U.S. National Electric Vehicle Safety Standards Summit

Summary Report

21 & 22 October 2010
Detroit, Michigan

Co-Hosted by SAE and NFPA

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EXECUTIVE SUMMARY

Electric vehicles and hybrid electric vehicles are seeing resurgence on U.S. roadways. As new vehicles based on electrical power sources proliferate, questions exist as to how well the current codes and standards adequately address all the safety concerns relating to these new vehicles, their components, and the supporting technology in the built infrastructure.

The U.S. National Electric Vehicle Safety Standards Summit was held on 21-22 October 2010 in Detroit Michigan to address safety related codes and standards issues. The Summit focused on the fundamental codes and standards centric areas of: vehicles; built infrastructure; and emergency responders.

The purpose of the Summit was to develop the base elements for an action plan for the safe implementation of electric vehicles, and using safety standards as the primary mechanism for this action plan. Specifically, the objectives of the event were the following: identify the relevant fire and electrical safety codes, standards and specifications; identify gaps in these codes, standards and specifications; identify related gaps in research, training, or communications which stem from OEM safety manual development and deployment; and develop the base elements for an action plan for necessary standards development and associated deployment activities to fill these gaps.

The Summit provided an important venue for the gathering of key individuals, organizations and agencies to develop a common knowledge to ensure that fire and electrical safety standards that impact electric vehicles will not serve as a barrier to their deployment. As a result, the information gathered throughout the Summit has revealed the following key areas where further focused attention is warranted:

- charging infrastructure;
- understanding battery hazards;
- vehicle features that address concerns of emergency responders;
- permitting and inspection;
- training and education; and
- aftermarket vehicles and components.

A review and synthesis of all the information considered throughout the Summit, including consideration of the critical elements of the six aforementioned key areas, results in the identification of the following three action plan considerations:

1) Vehicle Charging Infrastructure;
2) Battery Hazards Identification and Protection; and
3) Training for Emergency Responders and Enforcement Officials.

A significant positive result of this Summit has been the networking component that has established valuable dialogue between important constituent groups on certain critical issues.

This translates to continuing the facilitation of this dialogue on all levels as an important action item resulting from the Summit. Further to this point of maintaining on-going constructive dialogue, planning should be considered immediately for a similar follow-up Summit in the near future, such as next year.

ACKNOWLEDGEMENTS

The Summit was co-hosted by SAE International and the National Fire Protection Association. Appreciation is expressed to all who were involved with and assisted in the planning and implementation of the event, in particular the staffs of the respective co-hosting organizations.

SAE International has more than 121,000 members - engineers, business executives, educators, and students from more than 97 countries - who share information and exchange ideas for advancing the engineering of mobility systems. SAE is your one-stop resource for standards development, events, and technical information and expertise used in designing, building, maintaining, and operating self-propelled vehicles for use on land or sea, in air or space.

The mission of the international nonprofit National Fire Protection Association (NFPA), established in 1896, is to reduce the worldwide burden of fire and other hazards on the quality of life by providing and advocating consensus codes and standards, research, training, and education. NFPA is the world's leading advocate of fire prevention and an authoritative source on public safety, NFPA develops, publishes, and disseminates more than 300 consensus codes and standards intended to minimize the possibility and effects of fire and other risks. NFPA membership totals over 75,000 individuals around the world.

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1. INTRODUCTION AND BACKGROUND

Electric vehicles and hybrid electric vehicles are seeing resurgence on U.S. roadways. As of November 2009, the U.S. was the top hybrid electric market in the world with approximately 1.5 million vehicles.[1-1] Vehicles that run only on electricity powered by batteries promise to join hybrids soon. In 2009, President Barack Obama pledged to have one million plug-in hybrid electric vehicles on the road by 2015, and championed a $2.4 billion initiative, under the American Recovery and Reinvestment Act, intended to accelerate electric vehicle research and development.[1-2]

Safety codes and standards address a wide range of issues relating to vehicles. As new technology emerges that is supporting the proliferation of vehicles based on electrical power sources, questions exist as to how well the current codes and standards adequately address all the safety concerns relating to these new vehicles, their components, and the supporting technology in the built infrastructure.

From an overall perspective there are three basic realms of codes and standards orbits relating to electric vehicle safety. These are: (1) vehicles; (2) built infrastructure; and (3) emergency responders. Each of these three realms has different regulatory issues and consensus codes and standards. This is illustrated in Figure 1: Basic Realms of Focus on Electric Vehicle Related Codes and Standards.[1-3]

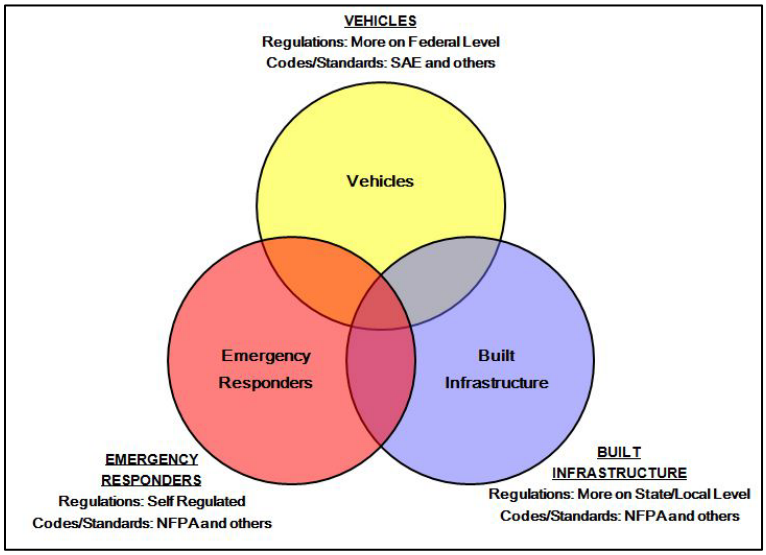

Figure 1: Basic Realms of Focus on Electric Vehicle Related Codes and Standards. [1-3]

First, on-board vehicles concerns are generally regulated more on a federal level, and are addressed by SAE and other vehicle oriented codes and standards. This area of interest pertains to the vehicle and all its components.

Second, the concerns and interests of emergency responders are basically self-regulated, with these organizations following model codes and standards provided by NFPA and other standards developers. For example, the NFPA has approximately 80 standards used directly by the fire service.

Third, the built infrastructure in the United States is normally regulated on the state or local level. This is consistent with the police power used to enforce building safety that is provided to state governments through the 10th Amendment of U.S. Constitution. Regulations are based on numerous model consensus codes and standards from NFPA and other organizations. Enforcing these requirements are the state and local fire marshals, fire inspectors, building officials, electrical inspectors, public health officials, and others with similar official enforcement duties.

In the United States there are a wide range of consensus model codes and standards that address electric vehicles and the multitude of issues relating to and supporting electric vehicles. These address or relate to safety issues for EVs and HEVs either in whole or in part, which are of interest to emergency responders and other safety professionals. They address concerns and provide information about not only the vehicle itself but also for the supporting infrastructure (e.g. charging stations and other similar auxiliary support equipment), as well as operational information for direct use by emergency responders.

Tables 1 and 2 summarize some of the applicable technical codes and standards that address safety design requirements directly relating to EVs and HEVs.[1-4] These documents are typically in constant revision cycles, resulting in new and/or updated editions on a regular basis. These two tables represent only a partial list of the more relevant codes and standards activities used to provide clarification at the Summit of some of the available standards on this topic. This information was available as the Summit to provide an example of some of the applicable standards, and is not intended to provide an exhaustive list of referenced publications. Further work on electric vehicles should consider the documents of other standards developing organizations that may have applicability (e.g. IEC, ICC, IEEE, ISO, NECA, NEMA, UL, etc)

Table 1: Examples of SAE Standards
Addressing Technical Issues Relating to EVs and HEVs. [1-4]

Document #	Document Title/Section
SAE J-537	*Storage Batteries* **(WORK IN PROGRESS)**
SAE J-1634	*Electric Vehicle Energy Consumption and Range Test*
SAE J-1711	*Recommended Practice for Measuring the Exhaust Emissions and Fuel Economy of Hybrid-Electric Vehicles*
SAE J-1715	*Hybrid Electric Vehicle (HEV) and Electric Vehicle (EV) Terminology* **(WORK IN PROGRESS)**
SAE J-1766	*Recommended Practice for Electric and Hybrid Electric Vehicle Battery Systems Crash Integrity Testing* **(WORK IN PROGRESS)**
SAE J-1772	*SAE Electric Vehicle Conductive Charge Coupler*

SAE J-1773	*SAE Electric Vehicle Inductively-Coupled Charging*
SAE J-1797	*Recommended Practice for Packaging of Electric Vehicle Battery Modules*
SAE J-1798	*Recommended Practice for Performance Rating of Electric Vehicle Battery Modules* **(WORK IN PROGRESS)**
SAE J-1850	*Class B Data Communications Network Interface*
SAE J-2288	*Life Cycle Testing of Electric Vehicle Battery Modules*
SAE J-2289	*Electric-Drive Battery Pack System, Functional Guidelines*
SAE J-2293 Part 1	*Energy Transfer System for EV Part 1, Functional Requirements and System Architecture*
SAE J-2293 Part 2	*Energy Transfer System for EV Part 2, Communications Requirements and Network Architecture*
SAE J-2344	*Guidelines for Electric Vehicle Safety*
SAE J-2380	*Vibration Testing of Electric Vehicle Batteries*
SAE J-2464	*Electric and Hybrid Electric Vehicle Rechargeable Energy Storage System (RESS) Safety and Abuse Testing*
SAE J-2711	*Recommended Practice for Measuring Fuel Economy and Emissions of Hybrid-Electric and Conventional Heavy Duty Vehicles*
SAE J-2758	*Determination of the Maximum Available Power from a Rechargeable Energy Storage System on a Hybrid Electric Vehicle* **(WORK IN PROGRESS)**
SAE J-2836 Part 1	*Use Cases for Communications between Plug-In Vehicles and the Utility Grid*
SAE J-2836 Part 2	*Use Cases for Communications between Plug-In Vehicles and the Supply Equipment (EVSE)* **(WORK IN PROGRESS)**
SAE J-2836 Part 3	*Use Cases for Communications between Plug-In Vehicles and the Utility grid for Reverse Flow* **(WORK IN PROGRESS)**
SAE J2836 Part 4	*Use Cases for Diagnostic Communication for Plug-in Vehicles* **(WORK IN PROGRESS)**
SAE J2836 Part 5	*Use Cases for Communication between Plug-in Vehicles and their customers.* **(WORK IN PROGRESS)**
SAE J-2841	*Utility Factor Definitions for Plug-In Hybrid Electric Vehicles Using 2001 U.S. DOT National Household Travel Survey Data*
SAE J-2847 Part 1	*Communications between Plug-In Vehicles and the Utility Grid*
SAE J-2847 Part 2	*Communication between Plug-in Vehicles and the Supply Equipment (EVSE)* **(WORK IN PROGRESS)**
SAE J-2847 Part 3	*Communication between Plug-in Vehicles and the Utility Grid for Reverse Power Flow* **(WORK IN PROGRESS)**
SAE J2847 Part 4	*Diagnostic Communication for Plug-in Vehicles* **(WORK IN PROGRESS)**
SAE J2847 Part 5	*Communication between Plug-in Vehicles and their customers* **(WORK IN PROGRESS)**
SAE J-2889	*Measurement of Minimum Sound Levels of Passenger Vehicles*
SAE J-2894 Part 1	*Power Quality Requirements for Plug-In Vehicle Chargers - Requirements* **(WORK IN PROGRESS)**
SAE J-2894 Part 2	*Power Quality Requirements for Plug-In Vehicle Chargers - Test Methods* **(WORK IN PROGRESS)**
SAE J-2907	*Power Rating Method for Automotive Electric Propulsion Motor and Power Electronics Sub-System*
SAE J-2908	*Power Rating Method for Hybrid-Electric and Battery Electric Vehicle Propulsion*
SAE J-2910	*Design and Test of Hybrid Electric Trucks and Buses for Electrical Safety*
SAE J-2929	*Electric and Hybrid Vehicle Propulsion Battery System Safety Standard – Lithium-based Rechargeable Cells* **(WORK IN PROGRESS)**
SAE J-2931 Part 1	*Power Line Carrier Communications for Plug-in Electric Vehicles* **(WORK IN PROGRESS)**
SAE J-2931 Part 2	*Inband Signaling Communication for Plug-in Electric Vehicles* **(WORK IN PROGRESS)**
SAE J-2931 Part 3	*PLC Communication for Plug-in Electric Vehicles* **(WORK IN PROGRESS)**
SAE J-2936	Vehicle Battery Labeling Guidelines **(WORK IN PROGRESS)**
SAE J-2946	Battery Electronic Fuel Gauging Recommended Practices **(WORK IN PROGRESS)**

SAE J-2950	Recommended Practices (RP) for Transportation and Handling of Automotive-type Rechargeable Energy Storage Systems (RESS). **(WORK IN PROGRESS)**
SAE J-2953	*Plug-In Electric Vehicle (PEV) Interoperability with Electric Vehicle Supply Equipment (EVSE)* **(WORK IN PROGRESS)**
SAE J-2954	*Wireless Charging of Electric and Plug-in Hybrid Vehicles* **(WORK IN PROGRESS)**

Table 2: Examples of NFPA Codes and Standards Addressing Technical Issues Relating to EVs and HEVs. [1-4]

Document #	Document Title/Section
NFPA 1	*Fire Code*
NFPA 30A	*Code for Motor Fuel Dispensing Facilities and Repair Garages*
NFPA 70	*National Electrical Code (NEC); Article 220, Branch Circuit, Feeder and Service Calculations; Article 625, Electric Vehicle Charging Systems; Article 626, Electrified Truck Parking Spaces; and other req.*
NFPA 70B	*Electrical Equipment Maintenance*
NFPA 70E	*Electrical Safety in the Workplace*
NFPA 88A	*Parking Structures*
NFPA 88B	*Repair Garages*
NFPA 289	*Fire Test for Individual Fuel Packages*
NFPA 400	*Hazardous Materials Code*
NFPA 450	*Guide for Emergency Medical Services and Systems*
NFPA 471	*Recommended Practice for Responding to Hazardous Materials Incidents*
NFPA 472	*Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*
NFPA 484	*Combustible Metals*
NFPA 502	*Road Tunnels, Bridges, and Other Limited Access Highways*
NFPA 513	*Motor Freight Terminals*
NFPA 556	*Guide on Methods for Evaluating Fire Hazard to Occupants of Passenger Road Vehicles*
NFPA 921	*Fire and Explosion Investigation*
NFPA 1000	*Fire Fighter Professional Qualifications Series (1000 – 1081)*
NFPA 1192	*Recreational Vehicles*
NFPA 1500	*Occupational Safety & Health Standards for Fire Fighters*
NFPA 1561	*Emergency Services Incident Management System*
NFPA 1600	*Disaster Planning and Emergency Preparedness*
NFPA 1670	*Standard for Technical Rescue Incidents*
NFPA 1710	*Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments*
NFPA 1720	*Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations and Special Operations to the Public by Volunteer Fire Departments*
NFPA 1851	*Selection, Care, and Maintenance of Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting*
NFPA 1971	*Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting*
NFPA 1999	*Protective Clothing for Emergency Medical Operations*
NFPA 5000	*Building Construction and Safety Code*

Section 1 Footnotes

1-1 Durso, F., “Plugged In”, NFPA Journal, National Fire Protection Association, Quincy MA, March/April 2010

1-2 NFPA Press Release, “NFPA Receives Grant to Develop Electric Vehicle Training Program for Emergency Responders”, www.nfpa.org, National Fire Protection Association, Quincy MA, 16 June 2010

1-3 Farr, R., “The Enforcement Infrastructure: In Support of Electric Vehicles and Similar Alternative Energy Transportation”, presentation at U.S. National Electric Vehicle Safety Standards Summit”, Detroit MI, 21 Oct 2010

1-4 “Blake, C., Buttner, W., Rivkin, C., "Vehicle Codes and Standards: Overview and Gap Analysis", National Renewable Energy Laboratory, Technical Report, NREL/TP-560-47336, February 2010” (supplemented with updates from applicable organization staff).

2. SUMMIT FORMAT, AGENDA AND VENUE

The "U.S. National Electric Vehicles Safety Standards Summit" was a two-day information sharing and planning event held on 21-22 October 2010 at Cobo Hall, Detroit, Michigan, USA. Over 100 attendees participated in the meeting that was co-hosted by SAE International and the National Fire Protection Association.

The purpose of the Summit was to develop the base elements for an action plan for the safe implementation of electric vehicles, using safety standards as the primary mechanism for this action plan. Specifically, the objectives of the event were the following:

- Identify the relevant fire and electrical safety codes, standards and specifications which address the safety hazards associated with the widespread implementation of electric vehicles.
- Identify gaps in these codes, standards and specifications (changes/enhancements and/or new standards).
- Identify related gaps in research, training, or communications which stem from OEM safety manual development and deployment.
- Develop the base elements for an action plan for necessary standards development and associated deployment activities to fill these gaps.

This Summit provided a venue for the gathering of key individuals, organizations and agencies that, working together, are developing a shared implementation plan to ensure fire and electrical safety standards that impact electric vehicles will not serve as a barrier to their deployment. The four major aspects of the safe deployment of electric vehicles addressed at the summit were:

- SDO Codes and Standards and OEM manuals addressing safety in the vehicle
- SDO Codes and Standards addressing the infrastructure surrounding electric vehicles (e.g. recharging stations, home recharging, battery storage, etc);
- SDO Codes and Standards which address emergency response to vehicle emergency events; and
- Other related Codes and Standards (E.g. user community specifications, insurance industry standards, etc).

The Summit took place over two full days and utilized the following format. For Day One, the Summit consisted of a series of presentations by key stakeholders in each of the four identified codes and standards area. Each presenter utilized a "white-paper" approach to address an assessment of existing standards in that area, standards development activities ongoing, identified potential gaps in both existing content and needed new standards, and offered recommendations of next steps.

Throughout Day One participants provided additional input and clarification through questions and answers at the end of each session. Table 3 provides a summary of the speakers who made presentation during Day One of the Summit:

Table 3: Speakers and Presentations during Summit Day One

Welcoming Remarks

- Ron Farr, State Fire Marshal, Michigan
- Jack Pokrzywa, Director of Operations of SAE Automotive Headquarters and Manager of SAE Ground Vehicle Standards, SAE International
- Christian Dubay, Vice President and Chief Engineer, National Fire Protection Association

Keynote Presentation

- "Driving the Safe and Effective Implementation of Electric Vehicles: Standards and Conformance-Based Solutions"; Joe Bhatia, President and CEO, ANSI

Session One: Vehicles

- "Battery and Labeling Standards"; Bob Galyen, Magna e-car
- "Hybrid/Electric Vehicle Battery Safety Standards"; Galen Ressler, General Motors LLC
- "Vehicle Standards Update: Hybrid Safety"; Ted Bohn, Argonne National Laboratory
- "NHTSA Safety Research Plan for RESS Equipped Vehicles"; Phillip Gorney, NHTSA

Session Two: Built Infrastructure

- "Current State of Codes and Electric Vehicle Infrastructure"; Mike Hittel, General Motors LLC
- "Standardization of Charging Support Equipment"; Kenneth Boyce, Underwriters Laboratories

Session Three: Emergency Responders

- "Fire Fighting, Rescue, and Incident Command"; Jeff Johnson, CEO of Western Fire Chiefs Association and IAFC Past President
- "Vehicle Fire and Technical Rescue"; Jeff Minter and George Burke, Madison Area Technical College, Wisconsin
- "The Enforcement Infrastructure: In Support of Electric Vehicles and Similar Alternative Energy Transportation"; Ron Farr, State Fire Marshal, Michigan

Session Four: Others

- "Owner/Operator Infrastructure Issues for Fleet Vehicles"; Patrick Fee, General Services Administration
- "Property Insurance Loss Prevention Concerns"; John Frank, XL Gaps
- "9-1-1 Connectivity: Electric Vehicle Rescues"; Cathy McCormick, OnStar

For Day Two, the attendees separated into three concurrent Workgroup breakout sessions of stakeholders i to review and complement the Day One assessment. Each of the three Working Groups had a central theme that served as their primary focus that they were to address first, followed by the other themes that were not their particular priority. These three Workgroup themes were vehicles, built infrastructure, and emergency responders.

