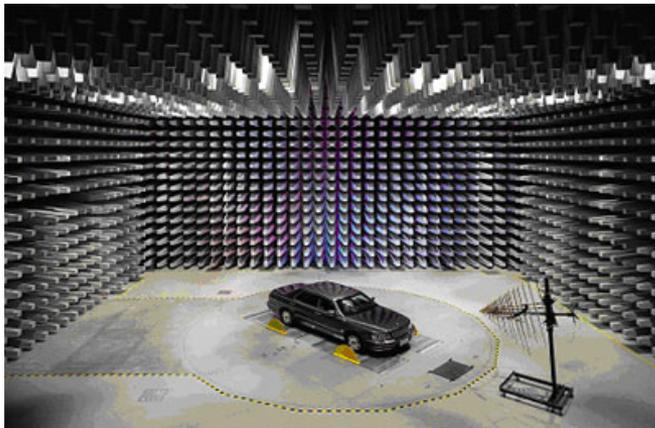
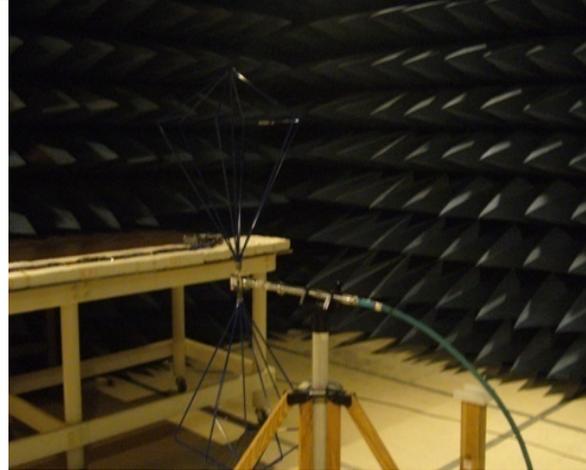
Performance Levels and Methods of Measurement of Magnetic and Electric Field Strength from EV/HEV Broadband, 9 kHz To 30 MHz

■ Focus:

1. Confirm the maximum emission surface;
2. Research the influence of the loading on the test results,
3. Compare the statistical value of various electric vehicles electromagnetic field emission and the limit.

Facilities

EMC Labs

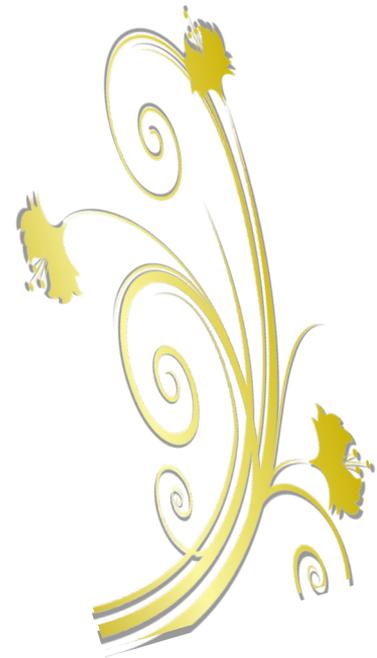


10-meter half-wave dark room (9 m diameter, 20-ton turntable, 4 × 100kW dynamometer), three-meter modus and CISPR25 full-wave dark room



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Future Work

- Testing the four EV and HEV in China
- Testing one PHEV in U.S.A. and China with ANL
- Testing other six cars in 2013
- Discussing the testing approach with U.S. partners
- Focus on the designing and controlling thoughts of excellent cars
- Benchmarking the components of the models



Test for next four E-drive cars:

■ On-going 2012 In-depth Vehicle Benchmarking:



Nissan Leaf



Fusion Hybrid



MY2010 Prius



Volt

- Research testing and evaluation method of Electric-Drive vehicles, including dynamic performance, braking performance, NVH, EMC, Economy, Emissions and so on.
- Analysis control strategy of vehicles, including Fail-Safe strategy.
- Component testing, including power system, motor, battery cell, battery system



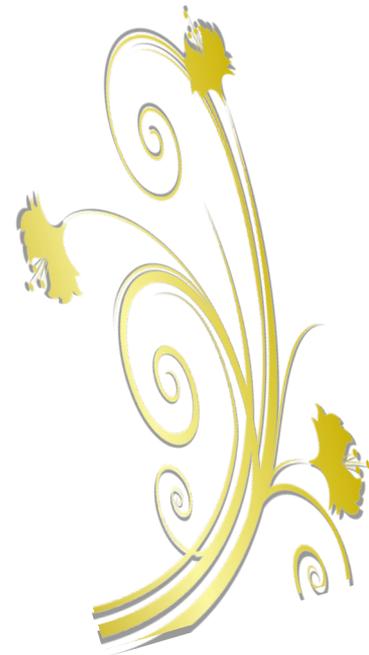
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Conclusion

- Evaluation for the consumers and governments
- Procedures and approaches are important to do the thing well
- Harmonize the procedure are necessary between U.S.A and China
- CAERI would like to learn previous experience our U.S.A. partners and contribute to that and test different cars continually





U.S.-CHINA CLEAN
ENERGY RESEARCH CENTER
中美清洁能源研究中心

Thanks for your time!



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