SUPPLIERS PARTNERSHIP FOR THE ENVIRONMENT

GUIDANCE DOCUMENT: EV BATTERY SAFE HANDLING & STORAGE

JULY 2023

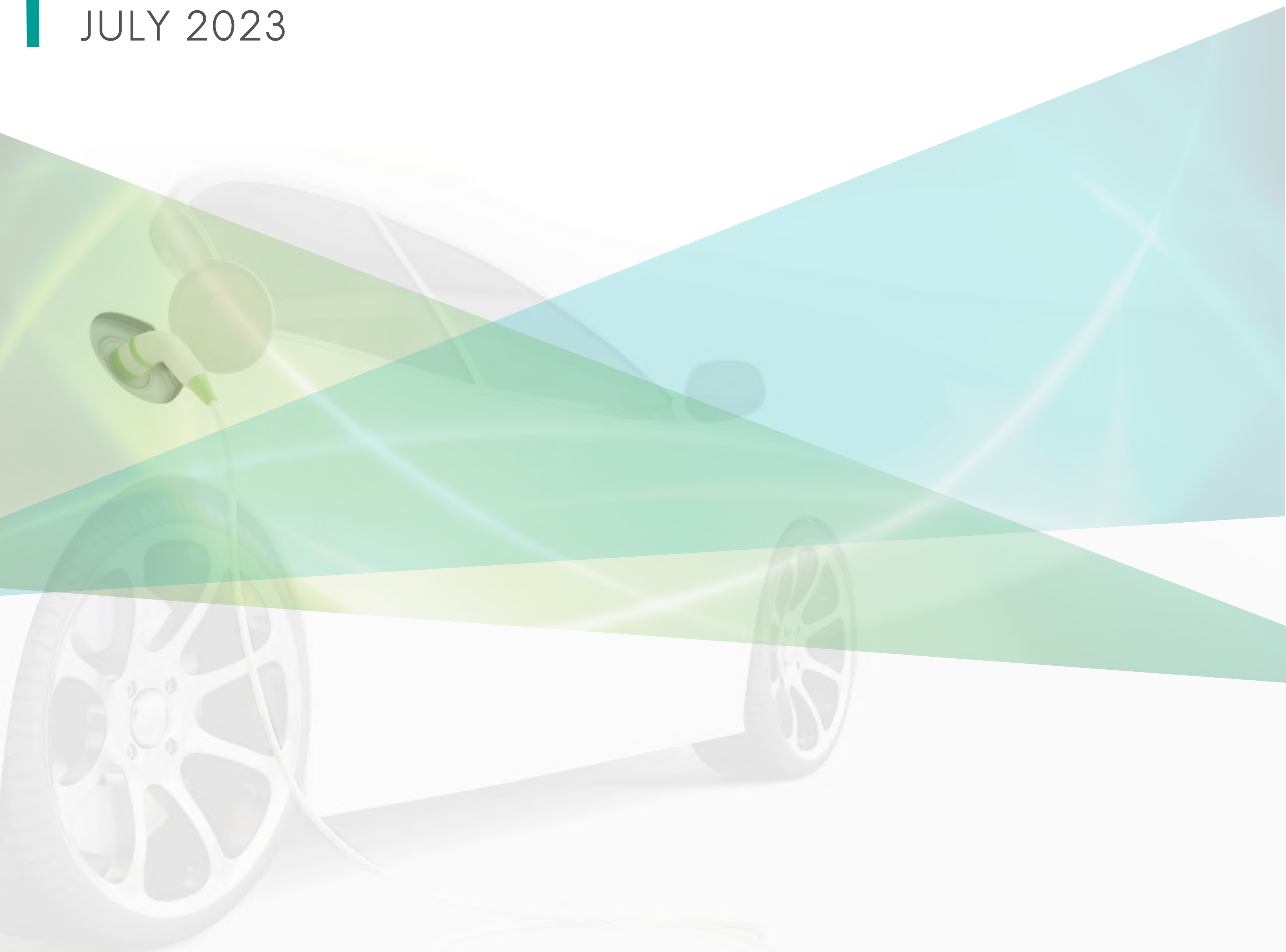

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TABLE OF CONTENTS

INTRODUCTION

Companies who handle electric vehicles (EVs) and/or EV batteries after they have been removed from a vehicle may not have the information or training needed to handle them safely. Individuals may at times find themselves taking risks in their earnest attempts to do the right thing. The purpose of this guidance document is to bridge this information gap in a fast-evolving new industry where real-life case studies and best practices are limited.