Each of the Day Two Working Groups addressed and responded to a set of structured questions to allow consistency between the independent discussions. At the end of Day Two a final

plenary session reported the results of each Workgroup's discussions to the full assembly, and allowed a single final collective discussion.

This overall Report serves as the documentation of the Summit, and includes the essential information that provides the basis for consideration of an action plan for codes and standards development and associated supporting activities to facilitate the safe implementation of electric vehicles.

3. DAY ONE PRESENTATION SUMMARY

The first day of the two day Summit was structured around a series of presentations by key stakeholders. The intent was to provide an assessment of existing standards, review ongoing standard development activities, and identify potential gaps, both in existing safety standards as well as in needed new standards or other related areas.

Specifically, welcoming remarks and a keynote presentation set the overall tone of the Summit, and subsequent presentation throughout the day were grouped into four basic groups bringing focus to the primary areas of safety standards development. The four basic groups represent the primary areas in which safety standards are involved with supporting electric vehicles, and these were:

1) Vehicles;
2) Built infrastructure;
3) Emergency responder; and
4) Other.

The "Vehicles" group addressed issues involving electric vehicles and the on-board equipment they contain. Additional focus was provided on vehicle batteries, recognizing that they are a key element of the overall electric vehicle package. Mention was made of the different standards applicable to the different types of electric vehicles, various configurations of batteries, vehicle oriented charging interconnections, considerations of consumers versus fleet or commercial applications, and safety features included in today's vehicle designs

The "Built Infrastructure" group focused on electric vehicle support equipment (EVSE) and facilities not on the vehicles but essential to the success of the overall electric vehicle program. The anticipated common scenario of an electric vehicle being recharged at a residence was mentioned multiple times and symbolizes the types of applications addressed during this part of the program. Examples of this type of supporting equipment and facilities include charging stations, electrical infrastructure support, battery storage, maintenance facilities, parts supply, etc. Issues raised during the presentations and subsequent discussion included clarification of specific sections of the National Electrical Code and other applicable codes and standards, indoor and outdoor charging stations, permitting and inspection, installation of charging infrastructure by electricians, use of listed equipment, role of the electrical utilities, and on-going maintenance.

The "Emergency Responder" group addressed the interests and concerns specific to the emergency response community, both for operational emergency first responders dealing with an emergency scene, as well as the enforcement infrastructure that is critical to the ultimate advancement of this technology. The concerns of the emergency response community extend well beyond the activities of handling a roadway vehicle related emergencies, and include other issues such as a fire within a building while a vehicle is charging, fire protection for vehicle

battery storage, etc. Vehicle related topics mentioned include providing better emergency responder input for certain on-board vehicle features such as color-coding of cables and emergency vehicle shut-offs, as well as promoting technologies that enhance emergency dispatch like telematics.

The final "Other" group included perspectives considered important for the overall issue but which didn't easily fit into the other three groups. This included the perspective of a user who is responsible for large electric vehicle fleet purchases and maintenance, an insurance perspective addressing built infrastructure fire protection concerns such as battery storage, and a new technology perspective that focuses on the advantages of telematics.

Each of these "other" presentations and the associated group discussion provided a useful supplement to the preceding group presentations. Specific examples included how large government electric vehicle fleet operators will likely assist in identifying implementation challenges, the need to properly address issues of batteries not in vehicles requires attention, and how new identification and reporting technology is becoming a valuable tool for emergency first responders.

The presentations in Day One provided helpful background information in each of the aforementioned areas. Each group session was followed by its own questions and answers involving all Summit attendees and providing additional clarification of the key concerns and topics of interest. A summary of the points raised was circulated to the Day Two Working Groups, and they provided additional clarification of their understanding of the issues discussed on Day One. Table 4 summarizes the key points addressed during Summit Day One, and is based on the chronological order the issues were mentioned and is not a prioritized list of the issues (with items numbered for the purpose of subsequent reference).

Table 4: Summary of Key Points Mentioned During Summit Day One

A) <u>Welcoming Remarks and Keynote Presentation</u>

1) Need to continue to stimulate public/private partnerships via standards development.
2) Not only are standards important but so is compliance mechanism.
3) Compliance approach is different for vehicles vs. built infrastructure vs. emergency responders.
4) Important issues for vehicle components like batteries include after-market and offshore products.
5) Electric vehicles is a critical cross-cutting standards issues and all affected stakeholders need to be involved.
6) National standards should be developed ready for international use.

B) <u>Session One: Vehicles (Presentations and Q&A Discussion)</u>

1) Significant industry activity is on-going with battery and labeling standards, though input from emergency responders into this effort would be beneficial.
2) Possible hazard concerns with batteries is important, both on-board vehicles as designed but also otherwise (e.g. storage, bulk transport, etc).
3) Certain vehicle electrical equipment has potential for rare but extreme failure (e.g. arc-flash, catastrophic failure), not only during emergencies but also during regular maintenance.

4) DC fast charging and other different approaches present unusual challenges.
5) Use of listed equipment for certain components such as batteries or charging stations is important, including aftermarket continued use of these components.
6) Regulatory oversight of vehicles occurs on the federal level, based on model standards.
7) Effect of repairs, maintenance, and user modifications of vehicles and vehicle components may present future safety challenges.
8) Malicious infiltration and use of software/hardware systems may compromise built-in safety.
9) Further assessment of the hazards of off-gassing during vehicle charging is required.
10) Crash worthiness of electric vehicle and vehicle systems is a key consideration of vehicle design.

C) <u>Session Two: Built Infrastructure (Presentations and Q&A Discussion)</u>

1) Technical needs and regulatory oversight of the electrical requirements for the built infrastructure is different than for the vehicle electrical system (i.e. charging station interface).
2) Three prime components of the built infrastructure are:
   i) installation codes and standards;
   ii) equipment standards (for listings of EVSE); and
   iii) enforcement.
3) Impact to/from the grid needs to be considered (e.g. vehicles being charged).
4) Charging stations need to be universal and not vehicle specific.

D) <u>Session Three: Emergency Responders (Presentations and Q&A Discussion)</u>

1) Need realistic standardized tests for equipment and components (e.g. battery tests).
2) Printed vehicle information for emergency responders becomes quickly outdated, and real-time up-to-date media is preferred.
3) Emergency responders need credible, consistent, clear, simple and accurate information on certain vehicle needs (e.g. vehicle shutdown, etc).
4) Design consistency on certain vehicle features would greatly benefit emergency responders (e.g. vehicle identification, power status indication, shutdown procedure, etc).
5) Fire service, emergency medical services, and law enforcement need to be considered as first responders, but also consideration needs to be given to tow/salvage operators and others.
6) Regulatory oversight of the built infrastructure occurs on the state or local level, based on model codes and standards (e.g. charging infrastructure in buildings).
7) Permitting processes in the built infrastructure varies between local jurisdictions, but are usually based on model codes and standards (e.g. for charging stations).

E) <u>Session Four: Other Issues and Concerns (Presentations and Q&A Discussion)</u>

1) Fleet vehicle operations will exemplify the implementation challenges we will all ultimately face as electric vehicles proliferate.
2) Insurance concerns include beyond the vehicle to the support infrastructure (e.g. battery storage, etc)
3) Telematics offers real-time information for emergency responders to allow for immediate size-up of vehicle emergency events.

F) <u>Day One Summary Discussion</u>

1) Auto technicians and mechanics will need similar training and education with regard to hazards, and certification should be considered for them.
2) The dialogue, networking, and collaboration at this summit is important and needs to be continued.

3) Understanding of battery technologies is lacking, and needs to be better shared by those leading these technologies with those less familiar but who could benefit from this information.
4) Education and training on hazard and safety concerns are huge issues, and current initiatives such as the DOE funded project for EV emergency responder training (administered through NFPA) are important.

4. WORKING GROUP REPORTS

Each Workgroup that met on Day Two was assigned a set of similarly structured questions. These questions were intended to allow consistency between the independent discussions, and utilized the following three basic categories: current practice; future trends; and other issues.

In addition, each of the three Workgroup had its own baseline theme. This assigned baseline theme was intended to be the priority subject for a particular group, and their priority to be addressed first. However, they were not excluded from addressing the other themes as time permitted. The themes assigned to the Workgroup were: Workgroup One- Vehicles; Workgroup Two - Built Infrastructure; and Workgroup Three - Emergency Responders.

At the end of Day Two, a final plenary session reported the results of each Workgroup's discussions to the full assembly, and allowed a single final plenary discussion. Following the Summit and this plenary discussion, the results from each of the Working Groups were consolidated into a single summary. Table 5 summarizes the consolidated Workgroup response to the structured questions

Table 5: Consolidated Workgroup Response to the Structured Questions

1) Current Practice
   a. What are the prioritized safety issues for standards to address (e.g. vehicle electrical cable color coding, extinguishing battery fires, charging station disconnects, etc)?

      General

      - **Primary Hazard Concerns** – The primary hazard concerns are fire, explosion, smoke, and electricity.
      - **Aftermarket Vehicles and Components** – Consideration of aftermarket use of vehicles and vehicle components including second life of repurposed batteries.

      Vehicles

      - **Hi-Voltage Cables** – Consider standardization of color coding and routing of high voltage cable in vehicles. Also address cables that are color coded and covered in black covering, and with other than color designation (e.g. patterned)
      - **Vehicle Type Identification** – Provide marking, labeling and badging of vehicle type including the battery technology or type including RFID. Use standardized indicators (badging) that indicates fuel sources, including battery chemistry. Consider vehicle RFID tags that could be detected by first responders and would warn of the presence of an EV.
      - **Procedures/Location for Vehicle Shutdown** – Consider common procedure and standardized disconnect location in vehicles in an easily accessible location. There is also a need for remote disconnecting means so that there is no risk in disconnecting a burning battery.
      - **Confirmation/Indicator of Vehicle Shutdown**. Consider common method to confirm vehicle shutdown based on standardized indicators, including verification that vehicle power has been disconnected.

Built Infrastructure

- **Connector Standardization** – Communication of information regarding connector standardization activity e.g. SAE J1772
- **EV Supply Equipment (EVSE) Listing Issues** – Need to standardize certain characteristics, e.g. color of the EVSE cord, orange, yellow, etc. Some of the current EVSE's are not listed. EVSEs are considered everything between the charger (on the vehicle) and the building wiring system.
- **Panel Board Fire Rating** – Consider integrity of fire rated wall for panel board.
- **Non-Vehicle Emergency Disconnects** – There is a need for emergency disconnects that are not at the vehicle.
- **Component Hazard Protection** – Consider all potential hazards of vehicle components, including requirements for manufacturing, recycling and service facilities. Provide fire protection based on MAQs (Maximum Allowable Quantities).

Emergency Responders

- **Standardized ERG Format** – Provide all emergency response guide information in a consistent, credible, accurate, and realistic format needed by emergency responders.
- **Emergency Scene Procedures** – Provide a standard format for emergency responders on steps to take at the scene of an incident.
- **Extrication Information** – Need standardized information on all EV cut zones for extrication.
- **Extinguishing Agent Types** – Information is needed for field use of the types of extinguishing agents that should be used.
- **Reference Standards Catalog** – Provide a catalog of applicable referenced standards addressing all aspects of electric vehicles that can be readily accessed by emergency responders for emergency events.
- **Emergency Response Performance Parameters** – Establish realistic performance parameters for emergency response.
- **Emergency Responders Standards Involvement** – The communications between first responders and standards developers should be promoted in both directions.
- **Battery Hazards** – Promote training on technology, including what happens when batteries are overheated, overcharged, or burn. Clarify specific hazards with specific batteries, e.g., there is no lithium hazards associated with lithium-ion batteries.
- **Water Immersion** – Promote training on water immersion, i.e. how to deal with vehicles that are submerged in water (fresh and salt water).
- **Shutdown Procedures** – Promote training on shutdown procedures, including where vehicles are supplied from one or more alternative power sources, (generators, PV, wind, etc.), to provide responders with sufficient information to facilitate the disconnection of all sources that supply the vehicle.

b. What are the perceived disparities in technical coverage for existing safety standards (e.g. extrication with vehicles using high strength alloys, charging station hazards, etc)?

General

- **Collaborative Education** – Better dissemination and education is needed, through collaboration, based on existing standards information.
- **Different Enforcement Models** – Maintain awareness of the disparity in enforcement models for different standards arenas (i.e. vehicles vs. built

infrastructure vs. emergency responders)

- **Aftermarket Vehicles and Components** – Address anticipated future hazards from aftermarket vehicles and related components.

Vehicles

- **Battery Issues** – Need to address multiple issues with batteries that recognizes their complexity (there is not uniform battery chemistry, geometry, etc), e.g. promote standardized testing, clarify how to handle damaged batteries, provide guidance on storage and handling, etc

Built Infrastructure

- **Charger Installation Standards** – Need to address details such as leakage of current, tolerances, etc
- **Circuit Installation** – Verify the load current for chargers, which is mentioned for Level 1 as being 16 amps maximum. This may need a dedicated circuit because it is a continuous load. In addition, other loads on the same circuit may exceed the circuit capacity. This circuit may also require GFCI protection. Clarify requirements for Level 2 chargers. Circuits rated at 40 amps are not generally available in the garage, but are often available elsewhere in a house, e.g. dryer plug. GFCI protection is not required for level 2, and this needs to be further addressed.
- **Wiring Installation** – Conventional wiring is okay for Level 1, though Level 2 and 3 requires consideration for additional protection. Continuous duty wiring requires upsizing (i.e., a difference between an EV and a dryer or range)
- **Damaged Cords and Plugs** – Shock and fire hazards from damaged cords and plugs at service stations and from owner cords and plugs at home. Inspection frequencies for this equipment are not clear.

Emergency Responders

- **Effectiveness of Extrication Tools** – Most cutting and extrication tools are ineffective on new high-strength alloys and composite.
- **Break away Emergency Shutdown** – Consider requirements for inherently safe break away emergency shut-down.
- **Permitting Qualifications** – Installer of EVSE (new branch circuit) may not be a licensed electrician, depending on state and local jurisdiction.
- **Streamlining of Permitting/Inspection Process** – Consider approaches to streamline, with a goal for a single day process, e.g. educating car dealers on permitting/load issues and having a contractor on retainer, or OEM providing turn-key supply (including upgrading the electrical system in the full cost estimate).

c. Are there existing standards on this topic that are not being fully utilized or implemented (e.g. outside North America, etc)?

General

- **Applicable Military Standards** – Consider DOD standards that are applicable for vehicles, built infrastructure, and emergency responders.

Vehicles

- **Domestic vs. International**– There are some ISO and IEC, as well as CEN and CENNELEC standards related to electric vehicles. We are not sure which ones may be applicable. There may be some harmonization potentials.

Built Infrastructure

- **DC Electricity**- DC Fast Charging raises questions about interaction of certain standards, e.g. JARI connector with UL 2202
- **Electrical Grid** – Further attention is needed to clarify the sharing of capacity within a neighborhood, i.e. transformers, etc. IEEE working group on Smart Grid, e.g. P2030, dealing with enabling, interconnectivity, etc… EPRI, IWC group along with OEMs and utilities are involved with this effort.

Emergency Responders

- **Vehicle International Travel** – Consideration of visiting vehicles crossing the borders of countries needs to be addressed

2) Future Trends

a. Based on current technological trends, what are the prioritized anticipated future hazards (e.g. batteries, charging stations, vehicle shut-downs, high strength alloys, component bulk storage, etc)?

General

- **Component Global Supply** – Global supply base of batteries and components to maintain safety, quality and reliability

Vehicles

- **Battery Swapping** – Battery swapping / warehousing posing increased risk (e.g. BetterPlace.com, leasing arrangements)
- **Vehicle Components and Alternative Fuels** –Consider the use of components that introduce unusual hazards such as ultra capacitors, and electric vehicles that also use alternative fuels such as hydrogen fuel cells.

Built Infrastructure

- **Power Quality** – Consider issues such as harmonics and other power quality issues.
- **DC Fast Charging** – For Level 3+ type charging arrangements, consider the impact of installations on the vehicle and on the house, e.g. heating, ventilation, compatibility/standardization between chargers and vehicles, etc. Also consider inductive charging methods.
- **Large Scale Disasters** – Special considerations are needed for handling certain details following large scale, natural or man-made disasters (e.g. reinstatement prioritization following mass power outage).
- **Battery Farms** – Address the concerns involving battery farms, such as those using second life vehicle components, on both small residential scale and large commercial scale.

Emergency Responders

- **Battery Storage** – Need to consider exposure fires, as well as electrical hazards due to exposure from or in water.
- **Composites and Materials** –Consider composites and materials being used in electric vehicles that introduce new challenges to emergency responders, such as high strength metal alloys to reduce vehicle weight but are resistant to conventional cutting and extrication tools.
- **Charging Station Emergencies** – Address emergency events involving EVs while charging.

b. Based on current technological trends, what are the prioritized anticipated future enhancements to safety (e.g. vehicle telematics, emergency responder training, etc)?

General

- **Overall Lifetime Product Stewardship** – Electric vehicles and all their components both on and off the vehicle need to have cradle to grave product stewardship.

Vehicles

- **Automatic Shutdown Methods** - Consider built in shut downs features, such as those that are already appearing in batteries.
- **Old Batteries** – Address handling and processing of damaged or retired vehicle batteries.

Built Infrastructure

- **Global Compatibility** – Promote global compatibility of all interacting components, such as connectors.

Emergency Responders

- **Telematics** – Need more integration of telematics with emergency responders, and more training on how to use the data received from telematics. More capability needed for communications centers to push telematics data to responders.
- **Standardized Training and Education** – Provide a centralized location for critical emergency responder information such as ERGs, to promote standardized training and education information. Continually update this information to add new and revised information as vehicles change.
- **Methods of Identifying Hazards** – Provide placarding of the bulk transport of vehicle components, including the packing/labeling of individual components in the transport system

c. What new standards are needed to address this topic in 5 years? 10 years (e.g. emergency responder data information exchange, etc)?

General

- **Non-Vehicle Applications** – Consider expansion beyond road vehicles to aviation and marine industries.

