SAE International

SURFACE VEHICLE RECOMMENDED PRACTICE

J2990 NOV2012

Issued 2012-11

Hybrid and EV First and Second Responder Recommended Practice

RATIONALE

Electrification of the vehicle industry is increasing at a rapid pace with many countries adopting goals for increasing the number of electrified vehicles (xEVs), including a US goal of having one million PHEV's on the road by 2015 and China's goal of 500 000 new energy vehicles in production by the end of 2015. This new propulsion technology in the automotive sector has raised concerns for these vehicles when involved in severe crashes because of the potential consequences associated with new hazards from the high voltage systems on board. While the high voltage system, under most crash situations, is likely to be protected and maintain electrical isolation from the rest of the vehicle, a rare but possible severe crash may compromise some of the safety features of the high voltage system. Due care needs to be taken when working around the electrified propulsion systems and components or charging systems, regardless of their condition.

Some progress has been made in educating first responders about safe procedures when working around xEVs involved in crashes. However, considerable work is needed to develop common and consistent procedures for emergency responders across the automotive industry. In addition, further effort is needed to identify and address the consequences of the new hazards associated with xEVs for second responders consisting of tow, storage, repair and salvage personnel.

INTRODUCTION

Recent electrified product offerings by automotive manufacturers have brought renewed attention to the post-crash safety of vehicles containing high-voltage electrified powertrains. The first generation of regulations associated with the safety of xEVs was developed in the early 1990's. Regulations and standards were put in place by both national and international regulatory bodies to service the communities and countries, where these vehicles were being introduced. Regulations and standards were developed by bodies such as the International Organization for Standards (ISO), US National Highway Traffic Safety Administration (NHTSA), and the National Fire Prevention Association (NFPA). These initial vehicles were predominantly full battery electric vehicles (BEV), utilizing high voltage and high energy batteries that provided the single primary energy source for propulsion. Experience was gained in using these standards and practices, with both the first generation of modern xEVs, which followed on approximately five years later. Hybrid electric vehicles have retained the high voltage electrical architecture of the BEV's, but utilized compact batteries with more advanced chemistries, while retaining a conventional internal combustion powertrain. This combination of features led to some initial confusion for first and second responders, in how the post-incident vehicle should be handled.

The most recent generation of xEVs has led to a renewed need for information, by first and second responders, in order to ensure their actions maintain the highest level of safety to individuals and the community. There has been a proliferation in the variety of makes, models, powertrain configurations, and electrified energy storage technologies that has come along with this new vehicle generation. A review of current regulations and standards has led to an understanding that there is an opportunity to provide a means to better coordinate and communicate those elements from many of the regulations, so that the first and second responders may apply a more standardized execution, and be more confident in their outcome. This recommended practice provides first and second responders with the ability to identify an xEV, avoid the hazards associated with the high voltage system, communicate hazard identification to other incident responders, and manage the risks in a manner consistent with best practices utilized by first responders, second responders and by the vehicle manufacturers and other responsible organizations.

FORWARD

The cross-functional task force examined a baseline crash scenario provided by NFPA (Reference Appendix A) involving a head on collision on a two lane road at approximately 45 mph. The assumed vehicles were a mid-sized sport utility vehicle and a mid-size passenger vehicle. The passenger vehicle contained two occupants that needed attention. The task force contrasted the emergency response of a traditional non-xEV passenger vehicle with an xEV passenger vehicle for the same crash scenario. For the xEV scenario, the passenger vehicle was assumed to be an electric vehicle (EV). This analysis was inclusive of the first responders and second responders up to and including vehicle salvage.

Several gaps were identified in the analysis of the response scenario for the xEV and are the focus of J2990 recommendations. The gaps identified are:

1. Consistent emergency response guides (ERG) for xEVs.
2. Consistent identification of xEVs at an incident scene.
3. High voltage system disabling practice.
4. Inspection process post-incident to determine if vehicle poses an abnormal safety risk.
5. Tow & recovery protocols post-crash for xEVs.
6. Communication strategy for ERG and hazard information.

TABLE OF CONTENTS

1. SCOPE

xEVs involved in incidents present unique hazards associated with the high voltage system (including the battery system). These hazards can be grouped into 3 categories: chemical, electrical, and thermal. The potential consequences can vary depending on the size, configuration and specific battery chemistry. Other incidents may arise from secondary events such as garage fires and floods. These types of incidents are also considered in the recommended practice (RP). This RP aims to describe the potential consequences associated with hazards from xEVs and suggest common procedures to help protect emergency responders, tow and/or recovery, storage, repair, and salvage personnel after an incident has occurred with an electrified vehicle. Industry design standards and tools were studied and where appropriate, suggested for responsible organizations to implement.

Nickel metal hydride (NiMH) and lithium ion (Li-ion) batteries used for vehicle propulsion power are the assumed battery systems of this RP. These battery chemistries are the prevailing technologies associated with high voltage vehicle electrification today and the foreseeable future. The hazards associated with these specific battery chemistries are addressed in this RP. Other chemistries and alternative propulsion systems including Fuel Cells are not considered in this version of SAE J2990.

1.1 Purpose

This SAE RP provides guidelines and education to first and second responders of incidents associated with xEVs and high voltage batteries. The RP is not intended to replace an emergency response guide or to be referenced at the scene of an emergency incident. Automotive OEM's are encouraged to reference this RP for industry design guidance when creating vehicle requirements and Emergency Response Guides (ERGs).

This RP is not intended to address battery specific hazards, but rather vehicles which contain aforementioned batteries. The RP does however consider batteries that may become separated from a vehicle as a result of a crash event or at storage and repair facilities where responders are involved.

1.2 Future Considerations

In order to expedite the release of the first version of this recommended practice, several topic areas were deferred for consideration in future revisions. These items include, but may not be limited to, the following:

- Contact 24 hour emergency hotline providers, such as CHEMTREC, to explore a potential feasibility study of 24 hour emergency hotline services for xEVs.
- Explore the potential benefit of establishing guidelines for a "battery fire and/or high voltage breach specific" Emergency Field Guide (EFG) or ERG that takes responders through a logical sequence responding to escalating emergency situations (i.e., what if scenarios).
- Explore changes to current incident reporting protocol to encourage acquisition and consolidation of data regarding incidents involving xEVs, battery fires and/or high voltage breach. This information can be used to develop further guidance for the first and second responder community.
- Establish means to gather experiential data from emergency incidents involving xEVs (i.e., capturing information through normal emergency reporting process by adding coding for xEV and particular battery chemistry).
- Issues associated with welded contactors within battery systems.
- End of life considerations for xEVs.
- Neutral overrides and steering column locks for xEVs with 12V systems disabled.
- Incorporate hydrogen fuel cell vehicle recommendations.
- Study recommendations for Electric Vehicle Supply Equipment (e.g., chargers) issues for first responders.
- Study possibility for common fastener or cover for a manual disconnect (MD) contained in passenger compartments.
- Document and explain default isolation systems of xEV's to help explain misconceptions with the xEV safety post-crash.

2. REFERENCES

2.1 Applicable Documents

NOTE: Users should ensure that the latest revision and legislative updates of these documents is being referenced.

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J1715 Hybrid Electric Vehicle (HEV) and Electric Vehicle (EV) Terminology

SAE J1766 Recommended Practice for Electric and Hybrid Electric Vehicle Battery Systems Crash Integrity Testing

SAE J2830 Process For Comprehension Testing Of In-Vehicle Icons

2.1.2 FMVSS Publication

Available from the Superintendent of Documents, U.S. Government Printing Office, Mail Stop: SSOP, Washington, DC 20402-9320.

FMVSS 305 Electric Powered Vehicles: Electrolyte Spillage and Electrical Shock Protection

FMVSS 208 Occupant Crash Protection

2.1.3 ISO Publications

Available from International Organization for Standardization, 1, rue de Varembe, Case postale 56, CH-1211 Geneva 20, Switzerland, Tel: +41-22-749-01-11, www.iso.org.

ISO 9186-1:2007Graphical symbols - Test methods - Part 1: Methods for testing comprehensibility

2.1.4 2012 Emergency Response Guidebook - A Guidebook for First Responders During Initial Phase of a Dangerous Goods/ Hazardous Materials Transportation Incident

Available from Council on Safe Transportation of Hazardous Articles (COSTHA), 7803 Hill House Court, Fairfax Station, VA 22039, Tel: (703) 451-4031, www.costha.com. In Canada, contact CANUTEC (613) 992-4624. In Mexico call SCT at 52-5-684-1275.

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.2.1 SAE Publications

SAE J1142 Towability Design Criteria and Equipment Use - Passenger Cars, Vans, and Light-Duty Trucks

SAE J2069 Recovery Attachment Points for Passenger Cars, Vans, and Light Trucks

SAE J2344 Guidelines for Electric Vehicle Safety

SAE J2464 Electric and Hybrid Electric Vehicle Rechargeable Energy Storage System (RESS) Safety and Abuse Testing

SAE J2929 Electric and Hybrid Vehicle Propulsion Battery System Safety Standard - Lithium-based Rechargeable Cells.

SAE J2950 Recommended Practices (RP) For Shipping Transport and Handling of Automotive - Type Battery System - Lithium Ion.

2.2.2 NFPA PUBLICATIONS

Available from National Fire Protection Agency, 1 Batterymarch Park, Quincy, MA 02169-7471, Tel: 617-770-3000, www.nfpa.org.

Electric Vehicle Emergency Field Guide (2012)

U.S. Vehicle Fire Trends and Patterns (2010)

NFPA 52, Vehicular Gaseous Fuel Systems Code (2010)

NFPA 70, National Electric Code

NFPA 704, Identification of Materials by Hazard Rating System

NFPA 1971: Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting.

2.2.3 U.S. GOVERNMENT

Available from the Document Automation and Production Service (DAPS), Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, http://assist.daps.dla.mil/quicksearch/.

National Highway Traffic Safety Administration. (2009) TRAFFIC SAFETY FACTS 2009: A Compilation of Motor Vehicle Crash Data from the Fatality Analysis Reporting System and the General Estimates System

United States Census Bureau. (2012) Statistical Abstract of the United States: 2012

DOT HS 811 574, 'Interim Guidance for Electric and Hybrid Electric Vehicles Equipped with High Voltage Batteries'

2.2.4 FIA Publication

Available from FIA Foundation for the Automobile and Society, 60 Trafalgar Square, London, WC2N 5DS, Tel: _44 (0) 207 930 3882

The On-Board Rescue Sheet: Helping the Rescuers (2010)

2.2.5 Jones and Bartlett Publications

Available from Jones & Bartlett Learning, 5 Wall Street, Burlington, MA 01803, Tel: (800) 832-0034, www.jblearning.com.

Fundamentals of Firefigher Skills

3. DEFINITIONS

Except as noted below, all definitions are in accordance with SAE J1715.

Additional definitions:

3.1 AUTOMATIC DISCONNECT

A device in any type of xEV which opens the primary high voltage circuit or circuits of the vehicle, and that is activated by automatic means such as a crash response or the operation of the vehicle ignition switch.

3.2 BADGING

Describes a durable emblem, insignia, or label securely affixed on the exterior surface of the xEV.

3.3 CURRENT INTERRUPT DEVICE

A device designed to interrupt the flow of electrical current during abusive conditions. Examples include circuit breakers, fuse, thermal cut-off, etc.

3.4 DIAGNOSTIC TROUBLE CODE

Information provided by an on-board diagnostic system for operators and repair technicians.

3.5 DRAIN DOWN TIME (12 Volt)

Refers to the discharge time for any reserve energy within the airbag/SRS system. It is the time it takes the airbag/SRS system to become inert after powering down the low voltage system by shutting off a vehicle's ignition and disconnecting the 12V (auxiliary) battery. See also High Voltage Drain Down Time.

3.6 FIRE

The emission of flames from a battery (approximately more than one second). Sparks are not flames.

3.7 ELECTRICAL PPE

See Personal Protective Equipment.

3.8 EMERGENCY FIELD GUIDE

A quick reference guide summarizing multiple OEM Emergency Response Guide information for easy access in the field.

3.9 EMERGENCY RESPONSE GUIDE

Summary of steps to perform in emergency situations involving a vehicle or hazardous materials.

NOTE: There is a hazardous materials ERG independent of ERG's produced by automotive OEM's.

3.10 FIRST RESPONDERS

Include but not limited to fire department, rescue squads, emergency medical, law enforcement, and in some instances military where the personnel are trained in assessing and treating injuries.

3.11 GVWR

Gross Vehicle Weight Rating.

3.12 HAZARDOUS MATERIALS

Goods that can harm persons, property, or environment and specified by law for identification, packaging for transport, use, storage, and/or disposal. (also known as, hazmat or dangerous goods).

3.13 HIGH VOLTAGE DRAIN DOWN TIME

Refers to the discharge time for any reserve energy within segments of the vehicle high voltage system. It is the time it takes a segment of the high voltage system to fall below the level of high voltage after sources of high voltage energy are disconnected from the system. See also Drain Down Time.

3.14 HIGH VOLTAGE SYSTEM

A vehicle system inclusive of the battery system and high voltage components (e.g., inverter modules, high voltage cables, etc.) powered by the battery system.

3.15 LEAKAGE

The visible escape of electrolyte or other liquids from a cell or battery system. (Derived From J2950).

3.16 LI-ION

Lithium-ion battery or cell.

3.17 MANUAL DISCONNECT

Manual Disconnect (MD) is a device in any type of electric vehicle which opens the primary high voltage circuit or circuits of the vehicle, and that is only activated by non-automatic means.

