KPA

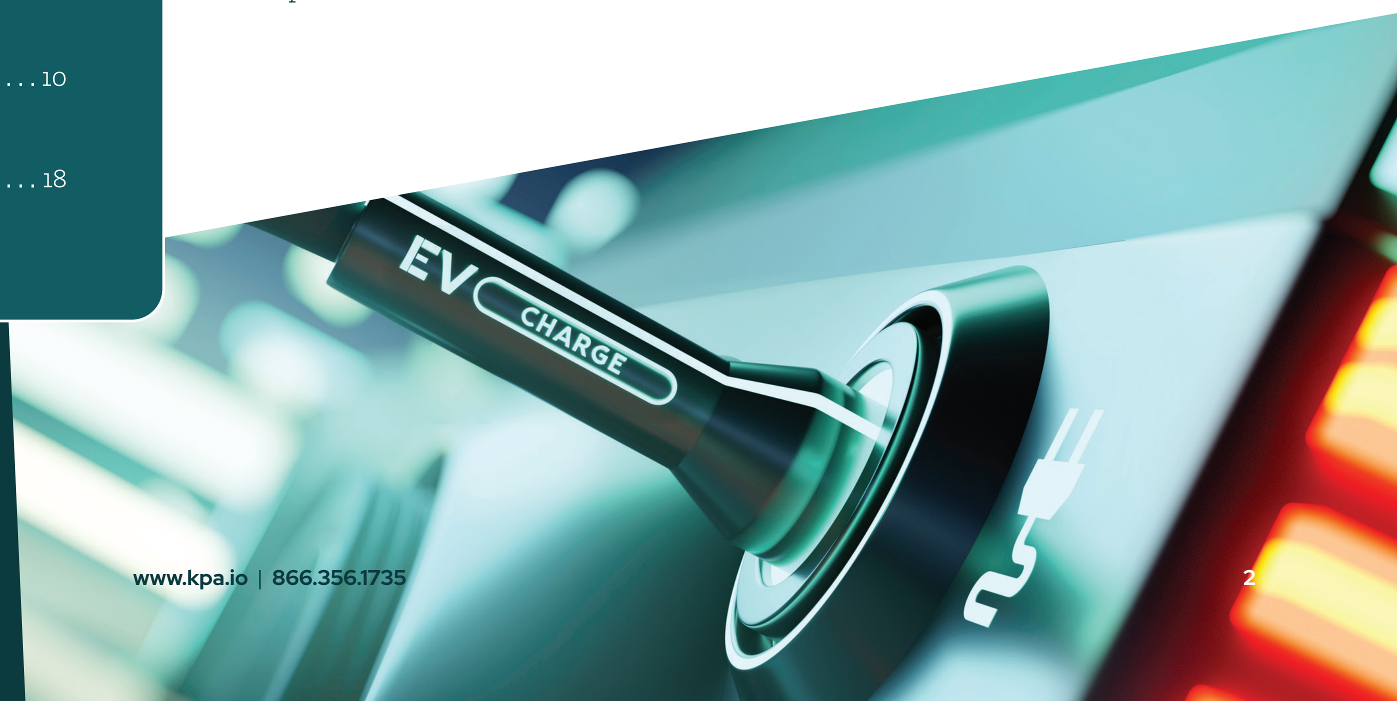
Plugging Into Electric Vehicle Safety

The Buzz on Electric Vehicle Safety

Contents

Electric Vehicles have hit the scene, and dealerships are working double-time to prepare for their arrival. With growing demand, dealers and collision centers need to understand both the new hazards introduced by EVs and the relevant OSHA, DOT, and EPA regulations.

So how can dealerships set their facilities up to provide a safe work environment while working with EVs? We've consulted EV safety professionals to bring safety pros the information they need to set their facilities and workers up for success.



Reducing EV Fire and Storage Hazards in Your Dealership

You've probably seen a news story about an electric vehicle fire—they make good drama. Maybe it was about a driver escaping from a blazing inferno that started in the electric vehicle they were driving just moments before. Or maybe the story was about untold property damage caused by the random ignition of a parked EV. These sensational tales attract viewers, but the truth about EV fires is much less dramatic.

Let's take a closer look at:

- EV Fire Risks
- Fire Severity
- Reducing EV Fire Hazards

Read on to learn steps you can take to mitigate these risks.

