Automotive Industry Standards for the Safe Use of Lithium-Ion Battery Packs

Keith Wilson
Technical Project Manager
SAE International – Global Ground Vehicle Standards

NTSB Lithium Ion Battery Safety Forum 04/11/13
Agenda

1. What and Who is SAE International?

2. How is SAE International Involved in Lithium Ion Battery Safety?
   a) SAE EV/Hybrid Vehicle Committees & Standards
   b) SAE Cooperative Research Project
SAE International is a global body of scientists, engineers, and practitioners that advances self-propelled vehicle and system knowledge in a neutral forum for the benefit of society.
Mobility is Our Mission

- Established in 1905
- First President – Andrew Riker
- First VP – Henry Ford
- Initial Membership totaled 30 Engineers including Charles Kettering, Orville Wright and Glenn Curtiss

- Today SAE is the largest producer of consensus based ground mobility standards in the world.
- Since its inception SAE has produced over 30,000 standards and currently has over 10,000 active standards.

NTSB Lithium Ion Battery Safety Forum 04/11/13
SAE International Today

Global Influence:
- 128,000 members from over 100 nations
- SAE committee members represent 51 countries
- SAE standards referenced in countries all over the world

40 SAE references in Canadian regulations
78 SAE references in ISO regulations
27 SAE references in UNECE regulations
25 SAE references in Global Technical Regulations
293 SAE references in US regulations (93 Unique Standards)
9 SAE references in Japan’s regulations
37 SAE references in Australian regulations

NTSB Lithium Ion Battery Safety Forum 04/11/13
SAE EV / Hybrid Vehicle Steering Committee

- Started – 2005
- Current Committee Membership
  - >1100 Individual Participants
  - >500 Companies
    - OEM’s
    - Suppliers
    - Government
    - Academia
- 12 EV / Hybrid Vehicle Subcommittees
- 7 Fuel Cell Standards Subcommittees

NTSB Lithium Ion Battery Safety Forum 04/11/13
Battery Standards Steering Committee

- Started – 2009
- Current Committee Membership
  - >290 Individual Participants
  - >160 Companies
    - OEM’s
    - Suppliers
    - Government
    - Academia
- 19 Subcommittees
49 SAE EV / Battery Standards Published Including:

Battery Life Assessment Testing: J240, J2185, J2288, J2801

Determining Material Properties of Li-Battery Separator: J2983

Battery Testing Methodologies: J537, J1495, J2380

Battery Recycling: J2984

Battery Transport: J2950

Battery Functional Guidelines: J2289

Battery / EV Safety: J1766, J2344, J2910, J2929, J2464, J2990

EV / Battery Fuel Economy & Range: J1634, J1711, J2711

Battery Performance Rating: J1798

Battery Packaging: J1797

Battery Power Rating: J2758

Terminology: J1715

Battery Labeling: J2936

Battery / EV Safety: J1766, J2344, J2910, J2929, J2464, J2990

EV Charging: J1772, J1773, J2293, J2836, J2841, J2847, J2894, J2931

NTSB Lithium Ion Battery Safety Forum 04/11/13
SAE EV / Battery Standards Related to Safety:

J1766 – Recommended Practice for EV & Hybrid Vehicle Battery Systems Crash Integrity Testing – defines test methods and performance criteria which evaluate battery spillage, retention and electrical isolation during specified crash tests.

J1772 - EV & Plug in Hybrid EV Conductive Charge Coupler defines the general physical, electrical, functional, safety and performance requirements to facilitate conductive charging of EV/PHEV vehicles.

J2344 – Technical Guidelines for Electric Vehicle Safety – defines safety guideline information that should be considered when designing electric vehicles for use on public roadways.

J2380 - Vibration Testing of Electric Vehicle Batteries describes the vibration durability testing of an electric vehicle battery module or pack.


J2910 – Design and Test of Hybrid Electric Trucks and Buses for Electrical Safety - provides direction to manufacturers on design requirements and test procedures intended to make these vehicles safer to operate, service, or recover from an accident.

J2929 – EV & Hybrid Vehicle Propulsion Battery Systems Safety Standard defines acceptable safety criteria for lithium based rechargeable battery systems.