3.18 MARKER

Describes a durable emblem, insignia, or label securely affixed on an interior surface within the passenger compartment of the xEV.

3.19 MOBILE APPLICATION

Software that runs on a smart phone, mobile phone, tablet, or portable device. Also referred to as Mobile Apps.

3.20 MSDS

Material Safety Data Sheet.

3.21 MOBILE DATA TERMINAL

Mobile electronic device such as a laptop or tablet computer mounted in emergency responder vehicle such as a fire apparatus, ambulance, truck or patrol car.

3.22 NATFC

National Alternative Fuels Training Consortium.

3.23 NiMH

Nickel Metal Hydride battery or cell.

3.24 ON-BOARD DIAGNOSTICS

Refers to a vehicle's self-diagnostic and reporting system.

3.25 PERSONAL PROTECTIVE EQUIPMENT

Any of various safety equipment that workers wear or use to prevent injury when working around hazards, such as high voltage electrical energy, chemicals, and/or fire.

3.26 RESPONSIBLE ORGANIZATION

The organization which is responsible for providing emergency response information. Examples are vehicle, battery system manufacturers, or third party suppliers of aftermarket conversion(s) including do-it-yourself conversions.

3.27 RUPTURE

The mechanical failure of a cell container or battery case induced by an internal or external cause, resulting in exposure or spillage but not ejection of solid materials.

3.28 SECOND RESPONDERS

Include but not limited to tow/recovery personnel, vehicle storage operators, repair/ service technicians, dismantlers and auto salvage personnel.

3.29 SMARTPHONE

A cellular telephone with built-in applications and Internet access. In addition to digital voice service, modern smartphones provide text messaging, e-mail, Web browsing, still and video cameras, MP3 player and video playback and calling. In addition to their built-in functions, smartphones run myriad free and paid applications, turning the once single-minded cellphone into a mobile personal computer. (From PC Magazine Encyclopedia, http://www.pcmag.com/encyclopedia_term/0,2542,t=Smartphone&i=51537,00.asp)

3.30 SUBJECT MATTER EXPERTS

An individual who is experienced in a specific area or topic and offers in depth knowledge.

3.31 SRS

Supplementary Restraint System (SRS) is the passive vehicle occupant safety systems in a vehicle (e.g., airbags) which supplement the use of seat belts.

3.32 TELEMATICS

Technology of sending and receiving information via telecommunication devices in vehicles.

3.33 VENTING

The release of excessive internal pressure from a Battery System cell, module or pack in a manner intended by design to preclude rupture or explosion.

3.34 xEV

Any electrified propulsion vehicle with a high voltage system, including but not limited to HEV, PHEV, PEV, BEV, FCEV, and EV.

3.35 TERMINOLOGY

The following shall apply to the use of these words:

Shall - "Shall" is to be used wherever the criterion for conformance with the specific recommendation requires that there be no deviation. Its use shall not be avoided on the grounds that compliance with the SAE Technical Report is considered voluntary.

Should - "Should" is to be used wherever noncompliance with the specific recommendation is permissible. "Should" shall not be substituted for "shall" on the grounds that compliance with the SAE Technical Report is considered voluntary.

4. RECOMMENDATIONS FOR XEV EMERGENCY RESPONSE GUIDES (ERG)

4.1 ERG Background

Manufacturer provided information and guidance to first and second responders varies greatly between manufacturers and often not used in the field due to complexity. A summary of issues and known alternatives are captured in APPENDIX B – PRO AND CON ANALYSIS OF EXISTING EMERGENCY RESPONSE GUIDES.

4.2 ERG Summary

There are many existing methods of communicating emergency hazards to responders, including OEM manuals, rescue cards or sheets, emergency field guides, mobile applications, and database systems. These multiple solutions bring unique attributes but lack consistency in format and content for the responder communities.

OEM manuals cover many of the necessary areas required for responders, but they vary in style and content from manufacturer to manufacturer. The text is often written from an engineering and technical mindset, rather than from a responder's point of view.

Rescue cards and emergency field guides attempt to summarize the essential information from OEM manuals. However, there are no universal standards and are largely a voluntary activity.

Mobile apps, while convenient and sometimes free, are too limited in scope (not enough vehicles, not updated frequently enough, lacking vehicle-specific disabling procedures) to be of much use at this time, but the concept of a free or very inexpensive mobile app needs to be considered (Note, Moditech iCRS Lite and upcoming NFPA EFG App may fill this space.)

Some commercially available apps and software currently cost hundreds or thousands of dollars (US). The cost for such information should be minimal, as many departments, especially rural and volunteer fire departments simply do not have the funds to purchase expensive systems.

A quick reference solution should also be comprehensive in the topics it addresses, and should include information on fire suppression, submersion, damaged HV battery hazards, etc. The NFPA Emergency Field Guide (EFG) (reference APPENDIX K - SAMPLE OF NFPA EMERGENCY FIELD GUIDE) does this well, but lacks standardized graphics. The EFG uses manufacturer graphics which are sometimes two dimensional, three dimensional, or even pictures of vehicles. The graphics also vary in that they are presented in color, black and white, or gray-scale.

There is not currently an ideal solution for a common set of information for emergency responders that exists. As a result, the task force recommends a blended solution taking the best parts of several solutions. The recommendation is to effectively summarize information, include relevant information (i.e., fire suppression, submersion hazards), distribute information in multiple platforms, standardized graphics and icons, consult with first and second responders, and consider low cost solutions. The ERG should be made available in one common format, such as a portable document file (PDF), and allow the user to repurpose.

4.3 ERG Recommendations

Emergency response guides need to provide information that can be summarized efficiently and be specifically tailored to first and second responders in the field. Below are specific recommendations to facilitate this goal.

4.3.1 Quick Reference Sheet (QRS)

A quick reference sheet (preferably one sheet, front and back) of the ERG should be made readily available as a supplement. This would allow easy adoption into third party smart apps and field guides to facilitate distribution. At a minimum, this quick reference sheet should contain the following information:

a. High voltage system component locations (per 4.3.2)
b. Supplemental Restraint System (SRS), including air bag inflators, and high strength steel locations.
   NOTE: SRS and High strength steel are not specific to xEVs, but are key information for any rescue sheet.
c. A minimum of two High Voltage/SRS disabling procedures (per recommendations of 6.3) with supporting diagrams as necessary (e.g., if a fuse is to be pulled, include a diagram of the fuse box indicating which fuse will be pulled).
d. Any special considerations for the particular vehicle (For example, fire extinguishment, tow & recovery, submersion, etc.).
e. Responsible organization contact information (For example, phone number and/or a website for further information).
f. For vehicles that do not meet the identification criteria listed in Section 5, then identification cues for responders should be included.

4.3.2 Standardized Graphics

Manufacturers should adopt a standardized set of graphics and icons to represent vehicle hazards, including high voltage systems, and component locations.

a. A top and side view representative of the vehicle should be utilized, similar to that utilized in the German standard rescue card (reference APPENDIX J - SAMPLE RESCUE CARDS, AS PROMOTED BY ADAC AND FIA FOUNDATION). Avoid overly-complicated graphic solutions such as 3D-style drawings or images. Consensus is that there is little value added and they may actually be too complex for fast, easy use on-site.
b. High voltage system components should be illustrated in a bright orange color and the vehicle body/chassis and non-essential components should be illustrated in a neutral color such as gray or black.

4.3.3 Consultation with Responders

First and second responders should be consulted to ensure OEM recommendations are useable. (For example: Terminology should be catered to first responders, not technicians).

5. RECOMMENDATIONS FOR XEV IDENTIFICATION

xEVs involved in unplanned events such as mechanical breakdowns, collisions, and vehicle fire scenarios can present new hazards associated with the stored energy in the vehicle's high voltage system. These hazards include potential injuries from chemical, electrical, and thermal exposure to members of the emergency responder community. Other incidents such as garage structure fires and flooding/water submersion may also present risks to these responders when an xEV is involved.

A standardized xEV identification methodology is necessary to help protect first and second responders including fire, rescue, emergency medical, law enforcement, tow and/or recovery, storage, repair, and salvage personnel during and after an unplanned incident of an xEV.

5.1 xEV Identification Background

During the development of the identification of xEV recommendations, there was significant amount of information studied. This supporting information is included under the Appendix section of this document. These appendices include:

APPENDIX A - BASELINE SCENARIO VALIDATION

This document analyzes crash statistics for vehicles and the response scenario involving an xEV.

APPENDIX C - FIRST RESPONDER ACTIVITIES AT HYBRID AND ELECTRIC VEHICLE COLLISION EVENTS

This document serves to list typical First Responder activities at hybrid and electric vehicle collision events. The information is based on a realistic timeline from initial summoning of these responders through their arrival and subsequent activities at a collision incident involving a hybrid or electric plug-in vehicle.

APPENDIX D - FIRST RESPONDER ACTIVITIES AT HYBRID AND ELECTRIC VEHICLE FIRE EVENTS

This document serves to list typical First Responder activities at hybrid and electric vehicle fire-related events. The information is based on a realistic timeline from initial summoning of responders through their arrival and subsequent activities at the vehicle fire incident.

APPENDIX E - FIRST RESPONDER ACTIVITIES AT HYBRID AND ELECTRIC VEHICLE SUBMERSION EVENTS

This document lists typical First Responder activities at hybrid and electric vehicle events when the vehicle is partially or fully submersed in water. This may involve still or moving body of water such as a pond, lake, or river as well as a vehicle caught in a flash flooding situation.

APPENDIX F - CURRENT STATUS OF EXTERIOR BADGING (2012)

This document lists some of the 2012 model year exterior badging names used by electric and hybrid passenger vehicles.

APPENDIX G - EXISTING EXTERIOR BADGING SIZE SUMMARY

This document summarizes sizes of existing rear badging of 82 vehicles and was used to justify the recommended height for the exterior badging of xEVs.

APPENDIX H - EXAMPLES OF EXISTING HYBRID AND ELECTRIC VEHICLE IDENTIFICATION SYSTEMS

This document provides some examples of hybrid and electric vehicle identification systems reviewed by the task force. .

APPENDIX I - EXAMPLES OF 2012 BADGING COMPLAINT WITH EXTERIOR BADGING RECOMMENDATIONS

This document presents several visual examples of existing 2012 Badging that would be considered compliant with the recommendations for exterior badging specifications.

5.2 xEV Identification Summary

xEV identification is necessary to provide first and second responders with information to clearly, accurately, and reliably determine that a given vehicle encountered at an unplanned incident (collision, fire, water submersion, etc.) contains a high-voltage system. Furthermore, the identification should be standardized, consistent, and reliable on exterior and/or interior locations on a passenger vehicle under 10 000 lbs (4536 kg) GVWR where manufacturers will visually identify that a given vehicle is an xEV.

Finally, the identification should be clearly recognizable as an xEV badge by an approaching responder from a distance of 50 feet. When first responders arrive at a highway incident, they size up the vehicle as they approach the scene. This scan of the scene for clues is done from a moving vehicle and having the lettering of a size to be read from 50 feet (15 meters), allows for this to be visible without having to be in a close proximity to the vehicle. Specifically for fire firefighters responding to a vehicle fire, a standard length of hose is 50 feet (15 meters), and that is a common distance firefighters and fire apparatus stage from a burning vehicle while preparing to advance and suppress the fire. From “Fundamentals of Firefighter Skills” (Jones and Bartlett, page 638) it states “Using the reach of the 1-3/4” hose, start approximately 50 feet from the car….”. Utilizing this standard will allow for this information to be readily available to any responder approaching the scene, and not rely on it having to be restated by those who arrived earlier. NFPA 704, chapter 9, ‘Identification of Materials by Hazard Rating System’ specifies a one inch text height to legibly identify a hazard from a distance of 50 feet (15.2 meters). This text height also appears to be a common height utilized today by OEM’s in rear badging (reference APPENDIX G - Existing Exterior Badging Size Summary). For these reasons, a 1” (25mm) exterior badge height is expected, in most cases, to provide adequate information to a first or second responder approaching the vehicle. (Note: while NFPA 704 standard supported the derivation of the 1" character height, no other requirements from that document are implied to be required to comply with SAE J2990.)

5.3 xEV Identification Recommendations

The initial and most important means of identifying that a vehicle contains high voltage systems for first or second responders arriving at an unplanned incident should be through the use of compliant hybrid or electric vehicle badges placed at standardized and consistent locations on the exterior of the xEV.

Manufacturers should identify the presence of an xEV in one of two methods:

1. A minimum of three (3) badges identifying the vehicle as an xEV shall be placed at standardized and consistent exterior locations on the vehicle, or

2. A minimum of one (1) exterior vehicle badge shall be placed in a prescribed exterior, rear location on the xEV and a minimum of one additional interior hybrid or electric vehicle marker shall be located in prescribed locations within the passenger compartment of the xEV.

5.3.1 Exterior Badging Locations

When the manufacturer desires to utilize three (3) exterior xEV badges, these three locations shall include:

1. One compliant xEV badge at an exterior location on the right, rear surface of the vehicle, such as the trunk, hatchback, or liftgate, but not on the bumper, so as to be clearly visible upon approach to the rear of the xEV. Note, the right rear location was chosen to provide first responders one consistent location for training, unlike other locations where placement is more flexible to suit OEM marketing needs and desires.

AND

2. Two compliant xEV exterior badges, one on each side of the vehicle. One on the left side and one on the right side of the vehicle such as the front fender, front door panel, or roof pillar trim, that allows the xEV badging to be clearly seen upon approaching either the left or right side of the xEV.