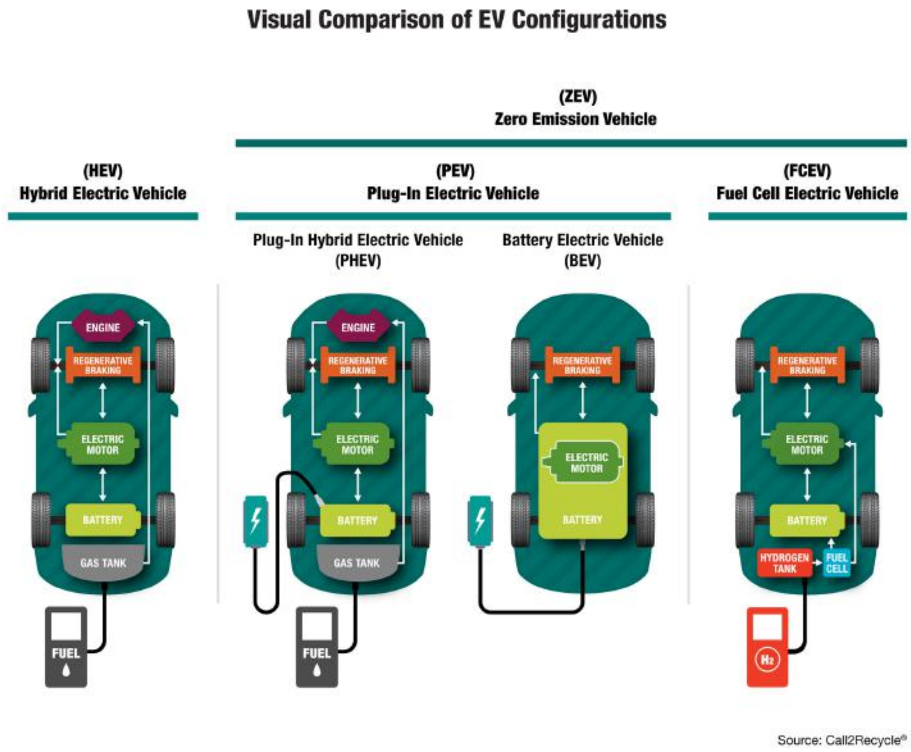
This document is written with battery holders in mind, including vehicle dealerships, auto dismantlers and recyclers, independent garages, auto shredders, warehouse operators, transportation operators, tow truck operators and yard holders, first responders, aftermarket diagnostic sites, battery repurposers, and battery remanufactures.

Batteries referenced in this document include lithium-ion (li-ion) electric vehicle traction batteries for battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and hybrid electric vehicles (HEVs) of light duty cars and trucks. Some of the guidance may be applicable to other types of lithium and nickel metal hydride (NiMH) batteries.

This document is provided for educational purposes only. It is the responsibility of every company handling EV batteries to understand and comply with all applicable laws and regulations.

BATTERY IDENTIFICATION

Hybrid vs. Plug-in Hybrid vs. Full Battery Electric vs. Fuel Cell



Hybrid electric vehicles (HEV) are vehicles with an internal combustion engine, an electric motor, and battery pack. The battery pack is recharged through regenerative braking.

Plug-in hybrid electric vehicles (PHEV) are vehicles with an internal combustion engine and an electric motor along with a battery pack that can be recharged from an external power source as well as from regenerative braking.

Battery electric vehicles (BEV) are powered solely by an electric motor with a battery pack that is recharged from an external source as well as from regenerative braking.

Fuel cell electric vehicles (FCEV) are also powered solely by an electric motor like a BEV, but instead of recharging the battery from an external source, they generate their own electricity when the fuel cell combines hydrogen stored in an onboard tank with oxygen.

End-of-Life vs. Damaged-Defective vs. Thermal Event Batteries

The US Department of Transportation (DOT) and Transport Canada require the shipper to accurately indicate whether a battery is classified as end-of-life (EOL) or damaged-defective (DD). The designation of EOL is assigned to a battery after ensuring the absence of any damage or defects.

Damaged battery characteristics include:

- Dents, punctures, cracks in battery outer shell.
- Damage including fluid(s) coming out from within the battery pack.
- Water damage and/or corrosion on the terminals*.
- Broken or damaged terminals.
- Loose wiring either inside the battery pack or protruding from the pack.
- Indications the battery has been opened and/or worked on.

Pictured: Damaged power storage unit battery with examples of loose wiring, soot from possible heat on electrical panel, and hard scratches to outer shell from possible hit.

Source: The Energy Security Agency

**If the electric vehicle and/or battery pack has been damaged due to flooding (salt water or fresh water) do not attempt to charge or drive the vehicle/battery. Call first responders as the battery pack may now be at risk of a thermal event.*

Thermal event battery characteristics

Thermal event batteries are classified as damaged and exhibit distinct characteristics that necessitate additional caution, such as:

- Bulging/Swelling.
- Melted plastic.
- Hot to touch.
- Emit white/grey smoke.
- A distinctive sweet bubble gum-like odor.
- Audible crackling sounds.
- Flames/sparks or visible fire.
- Presence of burn marks, along with black or gray fire soot.
- Visible charring or scorching on the battery pack.

Pictured: Example of a thermal event battery with melted plastic, burn marks, and visibly charred.

Source: The Energy Security Agency

Defective battery characteristics include:

- The battery management system is reporting a defective message.
- Determination of battery defectiveness by the vehicle manufacturer.

End-of-life battery definition:

- A used EV battery that has come to the end of its service life in its current vehicle. This battery does not exhibit any signs of damage, defects, or past or present thermal events.

Pictured: Example of an end-of-life EV battery

2017 plug-in hybrid battery
Source: Call2Recycle

SAFETY PREVENTION

Emergency Preparedness Plan

Developing an emergency preparedness plan is essential to mitigate risks associated with lithium-ion batteries. It is important to customize the plan according to specific facility requirements and adhere to local regulations. An emergency preparedness plan may contain several components. Consult with local regulations and authorities, such as local fire marshals or officials, to tailor the plan to the specific facility and jurisdiction of operations.

Hazard Assessment:

- Batteries may be at varying states of charge (measured in kilowatt-hours), physical size and shape, which may impact the response, personal protective equipment (PPE) required, training involved, and tools needed.
- Conduct a thorough hazard assessment to identify potential risks associated with lithium-ion batteries in material handling operations. Document and address these hazards in the emergency preparedness plan.

Emergency Response Team:

- Establish an emergency response team and assign clear responsibilities for implementing the fire prevention plan and conducting emergency drills.
- Designate trained personnel who will handle specific roles during emergencies.
- Make sure appropriate personal protective equipment (PPE) is available.

Training and Education:

- Provide training to all personnel on lithium-ion battery hazards, emergency response procedures, and proper use of fire suppression equipment.
- Conduct regular refresher training sessions to reinforce knowledge and keep personnel up to date with evolving safety practices.

