EVsafe.org	Standard Operating Guideline			
	Number:		Title:	**Electric Vehicle Fire Operations**

Section:	Emergency Response		
Issue Date:	DRAFT	Revision Date:	N/A
Approved By:			

PURPOSE:
Compared to internal combustion engine vehicle fires, firefighting tactics need to be modified to reduce the risk associated with emergencies involving Hybrid/Electric powered vehicles. In order to properly respond to these incidents and protect firefighters mitigating emergencies involving electric or hybrid vehicles, there are additional and separate challenges responding crews must consider.

SCOPE:
All Fire Personnel operating on scene of an electrical vehicle fire.

ACCOUNTABILITY:
Guidelines have been developed by the Department to identify a “best practice” for accomplishing a task. The Department has provided equipment and training that supports this practice. The primary responsibility for adherence of guidelines rests with all personnel. Only the ranking officer/firefighter has the authority to deviate from the guideline. However, the ranking officer/firefighter bears full responsibility for the deviation and must be able to explain the necessity of deviation.

DEFINITIONS:
Battery Ignition and Reignition – Battery cells that have been damaged and then go into thermal runaway are at high risk for catching fire. Once a cell has gone into thermal runaway and catches fire, cooling and suppression could prevent heat from the compromised cell from spreading to other cells and igniting again. Reignition of an EV battery occurs when individual battery cells catch fire at different times.

Cut Loops – Low voltage wire loops that first responders can safely cut to disconnect the high-voltage system from the rest of the vehicle. Severing cut loops will isolate high-voltage power inside of the battery – protecting the rest of the vehicle. The use of *cut loops* will not reduce the amount of *stranded energy* within the battery cells, only isolate the energy within the high-voltage power pack.

First Responder – Police officers, Firefighters, and Emergency Medical Personnel.

Second/Secondary Responder – Investigators, Roadside assistance, and Tow/Recovery companies.

Stranded Energy – Energy remaining in a cell after efforts to safely strand the stored energy in damaged lithium-ion cells. Stranded energy can impact how batteries can be safely removed, transported, and disposed. NFPA recognizes this as an important (and unresolved) issue as it poses a risk of electric shock and creates the potential for thermal runaway.

Thermal Runaway - an exothermic chemical reaction that occurs when the Li-Ion battery temperature reaches a point that causes additional chemical reactions that produce even more heat, which drives the temperature higher, causing further chemical reactions. Thermal runaway can spread rapidly if the high voltage battery is not sufficiently cooled.

GUIDELINE:

This guideline is intended to provide parameters and considerations involving electric vehicle emergencies. This guideline will consider response priorities established by the U.S. Fire Administration, National Traffic Safety Board (NTSB), the Society for Automotive Engineers (SAE), and the National Fire Protection Agency (NFPA).

Incident Actions:

The first arriving company should perform a proper size-up. This should include the extent of the fire and if it is a compartment fire or includes the electric components of the car. The best method for managing or controlling a battery fire is with water. High voltage battery pack fire initially start from under the vehicle, where the battery pack is located.

The following should be considered;

1. Protect your work area through established department policy and establish tactical priorities (fire, extrication, victim care).
2. Ensure the vehicle is in park and off, if possible.
3. Where safe, consider chocking all four wheels.
4. Attempt to locate and reference the Emergency Response Guide (ERG) that is available through the vehicle manufacturer.
5. Wear full PPE with SCBA with face-piece and establish an appropriate command structure.
6. Consideration and tactics may be categorized in offensive or defensive mode.
7. If available, a Thermal Imaging Camera should be used to assist with a 360-degree size up.
8. Secure a large, continuous, and sustainable water supply from one or more fire hydrants. (*You can expect to utilize anywhere between 3000 and 8000 gallons of water to effectively cool high voltage batteries down*).
9. Using only a small amount of water on high-voltage batteries might not be effective and could allow toxic gases to be released.
10. Extinguish small fires that do not involve the high voltage battery by use of standard fire extinguishing procedures.
11. If possible, the NTSB recommends disconnecting the 12-volt battery (which will depower the battery management system).
12. Evaluate if cut loops are available to isolate the high-voltage system.
13. When attacking the vehicle fire, understanding that once the contents of the fire are extinguished, sustained suppression operations on the battery pack may need to continue (due to battery ignition and reignition).