Additional xEV exterior badging is acceptable on the front surface of the vehicle as well as at additional exterior locations as desired by the OEM.

5.3.2 Exterior Badging Design

Parameters for the visual content of the exterior badging are defined, taking into account the needs of OEMs to effectively and creatively market their vehicles to the consumer as well as conformity and consistency in communicating the presence of an xEV to both first and second responders.

For exterior badging to consistently and reliably deliver its safety-oriented message to first and second responders, all required xEV exterior badging should clearly contain in its design one of the following:

1. the word ‘HYBRID’,
2. the word ‘ELECTRIC’, or
3. the letters ‘EV’

Combinations of words and letters with items listed above are allowed. For example: ‘PLUG-IN HYBRID’, ‘PHEV’, ‘BEV’ as exterior badging design elements would comply with the above recommendation.

The exterior badging system height should be a minimum 1 inch (25 mm) tall (per NFPA 704, chapter 9) and may incorporate colors, designs, fonts, or shapes as desired by the OEM. For vehicles where xEV badging height is less than 1 inch, the badging should be no smaller than the largest letters used in other exterior vehicle identification.

In lieu of the above designs, an OEM desiring to identify the exterior of their xEV for first and second responders may use a unique symbol, word or name plate as their exterior badging. Unique name plates are permitted as long as vehicle name is not used on any other vehicle with a propulsion system that is not an xEV. Examples of unique vehicle names currently used include Chevrolet ‘Volt’ and Nissan ‘Leaf’. Prior to use of a unique xEV exterior badging, the OEM should validate the first and second responder community’s human factors comprehension of said unique xEV name plate or badging as indicating a hybrid or electric vehicle as per SAE Standard J2830 or ISO 9186-1:2007. Unique xEV nameplates shall be on the rear of the vehicle as specified in 5.3.1, however the unique nameplate should not be restricted to the right rear location.

The unique xEV nameplate or exterior badging design height should be a minimum 1 inch (25 mm) tall and may incorporate colors, designs, fonts, or shapes as desired by the OEM. For vehicles where xEV badging height is less than 1 inch, the badging should be no smaller than the largest letters used in other exterior vehicle identification.

5.3.3 Interior Passenger Compartment Marker Locations

It is recommended that in the case when only one exterior xEV badging is provided, an interior xEV marker is also required. First responders are trained to recognize the importance of turning OFF the ignition system of any vehicle involved in a collision or other unplanned event. Therefore, the interior marker on the xEV should be a durable emblem or insignia securely affixed at a location visible from the driver or passenger window near the key ignition switch or the Start or power button on the instrument panel, console, or steering column. This interior marker should be as readily identifiable both when the vehicle is powered ON and when the vehicle is powered OFF.

An alternate location for the required interior xEV marker is on one side/surface of the driver's sun visor if said location allows conformance with applicable FMVSS 208 Standard or similar regulations.

5.3.4 Interior Marker Design

In order for the interior xEV marker system to consistently and reliably deliver its safety-oriented message to first and second responders, it is recommended that all required xEV interior markers clearly contain in its design one of the following examples:

1. the word 'HYBRID',
2. the word 'ELECTRIC', or
3. the letters 'EV'

Combinations of words and letters with items listed above are allowed. For example: 'PLUG-IN HYBRID', 'PHEV', 'BEV' as components of an xEV interior marker would comply with the above recommendation.

Words or letters utilized in the design of the interior marker should be a minimum height of the largest letter on the instrument panel, console, or steering column where marker is located and may incorporate colors, designs, fonts, or shapes as desired by the OEM.

In lieu of use of the above designs, an OEM desiring to identify the interior of their xEV for first and second responders may utilize a unique symbol, word or name plate as their interior marker. Unique name plates are permitted so long as said vehicle name is not utilized on any other vehicle with a propulsion system that is not an xEV type of system. Examples of unique vehicle names currently used include Chevrolet 'Volt' and Nissan 'Leaf'. Prior to use of a unique xEV name plate as the interior marker, the OEM should validate the first and second responder community's human factors comprehension of said unique xEV name plate and marker as indicating a hybrid or electric vehicle as per SAE Standard J2830 or ISO 9186-1:2007.

An example of an interior marker design that could be considered would be an ISO icon triangle with lightning bolt on a yellow background as shown in Figure 1.

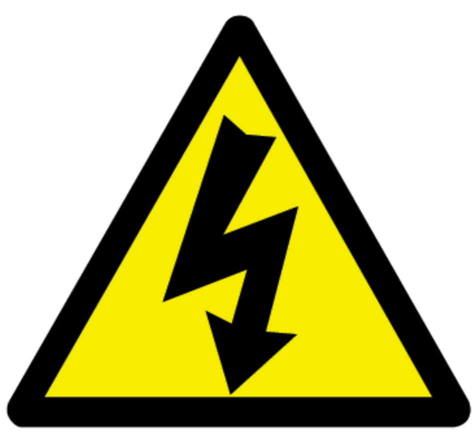


FIGURE 1 - EXAMPLE OF A UNIQUE MARKER

6. RECOMMENDATIONS FOR XEV HIGH VOLTAGE (HV) SYSTEM DISABLING

6.1 HV System Disabling Background

In order to achieve energy efficiency goals, xEVs frequently have multiple components that need high voltage power during normal operation. These components are generally distributed around the vehicle based on various design constraints, such as their required interactions with other systems or devices.

For xEVs involved in an impact or some other form of incident, it is desirable to have methods of limiting the number of components containing high voltage. This would serve to reduce the probability that a first responder or other person is inadvertently exposed to high voltage while simultaneously reducing the probability that high voltage might induce secondary events after the initial incident.

6.2 HV System Disabling Summary

This section describes multiple methods that vehicle designers can incorporate into xEVs to allow automatic or manual disabling of the high voltage systems after a vehicle impact or other vehicle incident. Because of the possibility of the impact causing damage to some of the disabling circuits it is recommended that designers incorporate two or more of these methods into the design of an xEV.

It should be noted that these methods generally do not completely remove high voltage from the vehicle. The intent of performing these HV shutdown procedures is not to eliminate HV but rather to limit its distribution around a vehicle.

6.3 HV System Disabling Recommendations

6.3.1 HV System Design Considerations for First Responder

Vehicle OEMs should provide a minimum of two methods of initiating the disconnection of the propulsion system from high voltage sources on xEVs. Responders should realize that these methods are only intended to cover the disconnection of high voltage; they <u>may</u> or <u>may not</u> simultaneously remove the vehicle's 12V, 12V components or other non-high voltages from the vehicle. Also consider that these other vehicle systems are simultaneously disconnected or de-energized, these other systems may not be disconnected or de-energized in the timeframe given below for the high voltage components.

To comply with this recommendation for high voltage disconnection, the following methods of initiating the disconnection are allowed (listed in order of preferred sequence):

1. Automatic shutdown of the high voltage system based on the detection of a prescribed level of vehicle impact that might damage the high voltage system or that activates the vehicle's SRS. Assuming no damage to the shutdown circuits, this method should disconnect the high voltage system and discharge the propulsion side of the automatic disconnect to less than or equal to 60 volts for DC buses or 30 volts for AC buses within the time period recommended by SAE J1766, 4.4.3.1.
2. Switching the xEV's ignition switch or power button to the OFF position and assuming no damage to the shutdown circuits or high voltage discharge circuits. This method should disconnect the high voltage system from the high voltage sources and discharge the high voltage system to less than or equal to 60 volts for DC buses or 30 volts for AC buses within 10 minutes of being initiated.

NOTE: To prevent unintended reactivation of the ignition switch or power button, if the vehicle has a key-FOB that could reactivate the high voltage system the FOB should be moved at least 5 meters from the vehicle.

3. Either cut or disconnect both the negative and positive 12V battery cables to discharge the 12V system and also cut or disconnect the DC/DC converter's 12V output cable. Some OEM designs may not require the DC/DC cables to be cut or disconnected to disable the high voltage system and the SRS system. In these cases, only the 12V battery cable needs to be disconnected. Assuming no damage to the shutdown circuits, this method should disconnect the high voltage system from the high voltage sources and discharge the high voltage system to less than or equal to 60 volts for DC buses or 30 volts for AC buses within 10 minutes of being initiated.

DESIGN NOTE: If the OEM shutdown procedure requires cutting the 12V battery cables and/or DC/DC converter cable, labels should be provided to give an indication of the cable cut location(s).

DESIGN NOTE: OEMs should consider first-responder access when packaging the cables suggested to be cut or disconnected. To facilitate easy identification OEMs should make cut-points close to the 12V supplying components and should also label the suggested cut points or disconnection points.

4. Removing the manual disconnect (MD) should not be one of the primary methods for first responders to disable the vehicle's high voltage circuits. Because there are a variety of MD designs, as well as MD mounting locations, it is often not time efficient for first responders to locate and activate the MD. Furthermore, first responders do not always have the Personal Protective Equipment (PPE) that may be required to activate the MD. Finally, the MD may not be accessible because of impact damage or because vehicle cargo may block access.

6.3.2 MD Design Considerations for First Responder

If the OEM does utilize the removal of the manual disconnect as a method for first responders to disable high voltage, the following manual disconnect design requirements should be met:

1. Activation of the MD should not require electrical PPE (e.g., high voltage electrical gloves) although it should be designed to be accessible by a gloved hand, where glove sizes are defined in *NFPA 1971: Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting.*
2. Activation of the MD should not expose the first responder to arch flash assuming the MD was not damaged and that the activation is performed in the correct sequence.
3. The MD should be colored orange for consistent identification across OEMs.
4. Tools should not be required to access or activate, unless that tool is part of the vehicle or the MD. When a tool is required, the tool should be clearly visible near the MD or instructions provided at the MD where to locate the tool.
5. Assuming no damage to the shutdown circuits, this method should disconnect the high voltage system from the high voltage sources and discharge the high voltage system to less than or equal to 60 volts for DC buses or 30 volts for AC buses within 10 minutes of being initiated.
6. Due to the variety of MD designs noted above, the MD should have an illustrated label on or near the MD that shows the steps for removal or disconnect.

NOTE: Relative to the Manual Disconnect, to comply with the recommendations of SAE J2929, section 4.13.2 the vehicle OEM may decide to have a high voltage shutdown time of within 5 seconds of the manual disconnect being actuated.

6.3.3 MD Design Considerations for Second Responder

If the OEM recommends that second responders remove the manual disconnect the following manual disconnect design requirements should be met:

1. Activation of the MD should be designed to be accessible by a hand in a leather work glove or in recommended OEM PPE. Activation of the MD should not expose the responders to arch flash assuming the MD was not damaged and that the activation is performed in the correct sequence.
2. The MD should be colored orange for consistent identification across OEMs.
3. Non-standard tools should not be required to access or activate, unless that tool is part of the vehicle or the MD.
4. Assuming no damage to the shutdown circuits, this method should disconnect the high voltage system from the high voltage sources and discharge the high voltage system to less than or equal to 60 volts for DC buses or 30 volts for AC buses within 10 minutes of being manually initiated.

7. RECOMMENDATIONS FOR HIGH VOLTAGE VEHICLE INSPECTION PROCESS POST-INCIDENT

7.1 Background

Inspection of high voltage vehicles post-incident is necessary to ensure the high voltage electrical system has properly shut down and the battery system has not been damaged. A two-stage inspection of these vehicles, one at the incident scene and a second at the storage site post incident, is recommended. At the incident scene, inspection is limited due to time constraints, accessibility and availability of high voltage personal protective equipment (PPE). For this reason, a series of initial inspection steps by the tow driver and / or first responders is recommended prior to removing the vehicle from the incident scene. A second inspection process is recommended once the vehicle has been delivered to a repair shop or storage facility where time and resources are more readily available.

The initial inspection process, described in 7.3, is to provide reasonable diagnostics to be used by first responders and tow personnel to determine if a vehicle exhibits a safety risk without the need for high voltage training or specialized tools. This initial inspection process relies on visual, audible and olfactory senses for indications of problems within the high voltage system and limits the use of specialized tools. This initial inspection should be completed at the incident scene.

If possible, it is highly recommended that within 24 hours of unloading a high voltage vehicle post-incident, a second inspection, possibly requiring high voltage training and specific tools, should be completed as identified in both 7.4 and 7.5. When a damaged xEV arrives at a storage facility post incident, the vehicle should be secured in a well-ventilated and isolated storage area, as described in 7.2.2, until the vehicle has completed a full inspection and it has been determined that the high voltage system is not significantly damaged. During and after isolation, a placard or some other identifier should be placed on the roof and hood of the vehicle to identify and warn others it is a high voltage vehicle with suspect damage. The OEM or responsible organization, as appropriate, should be contacted to determine additional inspection and diagnostic steps prior to removing the vehicle from isolation.

7.2 Summary

7.2.1 Potential Hazards of Damaged xEVs

xEVs with damaged high voltage systems may pose hazards during transit or during storage. These hazards may include loss of electrical isolation, exposure to potentially toxic materials and/or vapors, and potential vehicle / battery fires. (It should be noted that fires involving high voltage batteries resulting in damaged high voltage systems, may reignite days later if sufficient energy remains stored in the battery). Because of these potential hazards, the vehicle should remain isolated until after the vehicle has passed inspections specified in 7.4. Tow operators, facility personnel and vehicle owners should be made aware of these risks when towing and storing a damaged xEV per the inspection steps listed in 7.3 below. The tow operator should make arrangements to tow the vehicle directly to a suitable offsite location where the vehicle can be isolated per the recommendations in 7.2.2.

