

# 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.

### **U.S. National Electric Vehicle Safety Standards Summit Co-Hosted by SAE and NFPA**



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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.<sup>1-1</sup> 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.<sup>1-2</sup>

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.<sup>1-3</sup>

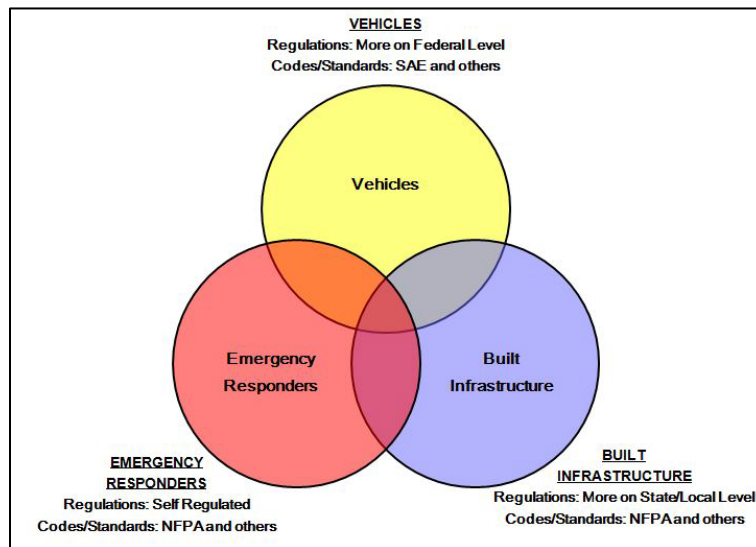


Figure 1: Basic Realms of Focus on Electric Vehicle Related Codes and Standards.<sup>1-3</sup>

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 10<sup>th</sup> 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.<sup>1-4</sup> 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.<sup>1-4</sup>

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



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 <b>(WORK IN PROGRESS)</b>
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 <b>(WORK IN PROGRESS)</b>
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) <b>(WORK IN PROGRESS)</b>
SAE J-2836 Part 3	Use Cases for Communications between Plug-In Vehicles and the Utility grid for Reverse Flow <b>(WORK IN PROGRESS)</b>
SAE J2836 Part 4	Use Cases for Diagnostic Communication for Plug-in Vehicles <b>(WORK IN PROGRESS)</b>
SAE J2836 Part 5	Use Cases for Communication between Plug-in Vehicles and their customers. <b>(WORK IN PROGRESS)</b>
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) <b>(WORK IN PROGRESS)</b>
SAE J-2847 Part 3	Communication between Plug-in Vehicles and the Utility Grid for Reverse Power Flow <b>(WORK IN PROGRESS)</b>
SAE J2847 Part 4	Diagnostic Communication for Plug-in Vehicles <b>(WORK IN PROGRESS)</b>
SAE J2847 Part 5	Communication between Plug-in Vehicles and their customers <b>(WORK IN PROGRESS)</b>
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 <b>(WORK IN PROGRESS)</b>
SAE J-2894 Part 2	Power Quality Requirements for Plug-In Vehicle Chargers - Test Methods <b>(WORK IN PROGRESS)</b>
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 <b>(WORK IN PROGRESS)</b>
SAE J-2931 Part 1	Power Line Carrier Communications for Plug-in Electric Vehicles <b>(WORK IN PROGRESS)</b>
SAE J-2931 Part 2	Inband Signaling Communication for Plug-in Electric Vehicles <b>(WORK IN PROGRESS)</b>
SAE J-2931 Part 3	PLC Communication for Plug-in Electric Vehicles <b>(WORK IN PROGRESS)</b>
SAE J-2936	Vehicle Battery Labeling Guidelines <b>(WORK IN PROGRESS)</b>
SAE J-2946	Battery Electronic Fuel Gauging Recommended Practices <b>(WORK IN PROGRESS)</b>

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

Table 2: Examples of NFPA Codes and Standards Addressing Technical Issues Relating to EVs and HEVs. <sup>1-4</sup>