Vehicles

- **Non-Passenger Vehicle Applications** – Consideration of issues applicable to motorcycles, all terrain vehicles and neighborhood EVs
- **Vehicle Service Providers** – Address the qualification of mechanics, as well as methods for investigation and other concerns for vehicle insurers.
- **Non-Battery Based Electric Vehicles** – Consider electric vehicles that are not based on storage batteries as their primary source of power, such as hydrogen fuel cell vehicles.
- **On-going Maintenance** –Clarify requirements for the on-going maintenance of electric vehicles.

Built Infrastructure

- **Battery Technology** – Address battery safety issues based on the wide range of battery types, configurations, geometries, chemistries, etc…
- **Electrical Grid**– Consider impact of widespread implementation of electric vehicles, i.e. impact on transformers, overall grid capacity, changing load patterns, system demand, equipment life span, etc
- **On-going Maintenance** –Clarify requirements for the on-going maintenance of electric vehicle charging stations, including how vulnerable features will be inspected and replaced such as connectors.

- **Connector Standardization** – The need to address the standardization of connectors needs to be done in a timely fashion.
- **Inductive Charging**– Assess the impact of Inductive charging methods, including the biological effects, either while stationary or while driving.
- **Charging Station Fire Protection**– Address possible need for built in fire protection measures for charging locations, such as what is currently required for conventional re-fueling stations

Emergency Responders

- **Telematics** – Standardize the protocols and data elements for telematics.
- **Battery Manufacturing and Storage** – Clarify requirements for battery manufacturing and bulk battery storage, including guidance on the hazard classification, type of built-in fire protection measures required, etc

d. What new research is needed to support existing and new standards (e.g. research supporting new fire test methods, etc)?

General

- **Loss and Failure Analysis** – Provide case studies of crash reports and similar emergency events, with statistical summaries and detailed case study analysis.

Vehicles

- **Battery Technology** – Address the various hazard concerns with vehicle batteries, both on-board the vehicles and while during manufacture and bulk storage of batteries. Consider the development of requirements for fire protection Maximum allowable Quantities.

Built Infrastructure

- **Electrical Grid** – Address interconnectivity in accordance with the NEC and other applicable codes and standards. Consider the impact of smart grid on present and future electrical supply, and its relationship to electric vehicles.

Emergency Responders

- **Battery Technology** – Develop consistent and credible recommendations for manual fire protection techniques for handling emergencies involving batteries, including fires, submersion, etc. Also develop recommendations for built-in fire protection measures for bulk storage and similar battery applications.

e. What constituent groups and/or organizations need to be involved (e.g. tow operators, fire investigators, etc)?

General

- **Interested Constituent Groups** – Include organizations that are not obviously represented in other groups, such as consumer representatives, AAA, insurance representatives such as IIHS, aftermarket installers, etc…

Vehicles

- **Manufacturers** – Include all automaker and battery manufacturers.
- **Vehicle Maintainers** – Include maintenance workforce and their methods for credentialing with the equipment, e.g. service technicians. Include service station operators.

Built Infrastructure

- **Manufacturers** – Include all manufacturers of equipment in the built infrastructure supporting electric vehicles, such as charging stations.

- **Charging Station Installers** – Include construction worker training for professionals working on charging stations. Include electrical contractors.
- **Regulators** – Provide support and training for regulators such as electrical inspectors, building officials, NHTSA, OSHA, etc
- **Model Code and Standards Developers** – Inclusion of all model building code and standards organizations.

Emergency Responders

- **Emergency First Responder**s –Include all applicable fire service, EMS and law enforcement representative.
- **Other Emergency Responders** –Include emergency responders who are not necessarily involved with the initial emergency response, such as tow operators, investigators, insurers, electric utilities, etc. Include emergency responders who may not be required at the scene of the emergency, such as dispatchers.
- **Trainers and Educators** –Include representatives who specialize in training and education, such as representative from state training academies.

3) Other Issues

a. Other than standards, what other methods, programs and mechanisms should be considered to promote electric vehicle safety?

General

- **Proactive Approaches** – Provide proactive approaches to instituting needed standards, codes and regulations.

Vehicles

- **Data Collection** – Establish robust data collection protocols, including data recorder methods, telematics, accident reports for multiple uses and venues. Address proprietary and privacy considerations as needed.
- **Consumer Training** –Provide consumer training for fueling/charging that covers the spectrum of fueling/charging options. Develop training and education information for use in driver's education programs.

Built Infrastructure

- **Metering Installation Issues** – Consider special rates and incentives offered by utilities, e.g. installation of separate and/or dedicated service (meter)
- **Financial Incentives** – Evaluate approaches for promoting the EV support infrastructure, e.g. road use taxes for electric vehicles.
- **Power Distribution Issues** –Provide information for consumers and the public on how problems with electrical power distribution, such as blackouts and brownouts, will be handled as electric vehicles proliferate (off-peak hour charging requirements).

Emergency Responders

- **Facilitate Permitting and Inspection Process** – Promote dialogue, training and education with inspectors and enforcers, engage key constituents including IAEI (International Association of Electrical Inspectors), NRTLs (Nationally Recognized Testing Laboratories), state/local licensing boards, permitting representatives, etc.

b. What is the recommended action plan to address the perceived disparities in technical coverage?

General

- **Training and Education Dissemination** – Provide better dissemination of training and education materials, through collaboration, based on existing and new standards information.
- **Research** – Promote efforts to facilitate research that will resolve questions and concerns that exist as possible barriers to the implementation of safe electric vehicle technology.
- **On-Going Collaboration** – Promote networking and sharing of credible and accurate information on all technical safety issues.
- **Defining Regulatory Landscape** – Clearly define the standards/regulatory landscape on an on-going basis, e.g., development of ANSI portal on relevant standards for EVs in relation to smart grid interoperability panel.
- **Acknowledging Regulatory Differences** – Maintain awareness that there is disparity in enforcement models for the different standards arenas (i.e. vehicles vs. built infrastructure vs. first responders).

Vehicles

- **Aftermarket vehicles and Vehicle Components** – Consider the development of techniques to handle authorized/endorsed components for aftermarket vehicles and vehicle components. This could be similar to methods and techniques used with listed components found in the built infrastructure.

Built Infrastructure

- **National Electrical Code Requirements** – Provide guidance to an NEC Task group on EVs. Identify key issues in the NEC and facilitate addressing them as soon as possible, e.g. clarifying Level 2 charging need for GFCIs, providing guidance on wiring requirements for Level 2 charging stations, etc
- **Installation Standards** – Facilitate NECA and other written installation guidance for contractors addressing EVs and charging stations.
- **Enforcement Mechanisms** – Utilize existing state and other jurisdictional based enforcement mechanisms that have been proven effective, e.g. transfer of ownership title as an inspection checkpoint.

Emergency Responders

- **Batteries** – Identify current gaps in battery test standards to address other concerns such as bulk transport. Inform fire departments of bulk storage or processing of batteries.

c. What is the single most important message that needs to be expressed by the safety infrastructure on this topic?

- **Collaboration to Support Training and Education** – Training, information, and awareness are essential. Support the development of education and training on all levels, though on-going dialogue, networking and collaboration.
- **Shutdown Methods for Emergency Responders** – Provide standardized approaches for emergency responders to shutdown power, on vehicles and for charging stations. Promote single point, easy to access, universal shut down procedures for on-board vehicle shutdown. Promote similar shutdown approach for de-energizing charging stations from the built infrastructure. Provide methods for confirming safe shutdown. Consider all scenarios requiring shutdown.

5. SUMMARY OBSERVATIONS

This report assembles all the pertinent documentation for the U.S. National Electric Vehicle Safety Standards Summit held in Detroit Michigan on 21-22 October 2010. A key part of the documentation is the synthesis of information gathered during the primary modes of input during the event, i.e., the Day One presentations and associated plenary discussions, and the Day Two Working Groups and associated plenary discussions.

The Summit provided an important venue for the gathering of key individuals, organizations and agencies that, working together, can develop a shared implementation plan to ensure fire and electrical safety standards that impact electric vehicles will not serve as a barrier to their deployment. An overall and significant positive result of the Summit, and worthy of special emphasis, is the networking component. Valuable dialogue has been established between important constituent groups on certain critical issues, and additional dialogue is anticipated across these networking bridges and established points of contact.

A stated purpose of the Summit has been to develop the base elements for an action plan for the safe implementation of electric vehicles, using safety standards as the primary mechanism for this action plan. Specific details that were sought while working toward this action plan include the following:

- Identify the relevant fire and electrical safety codes, standards and specifications which address the safety hazards associated with the widespread implementation of electric vehicles.
- Identify gaps in these codes, standards and specifications (changes/enhancements and/or new standards).
- Identify related gaps in research, training, or communications which stem from OEM safety manual development and deployment.
- Develop the base elements for an action plan for necessary standards development and associated deployment activities to fill these gaps.

These summary observations are the critical piece of the overall summit documentation that addresses the action plan. The information provided in this section has been distilled from the information collected throughout the Summit and preliminarily addressed in other portions of this report. From the beginning it has not been the intent to engage in tasks such as the development of an exhaustive list of relevant codes and standards, but rather to collectively bring to the surface the topics involving one or more constituent groups that need attention. This is especially important considering the on-going proliferation of electric vehicle technology, and the sensitivity to timeliness to ensure that existing (and lack-of) needed safety standards will not serve as a barrier to the deployment of electric vehicles.

The information at the Summit processed from the Working Groups is particularly important for determining next steps and future direction of an action plan. These summary observations

are, in part, a further distillation of the synthesized information provided in section 4 of this report (see Table 5), which has been compiled based on the raw Workgroup results included in their entirety in Annex B. The further refinement offered in these summary observations recognizes the need for an action plan and the common goal of all the attendees to ensure fire and electrical safety standards that impact electric vehicles will not serve as a barrier to their deployment.

A detailed review of the topics discussed throughout the overall Summit highlights the issues most often mentioned by the participants, and which appear to have the highest level of interest for further attention. The information gathered has revealed the key areas where further focused attention is warranted. This is conveniently summarized in Figure 2, Key Areas Indicated by the U.S. National Electric Vehicle Safety Standards Summit.

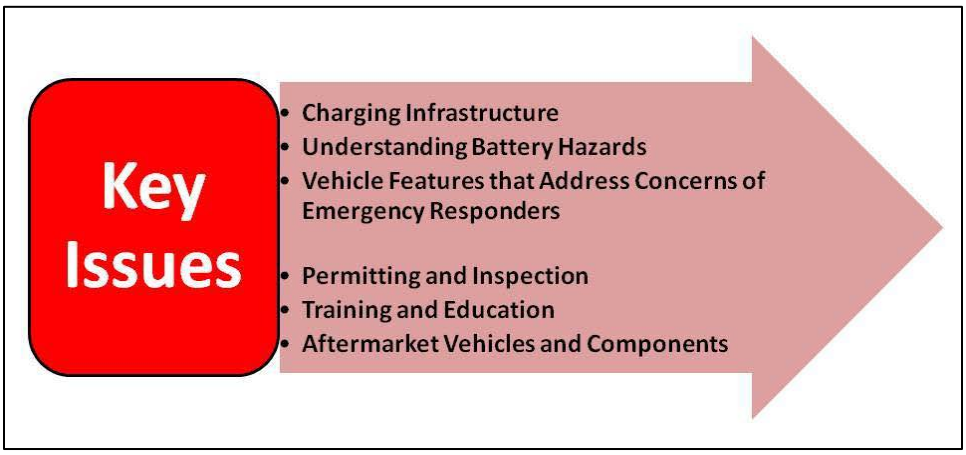

Figure 2: Key Areas Indicated by the U.S. National Electric Vehicle Safety Standards Summit

Table 6 provides a detailed summary of these specific key issues addressed by the Summit Working Groups. These are numbered in Table 6 for sake of reference and are not shown in any particular order of priority. The information in Table 6 is a further distillation of the synthesized information provided in section 4 of this report (see Table 5), which has been compiled based on the raw Workgroup results included in their entirety in Annex B.

Table 6: Specific Key Issues Identified by the Summit Working Groups

1. CHARGING INFRASTRUCTURE

1.1. EV SUPPLY EQUIPMENT (EVSE) LISTING ISSUES

1.1.1. **EV Supply Equipment (EVSE) Listing Issues** – Need to standardize certain characteristics, e.g. color of the EVSE cord, orange, yellow, etc. Some of the current EVSE's are not listed, though when they are listed they tend to be in accordance with the same standard (e.g. UL). EVSEs are considered everything between the charger (on the vehicle) and the building wiring system.

1.1.2. **Connector and Interface Components Standardization** – The need to address the standardization of connectors and interface components in a timely fashion.

1.2. **SPECIFIC ISSUES FOR CONSIDERATION BY THE NEC**

1.2.1. **National Electrical Code Requirements** – Provide guidance to an NEC Task group on EVs. Identify key issues in the NEC and facilitate addressing them as soon as possible, e.g. clarifying Level 2 charging need for GFCIs, providing guidance on wiring quality for Level 2 charging stations, etc

1.2.2. **Circuit Installation** – Verify the load current for chargers, which is mentioned for Level 1 as being 16 amps maximum. This may need a dedicated circuit because it is a continuous load. In addition, other loads on the same circuit may exceed the circuit capacity. Clarify requirements for Level 2 chargers. Circuits rated at 40 amps are not generally available in the garage, but are often available elsewhere in a house, e.g. dryer plug.

1.2.3. **Wiring Installation** – Conventional wiring is okay for Level 1, though Level 2 and 3 requires consideration for additional protection. Continuous duty wiring requires upsizing (i.e., a difference between an EV and a dryer or range)

1.2.4. **Power Quality** – Consider issues such as harmonics and other power quality issues.

1.2.5. **DC Fast Charging** – For Level 3+ type charging arrangements, consider the impact of installations on the vehicle and on the house, e.g. heating, ventilation, compatibility/standardization between chargers and vehicles, etc. Also consider inductive charging methods.

1.2.6. **On-going Maintenance** –Clarify requirements for the on-going maintenance of electric vehicle charging stations, including how vulnerable features will be inspected and replaced such as connectors.

1.2.7. **Installation Standards** – Facilitate NECA and other written installation standards for contractors addressing EVs and charging. .

1.3. **CHARGING STATION CONCERNS FOR EMERGENCY RESPONDERS**

1.3.1. **Break away Emergency Shutdown and Non-Vehicle Emergency Disconnects** – Consider requirements for inherently safe break away emergency shut-down. There is a need for emergency disconnects that are not at the vehicle.

1.3.2. **Charging Station Built-in Fire Protection**– Assess and clarify the need for possible built in fire protection measures at locations with multiple charging stations, if necessary, and comparable to requirements for conventional vehicle re-fueling stations.

1.4. **GRID RELATED ISSUES**

1.4.1. **Electrical Grid**– Consider impact of widespread implementation of electric vehicles, i.e. impact on transformers, overall grid capacity, changing load patterns, system demand, equipment life span, etc. Address interconnectivity in accordance with the NEC and other applicable codes and standards. Consider the impact of smart grid on present and future electrical supply, and its relationship to electric vehicles.

1.4.2. **Power Distribution Issues** –Provide information for consumers and the public on how problems with electrical power distribution, such as blackouts and brownouts, will be handled as electric vehicles proliferate (off-peak hour charging requirements).

1.5. OTHER ISSUES

1.5.1. **Inductive Charging**– Assess the impact of Inductive charging methods, including the biological effects, either while stationary or while driving.

1.5.2. **Large Scale Disasters** – Special considerations are needed for handling certain details following large scale, natural or man-made disasters (e.g. reinstatement prioritization following mass power outage).

1.5.3. **Metering Installation Issues** – Consider impact of special rates and incentives offered by utilities, e.g. installation of separate and/or dedicated service (meter)

1.5.4. **Financial Incentives** – Evaluate approaches for sustaining the EV support infrastructure, e.g. road use taxes for electric vehicles.

2. UNDERSTANDING BATTERY HAZARDS

2.1. GENERAL EMERGENCY RESPONDER CONCERNS

2.1.1. **Battery Issues** – Address safety issues that recognize the complexity of current battery technology, based on the wide range of battery types, configurations, geometries, chemistries, etc… Promote standardized testing, clarify how to handle damaged batteries, provide guidance on storage and handling, etc…

2.1.2. **Extinguishing Agent Types** – Credible information is needed for field use describing the extinguishing agents and methods that should be used for specific types of batteries, for batteries in vehicles and in non-vehicle applications (e.g. bulk storage and similar battery applications) that may require built-in fire protection measures.

2.1.3. **Automatic Shutdown Methods** - Promote inherent built in shut downs features, such as those that are already appearing in certain batteries.

2.2. NON-VEHICLE BATTERY ISSUES

2.2.1. **Battery Manufacturing, Transport and Storage** – Clarify requirements for battery manufacturing, bulk transport, and bulk battery storage, including guidance on the hazard classification, type of built-in fire protection measures, exposure from or in water etc… Establish fire protection requirements Maximum Allowable Quantities required by State Fire Codes and elsewhere, and clarify process for informing fire departments.

2.2.2. **Battery Swapping Facilities** – Clarify fire protection requirements at battery swapping and/or warehousing facilities and the possible risks they pose (e.g. leasing arrangements, BetterPlace.com, etc).

2.2.3. **Battery Farms** – Address the concerns involving battery farms, such as those using second life vehicle components, on both small residential scale and large commercial scale.

3. VEHICLE FEATURES THAT ADDRESS CONCERNS OF EMERGENCY RESPONDERS

3.1. GENERAL PROCESSING ISSUES

3.1.1. **Standardized ERG (Emergency Response Guide) Format** – Provide all emergency response guide information in a consistent, credible, accurate, and realistic format needed by emergency responders. Need standardized information on all EV cut zones for extrication.

3.1.2. **Emergency Responders Standards Involvement** – Promote better communications between first responders and standards developers in both directions.

3.1.3. **Vehicle Components and Alternative Fuels** –Consider the use of components that introduce unusual hazards such as ultra capacitors, and electric vehicles that also use alternative fuels such as hydrogen fuel cells.

3.2. VEHICLE SPECIFIC ISSUES

3.2.1. **Hi-Voltage Cables** – Consider standardization of color coding and routing of high voltage cable in vehicles. Also address cables that are color coded and covered in black covering, and with other than color designation (e.g. patterned)

3.2.2. **Procedures/Location for Vehicle Shutdown** – Consider common procedure and standardized disconnect location in vehicles in an easily accessible location. There is also a need for remote disconnecting means so that there is no risk in disconnecting a burning battery.

3.2.3. **Confirmation/Indicator of Vehicle Shutdown**. Consider common method to confirm vehicle shutdown based on standardized indicators, including verification that vehicle power has been disconnected.

3.2.4. **Battery Emergencies**– Develop consistent and credible recommendations for manual fire protection techniques for handling emergencies involving batteries, including fires,

submersion, etc.

3.2.5. **Effectiveness of Extrication Tools** – Consider composites and materials being used in electric vehicles and other new vehicles that introduce new challenges to emergency responders, such as high strength metal alloys to reduce vehicle weight but are resistant to conventional cutting and extrication tools.

3.3. **VEHICLE INFORMATION AND IDENTIFICATION**

3.3.1. **Vehicle Type Identification** – Consider marking, labeling and badging of vehicle type including the battery technology or type including RFID. Use standardized indicators (badging) that indicates fuel sources, including battery chemistry. Consider vehicle RFID tags that could be detected by first responders and would warn of the presence of an EV.

