IMIEV10
Diagnose, test and rectify faults in electric vehicle high voltage batteries

Overview

This standard covers the competence and knowledge technicians need to safely diagnose and rectify faults in an electric vehicle high voltage battery, to include determining the condition of the battery. The unit 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. This will involve diagnostic testing on the live system.

Performance criteria

You must be able to:

P1 Use suitable personal and vehicle protective equipment appropriate to the diagnosis and rectification activities carried out

P2 Notify all relevant persons of your intention to work on a high voltage system

P3 Support the identification of **faults/condition** by reviewing:

- P3.1 technical data
- P3.2 diagnostic test procedures

P4 Prepare the work area for safe working procedures as appropriate to the nature of the fault/repair

P5 Prepare, check and use all the required **equipment** following manufacturer's instructions

P6 Use **diagnostic methods** which are relevant to the symptoms presented

P7 Collect sufficient diagnostic information in a logical and systematic way to enable an accurate diagnosis of the high voltage battery **faults/condition**

P8 Identify and record any system deviation from manufacturer's specifications accurately

P9 Ensure your assessment of **components** and units identifies their condition and suitability for repair or replacement

P10 Promptly inform the relevant person(s) where repairs are uneconomic or unsatisfactory to the customer

P11 Carry out all diagnostic and rectification activities following:

- P11.1 manufacturers' instructions
- P11.2 recognised repair methods
- P11.3 your workplace procedures
- P11.4 health, safety and environmental requirements

P12 Work in a way which minimises the risk of:

- P12.1 **damage** to other systems
- P12.2 **damage** to other components and units
- P12.3 injury to self and others

P13 Ensure all repaired and replacement **components** and units conform to the manufacturers' operating specification and any legal requirements

P14 Adjust **components** and units, when necessary, correctly to ensure that they

operate to system requirements

P15 Dispose of unwanted **components** in line with local and national regulations

P16 Promptly record and report any additional **faults** you notice during the course of work

P17 Use testing methods which are suitable for assessing the performance of the rectified system

P18 Ensure the rectified system performs to the manufacturers' operating specification and any legal requirements prior to return to the customer

P19 Follow workplace procedures in case of emergency

P20 Ensure your records are accurate, complete and passed to the relevant person(s) within the agreed timescale and in the format required

P21 Complete all activities within the agreed timescale

P22 Promptly report any anticipated delays in completion to the relevant person(s)

Knowledge and understanding

You need to know and understand:

Use of technical information

K1 How to find, interpret and use sources of information on high and low voltage electrical and electronic, mechanical and fluid system operating specifications, diagnostic test procedures, repair procedures and legal requirements

K2 The importance of using the correct sources of technical information for electric vehicle battery system diagnosis and rectification

Legislative and organisational requirements and procedures

K3 the legislation, industry codes of practice or guidelines and workplace procedures relevant to:

- K3.1 health and safety
- K3.2 the environment (including waste disposal)
- K3.3 appropriate personal and vehicle protective equipment
- K3.4 legal requirements relating to the vehicle (including road safety requirements)

K4 Your workplace procedures for:

- K4.1 recording **fault/condition** location and correction activities
- K4.2 reporting the results of tests
- K4.3 the referral of problems
- K4.4 reporting delays to the completion of work

K5 How to confirm an electric vehicle and the high voltage battery 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

K6 The hazards associated with electric vehicle high voltage batteries

K7 How to reduce the risk of high voltage hazards when working on and around electric vehicle high voltage batteries

K8 The implications and effects of electricity through the human body

K9 The signs and symptoms of electrocution

K10 The implications of strong magnetic fields and high voltages and the effects on medical devices

K11 Workplace procedures that must be followed in the event of electric shock and other emergencies

K12 The hazards associated with electric vehicle batteries when exposed to

extreme temperatures, impact, flood and other adverse conditions

K13 How to store, dispose of, recycle and return any removed high voltage batteries and **components** in line with legislative and organisational requirements

K14 How to work safely avoiding **damage** to other systems, components and units and contact with leakage and hazardous substances

K15 The importance of working to agreed timescales and keeping others informed of progress

K16 The relationship between time, costs and productivity

K17 The importance of promptly reporting anticipated delays to the relevant person(s)

High and low voltage battery component faults/condition, their diagnosis and rectification

K18 How high and low voltage electrical, electronic, mechanical and fluid systems are constructed and operate

K19 How high and low voltage electrical, electronic, mechanical and fluid systems are dismantled, reassembled and adjusted to manufacturer's specifications

K20 The types and causes of high and low voltage electrical, electronic, mechanical and fluid system, component and unit **faults/conditions** and failures

K21 High and low voltage electrical, electronic, mechanical and fluid component unit and replacement procedures, the circumstances which will necessitate replacement and other possible courses of action

K22 The importance of working to recognised diagnostic and rectification procedures and processes and obtaining the correct information for diagnostic and rectification activities to proceed

K23 The importance of recording diagnostic and rectification information

K24 How to select the most appropriate **diagnostic testing** method for the symptoms presented