14. Use of a large volume of water will be necessary to cool and suppress the battery fire. Consider the use of multiple 1 ¾" hand lines to apply adequate water flow.
15. Anticipate longer fire-suppression times if the high-voltage battery is involved. Suppression can take an hour or longer.

Sufficient fire personnel and apparatus on scene will be needed to provide for an extended operation, and to monitor the battery's heat or possible secondary ignition. The heat from the fire may have damaged additional cells, which may require additional suppression activities (sometimes referred to as reignition).

Post Incident Actions:

Brief secondary responders and their personnel on the hazards, including;

- The vehicle should be isolated from other vehicles in junk yards and impound lots.
- NTSB recommends a 50' clear space around the vehicle once stored (until the battery can be discharged).
- Do not store inside a building.

An engine company may need to escort the vehicle to the recovery location.

1. Thermal events, such as Thermal Runaway, with the battery system can occur within several hours to a day or more after the initial fire is extinguished.
2. Preparation for the possibility for secondary fires should be considered and reported to oncoming or relief crews, or departments whose response territory are located where the vehicle is relocated.
3. Use a Thermal Imagine Camera to aid in determining if battery temperature is maintaining ambient temperature, reducing or increasing.

Investigation should follow NFPA 921 protocol for vehicle safety during post-response investigation, arson investigation, and vehicle investigation.

Safety:

1. Batteries should always be treated as energized (due to stranded energy).
2. The use of water on EV battery fires does not pose an electrical hazard to firefighters.
3. During overhaul do not make contact with any high voltage components.
4. EVs move silently, never assume the vehicle is powered off .
5. Never assume that an EV will not move on its own.
6. Batteries status and integrity should be constantly evaluated - they pose an ongoing risk to first and second responders.
7. Reignition is accompanied by a "whooshing" or "popping sound, followed by off-gassing of white smoke, electrical arcs, or sparks that reignite with visible flames or fire.

Table 1. Postincident inspection steps recommended by SAE J2990.

Step	Action	Notes
1	Inspect for signs of fire or smoldering.	Use thermal camera or infrared temperature probe if possible.
2	Listen for gurgling, bubbling, crackling, hissing, or popping noises from battery.	Sounds can indicate venting of overheated cells or arcing in high-voltage system.
3	If groups of battery cells have separated from battery enclosure, alert responders of potential exposure to high voltage or fire reignition.	Contact equipment manufacturer for depowering recommendations, packaging instructions, and disposal recommendations. If sufficient information is not available, consult latest version of US Department of Transportation/Transport Canada *Emergency Response Guidebook* for lithium-ion batteries (guide 147) or NiMH (guide 171).[a]
4	If vehicle is submerged, do not remove submerged service disconnect, but turn off ignition if possible. Disable vehicle by chocking wheels, placing in park, and removing ignition key or disconnecting 12-volt battery.	Understand that electric vehicles are designed to be safe in water. Small bubbles emanating from vehicle do not create shock hazard. Water damage to electrical components could lead to reignition. Do not store vehicle that has been submerged indoors until high-voltage energy is depowered.
5	Ensure that high-voltage system is disabled.	Refer to manufacturer's emergency response guide or emergency field guide to verify. At a minimum, disable 12-volt system.
6	Examine mechanical integrity of battery system.	Is enclosure ruptured, cracked, punctured, or dented?
7	Inspect for evidence of fire or heat damage.	Signs include smoke residue or heat damage around battery system and burnt odor from battery system.
8	Inspect for evidence of arcing in high-voltage system. Notify tow truck driver of potential hazards and recommendations for isolation.	Carbon traces indicate that isolation of high-voltage system has been lost.
9	Inspect for evidence of external battery leaks. Notify tow truck driver of potential hazards and isolation requirements.	Electrolyte of lithium-ion battery has sweet odor, like ether, that could indicate battery leak. Leaking electrolyte normally creates drops, not puddles.

SAE recommendations were retrieved from the NTSB's November 13, 2020 Safety Report on Battery Fires in EVs