



MOTOR VEHICLE TECHNOLOGY

**WORK SAFETY AND PERSONAL
PROTECTIVE EQUIPMENT APPLICATIONS
IN ELECTRIC VEHICLES**

2023-2-TR01-KA210-VET-000180148

**New Applications in Electric Vehicle
Technology According to 4.0 Standards**



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Innovative Sustainable
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EXPLANATIONS

AREA	Motor Vehicle Technology
PROFESSION	Electric Vehicles
MODULE NAME	Occupational Safety in Electric Vehicles and Personal Protective Equipment Applications
MODULE DESCRIPTION	This module is a learning material that addresses occupational safety risks and personal protective equipment (PPE) requirements in electric vehicle technologies, including safety procedures used in electric vehicle maintenance and repair, PPE types, international standards and safe intervention practices.
COMPETENCE	Recognizing occupational safety risks in electric vehicles, selecting and using PPE correctly, and implementing safe intervention procedures.
PURPOSE OF THE MODULE	<p>General Objective With this module, you will be able to apply occupational safety procedures in the maintenance and repair of electric vehicles, correctly select and use personal protective equipment, and safely intervene in high-voltage systems.</p> <p>Objectives</p> <ol style="list-style-type: none"> 1. Identify the primary hazards encountered in electric vehicle maintenance. 2. Explain the types and functions of personal protective equipment required for electric vehicle technicians. 3. Integrate best practices regarding the use of PPE into safe maintenance procedures. 4. Implement basic safety protocols such as de-energizing high-voltage systems, lockout/tagout (LOTO), and zero-energy verification. 5. Explain precautions to be taken against special risks in electric vehicles (high voltage, thermal runaway, chemical hazards, unintended vehicle movement, etc.).

1. PERSONAL PROTECTIVE EQUIPMENT (PPE) USED IN ELECTRIC VEHICLES

Electric vehicles pose special occupational safety risks due to high-voltage systems, battery hazards, and electric arc risks. To mitigate these hazards, technicians must adhere to strict safety protocols, including the proper selection and use of Personal Protective Equipment (PPE).

1.1. Major Hazards in Electric Vehicle Maintenance

- **High Voltage Exposure** – Systems in electric vehicles can operate at up to 800V DC.
- **Arc Flash and Arc Blast** – Sudden discharges can cause burns or explosions.
- **Electric Shock** – May occur as a result of damaged insulation or improper grounding.
- **Chemical Exposure** – From lithium-ion battery leaks (electrolyte is hazardous).
- **Thermal Burns** – May result from overheated components.
- **Mechanical Injuries** – Standard workshop hazards such as lifting, cutting, etc.

1.2. Personal Protective Equipment (PPE) for Electric Vehicle Technicians

To work safely in high-voltage systems, it is mandatory to use personal protective equipment and environmental protective equipment specific to electric vehicles.

The technical names and descriptions of basic PPE used during the maintenance and repair of electric vehicles are provided in Figure 1.1.

PPE Names	Technical Name	Function / Protection Provided	Visual
Insulated Gloves	Class 0 / Class 1 Rubber Insulating Gloves (ASTM D120, IEC 60903)	Protection against electric shock (up to 1000V AC / 1500V DC for Class 0)	

<p>Leather Protectors</p>	<p>Overglove for Electrical Insulating Gloves</p>	<p>Rubber gloves protect against mechanical damage</p>	
<p>Isolated Tools</p>	<p>VDE Certified Insulated Hand Tools (IEC 60900)</p>	<p>Protects against electric shock when working on live circuits</p>	
<p>Arc Flash Suit</p>	<p>Arc Rated Flame Retardant (AR/FR) Clothing (NFPA 70E, ASTM F1506)</p>	<p>Protects against burns from arc flash or explosions</p>	
<p>Face Shield / Arc Visor</p>	<p>Arc-Grade Face Shield with Chin Guard (ANSI Z87.1)</p>	<p>Protects the face against arc flash and flying particles</p>	
<p>Protective Goggles</p>	<p>ANSI Z87.1 Certified Protective Eyewear</p>	<p>Provides basic eye protection against dust, particles and sparks</p>	
<p>High Voltage Safety Boots</p>	<p>Electrically Insulating Dielectric Footwear (ASTM F2413)</p>	<p>Prevents current from passing through the feet</p>	

Hearing Protection	Earplugs or Ear Muffs (ANSI S3.19)	Provides hearing protection against loud noises	
Respiratory Protection	NIOSH Approved Respirator	Filters chemical vapors against battery gases or dust	
Battery Leak Kit	Chemical Spill Response Kit	Includes absorbent pad, neutralizer and PPE to clean up electrolyte spills	
Lockout/Tagout Kit	Electrical Lockout and Tagout Devices (OSHA compliant)	De-energizes and labels circuits before repair	
Insulated Mat	IEC 61111 Insulated Floor Mat	Prevents grounding when working near energized equipment	

Visual 1.1: Basic PPE Used in Electric Vehicle Maintenance and Repair



To play the video, click on the image or click the link below and open it with your browser

<https://youtu.be/pBXko25OeSM>

1.3. Best Practices for PPE in Electric Vehicle Maintenance

- Always check PPE for damage or wear before use.
- Use voltage detection devices (non-contact voltage testers) before starting work.
- Follow lockout/tagout (LOTO) procedures before starting any electrical work.
- Train technicians on arc flash risk assessment and selection of appropriate PPE based on hazard categories.
- Keep the work area tidy, clean, dry, and free of conductive tools and materials.
- Keep an emergency leak kit and fire extinguisher (Class D or lithium-ion specific) within reach.

1.4. Service Area Safety for Electric Vehicles

A dedicated service area should be established for the maintenance and repair of electric vehicles. Only qualified personnel trained in electric vehicles should be assigned to this area.



