

**Overview**

This standard covers the competence and knowledge technicians need to safely diagnose and rectify faults in hydrogen fuel cell electric vehicle (FCEV) systems. The unit also ensures that the technician is aware of the hazards posed by hydrogen fuel cell electric vehicle systems and the safe working practices to follow when carrying out diagnosis and rectification activities.

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

**N.B.** This NOS must be used in conjunction with IMIEV05. High voltage and high-pressure systems will be live during these activities.

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## Performance criteria

- You must be able to:
- P1 Identify that the vehicle has a hydrogen fuel cell electric vehicle system 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
  - P4 Ensure the working environment is suitable and safe, including zone classification
  - P5 Ensure the work area is clearly identified using signs and barriers as appropriate, following environmental standards and regulations all times
  - P6 Support the identification of **faults** by reviewing vehicle:
    - P6.1 technical data
    - P6.2 diagnostic test procedures
  - P7 Prepare the vehicle systems and work area for safe working procedures as appropriate to the vehicle and the nature of the **fault**
  - P8 Prepare, check and use all the required **equipment** following manufacturers' instructions
  - P9 Carry out tests and monitor for hydrogen leaks
  - P10 Use **diagnostic methods** which are relevant to the symptoms presented
  - P11 Collect sufficient diagnostic information in a logical and systematic way to enable an accurate diagnosis of the hydrogen fuel cell electric vehicle system **faults**
  - P12 Identify and record any system deviation from manufacturer's specifications accurately
  - P13 Ensure your assessment of components and units identifies their condition and suitability for repair or replacement
  - P14 Inform the relevant person(s) promptly where repairs are uneconomic or unsatisfactory to perform
  - P15 Carry out all diagnostic and rectification activities following:
    - P15.1 manufacturers' instructions
    - P15.2 recognised repair methods
    - P15.3 your workplace procedures

- P15.4 health, safety and environmental requirements
- P16 Work in a way which minimises the risk of:
  - P16.1 damage to other vehicle systems
  - P16.2 damage to other components and units
  - P16.3 injury to self and others
- P17 Ensure all repaired and replacement components and units conform to the vehicle operating specification and any legal requirements
- P18 Adjust components and units, when necessary, correctly to ensure that they operate to system requirements
- P19 Promptly record and report any relevant additional **faults** you notice during the course of work
- P20 Use **testing methods** which are suitable for assessing the performance of the rectified system
- P21 Ensure the rectified system performs to the vehicle operating specification and any legal requirements prior to return to the customer
- P22 Ensure your records are accurate, complete and passed to the relevant person(s) within the agreed timescale and in the format required
- P23 Complete all activities within the agreed timescale
- P24 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 The different types of hydrogen fuel cell electric vehicle systems and associated hydrogen storage systems
- K2 How to find, interpret and use sources of information on hydrogen fuel cell electric vehicle system operating specifications, diagnostic test procedures, repair procedures and legal requirements
- K3 Vehicle operating specifications relating to hydrogen fuel cell electric vehicle systems for the vehicle(s) on which you work
- K4 The importance of using the correct sources of technical information for hydrogen fuel cell electric vehicle system diagnosis and rectification

**Legislative and organisational requirements and procedures**

- K5 the legislation, industry codes of practice or guidelines and workplace procedures relevant to:
  - K5.1 health and safety
  - K5.2 hazardous and explosive atmosphere zone classification
  - K5.3 the environment (including waste disposal)
  - K5.4 appropriate personal and vehicle protective equipment
  - K5.5 legal requirements relating to the vehicle (including road safety requirements)
- K6 How to select, check and use appropriate **personal protective equipment** and vehicle protective equipment when working on hydrogen fuel cell electric vehicles
- K7 How to ensure the working environment is suitable and safe, including zone classification, when working on a hydrogen fuel cell electric vehicle
- K8 How to immobilise, store and mobilise a hydrogen fuel cell electric vehicle and its components safely in accordance with manufacturer's recommendations
- K9 Your workplace procedures for:
  - K9.1 evacuation in case of emergency
  - K9.2 recording **fault** location and correction activities
  - K9.3 reporting the results of tests
  - K9.4 the referral of problems
  - K9.5 reporting delays to the completion of work

- K10 The precautions necessary when handling hydrogen and using hydrogen related equipment
- K11 How to carry out a risk assessment on damaged and broken-down hydrogen fuel cell electric vehicles
- K12 How to confirm a hydrogen fuel cell electric vehicle is safe to work on, including testing for and monitoring hydrogen leaks and absence of high voltage
- K13 The hazards associated with hydrogen and hydrogen under high-pressure, including the physiological, mechanical and chemical effects of hydrogen
- K14 The hazards associated with hydrogen fuel cell electric vehicles when exposed to extreme temperatures, impact and other adverse conditions
- K15 The effects of electricity through the human body and the potential medical conditions that can occur regardless of voltage or current type present in hydrogen fuel cell electric vehicles
- K16 How to dispose of, recycle and return any removed hydrogen fuel cell electric vehicle components in line with legislative, environmental and organisational requirements
- K17 How to work safely avoiding damage to other vehicle systems, components and units and contact with leakage and hazardous substances
- K18 The importance of working to agreed timescales and keeping others informed of progress
- K19 The relationship between time, costs and productivity
- K20 The importance of promptly reporting anticipated delays to the relevant person(s)