J2950 – Recommended Practice for Battery Transportation and Handling – defines guidelines for identification, handling and shipping of RESS.
Recommended Practice on Electrified Vehicle Response for First and Second Responders - SAE J2990

1. Emergency Response Guides
   - Quick Reference Sheet – readily available as supplement
   - Standardized Graphics
   - Consultation with responders

2. xEV identification
   - Badges identifying the vehicle placed in consistent locations
   - Exterior badges design
   - Interior marker design

3. System disabling
   - High Voltage systems design for first responder.
   - Manual disconnect design for first and second responder

4. High voltage vehicle inspection & post-incident handling
   - At the incident scene
   - Tow & recovery
   - Storage site/post-incident
J2936 SAE Electrical Energy Storage Device Labeling Recommended Practice

Labeling guidelines for energy storage devices including cell, battery and pack level products:

**Use applications:**
- Mobility
- Stationary
- Secondary use

**Covers entire life spectrum:**
- Manufacturing
- Shipping
- Transportation
- Usage
- Re-usage
- Emergency
- Recycling
- Reclamation
50 New SAE EV / Battery Standards & Revisions In-Process including:

- Terminology (J1715)
- Recycling (J2984, J2974)
- Disconnect & Discharge Procedures (J3009)
- Secondary Uses (J2997)
- Charging (J1772, J1773, J2293, J2836, J2894, J2931, J2953, J2954)
- Safety (J2990 & J2990/1)
- Crash Safety (J3040)
- Range / Power (J2991, J1798, J2758, J2946)
- Testing (J3021, J2380, J3038)
- Start Stop Batteries (J3012)
- Packaging (J1797)
- Starter Batteries (J2801, J2981, J537)
- Fuel Cells (J2601, J1766, J2578, J2579)

NTSB Lithium Ion Battery Safety Forum 04/11/13
SAE Cooperative Research Project to Develop Repeatable Safety Performance Test Procedures for Rechargeable Energy Storage Systems (RESS)

Project Overview
SAE International

NTSB Lithium Ion Battery Safety Forum 04/11/13
Project Objectives:

- Develop Li-Ion RESS Safety Test Methods:
  - Vehicle level testing when possible
  - Component level testing when necessary
  - With and without loss of the control system
- Identify and Document:
  - Test Conditions
  - Boundary Limitations
  - Performance Criteria
- Develop Performance Based Safety Metrics
## Potential Test Conditions

1. Vibration  
2. Thermal Shock  
3. External Short Circuit Protection  
4. Overcharge Protection  
5. Over Discharge Protection  
6. Over Temperature Protection  
7. Under Temperature Protection  
8. Fire Resistance – Short Duration  
9. Fire Resistance – Long Duration  
10. Vehicle Crash Evaluations  
11. Water Intrusion Test  
12. Battery System Standard Cycle / Health Assessment Procedure  
13. Others?
SAE International RESS Cooperative Research Program

**Technical Review Team:**
- NHTSA
- Principle Investigator
- SAE Program Managers

- Review Procedures & Identify Gaps
- Develop Specific Test Procedure(s) in Focused Area
- Perform Research & Validation Testing
- Refine & Finalize Test Procedures
- Document Recommended Industry Standards & Metrics

Vehicle OEMs
- Battery Manufacturers
- Commercial Test Suppliers
- National Laboratories
- Research Foundations
- Government SMEs
- System Suppliers

GM
Toyota
Honda
M B

NTSB Lithium Ion Battery Safety Forum 04/11/13
Who’s participating in the Project?

**Vehicle OEMs:**
- GM
- Honda
- Toyota
- Nissan
- Daimler
- Volvo
- BMW (Pending)
- Tesla

**Battery System Suppliers:**
- AVL
- Electron Vault
- Bosch

**Commercial Battery Testing Laboratories:**
- TUV SUD
- Intertek

**National Laboratories:**
- Sandia National Laboratory

**Research Foundations**
- Southwest Research Institute

**Consultants:**
- Eclipse Energy
- ASG Renaissance
- Battery Safety Consulting, Inc.
SAE International was identified by the National Institute of Standards and Technology (NIST) as a leading standards organization identified in the NIST Framework and Roadmap for Smart Grid and "Interoperability Standards to Support Plug-In Electric Vehicles."

SAE International is a member of the Smart Grid Interoperability Panel which was explicitly established to support NIST in its fulfillment of its responsibilities pursuant to the Energy Independence and Security Act of 2007 ("EISA").

SAE International serves as an active developer and contributor to the ANSI EVSP Standardization Roadmap for Electric Vehicles.