Response Plan for Thermal Runaway Events and Chemical Spills:

- Develop a plan for responding to thermal runaway fires, chemical leaks, and/or off gas emissions resulting from lithium-ion batteries. Refer to the relevant section of the emergency preparedness plan for specific guidance on managing such events.

Communication and Alarms:

- Establish a communication protocol to ensure timely alerting of personnel during emergencies.
- Install a fire alarm system equipped with smoke detectors, heat detectors (such as thermal cameras), and gas detectors (such as 4-gas monitors). Position manual call points at appropriate locations for activation when needed.

Fire Suppression Systems and Equipment:

- Consider appropriate fire suppression systems, such as automatic sprinklers and/or robotic fire suppression units, based on the unique needs of the facility.
- Ensure fire suppression systems are strategically placed near lithium-ion battery storage, charging, and maintenance areas, and any additional areas posing a higher risk. Note that fire extinguishers are generally ineffective in extinguishing a lithium-ion battery pack fire.

Housekeeping and Maintenance:

- Maintain a clean and organized facility, eliminating flammable materials and clutter that may contribute to fire hazards.
- Regularly inspect and maintain lithium-ion battery storage areas.
- Train personnel on safe battery handling practices and emphasize the importance of proper housekeeping in mitigating risks.

Evacuation and Emergency Procedures:

- Establish clear evacuation procedures, including designated assembly points, and ensure all personnel are familiar with them.
- Conduct regular emergency drills to test the effectiveness of evacuation procedures and identify areas for improvement.
- Share emergency response procedures with the local fire department and provide a tour of the facility to support development of their response plan.
- Keep muster points away from areas where at-risk batteries are stored/sheltered outside.

Documentation and Review:

- Maintain records of training sessions, emergency drills, incident reports, and any modifications made to the emergency preparedness and fire prevention plan.
- Regularly review and update the plan based on lessons learned, industry best practices, and regulatory changes to ensure its continued effectiveness.

Additional Resources and Standards:

- OSHA's guidelines on Emergency Action Plans (29 CFR 1910.38)
- NFPA 1: Fire Code
- NFPA 10: Standard for Portable Fire Extinguishers
- NFPA 72: National Fire Alarm and Signaling Code
- NFPA 400: Hazardous Materials Code
- NFPA - Emergency Response Guides for Alternative Fuel Vehicles

Safe Handling of EV Batteries

High-voltage batteries can present significant risks if mishandled. Lithium-ion EV batteries can pose chemical, thermal, and electrical hazards. Handlers of EV batteries can be divided into two groups: those a) responsible for the movement and storage of the batteries and b) responsible for the work performed on the battery including its removal from a vehicle. It is recommended that personnel involved in battery handling take the following guidelines into consideration.

Training and Qualification:

- Following US Occupational Safety and Health Administration (OSHA) regulations, only "qualified persons" should handle batteries with voltages exceeding 50V.
- Qualified individuals should have experience and training in working with electricity, possessing knowledge about electrical hazards and safety practices.
- All personnel handling EV batteries must receive appropriate training on safe operating procedures, hazards, and emergency response protocols.
- OSHA HAZMAT training, including general awareness training, function-specific training, safety training, security awareness training, and in-depth security training, is required.
- See Standards for Electrical Safety in the Workplace: NFPA 70E Article 110.6, OSHA 29 CFR 1910.332 "Training" and Hybrid and EV First and Second Responder Recommended Practice SAE J2990.

Personal Protective Equipment (PPE):

- Wear appropriate PPE during battery handling, including safety glasses, electrical insulated gloves, and fire-resistant clothing OSHA 1926.441(g)(5) Example: Category 2 coveralls, faceshield, hard hat, and balaclava, plus Class 0 rubber voltage gloves and leather protector gloves combination.
- Suggest removing jewelry and other metal that could come in contact with electricity and other metal conductive parts of the battery and tools.

Employee Safety:

- Facilities handling li-ion batteries must adhere to OSHA requirements.
- Those requirements include ensuring that batteries are stored in enclosures with outside vents or well-ventilated rooms to prevent the escape of fumes, gases, or electrolyte spray into other areas (1926.441(a)(1)).
- Ventilation systems should be in place to facilitate the diffusion of gases and prevent the accumulation of explosive mixtures (1926.441(a)(2)).
- Use substantial racks and trays that are resistant to the electrolyte (1926.441(a)(3)).
- Construct floors of acid-resistant materials or protect them from acid accumulations (1926.441(a)(4)).
- Provide facilities within 25 feet (7.62 m) of battery handling areas for quick drenching of the eyes and body (1926.441(a)(6)).
- Ensure the availability of facilities to flush and neutralize spilled electrolyte and for fire protection (1926.441(a)(7)).

Storage:
- Store batteries in cool, dry, and well-ventilated areas, away from flammable materials.
- Fire suppression equipment, along with smoke detectors, gas detectors, and thermal heat sensers should be included in this area.
- Refer to specific guidelines in the corresponding section for safe storage practices.

Battery Inspection and Damage:
- Regularly inspect batteries for physical deformities, leaks, corrosion, heat build-up, swelling, and signs of thermal runaway.
- Do not use or attempt to repair damaged batteries.
- Follow proper segregation, handling, and transportation procedures for damaged batteries. Avoid tilting the damaged battery when moving.
- Consult the relevant section for battery identification guidelines.

Electrical Safety:
- Disconnect the power supply and deactivate all high-voltage systems before handling batteries.
- Utilize insulated tools to prevent electrical shocks.
- Follow lockout/tagout procedures to isolate electrical energy sources.
- Work in pairs, with one person ready with an insulated rescue hook to remove the other person from danger.
- Refer to the Standard for Electrical Safety in the Workplace, NFPA 70E, for further guidance.

