Safety Hazards

Battery Safety - High-Voltage Batteries in Electric, Hybrid, or Plug-in Hybrid Vehicles

On this page

What types of batteries are used in electric, hybrid, or plug-in hybrid vehicles?

Electric, hybrid, and plug-in hybrid vehicles have both high-voltage (200-800 volt) and low-voltage (12-volt lead-acid batteries) battery systems. The high-voltage system is the primary energy source and powers the electric motor(s) which move the vehicle, while the low-voltage system powers essential functions including lighting, wipers, basic controls, and safety systems such as airbags.

There are two types of high-voltage batteries commonly used:

- Lithium-ion (Li-ion) batteries are made of carbon and lithium. They are most often used in battery electric and plug-in hybrid electric vehicles.

- Nickel metal hydride (NiMN) batteries use hydrogen to store energy and include nickel and other metals, such as titanium, to secure the hydrogen ions. They are used in many hybrid vehicles.

This document covers high-voltage batteries used in electric, hybrid, or plug-in hybrid vehicles or similar large machinery.

- For information on low-voltage lead-acid batteries, please see Battery Charging - Industrial Lead-Acid Batteries and Garages – Lead-acid Batteries
- For information on lithium-ion batteries used in power tools, scooters, wheelchairs, power-assisted bicycles, etc., please see Battery Charging - Lithium-Ion Batteries.

NOTE: This OSH Answers document provides general guidance for high-voltage batteries used to operate vehicles and is not meant to replace the manufacturer's instructions or legislative requirements.

What workplaces may have concerns due to high-voltage batteries?

Workplaces include vehicle manufacturers, dealerships, repair garages, recycling facilities, scrap yards and others that sell, service, or work with or near high-voltage batteries. Other workers, such as emergency response services, collision clean-up, towing, or insurance damage estimators, may be exposed to these hazards due to the nature of their work.

In some cases, the exact type of high-voltage battery may not be known, for example, when a worker is responding to a collision.

NOTE: This OSH Answers document does not specifically cover concerns with recycling battery components other than general storage and handling.

What are the common hazards of high-voltage batteries?

Characteristics of batteries of the same type may vary by manufacturer. In all cases, check the original equipment manufacturer's manual or emergency response guide for details.

Generally speaking, hazards include:

Energy Storage and Electrical Safety

- Stored energy – While the high-voltage battery can be disconnected from the drivetrain or other systems, some stored energy remains. Shocks may result.
- Some components, such as airbags, will remain energized after the ignition is turned off, and the airbags may still deploy.

- Arc flash and arc blast – Rapid release of energy due to a short circuit, damage, or other faults may result in burns and injuries.
- Exposed or dislodged wiring, especially when the vehicle has been in a collision.

Fire and Thermal Runaway Events

A high-voltage battery can short-circuit, catch fire, and explode, causing a thermal runaway event. When these batteries are defective, damaged, or not operated safely, overheating in the cells can occur, resulting in a chemical reaction. During normal operation and charging, small amounts of heat are generated but are safely dissipated. During thermal runaway, the temperature within the battery cell is greater than what can be dispersed, and the excess heat initiates a chemical chain reaction resulting in an uncontrollable self-heating state of the cells.

The damage may not be visible. Damaged batteries may result from a collision, submersion (especially in salt water), a defect, etc.

The main hazards of thermal runaway include:

- Release of corrosive, flammable, and toxic liquids and gases
- Released liquids and gases can cause skin or eye burns or damage, are harmful if inhaled, and can cause other health effects
- Fire or explosion caused by the intense heat and the flammable liquids and gases from the battery
- Be aware that small fire sources, such as a spark, can ignite a lithium battery.

Smoke from a battery fire has toxic components. For example, fumes from burning lithium-ion batteries contain carbon dioxide, carbon monoxide, nitrous oxides, nitrogen dioxide, hydrogen chloride, hydrogen cyanide, hydrocarbons, and hydrogen fluoride. These fumes may cause irritation, illness, or death.

A thermal runaway event can be difficult to extinguish, and the battery can reignite a long time after the fire is initially put out.

