ASE Electrified Propulsion Vehicles (xEV)
High-Voltage Electrical Safety Standards
Level ONE – Electrically Aware Person

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Notice and Disclaimers

SECTION A – PURPOSE AND DEFINITIONS

<A0.1> Notice and Disclaimers

THE WORD **SHALL**, IN THIS STANDARD, IS USED TO IDENTIFY CONDITIONS THAT **ARE REQUIRED** AND **MUST** BE MET.

THE WORD **MAY**, IN THIS STANDARD, IS USED TO IDENTIFY CONDITIONS THAT **ARE RECOMMENDED** AND **MAY** BE MET.

***ASE Electrified Propulsion Vehicles (xEV) High-Voltage Electrical Safety Standards*, and its recommended practices are developed through a consensus standards development process approved and governed by ASE. This process brings together volunteers representing varied viewpoints and interests to achieve consensus on electrified propulsion vehicle safety issues. These *ASE Electrified Propulsion Vehicles (xEV) High-Voltage Electrical Safety Standards* are developed to serve as a guide, sharing existing industry standards, concepts, and practices followed by individuals working in the automotive, truck, and commercial electrical industry.**

ASE, its employees, its contractors, and consultants shall not be held liable for any personal injury, property damage, or other damages of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, or reliance on the *ASE Electrified Propulsion Vehicles (xEV) High-Voltage Electrical Safety Standards*. ASE, its employees, its contractors, and consultants also make no guarantee or warranty as to the accuracy or completeness of any information published herein.

<A0.2> Purpose

The purpose of the *ASE Electrified Propulsion Vehicles (xEV) High-Voltage Electrical Safety Standards* is to provide guidance, document, and establish electrical safety requirements, standards, procedures, and safe work practices relating to the development of an electrically safe working area for service professionals in North America working on or around electrified propulsion vehicles (xEVs)[1], alternating voltages >30 V AC rms and direct voltages >60 V DC[2], and conditions relative to the hazards arising from electrified propulsion vehicles and its components. The intent of this standard is to minimize exposure to these hazards and their associated impacts.

[1] Any electrified propulsion vehicle with a high voltage system, including, but not limited to, HEV, PHEV, PEV, BEV, FCEV, and EV – SAE J1715-1 SEP2022 Pg. 16 of 23.

[2] 30 V AC rms and 60 V DC per FMVSS 305 **High voltage source** means any electric component which is contained in the electric power train or conductively connected to the electric power train and has a **working voltage** greater than 30 V AC or 60 V DC. **Working Voltage** means the *highest root mean square voltage of the voltage source*, which may occur across its terminals or between its terminals and any conductive parts in open circuit conditions or under normal operating conditions.

Vehicles with high-voltage systems in some cases can be identified by:

- Vehicle badging and labels.
- Underhood high-voltage warning labels and cables.
- Batteries on roof or along frame rails (on trucks and busses).
- A charging port (on some, but not all, vehicles).

Electrified propulsion vehicles (xEVs) have high-voltage DC and AC systems; both are extremely dangerous and can cause personal injury, severe burns, electric shock, and even fatal injury. Alternating voltages >30 volts rms and direct voltages >60 volts are dangerous. Working on or near

high voltage energized electrical equipment or systems presents electrical hazards, such as shock and arc flash and blast. These high voltages are dangerous if proper safety precautions are **NOT** followed.

Potentially dangerous electrical currents can be produced or carried by any of these distinct types of high-voltage components:

1. High-voltage battery pack.
2. Battery Management System (BMS).
3. High-voltage battery charging equipment.
4. High-voltage cables, orange in color, connecting components.
5. Inverter power electronics.
6. Capacitors inside the vehicle's inverter-rectifier assembly.
7. DC/DC converter.
8. Modules/electronic control unit(s).
9. Electric motor(s), also known as motor-generator(s) – (Regenerative braking).
10. Air conditioning compressor.
11. High-voltage heater(s).