EV Fire Risks in Perspective

First, let's test your knowledge about the fire risk for:

- Internal combustion engines (ICE),
- Hybrid electric vehicles (HEV), and
- Battery electric vehicles (BEV).

Answer this question:

How likely are battery electric vehicles to catch fire, as compared with hybrid electric vehicles and internal combustion engines? Rank the order from most likely to least likely to catch fire.

a. BEV, ICE, HEV

b. BEV, HEV, ICE

c. ICE, HEV, BEV

d. HEV, ICE, BEV

e. ICE, BEV, HEV

Drumroll, please!

If you answered D, you are correct.

BEVs are the least likely to catch fire, according to data collected by the U.S. National Transportation Safety Board (NTSB) and analyzed by AutoinsuranceEZ. Not slightly less likely. A lot less likely. Then came ICE engines, followed by the riskiest—hybrids.

Here are the stats: There were 25.1 fires for every 100,000 BEVs sold. That's a rate of 0.03%. There were 1,500 fires for every 100,000 ICE vehicles sold. That's a rate of 1.5%. And now the worst of the bunch: hybrid electric vehicles. There were 3,500 fires for every 100,000 HEVs sold. That's a rate of 3.5%.

To put it into perspective, there were 140 HEV fires and 60 ICE fires for every one BEV fire!

Fire Severity

BEVs aren't exactly risk-free. We have to consider the severity of the fires as well.

ICE vehicles store gasoline or diesel fuel in the fuel tank, fuel lines, and fuel pumping system. ICE fuel fires are usually easily accessible; a person can extinguish a minor fire with an ABC fire extinguisher—the most common type.

EV batteries, on the other hand, are not easily accessible. A fire-resistant and puncture-resistant casing protects the battery from damage. It also prevents access to a battery fire, which means BEV fires tend to be more difficult to extinguish. You'll need to prepare accordingly.

5 Tips for Reducing EV Fire Hazards

Here are some tips for protecting your property and employees from EV fire hazards.

1	**ID and Label Damaged Vehicles**	Identify and clearly label vehicles that have been damaged in a collision—even those that could have been damaged. Employees need to know that those vehicles are a potential hazard so they can take the proper precautions.
2	**Park Damaged EVs in a Safe Zone**	Store damaged and at-risk vehicles in such a way as to prevent property damage should the vehicle catch fire. If possible, move EVs you've been working on to the storage area at the end of each work day. The National Highway Traffic Safety Administration (NHTSA) and the National Fire Protection Association (NFPA) recommend storing damaged lithium-ion batteries in a safe zone at least 50 feet away from buildings and other combustible material.
3	**Designate EV Work Areas**	Designate work bays that are dedicated to EVs. That way, employees who are trained to work on EVs can work in the same area and protect themselves against EV-specific hazards. Employees who are not trained to work on EVs should not enter those bays or expose themselves to EV hazards.
4	**Create an EV Fire-Response Plan**	You likely have a written Emergency Response Plan, but you also need a facility-specific response plan for EV fires. Things to cover include answers to these questions: ◆ What should employees do when an EV catches fire? ◆ Do responders need to wear special personal protective equipment (PPE)? ◆ Where on your property is it safe to store a damaged EV? ◆ How close can other cars be to an EV?
5	**Conduct Regular Inspections**	Regularly inspect electric vehicles and their batteries. Inspection improves the chance of an employee diagnosing a battery fault or failure before it leads to a more serious event, such as a fire.

Storing EV Batteries: 3 Tips for Reducing Hazards

We talked about EV fire mitigation, but now we need to consider the hazards associated with storing EV batteries separate from vehicles. There are times when you'll need to swap out an EV battery. And you'll need to store the old one until you can properly dispose of it. This could be an end-of-life (EOL) battery, meaning it no longer holds a viable charge. Or it could be a damaged, defective, or recalled (DDR) battery. Here are some tips for managing battery storage risks.

Use Proper Storage Containers

Maintain Proper Clearance

Designate a Storage Building

1. Use Proper Storage Containers

You need to properly contain old batteries until they leave the facility. Sometimes you can store a used battery in the shipping container it arrived in, but not always. Contact the battery supplier to determine if the shipping container is the proper packaging for storage, especially if you will be storing the battery onsite for a longer period, such as during a recall.