Chemical hazards

Both low- and high-voltage batteries contain electrolytes that can cause health effects. Health effects of exposure include toxicity, corrosivity, chemical burns, or respiratory issues. For example, lithium hexafluorophosphate can break down when exposed to high heat, damage, or overcharging and produce hydrofluoric acid. The risk of this chemical exposure is minimal when the battery is in good repair.

Chemicals common to non-electric or hybrid vehicles may also be present, such as those in the air conditioning, brake, or hydraulic systems.

Materials handling

Musculoskeletal injuries can occur when lifting or moving lithium-ion batteries as they can weigh 300 to 600 kg (660 to 1323 pounds). Moving or lifting may involve high force and awkward postures.

Damage may also occur when using forklift trucks to move the vehicles or the batteries.

What can the workplace do?

When workers may work with or near high-voltage batteries, the workplace should have policies and procedures in place that are appropriate to the activities conducted, such as storage, maintenance, or emergency response. Follow the hierarchy of controls.

How can energy storage and electrical hazards be addressed?

Control measures include:

- Develop a procedure which reduces the likelihood of workers coming into contact with energized systems or components.
- Do not overcharge (excess heat may be generated) or over-discharge (the battery may become unstable).
- Disconnect the low-voltage battery that controls the high-voltage system before removing the high-voltage battery and related cables.
- Verify there is no high-voltage energy present before working on a system by using a CAT voltmeter. Follow the manufacturer's instructions and wear any required personal protective equipment (PPE).
- Never leave a vehicle with a partially removed high-voltage battery for an extended period of time (e.g., overnight). Completely remove the high-voltage battery before leaving the vehicle unattended.
- Store damaged batteries away from flammable materials, preferably outdoors under a covered roof with open sides (protect from sunlight, rain and other elements, but allow for natural ventilation). Consult the battery and vehicle manufacturer's guidance for any specific distance. For passenger vehicles, the National Fire Protection Association (NFPA) recommends that passenger vehicles be stored at least 15.24 metres (50 feet) away from combustible materials for at least 30 days.
- Make sure workers are aware of which systems cannot be de-energized.
- Wear high-voltage insulated or dielectrically tested gloves. Test gloves before each use.

How can fires and thermal runaway events be addressed?

Fires may occur at any time, but there is a particular concern when damage to the batteries is suspected. It can take hours, days, or weeks for a thermal runaway event to occur.

Controls include:

- Follow the manufacturer's instructions for moving, storing, handling and transporting damaged batteries.
- Inspect batteries regularly for swelling, deformities, leaks, corrosion, heat build-up, and other signs of thermal runaway.
- Store high-voltage batteries in a segregated, designated storage area with controls to reduce the risk of fire (e.g., non-flammable materials are used for storage systems, racking and flooring are made from electrolyte-resistant materials, fire detection devices, fire suppression equipment, ventilation to the outdoors, temperature control, water runoff is directed away, etc.).
- Consider using a fire alarm system that monitors for smoke, gas, and heat. Gases include carbon dioxide (CO_2), carbon monoxide (CO), hydrogen sulfide (H_2S), and methane (CH_4) to help with early detection.
- Store batteries with appropriate spacing between units and limit the stack height to reduce the chance of a thermal runaway event from spreading.
- Prevent damage to batteries, cables or components, including tipping, dropping or falling, to reduce the risk of damage triggering a thermal runaway event.
- Do not use defective, damaged, flooded, or depleted electric or hybrid vehicle batteries.
- Follow the original equipment manufacturer's shipping and handling instructions for storage, repair, and when returning the defective batteries to them.

If a person detects fluid leaks, smoke, sparks, flames, gurgling, popping, or hissing noises, especially while transporting batteries or from a vehicle with a damaged high-voltage battery, they should immediately leave the area. If driving, pull over and exit the vehicle.

How should a high-voltage battery fire be fought?

Have a fire safety plan in place when high-voltage batteries are stored, maintained, dismantled, or transported.

Internal combustion engine vehicle fires may have a fuel tank failure, which results in a fire that peaks high but burns out fast. Electric vehicles, on the other hand, may have a fire which starts in their batteries. These fires develop more slowly, are not as large, but burn longer. Hybrid vehicles will have both fuel tanks and high-voltage batteries.