<A1> Working Individual Definitions

<A1.1> LEVEL ONE – Electrically Aware Person is designed for anyone who may encounter an EV in the workplace. This includes an individual who performs tasks in proximity of electrified propulsion vehicles in sales, service, repair, and/or related environments. The LEVEL ONE individual requires high-voltage electrical safety awareness to identify the hazards and reduce the associated risks when working on or near electrified propulsion vehicles (xEVs) and/or near high-voltage components of electrified propulsion vehicles.

Skills performed by this individual can be, but are not limited to:

- Operating (driving) an electrified propulsion vehicle.
- Performing maintenance and repairs not related to high-voltage systems or their components.
- Handling non- high-voltage components of electrified propulsion vehicles.
- Encountering electrified propulsion vehicles and/or high-voltage components of electrified propulsion vehicles while performing job-related tasks.

SECTION B – GENERAL REQUIREMENTS FOR ELECTRICAL SAFETY-RELATED WORK PRACTICES

<B2> Risks Associated with Electric Vehicle Repair Include:

- High voltage isolation.
- Risks after a collision, primarily those that involve high-voltage battery integrity.
- Fire safety in shops and for first responders.
- High-voltage work.
- The possibility of the vehicle turning on unexpectedly.

<B5> Aiding Persons Subjected to High Voltage

DO NOT directly touch any person being subjected to a high-voltage shock.

If possible, follow these 3 steps:

1. ***Call* 911** / emergency services.

2. ***Disconnect*** the source of high voltage:
    - Turn off the vehicle / switch off the ignition.
    - Turn off the high-voltage electrical supply at the source.
        - If the source is line voltage, it should be turned off at a service disconnect.
        - If the source is an electrified vehicle, the high-voltage system should be de-energized. Disconnect the high-voltage system through the manual service disconnect (MSD)[5]. Many newer, higher current systems use a low-voltage service disconnect lever to remove power from the contactor control circuits.
          [5] Manual service disconnect (MSD) is a SAE J1715 (Society of Automotive Engineers) standardized term to represent the orange removable connector that some electrified propulsion vehicles (xEVs) use.
        - If the source is the high-voltage battery, a disconnect may not be available.
3. ***Separate*** the person affected, or the electrical conductor, from the voltage supply using a non-conducting object such as:
    - an assistant wearing the proper high-voltage gloves and appropriate personal protective equipment (PPE).
    - an insulated retrieval hook (hot stick).

Note: A body tackle impact may be used if the insulated retrieval hook is not available, but **DO NOT** grab the person as you will become part of the circuit.

<B8> Physical Barriers, Signage, and Boundary Guarding

A defined combination of safety signs, cones, tape, tags, and a magnetic car topper identifying whether the vehicle is 1) energized or 2) non-energized **SHALL** be used to warn individuals about electrical hazards that might endanger them and to mark off electrified propulsion vehicle (xEV) service areas where necessary. Such signs and tags **SHALL** meet the requirements of applicable state, federal, or local codes and standards.

Barricades[10] **SHALL** be used along with signs and tags to prevent or limit access to work areas containing live activated components operating at **30 V AC rms or 60 V DC** or more and attendants shall be used when signs and barricades do not provide sufficient warning and protection from the electrical hazards.

Conductive barricades **SHALL NOT** be used where it might increase the likelihood of exposure to an electrical hazard.

[10] OSHA 1910.335(b)(2) (Occupational Safety and Health Administration) Barricades. Barricades shall be used in conjunction with safety signs where it is necessary to prevent or limit employee access to work areas, exposing employees to uninsulated energized conductors or circuit parts. Conductive barricades may not be used where they might cause an electrical contact hazard.

As required by the vehicle manufacturer, the technician **SHALL** maintain a defined safety zone around the work area and place warning signs when high-voltage system repairs are left unattended.

<B8.1> Shop Safety Alerting Techniques

Traffic in the area can pose a substantial hazard. This includes foot traffic, as well as vehicles and other types of shop equipment. Barriers, barricades, signs, and an attendant may be needed to prevent intrusion into the work zone.

