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

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SAE International – Global Ground Vehicle Standards

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

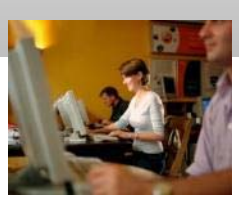
SAE International™ is a global body of scientists, engineers, and practitioners that advances self-propelled vehicle and system knowledge in a neutral forum for the benefit of society.

Commercial Vehicles

Automotive

Aerospace

Standards Development



Education

Premier events

Mobility is Our Mission






1910 Baker Model V Electric Victoria

2011 Chevrolet PHEV Volt

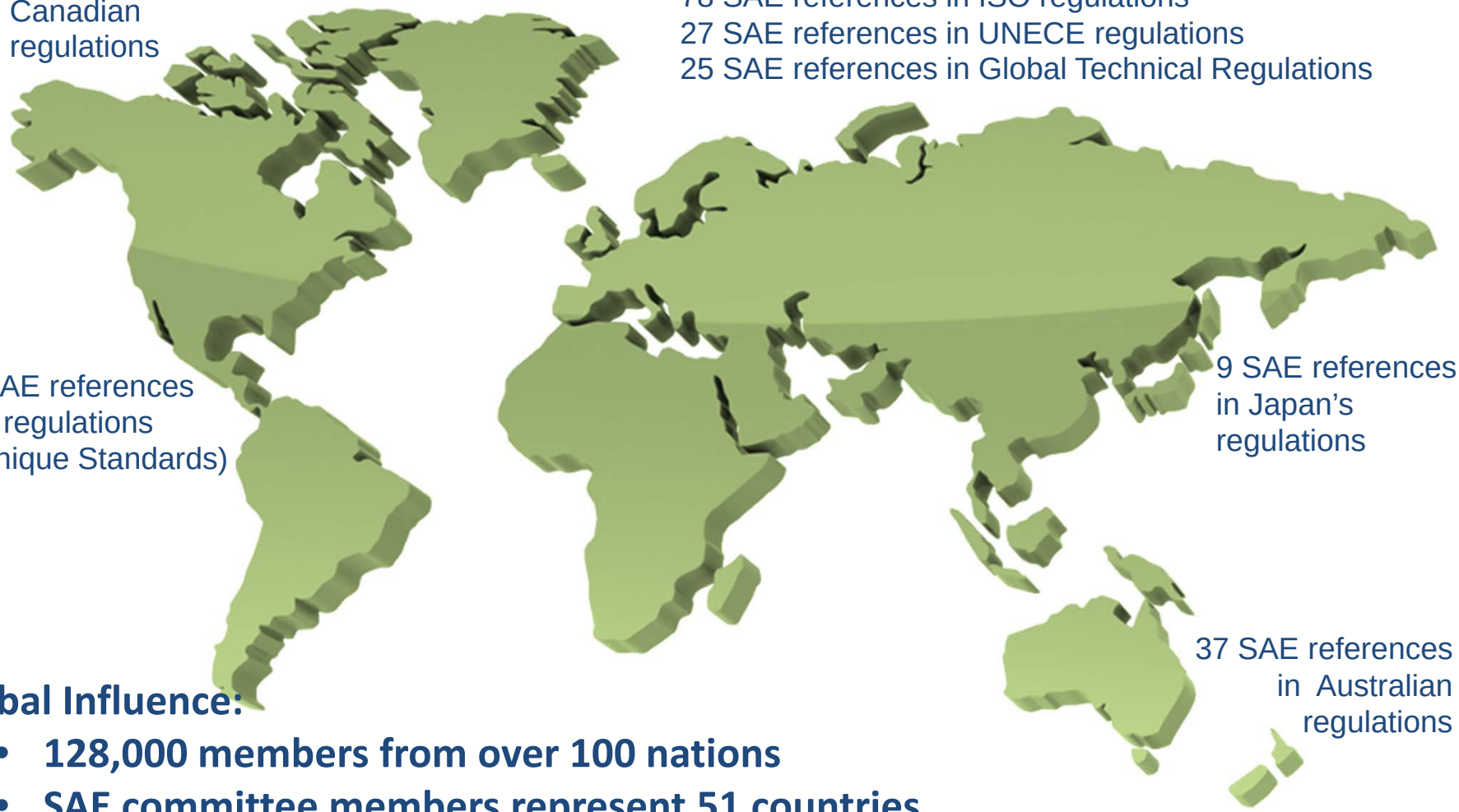
- **Established in 1905**
- **First President – Andrew Riker**
- **First VP – Henry Ford**
- **Initial Membership totaled 30 Engineers including Charles Kettering, Orville Wright and Glenn Curtiss**