2. Maintain Proper Clearance

You need to protect stored electric vehicle batteries from a wide variety of hazards that are part of everyday operations in a service department. Most battery manufacturers recommend 10 feet of clearance around stored batteries for anything that could harm the battery, including:

- **Chemicals**—consider potential reactions between the battery casing and fumes, electrolytes, or coolant
- **Electrical sources and electrical panels**—the battery should not be at risk of being subjected to a high-voltage jolt
- **Water**—consider how close the battery is to car washing or detailing, and whether it might be subjected to rain or snow
- **Employee operations**—only those trained on working with high-voltage batteries should work near EV battery storage
- **Traffic**—avoid high-vehicle-traffic areas and forklift operations

3. Designate a Storage Building

The best practice is to designate a storage building or shed with a roof and walls for battery storage, which keeps exposure to a minimum. Locate the building away from other structures and property when possible. Install a wide door to allow for forklift access and maneuverability.

Now that you understand the hazards associated with high-voltage EVs and their batteries, take the steps necessary to protect your employees and facilities. Check with your local fire marshal to be sure you've adequately mitigated the risks. Finally, add new risk-mitigation information to your safety manual and Emergency Response Plan.

Anatomy of an EV Battery

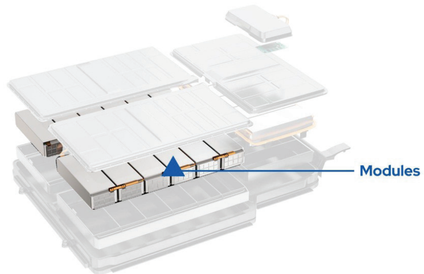
Assessing high-voltage lithium-ion EV batteries isn't the easiest task, but we'll break it down for you. Let's start first with understanding how EV batteries are constructed. For the purposes of this discussion, the most important parts of the battery are the cells, modules, cooling system, casing, and battery management system.

Cells

An EV's energy is stored in the battery cells. Each cell consists of two electrodes that collect current: an anode, which is positively charged, and a cathode, which is negatively charged. A solution called electrolyte separates the anode and cathode and transports positively charged ions between the cathode and anode terminals. When the battery is charging, lithium ions move from the anode to the cathode and store energy. When the battery is in use, lithium ions move from the cathode to the anode and discharge energy. The flow of ions is called electricity, which powers the motor.

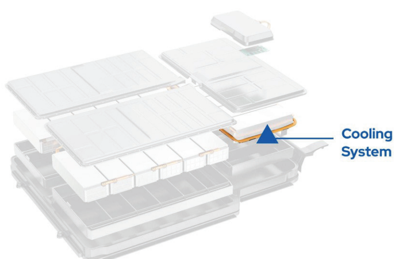
Modules

The battery manufacturer stores groups of cells in compact containers called modules, packs, or jars. These containers can look very different, depending on the battery manufacturer. From here forward, we refer to them simply as "modules."



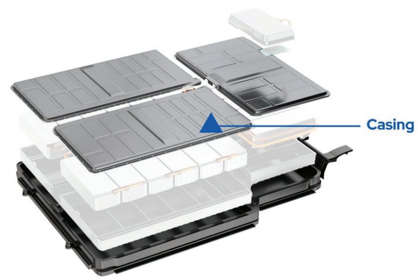
Cooling System

Energy discharge from lithium-ion batteries creates a great deal of heat. Electric vehicles are equipped with cooling systems that transfer heat away from the modules, similar to the traditional antifreeze/coolant systems in internal combustion engine vehicles.



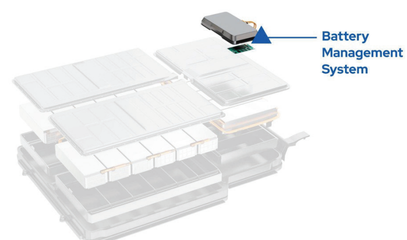
Casing

Cells, modules, and the cooling system are enclosed in a protective casing. This casing is designed to protect the modules from impact, chemicals, vehicle heat, environmental heat, and structural damage.



Battery Management System

A battery management system (BMS) is the "onboard computer." Its sensors communicate with the vehicle to ensure proper operation of the battery, the components powered by the battery, and the battery's interface with its energy supplies. Without a BMS, the battery system will not function as intended.



EV Hazards: How to Assess the Risk of Battery Fire

So far we've identified the steps a dealership can take to reduce the risks associated with electric vehicle (EV) fires and battery storage. Some of those solutions may not be feasible for every electric vehicle and every dealership. That means you need a way to determine which batteries pose more risk than others so that you can classify them as critical risk, high risk, or average risk.