7.2.2 Damaged xEV Storage Isolation Recommendations

xEVs that have sustained (or suspected) damage to the high voltage system should not be stored inside a structure until inspected per 7.4. During isolation, vehicle windows and / or doors should be opened sufficiently to allow ventilation in the vehicle and prevent build-up of potentially flammable gasses from a damaged battery system. For xEV's where the battery system is ruptured, vehicle exposure to elements such as rain should be avoided. The following methods are allowed for isolating a damaged xEV:

1. Open Perimeter Isolation: An area where the vehicle is separated from all combustibles and structures by a distance of not less than 50 feet (15.2 meters) from all sides of the vehicle/battery system. Per the recommendation provided by NHTSA (reference DOT HS 811 574, 'Interim Guidance for Electric and Hybrid Electric Vehicles Equipped with High Voltage Batteries').

2. Barrier Isolation: An area where the vehicle is separated from all combustibles and structures by a barrier constructed of earth, steel, concrete, or solid masonry designed to contain a fire from a stored vehicle from extending to adjacent vehicles. Barriers should be of sufficient height to direct any flame or heat away from the adjacent vehicles. If the barrier is provided only on 3 of the 4 sides of the vehicle, then the open side must maintain the separation distance as referenced above for the open perimeter isolation. It is not recommended to fully enclose the vehicle in a structure due to the risk of a post-incident fire extending to the structure and the possibility of trapped explosive or harmful gasses, therefore a roof is not recommended for the barrier construction.

7.3 Initial Damaged Vehicle Determination at Scene of the Incident

The following inspection steps are intended to ensure that the damaged xEV does not pose a greater than normal risk than that of a non-xEV and to highlight precautions if a greater risk is identified. It should be noted that fires involving high voltage batteries resulting in damaged high voltage systems, may reignite days later if sufficient energy remains stored in the battery. The following inspection steps are to be completed by each chain of command at the scene of the vehicle incident before relinquishing control of the vehicle. The tow operator should conduct the inspection steps prior to loading the vehicle.

7.3.1 Active Fire or Smoldering

Vehicle should be inspected for signs of fire including flames, smoke, arcing, or hot spots. A thermal camera or IR temperature probe may be useful to identify hot spots. If signs of fire are noted, then the local fire department should be notified immediately and if possible, the area around the vehicle should be cleared and vehicle doors should be opened if unlocked to avoid build-up of gasses. Once stabilized, the inspection process should be restarted. If no evidence of fire or smoldering is noted, then proceed to 7.3.2.

7.3.2 Evidence of an Unstable Battery System

If gurgling, bubbling, crackling, hissing or popping noises are heard from the battery system, then the local fire department should be notified immediately and, if possible, the area around the vehicle should be cleared and vehicle doors should be opened if unlocked to avoid build-up of gasses. These sounds can be indicative of cells venting from an overheated condition or arcing within the high voltage system. Once stabilized, the inspection process should be restarted. If no evidence of an unstable battery system is noted, proceed to 7.3.3.

7.3.3 Evidence of Battery Cell Groups Separated from Battery Enclosure

In extreme circumstances, if battery cell groups are seen separated from the battery enclosure, then responders should be alerted of the potential exposure to high voltage. The OEM or other responsible organization, as appropriate, should be contacted for OEM specific emergency response guide, packaging instructions and disposal recommendations. If sufficient information is not available, default to the 2012 or current version of the US Department of Transportation / Transport Canada Emergency Response Guidebook for lithium-ion (Guide 147) or NiMH (Guide 171) as appropriate.

In this rare circumstance, properly trained and equipped personnel for handling high voltage will be required to accomplish collection and proper disposal of the damaged battery and battery components. Separated battery parts should be individually collected and packaged in salvage packaging with non-conductive inner packaging and surrounded by a non-conductive and non-combustible, absorbent cushioning material (e.g., sand or vermiculite). SAE J2950 offers further recommendations for packaging of damaged battery systems.

Once separated battery parts are collected and high voltage isolation to the vehicle is verified (reference 7.5.2 of this document), high voltage PPE may be removed. Any leaked battery materials should be absorbed and collected for proper disposal per the safety data sheet or OEM specific emergency response guide. The tow driver and operator should be notified of potential hazards and recommendations from 7.2.1 above. Proceed to 7.3.4.

7.3.4 Ensure High Voltage System Disabled

The inspector should refer to the OEM ERG or an emergency field guide and verify the high voltage system has been properly disabled. If this information is not readily available, then, at a minimum, the 12V system should be disabled. Proceed to 7.3.5.

7.3.5 Battery System Mechanical Integrity

Examine the battery system for loss of mechanical integrity. Determine if the battery system enclosure is ruptured, cracked, punctured, or dented. If loss of mechanical integrity is identified, the tow driver should be notified of potential hazards and recommendations from 7.2 above. Proceed to 7.3.6.

7.3.6 Evidence of Fire or Heat Damage

Vehicle should be inspected for evidence of past fire events that had occurred around the battery system. These signs include smoke residue or heat damage around the battery system (for example melted plastic or carpet trim). Also a burnt odor emanating from the battery system may indicate internal fire damage to the battery system. If these or similar signs are noted, the tow driver should be notified of potential hazards and recommendations from 7.2 above. Proceed to 7.3.7.

7.3.7 Evidence of High Voltage System Damage

Vehicle should be inspected for evidence of arcing in the high voltage system such as carbon traces. These indicate that isolation of the high voltage system has/had been lost. The high voltage system should also be visually inspected for damage to orange cables and components. This damage might be pinched or lacerated orange cables and/or crushed inverter/converter modules. If these components appear damaged or arcing is noted, the tow driver should be notified of potential hazards and recommendations from 7.2 above. Proceed to 7.3.8.

7.3.8 Evidence of External Battery Leaks

Vehicle should be inspected to determine if leaks are from the battery system. (Note if the vehicle was submerged or extinguished with copious amounts of water, as these factors might explain the leakage.) If it is determined that the battery system is the source of the liquid (reference 7.3.8.1 below) or if the source is not determinable, the tow driver should be notified of potential hazards and recommendations from 7.2 above. Proceed to 7.3.9.

7.3.8.1 Battery leak symptoms

Lithium-ion battery electrolyte has a sweet ether-type odor associated with it and could indicate a battery leak. NiMH electrolyte is caustic and will be a strong base on the PH scale. It should be noted that engine or battery coolant using glycol will also be basic according to the PH scale. Contact the OEM for safety data sheets for the battery electrolyte in case of any spills. Safety data sheets should be referenced for proper PPE and disposal instructions.

It should be noted that the electrolyte stored in these batteries are, for the most part, absorbed by active materials and do not allow for significant amounts of external leaks, unlike the familiar flooded lead acid battery. Leaking electrolyte would normally occur in drops, not puddles.

7.3.9 Completed Inspection

After completing all inspection steps without issue, the high voltage vehicle is unlikely to pose a risk greater than that of a non-xEV after an incident. Control of the vehicle can now be relinquished and/or the vehicle can be loaded by a tow operator.

7.3.10 Vehicle Structure Integrity After Load

The vehicle should maintain structural integrity when loaded on a wrecker. If the vehicle rolls up on itself or loses integrity the inspection steps listed above in this section should be repeated to ensure damage has not occurred within the high voltage system.

7.4 High Voltage Vehicle Inspection Flow - Post Incident

In an isolated area (reference 7.2.2), the following inspection steps are to be followed to ensure the vehicle does not pose a greater risk than a non-xEV. Further inspection steps may be recommended by the OEM and they should be contacted prior to removing the vehicle from isolation. If all these steps are satisfactorily met, then the vehicle may be removed from isolation. It is important to locate and identify the battery and high voltage system in the vehicle prior to conducting the inspection. The responsible organization ERG or EFG typically provides this location.

The vehicle is to be marked and clearly identified as a high voltage vehicle during and after isolation to ensure persons are aware of the presence of a high voltage system and do not access the vehicle without proper training and PPE.

7.4.1 Active Fire or Smoldering

Vehicle should be inspected for signs of fire including flames, smoke, arcing, or hot spots. A thermal camera or IR temperature probe may be useful to identify hot spots. These signs may be visual or audible. If signs of fire are noted, then the local fire department should be notified immediately and, if possible, the area around the vehicle should be cleared and vehicle doors should be opened if unlocked to avoid build-up of gasses. When the fire has been extinguished, then a depower assessment per 7.9 should be completed, otherwise proceed to 7.4.2.

7.4.2 Evidence of an Unstable Battery System

If gurgling, bubbling, crackling, hissing or popping noises are heard from the battery system, then the local fire department should be notified immediately and, if possible, the area around the vehicle should be cleared and vehicle doors should be opened if unlocked to avoid build-up of gasses. These sounds can be indicative of cells venting from an overheated condition or arcing within the high voltage system. Once stabilized, a depower assessment per 7.9 should be completed.

If the sounds are not emanating from the battery system, but the battery is liquid cooled, a depower assessment per 7.9 should be completed, otherwise, proceed to 7.4.3.

7.4.3 Evidence of Fire or Heat Damage

Vehicle should be inspected for evidence of past fire events that had occurred around the battery system. These signs include smoke residue or heat damage around the battery system. Also a burnt odor emanating from the battery system may indicate internal fire damage to the battery system. If these or similar signs are noted, a depower assessment per 7.9 should be completed, otherwise proceed to 7.4.4.

7.4.4 Evidence of High Voltage System Damage

Vehicle should be inspected for evidence of arcing in the high voltage system such as carbon traces. These indicate that isolation of the high voltage system has/had been lost. The high voltage system should also be visually inspected for damage to orange cables and components. This damage might be pinched or lacerated orange cables and/or crushed inverter/converter modules. If these components appear damaged, the high voltage system needs to be disabled and secured to prevent enabling of the system prior to repair of the components. Contact the OEM or authorized service dealer for further information. Otherwise, proceed to 7.4.5.

7.4.5 Evidence of Vehicle Submersion

If it is determined that the vehicle was submerged in water, a depower assessment per 7.9 should be completed, otherwise proceed to 7.4.6.

7.4.6 Evidence of External Battery Leaks

Vehicle should be inspected to determine if any leaks are from the battery system. (Note if the vehicle was submerged or extinguished with copious amounts of water, as these factors might be explain the leakage.) If it is determined that the battery system is the source of the liquid (reference 7.4.6.1 below) or if the source is not determinable, the battery should be depowered per 7.9, otherwise proceed to 7.4.7.

7.4.6.1 Battery leak symptoms

Lithium-ion battery electrolyte has a sweet ether-type odor associated with it and could indicate a battery leak. NiMH electrolyte is caustic and will be a strong base on the PH scale. It should be noted that engine or battery coolant using glycol will also be basic according to the PH scale. Contact the OEM for safety data sheets for battery electrolyte in case of any spills. Safety data sheets should be referenced for proper PPE and disposal instructions.

It should be noted that the electrolyte stored in these batteries are for the most part absorbed by active materials and do not allow for significant amounts of external leaks, unlike the familiar flooded lead acid battery. Leaking electrolyte would occur in drops and not puddles.

7.4.7 Evidence of Internal Battery Leaks (For Liquid Cooled Battery Systems)

For liquid cooled batteries, the high voltage system should be inspected to ensure the cooling system is not leaking as this might indicate an internal leak inside the battery which could lead to short circuits or loss of high voltage isolation. If the battery system coolant reservoir is low, a depower assessment per 7.9 should be completed, otherwise proceed to 7.4.8.

7.4.8 Battery System Mechanical Integrity

Examine battery system for loss of mechanical integrity. Determine if the battery system enclosure is ruptured, cracked, punctured, dented or if broken pieces are separated from the battery system. If loss of mechanical integrity is identified, proceed to 7.5 for further vehicle and battery diagnostic steps. Otherwise proceed to 7.4.9.

7.4.9 Vehicle with Air Bags Deployed

If any of the vehicle airbags have deployed, this is evidence of a moderate to severe impact and further diagnostics are needed to determine high voltage system integrity. Proceed to 7.5 for further vehicle and battery diagnostic steps, otherwise proceed to 7.6.

7.5 Extended Vehicle and Battery System Diagnostics

CAUTION: The diagnostics in this section may require interfacing with the damaged vehicle. High voltage training, specialized tools, procedures and protective equipment may be required to perform these steps. Contact OEM or authorized service personnel for proper procedures and resources.

7.5.1 Battery Temperature

Measure the battery temperature via OBD or with a non-contact IR or thermal infrared camera to determine if the battery temperature continues to generate heat after removal from use; continued heat generation above ambient temperature indicates the pack is not stable and could develop further failures. The local fire department should be notified immediately and, if possible, the area around the vehicle should be cleared. When the temperature reaches ambient, a depower assessment per 7.9 should be completed, otherwise proceed to the next step.

7.5.2 High Voltage Isolation Faults

The battery system should maintain DC high voltage to ground isolation of not less than 100 Ω/V. Isolation measurement is to be performed in accordance with SAE J1766 procedure or per OEM recommended procedures. If isolation is less than 100 Ω/V, a depower assessment per 7.9 should be completed, otherwise proceed to 7.5.3.

7.5.3 Current Interrupt Faults

The battery system should be inspected to determine if any current interrupt devices such as fuses, breakers, etc. have been activated. When these devices are activated this could indicate a short or isolation fault in the high voltage system. If these devices are activated, it is recommended to contact the OEM for further instructions and guidance, as re-setting the device could cause more damage to the high voltage system. Otherwise, proceed to 7.5.4.