3.3.2. **Telematics** – Consider standardizing the protocols and data elements for telematics as a way to promote this technology. Promote more integration of telematics with emergency responders, and provide more training on how to use the data received from telematics. Address the improved capabilities needed for communications centers to share telematics data with on-scene emergency responders.

3.3.3. **Identify Bulk Component Hazards** – Clarify the required placarding for the bulk transport of certain vehicle components (e.g. batteries), including the packing/labeling of individual components in the transport system.

4. PERMITTING AND INSPECTION

4.1. **GENERAL ISSUES**

4.1.1. **Facilitate Permitting and Inspection Process** – Promote dialogue, training and education with inspectors and enforcers, engage key constituents including IAEI (International Association of Electrical Inspectors), NRTLs (Nationally Recognized Testing Laboratories), state/local licensing boards, permitting representatives, etc… Consider approaches to streamline, with a goal for a single day process, e.g. educating car dealers on permitting/load issues and having a contractor on retainer, or OEM providing turn-key supply (including upgrading the electrical system in the full cost estimate).

4.1.2. **Inspection Mechanisms** – Utilize existing state and other jurisdictional based inspection mechanisms that have been proven effective, e.g. transfer of ownership title as an inspection checkpoint.

4.1.3. **Installer Qualifications** – Clarify the qualification requirements for the installer of charging stations and/or electric vehicle supply equipment (e.g. new branch circuits), and the need for a licensed electrician depending on state and local jurisdiction.

4.2. **SPECIFIC CONCERNS**

4.2.1. **Damaged Cords and Plugs** – Address on-going inspection needs for shock and fire hazards for highly vulnerable components such as damaged cords and plugs at service stations and from residential cords and plugs. Clarify equipment inspection frequencies.

4.2.2. **Component Hazard Protection** – Consider all potential hazards of vehicle components subject to permitting in buildings, including requirements for manufacturing, recycling and service facilities. Provide fire protection based on MAQs (Maximum Allowable Quantities).

5. TRAINING AND EDUCATION

5.1. **GENERAL TRAINING AND EDUCATION ISSUES**

5.1.1. **Training and Education** – Development of education and training in both directions, based on dialogue, networking and collaboration that continues from this summit. Training, information, and awareness are essential. This should address key safety issues such as shutdown methods for emergency responders. Provide better dissemination of training

and education materials, through collaboration, based on existing and new standards information.

5.1.2. **Non-Passenger Vehicle Applications** – Consideration of issues applicable to motorcycles, all terrain vehicles and neighborhood EVs

5.1.3. **Non-Battery Based Electric Vehicles** – Consider electric vehicles that are not based on storage batteries as their primary source of power, such as hydrogen fuel cell vehicles.

5.2. **CONTENT DEVELOPMENT**

5.2.1. **Standardized Training and Education Process** – Provide a centralized location for critical emergency responder information such as ERGs, to promote standardized training and education information. Continually update this information to add new and revised information as vehicles change.

5.2.2. **Loss and Failure Analysis** – Provide case studies of crash reports and similar emergency events, with statistical summaries and detailed case study analysis.

5.2.3. **Data Collection** – Establish robust data collection protocols, including data recorder methods, telematics, accident reports for multiple uses and venues. Address proprietary and privacy considerations as needed.

5.3. **SPECIFIC EMERGENCY FIRST RESPONDER ISSUES**

5.3.1. **Effectiveness of Extrication Tools** – Consider composites and materials being used in electric vehicles and other new vehicles that introduce new challenges to emergency responders, such as high strength metal alloys to reduce vehicle weight but are resistant to conventional cutting and extrication tools.

5.3.2. **Battery Hazards** – Promote training on technology, including what happens when batteries are overheated, overcharged, or burn. Clarify specific hazards with specific batteries, e.g., there is no lithium hazards associated with lithium-ion batteries.

5.3.3. **Shutdown Procedures** – Promote training on shutdown procedures, including vehicles at charging stations supplied from one or more alternative power sources, (generators, PV, wind, etc), to provide responders with sufficient information to facilitate the disconnection of all sources that supply the vehicle.

5.4. **TRAINING AND EDUCATION FOR OTHERS**

5.4.1. **Vehicle Service Providers** – Address the qualification of mechanics, as well as methods for investigation and other concerns for vehicle insurers.

5.4.2. **Consumer Training** –Provide consumer training for fueling/charging that covers the spectrum of fueling/charging options. Develop training and education information for use in driver's education programs.

6. AFTERMARKET VEHICLES AND COMPONENTS

6.1. **GENERAL AFTERMARKET ISSUES**

6.1.1. **Aftermarket Vehicles and Components** – Address anticipated future hazards from aftermarket vehicles and related components. Consider the development of techniques to handle authorized/endorsed components for aftermarket vehicles and vehicle components, such as methods used in the built infrastructure with listed components.

6.1.2. **Overall Lifetime Product Stewardship** – Promote cradle to grave product stewardship for electric vehicles and all their components both on and off the vehicle.

6.2. **MAINTENANCE AND RE-PURPOSED EQUIPMENT**

6.2.1. **On-going Maintenance** –Clarify requirements for the on-going maintenance of electric vehicles and charging infrastructure.

6.2.2. **Old Batteries** – Address handling and processing of damaged or retired vehicle batteries, including second life of repurposed batteries.

Other additional issues were raised by the Workgroups that were general in nature, and they provide a general supplement to the six key areas of interest highlighted in Figure 2 and detailed in Table 6. These are grouped for consistency as: (1) overall problem scoping; and (2) processing considerations. The following paragraphs elaborate further on these other supplemental areas of interest.

Certain aspects of the Workgroup discussions highlighted multiple points of interest relating to the scoping of the electric vehicle concept. For example, it was pointed out that we need to consider future expansion beyond road-based electric vehicles to aviation, rail, and marine applications. Other interested stakeholders need to be considered such as emergency responders who are not necessarily involved with the initial emergency response (e.g. dispatchers, tow operators, investigators, insurers, electric utilities, etc), as well as consumer representatives, aftermarket installers, etc…

Various processing-related issues were also addressed by the Summit Workgroups, such as clearly defining the standards/regulatory landscape on an on-going basis. Mention was made of the need to facilitate research to resolve questions and concerns that exist as possible barriers to the implementation of safe electric vehicle technology. Despite the focus of the Summit on issues in the United States (as implied by the Summit's title), certain international regulatory concerns were still addressed such as compatibility of all interacting components (e.g. connectors) and the need to not exclude visiting vehicles crossing the borders of countries (e.g. for the United States involving Canada and Mexico).

The primary deliverable from the Summit, and for this report to capture, is to develop the base elements for an action plan for necessary standards development and associated deployment activities to address identified gaps. All the information collected throughout the Summit and documented herein allows us to have a unique perspective for consideration of these base elements.

The further refinement offered in these summary observations recognizes the need for an action plan and the common goal of all the attendees to ensure fire and electrical safety standards that impact electric vehicles will not serve as a barrier to their deployment. Based on a review and synthesis of all the information considered throughout the Summit, further distilled through the discussion from both days of the Summit, and reflected in this report as the progressively refined information in Annex B, Table 5 and Table 6, several critical topic areas emerge that have strong substantiation for further attention. These critical topic areas are summarized in Figure 3, Topics Identified for Action Plan Consideration as a Result of the U.S. National Electric Vehicle Safety Standards Summit, and are:

1) vehicle charging infrastructure;
2) battery hazards identification and protection; and
3) training for emergency responders and enforcement officials.

Figure 3: Topics Identified for Action Plan Consideration as a Result of the U.S. National Electric Vehicle Safety Standards Summit

With these topic areas as a backdrop, additional consideration for an action plan should likewise address the significant positive networking component that has established valuable dialogue between important constituent groups on certain critical issues. This translates to continuing the facilitation of this dialogue on all levels as an important action item resulting from the Summit. Further to this point of maintaining constructive dialogue going forward, planning should be considered immediately for a similar follow-up Summit in the near future, such as next year.

Annex A: Attendees at the U.S. National Electric Vehicle Safety Standards Summit

The following is a summary of the attendees at the "U.S. National Electric Vehicle Safety Standards Summit", held in Detroit, Michigan on 21-22 October 2010.

Table A-1: Attendees at the U.S. National Electric Vehicle Safety Standards Summit

Last Name	First Name	Organization
Almand	Kathleen	FPRF
Alsip	Robert	American Suzuki Motor Corp
Baker	George	OnStarLLC
Bhatia	Joe	American National Standards Institute
Blake	Cal	
Bloom	Michael	US General Services Administration
Bohn	Theodore	Argonne National Laboratory
Boyce	Ken	Underwriters Laboratories Inc
Brierton	Michael	Momentive Performance Materials
Brown	Stephen	Canadian Standards Association
Brunson	Judy	Mercedes-Benz R&D NA Inc
Burke	George	Madison Area Technical College
Burke	William	NFPA
Byczek	Rich	Intertek
Cammisa	Michael	Association of Intl Auto Manufacturers
Carroll	James	Connecticut Fire Academy
Casey	Colin	Navistar
Clancy	Edward	Mitsubishi Motors R&D of America Inc
Coffee	Jeffrey	Remy Inc
Cooper	Dave	Southwire Company
Cregar	Rich	Wake Technical Community College
Cunningham	Andrew	Volkswagen Group of America Inc
Cunningham	John	Nova Scotia Firefighter's School
Davis	Eric	Detroit Fire Department, Fire Marshal Division
Dawson	Matt	Magna Electronics
Dombrowski	Lee	BASF
Dubay	Chris	NFPA
Earley	Mark	NFPA
Emery	Jason	Waterbury FD (Emergency Training Solutions)
Farr	Ronald	Michigan Bureau Of Fire Services
Fee	Patrick	US General Services Administration
Fietzek	Cliff	BMW
Florence	Laurie	Underwriters Laboratories Inc
Frank	Randy	Randy Frank & Associates Ltd.
Frank	John	XL Global Asset Protection Serv. LLP

Last Name	First Name	Organization
Galyen	Robert	Magna International
George	Thomas	Tokio Marine Management
Gloddeck	Alfred	Nissan Motor Corp USA
Gopal	Madan	Tesla Motors
Grant	Casey	FPRF
Hamdan	Mazen	Arvin Meritor
Hendricks	Bob	Lexington Div of Fire & Emergency Services
Hildebrandt	Timothy	Chrysler LLC
Hittel	Mike	General Motors LLC
Ho	Li-Pen	GM Engineering Center
Hoemer	Beverly	SAE International
Hoemer	Rich	SAE International
Hubbard	Tim	Intertek
Johnson	Jeff	IAFC, and Tualatin Valley Fire & Rescue (Ret.)
Jongkind	James	American Honda Motor Co Inc
Kent	Rex	Sinclair Community College
Kilgore	Leslie	General Motors Global Purchasing
Klobuchar	John	XL Global Asset Protection Serv. LLP
Klock	Andrew	NFPA
Ledbetter	Kelly	EnerDel Inc
LeDuc	Marc	SAE International
Leicht	R.	Delaware Office of State Fire Marshal
Lenkeit	John	Dynamic Research Inc
London	Matt	Nissan North America Inc
Maguire	Patrick	Ford Motor Co
Manche	Alan	Schneider Electric
McCabe	James	American National Standards Institute
McCoy	David	Mercury Marine
McKenna	Larry	USFA
McMahon	Peter	NFPA
McVay	Malcolm	Aero Vironment Inc
McCormick	Cathy	OnStarLLC
Mercier	Charles	Southwire Company
Miller	Russ	US General Services Administration
Minter	Jeff	Madison Area Technical College
Moldoveanu	Andrei	NEMA
Momeni	Massoud	Toyota Motor Engineering & Mfg NA Inc
Nida	Nick	Mercury Marine
O'Brien	Michael	Michigan Bureau Of Fire Services
Olance	Mark	NAFTC
Onishi	Hirofumi	Alpine Electronics of America Inc
Osoro	Kerman	CIE Automotive
Parisi	Joseph	Ford Motor Co
Patwardhan	Satyajit	Green DOT Racing Inc

Last Name	First Name	Organization
Prettenhofer	Dave	A and D Technology Inc
Philion	Scott	Toyota Tsusho America
Pokrzywa	Jack	SAE International
Rege	Julia	Hyundai & Kia Corp
Ressler	Galen	General Motors LLC
Rock	Brian	Hubbell Inc
Rosamond	Al	NVFC and TN Fire Chiefs Association
Sato	Doug	Toyota
Sawyer	Steven	NFPA
Schomaker	Joe	Cooper Bussmann
Sprague	Stuart	Tesla Motors
Tabaddor	Priya	Underwriters Laboratories Inc
Talka	Donald	Underwriters Laboratories Inc
Thompson	Joseph	Nissan Technical Center NA Inc
Tyler	Bayly	Con Edison
VanLingen	Richard	Magna Electronics
Vitrano	Paul	Motorcycle Industry Council Inc
Wenzel	Kenneth	Chrysler Group LLC
White	Danny	Purdue University
Williams	David	Delta Township, MI
Wishart	Jeff	ECOtality Inc

Annex B: Workgroup Responses to Structured Questions

Each of the three Workgroup that met on Day Two had its own baseline theme. This assigned baseline theme was intended to be the priority subject for a particular group, and their priority to be addressed first. However, they were not excluded from addressing the other themes as time permitted. The themes assigned to Workgroup were:

- Workgroup One: Vehicles
- Workgroup Two: Built Infrastructure
- Workgroup Three: Emergency Responders

The structured questions addressed on Day Two of the Summit were separated into the following three basic categories: current practice; future trends; and other issues. Tables B-1 through B-3 provide an individual summary of the responses from each Workgroup to the structured questions

Table B-1: Summary of Workgroup One (Vehicles) to Structured Questions

1) Current Practice
   a. What are the prioritized safety issues for standards to address (e.g. vehicle electrical cable color coding, extinguishing battery fires, charging station disconnects, etc)?
      - Cables that are color coded and covered in black covering, and with other than color designation (e.g. patterned)
      - Marking, labeling and badging of vehicle type including the battery technology or type including RFID
      - Catalog of applicable referenced standards to address emergency events
      - Establishing realistic performance parameters for emergency response
      - Establish communication between first responders and standards developers in both directions
      - Consideration of aftermarket use of vehicles and vehicle components including second life of repurposed batteries
      - Common procedure / location for vehicle shutdown
      - Common confirmation / indicator of vehicle shutdown
      - Communication of information regarding connector standardization activity e.g. SAE J1772

   b. What are the perceived disparities in technical coverage for existing safety standards (e.g. extrication with vehicles using high strength alloys, charging station hazards, etc)?
      - Better dissemination and education, through collaboration, of existing standards information
      - After market vehicles and related components
      - Disparity in enforcement models for different standards arenas (i.e. vehicles vs. built infrastructure vs. first responders)

   c. Are there existing standards on this topic that are not being fully utilized or implemented (e.g. outside North America, etc)?

- Domestic vs. international standards disparities including consideration of visiting vehicles
- Consideration of DOD standards

2) Future Trends
   a. Based on current technological trends, what are the prioritized anticipated future hazards (e.g. batteries, charging stations, vehicle shut-downs, high strength alloys, component bulk storage, etc)?
      - Global supply base of batteries and components to maintain safety, quality and reliability
      - Battery swapping / warehousing posing increased risk (e.g. BetterPlace.com, leasing arrangements)
      - Special considerations in large scale, natural disasters (e.g. mass power outage and reinstatement prioritization)
      - Battery farms including second life vehicle components, small residential scale and large scale
      - Emergency events involving EVs while charging

   b. Based on current technological trends, what are the prioritized anticipated future enhancements to safety (e.g. vehicle telematics, emergency responder training, etc)?
      - Placarding of bulk transport of vehicle components, including the packing / labeling of individual components in the transport system
      - Handling / processing of damaged / retired batteries
      - Cradle to grave product stewardship

   c. What new standards are needed to address this topic in 5 years? 10 years (e.g. emergency responder data information exchange, etc)?
      - Consideration of issues applicable to motorcycles, all terrain vehicles and neighborhood EVs
      - Expansion beyond road vehicles to aviation and marine industries
      - Hydrogen fuel cell codes and standards
      - Inductive charging while driving or stationary (e.g. biological effects)
      - Built in fire protection measures for charging locations
      - Standardizing protocols and data elements for telematics

   d. What new research is needed to support existing and new standards (e.g. research supporting new fire test methods, etc)?
      - Fire protection measures for vehicle component storage i.e. batteries

   e. What constituent groups and/or organizations need to be involved (e.g. tow operators, fire investigators, etc)?
      - Inclusion of all model building code groups e.g. International Code Council

3) Other Issues
   a. Other than standards, what other methods, programs and mechanisms should be considered to promote electric vehicle safety?
      - Proactive approaches to instituting needed standards, codes and regulations

- Robust data collection activity including data recorder, telematics, accident reports for multiple uses and venues; privacy considerations need to be addressed

b. What is the recommended action plan to address the perceived disparities in technical coverage?
   - Better dissemination and education, through collaboration, of existing standards information
     - Defining the standards / regulatory landscape, e.g., development of ANSI portal on relevant standards for EVs in relation to smart grid interoperability panel
     - Sharing of credible and accurate information regarding technical suitability
   - Disparity in enforcement models for different standards arenas (i.e. vehicles vs. built infrastructure vs. first responders)
     - Use of authorized / endorsed components for after market vehicles (e.g. similar to listed components in built infrastructure) and built infrastructure with focus on key applicable safety concerns
     - Utilizing state and other jurisdictional based enforcement mechanisms
       - Transfer of ownership title as an inspection checkpoint

c. What is the single most important message that needs to be expressed by the safety infrastructure on this topic?
   - Development of education and training in both directions, based on dialogue, networking and collaboration that continues from this summit.

Table B-2: Summary of Workgroup Two (Built Infrastructure) to Structured Questions

1) Current Practice
   a. What are the prioritized safety issues for standards to address (e.g. vehicle electrical cable color coding, extinguishing battery fires, charging station disconnects, etc)?
      - EV Supply Equipment (EVSE) Listing Issues - Some of the current EVSE's are not listed. EVSEs are considered everything between the charger (on the vehicle) and the building wiring system.
      - EV Supply Equipment (EVSE) Listing Issues – Need to standardize certain characteristics, e.g. color of the EVSE cord, orange, yellow, etc
      - Installation issues – Consider integrity of fire rated wall for panel board
      - Battery Storage – Clarify specific hazards with specific batteries, e.g., there is no lithium hazards associated with lithium-ion batteries

   b. What are the perceived disparities in technical coverage for existing safety standards (e.g. extrication with vehicles using high strength alloys, charging station hazards, etc)?
      - Charger Installation Standards – Need to address details such as leakage of current, tolerances, etc
      - Circuit Installation – Verify the load current for chargers, which is mentioned for Level 1 as being 16 amps maximum. This may need a dedicated circuit because it is a continuous load. In addition, other loads on the same circuit may exceed the circuit capacity. This circuit may also require GFCI protection.