Fire Prevention and Detection:
- Involve the local first responders/authority having jurisdiction (AHJ) in developing fire prevention plans for the site.
- Promptly ship damaged or defective batteries to recyclers, avoiding prolonged storage. Follow required DOT/TDG shipping regulations (DDR).
- Maintain adequate spacing between batteries.
- Ensure proper air ventilation.
- Deploy thermal imaging cameras and 4-gas meters for fire detection where monitoring is necessary.

Emergency Response:
- Develop and implement an emergency response plan for battery-related incidents.
- Train personnel in recognizing and responding to fires, leaks, or thermal runaway events.
- Have appropriate fire suppression equipment, such as extinguishers and fire blankets, readily available.
- Call emergency services (911).
- Consider using water to extinguish fires and cool the battery.
- If safe, move the battery outdoors.
- When using equipment, prefer telehandlers over forklifts to keep problem batteries extended away from the cab.
- Refer to the relevant section for guidance on Emergency Preparedness.

Storage Considerations

When storing li-ion batteries, consider storage systems that mitigate the risks associated with fire, heat propagation, electric shock hazards, electrolyte and chemical leakage, emissions, pressure venting, and water runoff. Consulting with relevant authorities and fire safety experts is recommended to ensure compliance with regulations and the effectiveness of any fire suppression systems in place. Different considerations apply to indoor and outdoor storage, and a comprehensive approach should be taken.

Hazards to Consider:

- Thermal runaway (possible fire): Implement measures to prevent and mitigate the risks of thermal runaway events.
- Short circuit, arc flash or high voltage exposure: Take precautions to prevent accidental short circuits or exposure to high voltage.
- Release of electrolyte: Prevent electrolyte leakage and contain any potential spills or leaks.
- Propagation to other batteries or flammable sources: Design storage systems to limit the spread of fire or heat to adjacent flammable materials.
- Emissions of toxic and flammable gases and/or smoke: Address potentially harmful emissions through detection, ventilation, or treatment.
- Water runoff: Establish controls to manage water runoff resulting from electrolyte leaks or fire suppression activities.

Mitigation Strategies:

- Containment of batteries: Utilize packaging, structures, or spatial segregation to contain batteries and limit the spread of fire or heat.
- Reducing State of Charge: Consider reducing the state of charge of batteries before storage to mitigate chemical energy release and minimize magnitude of thermal events.
- Maintaining a cool environment: Store batteries at cooler temperatures to reduce the risk of battery degradation caused at higher temperatures over 27 degrees Celsius / 80 degrees Fahrenheit*. Source: Geotab
- Sensors for detection: Install sensors to detect heat and rising temperature, Carbon Dioxide (CO_2), Carbon Monoxide (CO), Hydrogen Sulfide (H_2S), and Methane (CH_4)for early hazard identification.
- Terminal protection: Store batteries with proper terminal protection to prevent shocks or electric discharge.
- Signage and warnings: Clearly label storage areas with high voltage warning icons or regulatory signage to indicate the presence of high voltage batteries.
- Water runoff controls: Implement measures to control and manage water runoff in compliance with local regulations.
- Spacing: Store batteries with appropriate spacing and limiting stack height to minimize the risk of thermal event propagation between batteries or groups of batteries.
- Fire suppression systems: Install fire suppression systems such as automatic sprinklers or robotic fire suppression equipment to limit the spread of fire in the event of a thermal event. Consult with fire safety personnel to ensure the adequacy of fire suppression systems.

Safety Tools & Materials to Assist with Being Safe

Various personal protective equipment (PPE) and specialized tools are available to assist with being safe. Additional materials for thermal runaway identification, containment, and extinguishing play a role in minimizing potential hazards.

Personal Protective Equipment for Safe Handling EV Batteries:
- Class 0: Rubber voltage gloves, leather protectors, and glove protection bag
- Category 2: Coveralls, balaclava, face shield, helmet
- Rubber-soled shoes: Footwear with rubber soles to minimize the risk of electrical shock.
- Insulated rescue hook: A specialized tool to safely remove personnel from hazardous situations.

Thermal Runaway Identification Materials:
- Thermal imaging camera: Handheld or installed cameras connected to alarm systems to detect and identify thermal runaway events.
- 4-gas meter: Monitors the presence of gases such as Carbon Dioxide (CO_2), Carbon Monoxide (CO), Hydrogen Sulfide (H_2S), and Methane (CH_4) to help with early detection.

Thermal Runaway Containment Materials:
- Vehicle fire blanket: Available in various sizes, these blankets can be used to cover and contain thermal runaways in electric vehicles, battery packs, and battery modules.
- Fire retardants: Manual application or automated systems using fire retardant agents to aid in containing thermal runaways.
- Overhead water sprinklers: Sprinkler systems strategically placed to provide water-based fire suppression.

Thermal Runaway Extinguishing Materials:
- Water from a fire hose: Standard fire suppression tool to douse fires and cool battery systems.
- Saltwater dunk tank: A specialized tank filled with saltwater to submerge and cool overheated batteries in a controlled manner.

Optional Infrastructure Upgrades

Various optional infrastructure upgrades may be considered to assist in minimizing potential hazards.

INDOORS

- Airflow: To maintain proper ventilation and minimize the buildup of potentially hazardous gases, consider incorporating rooftop venting and side doors with air flow mechanisms. These upgrades facilitate the efficient exchange of air, reducing the risk of gas accumulation.

- Alarm System: Enhance the effectiveness of the alarm system by integrating thermal imaging cameras and 4-gas meters. This integration allows for early detection of thermal runaway events that the human eye and nose can't detect as well.

- Water Runoff: Prepare for potential water runoff during fire suppression efforts by designing a drainage system capable of capturing and redirecting high volumes of water. This prevents water accumulation and ensures compliance with local regulations.

