

City & Guilds

**Level 3 Award in Component
Removal and Replacement in
Electric and Hybrid Vehicles
(7290-03)**

July 2022 Version 1.2

Qualification Handbook

Qualification at a glance

Subject area	Automotive
City & Guilds number	7290-03
Age group approved	16+
Entry requirements	None
Assessment	Online multiple-choice test Practical assessment
Approvals	Fast track or full approval required
Support materials	Sample test materials SmartScreen
Registration and certification	Consult the Walled Garden/Online Catalogue for last dates

Title and level	City & Guilds number	Accreditation number
City & Guilds Level 3 Award in Component Removal and Replacement in Electric and Hybrid Vehicles	7290-03	610/0081/0

Version	Date	Change detail	Section
V1.0	March 2022	Document created	All
V1.1	June 2022	Quality Assurance – new section added	2 – Centre Requirements
		Access arrangements and special considerations – new section added	
		Time constraints – further information added on time constraints related to MCQ test and practical assessment	4 – Assessment
		Grading – new section added	5 – Grading

		Sources of general information – updated information/links to current regulatory references	Appendix 1
		Useful contacts and back page – revised information	Useful contacts and back page
V1.2	July 2022	Unit 603 range 3.3	Unit 603

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1 Introduction

This document tells you what you need to do to deliver this qualification:

Area	Description
Who is the qualification for?	This qualification is designed for people looking to develop their knowledge and skills to allow them to safely carry out the removal and replacement of components on electric vehicle systems.
What does the qualification cover?	<p>This qualification covers the competence and knowledge 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.</p> <p>This qualification also ensures that candidates are aware of the effect that high voltage component technology has on other vehicle systems.</p>
What opportunities for progression are there?	<p>This qualification allows candidates to progress on to the following City & Guilds qualification:</p> <p>7290-04 – City & Guilds Level 4 Award in Diagnosis and Rectification of Faults in Electric and Hybrid Vehicles</p>
Who did we develop the qualification with?	This qualification has been developed using the National Occupational Standards as set by automotive industry experts.

Structure

City & Guilds Level 3 Award in Component Removal and Replacement in Electric and Hybrid Vehicles

City & Guilds unit number	Unit title	GLH
Mandatory		
603	Knowledge of Removing and Replacing Components in an Electric Vehicle High Voltage Powertrain and Ancillary Systems	28
613	Skills in Removing and Replacing Components in an Electric Vehicle High Voltage Powertrain and Ancillary Systems	5

Total Qualification Time

Total Qualification Time (TQT) is the number of notional hours which represents an estimate of the total amount of time that could reasonably be expected for a learner to achieve and demonstrate the achievement of the level of attainment necessary for the award of a qualification.

TQT is comprised of the following two elements:

1. The number of hours which an awarding organisation has assigned to a qualification for Guided Learning.
2. An estimate of the number of hours a Learner will reasonably be likely to spend in preparation, study or any other form of participation in education or training, including assessment, which takes place as directed by - but, unlike Guided Learning, not under the Immediate Guidance or Supervision of - a lecturer, supervisor, tutor or other, appropriate provider of education or training.

Title and level	GLH	TQT
City & Guilds Level 3 Award in Component Removal and Replacement in Electric and Hybrid Vehicles	33	38

2 Centre requirements

Approval

If your Centre is approved to offer the qualification 4290-71 you can apply for the new qualification approval using the **fast-track approval form**, available from the City & Guilds website.

Centres should use the fast-track form if:

- there have been no changes to the way the qualifications are delivered, and
- they meet all of the approval criteria in the fast-track form guidance notes.

Fast track approval is available for 12 months from the launch of the qualification. After 12 months, the Centre will have to go through the standard Qualification Approval Process. The centre is responsible for checking that fast-track approval is still current at the time of application.

To offer this qualification, new centres will need to gain both centre and qualification approval. Please refer to **City & Guilds Centre Approval Process Quality Assurance Standards document** for further information, see **Centre Document Library**.

Centre staff should familiarise themselves with the structure, content and assessment requirements of the qualifications before designing a course programme.

Resource requirements

Equipment

Centres must have access to sufficient equipment (including recommended Electric Vehicle safety tools and specialist equipment) in the college, training centre or workplace to ensure candidates have the opportunity to cover all of the practical activities. Further information on the equipment required can be found in the Assessment Pack.