- **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.**

SAE International Today

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

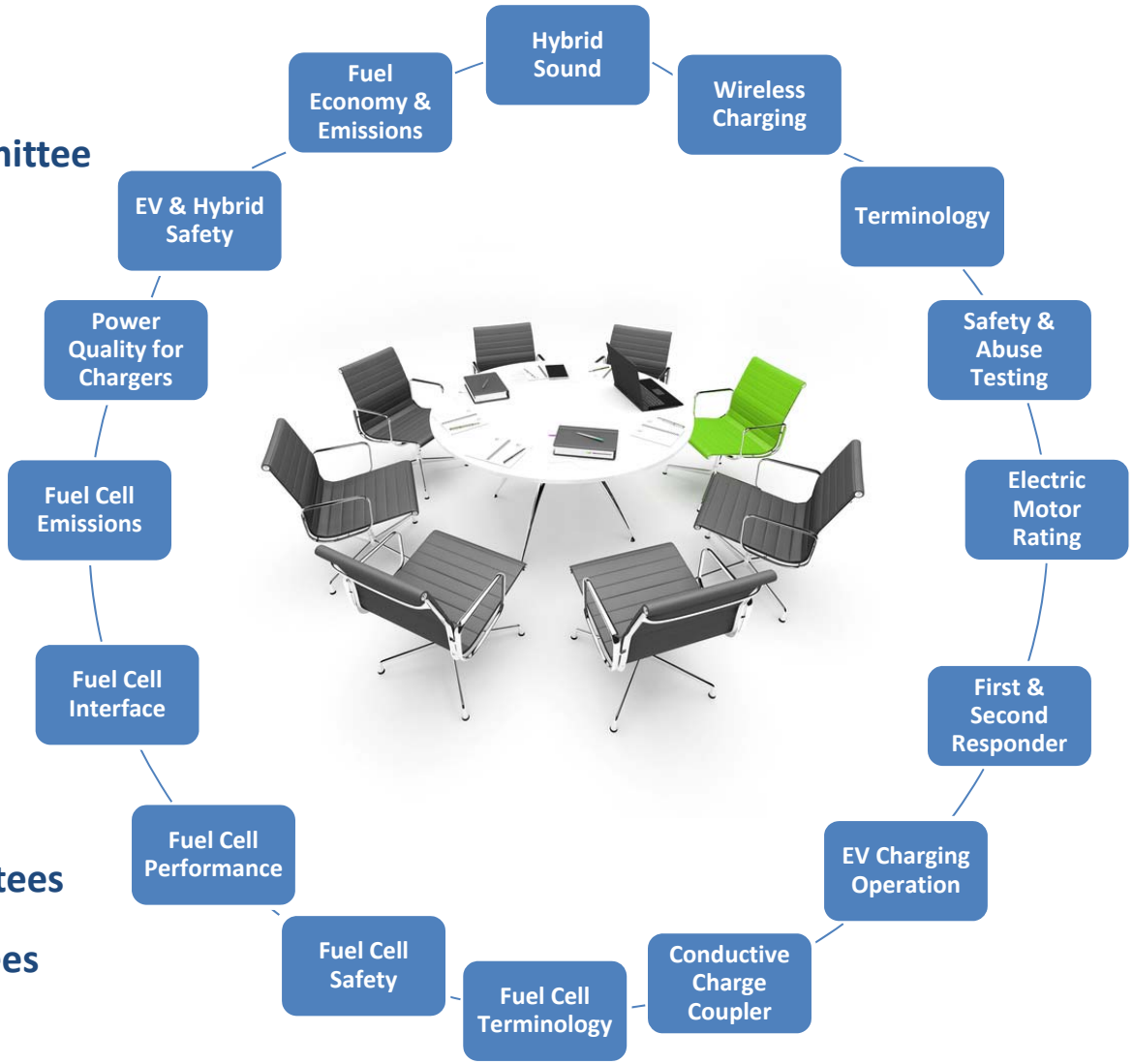
Global Influence:

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

SAE EV/Hybrid Vehicle Standards

SAE EV / Hybrid Vehicle Steering Committee

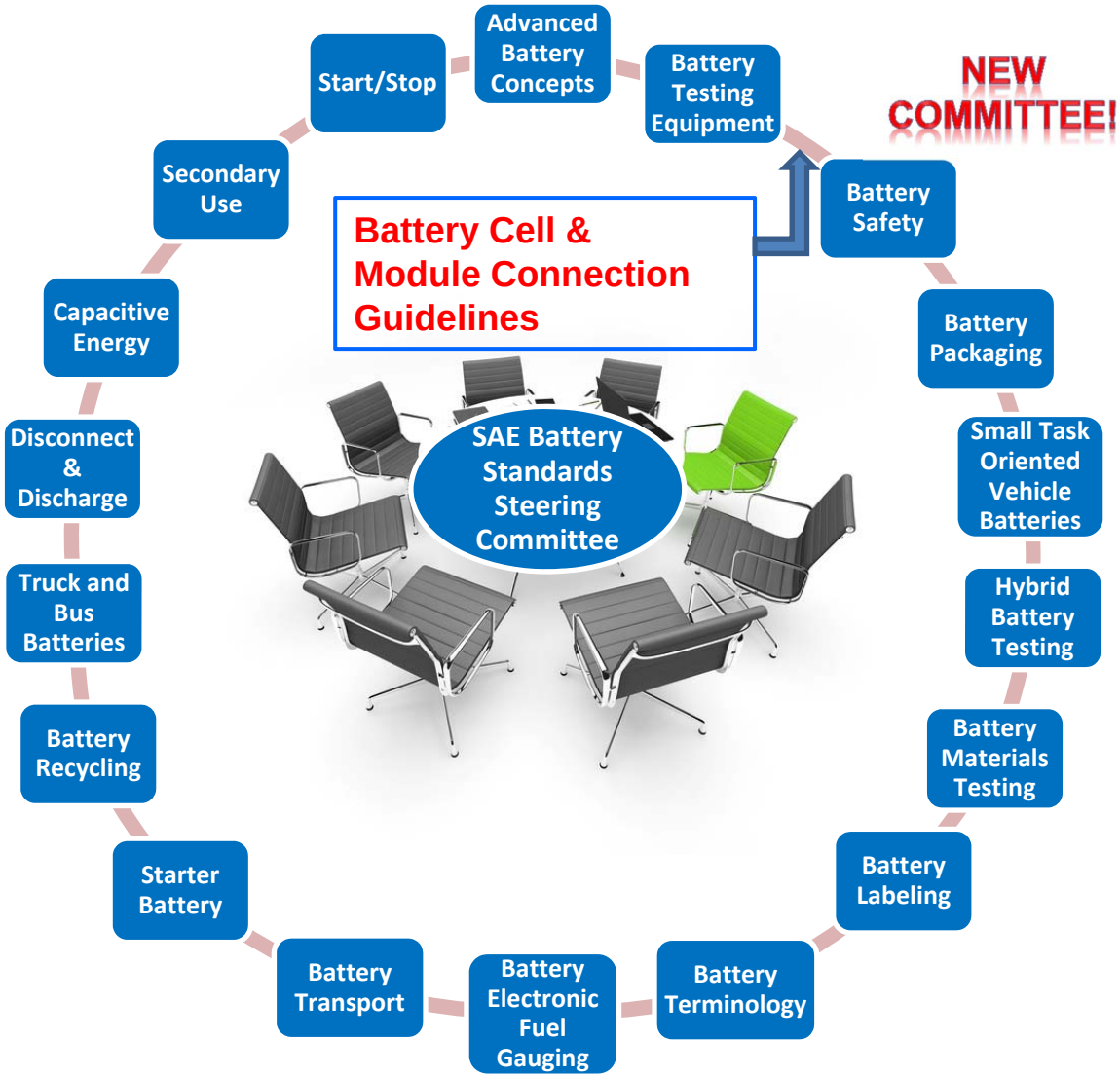
- Started – 2005
- Current Committee Membership
  - >1100 Individual Participants
  - >500 Companies
    - OEM's
    - Suppliers
    - Government
    - Academia
- 12 EV / Hybrid Vehicle Subcommittees
- 7 Fuel Cell Standards Subcommittees