- Section Separation: Implement measures to segregate different sections within the facility. Consider using cement blocks, cement firewalls, or fire curtains to create barriers. Consider maintaining a dead space of at least 50 feet between sections to mitigate the spread of fire and limit the impact of thermal events.

- Access and Egress: Be able to rapidly move an EV battery pack outdoors prior to entering thermal runaway via exit door(s) and/or ramp. There should be multiple separate exits from the building for people to leave that are separate from how EV battery packs enter and exit the building. Avoid charging battery packs at or near the building exits to minimize risks.

- Moving Batteries: Consider use of high load lift capacity forklifts to move EV batteries around the facility, including into and out of shipping containers and into and out of racking. Opt for telehandlers instead of forklifts when handling EV battery packs that are entering thermal runaway as they offer the advantage of extending the battery pack away from the driver, reducing the proximity to potential hazards. Avoid tilting the battery.

OUTDOORS

- Temporary Storage: Consider providing temporary storage under a shaded rooftop with open sides to allow for natural airflow. This configuration may help regulate temperatures and reduce the risk of thermal events. Suggest storing the EV batteries a minimum 50 feet from the building and structures.

- Alarm System: Integrate thermal imaging cameras and 4-gas meters into the outdoor alarm system to enable continuous monitoring and early detection of potential hazards.

- Water Runoff: Design and implement a drainage system that can effectively direct high volumes of water away from the battery storage area. Incorporate suitable measures for proper water runoff management, minimizing the potential for environmental impact.

- Section Separation: Similar to indoor facilities, consider use of cement blocks to create physical barriers between different sections within the outdoor storage area.   Without non-flammable section barriers, try to maintain a dead space of roughly 50 feet to limit the spread of fire.

- Exits and Corridors: Establish designated corridors for moving EV battery packs that may enter thermal runaway, keeping them separate from other battery packs and surrounding buildings. Provide multiple exits and corridors for personnel evacuation that are distinct from the paths used for EV battery pack movement. Avoid charging battery packs near these corridors to enhance safety.

- Moving Batteries: Consider prioritizing the use of telehandlers over forklifts when handling thermal event batteries. Telehandlers offer the advantage of extending the battery pack away from the driver, thus reducing potential risks.

Packaging

Packaging hazardous materials, including end-of-life lithium batteries, requires compliance with the US DOT regulations (Transport Canada's regulations vary in certain areas. Please read this Transporting Batteries bulletin and the Transportation of Dangerous Goods Regulations for more details). The regulations apply to individuals involved in the transportation of hazardous materials or those who manufacture or maintain packaging certified for transporting hazardous materials.

When packaging end-of-life lithium batteries, the shipper must follow specific guidelines to ensure safe transportation according to the regulations:

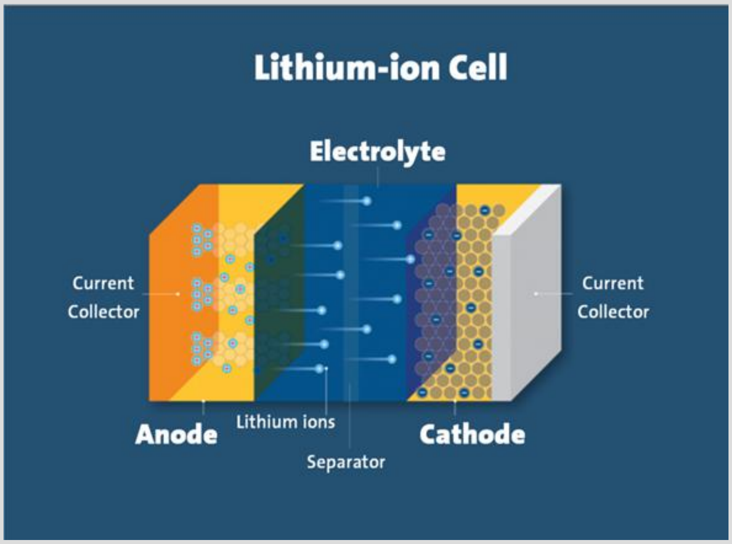
- Non-Metallic Inner Packaging: The battery must be completely enclosed in non-metallic inner packaging to prevent contact with other materials and protect against short circuits.
- Prevention of Battery Movement: Measures should be taken to secure the battery within the packaging and prevent movement during transportation. This helps minimize the risk of damage or accidental short circuits.
- Authorized Containers for Large Format End-of-Life Batteries: Large format end-of-life lithium batteries must be packed in authorized containers that meet UN packing group 2 (PGII) performance packaging criteria. The packaging should display a Class 9 lithium battery label, UN number, proper shipping name, and be accompanied by a shipper paper prepared by trained employees.
- Outer Packaging Materials: Authorized outer packaging materials can include wood, fiberboard, plastic, metal, or plywood. These materials must meet the UN packing group 2 performance packaging criteria.
- Exemption for Strong Outer Casings: End-of-life batteries weighing more than 12 kg (26.5 lbs.) that have a strong, impact-resistant outer casing do not require UN Packaging. Instead, they can be shipped in protective enclosures, strong outer packaging, or on a pallet or other suitable handling device.

Lithium-ion cells or batteries that have suffered damage, are defective, or have been recalled by the manufacturer due to safety concerns and possess the potential to generate hazardous heat, fire, or short circuits, are permitted to be transported exclusively by highway, rail, or vessel. These batteries must adhere to the following packaging requirements during transportation according to the regulations:

- Individual Non-Metallic Inner Packaging: Each cell or battery must be placed in an individual non-metallic inner packaging that fully encloses the cell or battery.
- Cushioning Material: The inner packaging must be surrounded by cushioning material that is non-combustible, electrically non-conductive, and absorbent. This provides additional protection and minimizes the risk of dangerous heat, fire, or short circuits.
- Packing Group 1 Rated Packaging: Each inner packaging must be placed in packaging rated for packing group 1, which can be made of metal, wood, or solid plastic, in accordance with the regulations.
- Marking and Labeling: The outer packaging must be marked with an indication that it contains a "Damaged/defective lithium ion battery" or "Damaged/defective lithium metal battery" as appropriate. The marking must be in characters at least 12 mm (0.47 inches) high.