Centre staffing

Staff delivering these qualifications must be able to demonstrate that they meet the following occupational expertise requirements. They should:

- be occupationally competent or technically knowledgeable in the area[s] for which they are delivering training and/or have experience of providing training. This knowledge must be to the same level as the training being delivered
- have recent relevant experience in the specific area they will be assessing
- have credible experience of providing training.

Centre staff may undertake more than one role, e.g., tutor and assessor or internal verifier, but cannot internally verify their own assessments.

Quality assurance

Approved centres must have effective quality assurance systems to ensure optimum delivery and assessment of qualifications. Quality assurance includes initial centre approval, qualification approval and the centre's own internal procedures for monitoring quality.

Centres are responsible for internal quality assurance and City & Guilds is responsible for external quality assurance. For more detail on this visit the **Quality Assurance Standards** documents on the City & Guilds website.

Standards and rigorous quality assurance are maintained by the use of:

- Internal quality assurance
- City & Guilds external quality assurance.

In order to carry out the quality assurance role, Internal Quality Assurers must

- have appropriate teaching and vocational knowledge and expertise
- have experience in quality management/internal quality assurance
- hold or be working towards an appropriate teaching/training/assessing qualification
- be familiar with the occupation and technical content covered within the qualification.

External quality assurance for the qualification will be provided by City & Guilds EQA process. EQAs are appointed by City & Guilds to approve centres, and to monitor the assessment and internal quality assurance carried out by centres. External quality assurance is carried out to ensure that assessment is valid and reliable, and that there is good assessment practice in centres.

The role of the EQA is to:

- provide advice and support to centre staff
- ensure the quality and consistency of assessments within and between centres by the use of systematic sampling
- provide feedback to centres and to City & Guilds.

Learner entry requirements

City & Guilds does not set entry requirements for this qualification. Entry is at the discretion of the centre. However, centres must ensure that learners have the potential and opportunity to gain the qualification successfully.

We recommend that centres ensure that learners hold a Level 2 qualification or above in a related area, or have relevant knowledge and experience in automotive studies, prior to starting the qualification.

Age restrictions

City & Guilds cannot accept any registrations for candidates under 16 as this qualification is not approved for under 16s.

Access arrangements and special considerations

For information on how to apply for access arrangements please refer to ***How and when to apply for access arrangements and special consideration (cityandguilds.com)***

3 Delivering the qualification

Initial assessment and induction

An initial assessment of each candidate should be made before the start of their programme to identify:

- if the candidate has any specific training needs
- support and guidance they may need when working towards their qualification
- any units they have already completed, or credit they have accumulated which is relevant to the qualification
- the appropriate type and level of qualification.

We recommend that centres provide an induction programme so the candidate fully understands the requirements of the qualification, their responsibilities as a candidate, and the responsibilities of the centre. This information can be recorded on a learning contract.

Support materials

The following resources are available for this qualification:

Description	How to access
MCQ sample assessment	www.cityandguilds.com
Learning Assistant	www.cityandguilds.com
SmartScreen	www.smartscreen.co.uk

Recording documents

Learners and centres may decide to use a paper-based or electronic method of recording evidence.

City & Guilds endorses several ePortfolio systems, including our own, **Learning Assistant**, an easy-to-use and secure online tool to support and evidence learners' progress towards achieving qualifications. Further details are available at: www.cityandguilds.com/eportfolios.

City & Guilds has developed a set of *Recording forms* for new and existing centres to use as appropriate. *Recording forms* are available on the City & Guilds website.

Although new centres are expected to use these forms, centres may devise or customise alternative forms, which must be approved for use by the external verifier, before they are used by candidates and assessors at the centre. Amendable (MS Word) versions of the forms are available on the City & Guilds website.

4 Assessment

Assessment of the qualification

Candidates must:

- successfully complete the following mandatory units: 603 and 613.

Summary of assessment methods

Candidates must successfully complete the multiple-choice questions for the essential knowledge and the practical assessment task for the skills.

Assessment Types			
Unit	Title	Assessment method	Where to obtain assessment materials
603	Knowledge of Removing and Replacing Components in an Electric Vehicle High Voltage Powertrain and Ancillary Systems	Multiple-choice questions	Examinations provided on e-volve
613	Skills in Removing and Replacing Components in an Electric Vehicle High Voltage Powertrain and Ancillary Systems	Practical assessment	Assessment Pack found on City and Guilds website / Walled Garden

Assessment strategy

The knowledge will be covered by multiple-choice questions for the essential knowledge criteria and an observed practical assessment including oral questioning for the skills criteria.