SAE Battery Standards

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

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

Battery Performance Rating: J1798

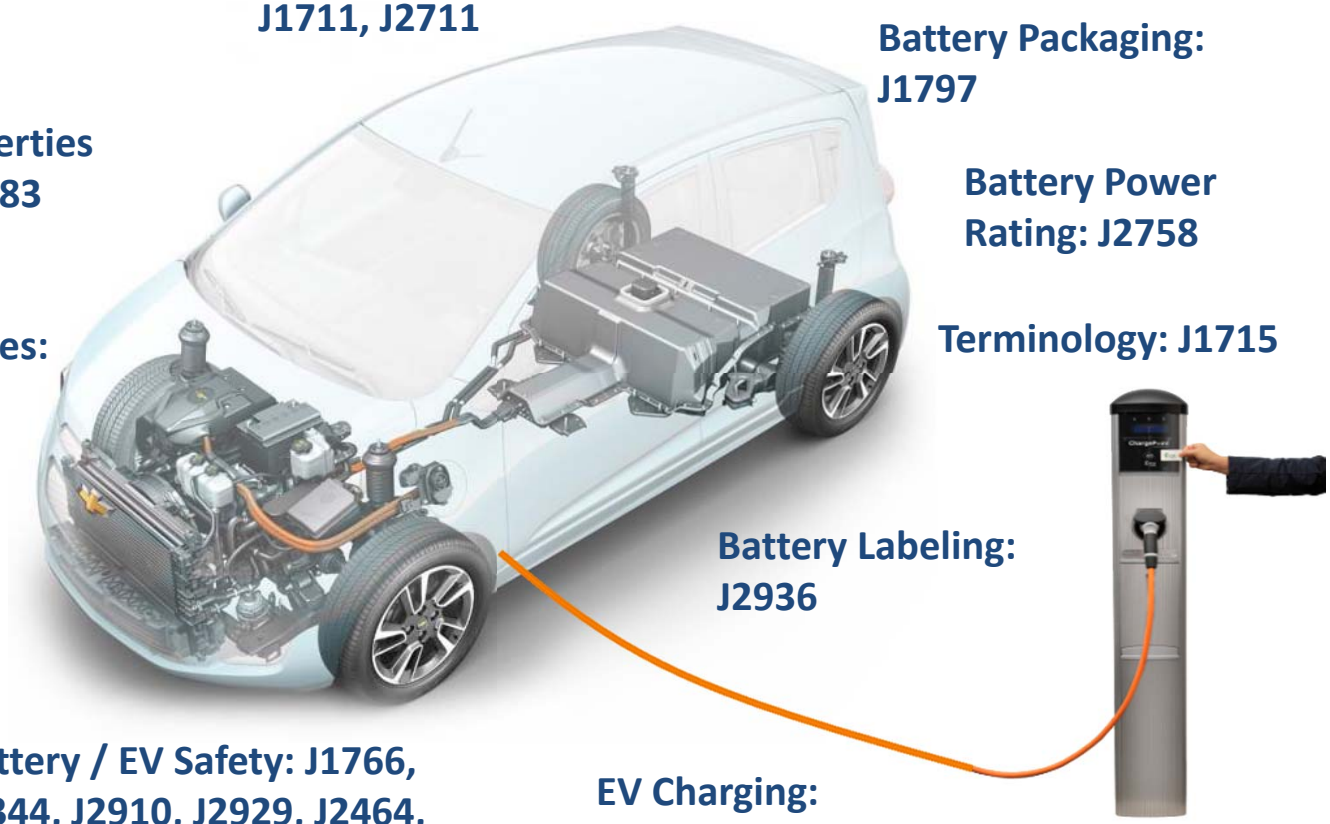
Battery Packaging: J1797

Determining Material Properties of Li-Battery Separator: J2983

Battery Power Rating: J2758

Battery Testing Methodologies: J537, J1495, J2380

Terminology: J1715



Battery Recycling: J2984

Battery Labeling: J2936

Battery Transport: J2950

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

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

Battery Functional Guidelines: J2289

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

J2464 - EV & Hybrid Vehicle Rechargeable Energy Storage System Safety and Abuse Testing Standard defines abuse and extreme environmental battery tests

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

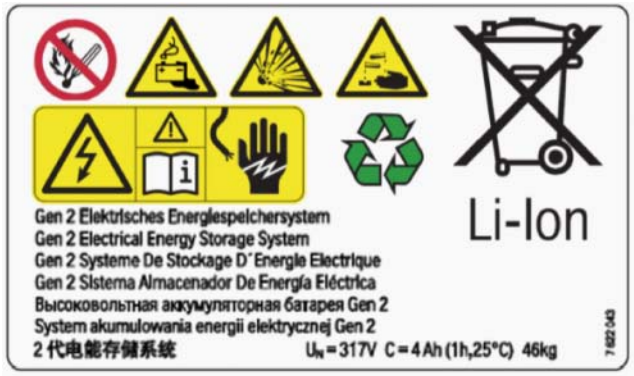
Labeling guidelines for energy storage devices including cell, battery and pack level products:

Use applications:

- Mobility
- Stationary
- Secondary use

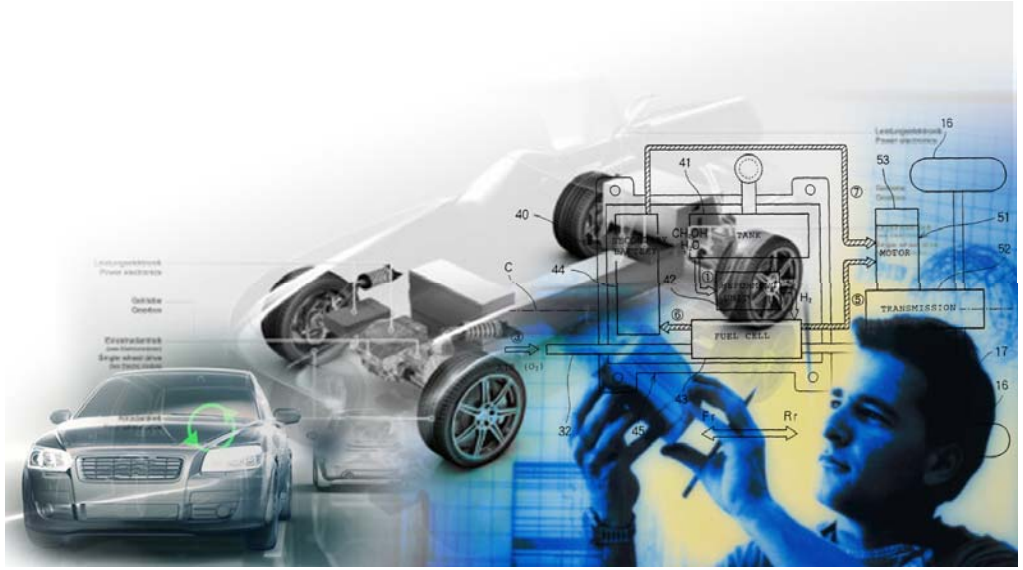
Covers entire life spectrum:

- 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)



SAE Cooperative Research Project to Develop Repeatable Safety Performance Test Procedures for Rechargeable Energy Storage Systems (RESS)

Project Overview
SAE International

SAE International
RESS Cooperative Research Program

Safety Performance of Rechargeable Energy Storage Systems (RESS)

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

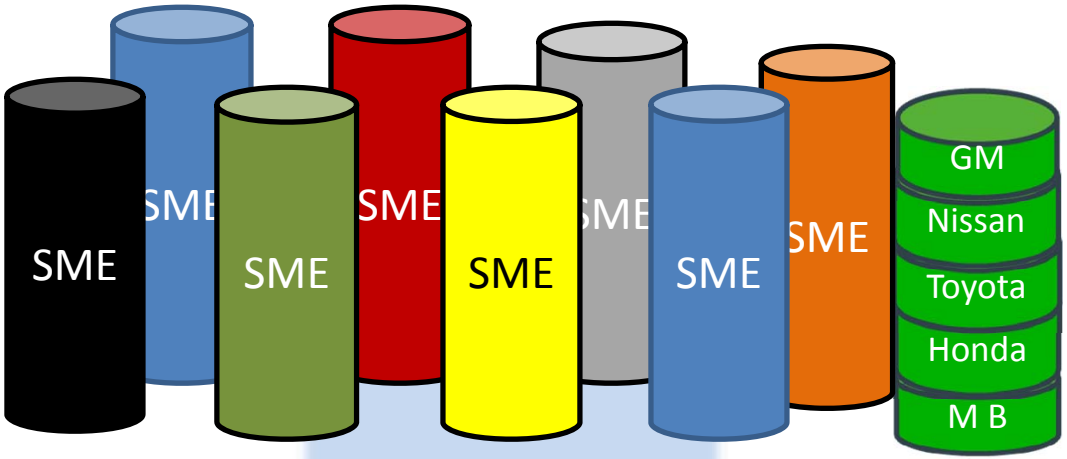
SAE International RESS Cooperative Research Program

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

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



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

Technical Review Team:

- NHTSA
- Principle Investigator
- SAE Program Managers

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 Involvement in National EV/Hybrid Vehicle Standardization Activities

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.



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