UNDERSTANDING THERMAL RUNAWAY

Thermal runaway occurs when the temperature inside a battery reaches the point that causes a chemical reaction to occur. This chemical reaction produces heat, which further drives the internal temperature higher, resulting in the destruction of the battery or, in severe cases, a fire.



Source: UL Electrochemical Safety Research Institute

In lithium-ion cells, the cathode and anode electrodes are physically separated by a component known as the separator. Defects in the cell that compromise the separator's integrity can cause an internal short circuit condition that may also result in thermal runaway. This is especially likely in cells of poorer quality.

Certain external conditions can also cause a thermal runaway:

- Overcharge: Can be due to incompatibility between cell and charger, or poorly designed battery management system (BMS)
- Multiple over discharges followed by charge: Repeatedly discharging the cell or battery pack below the cell recommended lower voltage threshold specified by the cell manufacturer and subsequently recharging the cell.
- External short circuit: A direct connection between the positive and negative terminals of the battery.
- Excessively high temperature: Exposure to extremely high ambient temperatures.
- Damage to a cell that results in gases forming that are susceptible to fire (electrolyte within a battery cell is flammable).

Containment of Thermal Runaway

The purpose of containing a thermal runaway is to provide a) the employees time to evacuate and b) the first responders time to assess the situation and gain control of the scene. It is recommended to take note of the following considerations in developing plans to address a potential thermal event.

To effectively contain a thermal runaway requires **pre-work** that can include:
- Having an emergency preparedness plan.
- Training employees on the signs of a thermal runaway.
- Training employees on how to react to a thermal runaway.
- Spacing between the battery packs; spacing between the work areas.
- Having cement or fire curtain barriers, or fire walls between work areas/storage areas.
- Having thermal imaging sensors and 4-gas meters active and connected to the alarm system.
- Having aerosols and suppression systems specifically designed for lithium battery thermal events.

To effectively contain a thermal runaway requires **tools** that can include:
- Fire blanket(s) for covering a large sized battery.
- Fire retardant pillows for smothering a small sized battery.
- Fire retardant materials for pouring over a battery.
- Appropriately rated aerosols and suppression systems specifically designed for lithium battery thermal events.
- Firefighting robots for automated responses to thermal events at all times of the day.
- Protective personal equipment to keep the employee(s) safe during the act of containment.
- A telehandler for moving the battery at extended lengths from the cab.

To effectively contain a thermal runaway **behavioral changes** should be considered:
- Remain calm.
- Work in teams of two.
- Cover the battery with a fire blanket, fire pillow, or retardant materials depending on which is appropriate.
- Wheel the battery outside if it is already on a table with wheels.
- Use a telehandler to pick up the battery, extend it away from the cab, and drive it outdoors.

Ending a Thermal Runaway

There are several scenarios for ending a thermal runaway one may wish to evaluate within the context of their emergency preparedness planning, each with its own advantages and considerations, including:

1. Let the EV battery burn itself out,
2. Spray the EV battery with large quantities of water from a fire hose, or
3. Place the EV battery in a water dunk tank (either with or without salt)

Scenario #1: Let the battery burn itself out
When this may be appropriate: If the battery is in a location where it will not do further harm and/or damage to people, infrastructure, and the environment.

Pros	Cons
• The battery consumes the remaining energy that's acting as fuel. • The flames burn off gases. • Water – a resource – is not used excessively and no need to contain the water run-off.	• Takes more time. • May cause damage to land under the battery. • May create downwind concern if gases are not burning off and resulting in smoke that travels with the wind. • Causes traffic jams if in high density public location.

Scenario #2: Spray the battery with large quantities of water from a fire hose
When this may be appropriate: If the battery is in a location where the thermal runaway needs to be contained to that battery, where there is risk of fire spreading to other infrastructure, where harm to humans is possible, and where traffic jams may occur.

Pros	Cons
• Safety of people and preservation of infrastructure by controlling flames. • Opportunity for fire fighters to use hydraulic ventilation to help manage/guide the off-gassing and smoke away from the target. • May help minimize traffic jams.	• May require significant amounts of water to be effective and time to apply water. • Water runoff may need to be contained. • Battery may need to be further de-energized prior to shipping to battery recycler. • Risk of battery re-ignition.

Scenario #3: Place the EV battery in a water dunk tank (either with or without salt)
When this may be appropriate: Through the creation of the emergency preparedness plan, the business, the authority having jurisdiction (AHJ), and its insurance provider may decide it would be appropriate to have a water dunk tank on the property ready for use. The tank sits empty in a designated location where first responders can fill with water and salt in correct proportions if desired. Salted water will extinguish the thermal runaway and de-energize the battery more efficiently than just water alone.

Pros	Cons
• Safety of people and preservation of infrastructure. • Water is contained and can be properly remediated when the situation is over.	• Will require significant amounts of water to be effective. • Battery may need to be further de-energized prior to shipping to battery recycler if it was submerged in just water (vs. salted water). • Risk of battery re-entering thermal runaway if it was submerged in just water (vs. salted water). • If salted water is used there may be off gassing that needs venting outdoors and/or a fire hose mist to redirect. • It can take multiple days to fully end the thermal runaway. • Proper disposal of water after event.