Time constraints

Multiple-choice online tests

The multiple-choice online test should be scheduled for candidates only once the Knowledge unit delivery for the associated test is complete and candidates are ready to take the assessment. The test should be sat under invigilated examination conditions, as defined by the JCQ: <http://www.jcq.org.uk/exams-office/ice---instructions-for-conducting-examinations>.

Practical assessments

Assessors should schedule the practical assessment for unit 613 once candidates have **passed** the Evolve on-line test for unit 603 and gained sufficient practice in order to fairly attempt the practical assessment to the best of their ability.

Candidates must complete their assessments within their registration period.

Recognition of prior learning (RPL)

Recognition of prior learning means using a person's previous experience or qualifications which have already been achieved to contribute to a new qualification. RPL is not allowed for this qualification.

Test specifications

The way the knowledge is covered by the multiple-choice question test is laid out in the table below:

Unit 603: Knowledge of Removing and Replacing Components in an Electric Vehicle High Voltage Powertrain and Ancillary Systems		
Duration: 1 hour		
LO number	Learning Outcome	Number of questions
1	understand the operation of electric vehicle systems	1
2	understand the features, function and construction of electric vehicle components and alternative fuel systems	3
3	understand the electrical and electronic principles relating to low and high voltage systems and components	6
4	understand the importance of adhering to health and safety legislation, regulations, guidelines and workplace procedures and know how to work safely around electric vehicles	6
5	understand the hazards associated with working on electric vehicles and how to minimise risk to yourself and others when removing and replacing components in an electric vehicle	4
6	understand how to test, remove and replace components in an electric vehicle	10
Total		30

The grade boundaries for this test will be approximately:

Pass - % 60, 18 marks

This boundary may be subject to slight variation to ensure fairness should any variations in the difficulty of the test be identified.

5 Grading

Grading of individual assessments

All the assessments within this qualification are graded at a Pass only.

Grading of qualification

The overall grading of this qualification is Pass/Fail only.

Candidates must achieve a Pass in:

- Unit 603 Multiple-choice online test
- Unit 613 Practical Assessment

to achieve a Pass in the full qualification.

6 Units

Availability of units

All of the units can be found in this document.

Structure of the units

The units each have the following:

- City & Guilds reference number
- Title
- Level
- Guided learning hours (GLH)
- Unit aim
- Assessment type
- Learning outcomes, which are comprised of a number of assessment criteria

Centres must deliver the full breadth of the range within the units. Specialist equipment or commodities may not be available to all centres, so centres should ensure that their delivery covers their use. This may be covered by a practical demonstration (e.g. video).

For the practical assessments for this qualification, centres should ensure that there are sufficient resources to complete the task but are not required to use all the equipment or commodities in the range.

Guidance for delivery of the units

This qualification is comprised of two **units**. A unit describes what is expected of a competent person in particular aspects of his/her job.

Each **unit** is divided into **learning outcomes** which describe in further detail the skills and knowledge that a candidate should possess.

Each **learning outcome** has a set of **assessment criteria** which specify the desired criteria that have to be satisfied before an individual can be said to have performed to the agreed standard.

Range statements define the breadth or scope of a learning outcome and its assessment criteria by setting out the various circumstances in which they are to be applied.

Unit 603

Knowledge of Removing and Replacing Components in an Electric Vehicle High Voltage Powertrain and Ancillary Systems

Level:	Level 3
GLH:	28
Relationship to NOS:	EV03: remove and replace components in an electric vehicle high voltage powertrain and ancillary systems.
Aim:	<p>To be able to identify and describe the function and operation of different types of electric and hybrid systems and components including charging.</p> <p>To understand the importance of legislation, and to understand the hazards associated with working on electric vehicles.</p> <p>To safely carry out the removal and replacement of components in isolated high voltage systems in an electric vehicle, and the effect that high voltage component technology has on other vehicle systems. High voltage systems include the powertrain and ancillary systems.</p>
Assessment type	Multiple-choice online test

Essential Knowledge

Learning outcomes

The learner will:

1. understand the operation of electric vehicle systems
2. understand the features, function and construction of electric vehicle components and alternative fuel systems
3. understand the electrical and electronic principles relating to low and high voltage systems and components
4. understand the importance of adhering to health and safety legislation, regulations, guidelines, and workplace procedures and know how to work safely around electric vehicles
5. understand the hazards associated with working on electric vehicles and how to minimise risk to yourself and others when removing and replacing components in an electric vehicle
6. understand how to test, remove, and replace components in an electric vehicle