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

### 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](http://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

<p><u>Welcoming Remarks</u></p> <ul style="list-style-type: none"> <li>• Ron Farr, State Fire Marshal, Michigan</li> <li>• Jack Pokrzywa, Director of Operations of SAE Automotive Headquarters and Manager of SAE Ground Vehicle Standards, SAE International</li> <li>• Christian Dubay, Vice President and Chief Engineer, National Fire Protection Association</li> </ul> <p><u>Keynote Presentation</u></p> <ul style="list-style-type: none"> <li>• “Driving the Safe and Effective Implementation of Electric Vehicles: Standards and Conformance-Based Solutions”; Joe Bhatia, President and CEO, ANSI</li> </ul> <p><u>Session One: Vehicles</u></p> <ul style="list-style-type: none"> <li>• “Battery and Labeling Standards”; Bob Galyen, Magna e-car</li> <li>• “Hybrid/Electric Vehicle Battery Safety Standards”; Galen Ressler, General Motors LLC</li> <li>• “Vehicle Standards Update: Hybrid Safety”; Ted Bohn, Argonne National Laboratory</li> <li>• “NHTSA Safety Research Plan for RESS Equipped Vehicles”; Phillip Gorney, NHTSA</li> </ul> <p><u>Session Two: Built Infrastructure</u></p> <ul style="list-style-type: none"> <li>• “Current State of Codes and Electric Vehicle Infrastructure”; Mike Hittel, General Motors LLC</li> <li>• “Standardization of Charging Support Equipment”; Kenneth Boyce, Underwriters Laboratories</li> </ul> <p><u>Session Three: Emergency Responders</u></p> <ul style="list-style-type: none"> <li>• “Fire Fighting, Rescue, and Incident Command”; Jeff Johnson, CEO of Western Fire Chiefs Association and IAFC Past President</li> <li>• “Vehicle Fire and Technical Rescue”; Jeff Minter and George Burke, Madison Area Technical College, Wisconsin</li> <li>• “The Enforcement Infrastructure: In Support of Electric Vehicles and Similar Alternative Energy Transportation”; Ron Farr, State Fire Marshal, Michigan</li> </ul> <p><u>Session Four: Others</u></p> <ul style="list-style-type: none"> <li>• “Owner/Operator Infrastructure Issues for Fleet Vehicles”; Patrick Fee, General Services Administration</li> <li>• “Property Insurance Loss Prevention Concerns”; John Frank, XL Gaps</li> <li>• “9-1-1 Connectivity: Electric Vehicle Rescues”; Cathy McCormick, OnStar</li> </ul>
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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

<p><b>A) <u>Welcoming Remarks and Keynote Presentation</u></b></p> <ol style="list-style-type: none"><li>1) Need to continue to stimulate public/private partnerships via standards development.</li><li>2) Not only are standards important but so is compliance mechanism.</li><li>3) Compliance approach is different for vehicles vs. built infrastructure vs. emergency responders.</li><li>4) Important issues for vehicle components like batteries include after-market and offshore products.</li><li>5) Electric vehicles is a critical cross-cutting standards issues and all affected stakeholders need to be involved.</li><li>6) National standards should be developed ready for international use.</li></ol> <p><b>B) <u>Session One: Vehicles (Presentations and Q&amp;A Discussion)</u></b></p> <ol style="list-style-type: none"><li>1) Significant industry activity is on-going with battery and labeling standards, though input from emergency responders into this effort would be beneficial.</li><li>2) Possible hazard concerns with batteries is important, both on-board vehicles as designed but also otherwise (e.g. storage, bulk transport, etc).</li><li>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.</li></ol>
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- 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) Session Two: Built Infrastructure (Presentations and Q&A Discussion)**

- 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) Session Three: Emergency Responders (Presentations and Q&A Discussion)**

- 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) Session Four: Other Issues and Concerns (Presentations and Q&A Discussion)**

- 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) Day One Summary Discussion**

- 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 Responders** –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.