Let's walk through the steps you need to take when inspecting and assessing:

- A Battery that's inside a vehicle
- A battery that's ready to be installed
- A battery that needs to be packaged and shipped offsite

Assessing a Battery Inside a Vehicle

Now that you know more about how a battery is constructed, let's talk about how to assess its condition. The first type we'll talk about is a battery that's housed inside the vehicle.

Visual observation of a battery inside a vehicle may be limited, and therefore, the risk of fire is greater than with a battery that has been removed. Follow the steps we've outlined below to assess whether a battery inside a vehicle is a critical risk, a high risk, or an average risk. Follow your dealership's standard operating protocols for handling critical-risk and high-risk EV batteries.

Critical Risk

Confirm that there is no critical risk to the battery before performing a more detailed assessment.

1. Is the battery emitting smoke or flames?
2. Are there visible sparks or arcing coming from the battery or other components?
3. Are you able to get a voltage reading from non-energized parts of the vehicle?

The answer to all of those questions should be a definitive, "No." Any "yes" answer is an indicator that the battery is a critical risk. If it is not, move on to the assessment of thermal codes, loss of isolation, and physical damage to determine if the battery is high risk or average risk.

Thermal Codes

Depending on the manufacturer of the vehicle/battery, you may be able to use the battery management system to run diagnostic tests. The purpose of these tests is to determine if the cells are generating heat when they should not be.

The critical question here is: Are the battery temperature logs recording temperatures of 122°F (50°C) or higher?

If so, let the vehicle rest for one hour and then retest. If temps remain high, the battery is at high risk of fire.

Loss of Isolation

Electrical faults don't always manifest as heat. Diagnostic tests may return high-risk energy codes, such as:

High-voltage codes	Over-voltage codes	State of charge codes

The presence of ANY of these code types means the battery is high risk.

Physical Damage

The casing for high-voltage batteries is designed to protect the fragile and volatile internal components, but it's not foolproof. It's best to conduct a visual assessment.

1. Is there evidence of prior fire?
2. Is there evidence of rupture, puncture, or high impact?
3. Is there evidence of incorrect disassembly or assembly?
4. Is there evidence of leakage, either electrolyte or coolant?
5. Is there evidence of damage to high-voltage components around the battery?
6. Is there evidence of damage to the vehicle near the battery?
7. Is there evidence of a collision that could have impacted the battery or its components?
8. Is there evidence of environmental damage (e.g., water, soil, flora)?

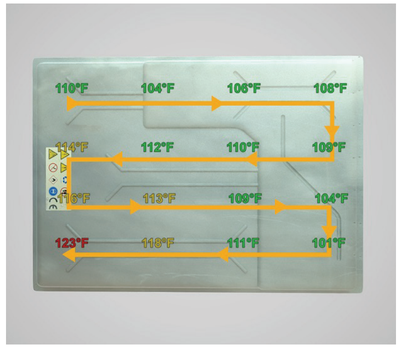
A "yes" answer means the battery is considered high risk.

Inspecting a Battery Outside a Vehicle

Sometimes you'll need to assess a battery that is outside of a vehicle. It could be a new battery you're getting ready to install, or a battery that the service department has removed and must now be packaged for shipping. Either way, you'll need to perform the proper assessments before installing or packaging it.

As with batteries housed inside a vehicle, you need to first perform a Critical Risk and Physical Damage assessment. Then you can test a battery for thermal stability. There is one final assessment for batteries you're preparing to package for shipping.

Thermal Stability



Batteries outside a vehicle are not exposed to heat generated through operation, so any signs of continuing heat generation are warning signs that the battery may be unstable. Follow these steps to test for thermal stability:

1. Use an infrared thermometer to measure the temperature along four parallel and equally spaced lines along the long edge of the battery. Place the thermometer 12 to 18 inches away from the battery when taking a reading.
2. Record the highest temperature along each parallel line.
3. Take a second set of readings one hour later.

The battery is considered high risk if:

- The temperature remains above ambient temperature across both readings; and/or
- The temperature increases from the first reading to the second.

