2.36 Vehicle Fires and Interim Guidance for Electric and Hybrid-Electric Vehicles Equipped with High Voltage Batteries

This procedure identifies operational tactics for safe handling of motor vehicle fires.

2.36.1 FIRE **CONTROL OPERATIONS**

The minimum level of protection for fire fighters is full protective clothing breathing air from their SCBA. -All crew members should be prepared for sudden flash and/or off gassing.

The minimum size of hose line is the 1-3/4" hand line.

A. APPARATUS PLACEMENT

Apparatus should be placed upwind and uphill of the incident if possible. This is to afford protection from hazardous liquids and vapors and reduces smoke in the work area. Consideration must be given to using the apparatus as a barrier, to shield the incident scene from traffic hazards. Consider using a second engine as a buffer. Warning lights should be left operating, in conjunction with the use of traffic cones where needed. Additional consideration should be given to positioning the apparatus at an angle to better allow the removal of any hose from the preconnected cross-lay compartments.

B. WATER SUPPLY

If the water carried on the responding apparatus will not be sufficient, early considerations must be given to additional water supply sources. A supply line or other engines may be required. Ladder companies may be used as an improvised standpipe at incidents on elevated freeways or parking garages. If on a limited access road with no water supply consider BSO Tanker21 for water, request early?

C. FIRE ATTACK

A working fire involving the interior of the vehicle passenger compartment will damage the vehicle beyond repair. As such, the attack plan should consider the vehicle as a "write off" and a safe and appropriate approach and fire attack must be implemented. Where patients are trapped in the vehicle, first water should be applied to protect the patients and permit rescue. When rescue is not a factor, first water should be applied for several seconds to extinguish fire or cool down the area under the vehicle to cool any fuel tanks or fuel systems and air suspensions. Foam will have no impact on an HEV Fire where the battery is involved.

Entry into the truck area must be obtain before releasing the vehicle.

D. Interim Guidance for Electric and Hybrid-Electric Vehicles Equipped with High Voltage Batteries

In the event of damage to or fire involving an electric vehicle (EV) or hybrid-electric vehicle (HEV):

• Always assume the high voltage (HV) battery and associated components are energized and fully charged.

• Exposed electrical components, wires, and HV batteries present potential HV shock hazards.

• Venting/hissing/sounds, electrolyte bubbling from battery, off-gassing HV battery vapors that look like steam, it is not steam, these are signs of an impending runaway that are potentially toxic and flammable.

• Physical damage to the vehicle or HV battery may result in immediate or delayed release of toxic and/or flammable gases and fire (Hydrogen/ Hydrogen Fluoride, Co and other flammable and explosive gases).

E. IDENTIFY VEHICLE

• Determine if the vehicle is an electric or hybrid-electric vehicle, and if it is, advise Dispatch and all responders that an electric or hybrid-electric vehicle is involved.

F. IMMOBILIZE VEHICLE

• Always approach vehicle from the sides to stay out of potential travel path. It may be difficult to determine if the vehicle is running due to lack of engine noise.

• If possible, chock the tires, place the vehicle into Park, and set the parking brake.

G. DISABLE VEHICLE

• Turn off the vehicle, move vehicle keys at least **16** feet away from the vehicle if it is safe to do so.

• If possible, disconnect the vehicle's 12-volt battery. CAUTION: Safety restraints, air bags and other safety systems may be active for up to five minutes after disconnecting the 12-volt battery

H. CRASHES DAMAGING THE AREA OF THE HV BATTERY

• If you detect leaking fluids, sparks, smoke, white smoke, flames, increased temperature, gurgling or bubbling sounds from the HV battery compartment, assume there is a battery fire. In haling trace amounts can be deadly.

• Wearing full Personal Protective Equipment (PPE) and Self-Contained Breathing Apparatus (SCBA) is a must.

• Be alert. There is a potential for delayed fire with damaged lithium-ion batteries.

2.36.2 NOTE: If the fire involves a lithium-ion battery, it will require large, sustained volumes of water for extinguishment. **Consider defensive tactics protect exposures and allow fire to burn out. It should take about an hour to burn out.**

• If there is active fire, consider establishing a water supply to support long-term operation.

• Use a hose line to apply water to extinguish the fire while continuing to cool the HV battery and its casing. Never attempt to penetrate the HV battery or its casing to apply water. This presents a significant safety hazard to firefighters

• Avoid contact with orange high voltage cabling and areas identified as high voltage risk by warning labels.

• Be alert. There is a potential for delayed ignition or re-ignition of a lithium-ion battery fire even after it is believed to be extinguished. This may remain an issue until the lithium-ion battery is properly discharged.