To play the video, click on the image or click the link below and open it with your browser

<https://youtu.be/qv9xnPe4prs>

Environmental protective equipment used in the service area not only protects employees and other personnel from electric shock but also serves an informative function.

The essential elements that should be present in the service area are:

- Battery room
- Emergency exit
- Fire extinguishers
- Fire pool
- Warning signs and safety signs



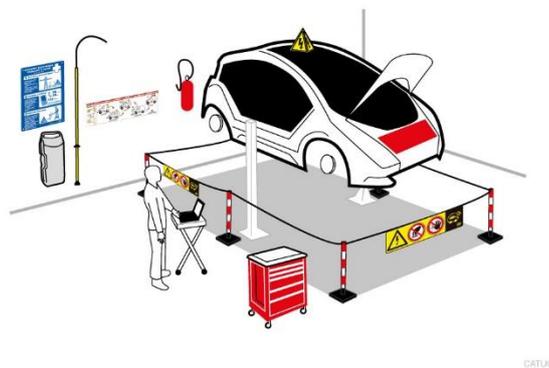
Visual 1.2: Safe Service Area Layout for Electric Vehicles

It shows the layout of the dedicated service area used for electric vehicle maintenance and repair. Safety equipment such as high-voltage signs, barriers, and fire extinguishers ensure the protection of both employees and surrounding personnel.



Visual 1.3 Safe Service Area Layout in Electric Vehicles

The service area is designed to ensure a safe working environment for electric vehicles. **Elements** such as high-voltage warning signs, safety barriers, emergency exits, fire extinguishers, and a battery room protect both technicians and other personnel from the risk of electric shock, fire, or accidents.



Visual 1.4 Service Area Safety in Electric Vehicles – Schematic Representation

A schematic diagram shows the layout of the safe service area for electric vehicles. The work area is demarcated by barriers, high-voltage warning signs are installed, and fire extinguishers, rescue hooks, and other necessary safety equipment are readily accessible. This layout ensures the safe operation of technicians and prevents unauthorized access to the area.



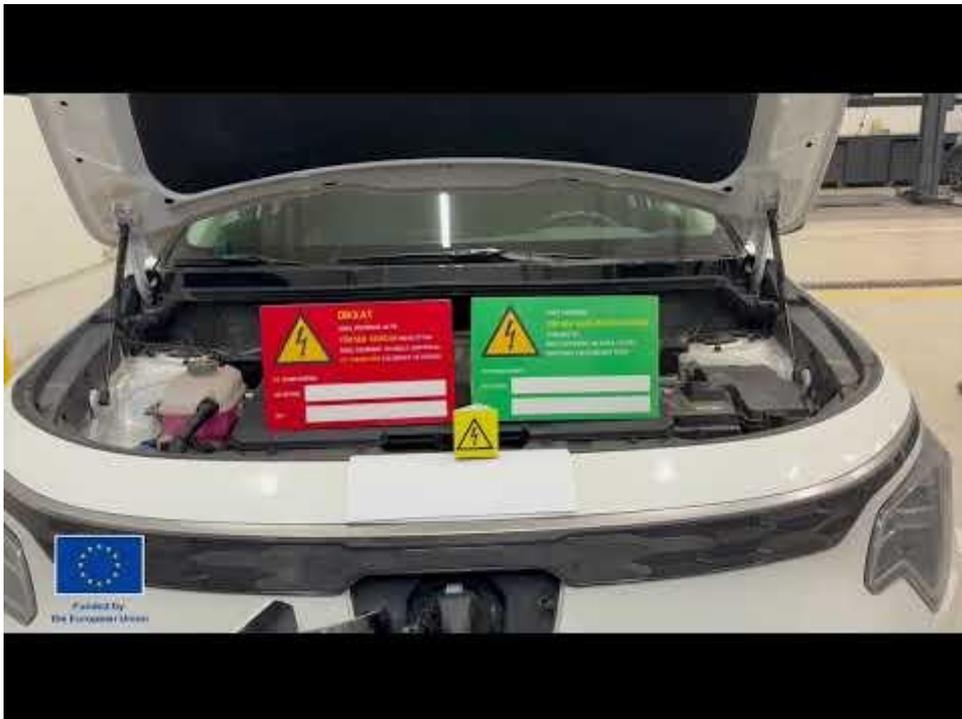
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2. OCCUPATIONAL SAFETY INSTRUCTIONS AND PROCEDURES

2.1. Safety Procedures for Electric Vehicle Maintenance and Repair

Due to the high-voltage systems and chemical hazards in electric vehicles, it is mandatory to adhere to specific international standards, national regulations, and manufacturer-specific procedures. These rules ensure the safety of technicians and the proper handling of electric vehicle components.



To play the video, click on the image or click the link below and open it with your browser

<https://youtu.be/8Vkwdmxv54g>

2.2. De-energizing High-Voltage Systems (Safe State Procedure)

Basic Procedure:

- Before starting any work, de-energize the high-voltage system (follow the OEM shutdown sequence).
- Use manufacturer-specific service disconnects or high-voltage interlock systems.
- Verify zero voltage at designated test points with a properly rated voltmeter.
- Disconnect the negative (-) terminal of the vehicle's 12V auxiliary battery. This action de-energizes the electronic control units.

- Use the yellow interlock connector (lock lever) to disconnect the battery high voltage. This step ensures that the high voltage is completely deactivated during maintenance.