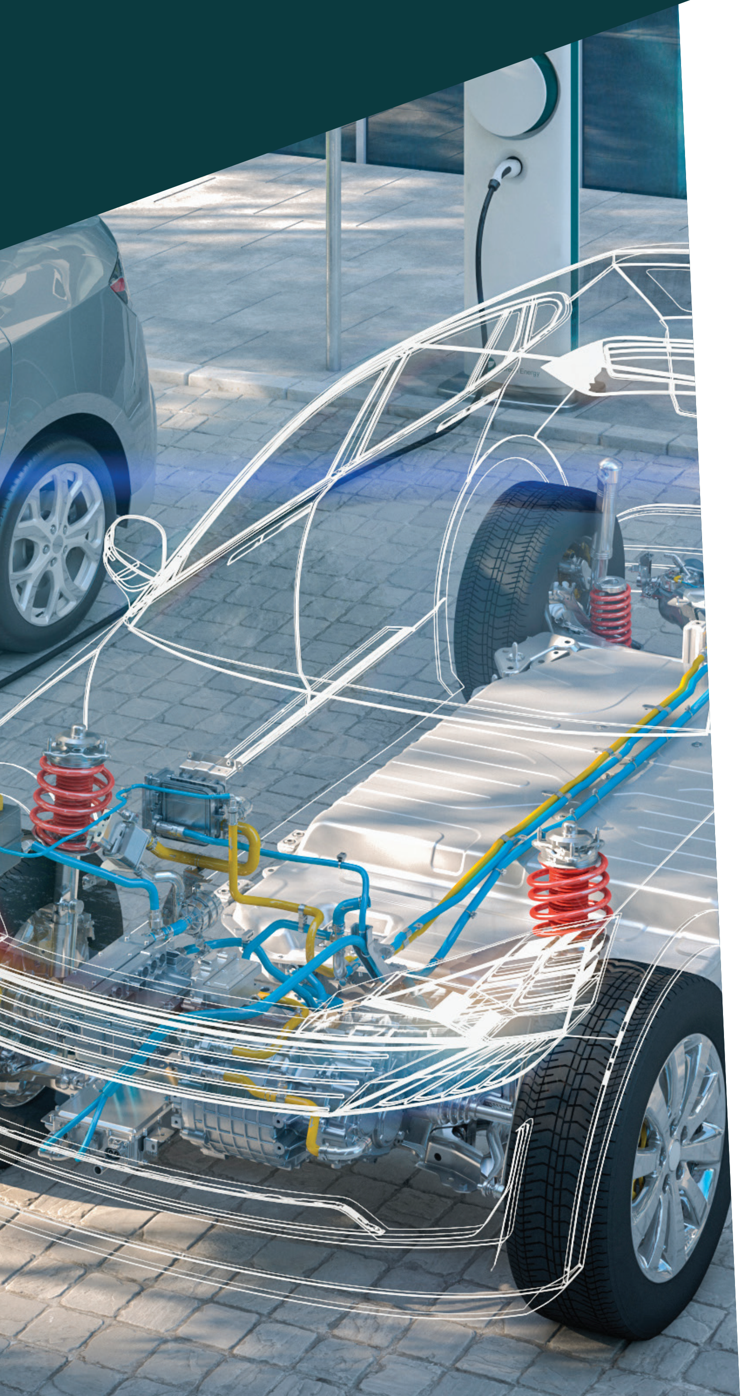
Shipping Readiness

When preparing a battery for shipment, first perform the Critical Risk, Physical Damage, and Thermal Stability assessments. Then you can assess a battery's readiness for shipping as follows:

1. Are all covers (metal or plastic) installed properly?
2. Are any covers missing?
3. Are all bolts, nuts, fasteners, and shipment brackets installed properly and correctly torqued?
4. Is the service plug secured?
5. Are all electrical wires and energized components (service plug port) protected from incidental contact?

Batteries that have all their parts, and all parts are secured and protected as necessary, are good to go for shipping. If you are unable to locate or adequately secure any of these parts, this battery may be considered high risk for shipping. Please contact your shipper partner, recycling partner, or OEM guidance to determine proper packaging protocols.

Performing these basic assessments on each battery, as appropriate to the circumstances, will allow you to classify each battery as critical risk, high risk, or average risk. By doing so, you will greatly reduce the risk of an EV battery fire in your dealership.



Understanding Electricity and Proper PPE

Electricity is an everyday part of our lives. Flip a switch and the lights turn on. Plug your phone in and the battery charges. At home, you may not think about how electricity works (until your power goes out). But when your work involves electrical vehicles, it's imperative to understand the mechanics of electricity and electrical personal protective equipment (PPE) in order to stay safe on the job.