For fires involving garages or exposures consider dragging or moving vehicle to safe haven and burn out.

Fire suppression challenges come from the li-ion battery chemistry, the high-voltages, a large battery size and weight and, typically, a floor pan-mounted battery location. For example, when arriving at an EV fire incident, responders could be confronted with two different yet related scenarios. In one, a li-ion battery-only fire is burning—meaning the fire is contained within the battery cells that are inside of the battery box.

A second scenario is a vehicle fire where the flames are consuming combustible materials inside and outside of the vehicle.

I. The high-voltage lithium-ion batteries are located in a watertight, fire-resistant box that can be made out of steel, aluminum or composite materials. While this box is designed to be watertight under normal operation of the vehicle, natural disasters and floods are far from normal operation. Water may leak into the battery box if the vehicle is partially or fully submerged in floodwaters. Water intrusion into the box can cause corrosion on the battery cells, which can cause a cell to fail, leading to a thermal runaway event. The possibility of corrosion and thermal runaway is multiplied several times when an EV's battery was immersed in salt water. One hazard that is not a concern is the possibility of electric shock from a submerged EV. EVs operate on direct current; electricity flows from the battery to the electric drive motors and then returns to the battery. The only way that someone could be electrocuted is if their body became part of that circuit. This can be prevented by avoiding the tell-tale orange high voltage cable that runs from the battery to the motors.

A. New prominent terms must be understood:

1. ***Stranded energy*** refers to the electrical current (voltage/amperage) that remains inside of a battery even when it's completely disconnected from everything else.
2. ***Thermal runaway*** and *off-gassing* both relate to the degrading of the rechargeable cells that make up an HV battery as they go through a heating, short-circuiting or burning process.
3. **Off-gassing** usually occurs during thermal runaway and involves the production of smoke, usually grey or white in color, that issues from the battery.
4. **Battery electric vehicles (BEVs)** – Vehicles consisting of a fully electric powertrain that is powered solely by an electric motor fueled by rechargeable batteries. Battery cells are typically located in the low points of the vehicle, such as the floorboard and truck areas.
5. **Cut loops** – Low-voltage wire loops that emergency responders can safely cut to disconnect the high-voltage system from the rest of an electric vehicle. Cutting the cut loop will not remove energy from the high-voltage battery.
6. **Hybrid electric vehicles (HEVs)** – Vehicles combining an internal combustion engine with an electric motor. These vehicles use the electric motor as a secondary power source powered by a nickel-metal hydride (NiMH) battery that is charged by the internal combustion engine. Powered can also generated through the turning of the wheels and brake application.
7. **Lithium-ion battery** – Rechargeable batteries consisting of cells containing lithium that produce an electric current by converting chemical energy into electrical energy. They are the preferred energy storage source for BEVs due to their ability to store large amounts of energy in a small sized vessel and retain and discharge high amounts of power.

2.36.3 EV fire tactics

***TICs*.** Use of a thermal imaging camera (TIC) might reveal where the runaway heat is inside of the battery box. Once the vehicle is extinguished it should be checked for Thermal Runaway up to **1 hour** after extinguishment before you release the vehicle to the tow operator. Preliminary reports suggest temps below 260

Extended duration firefighting may happen when li-ion batteries are involved in fire, a longer than expected vehicle firefighting operation might be required. Copious amounts of water may need to be provided for hours on hand to sufficiently cool and stop Thermal Runaway. You may need up to 30,000 gallons of water!

Vehicle tilt/lift. It's a reality that a floor pan-mounted battery limits access for fire suppression, which hinders members' ability to fight the fire and to gain access to the battery. To address this challenge, and if it can be done safely, firefighters should lift or tilt the vehicle enough so the cooling water can be concentrated on one area of the battery then moved to another as the battery and the errant cells that are inside of it cool down. Rescue 42, High-lift jacks, or other equipment from HM31 may provide equipment. Consider using a tow truck if available as well.

A. Anytime you are interacting with a hybrid or electric vehicle that has been involved in a collision, fire, mechanical failure or a water related incident, and you need guidance to ensure the vehicle is safe to release out of your care, call the ESA for a Risk Analysis at 1-855-372- 7233.

2.36.4 Structure Fire:

• Follow Regional Standard Operating Guidelines for structure fires that originate from or involve electric vehicles.
• If it can be done safely, remove the electric vehicle from the structure to facilitate extinguishment.
• Initiate fire attack using procedures for electric vehicle fires.

2.36.5 HAZARDOUS MATERIALS CONSIDERATIONS

• For public safety and/or environmental concerns regarding lithium-ion batteries or other hazardous substances, contact the Hazardous Materials Response Team.