Standards:

- **NFPA 70E (USA)** – Standard for Electrical Safety in the Workplace
- **ISO 6469-3** – Safety requirements for electric vehicles, Part 3: Protection against electrical hazards
- **IEC 61851 / IEC 62196** – Electric vehicle conductive charging systems

3. Disable Direct Hazards / Safety Regulations

6. Disconnect the 12 auxiliary battery negative (-) terminal.



7. Pull up the yellow lever (interlock connector) to cut off the high voltage.



Figure 2.1: Safely Disabling High Voltage in Electric Vehicles

2.3. Lockout/Tagout (LOTO) Procedures

Basic Procedure:

- Perform a LOTT to isolate electrical energy before servicing.
- Place lockouts and hazard tags on energy sources.
- Only authorized personnel may perform a LOTT and remove tags.

Standards:

- **OSHA 29 CFR 1910.147** – Control of Hazardous Energy (LOTO)
- **ISO 14118** – Prevention of Unexpected Startup

2.4. Verifying Zero Energy Condition

Basic Procedure:

- After shutdown, use test equipment to verify the absence of voltage.
- Wear Class 0+ gloves and use insulated tools during testing.
- Check test equipment on a known live source before and after testing (“live-dead-live” check).

Standards:

- NFPA 70E, Article 120.5
- IEC 61010-031 – Safety standard for test probes and equipment



Image 2.2: Hella Gutmann MT-HV High Voltage Tester

This professional HV tester is used to verify the absence of voltage in high-voltage batteries, inverters, and power electronics systems in electric vehicles. It complies with the IEC 61010 standard, has a CAT IV safety rating, and plays a critical role in the zero-energy verification process.

2.5. PPE Requirements and Use

Basic Procedure:

- Select PPE based on arc flash hazard category, voltage level, and battery type.
- Always wear arc-rated clothing, insulating gloves, face shield, and dielectric footwear.
- Wear a respirator and chemical-resistant gloves when working on battery systems.

Standards:

- NFPA 70E Table 130.5(C) – Arc flash PPE categories
- OSHA 1910 Subpart I – Personal protective equipment
- IEC 60903 / ASTM D120 – Insulating gloves

2.6. Battery Processing and Chemical Safety

Because batteries used in electric vehicles have high energy density, they require special safety precautions during handling, storage, and emergency response. Improper handling or negligence can pose serious risks of both electric shock and chemical hazards.

Basic Procedure:

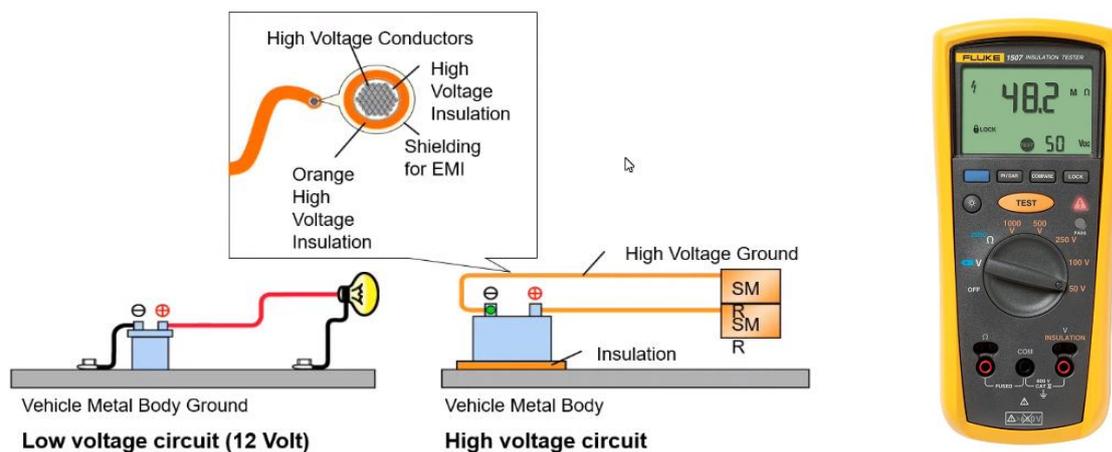
- Identify battery type: Li-ion, NiMH, etc.
- Use thermal imaging to check for overheating or thermal runaway risks.
- Use a leak response kit containing neutralizing agents in the event of an electrolyte leak.
- Store and dispose of batteries in accordance with hazardous waste regulations.

Standards:

- UN Test and Criteria Manual (Section 38.3) – Battery Handling Safety
- OSHA 1910.1200 – Hazardous Materials Communication Standard (HazCom)
- EPA Regulations – Hazardous waste regulations for battery disposal

2.6.1. Insulation Resistance Test (Using a Megohmmeter)

A megohmmeter is a device that measures very high resistance values by applying a high voltage to an object under test. The purpose of the test is to verify the insulation resistance between High Voltage (HV) circuits and the vehicle chassis using an insulation tester. The test is for diagnostic or preventative safety purposes.



Visual 2.3: Emergency Response in Electric Vehicles: Rescue with Insulation Rod

It is used to measure insulation resistance on HV components. Test procedures must be carried out in accordance with IEC 61557 and ISO 6469-3 standards.



Visual 2.4: Emergency Response in Electric Vehicles: Rescue with Insulation Rod

A person who has been electrocuted is safely treated with an insulating rod.

The technician performs safe operations on the high-voltage system using an insulating rod and personal protective equipment (PPE).



Visual 2.5: Service Area Safety Barriers in Electric Vehicles

The work area has been made safe by using chain barriers and high voltage warning signs in the service area.



Visual 2.6 Protection of High Voltage Components in Electric Vehicles with Insulation Cover

The risk of electric shock is reduced by covering the battery and high voltage connections with an insulating cover.