- Circuit Installation – Clarify requirements for Level 2 chargers. Circuits rated at 40 amps are not generally available in the garage, but are often available elsewhere in a house, e.g. dryer plug. GFCI protection is not required for level 2, and this needs to be further addressed.
- Wiring Installation – Conventional wiring is okay for Level 1, though Level 2 and 3 requires consideration for additional protection. Continuous duty wiring requires upsizing (i.e., a difference between an EV and a dryer or range)
- Permitting - Installer of EVSE (new branch circuit) may not be a licensed electrician, depending on state and local jurisdiction
- Permitting/Inspection – Consider approaches to streamline, with a goal for a single day process, e.g. educating car dealers on permitting/load issues and having a contractor on retainer, or OEM providing turn-key supply (including upgrading the electrical system in the full cost estimate)
- Battery Storage – Need to address multiple issues with batteries that recognizes their complexity (there is not uniform battery chemistry, geometry, etc), e.g. promote standardized testing, clarify how to handle damaged batteries, provide guidance on storage and handling, etc

c. Are there existing standards on this topic that are not being fully utilized or implemented (e.g. outside North America, etc)?
   - Installation - DC Fast Charging raises questions about interaction of certain standards, e.g. JARI connector with UL 2202
   - Impact on Grid – Further attention is needed to clarify the sharing of capacity within a neighborhood, i.e. transformers,
   - Grid Connection - IEEE working group on Smart Grid, e.g. P2030, dealing with enabling, interconnectivity, etc… EPRI, IWC group along with OEMs and utilities are involved with this effort.

2) <u>Future Issues</u>

a. Based on current technological trends, what are the prioritized anticipated future hazards (e.g. batteries, charging stations, vehicle shut-downs, high strength alloys, component bulk storage, etc)?
   - Power Quality Issues Harmonics and other power quality issues need to be explored.
   - Battery Storage – Need to consider exposure fires, as well as electrical hazards due to exposure from or in water.
   - DC Fast Charging – Consider the impact of installations on the vehicle and and on the house, e.g. heating, ventilation, compatibility/standardization between chargers and vehicles, etc
   - Battery Swapping – Evaluate to determine if this is the way of choice

b. Based on current technological trends, what are the prioritized anticipated future enhancements to safety (e.g. vehicle telematics, emergency responder training, etc)?
   - Emergency Events - Consider built in shut downs features that are already appearing in batteries

- Global connector compatibility

c. What new standards are needed to address this topic in 5 years? 10 years (e.g. emergency responder data information exchange, etc)?
   - Vehicle – qualification of mechanics; methods for investigation and other concerns for vehicle insurers
   - Telematics – standardization of data elements
   - Battery Storage – Clarify requirements via research for bulk battery storage, including guidance on the hazard classification, type of built-in fire protection measures required, etc
   - Battery Manufacturing – Provide research to address hazards and other concerns, similar to need to address storage issues
   - Connector Standardization – Address in a timely fashion
   - Future Grid Issues – Consider impact of widespread implementation of electric vehicles, i.e. impact on transformers, overall grid capacity, changing load patterns, system demand, equipment life span, etc

d. What new research is needed to support existing and new standards (e.g. research supporting new fire test methods, etc)?
   - Smart Grid – Addressing interconnectivity in accordance with the NEC

e. What constituent groups and/or organizations need to be involved (e.g. tow operators, fire investigators, etc)?
   - Maintenance workforce credentialing for equipment, e.g. service technicians
   - Construction worker training on charging stations
   - Training for electrical inspectors

3) <u>Other Issues</u>

a. Other than standards, what other methods, programs and mechanisms should be considered to promote electric vehicle safety?
   - Metering Installation Issues – Consider special rates and incentives offered by utilities, e.g. installation of separate and/or dedicated service (meter)
   - Financial Incentives – Evaluate approaches for promoting the EV support infrastructure, e.g. road use taxes for electric vehicles
   - Facilitate Permitting Process – Promote dialogue, training and education with inspectors and enforcers, engage key constituents including IAEI (International Association of Electrical Inspectors), NRTLs (Nationally Recognized Testing Laboratories), state/local licensing boards, permitting representatives, etc

b. What is the recommended action plan to address the perceived disparities in technical coverage?
   - NEC Task group on EVs – Identify key issues in the NEC and facilitate addressing them as soon as possible, e.g. clarifying Level 2 charging needs, providing guidance on wiring quality for Level 2 charging stations, etc
   - NECA Standards – Facilitate written installation guide for contractors addressing EVs
   - Batteries – Identify current gaps in battery test standards to address other concerns such as bulk transport. Inform fire departments of bulk storage or processing of

batteries.

c. What is the single most important message that needs to be expressed by the safety infrastructure on this topic?
   - Shutdown Methods for Emergency Responders – Provide standardized approaches for emergency responders to shutdown power, on vehicles and for charging stations. Promote single point, easy to access, universal shut down procedures for on-board vehicle shutdown. Promote similar shutdown approach for de-energizing charging stations from the built infrastructure. Provide methods for confirming safe shutdown. Consider all scenarios requiring shutdown, e.g. crash involving a parked EV being charged. Consider breakaway connections for charging, e.g. UL 2251.

Table B-3: Summary of Workgroup Three (Emergency Responder) to Structured Questions

1) Current Practice

a. What are the prioritized safety issues for standards to address (e.g. vehicle electrical cable color coding, extinguishing battery fires, charging station disconnects, etc)?
   - Primary hazard concerns are fire, explosion, smoke, and electricity
   - Standardized indicators (badging) that indicates fuel sources, including battery chemistry.
   - Info for the field that indicates what types of extinguishing agents should be used.
   - Standardization of color coding and routing of high voltage cable in vehicles.
   - One standardized disconnect location in the vehicle in an easily accessible location.
   - There is a need for information on all potential vehicle fire or shock hazards.
   - How do we verify that the vehicle power has been disconnected?
   - There is a need for remote disconnecting means so that there is no risk in disconnecting a burning battery.
   - There is a need for emergency disconnects that are not at the vehicle.
   - There are potential dangers in after-market modifications.
   - Vehicle RFID tags could be detected by first responders that would warn of the presence of an EV.
   - Need training on technology, including what happens when batteries are overheated, overcharged, or they burn.
   - Need training on how to deal with vehicles that are immersed in water (fresh and salt water).
   - Where vehicles are supplied from one or more alternative power sources,(generators, PV, wind, etc.) training is needed to provide responders with sufficient information to facilitate the disconnection of all sources that supply the vehicle.
   - What are the requirements for manufacturing, recycling and service facilities (MAQ protection features)?
   - Standardized format ERG.
   - Standard format on steps to take at the scene of an incident.
   - Need information on all EV cut zones for extrication (standardization).

b. What are the perceived disparities in technical coverage for existing safety standards

(e.g. extrication with vehicles using high strength alloys, charging station hazards, etc)?

- Some issues addressed above.
- Most cutting and extrication tools are ineffective on new high-strength alloys and composite.
- Shock and fire hazards from damaged cords and plugs at service stations and from owner cords and plugs at home. There are no inspection frequencies.
- Break away emergency shut-down requirements.

c. Are there existing standards on this topic that are not being fully utilized or implemented (e.g. outside North America, etc)?

- There are some ISO and IEC, as well as CEN and CENNELEC standards related to electric vehicles. We are not sure which ones may be applicable. There may be some harmonization potentials.

2) Future Trends

a. Based on current technological trends, what are the prioritized anticipated future hazards (e.g. batteries, charging stations, vehicle shut-downs, high strength alloys, component bulk storage, etc)?

- Use of ultra capacitors.
- Use of fuels such as hydrogen.
- Level 3+ charging. (heat, humidity, electric shock, arc flash, etc.)
- Inductive charging.
- Battery reuse.
- Level 3 chargers in residential garages.
- The 12 volt battery may no longer be necessary in the future.
- Composites and metals
- Battery technology and chemistry.
- Smaller, more compact cars, which could result in smaller cut zones, more integration of electronics, extrication problems, etc.
- It may not be possible to cut through the floor.
- Bigger batteries, longer range, higher voltage.
- Hybrid technologies using alternative fuels.

b. Based on current technological trends, what are the prioritized anticipated future enhancements to safety (e.g. vehicle telematics, emergency responder training, etc)?

- More integration of telematics with emergency response. More training on how to use the data received from telematics.
- More capability needed for communications center to push telematics data to responders. Centralized location for data for ERGs.
- More standardized training.
- Better education from top to bottom for first responders and manufacturers.
- Collaboration and feedback between fire service and industry.
- Availability of new cars for training.
- Availability of centralized training course.

c. What new standards are needed to address this topic in 5 years? 10 years (e.g. emergency responder data information exchange, etc)?

- Ongoing safety inspection of vehicles and charging stations.
- Updated standards on storage and handling of batteries as technology evolves.
- Telemetric data standards for pushing info to dispatch centers.

d. What new research is needed to support existing and new standards (e.g. research supporting new fire test methods, etc)?
   - The manufacture and storage of batteries (fire protection MAQs)
   - Case studies of accident reports with detailed analysis.

e. What constituent groups and/or organizations need to be involved (e.g. tow operators, fire investigators, etc)?
   - Tow operators, including dispatchers.
   - AAA
   - EV industry
   - After-market installers (Best Buy, etc)
   - EMS organization
   - Fire service
   - IIHS
   - Service station operators
   - Repair facilities
   - OSHA
   - Electric utilities
   - Electrical contractors
   - Electrical inspectors and building officials
   - All trainers
   - Consumer

3) <u>Other Issues</u>

a. Other than standards, what other methods, programs and mechanisms should be considered to promote electric vehicle safety?
   - Some testing mechanism be developed to ensure that vehicle is safe.
   - Consumer training for fueling/charging for the spectrum of fueling/charging options.
   - Driver's education program training.
   - Blackout/brownout problems.

b. What is the recommended action plan to address the perceived disparities in technical coverage?
   - Collaboration and feedback (industry/fire service)
   - Research
   - Training

c. What is the single most important message that needs to be expressed by the safety infrastructure on this topic?
   - Training, information, and awareness are essential.

Annex C: Summary of Day One Presentations

The following speakers made presentation during Day One of the Summit:

Keynote Presentation

- "Driving the Safe and Effective Implementation of Electric Vehicles: Standards and Conformance-Based Solutions"; Joe Bhatia, President and CEO, ANSI

Session One: Vehicles

- "Battery and Labeling Standards"; Bob Galyen, Magna e-car
- "Hybrid/Electric Vehicle Battery Safety Standards"; Galen Ressler, General Motors LLC
- "Vehicle Standards Update: Hybrid Safety"; Ted Bohn, Argonne National Laboratory
- "NHTSA Safety Research Plan for RESS Equipped Vehicles"; Phillip Gorney, NHTSA

Session Two: Built Infrastructure

- "Current State of Codes and Electric Vehicle Infrastructure"; Mike Hittel, General Motors LLC
- "Standardization of Charging Support Equipment"; Kenneth Boyce, Underwriters Laboratories

Session Three: Emergency Responders

- "Fire Fighting, Rescue, and Incident Command"; Jeff Johnson, CEO of Western Fire Chiefs Association and IAFC Past President
- "Vehicle Fire and Technical Rescue"; Jeff Minter and George Burke, Madison Area Technical College, Wisconsin
- "The Enforcement Infrastructure: In Support of Electric Vehicles and Similar Alternative Energy Transportation"; Ron Farr, State Fire Marshal, Michigan

Session Four: Others

- "Owner/Operator Infrastructure Issues for Fleet Vehicles"; Patrick Fee, General Services Administration
- "Property Insurance Loss Prevention Concerns"; John Frank, XL Gaps
- "9-1-1 Connectivity: Electric Vehicle Rescues"; Cathy McCormick, OnStar

All except two of the Day One speakers (Bhatia and Johnson) used PowerPoint presentations, and those that have been made available for this report are included in this Annex on the following pages.

U.S. National Electric Vehicle Standards Summit

Hosted by SAE International and National Fire Protection Association

October 21-22, 2010

Vehicle Standards Update: Battery and Labeling Standards

Robert L. Galyen, Chairman
SAE International Battery Standards Committee

Introduction

- Electrification of automobiles touch all aspects of the First Responders whether it be on the highway, home or manufacturing plants of the products used in the vehicles
- Standardization should cover all aspects of the pack, battery or module and the cell, and the interfaces to various types of vehicles
- Today we will focus on Safety and Labeling with a quick review of the other Task Force activities

Standardization Has Come a Long Way and Still Has a Long Way to Go

- Stricter fuel economy and emissions regulations are driving higher electrical energy and power levels, which require new requirements
- Various alternative drive-train applications (EV/P-HEV/HEV) and market segments (Auto/Truck/Bus) make standardization difficult to achieve

Charging the electric car | 100th Anniversary of First US Hybrid Car Patent by German inventor Henri Pieper | Thomas Edison with electric car in 1913

Difficulties in Developing Global Standards

1. Concern over loss of intellectual property for the members company
2. Professional pride or bias to a specific thought process
3. Reluctance to take a position on a specific issue
4. Cultural differences of opinion from various geographic regions
5. The standardization efforts are lagging the commercialization of new products

Committee Composition and Goals

- The Battery Standards Committee represents a wide cross section of transportation industry professionals
- There are ~100 companies represented with 11 Task Force Work Groups consisting of ~150 members
- Goal of safe, durable and cost effective electrified traction mobility

Scope

- The Battery Standards Committee reports to the Motor Vehicle Council.
- The Committee is responsible for developing and maintaining SAE Standards, Recommended Practices, and Information Reports related to the field of vehicle battery technology, including both starter and traction batteries.
- Standardization should cover all aspects of the pack, battery or module and the cell, and the interfaces to various types of vehicles
- Particular emphasis is currently being placed on advanced Hybrid and Electric Vehicle traction batteries.

SAE Battery Standards Committee

Task Force Work Groups

- Battery Safety
- Battery Labeling
- Battery Transportation
- Hybrid Battery Testing
- Electronic Battery Fuel Gauge
- Standardization
- Truck and Bus Battery
- Starter Battery
- Advanced Battery Concepts
- LEV's (Golf)
- Battery Recycling

Battery Safety Task Force

- Chairman - Galen Ressler, General Motors
- J2929 Electric and Hybrid Vehicle Propulsion Battery System Safety Standard – in balloting now!
- Being presented next on agenda

Battery Transportation Task Force

- Chairman: Tom Delucia of A123
- J2950 Recommended Practices for Transportation and Handling of Automotive-type Rechargeable Energy Storage Systems
- Scope: Covers identification, handling, and shipping of un-installed Rechargeable Energy Storage Systems

Hybrid Battery Testing Task Force

- Chairman: Richard Howlett of Nilar Battery Company
- Documents:
  - J1798 Performance Rating of Electric Vehicle Battery Modules
  - J2288-Life Cycle Testing of Electric Vehicle Battery Modules
  - J2758-Determination of the Maximum Available Power from a Rechargeable Energy Storage System on a Hybrid Electric Vehicle
  - J2289-Electric-Drive Battery Pack System: Functional Guidelines
- Scope:
  - Publish new or update existing SAE Standards
  - Identify existing standards that meet functional testing required and identify missing testing standards

Electronics Battery Fuel Gauge Task Force

- Chairman: Dr. Kurt Salloux of Global EI
- J2946 Battery Electronic Fuel Gauging Recommended Practices
- Scope: This document covers the recommended practices associated with reporting the vehicle's (hybrid and pure electric) battery pack performance details to the automobile user

Standardization Task Force

- Chairman: Richard Marks of Environmental Transportation Solutions
- Revision of J1797 for Packaging of Electric Vehicle Battery Modules
- Scope: Provides for common battery designs through the description of dimensions, termination, retention, venting system, and other features

Truck and Bus Battery Task Force

- Chairman: Greg Fritz of Magna E-Car Systems
- Utilizing existing SAE Battery Standards and developing new if necessary
- Scope: Informational Task Force created to ensure that the specific requirements of the Truck and Bus Industry are included in the ongoing activities by the Battery Standards Committee

Starter Battery Task Force

- Chairman: Robert Gruenstern of Johnson Controls Incorporated
- 2 documents under revision
  - J537 Storage Batteries
  - J2185 Life Test for Heavy Duty Storage Batteries
- Scope: Upgrade or create documents specific to the starting or cranking industry segment.

Advanced Battery Concepts Task Force

- Chairman: Dr. Anna Marie Sastry of University of Michigan
- No document at this time
- Scope: This is a new Task Force
- Special note: Investigate new technologies which require further standards development

LEV's and Golf Cars

- Chairman: Anthony Williams of EZGO Division of Textron
- Newly formed Task Force. First meeting next week.
- Scope: Develop energy storage standards relative to light electric vehicles and golf cars.

Battery Recycling Task Force

- Chairman: Dr. Tim Ellis of RSR Technologies
- No documents at this time
- Scope: New Task Force
- Special Note: The role of this task force is to investigate and inform the Committee on recycling technologies

Battery Labeling Task Force

- Chairman: Mark McGory, Jamac Label Co.
- J2936 Vehicle Battery Labeling Guidelines
- Scope: Provides labeling guidelines at all levels; component, sub-component, subsystem and system-level architectures

Transportation Sector

- Automobile
- Heavy truck & bus
- Rail
- Off road
- Agriculture

The New Normal

Petroleum

Electric

Symbols/Icons and Text

Poison/Danger

Corrosive!

Explosion Hazard

Electrocution/Shock

Attention!

Means of Identification?

- 1FMYU59H35WA00001
- VIN Positions 5,6, & 7 used to identify the vehicle line:
- Escape Hybrid AWD

Blue area denotes 'cut zone'

mj@jamac.com

Mark McGory
President

419-625-9790 ext 223

Summary

- The Battery Standards Committee leads the way in standardization for batteries which will play a predominate roll in transportation of the future
- It will take a concerted effort of science, engineering, policy, testing and validation to assure the battery systems of the transportation sector meet performance, life and safety expectations of the general consumer and first responders

Contact Information

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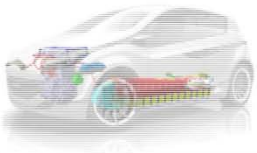


Hybrid/Electric Vehicle Battery Safety Standards

October 21, 2010
Galen E. Ressler, General Motors Company

U.S. National Electric Vehicles Safety Standards Summit
Developing an Action Plan for the Safe Implementation of Electric Vehicles

Purpose

- Provide an overview of the existing and planned battery safety standards and regulations applicable to hybrid and electric vehicles.
- Allow workshop participants to assess existing and planned standards and identify industry safety improvement needs for future hybrid and electric vehicles.