Learning outcome:

The learner will:

1. understand the operation of electric vehicle systems

Assessment criteria

The learner must know:

- 1.1 the operational and constructional **differences** between an **electric vehicle** and a non-electric vehicle
- 1.2 the different types of **electric vehicles** and their electrical systems
- 1.3 the advantages and disadvantages of different **types of charging systems** associated with **electric vehicles**

Range

- 1.1 **Differences** between
 - a) Traction motor / Internal combustion engines
 - b) Emissions
 - c) Starting systems
 - d) Shutting down (powering off)
 - e) Charging systems and power sources
 - f) Driving range
 - g) Braking systems
 - h) Layouts
 - i) Badging
 - j) Components

- 1.1-1.3 **Electric vehicle(s)**
 - a) Pure (PEV) / battery electric vehicle (BEV)
 - b) Extended range (ER-EV)
 - c) Range extended (RE-EV)
 - d) Fuel cell (FCEV)
 - e) Hybrid (HEV)
 - f) Plug-in hybrid (PHEV)
 - g) Mild hybrid
 - h) Micro hybrid

1.3

Types of charging systems

- a) Plugs / sockets (AC/DC)
- b) Trickle charging (3 pin socket)
- c) AC charging
- d) DC charging (charging station)
- e) Combined charging systems
- f) Hybrid self-charging systems

Learning outcome:

The learner will:

2. understand the features, function and construction of electric vehicle components and alternative fuel systems

Assessment criteria

The learner must know:

- 2.1 how to **identify** the **components** that make up the high voltage electrical system
- 2.2 how to locate **high voltage** electrical cables and **components in an electric vehicle**
- 2.3 the voltages of **high voltage components** fitted to different types of **electric vehicles**
- 2.4 the function and construction of **high voltage components**
- 2.5 methods of **sourcing information** applicable to component:
 - a) construction
 - b) removal
 - c) replacementwithin an **electric vehicle's** high voltage systems
- 2.6 how to use and interpret **technical information** applicable to component:
 - a) construction
 - b) removal
 - c) replacementwithin an **electric vehicle's** high voltage systems
- 2.7 the features, purpose and advantages of **alternative fuel components** and systems on **electric vehicles**
- 2.8 the features and benefits of different types of **energy storage systems**

Range

- 2.1 **Identify** from:
 - a) Labelling
 - b) Colour
 - c) Materials
 - d) Insulation
 - e) Cross-sectional area

- 2.1 **Components** types
 - a) Electrical
 - b) Electronic
 - c) Magnetic

- d) Chemical
- e) Mechanical

2.1-2.4 **Components / High voltage components**

- a) High voltage batteries (including Nickel-Metal Hydride (Ni-Mh), Lithium-ion)
- b) Inverter
- c) High voltage cables
- d) DC-to-DC convertor
- e) Fuel cell
- f) Cooling components
- g) PTC heaters
- h) Heat pumps
- i) High voltage air conditioning compressors
- j) Charging equipment and cables
- k) AC three phase motor/generators
- l) Power/battery management system
- m) Auxiliary systems
- n) Chassis and insulated earth return systems

2.2, 2.3,

2.5-2.7

Electric vehicle(s)

- a) Pure (PEV) / battery electric vehicle (BEV)
- b) Extended range (ER-EV)
- c) Range extended (RE-EV)
- d) Fuel cell (FCEV)
- e) Hybrid (HEV)
- f) Plug-in hybrid (PHEV)
- g) Mild hybrid
- h) Micro hybrid

2.5

Sourcing information from

- a) Manufacturer or vehicle technical information
- b) Job cards
- c) Equipment manufacturer's websites
- d) Internet / web-based systems
- e) Mobile phone applications

2.6

Technical information on

- a) Location of high voltage components
- b) Location of low voltage batteries
- c) Isolating and re-energising procedures
- d) Component replacement

2.7

Alternative fuel components

- a) Alternative fuels including hydrogen and liquefied petroleum gas
- b) Fuel tanks
- c) Fuel lines
- d) Fuel cell stack
- e) Batteries (high / low voltage)
- f) AC three phase motor / generators
- g) Power and battery management control units
- h) DC-to-DC convertor
- i) Cooling components

2.8

Energy storage systems

- a) Fully electric vehicle batteries
- b) Hybrid batteries
- c) Auxiliary battery
- d) Fuel cells
- e) Capacitors

Learning outcome:

The learner will:

3. understand the electrical and electronic principles relating to low and high voltage systems and components