To play the video, click on the image or click the link below and open it with your browser

<https://youtu.be/DyMaAmBYgEo>

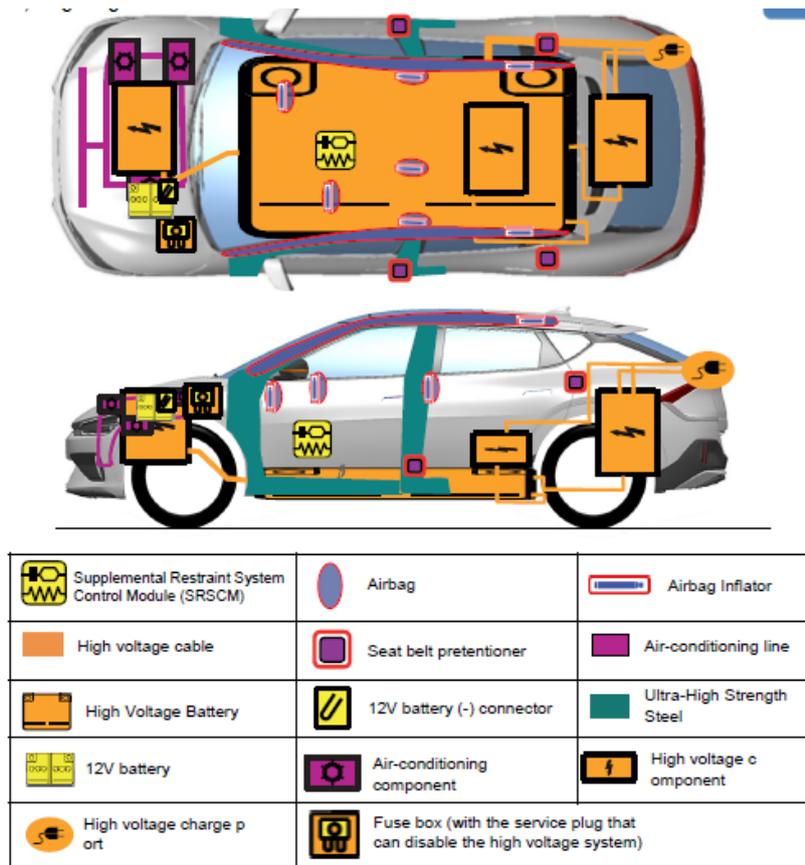
2.7. Fire Safety and Emergency Response

Basic Procedure:

- Keep Class D or lithium-ion-specific fire extinguishers nearby.
- In the event of thermal runaway (risk of fire spread), evacuate and isolate the vehicle.

- Use EV-specific fire blankets to suppress the spread of fire. Review emergency response catalogs.
- These catalogs are diagrams provided by manufacturers that show critical vehicle components, such as high-voltage cables, battery packs, airbag systems, safety plugs, and emergency cut-off points.

It serves as a vital guide for responding fire crews, technicians and emergency personnel.



Visual 2.7: Emergency Response Catalogue and Safety Points in Electric Vehicles



To play the video, click on the image or click the link below and open it with your browser

<https://youtu.be/i78yH-Lziwc>

2.8. Training and Certification

Basic Procedure:

- Technicians must receive training in:
 - o High voltage safety
 - o Arc flash protection
 - o First aid/CPR for electrical accidents
- Maintain training records and recertify annually as required by national laws.

Standards:

- **SAE J2990** – Hybrid and EV technician training requirements
- **OSHA 1910.332** – Training for workers exposed to electrical hazards

2.9 Best Practices Summary

- Always follow OEM repair manuals and OEM shutdown procedures.
- Do not disable safety interlocks and do not work on live systems without appropriate PPE and justification.
- Maintain safety signs, barriers, and high voltage warning labels in the work area.
- Perform a risk assessment and prepare a job safety analysis (JSA) before starting work.

3. WARNING SIGNS AND THEIR MEANINGS

Official warning signs and their meanings used for occupational safety in the maintenance and repair of electric vehicles (EVs) are listed below. These signs are determined according to EU and international standards such as ISO 7010, EN 60417, and IEC 60417.

3.1. Official Warning Signs for Electric Vehicle Maintenance and Repair (EU / International Standards)

Proper visual hazard communication is essential when working with electric vehicles. Technicians must be able to recognize warning signs indicating electrical, chemical, and thermal hazards and take appropriate precautions.

These signs are used in the following areas:

- Workshop signs
- Vehicles under maintenance
- High-voltage components
- Personal protective equipment (PPE)
- Tools and equipment

3.1.1. High Voltage Warning Sign

Symbol Code: ISO 7010-W012 / IEC 60417-6042

Meaning: Indicates the presence of high-voltage components (typically >60V DC or >25V AC RMS). Exposure can cause serious injury or death.

Places of Use:

- High voltage cables (orange sheathed)
- Power inverters
- Battery packs
- Inside the engine compartment or in HV enclosures



Example Symbol: Black lightning bolt within a yellow triangle.

3.1.2. Electrical Hazard / Electric Shock Risk Warning Sign

Symbol Code: ISO 7010-W012 / IEC variants

Meaning: Indicates the presence of live electrical parts. There is a risk of electric shock upon contact.

Applications:

- Live work areas



- Test panels
- Power tools and charging stations

Example Symbol: Black symbol within a yellow triangle indicating that the hand is in contact with a live wire/lightning bolt.

3.1.3. Fire Risk / Flammable Material Warning Sign

Symbol Code: ISO 7010-W021

Meaning: Indicates the presence of flammable materials or a fire risk.

Applications:

- Battery systems
- Storage areas
- Charging areas



Example Symbol: Black flame icon inside a yellow triangle.

3.1.4. Hazardous Chemicals / Corrosive Substances Warning Sign

Symbol Code: ISO 7010-W023 / GHS05 (CLP Regulation)

Meaning: Risk of exposure to corrosive chemicals (battery electrolyte, coolant, etc.).

Applications:

- *Battery modules
- *Coolant tanks
- *Chemical storage and disposal areas



Example Symbol: A burning hand inside a yellow triangle with liquid flowing from a test tube.