SAE International

National Fire Protection Association
The authority on fire, electrical, and building safety

Outline

- Background
- Automotive regulations
  - US FMVSS 305
  - DOT / UN transportation requirements
- Automotive standards
  - SAE
  - UL
  - ISO / IEC
- Conclusions

Background

Hybrid and Electric Vehicle Battery Types

- Many configurations and chemistries of batteries
- Lead-acid –
  - Primary current usage for starting/lighting/ignition/accessories
  - Past usage for hybrid and electric vehicles (EV1)

- Nickel-metal-hydride –
  - Current production hybrid batteries are primarily this type
  - Toyota Prius, Chevrolet Tahoe Hybrid, etc.
- Lithium ion/lithium polymer –
  - Current/future hybrid and electric vehicle batteries
  - Chevrolet Volt, Nissan Leaf, MB ML450 Hybrid

Background

Current Regulatory and Industry Standard Organizations

- Federal Motor Vehicle Safety Standards (FMVSS)
- DOT Transportation Regulations
- SAE Technical Reports (Standards, Recommended Practices, Information Reports)
- UL
- ISO / IEC
  - Often form basis for European regulation

Automotive Regulations

NHTSA FMVSS 305

- Post collision integrity requirements
- Initially created when lead acid batteries were primary technology
- Requirements cover:
  - High voltage electrical isolation
  - Battery retention
  - Electrolyte leakage

United States Department of Transportation Transportation Requirements

- Comprehends multiple transportation modes
- Different requirements for different technologies

SAE International® Standards for Lithium Ion Batteries

Existing

- SAE J2464 – Electric and Hybrid Electric Vehicle Rechargeable Energy Storage System (RESS) Safety and Abuse Testing
  - A body of tests which may be used for abuse testing of electric or hybrid electric vehicle Rechargeable Energy Storage Systems
- SAE J2289 - Electric-Drive Battery Pack System: Functional Guidelines
  - A checklist of design considerations for battery packs: mounting, operation, environment, durability, safety, etc.
- SAE J2344 - Guidelines for Electric Vehicle Safety
  - Provides introductory safety guideline information that should be considered when designing electric vehicles for use on public roadways
- SAE J1766 – Recommended Practice for Electric and Hybrid Electric Vehicle Battery Systems Crash Integrity Testing
  - Describes methods for evaluating the vehicle high voltage system performance when subjected to various FMVSS crash test procedures.
  - Similar in scope and content to current FMVSS 305

SAE International® Standards for Lithium Ion Batteries

In Process

- SAE J2929 – Electric and Hybrid Vehicle Propulsion Battery System Safety Standard – Lithium-based Rechargeable Cells
  - When published, will define a set of safety criteria for a lithium-based rechargeable battery system to be considered for use in a vehicle propulsion application.
  - Publication target: January 2011
- SAE J2950 - Recommended Practice for Transportation and Handling of Automotive-type Rechargeable Energy Storage Systems (RESS).
  - When published, will cover the recommended practices associated with identification, handling, and shipping of un-installed RESSs to/from specified locations (types) required for the appropriate disposition of new and **used** items.
  - Publication target: 1st quarter 2011

Underwriters Laboratories Standards for Lithium Ion Batteries

Existing

- UL 1642 – Lithium Batteries
  - Developed to reduce the risk of fire or explosion when lithium batteries are used in a product or are removed from a product and discarded.
  - Small format cells (<5 g metallic lithium)
- UL 2054 – Household and Commercial Batteries
  - Developed to reduce the risk of fire or explosion when lithium batteries are used in a product or are removed from a product and discarded.
  - Not lithium-ion specific

Underwriters Laboratories Standards for Lithium Ion Batteries

In Process

- UL 2580 – Batteries for Use in Electric Vehicles
  - When published, these requirements will cover nickel, lithium ion, and lithium ion polymer cells, cell modules, and battery packs for use in battery-powered vehicles. Requirements developed to evaluate the cells, cell modules, and battery pack's ability to safely withstand simulated abuse conditions.
  - Publication target: 3rd quarter 2011

ISO International Organization for Standardization / IEC Standards for Lithium Ion Batteries

Existing

- ISO 6469-1 – Electrically propelled road vehicles — Safety specifications — Part 1: On-board rechargeable energy storage system (RESS)
  - Sets standards for the on-board rechargeable energy storage systems (RESS) of electrically propelled road vehicles for the stated protection of persons inside and outside the vehicle and the vehicle environment

ISO International Organization for Standardization / IEC Standards for Lithium Ion Batteries

In Process

- ISO 12405-1,2 – Electrically propelled road vehicles -- Test specification for lithium-ion traction battery systems --
  - Includes standards for over-charge and over-discharge control
  - Part 1: High power applications - Publication target: 1st quarter 2012
  - Part 2: High energy applications - Publication target: Unknown
- IEC 62660-2 – Secondary lithium-ion cells for the propulsion of electric road vehicles - Part 2: Reliability and abuse testing
  - Publication target: 1st quarter 2011

Conclusions

- By mid-2011, published voluntary standards intended to address safety considerations for electric vehicle batteries
- Regulations may be revised to address the continuing evolution of future technologies

Argonne

U.S. National Electric Vehicle Safety Standards Summit

Vehicle Standards Update
Hybrid Safety

Theodore Peter Bohn, Argonne National Laboratory.

U.S. National Electric Vehicles Safety Standards Summit

Thursday, October 21

SAE International

ENERGY

Some Safety Related Facts:
Design, Development and Lab Practices Matter

- NFPA 70E article 110.8b requires hazard analysis for any circuits over 50v. Yet there are many electrical accidents that happen each year.

FACTS

- There are approximately 30,000 electrical shock accidents every year.
- Over 3600 disabling electrical contact injuries occur annually.
- Over 2000 workers are sent to burn centers each year with severe Arc-Flash burns.
- Over 1000 electrical workers die each year from workplace accidents.
- 60% of workplace accident deaths are caused by burn injuries.
- Electrocutions are the 4th leading cause of traumatic occupational fatalities.
- Estimates show that 10 Arc-Flash incidents occur every day in the U.S.
- 97% of all electricians have been shocked or injured on the job.
- Medical costs per person can exceed $4 million for severe electrical burns.
- Total costs per electrical incident can exceed $15 million.
- In the year 2002, work injuries cost Americans $146.6 billion.

Historical Perspective- GM Electrovair ~50 Years Ago

- Batteries in front and rear of vehicle, rear drive motor and rear electronics/cooling

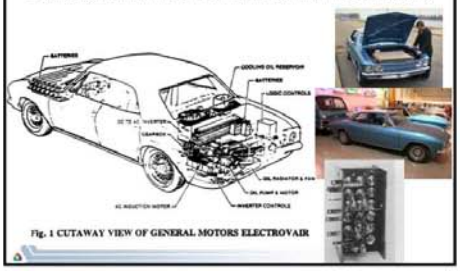
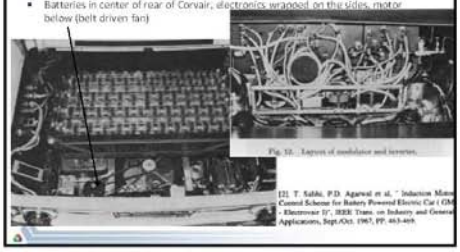


Fig. 1 CUTAWAY VIEW OF GENERAL MOTORS ELECTROVAIR

Electrovair Electronics Packaging
532V Silver Zinc Batteries

- Batteries in center of rear of Corvair, electronics wrapped on the sides, motor below (belt driven fan)

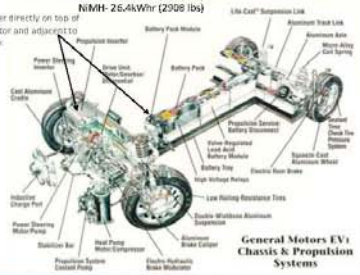


[2] T. Sakhi, P.D. Agarwal et al, " Induction Motor Control Scheme for Battery Powered Electric Car (GM - Electrovair I)", IEEE Trans. on Industry and General Applications, Sept./Oct. 1967, PP. 463-469.

Fast Forward ~ 30 years GM EV-1 Powertrain

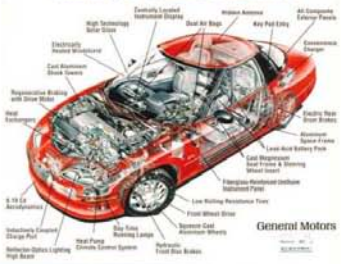
PbA- 16.5kWhr (3086 lbs)
NiMH- 26.4kWhr (2908 lbs)

- Note inverter directly on top of traction motor and adjacent to battery pack



General Motors EV1 Chassis & Propulsion Systems

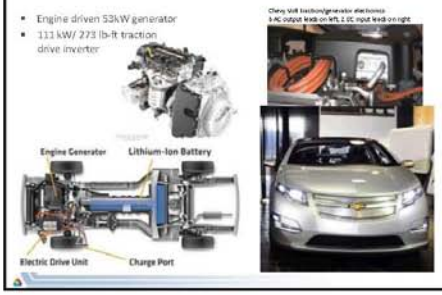
GM EV-1 Vehicle System Packaging-
Diversity of Advanced Materials



General Motors

Fast Forward to 2010: Chevy Volt

- Engine driven 53kW generator
- 111 kW/ 273 lb-ft traction drive inverter



Safety Features and Failure Modes:

Fused Mid-Pack Service Disconnect
Minimizes Exposed Voltages
(1/2 pack voltage)

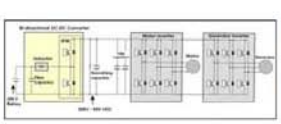
Main battery pack contactor terminals can weld in the closed position, allowing ½ energized system without causing fault detection error.
Some system cycle contactors to detect this.

Power Electronics Packaging

2004 THS-II Prius Inverter (50kW+33kW+21kW)

Boost Converter 21kW
½ bridge IGBT Module

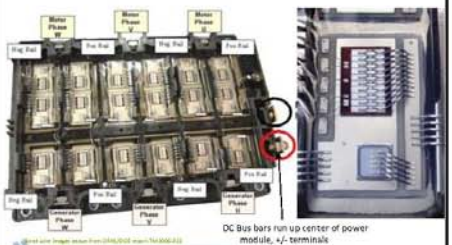
Increasing Power Density Via Increased Cooling Performance and Aggressive Packaging



Design Feature	LS 600h	Hybrid Camry	2004 Prius
DC-dc converter power rating	36.5 kW	30 kW	20 kW
Battery voltage	288 V	244.8 V	201.6 V
Filter capacitor (LV side)	500 Vdc, 370 µF	500 Vdc, 370 µF	600 Vdc, 282 µF
Inductor	329 µH at 1 kHz	212 µH at 1 kHz	373 µH at 1 kHz
Small resistor (HV side)	53.6 kΩ	53.6 kΩ	64.3 kΩ
Small filter capacitor (HV side)	750 Vdc, 0.6 µF 750 Vdc, 1.2 µF	750 Vdc, 0.9 µF	750 Vdc, 0.1 µF
Smoothing capacitor (HV side)	750 Vdc, 2629 µF	750 Vdc, 2098 µF	600 Vdc, 1,130 µF

Power Module Construction, Wire Bonds- Potential Failure Points

- Integrated Power Modules; 2004 Prius (18 IGBTs)



DC Bus bars run up center of power module, +/- terminals

Power Module Construction, Wire Bonds

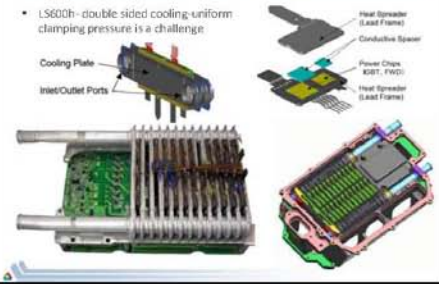
- Integrated Power Modules; 2010 Prius (18 IGBTs)

2010 Prius

Much wider power lead, bond ribbon

IGBT Module Evolution (180kW)- Double Sided Cooling

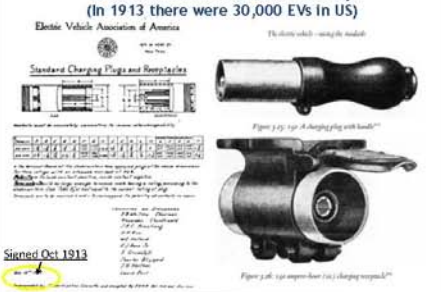
- LS600h- double sided cooling-uniform clamping pressure is a challenge



Inverter Failure Makes for Unhappy Customers

- LS600h- $108k vehicle (inverter removed in this photo-failure conditions unknown to observer)

Some Connector Standards History (In 1913 there were 30,000 EVs in US)



Fast Forward to 1990- 32A coupler for EVs SAE J1772 Conductive Standard

9 pins- Power, interlock, serial data (J1850)
Predates CAN and wireless communication

More Expensive, Galvanic Isolated SAE J1773 Inductive Charge Standard

Hughes MagnaCharge
- Paddle is primary coil,
- Vehicle inlet is secondary side of 'transformer' (52k)

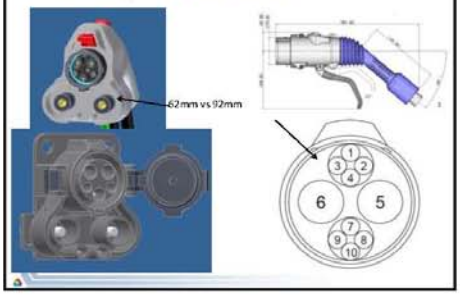
Charge station examples, including SAEJ1773 Inductive Coupler (56k)

Fast Forward Again- 2010 EV Push SAE J1772™- 19.2kVA Single Phase

Contact #	Connector Function	Vehicle Inlet Function	Description
1	AC Power (L1)	Charger 1	Power for AC Level 1 and 2
2	AC Power (L2,N)	Charger 2	Power for AC Level 1 and 2
3	Equipment ground	Chassis ground	Connect EVSE equipment grounding conductor to EV/PHEV chassis ground during charging
4	Control pilot	Control pilot	Primary control conductor (operation described in Section 5)
5	Proximity Detection	Proximity Detection	Allows vehicle to detect presence of charge connector

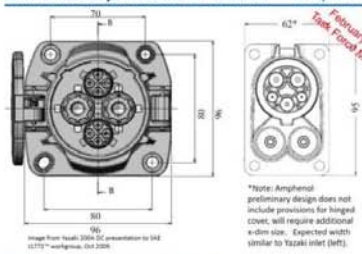
J1772-Focus on Compact, robust- 43mm diameter, 240v/80A

Next Challenge DC Fast Charging
SAE J1772-Hybrid vs JARI-ChAdEMO



Comparison of DC Connector Footprint

JARI 200A compared to 1772™ Combo Amphenol



*Note: Amphenol preliminary design does not include provisions for hinged cover, will require additional x-dim size. Expected width similar to Yazaki inlet (left).

Image from Yazaki 2004 DC presentation to SAE i1772™ workgroup, Oct 2004

JARI/TEPCO 50kW DC Connector, Station

57 Chargers in service in Japan and 1,000 chargers are scheduled to be installed by 2012.

Charger Specifications
- Input: 3-phase 200V
- Maximum DC output power: 50kW
- Maximum DC output voltage: 500V
- Maximum DC output current: 125A

5 minute charge for 40km (25 miles) driving range
10 minute charge for 80km (37 miles) driving range

- Two power; seven control/communication pins
- Two communication pins (typically CAN).
- Two pins for EV relay control.
- One Reference Ground pin for vehicle isolation monitor.
- One proximity or mating detection pin.
- One "ready to charge" pin.

SAE Hybrid Related Standards

- J1711 Recommended Practice for Measuring the Exhaust Emissions and Fuel Economy of Hybrid-Electric Vehicles
- J1715 Hybrid Electric Vehicle (HEV) & Electric Vehicle (EV) Terminology
- J1772 SAE Electric Vehicle and Plug in Hybrid Electric Vehicle Conductive Charge Coupler
- J2344 Guidelines for Electric Vehicle Safety
- J2836/1 Use Cases for Communication between Plug-in Vehicles and the Utility Grid
- J2836/2 Use Cases for Communication between Plug-in Vehicles and the Supply Equipment (EVSE)
- J2836/3 Use Cases for Communication between Plug-in Vehicles and the Utility Grid for Reverse Power Flow
- J2836/4 Use Cases for Diagnostic Communication for Plug-in Vehicles

SAE Hybrid Related Standards

- J2835/5 Use Cases for Communication between Plug-in Vehicles and their customers.
- J2841 Utility Factor Definitions for Plug-In Hybrid Electric Vehicles Using 2001 U.S. DOT National Household Travel Survey Data
- J2847/1 Communication between Plug-in Vehicles and the Utility Grid
- J2847/2 Communication between Plug-in Vehicles and the Supply Equipment (EVSE)
- J2847/3 Communication between Plug-in Vehicles and the Utility Grid for Reverse Power Flow
- J2847/4 Diagnostic Communication for Plug-in Vehicles
- J2847/5 Communication between Plug-in Vehicles and their customers
- J2894 Power Quality Requirements for Plug In Vehicle Chargers - Part 1: Requirements
- J2894/2 Power Quality Requirements for Plug in Vehicle Chargers - Part 2: Test Methods
- J2907 Power rating method for automotive electric propulsion motor and power electronics sub-system
- J2908 Power rating method for hybrid-electric and battery electric vehicle propulsion
- J2931 Electric Vehicle Supply Equipment (EVSE) Communication Model (Physical layer)
- J2953 Electric Vehicle Supply Equipment (EVSE)-PEV Compatibility Verification Reqs.
- J2954 Wireless Charging of Electric and Plug-in Electric Vehicles.

FMVSS 305
ELECTRIC POWERED VEHICLES: ELECTROLYTE SPILLAGE AND ELECTRICAL SHOCK PROTECTION

- Reference

- **Digest**: When and electric vehicle is in a collision the three following requirements are important:
  1) Don't spill electrolyte, especially on occupants.
  2) Battery modules inside the passenger compartment must stay where they are. Ones outside, stay outside.
  3) Maintain electrical isolation from passengers (500Ω/V)

- *I.e. After collision, minimize acid leaving vehicle, no batteries entering or moving in passenger compartment, no shocking the occupants or safety workers.*

Closing Comments:

- Electric Vehicles have been with us for 100+ years, safety standards need to progress with vehicles technology
- Connecting vehicles to the grid enables new safety features, and potential for mayhem.
- New current sensor technologies enable standard 60A load disconnect to be used as low cost compact EVSE sub-meter, as per California state mandated us on EVs.

Original/Stock

The National Highway Traffic Safety Administration

www.nhtsa.gov

Phil Gorney

Vehicle Safety Research
Crashworthiness division

Alternate Fuels – Li-ion Rechargeable Energy Storage Systems

NHTSA Mission …

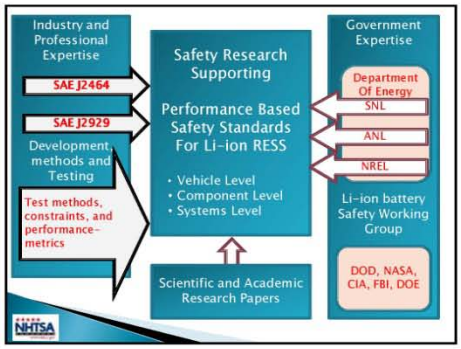
Save lives, prevent injuries and reduce economic costs due to road traffic crashes, through education, research, safety standards and enforcement activity.

NHTSA also conducts research on driver behavior and traffic safety, to develop the most efficient and effective means of bringing about safety improvements.

Research Questions

1) Assuming avoidance and/or containment of thermal runaway conditions in the RESS; what are the safety performance requirements of the RESS as a sub-component of a larger vehicle system when the vehicle is subjected to both normal and abnormal mechanical, electrical, and thermal abuse mechanisms during normal operational use, charging, crash, and post crash events?

2) What are the appropriate methods, boundary conditions and safety-metrics necessary to define test based performance criteria for repeatable and comparable standardization?