Assessment criteria

The learner must know:

- 3.1 the principles of chassis and insulated earth return systems as appropriate to electric vehicles
- 3.2 **electrical and electronic theories** including electrical terminology, symbols and units and application
- 3.3 electrical and electronic principals associated with ancillary systems, **sensors** and **actuators**, their application and operation
- 3.4 the operating principles of **electric vehicle** components
- 3.5 how **interaction** occurs between **components** within **electric vehicle** systems
- 3.6 how **electric vehicle systems** interact and communicate

Range

3.2 **Electrical and electronic theories**

- a) Ohms law
- b) Watts law
- c) Voltage
- d) Power
- e) Current (AC/DC)
- f) Resistance
- g) Magnetism
- h) Electromagnetism
- i) Electromagnetic induction

3.3 **Sensors**

- a) Voltage
- b) Current
- c) Temperature
- d) Position

3.3 **Actuators** (below to be in relation to hybrid and extended range vehicles only)

- a) Idle speed control
- b) Swirl flaps

- c) Exhaust Gas recirculation
- d) Purge Solenoid Valve Control
- e) Turbocharger
- f) Heating and air conditioning

3.4-3.6 **Electric vehicle(s)**

- a) Pure (PEV) / battery electric vehicle (BEV)
- b) Extended range (ER-EV)
- c) Range extended (RE-EV)
- d) Fuel cell (FCEV)
- e) Hybrid (HEV)
- f) Plug-in hybrid (PHEV)
- g) Mild hybrid
- h) Micro hybrid

3.5 **Component types**

- a) Electrical
- b) Electronic
- c) Magnetic
- d) Chemical
- e) Mechanical

3.5 **Components**

- a) High voltage batteries
- b) Inverter
- c) DC-to-DC convertor
- d) Cooling / heating components,
- e) High voltage air conditioning compressors
- f) Charging equipment and cables
- g) AC three phase motor/generators
- h) Power/battery management system
- i) Auxiliary battery

3.5-3.6 **Interaction**

- a) Between electric motor and engine
- b) Controller Area Network (CAN)
- c) Local Interconnected Network (LIN)
- d) Media Oriented Systems Transport (MOST)

- e) FlexRay
- f) SRS (Supplementary restraint systems)
- g) Braking systems including (ABS)
- h) Steering-By-Wire (SBW)

Learning outcome:

The learner will:

4. understand the importance of adhering to health and safety legislation, regulations, guidelines, and workplace procedures and know how to work safely around electric vehicles

Assessment criteria

The learner must know:

- 4.1 current **health and safety legislation, industry codes of practice** and **guidelines** relevant to working on **electric vehicles**
- 4.2 the importance of manufacturers guidance and the **precautions** necessary to take when:
 - a) charging an **electric vehicle**
 - b) connecting an auxiliary power source to an **electric vehicle**
 - c) **towing** or lifting an **electric vehicle**
- 4.3 how to select, check and use the appropriate **personal protective equipment** and **vehicle protective equipment**
- 4.4 how to ensure a **safe working environment**
- 4.5 how to store, dispose of, recycle, and return any removed high voltage components in line with legislative, environmental and organisational requirements
- 4.6 manufacturer's and workplace requirements and procedures for:
 - a) reporting/referring problems
 - b) making others aware that work is being carried out on an **electric vehicle**
- 4.7 workplace and safety procedures that must be followed in the event of an electric shock
- 4.8 how to **safely operate** an **electric vehicle**
- 4.9 how to **safely use charging systems** and plug in charging equipment
- 4.10 how to safely mobilise an **electric vehicle**
- 4.11 how to work safely avoiding damage to other vehicle systems, components and units and contact with leakage and hazardous substances

Range

- 4.1 **Health and safety legislation, industry codes of practice, guidelines**
 - a) Health and Safety at Work act
 - b) Electrical equipment regulations
 - c) Regulation No 100 of the Economic Commission for Europe of the United Nations (UNECE) – 'High Voltage means the classification of an electric component or circuit, if it's working voltage is > 60 V and ≤ 1500 V DC or > 30 V and ≤ 1000 V AC root mean square (ms)
 - d) Electricity at Work Regulations
 - e) HSE guidelines
 - f) Manufacturer technical repair information

- g) End of Life Vehicle regulations
- h) COSHH

4.1, 4.2

4.8, 4.9, 4.11 **Electric vehicle(s)**

- a) Pure (PEV) / battery electric vehicle (BEV)
- b) Extended range (ER-EV)
- c) Range extended (RE-EV)
- d) Fuel cell (FCEV)
- e) Hybrid (HEV)
- f) Plug-in hybrid (PHEV)
- g) Mild hybrid

