



Research Study Prospectus Best Practices for Emergency Response to Incidents Involving Electric Vehicle Battery Hazards

Background

The mission of the international nonprofit NFPA, established in 1896, is to reduce the worldwide burden of fire and other hazards on the quality of life by providing and advocating consensus codes and standards, research, training, and education. The world's leading advocate of fire prevention and an authoritative source on public safety, NFPA develops, publishes, and disseminates more than 300 consensus codes and standards intended to minimize the possibility and effects of fire and other risks. These safety procedures are widely used throughout the United States and other countries by emergency response professionals. NFPA membership totals more than 70,000 individuals around the world, and has sections devoted to the Fire Service, the International Fire Marshalls Association, and the Metropolitan Fire Chiefs.

In 2009, NFPA began a partnership with U.S. Department of Energy (DOE) and the automotive industry to develop and implement a comprehensive training program for emergency response to electric vehicle (EV) incidents. Currently, this program provides safety training to emergency responders (25,000 to date) in order to prepare them for their role in safely handling incidents involving EVs. It has a lack of data to draw on to address the potential hazards associated with damaged EV batteries.

The National Highway Traffic Safety Administration (NHTSA) has recently approached the NFPA to review the OEM (original equipment manufacturer) information on emergency response tactics for EV incidents involving battery hazards and assist in developing guidance for emergency responders. A preliminary review indicates that there is inconsistency and lack of technical substantiation for procedures associated with these incidents. In particular, NFPA has observed that although many manufacturers have provided procedures related to vehicle extrication processes (associated with collisions), there is very limited publically available validated information regarding response to fires involving electric vehicles, and towing and dismantling/disposal associated with damaged battery incidents.

Fires involving cars, trucks and other highway vehicles are a major concern to first responders. Using data collected by the National Fire Incident Reporting System (NFIRS), NFPA estimates^[1] that on average, there were 267,600 such vehicle fires per year in the United States during 2003-2007 to which fire departments responded. Of those fires:

- 49% are caused by (factor contributing to ignition) a mechanical failure or malfunction such as a leak, break, backfire, or worn out component.
- 23% are caused by electrical failures or malfunctions such as short circuits or arcs
- 5% are caused by exposure to other fires

^[1] Ahrens, Marty, "U.S. Vehicle Fire Trends and Patterns". June 2010, NFPA, Fire Analysis and Research Division

- 3% are caused by collisions or overturns. Almost 58% of the highway vehicle fire deaths resulted from fires caused by collisions or overturns.
- 8% of these fires were intentionally set.

Fire Service personnel are accustomed to responding to conventional vehicle fires, and generally receive training on the hazards associated with vehicle subsystems such as air bag initiators and seat belt pre-tensioners. Electric vehicles pose new unknowns to the fire service. In particular, members of the fire service have questions regarding:

- Appropriate personal protective equipment (PPE) to be used for responding to fires involving EV batteries:
 - Is current PPE appropriate with regard to respiratory and dermal exposure to vent gases and combustion products?
 - Is current PPE appropriate with regard to potential electric shock hazards?
 - What is the size of the hazard zone where full PPE, including respiratory protection, must be worn?
- Tactics for suppression of fires involving EV batteries:
 - How effective is water as a suppressant for large battery fires?
 - Are there projectile hazards?
 - How long must suppression efforts be conducted to place the fire under control and then extinguished? What level of resources will be needed to support these fire suppression efforts? Is there a need for extended suppression efforts?
 - What are the indicators for instances where the fire service should allow a large battery pack to burn rather than attempt suppression?
- Tactics and PPE to be used during overhaul and post-fire clean-up operations
 - How long should fire scenes be monitored for re-ignition events? What tools and metrics are available?
 - What hazards should fire-fighters be aware of during overhaul (e.g. partially energized battery packs or delayed thermal runaway reactions)?
 - What can be done to effectively identify and neutralize hazards encountered during overhaul?
 - What are appropriate damaged battery condition assessment, handling, towing and dismantling/disposal procedures?

Goal

The Foundation proposes to collaborate with the DOE and the automotive industry to develop the technical basis for NFPA's emergency responder training guidance for first responder emergency response procedures for EV battery incidents. In the light of recent incidents involving these hazards, we believe there is an urgent need to develop the technical basis for credible and centralized incident

response guidance. The focus of this research is on best practices for emergency responders, not on specific battery technology.

