

I. PURPOSE

The purpose of this policy is to increase safety for fire personnel at emergency incidents involving battery-energy-powered vehicles and mobility devices. This policy is provided for the safe and effective size up, operational awareness, procedures, and risk reduction of rescue, extrication, and firefighting incidents involving battery-powered transportation.

II. BACKGROUND

Battery-powered energy Lithium-Ion (Li-ion) batteries are becoming more prevalent in vehicles and micro-mobility devices. These vehicles and mobility devices are being used in everyday applications by the public and businesses and are commonly being stored, charged, sold, or repaired inside resident and commercial occupancies.

Fires involving lithium-ion batteries have been increasing at an alarming rate and can result in injuries and fatalities. Lithium-ion batteries can increase the intensity of a fire quickly and unlike a typical vehicle fire.

III. TERMINOLOGY

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:** When the stable state of batteries/cells rapidly fails due to increased heat from charging or external conditions such as fire, the cell transitions from a stable state to an unstable state and then to catastrophic failure of the cell.

Once thermal runaway begins it will propagate (spread, domino effect) to the adjacent battery cells. It may only take seconds for this dangerous event to take place. Usually, there is a "pop" or rupture sound heard preceding thermal Runaway with pressurized white smoke (flammable/toxic gases) venting moments before ignition.

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. Toxic gases from lithium-ion battery fires include high levels of hydrogen, hydrogen fluoride, hydrofluoric acid, and other hazardous gases.

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. Power can also be 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

IV. PROCEDURES

Operations – the minimum level of protection for firefighters shall be full protective clothing, and SCBA on-air. Members should be prepared for rapid fire intensification, deflagration, explosions, flame jetting up to 10ft away, rapid heat release rate increase, material ejection, reignition, and off-gassing.

Apparatus – Should be placed upwind of the incident with consideration of using the apparatus as a barrier. Placing the apparatus upwind will protect those working in the warm zone from possible inhalation of the toxic products of outgassing. Incidents involving battery-powered vehicles will typically be an extended operation.

Consideration must be given to additional water supply sources. Lithium-ion battery vehicle fires typically require 5,000 gallons of water and possibly up to tens of thousands of gallons. Establishing a water source early is important along with possibly an additional suppression apparatus.

Identify Vehicle: Determine if the vehicle is an electric or hybrid-electric vehicle and if it is, advise Fire Dispatch and all responders that an electric or hybrid-electric vehicle is involved. Look for identifying components such as badging, charging ports, labels, and orange high-voltage components. If an electric vehicle is involved, seek information from the emergency response guide (ERG) from the NFPA, Energy Security Agency (ESA 1-855-ESA-SAFE), or other resources.

Immobilize Vehicle: Always approach vehicles from the sides to stay out of potential travel paths. It may be difficult to determine if the vehicle is running due to a lack of engine noise. If possible, chock the tires, place the vehicle into Park, and set the parking brake. EV Vehicles have more torque than a common vehicle, chocking tires may not fully immobilize the vehicle.

Disable Vehicle: Turn off the vehicle, move vehicle keys/ FOBs or any device that has starting application for the vehicle, at least 25 feet away from the vehicle if it is safe to do so. If **necessary**, disconnect the vehicle's 12-volt battery. CAUTION: Safety restraints, airbags, and other safety systems may be active for up to five minutes after disconnecting the 12-volt battery. If extrication is needed, disconnect the first responder cut loop (**if batteries are not damaged 12-volt system runs a high voltage battery management system and avoid cutting to maintain HV batteries monitored and maintained with the system**).

Extrication: Prior to extrication, firefighters must understand where the high-voltage system and battery packs are located. These bright-colored wires and sealed packs are not to be touched or punctured and shall be avoided during extrication operations. These high-voltage areas may affect common tactics and locations of cuts, lifting, and spreading with extrication tools. Refer to vehicle-specific ERG for vehicle anatomy.

Hazards: Always assume the high voltage (HV) battery and associated components are energized and fully charged. **DO NOT MAKE CONTACT WITH ANY HIGH-VOLTAGE COMPONENTS.** Exposed electrical components, wires, and HV batteries present potential HV shock hazards. Venting/hissing/sounds, electrolyte bubbling from the 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).