4.2 **Towing precautions** to include

- a) Speed limitations
- b) Distance limitations
- c) Potential energising of components / systems

4.3 **Personal protective equipment** to include

- a) Overalls
- b) Feet protection
- c) Gloves (correctly rated)
- d) Eye protection
- e) Rubber mats
- f) Insulated tools

4.3 **Vehicle protective equipment** to include

- a) Seat covers
- b) Floor mats
- c) Steering wheel covers
- d) Wing protectors

4.4 **Safe working environment** to include

- a) Signage
- b) Barriers
- c) Cordoning
- d) Secure key box
- e) Spill kit

- f) Warning labels

4.8 **Safely operate** procedures include

- a) Ensure vehicle is in ready mode
- b) Check for warning symbols on dashboard
- c) Check for system displays and messages
- d) Check surroundings before moving off
- e) Awareness that an engine may start at any time on a hybrid vehicle

4.9 **Safe use of charging systems** procedures include

- a) Precautions when charging in the presence of water – e.g., rain, valeting bay
- b) Correct use of extension leads when charging
- c) Check suitability of power supply used when charging
- d) Signage
- e) Cabling and connections
- f) Risks to personal health and safety

Learning outcome:

The learner will:

5. understand the hazards associated with working on electric vehicles and how to minimise risk to yourself and others when removing and replacing components in an electric vehicle

Assessment criteria

The learner must know:

- 5.1 the **hazards** associated with **high voltage components**
- 5.2 how to reduce the risk of **hazards** when working on and around **electric vehicles**
- 5.3 the impact of **hazards** associated with **electric vehicles** when exposed to extreme temperatures, vehicle impact and other adverse conditions
- 5.4 the health **implications** of strong magnetic fields and electrical conductivity through the human body
- 5.5 the **hazards** associated with alternative fuel systems, including hydrogen fuel cells
- 5.6 the **hazards** associated with interrupting a circuit with high current flow and the need for high voltage circuit protection
- 5.7 how to carry out a **dynamic risk assessment** on damaged or broken-down **electric vehicles**

Range

5.1-5.3, **Hazards** to include
5.5-5.6

- a) Fire / thermal runaway
 - i. Exothermic reaction
 - ii. Endothermic reaction
- b) Explosion
- c) Pressures
- d) Arc flash
- e) Gases/fumes
- f) Chemicals
- g) Electric shock
- h) Damage to cables
- i) Dangerous voltage retention in components even when vehicle is switched off

5.1 **High voltage components**

- a) High voltage batteries (to include Nickel Metal Hydride (Ni-Mh), Lithium (Li-ion))
- b) Inverter
- c) High voltage cables

- d) DC-to-DC convertor
- e) Fuel cell
- f) Cooling components
- g) PTC heaters
- h) Heat pumps
- i) High voltage air conditioning compressors
- j) Charging equipment and cables
- k) AC three phase motor/generators
- l) Power/battery management system
- m) Auxiliary systems

5.2, 5.3, 5.6 **Electric vehicle(s)**

- a) Pure (PEV) / battery electric vehicle (BEV)
- b) Extended range (ER-EV)
- c) Range extended (RE-EV)
- d) Fuel cell (FCEV)
- e) Hybrid (HEV)
- f) Plug-in hybrid (PHEV)
- g) Mild hybrid
- h) Micro hybrid

5.4 **Implications**

- a) Cardiac arrest
- b) Muscle, nerve and tissue damage
- c) Thermal burns
- d) Medical equipment damage e.g., pacemakers

5.7 **Risk assessment** procedures include

- a) Risk assessment documentation and responsible persons
- b) Taking action to eliminate or reduce risk
- c) Observing, assessing, analysing an environment while working, to identify and remove risk
- d) Monitoring situation
- e) Reviewing situation

Learning outcome:

The learner will:

6. understand how to test, remove, and replace components in an electric vehicle

Assessment criteria

The learner must know:

- 6.1 how to identify faults and damage using **testing methods** in high voltage electrical systems and **components**
- 6.2 how to select and use the correct testing **equipment**
- 6.3 how to select, prepare, check, and use repair and replacement **equipment**
- 6.4 how to conduct tests on high voltage systems following safety and workplace procedures
- 6.5 how to conduct a test on energy sources and systems
- 6.6 how to determine the serviceability of a **component** in a high voltage system
- 6.7 the manufacturer's specification on the type and quality of **components** to be used for replacement
- 6.8 how to remove and replace a **component** on an **electric vehicle** system following manufacturer's instructions
- 6.9 the importance of **testing** and **evaluating** the performance of replacement components and the reassembled system against manufacturer's operating specifications and legal requirements and make a recommendation based on test results
- 6.10 the importance of ensuring all vehicle systems and **components** are functioning correctly and safely before the vehicle is released to the customer

Range

- 6.1 **Testing methods**
- a) Sensory (visual, sound, smell, touch for temperature or vibration)
 - b) Functional
 - c) Measurement (including fault code identification)

6.1, 6.6-6.8,

- 6.10 **Components**
- a) High voltage batteries
 - b) Low voltage batteries
 - c) AC three phase motor / generators
 - d) Cabling and wiring (wiring colour, size and cross-sectional area)
 - e) Relays and contactors
 - f) Electronic control units
 - g) On-board charger and charging port
 - h) DC-to-DC convertor

- i) Isolators
- j) Inverters/rectifiers
- k) Battery management units
- l) Vehicle start/stop control
- m) Driver instrumentation
- n) Multi-battery systems
- o) Drive trains (layout)
- p) Power sources, (engine / motor)
- q) Sensors (voltage, current, temperature, position, resolver)
- r) Ancillary components
- s) Air conditioning compressor
- t) Heating components

6.2-6.3

Equipment

- a) Electrical multimeters / voltmeter rated to a minimum 1000V (CAT. III) or 600V (CAT.IV) including leads and probes
- b) Other safe and appropriate electrical testing / repair and replacement equipment
- c) Hand tools
- d) Code readers
- e) Special tools (manufacturer specific testing/diagnostic equipment and software)
- f) Relevant safety equipment

6.9

Testing by

- a) Checking fault codes
- b) Checking voltage/current
- c) Checking wiring and cable routing
- d) Conducting road tests

6.9

Evaluating by

- a) Checking warning lights
- b) Checking on board displays
- c) Using diagnostic equipment
- d) Conducting a road test

Unit 613

Skills in Removing and Replacing Components in an Electric Vehicle High Voltage Powertrain and Ancillary Systems

Level:	Level 3
GLH:	5
Relationship to NOS:	EV03: Remove and replace components in an electric vehicle high voltage powertrain and ancillary systems
Aim:	To be able to demonstrate how to safely remove, test, evaluate and replace a component from an electric vehicle following manufacturers procedures.

Assessment type Practical assessment

Essential Skills

Learning outcomes

The learner will:

1. be able to work safely when removing and replacing components in a high voltage electric vehicle system, adhering to legislation, workplace, and manufacturer requirements
2. be able to remove, select and replace components in high voltage systems and accurately evaluate the performance of the rectified system

Learning outcome:

The learner will:

1. be able to work safely when removing and replacing components in a high voltage electric vehicle system, adhering to legislation, workplace, and manufacturer requirements

Assessment criteria

The learner must:

- 1.1 identify the type of **electric vehicle** being worked on
- 1.2 locate and record relevant information about the vehicle
- 1.3 ensure the work area is clearly identified using signs and barriers as appropriate, following environmental standards and regulations at all times
- 1.4 perform the correct procedures to make the vehicle safe prior to starting any work activities
- 1.5 ensure work cannot be started without relevant individuals knowledge and agreement
- 1.6 support work activities by adhering to:
 - a) system manufacturer's vehicle technical data
 - b) removal and replacement procedures
 - c) legal requirements
- 1.7 select and use the recommended personal protective equipment (PPE) and vehicle protective equipment (VPE) appropriate to removing and replacing components in a high voltage electric vehicle system
- 1.8 work in a way which minimises risk of:
 - a) injury to themselves
 - b) damage to their working environment
 - c) damage to other vehicle systems, components, and units
- 1.9 conduct a **dynamic risk assessment** on the vehicle and work area to determine any potential hazards

Range

- 1.1 **Electric vehicle(s)**
 - a) Pure (PEV) / battery electric vehicle (BEV)
 - b) Extended range (ER-EV)
 - c) Range extended (RE-EV)
 - d) Fuel cell (FCEV)
 - e) Hybrid (HEV)
 - f) Plug-in hybrid (PHEV)
 - g) Mild hybrid
 - h) Micro hybrid