The LEVEL TWO and/or LEVEL THREE technician(s) **SHALL** be responsible for safety and security when an electrified propulsion vehicle (xEV) enters the work area.

SECTION C – ESTABLISHING AN ELECTRICALLY SAFE WORK CONDITION

<C1> LEVEL ONE Knowledge and Skills

<C1.1> Maintain Proficiency in Electrical Safety (Refer to: *SECTION F – Test Instruments and Equipment for Electric Vehicle Applications in this document for detailed information*)

The person **MAY** be trained and tested for proficiency in:

- Emergency Response training including use of specialized response equipment.
- First-aid training including Cardiopulmonary Resuscitation (CPR).
- Electrified propulsion vehicle (xEV) Safety Training.

<C1.2> Safety Concepts on and around an Electric Vehicle

The person **SHALL** be trained and tested for proficiency in the following areas:

- Identify electrified propulsion vehicle (xEV) high-voltage components.
- Identify high-voltage circuits.
- Identify the various warning lights and labels on and around the vehicle.
- Understand the safety concerns associated with servicing electrified propulsion vehicles including:
    - Scheduled maintenance and conventional “low-voltage” services.
    - High-voltage services and repairs.
    - The shop’s procedures and safety practices for working on high-voltage systems.

The LEVEL ONE person **SHALL NOT** touch a Manual Service Disconnect (MSD) or any of the high-voltage components.

<C4> Employer (Shop) Responsibilities

Shops **SHALL** have, provide, and maintain:

- A safe working environment for electrified propulsion vehicles (xEVs) with a sufficient work area.
    - Service bay layout and workflow.
    - Adequate lighting to see the work being performed.
    - Access restriction and guarding.
    - Limits on foot traffic of other technicians and individuals.
    - Availability of Electric Vehicle Supply Equipment (EVSE) and suitable power supply.
    - Equipment and workbench(s) with non-conductive surfaces.
    - Rubber mats and a non-conductive area.
    - Secured storage area for high-voltage components, operational and/or damaged.
    - Storage of special equipment and personal protective equipment (PPE).
    - Lifting equipment for movement of high-voltage battery and heavy components.
    - Dual-post lift outfitted for battery fixture jack.
- Personal protective equipment (PPE) for LEVEL TWO and LEVEL THREE person(s).
- An electrified propulsion vehicle (xEV) Service Safety Kit: (Refer to: *<B8> Physical Barriers, Signage and Boundary Guarding in this document for detailed information*)
    - Magnetic car topper.

    - Electrified propulsion vehicle service bay caution barricades.
    - Electrified propulsion vehicle service bay caution cones.
    - Barricade caution tape.
    - Appropriate fire extinguisher.
    - Class-0 electrical safety gloves and leather over-gloves.
    - Glove leak tester.
    - Protective shield head gear.
- Proper tools and service equipment.
- Training and re-training including demonstration of proper safety procedures.
- A log/records of training and documentation.
- A glove certification/in service log.

OSHA 1910.335 (Occupational Safety and Health Administration) regulations require technicians to "demonstrate" their skills to their employer. Thus, employers **SHALL** verify an individual's ability to safely use test equipment and work on electrified propulsion vehicles (xEVs) following the original equipment manufacturer's (OEM) recommendations.

<C4.1> Provide Emergency Response Training and Equipment in the Case of an Electrocution or Injury
The LEVEL ONE, LEVEL TWO, and LEVEL THREE person(s) **SHALL** be trained.

<C4.2> Provide First Aid Training and Skills Assessment Including CPR (Cardiopulmonary Resuscitation)
The LEVEL ONE, LEVEL TWO, and LEVEL THREE person(s) **MAY** be trained.

<C4.4> Shops SHALL Align with Existing Safety Requirements and Regulations
NFPA 70E (National Fire Protection Association), OSHA (Occupational Safety and Health Administration), and regional/local.

