SALEM FIRE DEPARTMENT
STANDARD OPERATING GUIDELINE

TACTICAL GUIDELINES
LITHIUM-ION BATTERY RESPONSES

Effective Date:

DC Operations

Revised Date(s):

PURPOSE: This guideline establishes procedures for fire department personnel and equipment response to control emergencies with Lithium-Ion Battery fires.

GUIDELINE:

A. Background

a. Lithium-ion (Li-ion) batteries are becoming more prevalent in consumer products ranging in size from smaller products such as mobility devices up to and including use in large-scale power grid support. These smaller devices are used in everyday applications by the public and are consequently being stored, charged, sold, or repaired inside residential and commercial occupancies.

b. Fires involving lithium-ion batteries have been increasing at an alarming rate and have resulted in fatalities. Even when the initial cause of a fire was not the lithium-ion device, the involvement of lithium-ion batteries in a fire can increase the intensity of the fire.

c. Lithium-ion batteries are commonly used in mobility devices which include: Electric Bikes, Scooters, Hoverboards, Wheelchairs, and Vehicles.

B. Construction

a. **Battery cells** - the most common is the 18650 cell, which is cylindrical and slightly larger than an AA battery.

b. **Battery Pack (Module) -** is a group of battery cells connected in a series or parallel configuration.

c. Battery Packs may be permanently installed or removable from the mobility device. They are located externally on the frame, floorboard or rear rack of the mobility device but can be found internally on some devices. An internal mount is

common when the mobility device is foldable. The mobility device in the closed (folded) position may give direct access to the lithium-ion battery pack.

C. Hazards

a. Batteries may rupture and vent toxic flammable gases and/or explode violently when the gases ignite, when subject to the following:
   i. Thermal – Hot or Cold temperatures.
   ii. Physical – Impacted, crushed, or pierced.
   iii. Electrical – Over-charging or forced discharge, including internal manufacturing defects or internal short circuiting.
   iv. Drying after being wet.

b. It may be difficult to discern if a lithium-ion battery pack or cell is compromised; the resulting heat signatures may not be picked up by a Thermal Imaging Camera (TIC). A thermal imaging camera shall not be relied upon to determine if a Lithium-Ion battery pack or cell is compromised.

c. *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.
   i. Usually a "pop" or rupture sound heard proceeding Thermal Runaway with pressurized white smoke (flammable / toxic gases) venting moments prior to ignition.
   ii. Water may not prevent a battery from entering thermal runaway. If able to penetrate the battery case, water may provide a cooling effect on the adjacent battery cells. This cooling may reduce propagation to other cells.
   iii. Dry Chemical is ineffective for any type of lithium-ion related extinguishment.

d. *Flammable and Toxic Gases*. Lithium-ion batteries in thermal runaway produce many different gases. These gases combine to form a flammable, explosive and toxic atmosphere. Toxicity and flammability levels vary depending on specific battery technology and manufacturer. The white smoke from the battery is toxic and highly flammable. Lithium Hydroxide gas is produced when putting water onto these fires. The corrosive chemical will also run into the stormwater system.

e. *Unexpected Re-ignition*. Lithium-ion batteries are known to unexpectedly re-ignite (with no warning) minutes, hours or even days after all visible fire has been extinguished. Reignition is a common occurrence.

f. *Explosive force. L*ithium-ion batteries can rupture and ignite with such a force that walls are blown down resulting in structural damage and extensive fire spread.

D. Operations

Whenever the following procedures take place, Full PPE, SCBA and a charged hose line must be in position.

a. **Lithium-ion batteries or mobility devices involved in fire**:
Use a handline to extinguish the fire; flames from a Lithium-ion Battery should be knocked down with copious amounts of water. Water application should continue until conditions are dormant-that is when no more flame, gas, or smoke is being released from the battery or mobility device. Foam should not be used.

i. Li-Ion Batteries or mobility devices that are involved in a fire, found within a fire area, or subjected to elevated temperatures MUST be moved from the area in which members will be operating. This should be accomplished before overhaul operations begin.

ii. When a Lithium-ion battery or mobility device fire involves a suspicious fire, all members operating should be aware of the need for scene preservation prior to the arrival of the Deputy Fire Marshal.

iii. When possible, prior to overhaul around the lithium-ion battery or mobility device, members should conduct a diligent search for stray battery cells. These individual cells may have become dislodged from the battery pack during the fire or by the hose stream during extinguishment.

iv. Firefighters must not place the lithium-ion battery pack or cells in the pocket of their bunker coat or pants.

v. Members should only move the lithium-ion batteries by use of a non-conductive tool, a shovel with a wooden handle, or other methods that don't require members to carry them in their hands.

vi. The batteries or mobility device should be moved to the following location in order of preference until it can be appropriately over packed/mitigated by the Hazardous Materials Team:

1. Bathroom tub in an apartment, with all cells fully submerged in water.

2. Sink large enough that all cells can be fully submerged in water.

3. Garbage pail or bucket large enough that all cells are capable of being fully submerged in water.

4. Environmental services will be called by the Haz Mat Team once the battery is in the overpacked device to dispose of it appropriately.

vii. When the above options are impractical, the crew may remove the batteries or mobility device via a window.