1.9

Dynamic risk assessment procedures include

- a) Risk assessment documentation and responsible persons
- b) Taking action to eliminate or reduce risk
- c) Observing, assessing, analysing an environment while working, to identify and remove risk
- d) Monitoring situation
- e) Reviewing situation

Learning outcome:

The learner will:

2. be able to remove, select and replace components in high voltage systems and accurately evaluate the performance of the rectified system

Assessment criteria

The learner must:

- 2.1 prepare, check and use appropriate **equipment** following manufacturer's instructions
- 2.2 select replacement **components** which meet the manufacturers' recommendations or conform to operating specification
- 2.3 carry out **component** removal and replacement activities following:
 - a) manufacturers' instructions
 - b) industry recognised repair methods
 - c) health, safety and environmental requirements
- 2.4 record and report any faults or relevant issues noticed during inspection or repair work
- 2.5 evaluate the performance of the rectified high voltage system accurately using suitable testing methods
- 2.6 ensure the high voltage system performs to the manufacturer's operating specifications and legal requirements prior to returning to customer
- 2.6 record and report accurately to the relevant person(s) the work activities they have carried out on or near the vehicle

Range

- 2.1 **Equipment**
 - a) Electrical multimeters / voltmeter rated to a minimum 1000V (CAT. III) or 600V (CAT.IV) including leads and probes
 - b) Other safe and appropriate electrical testing equipment
 - c) Hand tools
 - d) Code readers
 - e) Special tools (manufacturer specific equipment and software)
 - f) Relevant safety equipment

- 2.2-2.3 **Component(s)**
 - a) High voltage batteries
 - b) Low voltage batteries
 - c) AC three phase motor / generators
 - d) Cabling and wiring (wiring colour, size and cross-sectional area)

- e) Relays and contactors
- f) Electronic control units
- g) On-board charger and charging port
- h) DC-to-DC convertor
- i) Isolators
- j) Inverters/rectifiers
- k) Battery management units
- l) Vehicle start/stop control
- m) Driver instrumentation
- n) Multi-battery systems
- o) Drive trains (layout)
- p) Power sources (engine / motor)
- q) Sensors
- r) Ancillary components

Appendix 1 Sources of general information

The following documents contain essential information for centres delivering City & Guilds qualifications. They should be referred to in conjunction with this handbook. To download the documents and to find other useful documents, go to the **Centre Document Library** on **www.cityandguilds.com** or click on the links below:

Quality Assurance Standards: Centre Handbook

This document is for all approved centres and provides guidance to support their delivery of our qualifications. It includes information on

- Centre quality assurance criteria and monitoring activities
- Administration and assessment systems
- Centre-facing support teams at City & Guilds / ILM
- Centre quality assurance roles and responsibilities.

The Centre Handbook should be used to ensure compliance with the terms and conditions of the Centre Contract.

Quality Assurance Standards: Centre Assessment

This document sets out the minimum common quality assurance requirements for our regulated and non-regulated qualifications that feature centre assessed components. Specific guidance will also be included in relevant qualification handbooks and/or assessment documentation.

It incorporates our expectations for centre internal quality assurance and the external quality assurance methods we use to ensure that assessment standards are met and upheld. It also details the range of sanctions that may be put in place when centres do not comply with our requirements, or actions that will be taken to align centre marking/assessment to required standards. Additionally, it provides detailed guidance on the secure and valid administration of centre-assessments.

Any centre-based assessments must be carried out in line with our Centre Assessment Standards Scrutiny (CASS) Strategy which can be found on **www.cityandguilds.com**.

Access arrangements - When and how applications need to be made to City & Guilds

provides full details of the arrangements that may be made to facilitate access to assessments and qualifications for candidates who are eligible for adjustments in assessment.

The **Centre Document Library** also contains useful information on such things as:

- Conducting examinations
- Registering learners
- Appeals and malpractice
- Reasonable adjustments

Useful contacts

Please visit the Contact Us section of the City & Guilds website, [Contact us](#)

City & Guilds

For over 140 years we have worked with people, organisations and economies to help them identify and develop the skills they need to thrive. We understand the life changing link between skills development, social mobility, prosperity and success. Everything we do is focused on developing and delivering high-quality training, qualifications, assessments and credentials that lead to jobs and meet the changing needs of industry.

We partner with our customers to deliver work-based learning programmes that build competency to support better prospects for people, organisations and wider society. We create flexible learning pathways that support lifelong employability, because we believe that people deserve the opportunity to (re)train and (re)learn again and again – gaining new skills at every stage of life, regardless of where they start.

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