NOTE: In the event of a fire, follow the shop's Emergency Action Plan (EAP) Standard Operating Procedure (SOP) and only fight a controllable fire if the fire is small and is not spreading to other areas, and escaping the area is possible by backing up to the nearest exit. Make sure someone has called 911 and has notified the fire department that the vehicle involved is an electrified propulsion vehicle (xEV). If the high-voltage battery appears to be the source of the fire, everyone must leave the building and/or area immediately.

SECTION D – SAFETY-RELATED WORK PRACTICES

<D1> High-Voltage Lithium-ion (Li-ion) Batteries and Systems

Battery packs in electrified propulsion vehicles (xEVs) typically range in voltage from 100 V to 400 V DC but can be as high as 800 V DC (common in new battery electric vehicles), or greater as production increases. Larger trucks and buses can have voltage exceeding 1200 V DC.

<D1.2> Accident Risks

The vehicle has redundant systems that are designed to prevent shock and reduce fire hazard exposure to occupants and first responders. However, if the battery is compromised and internal components are punctured, crushed, or damaged, a safety risk could be created. The Lithium-ion (Li-ion) battery pack may contain *stranded energy* if there is stored energy in the battery or capacitors after an accident.

Stranded energy can release a dangerous level of high voltage, from 100 V DC to 800 V DC or greater. Sizzling or popping noises, leaking, dripping fluids, a chemical smell, smoke, or sparks from the battery area are indicators of a shorting condition. Emergency responders should be notified.

Thermal runaway is an event described by NFPA (National Fire Protection Association) as an uncontrollable self-heating of a battery cell that begins when the heat generated within the battery exceeds the amount of heat that can be safely dissipated to ambient surroundings. In an accident, an overheated damaged cell may generate toxic and flammable gases that could reach a level high enough to ignite.

Lithium-ion (Li-ion) batteries can be very difficult to extinguish once they are on fire; the main goal of emergency personnel is to cool the battery by flooding the battery compartment with water.

LEVEL ONE (as defined by task), LEVEL TWO and LEVEL THREE workers **MAY** review the *SAE (Society of Automotive Engineers) Surface Vehicle Recommended Practice J2950* standard: (https://www.sae.org/standards/content/j2950_202006), *SAE Hybrid and EV First and Second Responder Recommended Practice* J2990 201907: (https://www.sae.org/standards/content/j2990_201907/) and/or the *NTSB (National Transportation Safety Board) Lithium-Ion Safety for the First Responders*: (https://www.ntsb.gov/safety/safetystudies/Pages/HWY19SP002.aspx) document(s) that instruct how to deal with damaged batteries and emergency response procedures.

NOTE: If the battery has been damaged or punctured, the vehicle should be isolated *at least 50 feet away from other flammable or combustible materials*.

<D3> Wiring/Cabling – SAE (Society of Automotive Engineers) Standards for Nominal System Voltage up to 1000 V (AC rms or DC)

Insulation/Sheathing and Connector Identification

Color-coded high-voltage cables in electrified propulsion vehicles (xEVs) warn of their potential danger. These are ORANGE[11], insulation or wrapping.

[11] High-voltage cables are required to be orange per US FMVSS 305 S5.4.1.2 (Federal Motor Vehicle Safety Standards) high-voltage cables. Cables for high voltage sources over 30V AC rms or 60 V DC which are not located within electrical protection barriers shall be identified by having an outer covering with the color orange.

<D5> Working On or Near Electric Vehicles

Labeling

The technician **SHALL** be familiar with and follow all original equipment manufacturer's (OEM) guidelines for identifying and following labeling on the vehicle and system being worked on. Warning labels are placed on the vehicle to indicate danger caused by electrical current.

- Special warning labels are found on the high-voltage battery.
- All high-voltage components and modular parts are labeled with an internationally recognized warning sign like:

- Labeled components **SHALL** not be opened or are to be opened **only** according to original equipment manufacturer's (OEM) instructions by a LEVEL TWO or LEVEL THREE person.

SECTION E – DE-ENERGIZING

The vehicle **SHALL** be secured according to the original equipment manufacturer's (OEM) instructions. For example: in park, wheels chocked, parking brake applied, and the vehicle system(s) de-energized/disabled.

