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Dangers from battery fire smoke inhalationâ€”PART 2

GREEN SHEET Report of Sacramento incident.

Additional submitted attachment is included below.

Sacramento Fire Department Preliminary Summary Report of Serious or Near Serious Injuries

GREEN SHEET

Electric Vehicle MVA and ensuing fire—causing respiratory injuries to responding firefighters.

April 11, 2025

Tesla Fire

6520 Riverside Bl, Sacramento

(CA-SCR-25-029878)

A Board of Review has not approved this Summary Report. It is intended as a safety and training tool, an aid to preventing future occurrences, and to inform interested parties. Because it is published on a short time frame, the information contained herein is subject to revision as further investigation is conducted and additional information is developed.

Incident Overview:

- April 11th, 2025 @ 22:04. MVA with electric vehicle (EV) lithium-ion battery (LIB) Fire Involvement.
    - Initial dispatch for MVA with major injury.
    - Upon arrival, crews discovered a single Tesla Model S had struck a tree.
- **Weather:**
    - Clear skies, temperature approx. 63°F, light winds from the south/southwest at 4-13 mph.
        - As of this writing, exact weather data for the closest weather station is no longer available.
- The vehicle's battery pack was compromised and had over 400 scattered battery cells across the roadway. A typical Tesla Model S LIB pack contains ~7,500 cells.
- E11 initiated patient care and identified battery cell ignition risk.
- The patient was transported to the ER in a Medic unit.
- E11 upgraded the incident to Level II Hazmat.
- Hazmat 30, Hazmat 7 and Special Ops (2293) were called to the scene.
- The main EV LIB pack reignited when the vehicle was moved for tow operations.
- Five firefighters exposed to smoke plume during tow operations were injured.
    - As of this writing, four firefighters are still unable to return to work from the injuries they sustained.

FACTORS TO CONSIDER

- **Victim Profile:**
    - Initially, a solo vehicle occupant was trapped.
        - The victim was successfully treated and transported.
    - Afterwards, the only threats were from potential EV LIB vapors.
- **Hazmat Considerations:**
    - Lithium-ion battery (LIB) battery pack of a Tesla EV compromised and intermittently in thermal runaway with thick white persistent vapor being produced.
    - Intermittent spontaneous ignition of individual ejected battery cells, white vapor being produced from individual cells.
- **Incident Priority:**
    - Life Priority initially.
    - After the occupant was successfully extricated and transported, the incident priority was environmental protection.
- **Incident Mode:**
    - Offensive initially.
    - Defensive later, after victim removal and transport to the ER.

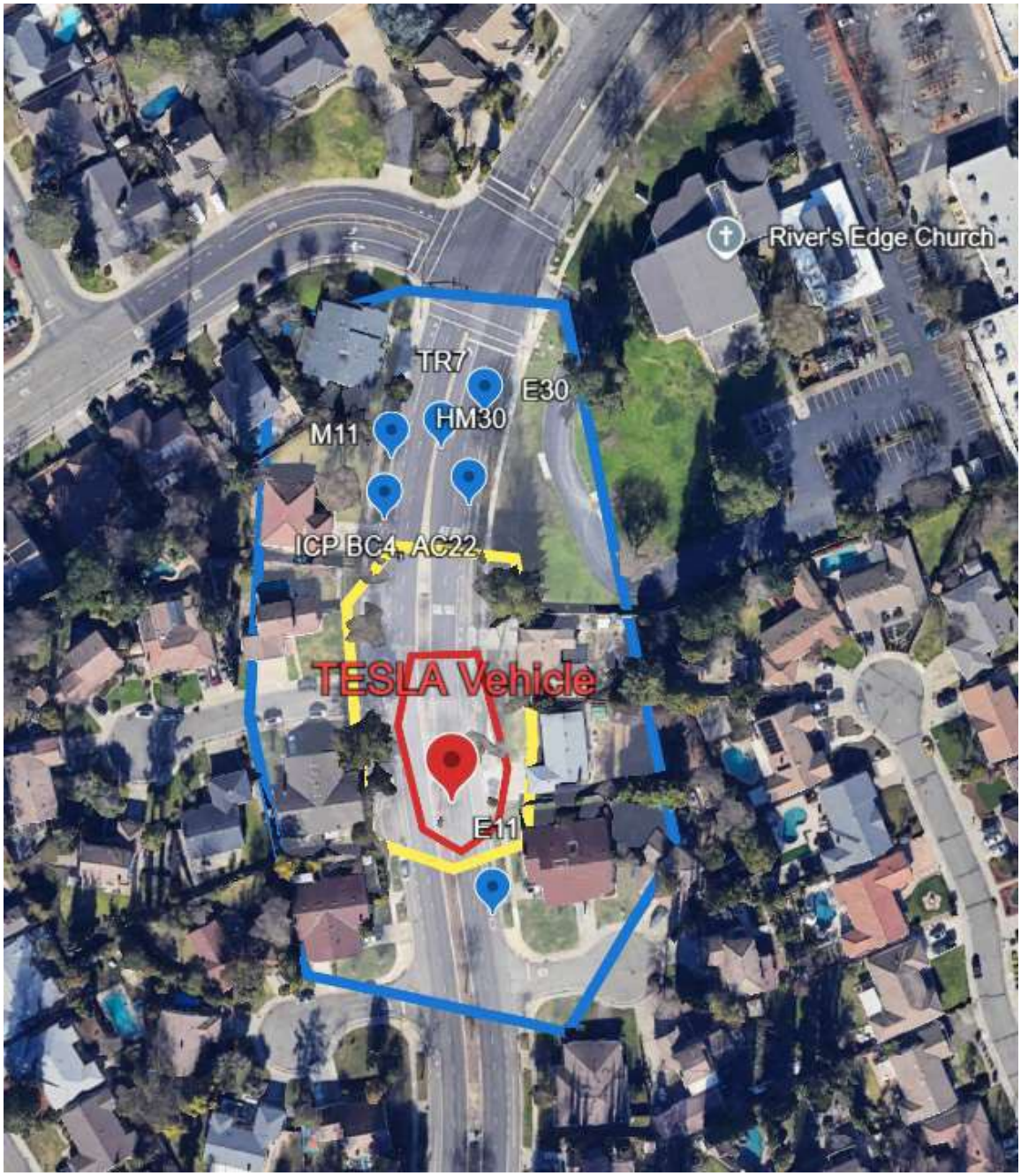
Sequence of Events:

SIN (Safety, Isolate, Notify)

- Crews found one occupant from a heavily damaged Tesla.
    - The patient was removed from the vehicle prior to the arrival of E11.
- After extrication and transport, crews recognized signs of battery compromise, including scattered lithium-ion cells intermittently and spontaneously entering thermal runaway.
- A Level II Hazmat response was initiated.

CIA (Command, Identification, Hazard Assessment)

- Hazmat crews arrived later and positioned at the previously established command post location.
- Lacking noticeable winds and unaware of wind direction, command and hazmat units positioned themselves approximately 200' to the north of the incident.
- Technical Reference position was established to look up best practices for the hazards presented by EV LIB.
- Hazmat Group Supervisor, Hazmat Assistant Safety Officer (ASO), Entry Team, and Back-Up Team were established.



PCP (PPE, Containment and Control, Protective Actions)

- E11 was left in place with a protection line.
    - E11 personnel were operating about 100’ upwind of the EV.
    - E11 personnel were not adversely affected by the LIB vapors, likely due to personnel remaining out of the vapor plume.
        - The importance of understanding the wind direction and its effects on operations cannot be overstated.

- Hazmat Entry Team entered the area to safely gather the ejected LIB cells for mitigation, storage, and disposal.
- The first responder cut loop was cut by the Entry Team at the direction of the Incident Commander.
    - Current guidance advises against cutting first responder cut loops in this situation.
        - However, with the level of destruction of this Tesla, we cannot say whether this action had any effect on the subsequent events.
        - It is unknown whether the battery management system (BMS) was functioning at all.
- Later, as the tow truck operator began to move the vehicle, a thermal runaway event occurred within the main EV LIB pack.
    - This event produced a large volume of white gas.
    - E11 was positioned nearby, and water was promptly applied to the battery pack.
        - A significant vapor plume was produced by the event.
            - The gases produced may resemble steam or smoke, but they contain highly toxic chemicals and metals. Unlike typical smoke, these vapor clouds may behave unpredictably, lingering low to the ground and dissipating slowly, depending on humidity, temperature, and wind conditions.
        - The vapor plume soon exposed support zone personnel approximately 200 feet away in what was now clearly the downwind direction.
- Crews attempted to disconnect their hoses and evacuate the area but were overcome by the vapor plume prior to being able to clear the area.
    - We know now that aggressive utilization of fog streams can be effective in these situations to protect crews and populations from the effects of these toxic vapor plumes.
    - When the crews were overcome by the vapor plume, they immediately began complaining about the noxious smell and taste of the vapors.
    - Crews then fled the area in their apparatus.
        - The vapor plume continued with the wind as the crew escaped its path.
        - The vapor plume then dissipated.

