Southern Manatee Fire Rescue District Directive		
DATE **September 2021**	**VOLUME** **#2** **FIRE OPERATIONS**	**NUMBER** **# 256**
CATEGORY POLICY		
SUBJECT Lithium Battery Emergencies		

PURPOSE:

The purpose of this policy is to develop best practice management principles when dealing with Lithium-Ion batteries. These Li-ion batteries are increasing in popularity for supplying energy in rechargeable batteries that is different from other battery cell systems. Although the focus is on vehicle hazards, this policy relates to all Li-ion battery related incidents.

BACKGROUND:

Li-ion battery cells are in wide consumer use today. As this technology has evolved and the energy densities have increased, the use of this technology has been applied across many consumer products, including the automotive industry. Li-ion battery cells arranged in large format Li-ion battery packs are being used to power EDVs. As EDVs enter the U.S. marketplace, there is an expectation of a large increase in the number and size of battery packs in storage and use.

Definitions:

DC	direct current
EDV	electric drive vehicle
HEV	hybrid electric vehicle
HV	hybrid vehicle
ICE	internal combustion engine
Li-ion	lithium-ion
NiMH	nickel metal hydride
PPE	personal protective equipment
SCBA	self-contained-breathing-apparatus
TIC	thermal imaging camera

EDVs involved in collision and fire incidents may present unique hazards associated with the high voltage system (including the battery system). These hazards can be grouped into three distinct categories: chemical, electrical, and thermal. The potential consequences can vary depending on, but not limited to, the size, configuration, and specific battery chemistry.

Currently, the fire service is searching for ways to manage the recent and forecasted increase in the number and type of EDVs and the potential fires that may result. In addition to the hazards described above, these vehicles may present additional challenges for the fire service. Many of these vehicles have operational features some of which fire service personnel are unfamiliar. For example, EDVs are normally silent when the vehicle is stopped. Thus, an EDV can be "on" and ready to drive if the accelerator is depressed. Similarly, many HEVs "hibernate" when they come to a stop. These vehicles are also poised to move if the accelerator is depressed. Emergency responders can no longer assume that a vehicle is "off" when they cannot hear the engine running.

Response:

EDVs contain high voltage batteries and electrical components that present the risk of shock and electrocution to first responders if not properly handled. These hazards are not typically encountered during responses to fires in conventional ICE powered vehicles. Firefighters are at risk for severe shock/injury/electrocution if they breach an energized high voltage electrical component or the high voltage battery. Firefighters may also be shocked by meeting an energized high voltage component that has been compromised by fire or collision damage.[1]

Personnel Safety:

All personnel working in the lithium battery fire or incident shall wear bunker gear with SCBA. The number of exposed personnel will be kept to an absolute minimum.

Fires may occur in an EDV high voltage battery, or a fire may extend to the battery. Most EDV batteries currently on the road are NiMH. However, the number of cars powered by Li-ion batteries is increasing. The use of water or other standard agents does not present an electrical hazard to firefighting personnel.

Despite the extensive usage of Li-ion hybrid vehicle battery in energy storage applications, they are susceptible to thermal runaway and fire which is the primary safety concern when used in hybrid electric vehicles (HEVs) and electric vehicles (EVs), The Li-ion hybrid vehicle battery systems used in these applications consist of multi-cell packs and modules where thermal runaway in a single cell can initiate thermal runaway in adjacent cells and consequently compromise the integrity of the entire battery system. The conditions which may lead to thermal runaway and fire in Li-ion hybrid vehicle battery fall into four categories:

1. Electrical Abuse: Over charging or undercharging cells
2. Thermal Abuse: Exceeding minimum battery cell temperature.
3. Mechanical Abuse: Caused by external mishap such as a crash.
4. Short-Circuit: Power failure on the battery cell components that lead to electrical short.

Some extinguishing agents may extinguish Li-ion hybrid vehicle battery electrolyte fires but may not control thermal runaway and the involvement of adjacent cells.

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Procedures (First Unit on-scene):

Firefighters are confronted with additional hazards and challenges when dealing with EDVs. The following best practices address EDV fires. These tasks include:

A. Identify the vehicle
B. Immobilize the vehicle
C. Disable the vehicle

[1] https://www.energy.gov/sites/prod/files/2014/02/f8/final_report_nfpa.pdf

D. Extricate the patient, if required
E. Fire extinguishment
F. Overhaul operations

A.<u>Identification of the vehicle</u>:
Identification of a vehicle as an EDV is the first challenge firefighters face upon arriving at a vehicle fire. In many instances, it may be readily apparent from the vehicle make/model or from exterior badges/logos. In other instances, it may not be so apparent. Damage sustained by the vehicle by either a collision/roll-over or the fire and smoke itself may make identification very difficult. During size-up of the incident, firefighters should look for warning labels on the vehicle that warn of high voltage.

If the fire is confined to the engine compartment or trunk, a firefighter may be able to get a clear view of the instrumentation on the vehicle's dashboard. In this case, firefighters should look for words and symbols that indicate the vehicle is an EDV. If the vehicle is "on", the firefighter may be able to see dash symbols indicating charge status of the battery, or that there isn't a fuel gauge.

Once identified as EDV, request additional to assist with water supply. A recommended water supply is 5,000 gallons accessible depending on thermal impact to the battery cell.

<u>B.Immobilize the vehicle:</u>
As with conventional ICE vehicles, it is important to place chocks to the front and rear of one of the wheels to prevent the vehicle from rolling. EDVs can hibernate; although it may not be obvious that the engine is running, the vehicle may be poised to move as soon as the accelerator is depressed. EDVs should be chocked to prevent any inadvertent movement of the vehicle as soon as possible. Chocking alone may not prevent all movement, setting the emergency brake and placing the vehicle in park can add additional protection against inadvertent movement.