The keyless fob, if equipped, **SHALL** be secured outside of key detection range by placing the key fob and/or high-voltage battery disconnects in a secured container.

<E6> Lockout/Tagout (LOTO)

Lockout/tagout procedures exist to protect technicians from potentially fatal electric shock. The technician should not risk someone re-energizing their work environment.

The technician **SHALL** maintain control of any removed fuses, relays, or manual service disconnect (MSD) in a secured location under lock and key (if possible) to prevent others from reinstalling these items without their knowledge.

Lockout is used in uncontrolled environments. Tagouts are used in controlled environments with an established group policy for the treatment and use of the tagout[13].

[13] The OSHA (Occupational Safety and Health Administration) standard for *The Control of Hazardous Energy* (Lockout/Tagout) (29 CFR 1910.147) for general industry, outlines specific action and procedures for addressing and controlling hazardous energy during servicing and maintenance of machines and equipment.

SECTION G – ADDENDUMS -- RESOURCES AND REFERENCES

Related and Referenced Regulations and Standards

ASTM International – www.ASTM.org

Standards and technical content development with over 12,000 ASTM (American Society for Testing and Materials) standards operating globally.

Electrical Safety Program Training (Example)

NFPA 70E (National Fire Protection Association) and OSHA 1910, Subpart S 331-335 (Occupational Safety and Health Administration), provides key elements for a "written" electrical safety program and should be referenced as the focus of training programs.

- Training
- Job Safety Planning
- Risk Assessment
- Engineering (Manufacturer Procedures)
- Electrically safe work condition (<50 V)
- Personal protective equipment (PPE) and Tools

Emergency Response Training, Specialized Response Equipment, and Circuit Isolation (Example)

- Electrified propulsion vehicle (xEV) Specialty Tools and Instruments – Use and Understanding
- High-voltage Isolation Safety
- First Responder Practices
- ESS – Energy Storage Systems

https://www.nfpa.org/~/media/Files/Code%20or%20topic%20fact%20sheets/ESSFactSheet.pdf

- Thermal Runaway
- Stranded Energy
- Toxic and Flammable Gasses Generated
- Deep Seated Fires
- NFPA (National Fire Protection Association) Field Guide Interpretation

FMVSS (Federal Motor Vehicle Safety Standards) **–** https://www.nhtsa.gov/

The Federal Motor Vehicle Safety Standards (FMVSS) are prescriptive U.S. federal regulations specifying design, construction, performance, and durability requirements for motor vehicles. The safety standards establish minimum performance requirements for manufacturers and the equipment used to make a vehicle. The NHTSA administers the Federal Motor Vehicle Safety Standards (FMVSSs), which outline various requirements to ensure vehicles meet the standards of safety that qualify roadworthiness.

- (FMVSS) 141 and 305
  https://www.ecfr.gov/current/title-49/subtitle-B/chapter-V/part-571#571.305

First-Aid Training Including CPR (Example)

- First Aid
  - Identify situations that require first aid response.
  - Assess an environment for safety.
  - Prioritize and apply first aid measures.
  - Evaluate appropriate responses to a person in distress.
  - Communicate effectively with 911 and emergency medical service (EMS) personnel.
  - Summarize the importance of company emergency plans, procedures, and policies.
- CPR – Cardiac Pulmonary Resuscitation.
- AED – Automated External Defibrillator.

IEC (International Electrotechnical Commission)

IEC 61010 are the *electrical requirements for laboratory test and measurement equipment*--microscopes, metrology equipment, FTIRs, Mass Spectrometers, or other devices in a laboratory. 61010 covers the electrical requirements and some of the other hazards for these types of equipment.

Where NFPA 70E (National Fire Protection Association) deals primarily with the personal protection equipment and test environment, IEC 61010 develops international standards for all electrical, electronic, and related technologies providing guidance to test equipment manufacturers regarding how they are designed and manufactured.