DDD – (Decontamination, Disposal and Documentation)

- Crews returned to the area and later escorted the vehicle and ejected cells to the planned disposal sites.
    - Approved disposal practices and sites are still being worked out at the time of this writing.
- While escorting the tow truck to the tow yard, three out of the four firefighters in the engine complained of feeling ill.
    - One of the four firefighters began vomiting out of their window.
    - The company called a medic and had the firefighter that was vomiting transported in an ambulance.
    - The engine company followed the ambulance to the hospital.
    - Another engine was dispatched to replace the initial engine.
        - The replacement engine finished escorting the damaged Tesla and the ejected cells to the planned disposal sites.
    - At the hospital, the two additional personnel that were symptomatic agreed to seek treatment for their injuries.
    - By the end of the night, two additional firefighters that were overcome by the vapor plume felt ill and sought treatment.

Overview of injuries

- *Ongoing testing indicates that toxic vapor plume composition can vary significantly throughout the plume.*
- *Symptoms and injuries from exposure can vary significantly because of the varied composition of chemicals found in the different areas of these toxic vapor plumes.*
    - Firefighter #1 was nauseous and vomiting. Transported to the ER in a Medic.
        - Within a week they felt recovered and returned to work.
    - Firefighter #2 felt nauseated and had flu-like symptoms for several days.
        - Flu-like symptoms persisted, but they felt well enough to return to work after a couple of weeks. They were able to work for 3 weeks.
        - Placed back off-duty with a constant decrease in exercise tolerance. 20% decrease in lung function. They have remained off work since then.
    - Firefighter #3 has significant respiratory and renal symptoms, as well as low exercise tolerance, persistent hypertension, tachycardia, and fatigue.
        - Two months later, they are still unable to work.
    - Firefighter #4 has severe persistent fatigue, low exercise tolerance and persistent respiratory symptoms.

        - Two months later, they are still unable to return to work.
    - Firefighter #5 has severe persistent respiratory symptoms with a 20% decrease in lung function, symptoms of fatigue, significant cardiac symptoms, and symptoms of renal compromise.
        - Two months later, they are still unable to work.

LESSONS REINFORCED BY THIS INCIDENT

Things that went well:

- Prompt extrication and treatment of the patient.
- Rapid identification of EV LIB risk and escalation to Level II Hazmat.

Other Recommendations not mentioned above:

- Establish Hot, Warm, and Cold zones early. The following distances are initial recommendations and are subject to change based on plume modeling by Hazmat teams.
    - Hot/Exclusion Zone- All personnel within 75 feet of a compromised EV must be on air.
    - Warm/Contamination Reduction Zone – Apparatus should be placed outside 150 feet, upwind if possible.
        - If not feasible, assess risk vs. gain and apply controls to limit exposure.
    - Cold/Support Zone- Upwind, 330’.
- Post-incident PPE procedures: If you operated in the vapors—gross decon **before** going off air and doffing PPE.
- Tow truck operators should be briefed, and their work should be coordinated with Command or Hazmat Group Supervisor due to risk of exposure and reignition.
    - A charged and staffed hose line needs to be in place during this process.
- Utilize fog streams as needed, when possible, to protect populations and personnel.
- Monitor for signs of thermal runaway at least 45 minutes post-extinguishment before attempting to relocate vehicle.
    - The return of thermal activity and vapor production resets this clock.
- Coordinate the containment and disposal of the vehicle, battery cells and runoff in consultation with Hazmat best practices.

Best recommended EV LIB practices at the time of this writing:

Purpose and Scope

This guideline provides strategies and tactics for suppression personnel to utilize during electric vehicle (EV) fires involving lithium-ion battery (LIB)-electric or hybrid vehicle battery packs.

Key Considerations

Hazards of lithium-ion / EV LIB Fires

- The incident priorities remain the same: Minimize risks to life, stabilize the incident, protect property, and protect the environment.
- A Level II Hazmat should be declared early, and appropriate actions may be taken prior to Hazmat team arrival to control hazards and improve overall scene safety.
- LIB thermal runaway can release highly toxic substances, including hydrogen fluoride (HF) and metal nanoparticles, both of which present severe acute and long-term health risks:
    - LIB thermal runaway vapors may look like steam but are often highly toxic aerosols.
- Full PPE and SCBA (on air) are required for all operations within the **75-foot exclusion (hot) zone** of confirmed LIB fires.
- Attempt to respond from an upwind direction. Attempt to place all apparatus, initiate operations, and establish the command post upwind of the incident.
    - Apparatus should be positioned outside of the **150 ft isolation (warm) zone**.
        - If not feasible, assess risk vs. gain and apply controls to limit exposure.
- A **330' support and evacuation (cold) zone** should be established.
    - If there is no threat to life or need for evacuation within 330 feet in any direction, it may be appropriate to allow the vehicle to burn to completion.
    - Evacuations, along with fire suppression tactics will allow us to mitigate the toxic plume's impact on populations.
- EV or hybrid LIB fires within structures or parking garages present unique challenges. Aggressive water applications and ventilation need to be utilized to protect life and property.