Scope

Conduct a research program to develop the technical basis for best practices for emergency response procedures for EV battery incidents to include:

1. Firefighting – PPE, suppression methods and agents, and clean-up/overhaul operations
2. Post incident procedures¹ - Damaged battery condition assessment, handling/isolation and tow/removal; de-energizing/discharging (as appropriate) and disposal

Activities

1. Firefighting Tactics – PPE, suppression tactics, and clean-up/overhaul operations for EVs
 - Review industry best practices for firefighting (e.g. PPE, suppression tactics and agents, clean-up) as available
 - Categorize battery technologies and select representative battery samples including samples of NiMH and lithium-ion based chemistries, packs that include plastic casing and packs that include metal casing, and packs that include cells with hard cases as well as soft pack polymer cells
 - Identify key required elements of emergency response PPE, tactics, and overhaul operations
 - Develop full scale fire testing plans for each battery pack to be tested. This plan will include:
 - Working with the battery pack manufacturers to identify an appropriate “package” for full scale testing. For example, a package may include a battery pack, its associated cooling system, and its mounting location (e.g. vehicle floor pan, trunk assembly, etc.)
 - Identifying, procuring, and modifying an appropriate vehicle fire trainer that can be modified to accommodate the various testing packages, provide an appropriate ignition source for the testing packages, and provide sufficient screening of individual battery packs during fire tests to maintain confidentiality of project participants
 - Identifying appropriate methods and equipment for measuring basic fire hazard parameters during fire testing in this scenario, including temperature, duration, heat release rate, products of combustion, etc as well as suppressant application approaches, and potential hazards associated with overhaul and cleanup
 - Developing a plan (with OEM input) for charging battery packs prior to testing and safe discharge/removal after testing
 - Conduct full scale fire testing as per the plans developed. For each battery technology type, testing will include one unsuppressed combustion test, followed by 2-4 tests with selected suppressants/tactical approaches
 - Report on the results of testing. The report should include:
 - Comparison of results between unsuppressed and suppressed scenarios, different battery types, and traditional vehicle full scale fire tests

¹ This activity will be limited to the compilation of existing case studies, best practices and possible field techniques.

- Suggested emergency responses approaches for fire fighting to include PPE requirements, extinguishing agents and quantities/duration and fire scene overhaul
2. Post Incident Procedures Best Practices: Damaged battery condition assessment, handling/isolation and tow/removal; de-energizing/discharging (as appropriate) and disposal/recycling
 - Review and compile case studies and industry best practices for handling, isolation, storage, de-energizing and discharging (as available)
 - Identify possible field techniques for battery damage assessment and monitoring (for example thermal imaging cameras, gas monitoring), de-energizing and discharging (as appropriate)
- 3: Technology Transfer:
 - Integrate the findings from Activities 1 and 2 into NFPA’s ongoing national EV training programs (web-based, classroom, train the trainer, ERGs) for emergency response to EV incidents through development of a special module on EV batteries
 - Present the results of the program to SAE’s ongoing activities to develop recommended practices on this topic
 - Implement the following specific tech transfer activities:
 - 4 webinars for emergency responders audiences through NFPA’s national learning management system
 - Presentations at 2 national meetings of the emergency response community

Reporting

Individual reports will be prepared for each activity above as well as draft and final reports. The final report will be made publicly available on the Foundation’s website and its availability will be communicated to the stakeholder communities, including the fire services, law enforcement, emergency medical services, tow operator associations and the auto industry.

Resources and Implementation

The Foundation proposes to conduct this project in collaboration with the Department of Energy, the Department of Transportation (NHTSA), the automotive industry, and the nation’s emergency response community to include: representatives from major fire service, EMS and law enforcement organizations, and tow and salvage operators including the Towing and Recovery Association of America.

The work will be overseen by a Project Technical Panel consisting of representatives of these organizations as well as individuals with technical expertise in fire protection and battery technology and emergency response tactics. The Panel will advise on the selection of an engineering contractor, advise on the detailed project workplan, and provide comments and input on all project reports.

The following roles, responsibilities and resources are projected at this time:

Project Management/Administration – Fire Protection Research Foundation

- Overall project management
- Management of Project Technical Panel, Research Principal Investigator, and Emergency response team activities
- Compilation of automotive industry best practices
- Publication and dissemination of results

- Technology transfer of best practices through NFPA's training programs and other mechanisms

Research Principal Investigator – A nationally recognized engineering/research organization

- Develop detailed field fire testing plans for Panel review
- Work with individual battery pack suppliers / donors to develop pack specific testing protocols including identifying an appropriate battery package to test
- Implement specific fire field testing plans,
- Procure fire test and measurement equipment as needed (in collaboration with test facility),
- Prepare interim and final technical reports

Emergency Response Team – representatives from first and second responder organizations will be invited to witness, advise, and develop baseline recommended tactics.

Field Test Facility/Field Testing Support – to include fire service support, fire test support, safety services for all testing.

Battery Packs - the Foundation will work with the automotive industry to identify sources for donation of and subsequent disposal of battery packs which are characteristic of the battery technologies that will be field tested.