NFPA (National Fire Protection Association) – www.NFPA.org

NFPA 70E, "Standard for Electrical Safety in the Workplace" is a standard of the National Fire Protection Association (NFPA). The document covers electrical safety requirements for employees. The NFPA is best known for publishing the National Electrical Code (NFPA 70).

While NFPA 70E training is NOT required by law, except for contractors to the Department of Energy [10CFR 851.23(a)(14)], meeting *OSHA (Occupational Safety and Health Administration)* requirements for electrical safety training is required by law. NFPA 70E helps employers meet the performance requirements of the OSHA standards for electrical safety.

As a *general* guideline relating to personal protective equipment (PPE), the technician may wear arc-rated (AR) Clothing, ***Category 2 PPE***, Minimum Arc Rating of 8 cal/cm^2 (33.5 J/cm^2) or ***Category 4***

PPE, Minimum Arc Rating of 40 cal cm^2 (167.5 J/cm^2), depending on the high-voltage battery chemistry and energy potential. NFPA Standard 70E Table 130.7(C)(15)(c), including arc-rated (AR) clothing, gloves, hard hat, safety glasses or goggles, hearing protection, and leather footwear as required for the voltage being worked on, identifies a complete list of personal protective equipment (PPE) categories and the appropriate arc-rated (AR) clothing for each rating.

NHTSA (National Highway Traffic Safety Administration) **–** https://www.nhtsa.gov/
The *National Highway Traffic Safety Administration* is responsible for keeping people safe on America's roadways through enforcing vehicle performance standards and partnerships with state and local governments. NHTSA reduces deaths, injuries, and economic losses from motor vehicle crashes through education, research, safety standards, and enforcement.

OSHA (Occupational Safety and Health) – OSHA 29 CFR 1910 Subpart S and CFR 1926 Subpart K[17, 18]
With the Occupational Safety and Health Act of 1970, Congress created the Occupational Safety and Health Administration (OSHA) to ensure safe and healthful working conditions for workers by setting and enforcing standards and by providing training, outreach, education, and assistance. OSHA sets enforcement policy and targeted inspection programs and responds to fatalities, catastrophes, and complaints.

[17] OSHA (Occupational Safety and Health Administration) considers all voltages of 50 volts or above, AC or DC hazardous. Electric current, not voltage, passing through the human body causes injury, and the amount of current passing through an object depends on the resistance of the object.

[18] 29 CFR 1910.303(g)(2)(i) generally requires "live parts of electric equipment operating at 50 volts or more" to be "guarded against accidental contact by use of approved cabinets or other forms of approved enclosures" or by other specified means. The guarding requirement does not distinguish between AC and DC voltages. Therefore, the requirement applies to live parts operating at 50 volts or more AC or DC.

- OSHA 1910.132 (Occupational Safety and Health Administration) requires hazard assessment of mechanical, shock, chemical, and electrical explosion (arc flash). Mitigation of hazard can come from design, work practices, or personal protective equipment (PPE).
- Hazards depend on:
  - Vehicle operating voltages.
  - Battery design and chemistry.
  - Electrical bus design and insulation protection.
- Hazards increase due to improper work practices, defective or damaged batteries, or vehicle assembly and damaged vehicles leading to damage of the battery and/or structure.

OSHA General and Specific Duty Clauses
The *general duty* clause requires workplaces to be free from recognized hazards.
Specific duty clauses require employers to comply with OSHA (Occupational Safety and Health Administration) standards.

- General Requirements in 1910.132
- Eye and Face Protection in 1910.133
- Foot Protection in 1910.136
- Electrical Protective Equipment in 1910.137
- Hand Protection in 1910.138
- The Control of Hazardous Energy (Lockout/Tagout) in 1910.147
- Safeguards for Personal Protection in 1910.335
- Electrical Protective Equipment in 1910.335(a)(1)(i)