Research Plan

1a) Acquire empirically derived performance criteria for statistical or analytical research data
- Develop test methods
- Develop test boundary conditions
- Develop safety performance-metrics

Operational conditions of the vehicle will include:
- Charging
- Normal operation
- Storage
- Crash and post Crash

Origin of fault (based on Industry/Government experience)
- Mechanical
- Electrical
- Thermal

1b) Test vehicles and/or battery packs

Research Plan

1) Two separate contracts will be awarded with an objective to develop and document repeatable vehicle level safety performance tests and methods with accurate boundary and/or limit test conditions for the battery pack and/or vehicle in which the testing should be conducted. In addition, detailed quantifiable measurement, performance criteria, and safety-metrics must be developed and documented which may be used by NHTSA to objectively measure and compare safety performance of a RESS equipped vehicle or component system in their analysis. The safety performance tests and methods will address potential failure modes associated with RESS component failure, control system failure, and/or reaction to potential normal and abnormal abuse conditions and their associated limitations. These failure modes, the most severe of which results in thermal runaway of the battery cells, modules, pack(s), could result in potentially toxic or harmful effluent venting into a vehicle passenger compartment, fire, or explosion. The safety performance and test methods must consider all functional modes of operation including charging, storage, normal operation, and abnormal operation such as crash events. These methods should be considered at vehicle level, when possible, and component level when necessary while documenting the criteria necessitating the differentiation.

Mechanical Abuse Mechanisms

- Mechanical Shock Test (Crash Pulse)
- Vibration
- Drop Test (Service Remove or Install)
- Penetration
- Immersion
- Crush
- Thermal Shock
- Enclosure Integrity
- Humidity/Moisture Exposure

Electrical Abuse Mechanisms

- Short Circuit
- Overcharge
- Over-discharge/ cell reversal

Thermal Abuse Mechanisms

- Fire Resistance
- Propagation Resistance
- Thermal Control

Research Plan (cont.)

2) Failure Modes and Effects Analysis (FMEA)

3) Analytical Model of a RESS Control System

Objective: to structure a generic control system model that allows a predictable and comparative performance basis for fault inputs. This model is to be used to compare OEM control system performance and associable criteria to establish minimal requirements

- FMEA
- FTA Fault Tree Analysis
- Probabilistic Risk Assessment

Current State of Codes and EV Infrastructure

Michael J. Hittel, PE
michael.j.hittel@gm.com

History of EV's – Part 1

- 1832 – first "electric carriage" w/ non-rechargeable batteries
- 1859 – rechargeable lead-acid battery
- 1897 – first large scale production of EV in US
- 1900 – 28% of vehicles produced in US
- 1908 – mass production of ICE's
- 1912 – Invention of electric starter

DECLINE IN EV's….

History of EV's – Part 2

- 1966 - Congressional Bills recommending EV's
- 1976 - Electric and Hybrid Vehicle Research, Development, and Demonstration Act
- 1990 – CARB passes ZEV mandate
- 2007 - Energy Independence and Security Act (EISA)
- 2009 – ARRA and other DOE initiatives

History of EV Standards

- 1991 National Electric Vehicle Infrastructure Working Council (EPRI-IWC)
- 1996 NFPA – NEC introduced installation requirements
- SAE – architectural specifications
- UL – safety standards for listing

CMP 12 Responsibility

- 610: Cranes & Hoists
- 620: Elevators, Dumbwaiters, Escalators, Moving Walks, Platforms Lifts, Stairway Chairlifts
- **625: Electric Vehicle Charging Systems**
- **626: Electrified Truck Parking Spaces**
- 630: Electric Welders
- 640: Audio Signal Processing, Amplification, Reproduction Equipment
- 645: Information Technology Equipment
- 647: Sensitive Electronic Equipment
- 650: Pipe Organs
- 660: X-Ray Equipment
- 665: Induction and Dielectric Heating Equipment
- 668: Electrolytic Cells
- 669: Electroplating
- 670: Industrial Machinery
- 685: Integrated Electrical Systems

Article 625 Structure

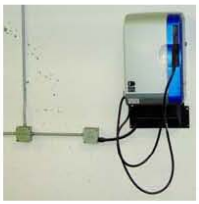
- Part I – General (625.1 – 625.5)
- Part II – Wiring Methods (625.9)
- Part III - Equipment Construction (625.13-625.19)
- Part IV – Overcurrent Protection (625.21-626.26)
- Part V – Electric Vehicle Supply Equipment Locations (625.28-625.30)

625.1 Scope

"The provisions of this article cover the electrical conductors and equipment external to an electric vehicle that connect an electric vehicle to a supply of electricity by conductive or inductive means, and the installation of equipment and devices related to electric vehicle charging."

625.2 Definitions

- Electric Vehicle
- Electric Vehicle Supply Equipment (EVSE)
  - Flexible cable
  - Disconnecting means
  - Enclosures
  - Power Outlet
  - Off-Vehicle Charging Equipment
  - Electric Vehicle Connector
- Electric Vehicle Coupler (THE INTERFACE)
- Electric Vehicle Inlet (part of the vehicle)
- Electric Vehicle Nonvented Storage Battery
- Personnel Protection System



Picture courtesy of IAEI

Cord and Plug Connected?

- Article 625.13 states:

"Electric vehicle supply equipment rated at 125 volts, single phase, 15 or 20 amperes or **part of a system identified and listed as suitable for the purpose and meeting the requirements of 625.18, 625.19, and 625.29** shall be permitted to be cord-and-plug-connected. All other electric vehicle supply equipment shall be permanently connected and fastened in place. This equipment shall have no exposed live parts.

Cord and Plug Connected?

- 625.18 addresses interlock requirements that establishes that the EVSE is plugged into the vehicle as a permissive for the charging power circuit going to the cable/connector.
- 625.19 addresses automatic de-energization of the cable/connector when it is exposed to strain that could result in exposing current carrying components of the cable/connector.
- 625.29 addresses Location and Ventilation Requirements.

Article 625 - 2011 Highlights

- An electric motorcycle will now be considered an Electric Vehicle.
- Def'n: **Rechargeable Energy Storage System.** Any power source that has the capability to be charged and discharged. Informational Note: Batteries, capacitors, and electro mechanical flywheels are examples of rechargeable energy storage systems.
- Def'n: **Plug-In Hybrid Electric Vehicle.** A type of electric vehicle intended for on-road use with the ability to store and use off-vehicle electrical energy in the rechargeable energy storage system, and having a second source of motive power.
- "Charging" term change to "Power Transfer" to facilitate Interactive Systems (625.26)
- Proposals to limit the application of cord-and-plug connected equipment failed. CMP 12 re-affirmed equipment that meets the requirements of 625.18, 625.19, and 625.29 are permitted.

EV-Related UL Standards

- UL 2202, the Standard for Safety of Electric Vehicle (EV) Charging System Equipment
- UL 2231, the Standard for Safety of Personnel Protection Systems for EV Supply Circuits
- UL 2251, the Standard for Safety of Plugs, Receptacles, and Couplers for EV's
- UL Subject 2594 for EVSE

SAE J1772 EV COUPLER

- Two pins for power (ac line 1 and ac line 2/neutral)
- One pin for ground
- One pin for signals related to the amount of current allowed for the particular vehicle model being charged
- One pin for preventing the car from being moved while charging is under way.

EV Connector

EV Inlet

Other SAE J1772 Terminology

- AC Level 1 Charging*
  - 120V AC charging from standard 15 or 20 amp NEMA outlet, on-board vehicle charger (~1.9kw)
- AC Level 2 Charging*
  - 208 – 240 AC charging up to 80 amps, on-board vehicle charger (~19kw)
- DC Charging (Level 3 - Fast Charging)**
  - Off-board charger connects directly to vehicle high voltage battery bus
  - Charger controlled by vehicle which allows for extremely high power transfer (>100kw) and thus faster recharge times (minutes instead of hours)
  - Actual charge rate limited by battery chemistry, infrastructure and other factors

** Same charge coupler used for AC Level 1 and 2 charging*

*** Requires unique charge coupler other than the AC level 1 and 2 coupler. Currently under development.*

the standard in safety | Underwriters Laboratories

U.S. National Electric Vehicle Safety Standards Summit

October 21, 2010

Built-Infrastructure: Charging Equipment, Standards and Code Issues

Ken Boyce
Underwriters Laboratories Inc.

EV Standard Development

- Many parties developing EV/LEV product standards including IEC, ISO, NFPA, SAE, UL
- Focus of these standards reflect different aspects, geographies, etc.
- Effective coordination is important

Safety Standard Objectives

- Address safety for reasonable use & misuse considering HBSE principles
- Compatibility with applicable model installation codes (e.g. NEC) essential; compatibility with other applicable standards a goal
- UL's suite of EV product safety standards have grown from involvement dating back to the 1990s

EV Product Safety Issues

- Product safety standards focus on minimizing risks of electric shock, fire, and injury
- Address environment regarding:
  - –ready consumer access
  - –exposures - temperature, humidity, water, oil, dust, UV radiation
  - –application - equipment response to abuse, vibration, etc.

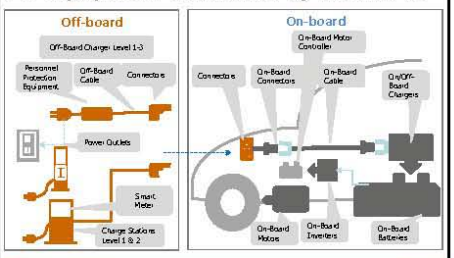
EVSE/Charger Safety Issues

- Protection from shock hazards;addressed through personnel protection devices
- Interconnection issues considering connector variations
- Protection from abuse and environment
- Compatibility with NEC Article 625

Benefits of Standards

- Rapidly evolving EV technology and global supply base demands standardization relative to infrastructure, designs & safety
- A safe and secure infrastructure is key to deployment and acceptance of EVs
- UL actively involved with stakeholders to develop standards and test methods to promote safe EV use & deployment

EV equipment addressed by standards



EV Equipment Safety Standards

Products	Standards	Scope
Supply Equipment	UL 2594 IEC/EN 62196*	EVSE products such as EV Cord Sets, EV Charge Stations, and EV Power Outlets supplying power from an Board charger
Personnel Protection System	UL 2231-1 UL 2231-2	Personnel Protection Equipment (PPE) as required by the NEC to protect against electric shock
On-Board Cable	UL 62 IEC 60245	Type EV cables in accordance with the National Electrical Code
Plug/Coupler	UL 2251 IEC/EN 62196	EV connector and inlet/coupler for connecting power to an electric vehicle, harmonized by SAE J 1772
On/Off-Board Charger	UL 2202 IEC/EN 61851-1, IEC 61851	On-board or off-board products supplying charging current to a battery
Batteries	UL 2580 UL 1642 SAE J2929 ISO*	Batteries and battery packs for Lithium or other technologies depending on scope of standard
On-board AC cable	UL 2238, 2238	On-board cables and connectors
On-board motor	UL 1004-7 IEC/EN 60034	Electric motors such as those used to provide traction torque for the vehicle.
On-board converter/inverter	SAE J1850 IEC/EN 61851	On-board converters & inverters to modify voltage levels
Charging Station Meter	UL SAE 2735	Utility Smart Meters
		* Under development

Issues Going Forward

- Connector compatibility with emerging infrastructure – US and global
- Completion of efforts to comprehensively address safety requirements for products
- Holistic alignment and coordination of system safety standards
- Safety implications of practical use and market practices – e.g. battery swapping

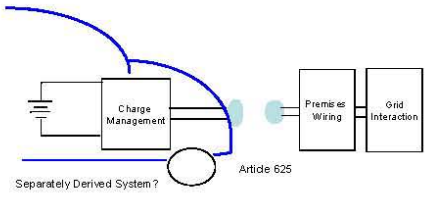
Connector Compatibility

- Development of RPs is a positive, but lack of standardization will present infrastructure challenges
- Different connectors are being used and will continue to be used in North America & globally
- Backwards compatibility must be considered

Comprehensively address safety

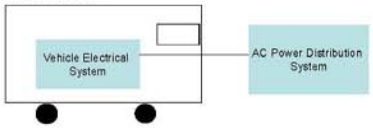
- Many component standards exist, but need to continue to work to make sure the right content is there
- All safety-related components should be addressed
- Codes need to be reviewed to make sure they anticipate key issues

Code Scenario 1



Code Scenario 2

Safety of RV Systems are addressed by Code in NEC Article 551, Recreational Vehicles and Recreational Vehicle Parks



Safety of other vehicles?

Code Scenario 3

Community/Local energy storage with repurposed vehicle batteries

- **Technology and installations not adequately addressed by present content of NEC Article 480, Battery Installations**
- **Consumer/First Responder safety must be addressed**

Holistic System Coordination

- Coordination of requirements to address "handshakes" among standards, and between standards and codes
- Responsible consideration of possible practical "worst cases" based on what can be possibly interconnected

Safety of practical use/market practices

Anticipate safety implications of practical use, such as:

- **Battery swapping and quick charging stations pose new hazards with impacts on warranty, safety and public perception**
- **Potential for after-market "cheaters" to adapt vehicle connector to other charger configurations**

Conclusion

- Much work has been done in EV product standards development
- Remaining work is being diligently pursued by standards development community
- Collaboration and involvement of key stakeholders will result in the best set of cohesive EV standards & codes supporting safe deployment

Thank you

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Vehicle Fire & Technical Rescue

Presented By:

- George Burke
  - Fire Science Instructor
- Jeffrey Minter
  - Automotive Instructor

MADISON AREA TECHNICAL COLLEGE

Initial Chain of Events

- Call comes in
  - Quality of information varies greatly
- Dispatch
  - Call center processes information received
  - Determines incident response requirements
    - May vary by the type of incident (fire/crash)
  - Dispatch appropriate trucks based on initial information

Typical Response

- Minimum of 1 engine and/or truck dispatched
- Typical crew of 2-4 firefighters

Scene Safety Responsibilities

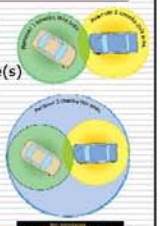
- First Responder
  - Personal and team safety
  - Patient

Scene Survey

- Initial survey upon arrival
  - Type of incident
  - Number of vehicles involved
  - Type of vehicle(s) involved

Scene Survey (Cont)

- Inner/Outer circle survey
  - Potential patients
    - In and/or out of the vehicle(s)
      - Will extrication be required
  - Additional hazards
    - Down power lines
    - Fuel leaks, Etc.



Scene Management

- First officer on scene assumes command
  - Requests additional resources as needed
  - Coordinates with various responding agencies
    - Police
    - Fire
    - EMS
    - Utility company

Securing the Scene

- Traffic control as needed
- Vehicle stabilization

Patient Care

- First responders may enter the vehicle prior to extrication for
  - Patient assessment
  - Patient care

Extrication

- Forcible removal of various portions of the vehicle to gain access to patients
- Every extrication is different

Extrication Concerns

- Air bags
  - Un-deployed bags
  - Inflation canisters
- Various types of new metals
  - May affect extrication techniques
- 12 Volt battery location

Vehicle Fire Concerns

- Flammable or reactive compounds or components
- Accessibility of components for fire suppression
- Identification of fuel type
  - Gasoline
  - CNG
  - LPG
  - Etc.

New Concerns with EV/HEV

- Vehicle Identification
- High voltage
  - Component locations
  - Shut-down procedures
- Idle stop/silent launch
- Identification of battery type/location in hybrid/electric vehicles
- Different weight distribution
  - How might it affect vehicle stabilization

Potential Improvements

- Standardized method of EV/HEV Identification
  - Some type of visual indicator on or near the VIN plate?

- Standardized visual indicator indicating vehicle power status (on/off)
  - Possible LED(s) near VIN plate?

Potential Improvements (Cont)

- Standardized shut down for HV system
  - Under-hood disconnect not requiring HV gloves
  - 12V disconnect switch disconnecting power to
    - HV Contactors
    - SRS Module
    - PCM (Fuel Control)
- Better marking of HV cables and components
  - Example of concern:
    - Orange cables are being covered by black panels on underside of vehicles

THE ENFORCEMENT INFRASTRUCTURE

IN SUPPORT OF ELECTRIC VEHICLES AND SIMILAR ALTERNATIVE ENERGY TRANSPORTATION

Ron Farr
State Fire Marshal, Michigan

U.S. National Safety Standards Summit
21-22 October 2010 Detroit, Michigan

THE ENFORCEMENT INFRASTRUCTURE

PRESENTATION OUTLINE

1) Introduction and Background
2) Safety Infrastructure Overview
3) Permitting Officials Infrastructure
4) Permitting Process Fundamentals
5) Summary of Enforcement Community Concerns

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1) Introduction and Background

Three Realms of Focus for Electric Vehicle Safety Codes and Standards

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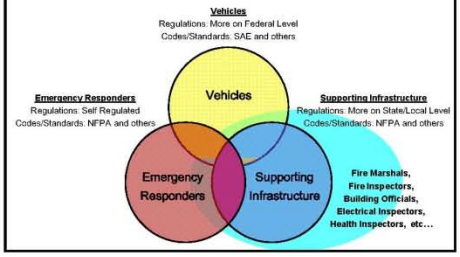
1) Introduction and Background



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1) Introduction and Background

New Alternative Fuels in Motor Vehicles of Interest to Enforcers

Types of Alternative Fuels Used in Motor Vehicles

based on classifications set by the U.S. EPA, per the Clean Air Act Amendment of 1990 and Energy Policy Act of 1992.