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. Inhaling trace amounts of these toxic off-gasses can be deadly. Wearing full Personal Protective Equipment (PPE) and Self-Contained Breathing Apparatus (SCBA) is a must. There is a potential for delayed fire with damaged lithium-ion batteries. Lithium-ion battery packs that have been damaged have been known to have delayed ignition and re-ignition up to days later. **If the vehicle is towed make arrangements with the Tow Company to have the vehicle towed on a flatbed or dollies to prevent regeneration of power as the vehicle moves to the tow yard or repair shop.**

IV-A. Electric, hybrid-electric fires

Fire Attack – a fire involving an electric vehicle (EV) can involve just the passenger compartment or the battery pack or both. If a fire has only involved the passenger compartment, treat it as a typical vehicle fire and apply water for rescue and suppression. If water is not readily available a dry chemical extinguisher will protect to permit rescue of occupants only. If the fire involves the battery pack, it is assumed that the battery pack is in thermal runaway and will not be able to rapidly be extinguished. Priorities should then be changed to protect exposure and consider letting the vehicle and battery burn.

FOAM WILL HAVE NO IMPACT ON THE SUPPRESSION OF AN ELECTRIC BATTERY VEHICLE FIRE WHERE THE BATTERY PACK IS INVOLVED.

If a defensive attack is taken, consider using a tow truck or wench to move the vehicle away from exposures and into an open area where it can burn freely.

If an offensive attack is approached, battery packs in EV vehicles are typically located on the floor pan-mounted area which gives limited access for fire suppression. If safe, firefighters should lift or tilt the vehicle to one side to allow for passive cooling of the battery pack on the underside of the vehicle. This lift can be accomplished with a hydraulic spreader and cribbing (for vehicles with heat dissipation on the bottom of cars Ex. Tesla, for vehicles with sealed floor pans, insert a nozzle into the vehicle and flood the interior “Make it a hot tub”. A typical EV vehicle battery pack cooling requires approximately 70 gallons per minute of passive cooling to the involved battery pack area. Consider the use of an unmanned portable monitor gated down to 70gpm and directed at the battery pack. A thermal imaging camera can be used to identify where in the battery pack thermal runaway is occurring, studies show the battery will be above 200 degrees Fahrenheit at the start of thermal runaway the products burning produce temperatures above 1500 degrees Fahrenheit. **Do not attempt to penetrate the HV battery or its casing to apply water.**

Consideration should be given to calling for **Hazmat** for atmospheric monitoring due to the hazardous and toxic chemicals in the smoke from a lithium-ion battery fire. Runoff from extinguishment can be hazardous. Fire hose will be contaminated along with bunker gear; cleaning of hose and equipment is paramount.

EV fires involving the battery pack commonly reignite, monitoring of the battery pack must continue for 1 hour post-extinguishment before releasing the vehicle to the tow company. Any signs of thermal runaway or off-gassing are to be monitored during that time.

IV-B. Structural fires involving lithium-ion batteries (mobility devices, Battery home generation systems, and EV vehicles)

For fires involving garages or exposures consider dragging or moving vehicles to open areas and allow them to burn out.

Structural fires involving lithium-ion batteries will release heat and flames faster and hotter than normal household materials. Battery packs in thermal runaway typically cause deflagration along with an explosion capable of blowing out windows and doors and creating flashover conditions in less than 1 minute. Lithium-ion batteries are used in mobility devices such as electric bikes, scooters, hoverboards, and wheelchairs.

These devices may not be able to be extinguished fully with just water and will need to be removed, if safe to do so, from the structure and placed outside in an open area. If unable to be removed from the structure, items can be submerged in a bathtub, sink, or bucket large enough to fully submerge the item. Battery-pack-powered devices shall not be removed via the elevator.

Firefighters should not place battery packs or cells inside bunker gear pockets for removal and should attempt to remove cells with a shovel with a wooden handle or any other non-conducting equipment that allows members to not carry items in their hands.

IV-C. Submerged Electric Vehicle

Vehicles that are submerged in water are safe to touch as the High voltage system is isolated from the chassis. Do not touch the submerged HV cables or components directly.

REFERENCES

ESA. (n.d.). (bulletin). *Thermal Events. First Responder Checklist for Electric Vehicle Thermal Events.*

FDNY. (2022). (tactics and procedures.). *Lithium-Ion Battery Mobility Device Fires.* New York City, NY.

IAFC. (2021). (bulletin). *Fire Department Response to Electric Vehicle Fires.* Chantilly, VA.