It is important to evaluate these methods within the context of an emergency preparedness plan and considering such factors as the location, potential risks, available resources, and environmental impact. Collaborating with the AHJ and relevant stakeholders can help determine the most appropriate method for ending a thermal runaway while prioritizing safety and minimizing potential damage.

De-energizing a Battery

De-energizing an EV battery prior to shipping may be appropriate in some situations where the risk of a thermal runaway during transport is deemed high. The EV battery may have been heavily damaged (dropped, struck, or involved in a vehicle accident), or had a thermal runaway event. If a battery is considered damaged, defective or recalled (DDR), refer to the manufacturer's instructions regarding de-energization and potential risks.

Using a water dunk tank with the correct ratio of water to salt. Consider contacting a professional organization with experience and the processes in place to manage a dunk tank or establish those skills and processes within your organization with the input of trained professionals.

Using an oscillator or other appropriate tool to de-energize the battery. Consider contacting a professional organization with experience and the processes in place to use an oscillator, load bank, resistor or other appropriate device or establish those skills and processes within your organization with the input of trained professionals.

ROLES OF AUTHORITIES

Fire Marshals

The local fire marshal and/or authority having jurisdiction (AHJ) has the final say on how the site is prepared for handling EVs and EV batteries. Having an emergency preparedness plan and the physical site reviewed by the AHJ is a very good idea and in many jurisdictions required by law. The recommendations of one AHJ may differ from an AHJ in another jurisdiction.

Department of Transportation (DOT)

The Department of Transportation (DOT) plays a role in governing and regulating the proper shipping and handling of lithium-ion (li-ion) batteries. Their regulations, specifically the Hazardous Materials Regulations (HMR) (49 CFR Parts 100-180)(49 CFR 173.185), are enforced by the Pipeline and Hazardous Materials Safety Administration (PHMSA) division of the DOT. These regulations ensure the safe transportation of hazardous materials, including li-ion batteries, by various modes of transportation such as highway, rail, vessel, and air.

The HMR sets forth comprehensive guidelines and requirements for the packaging, labeling, marking, and documentation of hazardous materials, including li-ion batteries, to prevent accidents, leaks, or other incidents during transportation. These regulations cover aspects such as proper training, packaging design, and handling procedures to minimize the risks associated with transporting hazardous materials. The DOT regulations governing training can be found in 49 CFR §172.704. These requirements apply to employees designated as Hazardous Materials Employees and ensure that they receive adequate training on the safe handling, packaging, and transportation of hazardous materials, including li-ion batteries. Training programs focus on educating employees about the potential hazards, emergency response protocols, and compliance with relevant regulations to ensure the safe transportation of hazardous materials.

OSHA

Companies engaged in the production, storage, or handling of lithium batteries are required to comply with OSHA standards to ensure workplace safety. OSHA (Occupational Safety and Health Administration) is a regulatory agency that establishes and enforces standards to protect the health and safety of workers. Under OSHA regulations, employees involved in dealing with lithium-ion batteries must receive training on Hazardous Materials Regulations (HAZMAT) that are relevant to their job functions. This training ensures that employees are knowledgeable about the potential hazards associated with lithium batteries and are equipped to handle them safely. Compliance with these regulations helps mitigate risks and promotes a safe working environment.

In addition to HAZMAT training, OSHA regulations encompass other important aspects related to the handling of lithium batteries. Emergency planning requirements are mandated under 29 CFR 1910.38 and 29 CFR 1926.35. These requirements necessitate the development and implementation of effective emergency response plans in case of incidents or accidents involving lithium batteries. Such plans ensure that employees are prepared to respond appropriately to emergencies, minimizing potential injuries or property damage.

Furthermore, OSHA regulations address hazardous waste operations, which include the proper management and disposal of lithium batteries. Hazardous Waste Operations and Emergency Response (HAZWOPER) standards (29 CFR 1910.120(q)) outline procedures for handling hazardous materials, including lithium batteries, during cleanup operations, emergency response, and other related activities. Compliance with these standards helps prevent environmental contamination and ensures the safe handling of hazardous waste.

Fire protection is another crucial aspect addressed by OSHA regulations. Companies working with lithium batteries must have appropriate fire suppression equipment, fire detection systems, and alarm systems in place to mitigate the risk of fire incidents. These measures are essential for early detection and response to fires, protecting employees and property from harm.

It is important to note that the specific OSHA requirements and regulations applicable to lithium batteries may vary depending on the business sector and the nature of operations. Each company is responsible for identifying and implementing the OSHA requirements that are relevant to their specific practices and ensuring compliance to maintain a safe workplace.

EPA

Handlers of electric vehicle (EV) and large format batteries are subject to regulations regarding the generation and management of hazardous waste. The EPA (Environmental Protection Agency) provides recommendations and guidelines for the proper handling and disposal of lithium-ion (li-ion) batteries, especially at the end of their life cycle.

The EPA recommends that all li-ion batteries be managed in accordance with the federal "universal waste" regulations outlined in 40 CFR 273. These regulations provide a framework for the management, labeling, and storage of universal waste, including li-ion batteries. The specific requirements within universal waste regulations may vary based on the quantity of waste generated by a user.

Under universal waste regulations, handlers of li-ion batteries are not required to use hazardous waste manifests. However, it is mandatory that universal waste is sent to a permitted hazardous waste facility or to a hazardous waste recycler or universal waste final destination facility for appropriate disposal or recycling.

Business Requirement – Insurance Providers

The company’s insurance provider is a partner to the company handling EV batteries and will have a point of view on handling EV batteries at the site from a risk insurance perspective. This view may align with the AHJ or may differ depending on the level of risk the insurance provider and company owner are willing to take. It is recommended that organizations notify their insurance provider regarding the storing or handling EV batteries on the company premises.