NOTE: Post-incident, most vehicles are designed to open the main contactors between the battery and the vehicle high voltage system isolating the stored energy in the battery system from the rest of the vehicle. This is normal and not considered a current interrupt fault for the purpose of this inspection step.

7.5.4 High Voltage System Diagnostic Trouble Codes (DTCs) Present

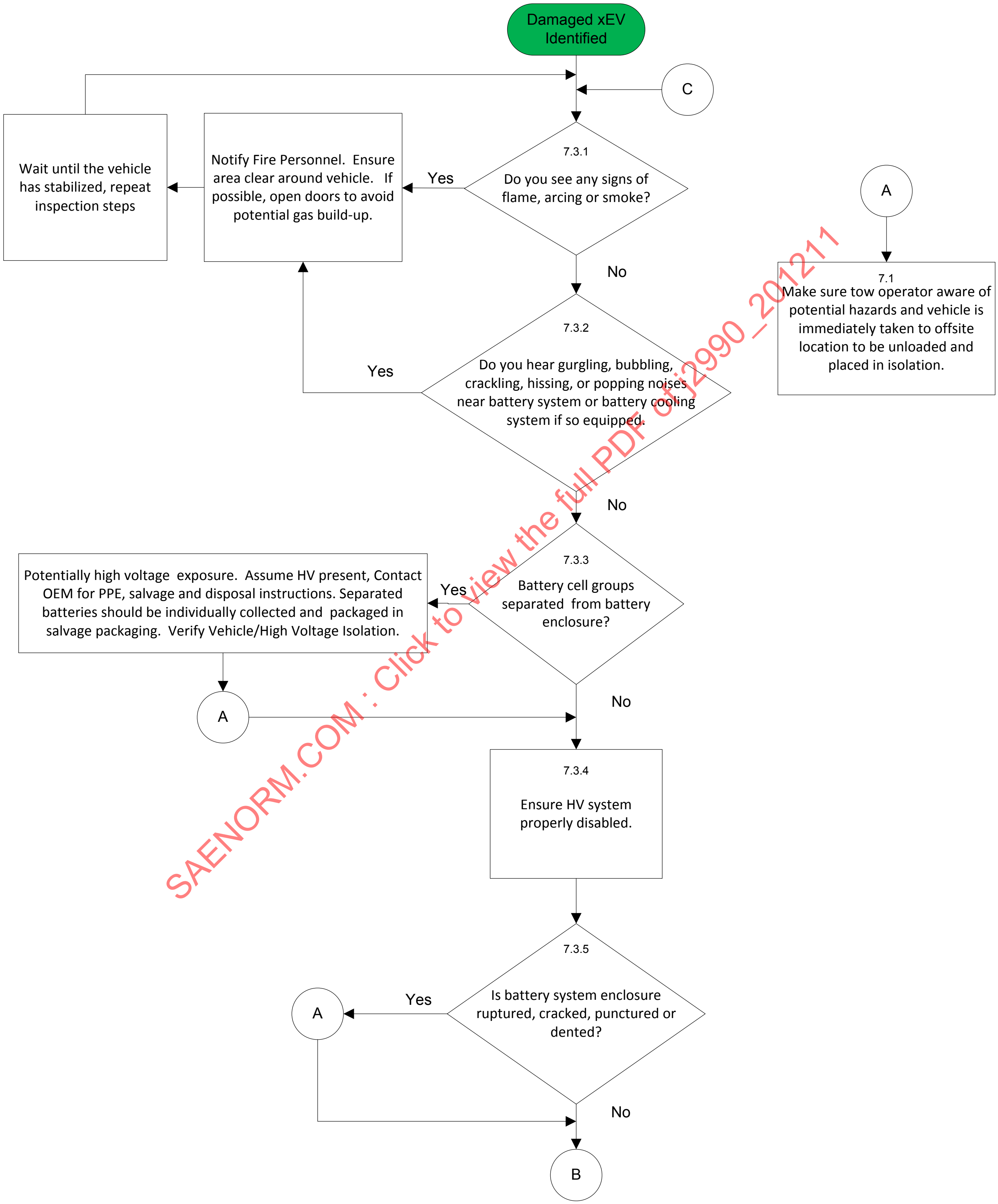
The vehicle and battery system should be interrogated for DTCs to see if any internal faults have been detected by the vehicle or battery control systems. The OEM or an authorized service dealer should be contacted for proper procedures and equipment to read these codes. Follow the OEM service procedures for any fault indicated, otherwise proceed to 7.6.

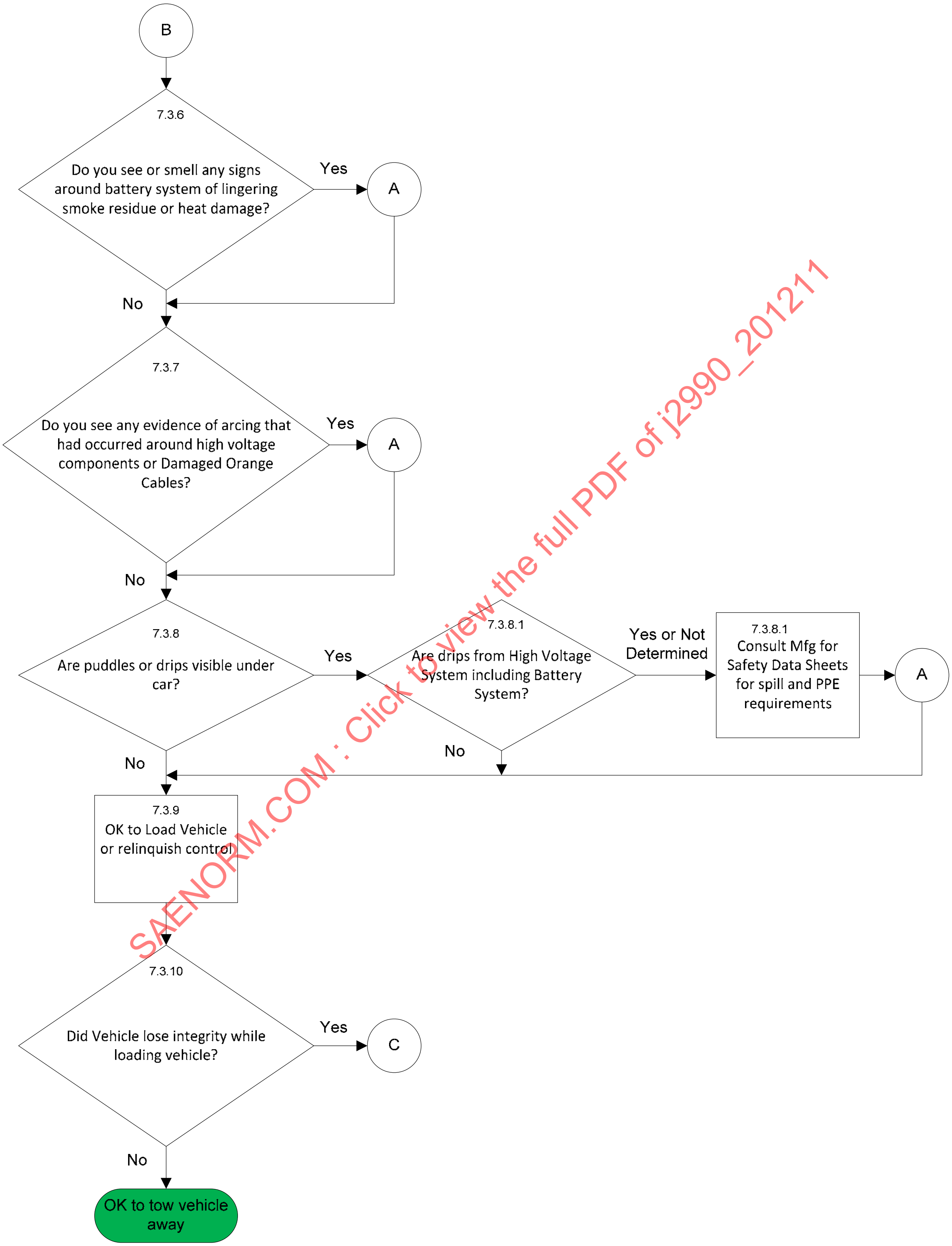
7.6 Completed Inspection

After completing all the inspection steps without issue, the vehicle is unlikely to pose a greater than normal risk than any other powered vehicle might after an incident. The vehicle can be removed from isolation, but still should be clearly and easily identifiable as a vehicle with high voltage present to prevent accidental exposure by unaware persons around the vehicle.

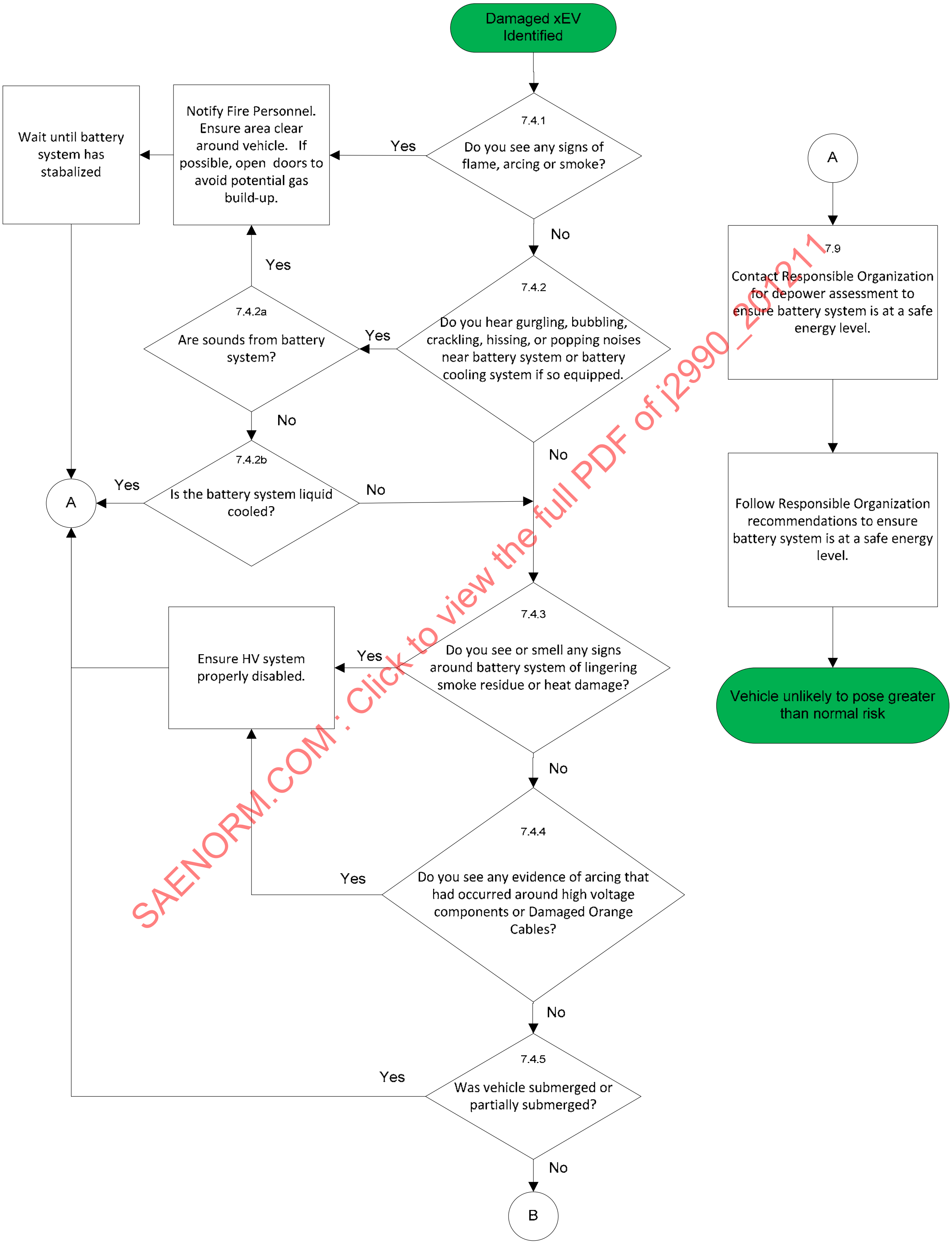
(The rest of this page is intentionally left blank)