3.1.5. Toxic Substance Warning Sign

Symbol Code: ISO 7010-W016

Meaning: Indicates areas where toxic substances (e.g., battery gases) may be present.

Applications:

- Battery rooms
- Ventilation systems
- Leak collection areas



Example Symbol: Black skull and crossbones icon inside a yellow triangle.

3.1.6. High Noise Level Warning Sign

Symbol Code: ISO 7010-W087

Meaning: Hearing protection is mandatory due to the risk of hearing damage.

Application Areas:

- Workshops where pneumatic/electric tools are used
- Emergency discharge situations (arc flash)



3.1.7. General Hazard/Area Hazard Warning Sign

Symbol Code: ISO 7010-W001

Meaning: Indicates the presence of a general hazard or risk.

Usage Areas:

- Workshop entry points
- Vehicle quarantine areas
- Test areas



Example Symbol: Black exclamation point inside a yellow triangle.

3.2. Mandatory Use of Personal Protective Equipment (PPE)

Personal Protective Equipment (PPE) are defined as mandatory action signs, not warnings. They are displayed within a blue circle in the ISO 7010 "M" series and are often used in conjunction with hazard symbols (Figure 3.1).

ISO Code	Meaning	Visual
ISO 7010-M009	Wear protective gloves	
ISO 7010-M004	Wear eye protection	
ISO 7010-M010	Wear protective clothing	
ISO 7010-M002	Refer to the user manual	
ISO 7010-M008	Wear protective shoes	

Visual 3.1 Mandatory Signs Indicating the Use of PPE in Electric Vehicles



To play the video, click on the image or click the link below and open it with your browser

<https://youtu.be/EJleG1aMRoo>

3.2.1. Practical Use

Electric vehicle (EV) workshops are required to:

- Visibly display these symbols in all relevant locations
- Use durable, weather/chemically resistant labels
- Include warning signs in training materials and maintenance manuals
- Clearly mark all high-voltage areas
- Follow the ISO 7010 hierarchy: warning (yellow triangle), prohibited (red circle), and mandatory (blue circle)

3.2.2. References

- **ISO 7010** – Graphical symbols – Safety colors and safety signs
- **IEC 60417** – Graphical symbols for use on equipment
- **CLP Directive (EC No 1272/2008)** – Classification, labeling, and packaging of substances and mixtures
- **EN ISO 7010+A7** – Application of warning signs in workplaces

4. RISKS SPECIFIC TO ELECTRIC VEHICLES AND PRECAUTIONS TO BE TAKEN

Electric vehicles differ significantly from internal combustion engine (ICE) vehicles primarily due to their high-voltage systems, energy storage structures, and electronic control architectures. These differences present unique safety risks during maintenance and service.

4.1. High-Voltage Electrical Systems

Electricity is a physical phenomenon caused by charged particles, whether stationary or moving.

Electricity is a form of energy. Electricity is generated by the movement of subatomic particles called "electrons" that orbit each atomic nucleus.

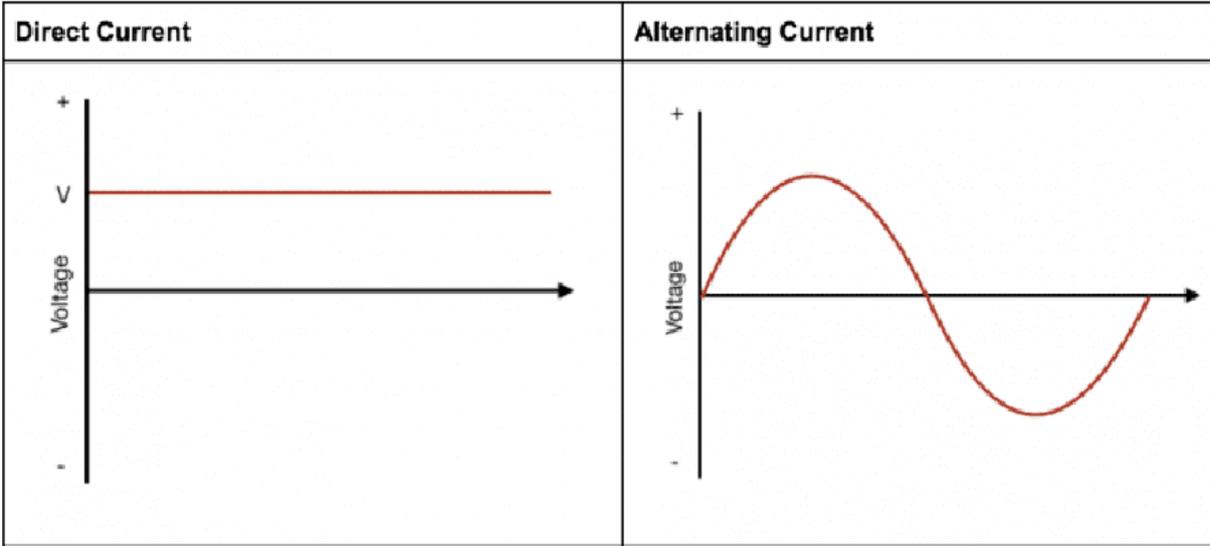


Figure 4.1: DC Voltage graph

Figure 4.2: AC Voltage graph

Electric vehicles require high-voltage electrical infrastructure to achieve the desired performance and range. Current values above 60 V for alternating current, above 30 V for direct current, and above 10 mA are hazardous to human health. (Figure 4.3)

The effect of Impact Multiplication		DC (mA)		AC (mA)			
				60 Hz		1,000 Hz	
		Male	Female	Male	Female	Male	Female
A slight tickling sensation		5.2	3.5	1.1	0.7	12	8
Painless shaking Muscles can move freely		9	6	1.8	1.2	17	11
Painful shaking Muscles can move freely		62	41	9	6	55	37
Painful shaking Muscles are almost incapable of being moved voluntarily		74	50	16	10.5	75	50
Severe, painful shaking Muscle contractions that make breathing difficult		90	60	23	15	94	63
Possible cause of ventricular fibrillation	Current flow time 0.03 sec.	1,300		1,000		1,100	
	Current flow time 3.0 sec.	500		100		500	

Explanations:

- Ventricular fibrillation is a condition in which the heartbeat becomes irregular due to the current flowing through the heart exceeding a certain level.
- Ventricular fibrillation of the heart is defined as the rapid opening and closing of the ventricles.
- Ventricular fibrillation can lead to death within minutes, even if the person is removed from the power source.

