

**Overview**

This standard covers the competence and knowledge technicians need to safely carry out the removal and replacement of components in isolated high voltage systems in an electric vehicle. High voltage systems include the powertrain and ancillary systems. It also ensures that the technician is aware of the effect that high voltage component technology has on other vehicle systems.

For the purposes of this standard, an electric vehicle is any vehicle that is in part or wholly electrically propelled. This would include

- Hybrid (HEV) - to include mild/micro hybrid vehicles where the voltage is considered dangerous.
- Plug-in Hybrid (PHEV)
- Extended Range Electric Vehicle (ER-EV) or Range Extended Electric Vehicle (RE-EV)
- Battery Electric Vehicle (BEV) or Pure Electric Vehicle (PEV)
- Fuel Cell Electric Vehicle (FCEV).

**Warning: It has been recommended by industry experts that only those with suitable training and experience on working with electric vehicles should carry out the functions below.**

## Performance criteria

- You must be able to:
- P1 Identify the electric vehicle type and collect relevant technical information
  - P2 Wear personal protective **equipment** (PPE) and use vehicle protection **equipment** (VPE) appropriate to the work activities you are carrying out
  - P3 Ensure the vehicle is safe to work on and cannot be started without your knowledge and agreement
  - P4 Ensure the work area is clearly identified using signs and barriers as appropriate, following environmental standards and regulations at all times
  - P5 Support your work activities by reviewing:
    - P5.1 system manufacturer's vehicle technical data
    - P5.2 removal and replacement procedures
    - P5.3 legal requirements
  - P6 Prepare, check and use all the appropriate **equipment** required following manufacturers' instructions
  - P7 Work in a way which minimises the risk of:
    - P7.1 damage to other vehicle systems, **components** and units
    - P7.2 damage to your working environment
    - P7.3 injury to yourself and others
  - P8 Select replacement **components** which meet the manufacturers' recommendations or conform to operating specification
  - P9 Carry out **component** removal and replacement activities following:
    - P9.1 manufacturers' instructions
    - P9.2 industry recognised repair methods
    - P9.3 health, safety and environmental requirements
  - P10 Record and report any relevant/related faults you notice during the course of your work
  - P11 Use suitable **testing methods** to ensure the rectified system performs to the vehicle operating specification and any legal requirements prior to return to the customer
  - P12 Ensure your records are accurate, complete and passed to the relevant person(s) promptly in the format required

## Knowledge and understanding

You need to know and understand:

### Use of technical information

- K1 How to identify an electric vehicle and its type
- K2 How to find, interpret and use sources of information applicable to **component** removal and replacement within an electric vehicle's high voltage systems
- K3 The importance of using the correct sources of technical information for electric vehicle **component** construction
- K4 Why manufacturers' specifications are important and the implications of not following them

### Legislative and organisational requirements and procedures

- K5 The health and safety legislation, industry codes of practice or guidelines and workplace procedures relevant to working with electric vehicles
- K6 How to select, check and use appropriate personal protective **equipment** and vehicle protective **equipment** when working on electric vehicles
- K7 How to ensure the environment is safe when working on an electric vehicle
- K8 Your workplace procedures for:
  - K8.1 [documenting removal and replacement activities](#)
  - K8.2 referral/reporting of problems when working with electric vehicles
  - K8.3 how to make others aware that work is being carried out on an electric vehicle
- K9 The precautions necessary when using plug-in charging equipment.
- K10 How to carry out a risk assessment on damaged and broken-down electric vehicles
- K11 How to confirm an electric vehicle is safe to work on and the precautions you should take to ensure the high voltage system cannot be re-energised without your knowledge and agreement
- K12 The hazards associated with electric vehicle high voltage **components**, including batteries
- K13 How to reduce the risk of high voltage hazards when working on and around electric vehicles
- K14 The implications and effects of electricity through the human body
- K15 The implications of strong magnetic fields and the effects on medical devices
- K16 Workplace procedures that must be followed in the event of electric shock

You need to know  
and understand:

- K17 The hazards associated with electric vehicles when exposed to extreme temperatures, impact and other adverse conditions
- K18 How to store, dispose of, recycle and return any removed high voltage **components** in line with legislative, environmental and organisational requirements
- K19 How to work safely avoiding damage to other vehicle systems, **components** and units and contact with leakage and hazardous substances
- K20 The hazards associated with all fuel sources and systems, including alternative fuels and hydrogen fuel cells

**Electrical and electronic principles**

- K21 The principles of chassis and insulated earth return systems as appropriate to electric vehicles
- K22 Basic electrical and electronic principles, including ohms law, voltage, power, current (ac/dc), resistance, magnetism, electromagnetism and electromagnetic induction
- K23 Specific high voltage circuit protection
- K24 Electrical and electronic principles associated with ancillary systems, including types of sensors and actuators, their application and operation
- K25 The interaction between electrical, electronic, magnetic, chemical and mechanical **components** within electric vehicle systems
- K26 The operating principles of electric vehicle **components**
- K27 How electric vehicle systems interact and communicate

**Vehicle equipment faults and their correction**

- K28 How to identify faults and damage in electric vehicle high voltage electrical systems and **components**
- K29 How to remove, replace, test and evaluate the performance of replacement **components** and the reassembled system against operating specifications and legal requirements
- K30 The importance of ensuring **components** are functioning correctly before release to the customer

