
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

Legislative and organisational requirements and procedures *

K4 The health and safety legislation, industry codes of practice or guidelines and workplace procedures relevant to working with electric vehicles

K5 How to select, check and use appropriate personal protective *equipment and vehicle protective **equipment** when working on electric vehicles

K6 How to ensure the environment is safe when working on an electric vehicle

K7 Your workplace procedures for the:

K7.1 referral/reporting of problems when working with electric vehicles

K7.2 how to make others aware that work is being carried out on an electric vehicle

K8 The precautions necessary when using plug-in charging equipment.

K9 How to carry out a risk assessment on damaged and broken-down electric vehicles

K10 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

K11 The hazards associated with electric vehicle high voltage **components**, including batteries

K12 How to reduce the risk of high voltage hazards when working on and around electric vehicles

K13 The implications of electrical conductivity through the human body

K14 The implications of strong magnetic fields and the effects on medical devices

K15 Workplace procedures that must be followed in the event of electric shock

K16 The hazards associated with electric vehicles when exposed to extreme temperatures, impact and other adverse conditions

K17 How to store, dispose of, recycle and return any removed high voltage **components** in line with legislative, environmental and organisational requirements

K18 How to work safely avoiding damage to other vehicle systems, **components** and units and contact with leakage and hazardous substances

K19 The hazards associated with alternative fuel sources and systems, including hydrogen fuel cells

Electrical and electronic principles

K20 The principles of chassis and insulated earth return systems as appropriate to electric vehicles

K21 Basic electrical and electronic principles, including ohms law, voltage, power, current (ac/dc), resistance, magnetism, electromagnetism and electromagnetic

induction

K22 Specific high voltage circuit protection

K23 Electrical and electronic principles associated with ancillary systems, including types of sensors and actuators, their application and operation

K24 The interaction between electrical, electronic, magnetic, chemical and mechanical **components** within electric vehicle systems

K25 The operating principles of electric vehicle **components**

K26 How electric vehicle systems interact and communicate

Vehicle equipment faults and their correction

K27 How to identify faults and damage in electric vehicle high voltage electrical systems and **components**

K28 How to remove, replace, test and evaluate the performance of replacement **components** and the reassembled system against operating specifications and legal requirements

K29 The importance of ensuring **components** are functioning correctly before release to the customer

High voltage systems and components removal and replacement

K30 How high voltage **components** function and are constructed, including battery modules, electric motors and associated **components**

K31 How to identify the **components** which make up the high voltage electrical system

K32 How to identify the location of high voltage cables and **components**, for example, by labelling and colour

K33 The different voltages associated with **components** in electric vehicles

K34 The manufacturers' specification for the type and quality of **components** to be used for replacement

K35 The different types of energy storage systems and voltages associated with electric vehicles

K36 The **components** of alternative fuel sources and systems on electric vehicles, including hydrogen fuel cells

Use of tools and testing equipment and testing techniques

K37 How to select and use the testing **equipment** required

K38 How to select, prepare, check and use all the repair and replacement **equipment** required

K39 How to conduct tests on isolated high voltage systems following safety and workplace procedures

K40 How to conduct a test on energy sources and systems

K41 How to determine the serviceability of a **component** in a high voltage system

K42 How to interpret the results of your tests and make recommendations based on these results

K43 The importance of basing your recommendations on test results

Vehicle system operation

K44 The main differences between an electric vehicle and a non-electric vehicle and its basic operation, including regeneration

K45 How to safely operate an electric vehicle

K46 The specific manufacturer's guidelines and the precautions necessary when charging, connecting an auxiliary power source to or towing/lifting an electric vehicle

K47 How to mobilise an electric vehicle safely

K48 The charging systems (types and modes) associated with electric vehicles and how to charge electric vehicles safely

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 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

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.

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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Relevant Occupations	Auto-electrical Technician (Automotive), Automotive Aftermarket Electrical Enhancement Technician (Automotive), Heavy Vehicle Diagnostic Technician (Automotive), Heavy Vehicle Fleet/Service Manager (Automotive), Heavy Vehicle Master Technician (Automotive), Heavy Vehicle Service Technician (Automotive), Heavy Vehicle Trailer Diagnostic Technician (Automotive), Heavy Vehicle Trailer Fleet/Service Manager (Automotive), Heavy Vehicle Trailer Master Technician (Automotive), Heavy Vehicle Trailer Service Technician (Automotive), Lift Truck Service Technician (Automotive), Lift Truck Trailer Diagnostic Technician (Automotive), Lift Truck Trailer Master Technician (Automotive), Lift Truck Workshop Controller , Light Vehicle Diagnostic Technician (Automotive), Light Vehicle Fleet/Service Manager (Automotive), Light Vehicle Master Technician (Automotive), Light Vehicle Service Technician (Automotive), Mechanical, Electrical and Trim Assistant Technician (Automotive), Mechanical, Electrical and Trim Technician (Automotive), Motorcycle Diagnostic Technician, Motorcycle Fleet/Service Manager (Automotive), Motorcycle
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Master Technician (Automotive), Motorcycle Service Technician, Workshop Supervisor (Automotive), Bus and Coach Mechanic, Bus and Coach Electrician, Bus and Coach Mechelec, Bus and Coach Master Technician

Suite

Electric and Hybrid Vehicles, Maintenance and Repair - Light Vehicle, Maintenance and Repair - Heavy Goods and Public Service Vehicles

Keywords

Electric vehicle: maintenance and repair; electrical components; high voltage;