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2) Safety Infrastructure Overview

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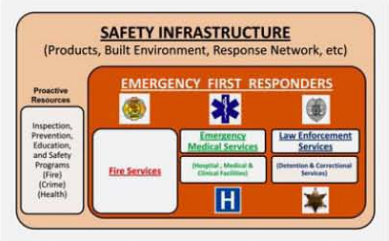


Overall Safety Infrastructure, Including Emergency Responders

2) Safety Infrastructure Overview

8

Duties of Fire Marshal ← → Scope of NFPA 1, *Fire Code*

1.1.1 The scope includes, but is not limited to, the following:
(1) **Inspection** of permanent and temporary buildings, processes, equipment, systems, and other fire and related life safety situations
(2) **Investigation** of fires, explosions, hazardous materials incidents, and other related emergency incidents
(3) **Review of construction plans, drawings, and specifications** for life safety systems, fire protection systems, access, water supplies, processes, hazardous materials, and other fire and life safety issues
(4) **Fire and life safety education** of fire brigades, employees, responsible parties, and the general public
(5) **Existing occupancies** and conditions, the design and construction of **new buildings**, **remodeling** of existing buildings, and additions to existing buildings
(6) Design, alteration, modification, construction, maintenance, and testing of **fire protection systems and equipment**
(7) Access requirements for fire department operations
(8) Hazards from **outside fires** in vegetation, trash, building debris, and other materials
(9) Regulation and control of **special events** including, but not limited to, assemblage of people, exhibits, trade shows, amusement parks, haunted houses, outdoor events, and other similar special temporary and permanent occupancies
(10) **Interior finish, decorations, furnishings**, and other combustibles that contribute to fire spread, fire load, and smoke production
(11) Storage, use, processing, handling, and on-site transportation of **flammable and combustible gases, liquids, and solids**
(12) Storage, use, processing, handling, and on-site transportation of **hazardous materials**
(13) Control of **emergency operations and scenes**
(14) Conditions affecting **fire fighter safety**
(15) Arrangement, design, construction, and alteration of **new and existing means of egress**

2) Safety Infrastructure Overview

9

Fire Service and Emergency Response Organizations

Primary Components of a Typical Fire/Rescue Service Organization

2) Safety Infrastructure Overview

10

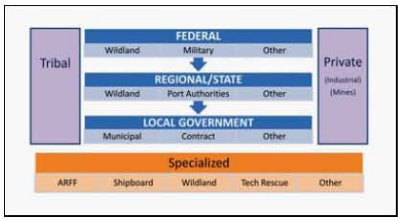
Fire Service and Emergency Response Organizations

Types of Fire Service Related Personnel

2) Safety Infrastructure Overview

11

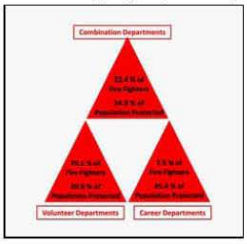
Fire Service and Emergency Response Organizations



2) Safety Infrastructure Overview

12

Fire Service and Emergency Response Organizations



Overview of U.S. Fire Service

2

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2) Safety Infrastructure Overview

Fire Service and Emergency Response Organizations

Overview of U.S. Fire Service

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2) Safety Infrastructure Overview

Fire Service and Emergency Response Organizations

Overview of U.S. Fire Service

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U.S. National Electric Vehicle Safety Standards Summit

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3) Permitting Officials Infrastructure

Overview of Individuals/Organizations that Function as AHJs

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3) Permitting Officials Infrastructure

Fundamental Components of a Typical Permitting Process

18

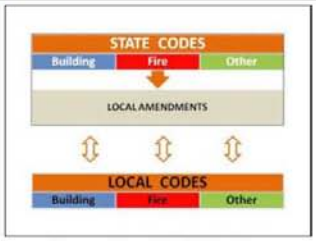
3) Permitting Officials Infrastructure

Building Department Focus	Fire Department Focus
• New (& existing) • Safety & other non-safety issues • Approval to build	• Existing (and new) • Safety & emergency response • Approval to operate

Focus of Typical Building and Fire Departments

3

3) Permitting Officials Infrastructure



State and Local Code Overview

3) Permitting Officials Infrastructure

- Permitting Infrastructure: Summary Observations
  - Permitting process in each state is unique and can vary widely, and can differ further at the local level
  - Who owns the property directly impacts the permitting process (e.g. federal or state government)
  - The AHJ may include officials with statutory authority and others with non-statutory authority
  - The permitting process frequently involves local fire official, local building official, and/or state level officials
  - Local fire departments are often focused on approval to operate, while local building departments are often focused on approval to build

U.S. National Electric Vehicle Safety Standards Summit

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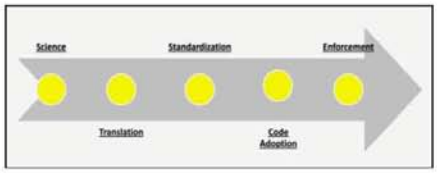
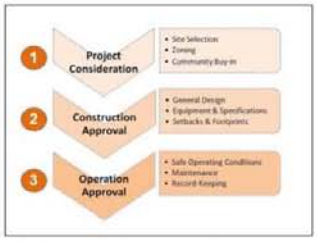
4) Permitting Process Fundamentals



Safety Infrastructure Spectrum

4) Permitting Process Fundamentals



Fundamental Steps of Permitting Process

4) Permitting Process Fundamentals

Influencing Factors in Determining Jurisdictional Authority

25

4) Permitting Process Fundamentals

Mini/Maxi Concept for Use of State Codes

26

4) Permitting Process Fundamentals

- Summary Observations
  - Police power used to enforce building safety is provided to State governments through 10th Amendment of U.S. Constitution
  - "Home Rule" describes how a State has delegated its police powers to its local jurisdictions
  - Local Fire Marshal and local Building Official are most often the key individuals in permitting process
  - Review by other local Boards and Commissions (e.g. environmental, historic, etc) is possible and depends on various factors

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4) Permitting Process Fundamentals

- Summary Observations (continued)
  - Review by local Zoning Board of Commission is often (but not always) required
  - Review at County or State level may be required in addition to local review
  - Three key factors influencing jurisdictional authority are:
    - (1) Property Owner;
    - (2) Geographic Location; and
    - (3) Type of Occupancy
  - Buildings and facilities owned by the State or Federal governments are a common exception to local permitting

28

4) Permitting Process Fundamentals

- Summary Observations (continued)
  - Utilizing equipment that is "listed" by a nationally recognized laboratory will greatly facilitate permitting process
  - Unique and unfamiliar installations to the AHJ are more likely to require special review and take longer time to process
  - Permitting officials generally welcome efforts to streamline the review process (e.g. centralized review by State Fire Marshals office)

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5) Summary of Enforcement Community Concerns

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5) Enforcement Community Concerns

Key Emergency Scenarios for EVs and HEVs

31

5) Enforcement Community Concerns

- Summary Observations

  Concerned and Interested in multiple facets of electric vehicle safety…

  - **Vehicles Concerns**: Power-down process, Labeling, Color-coding of hi-voltage cables, etc…
  - **Infrastructure Concerns**: Charging stations disconnects, Automatic shutdowns, Protection from physical damage, Tripping hazards, etc…
  - **Other Concerns**: Vehicle salvage & removal, Bulk storage or transport of vehicle batteries, etc…

EV Battery Examples

NiMH Liquid Cooled EV Battery Module

Lithium Ion Air Cooled EV Battery Module

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THE ENFORCEMENT INFRASTRUCTURE

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Ron Farr
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Public Buildings Service

the office of facilities management and services programs

sustaining world-class facilities and services

GSA's Approach to Electric Vehicle Supply Equipment and Infrastructure

Patrick Fee,
Director, Building Operations Division
Office of Facilities Management
Public Buildings Service

October 21, 2010

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General Service Administration (GSA)

- Federal Acquisition Service (FAS)
  - Super Store for the Federal Government
- Public Buildings Service (PBS)
  - Landlord for Federal Agency Tenants

2

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GSA's Goals

- Federal Acquisition Service (FAS)
  - Federal fleets are required to reduce petroleum consumption and to use more alternative fuels for its vehicles. Electricity provided from an external source is considered an alternative fuel.
- Public Buildings Service (PBS)
  - Federal Building are required to reduce energy consumption.

3

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FAS FedBizOps.gov

- Office of Acquisition Operations, Office of Travel, Motor Vehicles and Card Services(QMA)
- Solicitation Number: QMAA-JC-100001-N
- **Electric Passenger Cars and Cargo Vans, to include Electric - Extended Range Vehicles**
- Posted Date: September 23, 2010
- Response Date: Oct 21, 2010 2:30 pm Eastern, extended to Oct 28, 2010.

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FAS FedBizOps.gov

- **Section A.1 – ADDITIONAL INFORMATION FOR STANDARD FORM 1449**
- The due dates for which offerors are to submit AutoBid pricing and hard copy technical and price proposals is changed;
- **FROM:**
- Hard copy Technical and Price Proposals are due October 21, 2010 at 2:30 p.m. Easter Time. AutoBid pricing is due October 20, 2010 at 5:00 p.m. Eastern Time.
- **TO:**
- Hard copy Technical and Price Proposals are due October 28, 2010 at 2:30 p.m. Eastern Time. AutoBid pricing is due October 27, 2010 at 5:00 p.m. Eastern time.

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PBS FedBizOps.gov

- Request For Information
- **Electric Vehicle Charging**
- Posted Date: TBD
- Response Date: TBD

6

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GSA Past

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GSA Past

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GSA Holding on to the Past

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GSA Today

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GSA Today

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GSA Tomorrow

12

GSA Issues

Utility Supply
Transactions
Electric Vehicle Supply Equipment
Data Collection

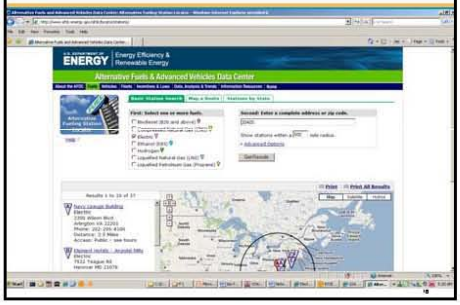
GSA Issues

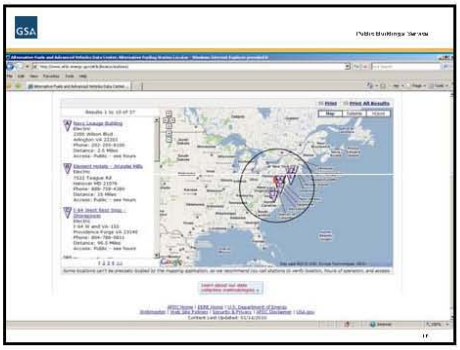
Location, Location, Location (Cities – Manufacturers)
Infrastructure (design, current & future)
Fleet Vehicles (100 to thousands)
Smart Grid
Charging Model (peak / off peak)
Range Anxiety
Privately Owned Vehicles (GAO & AOC)
- Tenant made it to work, now the battery is dead
- Outlease?

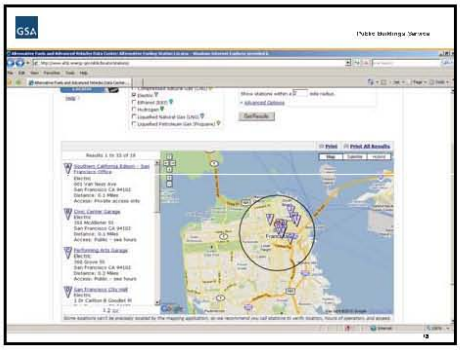
Wex Card

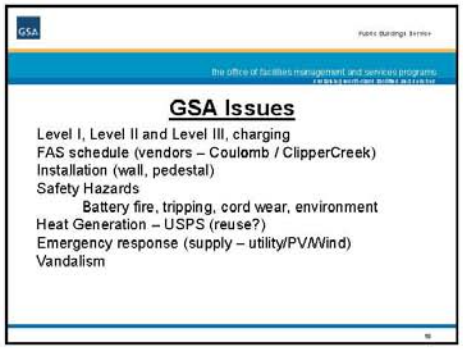
GAO & AOC

Appropriations Decisions:
B-320116, Architect of the Capitol--Availability of Funds for Battery Recharging Stations for Privately Owned Vehicles, September 15, 2010 http://www.gao.gov/decisions/approp/320116.htm
Without statutory authority, the Architect of the Capitol (AOC) may not use appropriated funds to install battery recharging stations for privately owned hybrid or electric vehicles on the Capitol grounds nor establish a program where employees reimburse AOC for costs related to the use of recharging stations for employees' personal vehicles. Personal expenses are not payable from appropriations without specific statutory authority. The use of appropriations for recharging personal vehicles of employees is a matter for Congress to address through legislation.





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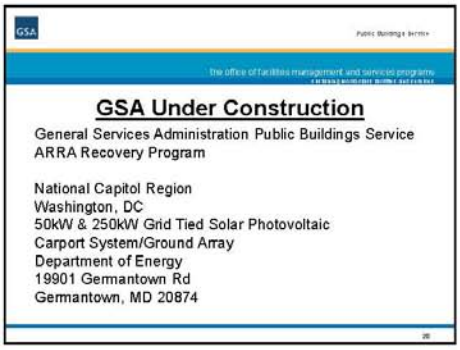
GSA Issues
Level I, Level II and Level III, charging
FAS schedule (vendors – Coulomb / ClipperCreek)
Installation (wall, pedestal)
Safety Hazards
Battery fire, tripping, cord wear, environment
Heat Generation – USPS (reuse?)
Emergency response (supply – utility/PV/Wind)
Vandalism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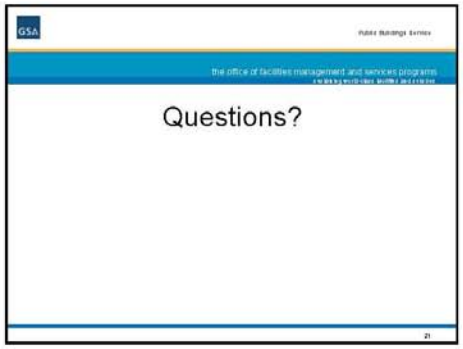
GSA Under Construction
General Services Administration Public Buildings Service
ARRA Recovery Program
National Capitol Region
Washington, DC
50kW & 250kW Grid Tied Solar Photovoltaic
Carport System/Ground Array
Department of Energy
19901 Germantown Rd
Germantown, MD 20874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Questions?

Property Insurance Loss Prevention Concerns with Electric Vehicles

U.S. National Electric Vehicle Safety Standards Summit
October 21, 2010
John Frank, PE, CFPS
SVP, Loss Prevention Center of Excellence

XL

What we ARE NOT going to talk about

- Response to motor vehicle accidents
- Hazards to vehicle operators
- Hazards at consumer recharging operations
- Hazards at residences
- Bulk vehicle transport of batteries
- Recycling operations
- Answers to your questions

So what are we going to talk about?

- What we know now
- What's in the accessible literature
- Why car size batteries differ from laptop batteries to us
- Challenges and questions (what we know we don't know)

What we know already

- Electric forklifts, golf carts, and other small short-range vehicles
- Traditional truck and car batteries
- Unlimited Power Supplies
- Flashlight type batteries
- Small lithium-ion batteries (cell phones/laptops)

Quick Literature Search

- NFPA 505 *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operations*
  - based on lead or nickel-ion batteries and contains only basic guidance.
  - Discusses hydrogen hazard but no guidance. NFPA 70 Article 480 just says to vent
- Other NFPA standards looked at: 75, 110, 111, 120, 130
- NFPA *Fire Protection Handbook* has a chapter on fuel cell vehicles

Quick Literature Search

- XL GAPS Guideline 5.7.4, *Stationary Batteries*
  - Lead Acid and Ni-Cad
  - Battery rooms treated as NFPA 13 OH occupancies
  - Specific guidance on hydrogen veneration during recharging
- FM Data Sheet 5-23, *Emergency and Standby Power Systems*
  - Lead acid and Ni-Cad
  - Basic guidance on hydrogen venting

XL

Quick Literature Search

- Nothing found on lithium-ion batteries specifically
- Nothing found manufacturing or storage risks of large lithium-ion batteries
- Found one YouTube ad for a company specializing in fire protection for lithium-ion battery plants. No technical details.

So what's different?

- Other operations are of smaller scale or secondary to the main operation
- Very limited experience in large scale lithium-ion manufacturing or storage

Challenges

- Ability of fire service to complete final extinguishment in battery warehouses
- Fire control in battery manufacturing areas
  - Unknown process hazards
  - How will water perform (sprinklers and hose streams)
  - Class D extinguishers? Lith-X? Argon?
- Ignition caused by batteries
  - Need understanding of different types of batteries
  - Are electric vehicle batteries different than computer/cell phone batteries?

Challenges

- Commodity classification??
- Confusion about technologies (fuel cell, battery, hybrid and even to alternative liquid and gaseous fuels) Will the fire service know what to do at a factory fire?
- Much information is proprietary

Specifics

- How much lithium, how does it behave, are they all the same?
- Electrolyte flammability hazard?
- How will they act in combination?
- Do they evolve hydrogen when charged?
- Is Lith-X the right agent, or Argon?

Concern about fires

- *"When a fire like this happens, it is usually caused by an internal short in the battery. Recall from the previous section that lithium-ion cells contain a separator sheet that keeps the positive and negative electrodes apart. **If that sheet gets punctured and the electrodes touch**, the battery heats up very quickly"*
  - From howstuffworks.com
- *"The researchers have identified the growth of metal fibers – called dendrites – within li-ion batteries. As they grow, these fibers can cause short circuits within the battery, in turn leading to overheating and fires"*.
  - From Autoblog.com

Concern about fires

- Self-growing dendrites?
- Dropping? Forklift tine puncture?
- How to extinguish, self-perpetuating ignition source?
- Web articles on how to prevent fires; what really works and what doesn't?

What we would like to see next

- What we missed, challenges we did not think about yet
- e-learning course on battery and alternate fuel technology (difference between batteries and fuel cells for examples)
- What is known now that addresses our concerns
- Research plan to address concerns for what is not known now
  - Fire testing

Questions, Comments, and Discussion

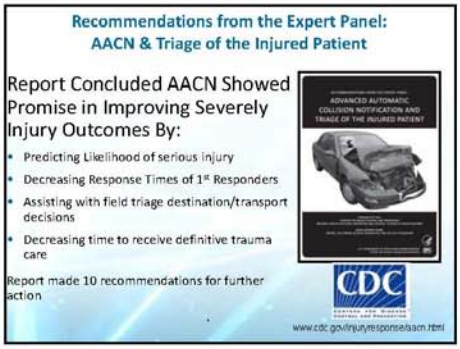

9-1-1 Connectivity
Electric Vehicle Rescues
OnStar


Chevrolet Volt Continuous Safety
Protection Before, During, and After Vehicle Collisions
BEFORE
DURING
AFTER
STABILITRAK
Electronic Stability Control System
Anti-Lock Braking System
Daytime Running Lights
Systems to Help Absorb Energy from Impact
OnStar
Automatic Crash Response
Automatic High Voltage Shutoff
Fuel Sender Shutoff
Automatic Door Unlock
Automatic Flashers
Post-Crash Occupant Protection
Comprehensive Safety

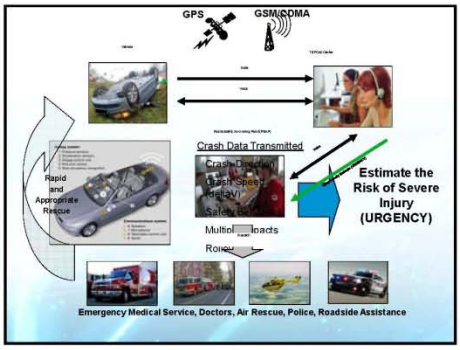

OnStar – How It Works
Features
• Powerfully simple
• Fully integrated, 3-button system
– GPS positioning
– Advanced voice recognition
– Cellular wireless connectivity
➢ Voice and data
• Trained advisors serve >5.8 million subscribers 24x7x365
OnStar Call Centers
Advisor Application


Monthly Emergency and Security Interactions
Automatic Crash Response 2,200/Month
Emergency Services 10,000/Month
Good Samaritan 7,000/Month
Stolen Vehicle Assistance 440/Month
Remote Door Unlock 64,000/Month
Roadside Assistance 29,700/Month
One Very Hardworking Button
Over 315 Million Cumulative Service Interactions


Automatic Emergency Services
AUTOMATIC CRASH RESPONSE STATUS


Recommendations from the Expert Panel:
AACN & Triage of the Injured Patient
Report Concluded AACN Showed Promise in Improving Severely Injury Outcomes By:
• Predicting Likelihood of serious injury
• Decreasing Response Times of 1st Responders
• Assisting with field triage destination/transport decisions
• Decreasing time to receive definitive trauma care
Report made 10 recommendations for further action
CDC
www.cdc.gov/injuryresponse/aacn.html


OnStar Working with Public Safety


GPS
GSM/CDMA
Crash Data Transmitted
Rapid and Appropriate Rescue
Estimate the Risk of Severe Injury (URGENCY)
Emergency Medical Service, Doctors, Air Rescue, Police, Roadside Assistance


As an Enhancement to Emergency Services,
OnStar Will Now Provide EMD Using MPDS Protocol
Advisor 1
Bridges Advisor 2 with customer then calls PSAP
Advisor 2 EMD
Advisor 1
Able to bridge customer/Advisor 2 and PSAP, if PSAP desires
Public Safety Answering Point


Resources/Information
www.onstar.com/publicsafety
www.gmstc.com


First Responder Training Tour
•Southeast, MI
•San Francisco, CA
•Los Angeles, CA
•Austin, TX
•New York City Area
•Washington DC Area