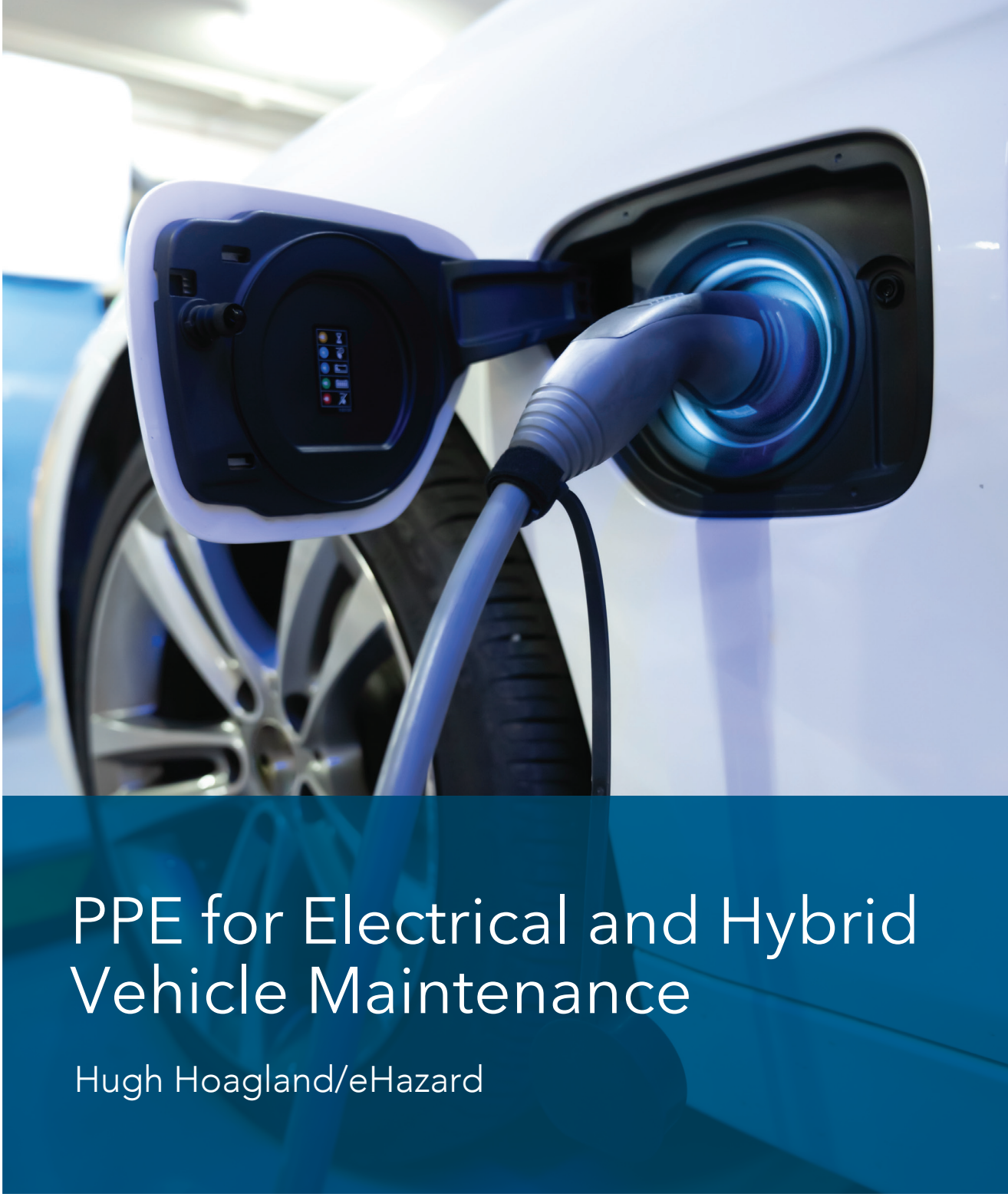

PPE for Electrical and Hybrid Vehicle Maintenance

Hugh Hoagland/eHazard

e-Hazard®

Is your team equipped with the required PPE for electrical and hybrid vehicle maintenance?

Hybrid and electrical vehicles are experiencing record growth, with sales outpacing overall market performance, according to analysis by Kelly Blue Book and Cox Automotive Group. And with more of these vehicles on the road, mechanics and service technicians are facing more hazards, due to the increase in the vehicles' operating voltage and frequencies.

Electrical vehicles (EVs) fundamentally change the safety issues in vehicle maintenance, and require advanced and complex protections for auto mechanics and service technicians, especially for shock, potential arc flash, electrical/battery fires and chemical solvents used in many EV and hybrid battery systems.