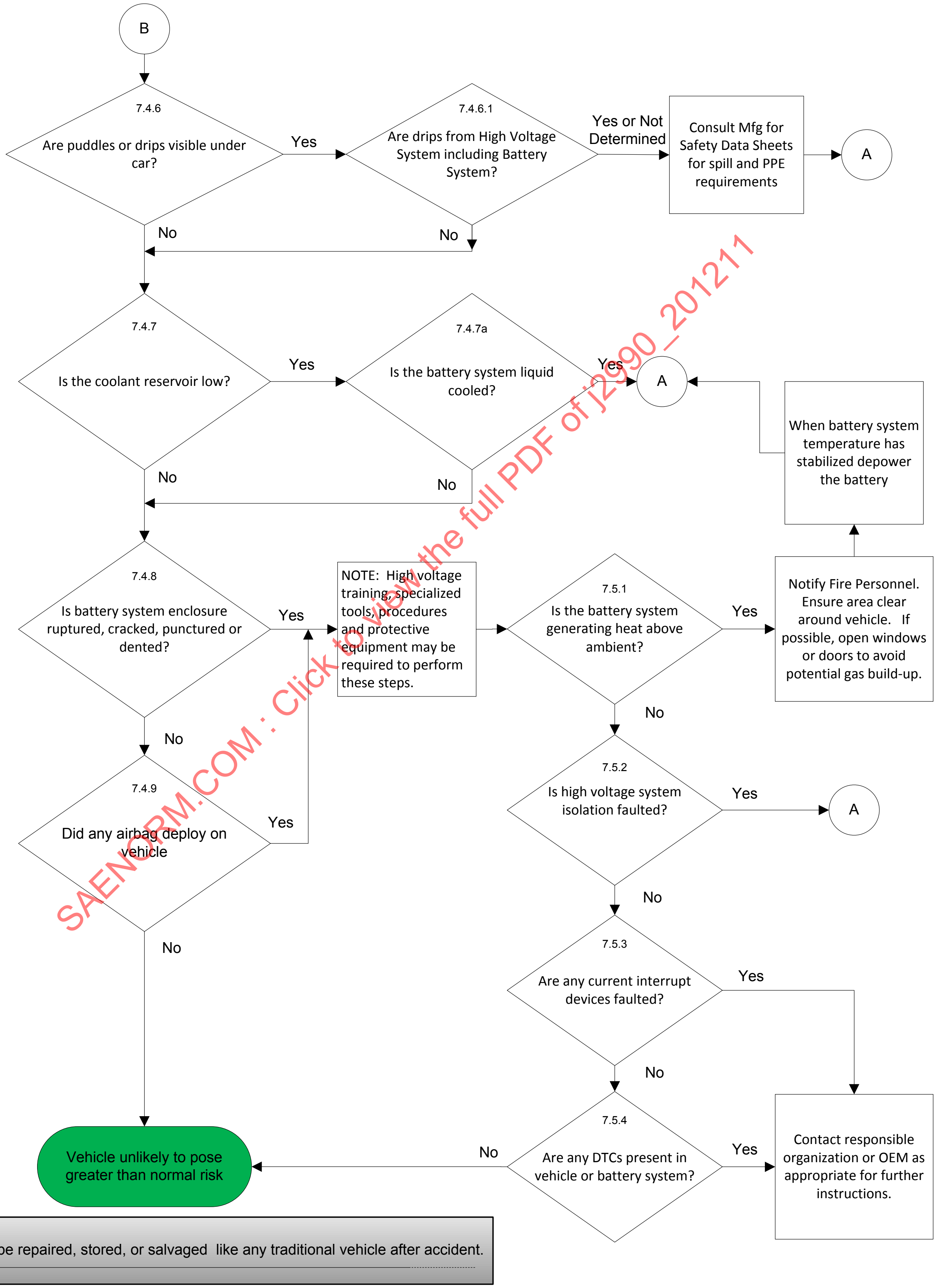
7.7 High Voltage Vehicle Inspection Flow Chart On Scene




B
7.3.6
Do you see or smell any signs around battery system of lingering smoke residue or heat damage?
Yes
A
No
7.3.7
Do you see any evidence of arcing that had occurred around high voltage components or Damaged Orange Cables?
Yes
A
No
7.3.8
Are puddles or drips visible under car?
Yes
7.3.8.1
Are drips from High Voltage System including Battery System?
Yes or Not Determined
7.3.8.1
Consult Mfg for Safety Data Sheets for spill and PPE requirements
A
No
No
7.3.9
OK to Load Vehicle or relinquish control
7.3.10
Did Vehicle lose integrity while loading vehicle?
Yes
C
No
OK to tow vehicle away

7.8 High Voltage Vehicle Inspection Flow Chart Post Incident




B
7.4.6
Are puddles or drips visible under car?
Yes
7.4.6.1
Are drips from High Voltage System including Battery System?
Yes or Not Determined
Consult Mfg for Safety Data Sheets for spill and PPE requirements
A
No
No
7.4.7
Is the coolant reservoir low?
Yes
7.4.7a
Is the battery system liquid cooled?
Yes
A
When battery system temperature has stabilized depower the battery
No
No
7.4.8
Is battery system enclosure ruptured, cracked, punctured or dented?
Yes
NOTE: High voltage training, specialized tools, procedures and protective equipment may be required to perform these steps.
7.5.1
Is the battery system generating heat above ambient?
Yes
Notify Fire Personnel. Ensure area clear around vehicle. If possible, open windows or doors to avoid potential gas build-up.
No
No
7.4.9
Did any airbag deploy on vehicle
Yes
7.5.2
Is high voltage system isolation faulted?
Yes
A
No
No
7.5.3
Are any current interrupt devices faulted?
Yes
No
7.5.4
Are any DTCs present in vehicle or battery system?
Yes
Contact responsible organization or OEM as appropriate for further instructions.
No
Vehicle unlikely to pose greater than normal risk
Vehicle should be repaired, stored, or salvaged like any traditional vehicle after accident.

7.9 Battery Depower Assessment

The responsible organization (such as the OEM), should specify a procedure to assess a vehicle post incident. (For example bring the vehicle to an authorized service dealer). Depending on the battery system damage, the responsible organization should recommend how to safely bring the battery system to an energy level where the battery system minimizes potential hazards.

The second responder should contact the responsible organization to seek further guidance to ensure the battery system is at a safe energy level. As a result of the responsible organization determination, depower instructions will be provided if necessary. The depower instructions should specify required training, equipment, and qualifications where applicable. In case the responsible organization performs the depower procedure, the depower instructions do not need to be provided to the second responder. The vehicle should remain in isolation until it is determined that the battery system is at a safe energy level where the vehicle is unlikely to pose a greater than normal risk.

7.10 Tow Recommendations

When towing an xEV it is important to ensure electric motors are not rotating during tow. The electric motors are often mechanically connected to the vehicle wheels even when the vehicle is not turned on and if the wheels are moving, then voltage could be generated. The voltage level generated will correspond to the speed of the motor which is connected to the wheels. The generated voltage may exceed the component ratings in the high voltage system potentially allowing arcing to occur. There is also a risk at lower voltages if the high voltage components are damaged and arcing may occur below the system rating or the battery may become overcharged. For this reason it is recommended to transport damaged vehicles on flat beds to avoid this potential. If a flatbed is not available, the responsible organization's ERG should be referenced for alternative transport methods.

When the vehicles are required to be recovered (e.g., a vehicle veered off the road 100 yards) where the wheels must turn prior to loading on the wrecker, the speed of the vehicle should be kept less than 5 mph to prevent excessive voltage generation in the high voltage system.

When loading or recovering xEVs, tow operators should avoid direct contact with the battery or battery assembly. The vehicle should not be lifted or supported by the battery system.

8. RECOMMENDATIONS FOR XEV EMERGENCY RESPONSE HAZARD COMMUNICATION

8.1 Hazard Communications Background

During 2011, NHTSA issued a questionnaire to automotive OEM's about the introduction of vehicles containing lithium batteries. One statement raised by NHTSA on this questionnaire was:

"The 24-hour contact name and phone number that emergency response personnel may use to contact your company directly from the scene of the crash/incident involving a vehicle with a lithium battery manufactured by your company to receive immediate answers to pertinent questions."

This task force recognized that most OEM's did not have a 24 hour contact name and phone number and agreed to investigate the need for this service. As a result, the following conclusions and recommendations are captured below. APPENDIX L – SUMMARY OF 24 HOUR COMMUNICATION INVESTIGATION documents the issues identified during the investigation.

8.2 Hazard Communications Summary

Attempting to adapt the current model for a 24 hour contact does not seem appropriate at this point in time; it does however warrant further exploration. Further dialog with CHEMTREC and similar companies could develop the proper steps and recommendations needed for this type of system, but as of today it is not adequate to meet the needs of emergency responders for xEV's.

Technology trends toward increased use of smartphone and connected tablet devices make these ideal candidates to access specialized information in an emergency. The keys to successful implementation of this medium include identification of the most important information needed for incidents involving battery fires and/or high voltage breach, condensing this information into easily usable information elements and making the information easily searchable.

Vehicle telematics may offer notification to first responders of vehicle type, crash severity, and location of vehicle. This information is beneficial to the first responder, but these systems are typically pay for use and require an active subscription to operate. As a subscription or pay for use system, this cannot be depended on to consistently provide necessary information to first responders and therefore cannot be relied upon as a consistent method to communicate vehicle hazards at this time.

Finally, as Li-ion battery technology in motor vehicles is in its infancy, there is more that industry doesn't know about behavior in major collisions and fire emergencies than is known. While the emergency response community already has robust incident reporting practices, there may be room to improve existing reporting processes to specifically identify incidents involving xEVs and more notably, incidents involving battery fires and/or potential high voltage breach.

8.3 Hazard Communications Recommendations

1. A 24 hour telephone hotline is not an appropriate communications medium for first and second responders at this time. In lieu of a 24 hour hotline, it is recommended that the OEM's provide ERG's in a digital format available 24/7 and accessible via links from a commonly known website. Several organizations today have the potential to offer central locations for accessing OEM ERG's including:

    - National Fire Protection Association - NFPA (www.nfpa.org)
    - End of Life Vehicle Solutions - ELVS (www.elvsolutions.org)
    - National Automotive Service Task Force – NASTF (www.nastf.org)

2. Placing basic emergency instructions and information about the hazards and safety systems of the battery system on the web will allow for quick connection to the information source, provided the technology infrastructure exists. This information is already being summarized by select organizations and provided in other forms such as field manuals and smartphone/tablet applications further enabling access to this information.

3. Further, it is recommended that this information is made readily available to third parties (for example NFPA) to extract specific contents regarding battery fire and/or high voltage safety protocols during an emergency response so this information can be summarized as an Emergency Field Guide (EFG), or other summary document.

9. NOTES

9.1 Marginal Indicia

A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

PREPARED BY THE HYBRID AND EV FIRST AND SECOND RESPONDER TASK FORCE COMMITTTEE

APPENDIX A - BASELINE SCENARIO VALIDATION

The baseline scenario presented to the SAE J2990 task force involves the following:

Scenario: Two lane road, Full EV and mid-SUV head-on collision approximately 45 mph. Two (2) occupants in each vehicle need attention. Steam or smoke is coming from the scene. Not sure origin of smoke.

To validate the Committee's chosen scenario, the task force conducted elemental research into crash statistics and types of collisions in the U.S. It is believed that the baseline scenario selected accurately represents a typical vehicle collision event in the U.S. The latest nationwide crash statistics provided by the U.S. Dept. of Transportation, National Highway Traffic Safety Administration, reveals that in 2009, police reported 5,505,000 motor vehicle traffic crashes (NHTSA Traffic Safety Facts 2009. Retrieved from http://ww1.prweb.com/prfiles/2011/11/30/9003227/CRASH%20DATA.pdf)

According to the NHTSA report:

- twenty-eight percent of those crashes (1.52 million) resulted in an injury.
- fewer that 1 percent (30,797) resulted in a death (p45).
- head-on or frontal off-angle collisions accounted for 28.6% of the collisions
- rear end collisions were reported in 31.5% of the crashes documented.
- at or near an intersection was the reported location for 1,158,000 injury crashes (p52).
- collision with another motor vehicle in transport was the most common first harmful event for fatal, injury, and property-damage-only crashes (p45).

APPENDIX B - PRO AND CON ANALYSIS OF EXISTING EMERGENCY RESPONSE GUIDES

This appendix provides an outline of the pro and con analysis performed by the SAE J2990 task force to identify the critical elements of the emergency response guides. This analysis formed the basis for developing the recommendations in Section 4 and is included here to summarize the known differences in existing means and proposals for communicating emergency response guide information.

1. Operational and extrication challenges associated with xEVs

These challenges can be mitigated by better availability and presentation of rescue information.

1.1. High strength steel in chassis: Many fielded cutting tools are inadequate to deal with high strength steel.

1.1.1. Insufficient cutting force (due to stronger vehicle materials)

1.1.2. Insufficient shear angle (due to wider roof pillars)

1.2. Boron steel tubing inserted in "A" pillar. Clean chop saw, (new blade) is required to cut.

NOTE: This is an issue with many newer vehicles and is not unique to xEVs, but relevant insofar as it is addressed in several of the response card proposals/ solutions.

1.3. High Voltage System Issues (batteries, cabling and other components).

1.3.1. Identification and Labeling

1.3.1.1. HV components are orange or have HV warning labels.

1.3.1.2. Locations may not be apparent without system diagrams due to varying locations in different models.

1.3.2. Potential problems with damaged HV batteries

1.3.2.1. Off-Gassing (potentially toxic and/or flammable gases) due to damage-induced thermal event / thermal runaway.

1.3.2.2. Delayed fire potential (thermal runaway)

1.3.2.3. Post-extinguishment re-ignition hazard

1.3.3. MSDS may not be readily available or accessible to emergency responders.

1.3.4. Recommendations for fire extinguishment vary from manufacturer to manufacturer, and may not specifically address the distinction between a battery fire and a vehicle fire (some recommend dry-chem, which is useful on conventional vehicle fires, but may not be effective in extinguishing an HV battery fire.)

1.4. Manual service disconnects

1.4.1. Mixed messages on the use of service disconnects.

1.4.2. Varying levels of electrical PPE recommended.

NOTE: This is being more directly addressed in Section 6, but is relevant due to service disconnect usage references in responder guides.

2. External identification of xEVs

2.1. Inconsistent terminology (Hybrid, Zero Emissions, E-Drive, IMA)

2.2. Inconsistent placement - May have anywhere from zero external badges to four. Locations vary from front fenders, rear trunk/lift gate, doors, other.