K25 How to carry out systematic **diagnostic testing** of high and low voltage electrical, electronic, mechanical and fluid systems using prescribed processes or formats

K26 How to assess the condition of high and low voltage electrical, electronic, mechanical and fluid components and units

K27 How to interpret test results and data in order to identify the location and cause of high and low voltage system **faults/condition**

K28 How to carry out the rectification activities in order to correct **faults/condition** in the high and low voltage electrical, electronic, mechanical and fluid systems

K29 The relationship between test methodology and the **faults/condition** and the use of appropriate testing methods

K30 How to make cost effective recommendations for rectification

Electrical and electronic principles

K31 Electrical and electronic principles, including ohms law, voltage, power, current (ac/dc), resistance, magnetism, electromagnetism and electromagnetic induction

K32 Electrical symbols, unit and terms

K33 Electrical and electronic principles associated with high voltage systems, including types of sensors and actuators, their application and operation

K34 The operating principles of electric vehicle **components**

K35 How electrical and electronic high and low voltage systems operate, including electrical component function, electrical inputs, outputs, voltages and oscilloscope patterns, digital and fibre optics principles

K36 How electrical and electronic systems interlink and interact, including multiplexing

K37 The interaction between electrical, electronic, magnetic, chemical and mechanical systems

K38 The principles of chassis and insulated return systems as appropriate to electric vehicles

K39 Specific high voltage circuit protection

Battery technologies and chemistries

K40 Different battery cell technologies and chemistries

K41 Charging/discharging characteristics of different types of cells

K42 How series and parallel configurations affect voltage and current

K43 How to balance battery cells and the importance of doing so

K44 The effects of chemical leakage and how to deal with different chemicals

K45 The different terminologies used within the battery pack

K46 Battery thermal management, direct and indirect

K47 Battery isolation monitoring systems

Use of diagnostic and rectification equipment

K48 How to prepare and check the accuracy of **diagnostic testing equipment**

K49 How to use diagnostic and rectification **equipment** for high and low voltage electrical, mechanical, electronic, and fluid systems, specialist repair tools and general workshop equipment

K50 How to carry out tests and procedures to determine the condition of the battery cells or modules

K51 How to use diagnostic and test equipment and interpret the results to ensure the integrity of the high voltage system, the state of charge and state of health

Scope/range

1. **Faults/condition** within:
   - 1.1. High voltage electrical system and components
   - 1.2. Low voltage electrical and electronic systems and components
   - 1.3. Mechanical components
   - 1.4. Fluid systems

2. **Diagnostic methods** are
   - 2.1. sensory
   - 2.2. measurement
   - 2.3. functional testing

3. **Diagnostic testing** is defined as:
   - 3.1. Identify the fault/condition
   - 3.2. Verify the fault/condition
   - 3.3. Collect further information
   - 3.4. Evaluate the evidence
   - 3.5. Carry out further tests in a logical sequence
   - 3.6. Rectify the problem/condition
   - 3.7. Check all systems

4. **Equipment** is
   - 4.1. diagnostic and rectification equipment for high voltage systems
   - 4.2. diagnostic and rectification equipment for low voltage systems
   - 4.3. diagnostic and rectification equipment for mechanical systems
   - 4.4. diagnostic and rectification equipment for fluid systems
   - 4.5. specialist repair tools
   - 4.6. general workshop equipment

5. **High voltage protective equipment** includes but is not limited to:
   - 5.1. insulated high voltage/chemical protection gloves
   - 5.2. face shield

5.3. electrical/fire resistant clothing/apron
5.4. insulated tools
5.5. rubber mat
5.6. insulated sheets and covers

6. **Condition** of battery components includes but is not limited to**:**

6.1. overheating
6.2. physical damage
6.3. chemical leakage
6.4. corrosion
6.5. water damage
6.6. reduction in energy holding capacity
6.7. overcharging /undercharging
6.8. isolation faults

7. **Components** include:

7.1. contacters
7.2. bus bars
7.3. resistors
7.4. connectors
7.5. cables
7.6. insulators
7.7. cooling components
7.8. thermal bonding
7.9. fuses
7.10. disconnects
7.11. current sensors
7.12. temperature sensors
7.13. voltage sensors
7.14. water leakage sensors
7.15. swell sensors
7.16. battery management system

8. **Chemistries** include**:**

8.1. Lead-acid batteries (Pb-PbO2)
8.2. Alkaline (Ni-Cad, Ni-Fe and Ni-MH)
8.3. Sodium-nickel chloride (Na-NiCl)
8.4. Sodium-sulphur (Na-S)
8.5. Lithium-ion (Li-ion)

9. **Technologies** include:

9.1. Cylinder
9.2. Blade
9.3. Pouch
9.4. Prismatic

Additional Information

Glossary

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

Battery terminologies - to include cell, module, string, blade, pouch, cylindrical, prismatic, tower, pack.

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 V and ≤ 1 500 V DC or > 30 V and ≤ 1 000 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.

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

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

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

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