<u>C. Disable the vehicle:</u>
Determine the status of the vehicle by viewing the dash display, the position of the key in the ignition, and/or the power button to see if it has a lit indicator light. If the vehicle is "on", turn the key to the "off" position. Some EDVs operate with a proximity key. If the proximity key is within range of the vehicle (usually less than 16 feet), the vehicle is powered "on" by a button on the dash. Turn the vehicle "off" by pressing this button. Then remove the key from the ignition and place it beyond the range of the vehicle (typically greater than 16 feet). In addition to the high voltage battery that powers an EDV motor, there is a conventional 12- volt battery located somewhere on the vehicle. The 12-volt battery powers many of the vehicle accessories and is used to control high voltage contactors. Disconnecting the 12-volt battery's ground cable will prevent the vehicle from powering up. Cutting the 12-volt battery in a vehicle that is "on", however, will not turn the vehicle "off", as power supplied by the DC/DC convertor may keep the contactor closed. After the vehicle has been powered down by the key/ignition button,

firefighters should further disable the vehicle by disconnecting the 12-volt battery's cables, negative terminal first.

It may take up to ten minutes for a high voltage system to dissipate its energy after the main has been pulled/switched off. However, it should be noted that high voltage will still be present within the battery pack and on the battery pack side of the high voltage main disconnect switch.

Should the EDV be plugged into a charging station at the time of a fire, Isolate the electrical supply to the charging station from a safe location by trained professionals prior to any attempts at disabling the high voltage system within the vehicle.

<u>D. Extrication of patient:</u>
An incident involving the extrication of victims from an EDV, response personnel should use the steps identified above to immobilize and disable the vehicle. Due to the degree of damage to the vehicle and/or the physical aspect of the vehicle, responders may have to employ secondary methods for disabling the vehicle, as described above. The supplemental restraint systems in most vehicles will remain active if the 12-volt batteries are not disconnected. A damaged high voltage battery may emit corrosive, toxic, and flammable fumes. In addition, responders should use ventilation techniques to protect the occupants of the vehicle and prevent the build-up of flammable vapors in the trunk or passenger compartment. A charged attack line should be staged near the vehicle during extrication. Responders should constantly monitor for indications that a damaged battery may be overheating, such as sparking, smoking, or making bubbling sounds.

During stabilization and extrication, response personnel must avoid inadvertent contact with all high voltage cabling and high voltage components. **Response personnel should never cut through any high voltage electrical component.** Personnel performing the extrication should visually check for the presence of high voltage electrical cabling and components of the supplemental restraint system prior to initiating every cut or displacement. The location and routing of high voltage components may prevent some advanced extrication techniques, such as trunk tunneling and gaining access through the underside or floor pan of the vehicle if no battery pack is present. Typically, high voltage lines are orange in color.

<u>E. Extinguishment of Fire:</u>
Fires confined to the cabin or trunk of an EDV can be extinguished using tactics associated with ICE vehicles. EDVs contain the same amounts of toxic by-products as conventional vehicles, as well as the previously discussed projectile hazards. Firefighters should be in full PPE and SCBA donned. Firefighters must avoid contact with any orange electrical cables and components that have high voltage warning labels. If a fire has burned warning labels or rendered them otherwise illegible, firefighters should not touch any electric drive or drive system component. Firefighters should never attempt to breech a high voltage battery or its housing for any reason. Many high voltage components are directly accessible from the engine compartment. Defensively applying a fog stream through existing openings in the wheel-wells and grill can be done safely to knock down the fire. **Firefighters should not attempt to force entry into the engine**

compartment with prying tools, nor should they attempt to spike or cut the hood or fenders with a piercing nozzle, cutting tool, or prying tool. Performing any of these tasks could result in a firefighter being severely shocked. Firefighters maybe unable to gain access to the engine compartment. In this instance, defensive fire suppression tactics should be employed until the fire is completely extinguished. In some cases burn times have been noted at 2 hours. If the high voltage battery is involved in the fire, an offensive attack may be recommended if there are exposures (other vehicles, buildings, etc.). If the high voltage battery is not involved in the fire, an offensive attack may be mounted regardless of whether there are exposures.

Water-based extinguishing agents provide the most cost-effective method to fight fires. Water may be able to mitigate or halt the propagation of thermal runaway to surrounding batteries. Check for pre-existing access into the battery cell and use them for ad designed, if found. It is recommended manning hose lines on extinguished battery cells long after extinguishment.

G. Overhaul Operations:

Following extinguishment, the EDV must be properly overhauled. Responders should first verify the vehicle has been properly immobilized and disabled and take appropriate steps to accomplish these tasks if they have not been completed. As during all phases of any response to incidents involving an EDV, responders must avoid contact with any high voltage component during the overhaul phase of the incident. Responders should never attempt to cut, breach, or remove the high voltage battery or any high voltage component. Diligent thought and care should be exercised before manipulating the EDV in any way with any forcible tools. During overhaul, firefighters will verify that the fire has been completely extinguished with TIC, but it may be difficult to assess the battery compartment area**. It is highly recommended that firefighters should not drive prying tools into any area that may house battery cells or cover high voltage components.** Upon extinguishment, firefighters should also carefully observe the high voltage battery compartment to ensure it is not smoking, sparking, or making bubbling sounds.

When turning over the vehicle to recovery company, brief them on the hazards and awareness of possible reignition hours after storage. Recommend isolation of the vehicle away from other stored combustibles.