In this chapter, we explain:

- Basic Electrical Terms
- How to Calculate Voltage and Wattage
- The Risks of Working With Electric Vehicles
- How to Protect Yourself With Personal Protective Equipment

1 Basic Electrical Terms

Let's start with the basic terminology.

Electricity	Electricity is a function of electron movement. An electron is a particle and a component of each and every atom. The continual flow of electrons from one atom to another is what creates electrical current.
Current	An ampere, shortened to "amp" or abbreviated as "A," is the standard measurement of electrical current that moves past one point of an electrical circuit. One amp is over 6,000,000,000,000,000,000 electrons per second, or six quintillion.
Voltage	Voltage, shortened to "volt" or abbreviated as "V," is used to measure electric potential difference, which is the force that pushes electrons through the circuit.
Resistance	Electrical resistance is measured in ohms, which is abbreviated as "Ω." An ohm is a measure of the conductivity of the medium through which the current is flowing. Mediums like copper, which have low resistance, are good conductors.
Wattage	Wattage, shortened to "watt" or abbreviated as "W," is a measure of the amount of work or power that can be performed with the electricity that is supplied. In other words, it is the rate at which energy can be transferred from electricity to some other function, such as powering a vehicle or lighting a bulb.

2 How to Calculate Voltage and Wattage

Determining Voltage

You can determine voltage (V) by multiplying current (A) times resistance (Ω). In other words, a circuit requires one volt of pressure to push one amp of current through one ohm of resistance. That relationship is represented by this formula:

V = A x Ω

If resistance increases, we require more voltage to move the same amount of current.

Suppose you're using a 12 V source. If the resistance is 100 ohms, the amperage is 100 divided by 12, or .12 A.

12 V = .12 A x 100 Ω

Now double the resistance to 200 ohms. The amperage is 12 divided by 200, or .06 A. Amperage is halved when the resistance doubled.

12 V = .06 A x 200 Ω

Determining Wattage

Wattage is the work that gets done by electrical current. A watt of work is a function of the voltage and amperage of an electrical system. It is calculated as follows:

W = A x V

Suppose you have a 12 V source and .06 A. The wattage is 12 x .06, or .72.

3 The Risks of Working With Electric Vehicles

High-Voltage Batteries Are, Well, Electrifying

Electric vehicles (EVs) present a significant risk to the technician. A high-voltage battery creates a large amount of pressure (voltage) in order to move an electrical current through any medium, including you!

If a person enters an electrical circuit, it only takes 10 mA or 0.01 A to paralyze the respiratory system. Currently, EV batteries operate at 200 V to 800 V. The resistance of a human body varies wildly and can be anywhere between 500 Ω and 100,000 Ω. If we assume skin resistance to be 20,000 Ω, we arrive at:

$$\mathbf{V = A \times \Omega \rightarrow 200\,V = A \times 20{,}000\,\Omega \rightarrow A = 200\,V / 20{,}000\,\Omega \rightarrow A = 0.01}$$

This calculation assumes the smallest of today's high-voltage batteries and reasonable resistance factors. The 10 mA result is enough to kill a human being. Due to the wide variety of factors that contribute to skin resistance, exposure to a high-voltage battery is a very risky endeavor. That's where personal protective equipment comes into play.

4 Staying Safe With Proper PPE

There are three types of PPE for working safely with electricity: safety glasses, insulated gloves, and arc-flash equipment.

An arc flash is the combination of light and heat produced when current travels through the air or ground or another voltage phase, called an arc fault. Arc-flash equipment generally consists of footwear, pants, a long-sleeved shirt, gloves, and headgear—all specially designed to protect the wearer from burns. Most electric vehicle manufacturers do not require technicians who work with EVs to wear arc-flash equipment. That's because no manufacturer requires technicians to open a battery case under any circumstances.

For the work you perform, you must wear safety glasses and lineman gloves (also called lineman's or electrician's gloves).

Safety Glasses

Safety glasses protect the wearer from hazards to the eyes and should be a standard part of every technician's work uniform. It is always a good idea to confirm that the glasses comply with ANSI Z87+ standards: They must provide protection from impact and chemical exposure, and they must protect the peripherals.

Lineman Gloves

Commonly called hybrid or EV gloves, lineman gloves are designed to prevent the wearer from becoming part of an electrical circuit. You should wear them any time you are working with the high-voltage system, whether that is the battery or the energized components of the vehicle.