ADDITIONAL RESOURCES

There are several published resources that may be helpful to those seeking additional information on the topics referenced in this document.

Note that the following resources are provided for educational purposes only. SP cannot endorse, guarantee or recommend any information, products or services provided by any 3rd party organization, and SP and its member companies make no warranty, expressed or implied, and assume no liability for the resources listed here.

Additional Regulatory Information

- IATA Lithium Battery Guidance Document
- US DOT PHMSA Lithium Battery Resources
- US DOT PHMSA Damaged, Defective, or Recalled (DDR) Lithium Batteries Risk Guidance
- US DOT PHMSA Safety Advisory Notice for the Transportation of Lithium Batteries for Disposal or Recycling
- US EPA Lithium Battery Recycling Regulatory Status and Frequently Asked Questions Memo
- Regulations Governing Shipment of Electric Vehicle (EV) Batteries in the U.S. This guidance document identifies current U.S. EV battery transportation regulations by chemistry (lithium-ion vs. nickel-metal hydride), by state of health (end-of-life vs. damaged-defective-recalled), and by mode of transportation (land / rail, air, or sea), and then links those regulations to types of shipping containers permitted for use.
- Transport Canada's Transportation of Dangerous Goods Regulations
- Transport Canada's Transporting Batteries bulletin

Standards, Codes & Guidance

- **FM Global Property Loss Prevention Reference Data Sheets**
  - DS 8-1: Commodity Classification. Data sheet that provides guidance on classifying stored hazardous materials.
  - DS 8-9: Storage of Class 1, 2, 3, 4 and Plastic Commodities. Data sheet that provides fire protection recommendations when storage hazardous materials in hazard classes 1, 2, 3, 4, as well as plastic commodities and other hazardous materials not in classes 1, 2, 3 and 4.
- **International Association of Fire Chiefs**, Fire Department Response to Electric Vehicle Fires Bulletin intended to guide pre-response, response and post-event responses to electrical vehicle fires.
- **International Code Council (ICC)** – International Fire Codes (IFC) (note that applicable publication years will vary by local jurisdictions)

- **National Fire Protection Association (NFPA)**
  - NFPA - Emergency Response Guides for Alternative Fuel Vehicles. NFPA maintains a collection of Emergency Response Guides from 35+ alternative fuel vehicle manufacturers, which include information on disabling high voltage batteries and components.
  - NFPA Emergency Field Guide. This guide covers aspects of electric, hybrid, fuel cell, and gaseous fuel hazard awareness and procedures — including information from related NFPA codes.
  - NFPA Alternative Fuel Vehicles Training Program for Emergency Responders Online Training. This self-paced online training is designed to teach emergency responders how to safely deal with emergency situations involving alternative fuel passenger vehicles, trucks, buses, and commercial fleet vehicles.
- **Society of Automotive Engineers (SAE) International**
  - SAE J3235: Best Practices for Storage of Lithium-ion Batteries. SAE J3235 is a Standard that aids in mitigating risks while storing lithium-ion cells, batteries and battery systems used in electric vehicles as well as energy storage systems and other large format industrial applications.
  - SAE J2950: Recommended Practices for Shipping Transport and Handling of Automotive-Type Battery System-Lithium Ion. SAE J2950 is a Recommended Practice (RP) intended to aid in the identification, handling and shipping of lithium-ion batteries, and also includes recommendations for determining transportability of possibly damaged/defective batteries.
  - SAE J2984: Chemical Identification of Transportation Batteries for Recycling. SAE J2984 is a document that contains a chemistry identification system that can be used to support recycling rechargeable batteries and battery systems equal to or greater than 12 volts used in transportation applications.
  - SAE J2990: Hybrid and EV First and Second Responder Recommended Practice. This document aims to describe the potential consequences associated with hazards from xEVs and suggest common procedures to help protect emergency responders, tow and/or recovery, storage, repair, and salvage personnel after an incident has occurred with an electrified vehicle.

OEM Manuals / Guides

- Information related to an EV battery, including proper handling practices for emergency responders and dismantlers, is generally provided by OEMs for their electric vehicles. The links below will direct you to some of the online resources provided directly by SP OEM members relating to their products.
  - FCA US LLC (Chrysler, Dodge, Fiat, Jeep, Ram)
  - Ford / Lincoln
  - General Motors (Chevrolet, GMC, Buick, Cadillac, Saturn)
  - Honda / Acura
  - Toyota / Lexus

APPENDIX: SELF-ASSESSMENT CHECKLIST

This self-assessment checklist is provided for educational purposes only to assist readers in reviewing the topics covered in this guidance document.

Battery Identification

- ☐ **End-of-life characteristics identified and published for employees to reference**
- ☐ **Damaged-defective characteristics identified and published for employees to reference**
- ☐ **Thermal runaway characteristics identified and published for employees to reference**

Safety Prevention & Event Management

- ☐ **Emergency preparedness plan**
- ☐ **Meeting with fire marshal or authority having jurisdiction (AHJ)**
- ☐ **Meeting with company's insurance provider**
- ☐ **Employee emergency response training**
- ☐ **Employee hazmat shipper certification training**

Procurement of appropriate:
  - ☐ **Personal protective equipment**
  - ☐ **Thermal runaway response systems and containment materials**

- ☐ **Integration of thermal imaging cameras and 4-gas meters into alarm system**

Optional infrastructure upgrades:
  - ☐ **Outdoor**
  - ☐ **Indoor**

- ☐ **Battery temporary storage plans**
- ☐ **Thermal runaway containment and extinguishing plans**
- ☐ **Water runoff management plan**
- ☐ **Battery packaging materials for shipping**

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Disclaimer

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Contact

Please submit any feedback on this guidance document or suggestions for future improvements to info@supplierspartnership.org