Figure 4.3: The Effects of Electric Current on the Human Body

In general, in the automotive industry, direct current voltages above 60 Volts are classified as "high voltage".

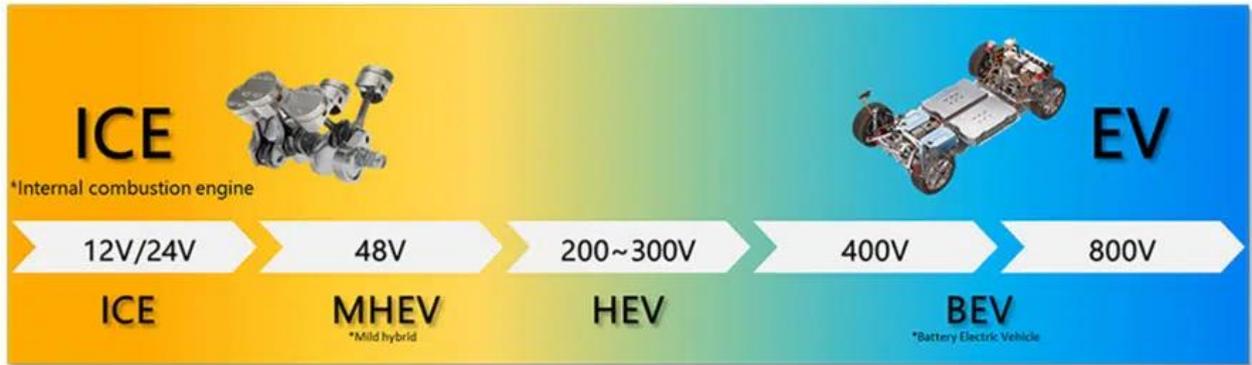


Figure 4.4: Voltage Levels According to Vehicle Technologies

Orange cables and high-voltage warning signs are used in electric vehicles to indicate systems operating at high voltage. (Image 4.5, Image 4.6)

The vehicle is equipped with sensors, ECUs, contactors, and switches for safety purposes.

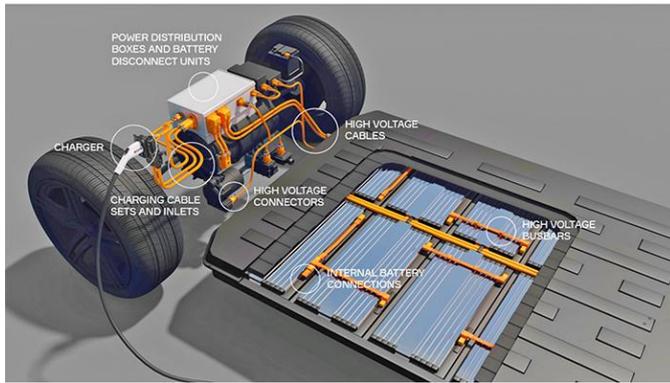


Image 4.5: Orange Cables Indicating High Voltage Lines in Electric Vehicles



Visual 4.6: High Voltage Warning Label

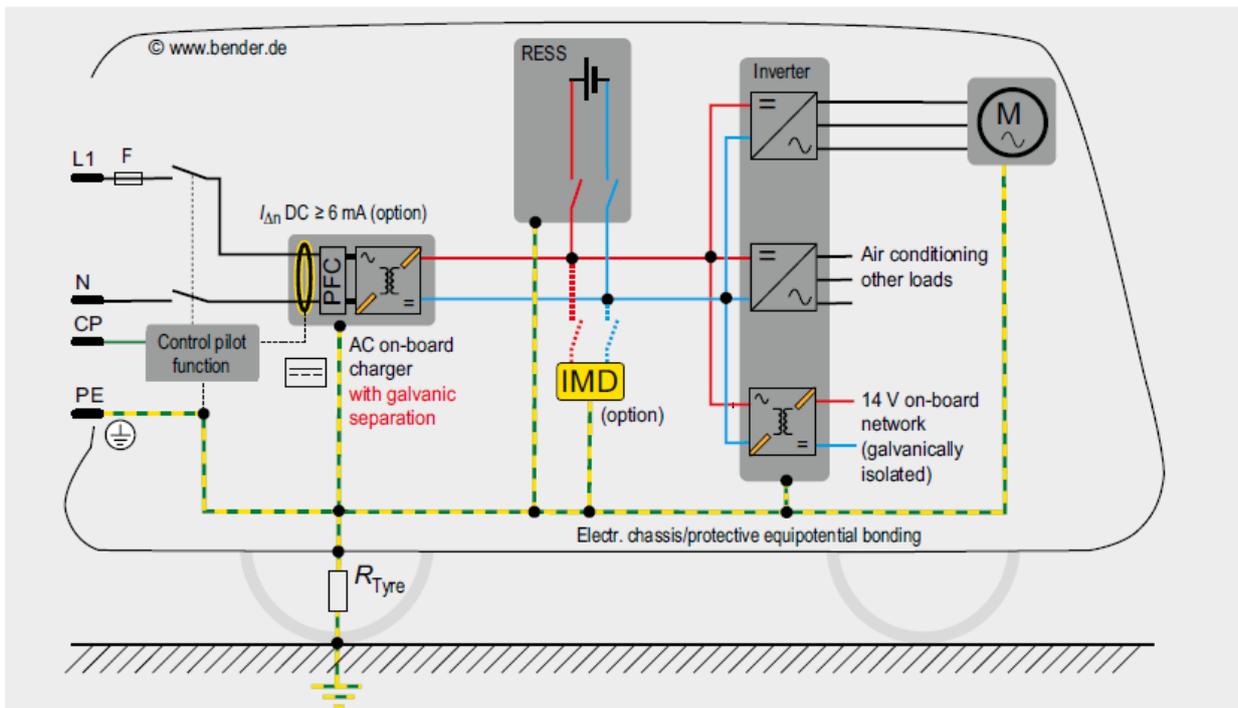
Both the positive and negative terminals of each high-voltage circuit are isolated from the chassis. When high-voltage circuits need to be disconnected for vehicle maintenance, the battery high voltage is disconnected using the service plug. (Figure 4.7, Figure 4.8)