Here's what you need to know about wearing lineman gloves:

Proof Test Every Six Months	Lineman gloves require proof testing every six months to ensure their integrity. Even a microscopic perforation can compromise the gloves, allowing the wearer to enter into the circuit. Proof testing must be performed by a laboratory accredited by the North American Independent Laboratories for Protective Equipment Testing.
Inspect and Air Test Before Each Use	Physically inspect and air test the gloves using an air testing kit before each use. You're looking to identify tears, holes, ozone damage, cuts, defects, or material swelling or thinning. Perform air testing in compliance with the glove manufacturer's recommendations and glove type requirements.
Wear the Correct Class	There are six main classes of lineman gloves: 00, 0, 1, 2, 3, and 4. Automotive technicians use Class 00 or Class 0 gloves. Class 00 gloves are rated for 500 V use and Class 0 gloves are rated for 1,000 V use.
Wear with Leather Gloves	Never use lineman gloves without a pair of leather protector gloves over top. They are designed to protect the insulated gloves from wear and tear, such as cuts, abrasions, and punctures. There are limited exceptions to this requirement, but considering the high voltage of electric vehicle batteries, leather protectors are required.

Other Sources for Safety Information

Vehicle and battery manufacturers publish their recommendations for safety precautions, personal protective equipment, and any other administrative or engineering controls. These publications should be your first reference point when you perform maintenance work on an EV high-voltage system.

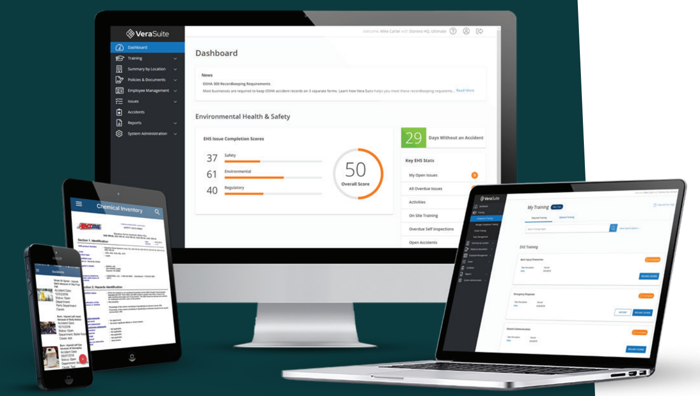
A dealership should also perform a hazard assessment for electric vehicle work to determine to which hazards employees are exposed and how to control those hazards. You may also reference OSHA 1910.137 – Electrical Protective Equipment and NFPA 70E, though those regulations are not specific to electric vehicles.

KPA Helps You Stay on Top of Electric Vehicle Safety & Compliance

We designed KPA's EV safety and compliance solution to help you prepare your facility, educate your staff, and document/maintain OSHA compliance. The elements of the program include consulting, documents, and training delivered through the Vera Suite platform.

On-site Consulting

- KPA facilitates onsite management meetings to discuss EHS priorities for your business. KPA provides onsite consultation and assists management to install training, documentation, and procedures.
- Through our VeraSuite software platform, KPA's onsite consultants record observed compliance issues along with the associated picture of the issue, corrective action needed, due date, and name of the person responsible for correcting the issue.



About KPA

KPA helps dealerships improve safety and stay compliant. Trusted by 10,000+ clients, including 8 of the top 10 automobile dealership groups, KPA offers a unique combination of expert Environment, Health, and Safety (EHS), HR, and Sales F&I consulting, software, and training. KPA enables dealers to comply with state and federal regulations and proactively manage programs to reduce costs, minimize risk and increase productivity.

*For more information visit **www.kpa.io** or call **866.356.1735.***

Documents and Informational Content

- EV Preparedness Checklist
- Self-Inspection High Voltage Battery Assessment - In Vehicle
- Self-Inspection High Voltage Battery Assessment - Outside Vehicle
- Self-Inspection High Voltage Battery Assessment - Thermal Scan
- Electric Vehicle Safety Written Program Template
- Shipping Guide for EV Batteries

Training

- Electric Vehicle Safety - General Awareness
- Forklift Training
- Monthly Focus on Safety Self-Directed Training:
  - Electric Vehicle Battery Hazards
  - Identifying Electric Vehicle Battery Problems
  - EVs: Understanding Electrical Hazards & PPE