STANDARD OPERATIONAL PROCEDURE (BCoFD)

S.O.P. #: TACTICAL OPERATIONS MANUAL # 40
SUBJECT: LITHIUM-ION BATTERY INCIDENTS
DIVISION: EMERGENCY OPERATIONS
6/16/23

Objective: To establish guidelines and procedures for all fire department personnel responding to incidents involving lithium-ion batteries.

As the use of lithium-ion battery operated products has increased in the nation, so has the rate of incidents involving these batteries. The hazards associated with these incidents has resulted in many injuries and fatalities in the community and pose a significant safety concern to fire service personnel.

Section 1: Identification
It is important to understand the anatomy of lithium-ion batteries because any damage to the structure secondary to heat and/or physical impact may cause a catastrophic failure and subsequent thermal runaway.

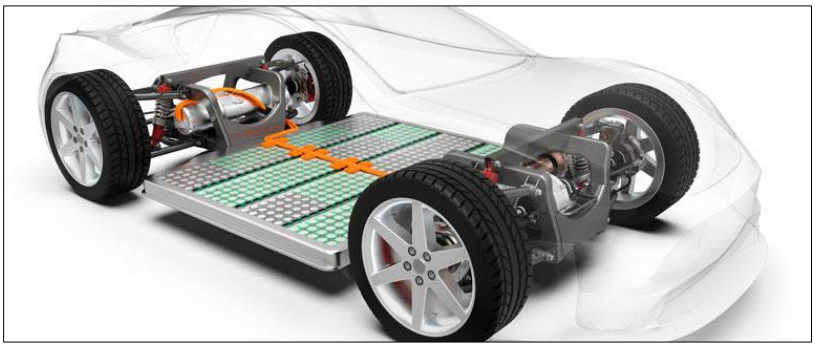
A. Lithium-ion battery cells are made of four components- the anode, cathode, separator, and electrolyte. Lithium-ion moves from the anode to the cathode creating free electrons, or the electrical potential.

B. Lithium-ion batteries can be found in many applications in the community such as, but not limited to:
    1. Small mobility devices- electric bikes, scooters, hoverboards, wheelchairs, etc.
    2. Personal electronic devices
    3. Hybrid/fully electric powered vehicles or EVs
    4. Residential, commercial, and utility-scale Energy Storage Systems (ESS)

C. Configurations:
    1. Individual battery cells:

2. Battery packs or modules with battery management system:

3. Electric Vehicle (EVs):



4. Energy Storage Systems (ESS):

D. Lithium-ion batteries/modules/devices are considered **compromised**:
   1. If they are/were directly on fire or in thermal runaway.
   2. Are found within close proximity of a fire, even if not appearing to be damaged.
   3. If they had any exposure to heat, water, or physical damage.

Section 2: Hazards

A. Rupture/Explosion
    1. Batteries can rupture and explode when overcharged, subjected to extreme heat and cold conditions, forced to exceed its working limit during use, have internal manufacturing defects, or when physically damaged from crushes, punctures, and impacts.
    2. Explosions can be accompanied by intense heat and the venting of toxic gases. The violent and unexpected nature of these incidents cause higher rates of exposure and limits the ability to egress quickly away from the danger.

B. Thermal Runaway
    1. Occurs when a lithium battery becomes unstable due to internal or external factors, creating an irreversible thermal event resulting in a fire or explosion. Heat transfer can quickly propagate thermal runaway in adjacent cells continuing the process throughout the battery pack.
    2. Often a "popping" sound is heard accompanied by a pressurized plume of smoke before ignition occurs.
    3. Water is ineffective at "extinguishing" a battery in thermal runaway, however it will serve to cool the surrounding battery cells, possibly reducing propagation.

C. Off-Gassing
    1. The electrolyte in a lithium-ion battery is flammable. If gases emitted during a fire are not immediately ignited, the risk for a gas explosion later in the event may become imminent.
    2. Lithium-ion batteries also release other toxic gases, such as carbon monoxide (CO) and carbon dioxide (CO2) during heating. These levels may vary depending on the type of battery and manufacturer.
    3. At extreme temperatures, hydrogen fluoride (HF) may be formed posing a serious toxic threat, especially in confined spaces.

D. Re-ignition
    1. Lithium-ion batteries are known to often re-ignite minutes, and possibly even days, after fire has been extinguished or after a battery/battery module has been comprised by heat, water, physical damage, etc. This significantly increases the chance of secondary fires if not identified and overpacked appropriately.

Section 3: Response Guidelines

Note: Overpacking is the process of placing a lithium ion battery in an approved container that renders it safe for transportation. This is a function of and should only be completed by trained members of the HAZMAT TEAM.

A. Electric Vehicles (EVs)

1. Once a fire involving an EV has been reported or identified, immediately request HAZMAT, consider upgrading incident as appropriate.
2. Consider water sources and develop plan to support the large quantities of water potentially needed to mitigate these incidents. Request additional engines and tankers as necessary to support water supply operations. *Consider designating a water supply officer when handling fires on highways and in rural water areas.*
3. Designate hot zone immediately. All personnel operating in hot zone are to be in full turn-out gear with SCBA and on air.
4. Effect immediate rescues.
5. Identify and protect exposures.
6. If operating on highways, notify appropriate agencies of a significant traffic incident and maintain situational awareness.
7. Consider **nonintervention** if-
    a. The EV batteries are in thermal runaway *and*
    b. The EV is positioned in such a way as it does not pose a threat to the public and/or an exposure issue to surrounding structures
8. When **intervention** is necessary-
    a. Flood passenger compartment with copious amounts of water to dissipate heat.
    b. If possible, flow water onto battery module or directly in holes or cracks, if present, to directly cool down battery cells and prevent propagation.
9. Conduct a battery sweep of the surrounding area to locate cells that may have been expelled from vehicle. Individual cells free of the vehicle will need to be overpacked.
10. EVs must be removed from scene with a flatbed truck only. Wheel movement can produce energy and cause re-ignition. **Confirm the tow company is aware the vehicle is an EV. Due to the possibility of re-ignition, the vehicle should be stored away from structures and other vehicles.**