Visual 4.7: High Voltage Battery and Power Distribution System in Electric Vehicles



Visual 4.8: High Voltage Service Plugs in Electric Vehicles



Visual 4.9: High Voltage Insulation and Grounding in Electric Vehicles

Figure 4.9 shows how the battery (RESS), inverter, and charging system are protected by chassis-ground connections, galvanic isolation, and an insulation monitoring device (IMD). The IMD continuously monitors the insulation resistance between the HV circuit and the vehicle chassis, alerting the system to the risk of stray current and improving safety. In accordance with ISO 6469-3 and IEC 61557 standards, IMD devices continuously monitor HV insulation resistance.

- EVs typically operate on high-voltage DC systems ranging from 400V to 800V, and up to 1000V in heavy-duty applications.
- Components include battery packs, inverters, DC/DC converters, on-board chargers, and drive motors.

Risks:

- Electric shock (can cause serious injury or cardiac arrest)
- Arc flash or arc explosion when opening HV circuits under load
- Burns from live parts or overheated components

Precautions:

- Always de-energize HV systems before servicing (follow OEM shutdown protocols).
- Wear Class 0 or Class 1 insulating gloves according to IEC 60903.
- Use insulating tools certified to IEC 60900.
- Perform zero voltage verification (“live-dead-live” testing).
- Follow lockout/tagout (LOTO) procedures.

4.2. Thermal Runaway and Battery Fire Hazards

Definition:

- Lithium-ion batteries can undergo thermal runaway due to overcharging, impact damage, or internal failure.
- Battery fires are difficult to extinguish and can reignite after cooling.

Battery Fires: A fire can start when a battery fails to maintain optimal operating conditions or deteriorates. Batteries are susceptible to overheating and overcharging. Overheating initially occurs in a single battery cell, but can quickly spread to all other cells in the battery pack. While battery manufacturers strive to minimize this risk, a cell that has undergone thermal runaway cannot be recovered. Therefore, battery fires are one of the most critical hazards in electric vehicle maintenance due to both their rapid spread and the risk of reignition.



Image 4.10: Vehicle Body and Extinguishing Practice After an Electric Vehicle Battery Fire

This image shows the complete destruction of an electric vehicle battery after it has burned. Battery fires often last a long time and require specialized extinguishing methods (e.g., immersion in a pool of water).

Causes of Battery Fires:

Lithium-based batteries can cause undesirable effects when exposed to external impact or extreme operating conditions. These can include sparks, flammable gases, and toxic fumes. They also pose a risk of sustained combustion, jet flames, or gas explosions. However, many other factors can trigger a battery fire. These factors include charging system failure, overloading cables, ignition of surrounding flammable materials, and even arson.

Risks:

- Explosions due to gas release or cell explosion
- Toxic fumes (HF, CO, VOCs)
- Fire spreading to surrounding vehicles or structures

Precautions:

- Monitor battery temperature with thermal imaging devices.
- Use non-contact voltage testers before accessing the battery.
- Store damaged batteries in quarantine areas.
- Have a Class D fire extinguisher or lithium-ion fire blanket available.

- Follow End-of-Life (EOL) protocols for damaged batteries.

4.3. Chemical Hazards

Definition:

- Lithium-ion batteries contain electrolytes (most often lithium hexafluorophosphate in organic solvents) that are often corrosive and toxic.
- EV coolers can also be flammable or chemically reactive.

Risks:

- Skin burns, respiratory irritation, toxic exposure
- Environmental contamination in the event of leaks

Precautions:

- Wear chemical-resistant gloves and eye protection according to EN 374.
- Use leak collection kits and neutralizing agents.
- Ensure adequate ventilation when handling battery packs.
- Treat and dispose of waste in accordance with the EU Hazardous Waste Directive and REACH regulations.

4.4. Unintended Vehicle Movement

Definition:

- EVs may run silently or move when controls are energized or systems are not properly disabled.
- High torque is instantly available, even at 0 RPM.

Risks:

- Crushing injuries or collision with objects in the workshop

Precautions:

- Use wheel chocks and mechanical locking equipment.
- Post "In Service - Do Not Operate" signs.
- Verify that the vehicle is in safe or service mode before starting work.

4.5. Control System Complexity and Software Security

Definition:

- EVs rely on complex electronic control systems (ECUs, CAN, LIN, Ethernet).
- Diagnostics, updates, and configurations require OEM diagnostic tools.

Risks:

- Incorrect programming can lead to system failure or security risks.

- Live testing of components can unexpectedly energize the system.

Precautions:

- Follow OEM software update protocols and back up original configurations.
- Use OEM-compatible diagnostic interfaces.
- Avoid performing firmware updates near high-voltage components unless instructed to do so.