#### **Hydrogen fuel cell and the vehicle system principles**

- K21 The basic construction of a hydrogen fuel cell
- K22 The electrochemical reactions in a fuel cell
- K23 How a fuel cell operates
- K24 The by-products of the fuel cell chemical reaction
- K25 The differences between different fuel cell technologies which may come into automotive use, for example solid oxide (SOFC) and alkaline fuel cells (AFC)
- K26 The reasons for connecting fuel cells into a stack
- K27 Hydrogen fuel storage, supply and re-fuelling systems on-board the vehicle
- K28 The sources of hydrogen

- K29 The components and operation of the air intake system associated with hydrogen fuel cell vehicles
- K30 The components and operation of the exhaust system associated with hydrogen fuel cell vehicles
- K31 How the fuel cell high voltage system and other vehicle system interacts with the EV high voltage system
- K32 The output voltages associated with hydrogen fuel cell systems

#### **Vehicle system operation**

- K33 The main differences between a hydrogen fuel cell electric vehicle (FCEV) and a battery electric vehicle (BEV) and its operation
- K34 How to safely operate a hydrogen fuel cell electric vehicle
- K35 The specific manufacturer's guidelines and the precautions necessary when charging, connecting an auxiliary power source to or towing/lifting an electric vehicle
- K36 The evacuation and re-fuelling systems associated with hydrogen fuel cell electric vehicles and how to operate them safely

#### **Use of diagnostic and rectification equipment**

- K37 How to prepare and check the accuracy of **diagnostic testing equipment**
- K38 How to use diagnostic and rectification **equipment** for hydrogen fuel cell electric vehicle systems, specialist repair tools and general workshop equipment

#### **Hydrogen fuel cell electric vehicle system component faults, their diagnosis and rectification**

- K39 The components of alternative fuel sources and systems on electrically powered vehicles, including hydrogen fuel cells
- K40 How hydrogen supply system components function and are constructed
- K41 How the hydrogen fuel cell electric vehicle system and other vehicle systems interlink and interact, for example, dashboard, SRS systems and re-fuelling systems
- K42 How hydrogen fuel cell electric vehicle systems are dismantled, reassembled and adjusted to manufacturer's specifications

- K43 The types and causes of hydrogen fuel cell electric vehicle system, component and unit **faults** and failures
- K44 Hydrogen fuel cell electric vehicle system component unit and replacement procedures, the circumstances which will necessitate replacement and other possible courses of action
- K45 The importance of working to recognised diagnostic and rectification procedures and processes and obtaining the correct information for diagnostic and rectification activities to proceed
- K46 The importance of recording diagnostic and rectification information
- K47 How to select the most appropriate **diagnostic testing method** for the symptoms presented
- K48 How to carry out systematic **diagnostic testing** of hydrogen fuel cell electric vehicle systems using prescribed processes or formats
- K49 How to assess the condition of hydrogen fuel cell electric vehicle system components and units
- K50 How to interpret test results and vehicle data in order to identify the location and cause of hydrogen fuel cell electric vehicle system **faults**
- K51 How to carry out the rectification activities in order to correct **faults** in the hydrogen fuel cell electric vehicle system
- K52 The relationship between test methodology and the **faults** repaired – the use of appropriate **testing methods**
- K53 How to make cost effective recommendations for rectification

**Scope/range**

- 1. PPE includes:**
  - 1.1. Anti-static shoes
  - 1.2. Anti-static overalls
  - 1.3. Anti-static bonding straps
  - 1.4. Personal hydrogen leak detector
  - 1.5. Absence of oxygen monitor
  - 1.6. Appropriate high voltage PPE
  
- 2. Working environment safety equipment includes:**
  - 2.1. hydrogen leak detector
  - 2.2. flame detection
  - 2.3. anti-static flooring
  - 2.4. ventilation and extraction equipment
  - 2.5. alarms, visual and audible
  
- 3. Faults occur within:**
  - 3.1. Fuel cells and fuel cell stack
  - 3.2. Hydrogen on-board fuel storage and supply systems (tanks, valves etc.)
  - 3.3. Fuel cell hydrogen delivery system (pressure regulator, injector etc.)
  - 3.4. Safety and control systems
  - 3.5. Mechanical and electrical components
  - 3.6. Fluid systems
  - 3.7. Air supply system
  - 3.8. Exhaust system
  - 3.9. On-board refuelling system
  
- 4. Diagnostic methods are**
  - 4.1. sensory
  - 4.2. measurement
  - 4.3. functional testing
  
- 5. Diagnostic testing is defined as:**
  - 5.1. Identify the fault



- 5.2. Verify the fault
- 5.3. Collect further information
- 5.4. Evaluate the evidence
- 5.5. Carry out further tests in a logical sequence
- 5.6. Rectify the problem
- 5.7. Check all systems

**6. Equipment is:**

- 6.1. diagnostic and rectification equipment for hydrogen fuel cell electric vehicle systems
- 6.2. hand tools
- 6.3. code readers
- 6.4. special tools, for example manufacturer specific equipment and software
- 6.5. safe and appropriate electrical testing equipment
- 6.6. hydrogen evacuation (purge) equipment

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**Additional  
Information****Glossary**

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

**Faults** - for example poisoning, hydrogen supply and delivery, air supply, exhaust, driver information systems, sensors, actuators, re-fuelling

**Fuel cell system** - includes fuel cell and fuel cell stack, hydrogen storage and supply, on-board fuelling systems and safety and control systems

**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.

**Hazards associated with hydrogen and hydrogen fuel cell electric vehicle systems** - physiological (e.g. frostbite, respiratory ailments, injury from unexpected release of pressure and asphyxiation), mechanical (for example, embrittlement) and chemical (flammable - burns without visible flame, causes explosive atmospheres).

**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.**

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

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

**Vehicle** - Fuel Cell Electric Vehicle (FCEV)

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