Tools and Equipment Covered

- Fire attack hose lines
    - Firefighters should deploy a minimum of two 150+ GPM hose streams to suppress thermal runaway and protect exposures.
    - Approach from offset positions upwind, alternate between fog and straight streams, and push the fire and vapors away from suppression personnel as you approach.

        - Consider utilization of positive pressure ventilation (PPV) fans.
    - The Captain should request additional resources as indicated and use available monitoring tools (e.g., 4-gas meters, TICs) to assess ongoing risk.
        - The Captain should prioritize stretching an additional line with a fog nozzle to have available for toxic plume mitigation and personnel protection.
    - The Engineer should establish a water supply and ready a booster line for gross decon.

<u>Recommended Procedural Guidelines</u> SIN –
(Safety, Isolate, Notify)

- Confirm vehicle is an EV or hybrid.
    - Evaluate fire behavior and potential for battery pack involvement and thermal runaway.
- If the high-voltage battery pack is not involved, proceed with standard vehicle fire tactics.
    - Up to 60% of fires in EVs do not involve thermal runaway of the LIB pack.
        - On these fires, standard vehicle fire tactics can prevent EV LIB packs from entering thermal runaway.
- If the LIB is involved in thermal runaway, declare a Level II Hazmat.
    - Request other additional resources as needed.
- Establish clear hazard zones as described above.
    - Adjust based upon HMRT recommendations.

CIA - (Command, Identification and Hazard Assessment)

- Assume Command.
- Identify exposures and threatened populations.
- Formulate an incident action plan.

PCP – (PPE, Containment and Control, Protective Actions)

- Full PPE, with SCBA (on air), is required for **any operations within 75 feet.**
    - Avoid approaching directly in front of or behind an EV with suspected battery fire — these are common jet-flame ejection paths.
    - Do not attempt to access or open battery compartments.

DDD – (Decontamination, Disposal and Documentation)

- Decontaminate all personnel that were potentially exposed to toxic smoke.
    - Use a booster line to gross decon any personnel who operated in vapors.
        - Gross decon should occur **before** personnel doff PPE and SCBA.
    - Anyone who is handling PPE should use medical gloves. PPE should be double bagged.
        - Bagged PPE should be routed to SSC and then left outside the utility shop.
    - Exposed personnel should follow-up with exposure reporting.

- Utilize the TIC, 4-gas monitor, and observation to confirm the absence of fire, smoke, audible popping/hissing, or increasing temperatures present in the high- voltage battery for at least 45 minutes before releasing to law enforcement, tow companies, etc.
    - Hazmat personnel should brief secondary responders on potential hazards.
    - Disposal plans should be coordinated with the Hazmat Group Supervisor and County Hazmat.
- Runoff water may be contaminated and require Hazmat evaluation.
    - The Hazmat team should evaluate runoff for potential contaminants.
    - Any significant findings or environmental impacts must be addressed, documented, and reported in accordance with standard Hazmat protocols.

First Responder Cut-Loop Guidance

The first responder cut loop is designed to disable high-voltage systems in EVs to reduce risks to first responders during rescue efforts. However, cutting the loop also depowers the battery management system (BMS), which may disable critical safety functions, including active cooling. Timing is crucial. Cutting the loop too early, particularly during early battery distress (e.g., smoke without flame), may accelerate thermal runaway.

Do not cut the loop if:

- The battery pack is smoking or showing signs of early thermal instability.
    - The BMS may still be actively cooling the battery and preventing escalation.
- Cutting the loop in this phase may disable pumps or fans and worsen the situation.

Cut the loop only if:

- The action supports life safety or rescue and can be performed safely.

Summary

- Lithium-ion/EV fires are an evolving threat. This document is intended to remain dynamic. Initiate operations from upwind and attempt to establish zones: **Exclusion / Hot Zone: 75 ft, Isolation / Warm Zone: 150 ft, Support / Evacuation / Cold Zone: 330 ft** prior to initiating operations to protect both responders and the public.