4.6. Special Workshop Requirements

EV maintenance workshops must meet technical safety criteria such as:

- Insulated floor mats (IEC 61111)
- High-voltage markings and restricted areas (ISO 7010)
- Fireproof storage cabinets for battery modules
- First-aid kits for electrical injuries and chemical exposure
- Emergency response plans for battery fires or leaks

4.7. Training and Personnel Requirements

Personnel working on EVs must be trained in:

- Identifying high-voltage components and safe areas
- Using PPE correctly
- Conducting an arc flash risk assessment
- Understanding first-response protocols

Training must comply with the following standards:

- DIN VDE 0105-100 (Germany/EU)
- ISO 18246 – Safety requirements for the repair and maintenance of EVs
- SAE J2990 – EV service technician training

4.8. Special Risks and Precautions to Be Taken

Risk Type	Example Cases	Precautions
High Voltage	Battery packs, inverters, HV cables	De-energize the system, use isolated tools, wear appropriate PPE (gloves, glasses, etc.)
Arc Flash	Contactors, fuses, HV connections	Wearing arc-protective clothing, face shields and insulating gloves

Battery Fire	Cell damage, overheating, thermal runaway	Keep a fire blanket or Class D fire extinguisher on hand and monitor battery temperature.
Chemical Hazard	Electrolyte leakage, coolant leakage	Wearing chemical-resistant gloves and eyewear, ensuring good ventilation, and using leak collection kits
Unwanted Vehicle Movement	Quiet operation, instantaneous activation of high torque	Using wheel chocks, putting the vehicle in service mode, and posting warning signs
Software / Control Errors	ECU incorrect programming, live tests	Using OEM (manufacturer) tools, backing up configurations, not performing any actions other than those instructed

Visual 4.1: Specific Risks and Precautions to Be Taken

5. SAFETY PRACTICES IN ELECTRIC VEHICLES

Ensuring occupational safety during the maintenance and repair of electric vehicles (EVs) is crucial due to their unique electrical systems and components.

The following provides a comprehensive summary of essential safety elements, including personal protective equipment (PPE), safety instructions, warning signs, and risks specific to EVs, with visual aids for better understanding.

5.1. Personal Protective Equipment (PPE) for Electric Vehicle Maintenance

When servicing EVs, technicians should wear appropriate PPE to reduce electrical and mechanical hazards. (Figure 5.1)

5.1.1. Recommended Personal Protective Equipment

Safety Eyewear: Protects eyes from particles and potential electrical hazards.

Rubber Insulating Gloves (Lineworker Gloves): Prevents electric shock from high-voltage components.

Leather Over-the-Coat Gloves: Provides additional protection over rubber gloves and is resistant to cuts and punctures.

Face Shield: Protects the face and neck from arc flash and thermal hazards.

100% Cotton Clothing: Reduces the risk of ignition compared to synthetic materials.

Dielectric Shoes: Insulating boots prevent the flow of electricity through the feet.



Visual 5.1: EINTAC – Technician Safety Kit

Mandatory Use of PPE: Indicates areas where specific PPE must be worn.



Visual 5.3: Prosol – Electric and Hybrid Vehicle Safety Signs

5.4. Risks and Mitigation Measures Specific to Electric Vehicles

EVs present unique hazards that require special safety precautions. (Figure 5.4)

5.4.1. Identified Risks and Precautions

Electric Shock from High Voltage Systems:

Precaution: Always de-energize the system and use insulated tools and PPE.

Arc Flash Incidents:

Precaution: Wear arc-rated clothing and a face shield; avoid working on live circuits.

Battery Thermal Runaway:

Precaution: Monitor battery temperatures and handle damaged batteries with care.

Exposure to Hazardous Chemicals:

Precaution: Wear appropriate PPE and work in well-ventilated areas.

Magnetic Field Interference:

Precaution: Be aware that strong magnets can interfere with medical devices; restrict access where necessary.



Figure 5.4: PMM Online – Health and Safety in Electric Vehicles

5.5. Example Application: Safe Handling of High-Voltage Batteries

5.5.1. Scenario: Servicing a high-voltage battery pack in an electric vehicle.

Step-by-Step Safety Protocol:

1. Preparation:

- Review the service manual for the vehicle's designated procedures.
- Prepare all necessary PPE and tools.

2. Vehicle Isolation:

- Place the vehicle in service mode and disable high-voltage systems.
- Prevent the vehicle from moving by using wheel chocks.

3. Personal Protection:

- Wear safety glasses, rubber insulated gloves and leather protective clothing, a face shield, and 100% cotton clothing.

4. Battery Handling:

- Carefully remove the battery terminals with insulated tools.
- Avoid contact with the battery terminals and internal components.

5. Emergency Preparedness:

- Have a Class D fire extinguisher and a leak containment kit with you.
- Ensure all personnel are trained in emergency response procedures.



Visual 5.5: EINTAC – Technician Safety Kit



Visual 5.6: Electric Vehicle Safety Kit



To play the video, click on the image or click the link below and open it with your browser

<https://youtu.be/03vQnoWQNCI>

5.6. Additional Resources

This section contains additional online resources where you can find more detailed technical information on occupational safety, high-voltage batteries, and maintenance practices in electric vehicles.

5.6.1. Thermal Runaway

Thermal runaway risks and prevention methods in electric vehicle batteries.

<https://www.guchen-connector.com/blog/industry-blog/thermal-runaway-risk-prevention-in-electric-commercial-vehicles.html>

5.6.2. High Voltage Risks

The hazards and safety precautions of high-voltage systems in electric vehicles.

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

5.6.3. Repair Practices

Best practices for safe disconnection during the service and repair of high-voltage batteries.

<https://www.repairerdrivenews.com/2021/09/09/i-car-offers-best-practice-guide-for-disconnecting-high-voltage-ev-batteries/>

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