2.3. Some manufacturers are dropping xEV badging altogether with the expectation that most vehicles will be some version of hybrid or electric in the near future.

NOTE: This issue is addressed in Section 5, but is relevant because all variants of responder guides address identification.

3. Emergency Response Guides (ERG's)

Technical information, content, and format/layout vary from manufacturer to manufacturer, often limiting usefulness in the field.

3.1. Not easily accessible: Electronic versions (PDF) are available from all manufacturers, but not always easily located.

NOTE: NFPA and a few private companies host consolidated ERG repositories to aid in finding them. Additionally, they may not have the latest models/changes.

(Example: www.evsafetytraining.org/resources)

3.2. The ERGs can be as much as 67 pages long per vehicle, making it cumbersome to keep hard copies for all vehicles on an apparatus. Manufacturer info is thorough, but often too in-depth for field use.

3.3. Some ERGs contain repurposed information from shop and technical manuals with little consideration for customizing content to first responder needs, terminology, and practices.

EXISTING SOLUTIONS AND PROPOSALS, PRO AND CON.

This list is not exhaustive, but represents a cross-section of available solutions to the problems identified above.

4. Fédération Internationale de l'Automobile (FIA) Foundation Proposal

SUMMARY: Provide relevant rescue information for each airbag-equipped vehicle model on a standardized A4 rescue sheet (following the German rescue card template). See APPENDIX J – SMAPLE RESCUE CARDS, AS PROMOTED BY ADAC AND FIA FOUNDATION for sample.

4.1. German standard (Allgemeiner Deutscher Automobil-Club (ADAC) -Style) on-board rescue sheet.

4.2. A summary of the proposal can be found at: www.rescuesheet.info

4.3. On this rescue sheet, indicate the recommended cutting points to facilitate cutting high-strength steel structures and prevent cutting into airbag inflators and other dangerous components.

4.4. Attach onboard (OB) rescue sheet to driver's side sun visor.

4.5. Place ADAC Rescue Sticker on windscreen to alert responders that vehicle has an OB rescue sheet.

4.6. Have these sheets in new delivered vehicles.

4.7. Support eventual migration to digital format based on VIN or license plate.

PRO:

- Limited to one or two pages (single sheet) - quick reference.
- Window sticker concept is an excellent indicator to responders that information is in vehicle.
- Standardized, common graphics and symbols.
- Provides locations of:
  - High strength steel locations and cut points
  - SRS components,
  - HV components

CON:

- As proposed, does not address shutdown methods for disabling HV systems or SRS.
- Does not address special circumstances (fire, submersion, HV battery damage, towing, etc.)
- Window sticker can be lost or obscured during crash.
- Owner/operator may not leave the OB card in its intended location (may be considered a nuisance if operator uses sun visor).

5. International Organization for Standardization (ISO) Vehicle Extrication Card Proposal

SUMMARY: Proposed Technical data cards with quick-reference information. See APPENDIX H – EXAMPLES OF EXISTING HYBRID AND ELECTRIC VEHICLE IDENTIFICATION SYSTEMS for Samples.

5.1. These extrication cards include vehicle technical data such as:

- The location of airbags, pyrotechnic pretensioner
- Parts of the passenger compartment not to be cut
- The location of the fuel tank
- The location of battery, and for electric, hybrid or CNG-LPG vehicles
- The location of high voltage electric circuit or electric safety plug in, of gas tank, gas cap.

5.2. Color coding of vehicle with safety icons alerting responder to critical information.

PRO:

- Limited to two pages (single sheet) – Quick Reference
- Standardized symbols, high quality CAD graphics.
- Provides locations of key components (SRS and HV components, 12V battery, High strength steel/structural reinforcements)
- Provides both cut points and DO NOT CUT points
- More extensive SRS component information than provided in German standard diagrams.

CON:

- As proposed, does not address shutdown methods for disabling HV systems or SRS.
- Use of Cut, Do Not Cut, and Inadvisable-to-cut zones increases first responder decision load. Sometimes fewer options is better.
- The 3D-style graphics are potentially more difficult to interpret than 2D graphics (as in the German Standard).
- Does not address special circumstances (fire, submersion, HV battery damage, towing, etc)
- No apparent plan for distribution and standardization of availability of cards (Where will they be stored? Will they be in the vehicle? Will responders have them?

6. NFPA EV Emergency Field Guide (EFG)

SUMMARY: A consolidated quick reference guide for hybrid and electric vehicles. See appendix C for sample.

6.1 Incorporates both vehicle-specific sheets with critical shutdown and extrication information, and generic, special-circumstances guidance that is not vehicle-specific (Fire, Submersion, HV battery damage, towing and post-incident handling) into a single handbook. Available in print, soon available in interactive PDF, online, and as an installable app.

6.2 Provides locations of HV and SRS components

PRO:

- Comprehensive- includes nearly all current xEVs in the US market consolidated into one handbook.
- Available in multiple formats (print, electronic, etc.)
- Standardized layout/format for quick-reference.
- Provides Primary and alternate shutdown methods for disabling HV systems and SRS.
- Provides location/type of immobilization and shutdown components (parking brake, ignition, park gear, etc.) to save time.
- Provides identification cues
- Inexpensive for the level of detail offered.

CON:

- Uses manufacturer system graphics and images—therefore not standardized.
- Due to reliance on manufacturer information from their ERGs, some vehicles have varying degrees of detail.
- The onus is on responders to ensure they have the most up-to-date version (Updated semi-annually).
- Currently limited to US market.

7. Hybrid Vehicle Extrication Guide (Extricate) - Mobile App (Moditech, FA)

SUMMARY:An easy-to-use free mobile app to aid in extrication and emergency response.

7.1 Uses bespoke standardized graphics to show HV and SRS component locations as well as structural reinforcements.

PRO:

- Free
- Mobile application can be downloaded onto smart phones
- Easy to use
- Standardized graphics

CON:

- Number of vehicles listed is limited
- Does not address special circumstances (fire, submersion, HV battery damage, towing, etc.)
- Does not address shutdown methods for disabling HV systems or SRS.
- Not updated regularly and may be dated material

8. First Responder QRG - Mobile App (NAFTC)

SUMMARY:An easy-to-use free mobile app to aid in extrication and emergency response.

8.1 Uses standardized graphics to show HV and SRS component locations as DO NOT CUT zones.

8.2. Includes Identification cues and image gallery

PRO:

- Free
- Mobile application can be downloaded onto smart phones
- Easy to use
- Standardized graphics
- Identification cues and image gallery
- Attempts to address securing/ shutdown methods and procedures

CON:

- Number of vehicles listed is limited and
- Not currently scheduled to be updated (Requires grant funding)
- Does not address special circumstances (fire, submersion, HV battery damage, towing, etc.)
- Securing and shutdown methods for HV systems or SRS are mostly generic, one-size-fits-all solutions and do not reflect vehicle-specific manufacturer guidance.

9. CRS - (Moditech)

SUMMARY: A comprehensive, modular software package containing vehicle information to aid in crash response.

9.1 Uses German standard style graphics to show HV and SRS component locations, avoidance zones, etc.

9.2 Includes photographic images of interior airbag locations, etc.

PRO:

- Extremely detailed
- Cover all vehicles, not just xEV (Conventional, CNG, Fuel Cell, etc.)
- Standardized graphics (German Standard)
- Addresses shutdown/disabling methods and procedures (accurately)
- Covers vehicles from several continents (not limited to North America)
- Several variants (mobile app, etc.)
- Frequently updated
- Mobile “Lite” version offered for a low price.
- Optional VIN scanning capability

CON:

- Expensive (hundreds to thousands of dollars, depending on options)
- Does not address special circumstances (fire, submersion, HV battery damage, towing, etc.)
- Large electronic database- up to 40GB (may exceed host system storage)

APPENDIX C - FIRST RESPONDER ACTIVITIES AT HYBRID AND ELECTRIC VEHICLE COLLISION EVENTS

First and second responders study, prepare, and train for responding to various vehicle scenarios such as this baseline one. What is different about this scenario from a first responder perspective is that it involves an electric vehicle and a conventional internal combustion engine vehicle. The propulsion system of this electric vehicle, similar to that of a hybrid vehicle as well, is different from that of the familiar gas-powered SUV described in this scenario and may pose risks to responders if they are not addressed properly during this incident. The assumption is made that the hybrid or electric vehicle is compliant with the identification system later in this document; the following narrative describes typical actions that can and would be employed as this scenario unfolds.

At this incident, once responders arrive, position their emergency vehicles, and begin to approach the crash-damaged vehicles, they will be conducting a visual, walk-around scene assessment process referred to as a 'size-up' by the responder community. If during this initial approach and size-up, responders identify at least one of the compliant exterior badgings on the electric plug-in vehicle, that discovery puts their hybrid and electric vehicle tactics plan into action. Due to this initial identification of the presence of the crash-damaged electric vehicle, emergency procedures unique to hybrid and electric vehicle incidents would be initiated including specific efforts to immobilize the electric vehicle and then what is called 'disable' or shut down the HV systems.

Because the vehicle was identified as an electric vehicle from its compliant exterior badging, no responder or civilian individual on the scene would be permitted to walk or stand directly in front of the vehicle, for example. Until the vehicle is immobilized and unwanted forward movement can be prevented, this is a unique danger area known by responders when confronted with hybrid or electric vehicles. In addition, because they quickly identified the presence of the electric vehicle badging upon their approach, trained personnel would immediately be assigned to access the interior of the vehicle and shut down the vehicle's ignition system. Again, this unique action is intended to help isolate high voltage to the HV battery itself and allow HV voltages to dissipate throughout HV components. In addition, because of the presence of the electric vehicle, responders will be working with two separate electrical systems; the 12-volt and the HV system. This is a process that first responders find unique to hybrid and electric plug-in vehicle incidents.

Emergency medical responders inside the vehicle, knowing that they are dealing with occupants of an electric vehicle, fulfill specific assignments from their interior location with the patient.

If entrapment were involved, fire and rescue personnel would fully complete the identification, immobilize, and disable protocol prior to beginning their forcible entry and extrication activities.

From a first responder perspective, knowledge of the presence of a potential hazardous vehicle system must occur in a reliable and timely a manner. The initial building block of all existing state and national hybrid and electric vehicle training programs begins with identification by the individual responder that the specific vehicle to be worked on is in fact one employing a high-voltage electrical system. Identification begins the process of safely and efficiently dealing with the situation and performing tasks effectively. The scope of this project proposal is to address a reliable, standardized, and effective means for clearly identifying safety-related warning or hazard information associated with a hybrid and EV immediately available to first responder fire, law enforcement, emergency medical, and rescue personnel.

APPENDIX D - FIRST RESPONDER ACTIVITIES AT HYBRID AND ELECTRIC VEHICLE FIRE EVENTS

Although not an element of the baseline scenario, the possibility of first responders encountering a hybrid or electric vehicle involved in fire has been considered by the taskforce. Study of the 2012 document, U.S. VEHICLE FIRE TRENDS AND PATTERNS, produced by the National Fire Protection Association, Quincy, MA allowed this taskforce to reach consensus that interior markers or other identification of the burning vehicle as a hybrid or electric vehicle would not be considered effective due to the probable destruction of the interior of the burning vehicle.

APPENDIX E - FIRST RESPONDER ACTIVITIES AT HYBRID AND ELECTRIC VEHICLE SUBMERSION EVENTS

Another potential situation that is not an element of the baseline scenario is that of first responders encountering a hybrid or electric vehicle submerged either partially or fully in water. Current state and national training programs as well as interim guidelines for the National Highway Traffic Safety Administration advise first responders to remove the vehicle from the water and then accomplish specific safety procedures on the hybrid or electric vehicle. In this case, exterior badging, securely affixed to the vehicle, will provide the most reliable means of identification for first responders.

During our analysis, there was no data made available to suggest submersion in fresh vs. salt water alters the risk to responders. No actual submersion test data has been made available to the task force. Future revisions may re-examine this issue if data is made available to the task force.

APPENDIX F - CURRENT STATUS OF EXTERIOR BADGING (2012)

Using a random sampling of selected 2012 model year vehicles available in North America, research has shown that it is common for a vehicle to display marketing-related information on one or more of its exterior surfaces. These markings, referred to as 'badging', can include the name of the manufacturer, the model of the vehicle, along with other features or amenities of the vehicle. Typically, exterior badging has been employed by the OEM to assist in the marketing of the vehicle to the consumer. No organized, standardized, or regulated means exists for badging to communicate important safety-related information to first or second responders.

The survey of 2012 model year hybrid and electric vehicles and several 2013 models revealed that exterior badging included use of a wide variety of words, various icons, multiple uses of colors, and different sizes. The badging consisted of no standardized, industry-wide wording, consistent icon use, color, or standardized location on the exterior of the vehicle. In fact, one OEM produces a hybrid vehicle that is absent of any exterior badging indicating that it is a hybrid vehicle. Although some exterior badging was very clear in its meaning, the wording of much of the badging, icons, and colors displayed had a wide variety of meanings that can be perceived to easily be confusing to first and second responders.

The 2012 model year review identified that the most common and consistent location for vehicle badging was the rear of the vehicle; truck lid, hatchback, or liftgate. When gasoline-electric hybrids and electric plug-in vehicles were sampled, the most common exterior badging location remained at the rear however the vast majority of OEMs also use three-sided badging for marketing purposes, as well. One vehicle, the 2012 VW Jetta Hybrid, is unique in that the vehicle employs four-sided exterior badging indicating that it is a hybrid vehicle.