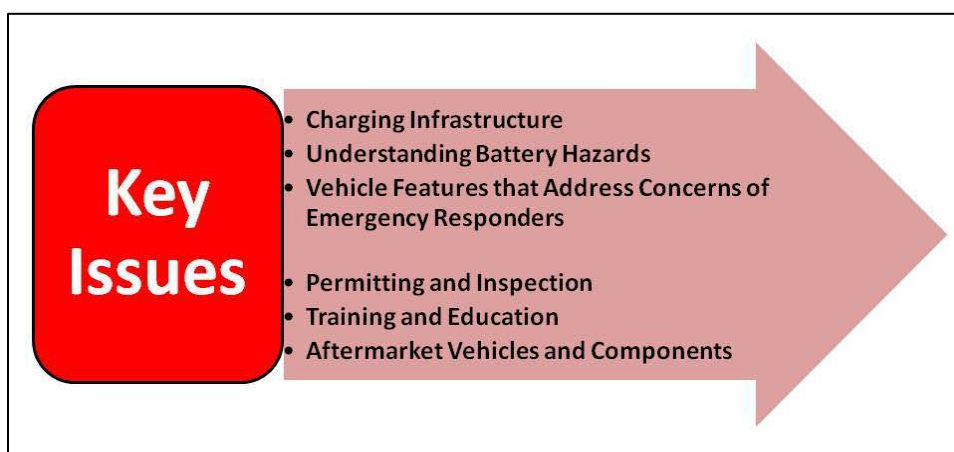


Figure 2: Key Areas Indicated by the U.S. National Electric Vehicle Safety Standards Summit

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

<p><b>1. CHARGING INFRASTRUCTURE</b></p> <p><b>1.1. EV SUPPLY EQUIPMENT (EVSE) LISTING ISSUES</b></p> <p>1.1.1. <b>EV Supply Equipment (EVSE) Listing Issues</b> – 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.</p> <p>1.1.2. <b>Connector and Interface Components Standardization</b> – The need to address the standardization of connectors and interface components in a timely fashion.</p> <p><b>1.2. SPECIFIC ISSUES FOR CONSIDERATION BY THE NEC</b></p>
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- 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
<b>Galyen</b>	Robert	Magna International
<b>George</b>	Thomas	Tokio Marine Management
<b>Gloddeck</b>	Alfred	Nissan Motor Corp USA
<b>Gopal</b>	Madan	Tesla Motors
<b>Grant</b>	Casey	FPRF
<b>Hamdan</b>	Mazen	Arvin Meritor
<b>Hendricks</b>	Bob	Lexington Div of Fire & Emergency Services
<b>Hildebrandt</b>	Timothy	Chrysler LLC
<b>Hittel</b>	Mike	General Motors LLC
<b>Ho</b>	Li-Pen	GM Engineering Center
<b>Hoemer</b>	Beverly	SAE International
<b>Hoemer</b>	Rich	SAE International
<b>Hubbard</b>	Tim	Intertek
<b>Johnson</b>	Jeff	IAFC, and Tualatin Valley Fire & Rescue (Ret.)
<b>Jongkind</b>	James	American Honda Motor Co Inc
<b>Kent</b>	Rex	Sinclair Community College
<b>Kilgore</b>	Leslie	General Motors Global Purchasing
<b>Klobuchar</b>	John	XL Global Asset Protection Serv. LLP
<b>Klock</b>	Andrew	NFPA
<b>Ledbetter</b>	Kelly	EnerDel Inc
<b>LeDuc</b>	Marc	SAE International
<b>Leicht</b>	R.	Delaware Office of State Fire Marshal
<b>Lenkeit</b>	John	Dynamic Research Inc
<b>London</b>	Matt	Nissan North America Inc
<b>Maguire</b>	Patrick	Ford Motor Co
<b>Manche</b>	Alan	Schneider Electric
<b>McCabe</b>	James	American National Standards Institute
<b>McCoy</b>	David	Mercury Marine
<b>McKenna</b>	Larry	USFA
<b>McMahon</b>	Peter	NFPA
<b>McVay</b>	Malcolm	Aero Vironment Inc
<b>McCormick</b>	Cathy	OnStarLLC
<b>Mercier</b>	Charles	Southwire Company
<b>Miller</b>	Russ	US General Services Administration
<b>Minter</b>	Jeff	Madison Area Technical College
<b>Moldoveanu</b>	Andrei	NEMA
<b>Momeni</b>	Massoud	Toyota Motor Engineering & Mfg NA Inc
<b>Nida</b>	Nick	Mercury Marine
<b>O'Brien</b>	Michael	Michigan Bureau Of Fire Services
<b>Olance</b>	Mark	NAFTC
<b>Onishi</b>	Hirofumi	Alpine Electronics of America Inc
<b>Osoro</b>	Kerman	CIE Automotive
<b>Parisi</b>	Joseph	Ford Motor Co
<b>Patwardhan</b>	Satyajit	Green DOT Racing Inc

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

- 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 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) Other Issues

- 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) Other Issues

- 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.