- Eye and Face Protection in 1910.335(a)(1)(v)
- Insulated Tools in 1910.335(a)(2)(i)
- OSHA 1910.147(a)(1)(i) – This standard covers the servicing and maintenance of machines and equipment in which the unexpected energization or startup of the machines or equipment, or release of stored energy, could harm employees. This standard establishes minimum performance requirements for the control of such hazardous energy.
- 1910.147(a)(3)(i) – This section requires employers to establish a program and utilize procedures for affixing appropriate lockout devices or tagout devices to energy isolating devices, and to otherwise disable machines or equipment to prevent unexpected energization, start up or release of stored energy to prevent injury to employees.
- 1910.147(b) – Definitions applicable to this section.
  - **Energized**. Connected to an energy source or containing residual or stored energy.
  - **Energy isolating device**. A mechanical device that physically prevents the transmission or release of energy, including but not limited to the following: A manually operated electrical circuit breaker; a disconnect switch; a manually operated switch by which the conductors of a circuit can be disconnected from all ungrounded supply conductors, and, in addition, no pole can be operated independently; a line valve; a block; and any similar device used to block or isolate energy. Push buttons, selector switches and other control circuit type devices are not energy isolating devices.
  - **Energy source**. Any source of electrical, mechanical, hydraulic, pneumatic, chemical, thermal, or other energy.
- 1910.147(c)(1) – Energy control program. The employer shall establish a program consisting of energy control procedures, employee training and periodic inspections to ensure that before any employee performs any servicing or maintenance on a machine or equipment where the unexpected energizing, startup or release of stored energy could occur and cause injury, the machine or equipment shall be isolated from the energy source and rendered inoperative.
- 1910.147(c)(2) – Lockout/tagout.
  - 1910.147(c)(2)(i) – If an energy isolating device is not capable of being locked out, the employer's energy control program under paragraph (c)(1) of this section shall utilize a tagout system.
  - 1910.147(c)(2)(ii) – If an energy isolating device is capable of being locked out, the employer's energy control program under paragraph (c)(1) of this section shall utilize lockout, unless the employer can demonstrate that the utilization of a tagout system will provide full employee protection as set forth in paragraph (c)(3) of this section.
- 1910.147(c)(3) – Full employee protection.
  - 1910.147(c)(3)(i) – When a tagout device is used on an energy isolating device which is capable of being locked out, the tagout device shall be attached at the same location that the lockout device would have been attached, and the employer shall demonstrate that the tagout program will provide a level of safety equivalent to that obtained by using a lockout program.
  - 1910.147(c)(3)(ii) – In demonstrating that a level of safety is achieved in the tagout program which is equivalent to the level of safety obtained by using a lockout program, the employer shall demonstrate full compliance with all tagout-related provisions of this standard together with such additional elements as are necessary to provide the equivalent safety available from the use of a lockout device. Additional means to be

considered as part of the demonstration of full employee protection shall include the implementation of additional safety measures such as the removal of an isolating circuit element, blocking of a controlling switch, opening of an extra disconnecting device, or the removal of a valve handle to reduce the likelihood of inadvertent energization.

OSHA Interpretation on Arc Flash Hazards

Arc-flash hazards are also addressed in OSHA 1910.335(a)(1)(v) (Occupational Safety and Health Administration), 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 OSHA 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" The OSHA 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. ….. The supplemental measures, which could include the use of arc-rated (AR)/flame-resistant (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) …."
https://www.osha.gov/laws-regs/standardinterpretations/1993-09-09-3 and
https://www.osha.gov/laws-regs/standardinterpretations/2006-11-14

SAE International Standards (Society of Automotive Engineers)

- J2344: 2010, "Guidelines for Electric Vehicle Safety"
- J1715-1 and/or J1715-2 standardized terminology
- J2990 – Hybrid and electrified propulsion vehicle (xEV) First and Second Responder Recommended Practice
- J3108 – Electrified propulsion vehicle (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)
- J2950 – Surface Vehicle Recommended Practice
- J1715-1 – Hybrid Electric Vehicle (HEV) And Electric Vehicle (EV) Terminology
- J1715-2 – Battery Terminology
- J1772 – SAE Electric Vehicle And Plug In Hybrid Electric Vehicle Conductive Charge Coupler

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