While sales of EVs and hybrids continue to climb, specialized electrical safety training for mechanics, service techs and managers is trying to keep up. Couple that with limited work safety standards for EV maintenance, servicing and repair, and concerns about the hazards of electric shock and arc flash, and the risks that come from working on batteries grows.

As you consider the protections needed for your employees working on EVs and hybrids, it's important to know that OSHA (Occupational Safety and Health Administration) recognizes all uncontrolled energy as a potential hazard, but **50 volts is the starting point of most regulations.** This does not mean that lower voltages cannot be dangerous in certain contexts, but **anything greater than 50-volt exposure is regulated under the OSHA 1910.300 series rules.** Even more rigorous regulation enters the picture for anything greater than 600 volts, considered "high voltage" by OSHA.

As you work to grow with the increased consumer and fleet demand for EV and hybrid service, the best source of information is vehicle manufacturer. They alone will be likely to have all the battery, electrical bus work and other specifications critical to safely working on these vehicles. The larger the battery or the higher the voltage, the greater the hazard.

While it's not clear whether the scope of OSHA 1910.331 includes EVs, the principles are clearly applicable. OSHA's hazard assessment requirements are often cited in injury citation fines using OSHA1910.132, which requires that mechanical, shock, chemical and electrical explosion (arc flash) be considered during the employer's assessments for proper PPE.

Bear in mind too that it's important to clearly designate mechanical workers and electrical workers. Different color uniforms for mechanical and electrical workers can help, providing a simple and obvious visual cue that each person is in the right protective clothing for their specialty.

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Are you taking the proper steps to protect your employees as they service EVs and hybrids? We'll delve into the risks and protections, drawing from OSHA requirements for similar electrical installations, NFPA work practices – specifically NFPA 70E – and experience with capacitors and batteries offered by the Department of Energy.

The Hazards

SHOCK

The greatest hazard in working on an EV is electric shock or electric burns, even in hybrid vehicles and other vehicles with >50V. Typical EV's are often 48-120V for cars and small vans.

When voltage can easily penetrate human skin, the current needed to cause fatal injury is only 0.5 mA. OSHA considers anything 50V or greater potentially fatal. In fact, OSHA requirements demand the use of rubber-insulating gloves specifically rated for the voltage. Voltage-rated (VR) gloves in the US must meet ASTM D120. When working on typical EVs less than 1000V, a Class O glove is needed.[1]

OSHA also requires inspection of gloves before each use by a qualified worker, and to be sent off for proper electrical testing a minimum of every six months.[2]

COMMON SHOCK PPE

- Properly rated voltage-rated gloves meeting ASTM D120, tested within the last six months per OSHA law
- Proper mechanically protective overgloves (to protect the insulated gloves) meeting ASTM F696 and/or ASTM F3258
- Insulating sleeves meeting ASTM D1051, if work practices cannot prevent touching energized parts using gloves alone-- see OSHA 1910.137 for details on shock PPE requirements[3]
- Mats, blankets, or sheeting (meeting ASTM D178 or D1048, F2320 or F1742)
- Aprons (ASTM F2677), if needed

ARC FLASH

Arc flash is a recognized hazard of batteries. In fact, the US Department of Energy reports battery fires as a major recognized hazard, especially from damaged batteries.

The hazard is even inherent to some battery designs, as many of the EV batteries use flammable solvents for lithium ion batteries.[4] When asked if PPE is required by OSHA when there are electrical hazards, OSHA responded as follows in an interpretation letter:

"Arc-flash hazards are also addressed in §1910.335(a)(1)(v), Safeguards for personnel protection, which requires that personal protective Equipment (PPE) for the eyes and face be worn whenever there is danger of injury to the eyes or face from electric arcs or flashes or from flying objects resulting from an electrical explosion. In addition, paragraph (a)(2)(ii) of §1910.335 requires, in pertinent part, the use of protective shields, barriers, or insulating equipment **"to protect each employee from shocks, burns, or other electrically related injuries while that employee is working . . . *where dangerous electric heating or arcing might occur*" (emphasis added). The §1910.335(a)(2)(ii) safeguard selected – shield, barrier, or insulating material – must fully protect employees from electric shock, the blast, and arc-flash burn hazards associated with the incident energy exposure for the specific task to be performed.** However, in situations where a fully protective safeguard could be used as an alternative, OSHA will, under its policy for de minimis violations, allow employers to use, instead, safeguards that are not fully protective, provided that the employer implement additional measures. **The supplemental measures, which could include the use of arc-rated FR clothing appropriate to the specific task, must fully protect the employee from all residual hazardous energy (e.g., the resultant thermal effects from the electric arc) that passes the initial safeguard."** [5]

Due to battery fires/explosions in some undamaged vehicles with a design flaw, the National Highway Traffic Safety Administration recently recommended that owners of more than 50,000 EVs across the U.S. park their relatively new vehicles outside until further notice. These vehicles were only two to five years old. [6] Safety of workers is paramount, and these common PPE recommendations can be helpful in saving lives.