B. Energy Storage Systems (ESS) utilizing Lithium-Ion Batteries
    1. Small-scale Residential ESS Response:
        a. Identify and notify command if fire is involving a residential ESS
        b. Request HAZMAT and utility company response
        c. Quickly identify and operate all power disconnects to isolate battery system. **Even with power "secured", stranded energy in batteries still pose a significant electrical hazard.**
        d. Ventilate structure immediately as off-gassing has potential to cause an explosion.
        e. No overhaul is to be performed directly on ESS or ESS components
        f. If applicable, refer to manufacturer for specific guidance for individual systems.
    2. Large-Scale Commercial and Utility-Scale ESS Response:
        a. Position all equipment a safe distance away from unit smoking or on fire, at least 150' to start.
        b. Evacuate area and effect immediate rescues if necessary.
        c. Request HAZMAT and utility company response
        d. Establish zones considering weather conditions and topography.

e. Make contact with facility representative and, if available, refer to the established Emergency Response Plan (ERP) developed for the system.
f. Set up for defensive operations utilizing aerial, deck-mounted, and un-manned master stream devices.
g. Focus cooling efforts on surrounding units to prevent propagation, allowing involved unit/batteries to burn out.
h. Coordinate with facility representative when utilizing advanced hazard mitigation efforts, such as supporting suppression systems via a remote Fire Department Connections (FDCs) and isolating energy to system with disconnects and shut-offs.

C. Structure Fires and other Fires Involving Lithium-Ion Batteries or Lithium-Ion Battery Devices
1. Work to quickly identify if a fire is involving lithium-ion batteries/devices. Relay information to dispatch and members operating on the incident.
2. Request HAZMAT response.
3. Designate hot zone immediately. All personnel operating in hot zone are to be in full turn-out gear with SCBA and on air even when fire is not located in a confined area or structure.
4. Consider **non-intervention** if-
   a. The batteries/battery devices are in thermal runaway and
   b. The location of the batteries/battery devices do not pose a threat to the public and/or an exposure issue to surrounding structures
5. When **intervention** is necessary-
   a. Utilize copious amounts of water until conditions are dormant – when no flame, gas, or smoke is being released from battery.

Always maintain situational awareness during any fire incident to identify rapidly changing conditions caused by devices utilizing lithium batteries going into thermal runaway, or re-ignition of already compromised batteries.

D. Overhaul Operations
1. Perform a “Battery Sweep”, or a quick search for lithium-ion battery cells, modules, or lithium-ion devices on all fire incidents prior to the beginning of overhaul operations.
2. Immediately notify command when compromised lithium-ion batteries/devices are identified. Request HAZMAT response for overpack and coordination of disposal.
3. All compromised lithium-ion batteries/devices found are to be removed from interior structures and placed in an open, exterior holding area away from members, the public, and other exposures. Monitor exterior holding area with batteries/devices until overpack is completed.

   Utilize non-conductive tools, such as wood-handled shovels, to move batteries/devices. Never directly handle compromised batteries/devices.

4. If removal of batteries/devices to exterior holding area cannot be completed safely, such as in high-rises, wide-rises, or large commercial buildings, an interior holding area can be utilized until overpack can be completed. An interior holding area can be:
    a. A bathtub or sink of water large enough to fully submerge battery cells or devices.
    b. A bucket or container of water large enough to fully submerge battery cells or devices.
5. When utilizing an interior holding area, ventilation must be considered due to flammable off-gassing even while batteries/devices are submerged in water.
6. If an interior holding area is not practical, compromised batteries/devices can be lowered out of a window utilizing a rope and bucket. **Members on the exterior assisting in window removal must be in full PPE, SCBA, on air.**
7. When window removal is not practical, such as in a high-rise building, an area away from operations can be determined to temporarily store the batteries/device. A member will be designated to keep watch with a charged handline until overpack has been completed.
   Compromised lithium-ion batteries/devices shall NEVER be moved down multi-story, multi-residential stairwells or via an elevator unless they have been overpacked.
8. For ruptured lithium-ion battery modules/devices, care should be taken to search for stray battery cells that are ejected by the force of the explosion or displaced by hose streams during extinguishment. *Cells left behind, damaged or un-damaged, run the risk of igniting or re-igniting causing secondary fires.*
9. If the incident is determined to be criminal and/or a cause and origin investigation will be necessary, the Incident Commander (IC), in coordination with the HAZMAT team and the Fire Investigation Division (FID), will determine the appropriate actions to preserve the scene while maintaining the safety of those completing the investigation. In these instances, please contact the on-duty/on-call FID/Arson Team Commander through Fire ADO.
10. The HAZMAT Team on scene shall:
    a. Handle the overpack of compromised lithium-ion batteries.
    b. Conduct metering and detection of toxic and flammable gases associated with thermal runaway.
    c. Determine appropriate decon procedures.
    d. Coordinate with the Incident Commander (IC), Maryland Department of the Environment (MDE), and, if requested, the Fire Investigation Division (FID).