**High voltage systems and components removal and replacement**

- K31 How high voltage **components** function and are constructed, including battery modules, electric motors and associated **components**
- K32 How to identify the **components** which make up the high voltage electrical system
- K33 How to identify the location of high voltage cables and **components**, for example, by labelling and colour
- K34 The different voltages associated with **components** in electric vehicles
- K35 The manufacturers' specification for the type and quality of **components** to be used for replacement
- K36 The different types of energy storage systems and voltages associated with electric vehicles
- K37 The **components** of all fuel sources and systems on electric vehicles, including hydrogen fuel cells

**Use of tools and testing equipment and testing techniques**

- K38 How to select and use the testing **equipment** required
- K39 How to select, prepare, check and use all the repair and replacement **equipment** required
- K40 How to conduct tests on isolated high voltage systems following safety and workplace procedures
- K41 How to conduct a test on energy sources and systems
- K42 How to determine the serviceability of a **component** in a high voltage system
- K43 How to interpret the results of your tests and make recommendations based on these results
- K44 The importance of basing your recommendations on test results

**Vehicle system operation**

- K45 The main differences between an electric vehicle and a non-electric vehicle and its basic operation, including regeneration
- K46 How to safely operate an electric vehicle
- K47 The specific manufacturer's guidelines and the precautions necessary when charging, connecting an auxiliary power source to or towing/lifting an electric vehicle

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- K48 How to mobilise an electric vehicle safely
  - K49 The charging systems (types and modes) associated with electric vehicles and how to charge electric vehicles safely
  - K50 The implications of remote vehicle control

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**Scope/range**

- 1. Equipment includes:**
  - 1.1. hand tools
  - 1.2. code readers
  - 1.3. special tools, for example manufacturer specific equipment and software
  - 1.4. safe and appropriate electrical testing equipment
  - 1.5. relevant safety equipment
  
- 2. Testing methods include:**
  - 2.1. sensory
  - 2.2. functional
  - 2.3. measurement
  
- 3. Components include:**
  - 3.1. high voltage batteries
  - 3.2. motors/generators
  - 3.3. cabling and wiring
  - 3.4. relays and contactors
  - 3.5. electronic control units, sensors and actuators
  - 3.6. on-board charger and charging port
  - 3.7. isolators
  - 3.8. inverters/rectifiers
  - 3.9. battery management system (BMS) units
  - 3.10. vehicle start/stop control
  - 3.11. driver instrumentation
  - 3.12. multi-battery systems
  - 3.13. drive trains
  - 3.14. power sources
  - 3.15. ancillary systems and components

**Additional  
Information****Glossary**

*This section contains examples and explanations of some of the terms used but does not form part of the standard.*

**Hazards associated with high voltage electrical vehicle components** - exist not only during work on high voltage systems, as specified above, but also on all other high-power electrical drive systems and high-pressure storage systems. Vehicle and equipment manufacturers' guidance should be followed at all times.

**High voltage** – Regulation No 100 of the Economic Commission for Europe of the United Nations (UNECE) — Uniform provisions concerning the approval of vehicles with regard to specific requirements for the electric power train, states that: 'High Voltage' means the classification of an electric component or circuit, if its working voltage is  $> 60 \text{ V}$  and  $\leq 1\,500 \text{ V DC}$  or  $> 30 \text{ V}$  and  $\leq 1\,000 \text{ V AC}$  root mean square (rms). Electricity at Work Regulations (1989), and associated HSE guidance should be followed at all times.

**N.B. Some electric vehicles may operate at voltages below or above industry recognised standards.**

**Sources of information applicable to electric vehicles** - examples include hard copy manuals, data on computer and data obtained from on-board diagnostic displays.

**Sensory testing methods** - include looking, listening, smelling, touching for temperature or vibration.

**Vehicle** - any vehicle that is in part or wholly electrically propelled. This would include

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- Extended Range Electric Vehicle (ER-EV) or Range Extended Electric Vehicle (RE-EV)
- Battery Electric Vehicle (BEV) or Pure Electric Vehicle (PEV)



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- Fuel Cell Electric Vehicle (FCEV)

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<b>Relevant occupations</b>	Heavy Vehicle Trailer Service Technician (Automotive); Heavy Vehicle Trailer Diagnostic Technician (Automotive); Heavy Vehicle Trailer Master Technician (Automotive); Heavy Vehicle Trailer Fleet/Service Manager (Automotive); Heavy Vehicle Service Technician (Automotive); Heavy Vehicle Diagnostic Technician (Automotive); Heavy Vehicle Master Technician (Automotive); Heavy Vehicle Fleet/Service Manager (Automotive); Light Vehicle Service Technician (Automotive); Light Vehicle Diagnostic Technician (Automotive); Light Vehicle Master Technician (Automotive); Light Vehicle Fleet/Service Manager (Automotive); Mechanical, Electrical and Trim Assistant Technician (Automotive); Mechanical, Electrical and Trim Technician (Automotive); Motorcycle Service Technician (Automotive); Motorcycle Diagnostic Technician (Automotive); Motorcycle Master Technician (Automotive); Motorcycle Fleet/Service Manager (Automotive); Lift Truck Service Technician (Automotive); Lift Truck Trailer Diagnostic

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Technician (Automotive); Lift Truck Trailer Master Technician (Automotive); Lift Truck Workshop Controller (Automotive); Auto-electrical Technician (Automotive); Automotive Aftermarket Electrical Enhancement Technician (Automotive); Workshop Supervisor (Automotive); Bus and Coach Mechanic; Bus and Coach Electrician; Bus and Coach Mechelec; Bus and Coach Master Technician

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**Suite**

Electric and Hybrid Vehicles;

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**Key words**

Electric Vehicle; maintenance and repair; electrical components; high voltage.

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