viii. When the battery or mobility device is in a location that makes removal via a window not practical, such as in an upper story apartment in a mid-rise building, the crew may move the batteries or mobility device to a different location on the fire floor and ensure the batteries are protected by a charged hose line. The charged hose line will remain in place until overpacking/mitigation procedures have been completed by the Hazardous Materials Team.

ix. A lithium-ion battery or mobility device shall NOT be moved in an elevator or via stairs unless overpacked. If an elevator is used, the overpacked device will be sent without personnel present.

b. **Stationary ESS Considerations**:
In cases of thermal runaway involving an Energy Storage System (ESS), personnel should use copious amounts of water to cool adjacent batteries, enclosures, and exposures to allow time for the battery to burn out. Some batteries may take several hours, or even days, to fully burnout. If a large commercial ESS is involved in fire or off-gassing, personnel should remain at least 300 feet away from the involved equipment. Consult with the Hazardous Materials Team.

i. Ensure all master breakers are turned off prior to initiating fire attack. There can be up to three separate breakers.

ii. Cover the panels of Photo Voltaic (solar) systems with a minimum 8 mil tarp to block out light. Emergency lights from vehicles are enough to cause the panels to produce power.

iii. **NO OVERHAULING SHALL BE PERFORMED ON ANY ESS.**

iv. The Incident Commander should transfer responsibility to power company representative for decommissioning\fire watch.

c. **Electric Vehicles (EV):**

i. Hybrid and Electric Vehicles contain large lithium-ion batteries that are extremely challenging to extinguish when on fire. Vehicle fires may never be fully extinguished. The IC will need to determine whether to let the fire burn or extinguish the fire. The IC needs to also consider moving vehicles away from exposed structures. Contact the Hazardous Materials Team for technical advice.

ii. USE OF WATER TO FIGHT A HIGH-VOLTAGE BATTERY FIRE. If the battery catches fire, is exposed to high heat, or is generating heat or gases, use large amounts of water to cool the battery. It can take between 3,000-8,000 gallons of water, applied directly to the battery, to fully extinguish and cool down a battery fire.

iii. Always establish or request additional water supply early.

iv. Apply water directly to the battery. If safety permits, lift, or tilt the vehicle for more direct access to the battery. Water may be applied onto the pack from a safe distance ONLY if a natural opening (such as a vent or opening from a collision) already exists. Do not open the battery for the purpose of cooling it.

v. **DO NOT TOUCH ORANGE CABLES**. They carry high voltage up to 400V, some makes up to 900V. **NEVER CUT ORANGE WIRING ON ANY TYPE OF ELECTRIC VEHICLE.** Cutting the low voltage cable on any EV does not remove the energy that is stored in the battery.

vi. The use of EV battery blankets may be used to protect exposures but WILL NOT EXTINGUISH THE FIRE. The use of a large dumpster and sand may be needed for vehicle transport to the disposal facility.

vii. Battery fires can take up to 24 hours to fully cool. After suppression and smoke has visibly subsided, a thermal imaging camera can be used to actively measure the temperature of the high voltage battery. There must be no fire, smoke, audible popping/hissing, or heating present in the high voltage battery for at least 45 minutes before the vehicle can be released to vehicle transporters.

viii. When an EV is removed from the scene of a fire, a rollback tow vehicle (Flatbed) is required for transport. Consideration should be given to escorting the tow vehicle with a fire engine to the disposal location during transport. A Hazardous Materials disposal company will need to be contacted.

ix. Storage at a disposal facility must have area separation from other combustible hazards for up to 90 days after the incident.

x. Consider any EV that has been involved in a high-speed collision to have a compromised battery system. All the previous directions should be followed.

d. **Electrical Vehicle Supply Equipment (EVSE):**

i. EVSE Charging devices can be installed outside, inside residential homes, and inside parking garages.

ii. EVSE fires are electrical fires and contain extremely high voltage. Use CO2 and dry chemical extinguishers. DO NOT USE WATER OR FOAM ON EVSE FIRES. Do not touch any components of the EVSE.

E. Safety

a. Full PPE with a donned facepiece must be always worn with lithium-ion batteries or mobility devices that have been involved in fire or subjected to elevated temperatures. Due to the rapid re-ignition danger when involved in fire or subjected to elevated temperatures, full PPE with a donned facepiece must also be always worn during the following:

i. Whenever members are operating in the immediate area / same room.

ii. When handling or removing from an area to the bathtub, sink or bucket.

iii. When securing a mobility device with a rope for removal via window.

iv. Physical damage (impacted, crushed, or pierced) to the Mobility Device or Battery.

F. Incident Command Considerations

a. The Haz Mat Team shall be special called to any fire or incident involving a lithium-ion battery or mobility device suspected of being powered by a lithium-ion battery.

b. A charged handline shall remain ready until Haz Mat units have completed over packing and mitigation procedures. The Haz Mat Team will have the appropriate container and materials for overpacking.

c. The IC will decide on establishing a Fire watch for the over-packed batteries or vehicle. This is to ensure the battery is no longer producing heat and smoke prior to having it removed. The Haz Mat Team will give technical information for these scenarios to assist the IC.

CROSS REFERENCE: SOG 4.31 ELECTRICAL EMERGENCY AND ENERGIZED EQUIPMENT OR MACHINERY (LOCK OUT/TAG OUT) PROCEDURES

DISTRIBUTION: WVCC
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