Hybrid and electric vehicles do not require special fire suppression equipment. However, large amounts of water are required. Extinguishing high-voltage battery fires is difficult and can take up to 40 times more water than internal combustion engine fires. Reignition is also common.

Smothering techniques, such as foam or fire blankets, may also not be effective because a lithium-ion battery can produce oxygen during the combustion process. In some situations, and if it is safe to do so, letting it burn in place is an option.

Do not blindly pierce the vehicle's hood to gain access to the engine compartment. Shock may result.

Wear full PPE with a self-contained breathing apparatus (SCBA) with a face-piece mask, where required.

How can chemical hazards be addressed?

Control measures include:

- Read all safety or warning labels and consult the safety data sheet (SDS).
- Have emergency eyewash or shower stations close by, with no obstructions along the path (e.g., stored materials, doors, etc.).
- Use extreme care to avoid spilling or splashing of liquids.
- Have specific safe work procedures if hydrofluoric acid is present. Use treatment solutions or gels of calcium gluconate in addition to emergency eyewashes or showers.
- Make sure the appropriate respirator, eyewear, and protective clothing are available to workers and worn.

How can material handling hazards be addressed?

Control measures include:

- Use mechanical lifting or transporting devices.
- Use a forklift or similar equipment.
- If performing a team lift, assign a leader. Determine a set of commands to be used, such as "lift," "walk," "stop," and "down." Make sure that everyone knows what to do when they hear the command. Follow the commands given by the team leader.
- Practice team lifting and carrying together before attempting the task.
- Do not damage or drop the battery.

How can safety hazards be addressed?

Control measures include:

- Make sure the vehicle ignition is off.
- Keep the proximity key (remote/fob) away from the vehicle to avoid an unintentional restart, as needed.
- Enable any vehicle signals and sounds to alert workers, if provided.

What are some protective measures when a vehicle has been in a collision?

For safety,

- High-voltage batteries in vehicles are usually protected by the vehicle's structure or in a metal case.
- The high-voltage systems are isolated from the vehicle's chassis so the vehicle can be touched even after a severe crash without coming into contact with electricity from the high-voltage battery.
- Vehicles are equipped with a high-voltage automatic disconnection system, which activates when the vehicle's passenger protection systems (such as the airbags and similar systems) are deployed.
- Vehicles also have fuse and fault protections to disable high-voltage systems if they experience a fault, short, thermal runaway event, or other damage.

After a collision:

- Inspect for water intrusion, fire damage, leaks, smoke or flame, or damage to the high-voltage cables.
- Store the vehicle (or battery if separated from the vehicle) away from other vehicles, preferably outdoors.
- Follow the manufacturer's guidelines for disconnecting batteries. Use insulating gloves when disconnecting the interlock connection.
- Monitor the stored vehicle for warning signs. An event may take hours, days or weeks to occur.
- Provide adequate ventilation if the vehicle needs to be covered to protect it from the weather because gases released from the battery may be trapped under the cover.

What should emergency first responders and tow drivers know about high-voltage batteries?

In addition to the fire suppression measures discussed above, after a vehicle has been in a collision:

- Look for badges or labelling that indicate it is a hybrid or electric (or zero emissions) or look for the vehicle’s model name. Some vehicles do not have indications on the outside. Look for other signs such as indicators on the engine or the use of orange cabling.
- Always approach the vehicle from the side or have an escape path if it begins to move. The vehicle may be on (running), and you may not be aware.
- Chock the tires to prevent movement. If possible, activate the emergency brake.
- Turn the vehicle off if it's safe to do so.
- Move the Bluetooth key (fob) more than 16 feet (about 5 metres) away to make sure it will not start up again unexpectedly.
- Disconnect the 12-volt battery.
- Follow towing and recovery recommendations from the vehicle’s manufacturer.
- Listen and look for any battery damage—leaks, sparks, smoke, flames, increased temperature, or gurgling, popping, or hissing noises from the battery compartment. Notify the fire department immediately if they are not already on scene, as these are signs of a thermal runaway event. Continue to watch the battery, as these indicators may not occur right away.

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