In the NFPA 70E (C)(15)(b) table for Arc Flash from "storage batteries, dc switchboards, and other dc supply sources," with greater than 100 volts and less than or equal to 250 volts, require PPE Category (CAT) 2-3 depending on fault current available and CAT 2-4 if the voltage is greater than 250 but less than 600 volts. Higher voltages require a more complex method to determine the arc rating required.

COMMON ARC FLASH PPE

Because the minimum PPE in NFPA 70E for batteries and dc buses is PPE Category 2 (minimum 8 cal/cm² protection), it's often the starting point of exposed workers' daily wear to assure that the clothing will not increase injury, a common problem in arc flash and flash fire conditions.

This could meet the potential hazard of most of the hybrid batteries in small EVs (check NFPA 70E or the manufacturer's recommendations).

- An additional flash suit may be needed with some batteries for testing exposed bus work (if this is possible) and in removal of or replacement of batteries, especially in damaged vehicles.
- The proper PPE may even be something like fire fighters' turnout gear. Again, consult with the vehicle manufacturer.
- Your workers must be both trained and designated. Choose different color uniforms to designate your maintenance and electrical workers. Clothe workers with electrical qualifications in AR gear to help protect them from arc flash hazards. This practice is often used in the petrochemical industry.

CHEMICAL EXPOSURES

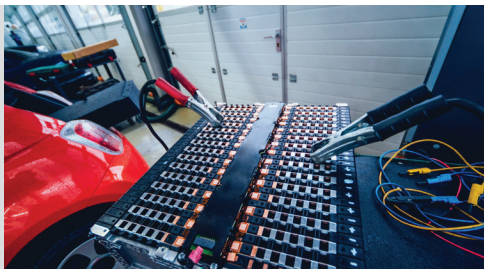
When handling electrolyte from open systems or damaged systems, OSHA requires the following PPE: "face shields, aprons, and rubber gloves shall be provided for workers handling acids or batteries." (OSHA 1926.441(a)(2)).

OSHA regulations and NFPA 70E also require proper ventilation and eye/body wash stations be present in the workplace.

Note, some AR gear will withstand acids and bases better than others. While fabrics cannot protect the body from acid exposures, many companies have found that aramid blends that do not contain cellulosic fibers withstand drips of acid without forming holes. Functionally, these garments do not protect from the acid since it can still permeate the woven fabric, but they will last longer when small droplets of acid can hit the clothing. Coated AR aprons and coated or laminated AR chemical rated rain wear can protect from the acid and arc flash if present. Normal chemical suits may claim to be "FR" but most of these are melting materials which can still cause severe injury. Chemical suits or aprons used when acids or bases could cause injury should be AR rated ASTM F1891 or Flash Fire rated ASTM F2733.

COMMON CHEMICAL PPE

- Face shields
- Goggles and/or safety glasses
- Rubber gloves
- Chemical AR aprons, chemical rated suits or AR rain wear



MECHANICAL

Like any vehicle, EVs have mechanical hazards, including:

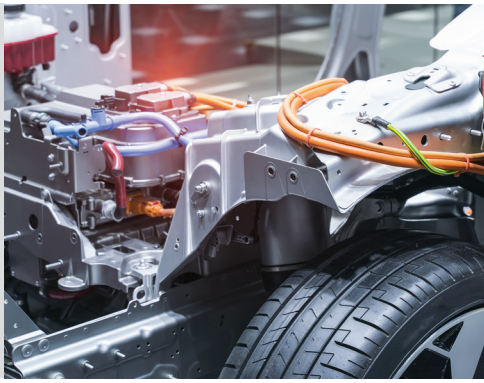
- Heavy parts (drop hazard)
- Moving parts (pinch hazards)
- Metallic parts (cut hazards)

Equip your employees with cut-resistant or impact-resistant work gloves, which can be helpful in protection from these hazards (see ANSI/ISEA 105 glove classifications).

Other hazards like bump hazards can be prevented by using proper work techniques and tools, and wearing a bump cap or hard cap in some work settings. Slip resistant work shoes (ANSI Z41 or ASTM F2413) or voltage-rated shoes can be worn if needed (VR shoes must meet ASTM F2413 or ASTM F1117).

COMMON MECHANICAL PPE

- Work gloves (ANSI 105, NFPA 2112, ASTM F2675)
- Work uniform with mechanical protection and flame resistance (ASTM F1506 and/or NFPA 2112), if needed
- Bump cap
- Safety glasses/goggles (ANSI Z87.1)
- Face shield (arc and/or chemical protective, depending on task).