The review of the 2012 hybrid and EV models also revealed that wording, icons, and colors varied widely among OEMs. Shown below in this brief listing, are examples of exterior badging. If shown in lower case letters, the representation is that the lower case letters reflect the appearance of the actual exterior badging. The following examples are selected for discussion purposes and are not inclusive of all 2012 model year vehicles:

'E=lectric' (plus icon of roadway with a green leaf) Ford Focus EV

'E=nergi' (plus icon of roadway with a green leaf) Ford Fusion Plug-in Hybrid

'HYBRID' (plus icon of roadway with a green leaf) Ford Fusion Hybrid

'Active Hybrid 3' (5) (7) BMW 3-, 5-, or 7-series Hybrid

'HYBRID VW' Jetta Hybrid

'e-tron' 2013 Audi A-3 Electric

'Blue drive' (plus green leaf above wording) 2013 Hyundai Elantra EV
electric 2013 Hyundai Electric vehicle

'Blue drive' (plus green leaf above wording) 2013 Hyundai Sonata Hybrid vehicle

'hybrid' 2013 Hyundai Sonata Hybrid vehicle

'electric drive' SMART car Electric vehicle

'HYBRID' KIA Sonata Hybrid

'HYBRID' Mercedes S-400 Hybrid

'PLUG-IN HYBRID' Volvo V60 Plug-in Hybrid
'hybrid' Porsche Cayenne S Hybrid

'PLUG-IN HYBRID' (plus blue and silver icon) Toyota NS4 Plug-in Hybrid

‘HYBRID SYNERGY DRIVE’ Toyota NS4 Plug-in Hybrid

‘PLUG-IN HYBRID’ Toyota Prius V Plug-in Hybrid

‘HYBRID SYNERGY DRIVE’ Toyota Prius V Plug-in Hybrid

‘HYBRID’ (plus blue and silver icon) Toyota Prius C Hybrid

‘HYBRID SYNERGY DRIVE’ Toyota Prius C Hybrid

‘ELECTRIC’ Toyota RAV-4 Electric

‘RX400h’ Lexus RX400 Hybrid

‘LS 600h’ L Lexus LS 600 Hybrid

‘HYBRID’ Honda Insight Hybrid

‘EV’ Honda FIT Electric

‘VOLT’ Chevrolet VOLT Electric

‘LEAF’ Nissan LEAF ELECTRIC

‘ZERO EMISSION’ Nissan LEAF ELECTRIC

‘ALL-ELECTRIC’ (with green colored ‘E’) CODA Electric

APPENDIX G - EXISTING EXTERIOR BADGING SIZE SUMMARY

A random sample of 82 vehicles was taken in Plano, TX parked on residential streets. The exterior rear badging height and length and location (right or left) was documented. The smallest height was Chrysler 200 sedan. The text "CHRYSLER" is centered in a wing-like rear emblem. The font was measured to be 0.5cm x 8.5cm. It was noted that after looking at 85 vehicles, this size is vastly insufficient to be of value to a responder as they approach an xEV at an incident.

The Ford Fusion sedan had two exterior rear badgings; FUSION on the left side and SE on the right side of the trunk lip. The FUSION badge, in all uppercase letters, measured 1.75cm in height by 14cm in length. The SE badge on the right side was of the same height, 1.5cm, and was 5cm in length. It was noted that a height of 1.75 cm was also too small of a size to be effective, even in all uppercase letters.

Reviewing samples, it became apparent that any text comprising a rear badge that was less than 2.0cm in height had reduced effectiveness. The average height of the sample vehicles was between 2.36cm and 2.4cm (just less than 1 inch) and appeared to represent what could be considered a minimum height to be able to effectively convey the message of the badging to a responder as they approach the rear of the vehicle.

RANDOM SAMPLE OF EXTERIOR REAR BADGING SIZE SUMMARY (units in cm):

OEM	Model	Type	Left Rear	height	width	XXXXX	right rear	height	width	NOTES
Chrysler	Town&Country	Minivan	CHRYSLER	1.5	26	1	TOWN & COUNTRY	1.5	33	
Honda	Odyssey	Minivan				1	ODYSSEY	3	21	
Toyota	Sienna	Minivan	TOYOTA	2	12	1	SIENNA XLE	2	29	
			MINIVAN Average Badge Ht	**1.75**			**MINIVAN Average Badge Ht**	**2.1667**		
Ford	F 150	Pickup truck	F150	4	20.5	1				
Ford	F250	Pickup truck	SUPER DUTY	7	104	1				Stamped into tailgate of F-250
GMC	Sierra	Pickup truck	SIERRA	3	26	1	GMC	4	18	
Mazda		Pickup truck	MAZDA	7	39.5	1				Decal on tailgate of pickup truck
Toyota	Tundra	Pickup truck	TUNDRA	4	36	1	4 X 4	4	5	
Toyota	Tacoma	Pickup truck	TOYOTA	9	57	1	TACOMA LX	2	25	older pickup with decal badging embossed onto
			Pickup Truck Average Badge Ht	**5.667**			**Pickup Truck Average Badge Ht**	**3.3333**		
Acura	TL	Sedan	ACURA	2	35	1	3.2TL	2	13.5	
Acura	RSX	Sedan	ACURA	2.5	15.75	1	RSX	2.5	13	
Audi	A4	Sedan	A4	3.5	8.5	1	1.8T	2	9.5	
BMW	5-series	Sedan				1	530i	2	16	
Cadillac	CTS	Sedan	CTS	1.75	12	1	3.6	1.75	9	
Chevrolet	Cavalier	Sedan	CAVALIER LS	2	23	1				Bowtie; 4cm x 12cm
Chevrolet	Impala	Sedan	IMPALA LT	2.25	23	1				
Chevrolet	Camaro	Sedan				1	SS	2	9	Bowtie badge in center, rear; 5cm x 16cm
Chevrolet	Malibu	Sedan	MALIBU LT	2	18	1				
Chrysler	200	Sedan	CHRYSLER	0.5	8.5	1				TOO small, in center of wing emblem-shaped
Chrysler	PT Cruiser	Sedan				1				No rear badging, pt CRUISER badging on doors; 1cm p & t, 2cm x 16cm CRUISER
Dodge	Charger	Sedan	CHARGER	1.5	20	1	SRT8	2	15	
Ford	Fusion Hybrid	Sedan	FUSION	1.5	14	1	HYBRID	1.5	12.5	also badged with logo of road; 4cm x 4cm
Ford	Focus	Sedan	FOCUS	2.5	18.5	1				
Ford	Taurus	Sedan	TAURUS	1.75	22	1	SEL	1.75	8.5	
Ford	Taurus	Sedan	TAURUS	2	22	1	SEL	1.75	11	
Ford	Escort	Sedan	ESCORT SE	2	24.5	1				
Ford	Fusion	Sedan	FUSION	1.75	14	1	SE	1.5	5	TOO small!
Ford	Fusion	Sedan	FUSION	1.5	14	1	SE	1.5	5	
Ford	Taurus	Sedan	TAURUS SE	3.5	20	1				
Ford	Fiesta	Sedan	SE	1.75	5	1	FIESTA	3	15	
Honda	Civic	Sedan	CIVIC	1.5	18	1				
Honda	Accord	Sedan	ACCORD	2.5	17	1				H logo; 6cm x 7cm
Honda	Accord	Sedan	ACCORD	2.5	21	1				
Honda	Accord	Sedan	ACCORD	1.5	17	1				
Hyundai	Elantra	Sedan	HYUNDAI	2	12	1	ELANTRA	1.75	15	
Hyundai	Sonata	Sedan	HYUNDAI	2	14	1	SONATA	2	20	
Hyundai	Accent	Sedan	HYUNDAI	2	14	1	ACCENT	1.75	16	2cm height is ideal minimum size!
Hyundai	Elantra	Sedan	HYUNDAI	2	12	1	ELANTRA	1.75	16	
Hyundai	XG300	Sedan	HYUNDAI	2.25	30	1	XG300	3.5	15	
Infiniti	I 30	Sedan	INFINITI	2	30	1	I30	3.5	8.5	
Lexus	LS400	Sedan	LEXUS	2.5	19	1	LS400	2	17.5	CIRCLE with L logo; 10cm x 8cm
Lincoln	MKZ	Sedan	LINCOLN	2.5	25	1	MKZ	2.5	15	Z' of MKZ is enlarged; 3.5cm height

EXTERIOR BADGING SIZE SUMMARY Continued:

Mazda	6	Sedan	MAZDA 6	2.5	20	1				
Mazda	3	Sedan	MAZDA3	2.5	20	1	2.5	2.5	10	
Mercedes	C300	Sedan	C300	2.5	16	1				
Mitsubuishi	Galant	Sedan	GALANT	2	19	1				
Mitsubuishi	Galant	Sedan	GALANT	1.25	32	1	ES	1.75	9	
Nissan	Altima	Sedan	ALTIMA	3	19	1	2.5SL	3	14	
Nissan	Maxima	Sedan	MAXIMA	2.5	47	1				MAXIMA is centered at rear
Nissan	Maxima	Sedan	MAXIMA	2.5	34	1				Badging is centered on rear trunk
Pontiac	G8	Sedan	GT	3	9	1	PONTIAC G8	1.5	16	G8 Badging is 3cm x 9cm
Scion	tC	Sedan				1	tC	3	10	
Scion	xA	Sedan				1	xA	2	3	xA is 11cm in length, x = 2cm height, A = 3cm
Toyota	Camry	Sedan	TOYOTA	2	11	1	CAMRY LE	2	19	
Toyota	Yaris	Sedan	TOYOTA	2	12	1	YARIS	3	12	
Toyota	Camry	Sedan	CAMRY	2	16.5	1	SE	2	6.5	
Toyota	Corolla	Sedan	COROLLA	2	36	1	CE	2	7	
Toyota	Solara	Sedan	SOLARA		36	1	SLE	1.5	10	TOYOTA badge also on left; 2cm x 9.5cm
Toyota	Avalon	Sedan	AVALON	2	44	1	TOURING	2	14	
Toyota	Corolla	Sedan	COROLLA	2	17	1	LE	2	5	
Toyota	Yaris	Sedan	TOYOTA	2	12.5	1	YARIS	3	14	
Toyota	Prius	Sedan	PRIUS	2	18.5	1	HYBRID SYNERGY DRIVE	3.5	8.5	text of HSD badge is on a plate, door badging is
Volvo	S90	Sedan	VOLVO	2.5	19.5	1	S90	3	13	
Nissan	Rogue	SUV	ROGUE	3	16.5	1	SL	2.5	7	
Chevrolet	Equinox	SUV				1	EQUINOX LT	2	24	
Chevrolet	Tahoe	SUV	TAHOE	3.5	28	1	CHEVROLET	3	33	Tahoe badge has BowTie logo at beginning of
Chevrolet	Suburban	SUV	SUBURBAN	2.75	40	1	CHEVROLET	3	33	
Chevrolet	Equinox	SUV	EQUINOX LS	2.5	25	1				
Ford	Expedition	SUV	EXPEDITION	2.5	23.5	1				
Ford	Escape	SUV	ESCAPE	2	18	1				
Ford	Escape	SUV	ESCAPE	5	21	1				text set on larger background plate
GMC	Envoy	SUV	ENVOY	3.5	27	1	GMC	4	17.5	XL badging also on left; 2cm x 6cm
Hyundai	Tuscon	SUV	HYUNDAI	2.5	17	1	TUSCON	2.5	26	4WD badging also; 3cm x 10cm V6 badging;
Hyundai	Sonata	SUV	SONATA	2	23	1				
Kia	Sorento	SUV	SORENTO	2.5	25	1	LX	2.5	6	
KIA	SOUL	SUV	SOUL	3	16.5	1				
Lexus	GX 478	SUV	LEXUS	2.5	20	1	GX478	2.5	21	
Lexus	GX470	SUV	LEXUS	2.5	20	1	GX470	2.25	21	
Mitsubuishi	Montero	SUV	MONTERO	2.5	25	1				
Nissan	Armada	SUV	ARMADA	4	29.5	1	SE	4	9	
Nissan	Murano	SUV	MURANO	3	24	1	SL	3	9.5	
Suzuki	SX4	SUV	SUZUKI	2	15	1	SX4	2.5	11.5	
Toyota	Sequoia	SUV	SEQUOIA	3.5	26	1	V8	4	9	
VW	Touraeg	SUV	TOURAEG	3	22	1	V8	3	6	
KIA	RIO	SUV	RIO	3.5	11	1				
OEM	**Model**	**Type**	**Left Rear**	**height**	**width**	**XXXXX**	**right rear**	**height**	**width**	**NOTES**
PASSENGER VEHICLE Average Left Side Badge Ht(cm)				**2.362**				**2.402**		**PASSENGER VEHICLE Average Right Side Badge Ht(cm)**
76	**Number of Vehicles in Passenger Vehicle Sample**									
	All Vehicles Average Badge Ht Left Side			**2.646**	**1.03208**	**inches**		**2.4492**	**0.955**	**All Vehicles Average Badge Ht Right Side**
			cm x 0.39* = in		*Shown as 0.39 after rounding to the nearest hundredth.					

APPENDIX H - EXAMPLES OF EXISTING HYBRID AND ELECTRIC VEHICLE IDENTIFICATION SYSTEMS

1) Single-page, two-sided vehicle data information sheet proposed to ISO for consideration as an ISO document. Referred to as “Road vehicles – Vehicle extrication card / Rescue Sheet” ISO Proposal N 3159 (10/2011)