NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION
RESEARCH PROGRAM ON LITHIUM-ION BASED ENERGY RECHARGEABLE STORAGE SYSTEM (RESS)

WP.29 – WORLD FORUM FOR HARMONIZATION OF VEHICLE REGULATIONS
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Research Objective:

To research and develop repeatable test based safety performance tests, tools, and comparison metrics for Li-ion based RESS, and provide initial data for analysis.

• These tests and metrics will provide data and enable NHTSA to generate and compare safety critical performance data from RESS equipped vehicles and component systems during all normal and abnormal use conditions and crash and post crash events.

• The results of this research could potentially be used by NHTSA and the EV-SGS GTR informal working group to support and establish minimal safety performance standards and compliance test procedures for RESS equipped passenger vehicles and light truck applications.

• The methods of research will include:
  • Failure Modes and Effects Analysis (FMEA)
  • Test Procedures Development
  • Analytical Tools Development for Control System Safety Performance
Lithium-ion based Rechargeable Energy Storage Systems (RESS)

NHTSA Vehicle Safety Research – RESS Research Program Projects & Process Flow

Failure Modes Effects and Criticality Analysis (FMECA)
• Identify and rank all Failure modes and rank based on likelihood and severity

Test Procedures Development
• Develop performance based test procedures for failure modes identified from: FMEA, Industry Standards, Industry Experience, and DOE/NL programs

Analytical Tools for Control System Safety Performance
• Develop safety-performance requirements and methods to measure RESS control systems

Comparable Safety Metrics with Data for Li-ion RESS

NHTSA Policy and Rulemaking & EV-SGS GTR
Lithium-ion based Rechargeable Energy Storage Systems (RESS)

Failure Modes Effects and Criticality Analysis (FMECA)

- **Task 1.** Develop Task Order Program Management and Technical Work Plan
- **Task 2.** Conduct Technology and Vehicle Inventory Review
- **Task 3.** Develop Li-ion Vehicle Concept Model for FMEA
- **Task 4.** Develop a Hazards Matrix
- **Task 5.** Conduct the FMECA
- **Task 6.** Compare FMECA to Codes and Standards and Identify Gaps
- **Task 7.** Compile Final Project Report and Conduct Peer Review
Lithium-ion based Rechargeable Energy Storage Systems (RESS)

Status: Failure Modes Effects and Criticality Analysis (FMECA)

- Draft Final Report - December 2011
- Independent FMEA application variants:
  - Hybrid Electric Vehicles (HEV)
  - Plug-in Hybrid Electric Vehicles (PHEV)
  - Battery Electric Vehicles (BEV)
- RESS designs representing current model and near term production intent
- RESS operating conditions:
  - Charging
  - Storage
  - Normal Use
- Crash (and Post-Crash) event
- FMECA – criticality where applicable
Lithium-ion based Rechargeable Energy Storage Systems (RESS)

Test Procedures Development

Complete single and dual point/level failure modes including loss of the control system

- Develop repeatable test procedures
- Develop test boundary conditions and limits
- System level scope including RESS Enclosure performance and propagation characterization
- Develop comparable safety performance-metrics
- Perform test for data and repeatability validation

RESS operating conditions:

- Charging
- Storage
- Normal Use
- Crash (and Post-Crash) event

(Continued)
Lithium-ion based Rechargeable Energy Storage Systems (RESS)

Fault mechanisms in which the Vehicle Level Test Procedures will be premised and expanded upon to further system level performance

### Mechanical
- Mechanical Shock (Crash Pulse)
- Vibration
- Drop Test (Service Remove or Install)
- Immersion
- Penetration (rapid rate “road hazard”, or crash)
- Crush (crash event and post crash performance)
- Humidity/Moisture Exposure
- Chemical Exposure

### Electrical
- Short Circuit (hard and soft)
- Overcharge
- Over-discharge/ cell reversal

### Thermal
- Fire Resistance
- Propagation Resistance
- Control
- Shock
Lithium-ion based Rechargeable Energy Storage Systems (RESS)

Status: Test Procedures Development

- Contract(s) awards in September, 2011 and Draft Final Report(s) is scheduled for September 2013
**Lithium-ion based Rechargeable Energy Storage Systems (RESS)**

**Analytical Tools Development for Control System Safety Performance**

Develop a high-level analytical tool set to define and/or evaluate potential minimal control system performance requirements. Use these analytical tools, conceptually based on probability or criticality functions, to measure active control, redundancy, and passive protection performance for each of the control critical sequences which may result in a failure mode identified in the FMEA.

1. **Identify all safety variables and functional relationships in the RESS control environment (based on existing RESS control system(s))**
2. **Generate Probability and Criticality metric set for each variable functional equation**
3. **Analyze the variables with respect to FMECA**
4. **Establish functional requirements to meet criticality equations (from prior step)**
5. **Develop hardware (HIL) and software measurement tools for performance testing**
6. **NHTSA Policy and Rulemaking & EV-SGS GTR**
Lithium-ion based Rechargeable Energy Storage Systems (RESS)

Status: Analytical Tools Development for Control System Safety Performance

• Development partnership – Unidentified
  • Timing – coincidence with test procedures (24 months)
• Conceptual Scope:
  • Based upon probability and/or criticality functions derived from: FMEA, fault tree analysis (FTA), and control logic flow diagrams
  • Separate tools for HEV, PHEV, and BEV applications
  • Potential for adaptation to HIL analyzer for testing/comparing OEM systems
Other NHTSA Safety Activities

• Work with the first/second/third responders to provide safety guidance on issues of fire rescue, towing and storage EVs as well as disposal and recertify of RESS.