Training

Service managers looking to be on the leading edge of training for their employees in EV maintenance and safety will fortunately find good resources. The primary source for training on a specific model should be the vehicle manufacturer. SAE, NFPA and many electrical safety-training companies offer training for workers at plants producing EV batteries and for mechanics and engineers working on EVs based on common electrical safety principles. See these resources:

https://www.e-hazard.com

https://www.sae.org/learn/content/c1732/

https://www.nfpa.org/News-and-Research/Data-research-and-tools/Electrical/Electric-Hybrid-Vehicle-Safety-Training-for-Emergency-Responders

https://www.fireengineering.com/articles/2007/10/hybrid-vehicle-hazards.html

Fluke Safety Measurement Basics for EVs
https://dam-assets.fluke.com/s3fs-public/3034738_6003_ENG_B_W.PDF

Talk to a Cintas Service Representative to learn about available PPE for EV and hybrid service and maintenance.

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Other Reading

SAFETY NORMS FOR WORKING ON HIGH VOLTAGE ELECTRICAL VEHICLES

https://evreporter.com/high-voltage-electric-vehicles/

MASS GOVERNMENT

https://www.mass.gov/files/high_voltage_safety_with_hybrids_and_electric_vehicles.pdf
https://www.nhtsa.gov/sites/nhtsa.gov/files/interimguide_electrichybridvehicles_012012_v3.pdf

ELECTROLYTE SPILLAGE

https://medium.com/batterybits/electric-vehicles-the-perilous-state-of-battery-safety-4efa85bc6b4

INVESTIGATING SAFETY ISSUES RELATED TO ELECTRIC VEHICLE WIRELESS CHARGING TECHNOLOGY

https://ieeexplore.ieee.org/document/6861757

LITHIUM-ION BATTERY SAFETY ISSUES FOR ELECTRIC AND PLUG-IN HYBRID VEHICLES

https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/12848-lithiumionsafetyhybrids_101217-v3-tag.pdf

Other Standard Resources

SAE International Standards

J2344: 2010, "Guidelines for Electric Vehicle Safety".

J2990 - Hybrid and EV First and Second Responder Recommended Practice

J2990/1 - Gaseous Hydrogen and Fuel Cell Vehicle First and Second Responder Recommended Practice

J3108 - xEV Labels to Assist First and Second Responders, and Others (high voltage safety info.)

J2344 - Guidelines for Electric Vehicle Safety (EV, HEV, PHEV and FCV high voltage systems)

ASTM International Standards see www.ASTM.org

NFPA Standard NFPA 70E, see www.nfpa.org

[1] NFPA 70E, 2021 Edition Table 130.7(C)(7)(a). Cintas provides voltage rated gloves on a rental basis and the service allows for electrical testing from their third-party testing provider based on the customer's determined testing period.

[2] OHSA 29 CFR 1910.137(c)(2)(viii). Cintas rental of Class O (up to 1000V gloves) or higher-class gloves, if needed, allows for electrical testing at a term no greater than six months with a voltage rated rental glove program. Another source of glove testing is an accredited organization www.nail4pet.org The use standard for rubber insulating gloves is ASTM F496.

[3] 1910.137(c)(2)(ix)

[4] Vehicle Battery Safety Roadmap Guidance, NREL Publication, Daniel H. Doughty, Ph. D. Retrieved 7-1-2021 https://www.nrel.gov/docs/fy13osti/54404.pdf. "To increase an all-electric vehicle's driving range, the vehicle traction application will require high voltage, which in turn requires long strings of cells, long life, and high energy. Finally, because the focus of this study is on EV's and HEVs that are passenger vehicles, fire safety is a primary concern. Batteries with flammable electrolytes present challenges when designing the safety of a vehicle's energy storage device. These safety concerns are especially acute for PHEV and EV applications where vehicles may be charged in confined garage spaces of private residences and commercial businesses." See p. v and elsewhere.

[5] https://www.osha.gov/laws-regs/standardinterpretations/2006-11-14. See also https://www.osha.gov/laws-regs/standardinterpretations/1993-09-09-3. OSHA on regulations on batteries and battery charging. https://www.osha.gov/laws-regs/regulations/standardnumber/1926/1926.441. Vehicle Standards on EV's and electrolyte spillage. https://www.federalregister.gov/documents/2016/03/10/2016-05187/federal-motor-vehicle-safety-standards-electric-powered-vehicles-electrolytespillage-and-electrical

[6] https://www.nfpa.org/News-and-Research/Publications-and-media/Blogs-Landing-Page/NFPA-Today/Blog-Posts/2021/07/15/National-Highway-Traffic-Safety-Administration-issues-safety-warning-about-Chevy-Bolt. https://www.nhtsa.gov/press-releases/consumer-alert-important-chevrolet-bolt-recall-fire-risk