ASSESSMENT CRITERIA FOR IMI ELECTRIC/HYBRID VEHICLE QUALIFICATION (VRQ)

IMI Level 3 Award in Electric/Hybrid Vehicle System Repair and Replacement

QFQUAL I.D: 603/1468/0

IMI QUALIFICATION

Note: This guidance is supported by the following documents

- *Practical Assessments*
- *Candidate Assessment Summary*

Level 3 Award in Electric/Hybrid Vehicle System Repair and Replacement

LEARNER ENTRY REQUIREMENTS

Learner entry for this VRQ should be assessed on an individual basis. Selection criteria for entry should take into account each applicant's existing academic/vocational qualifications and experience in working in the retail automotive industry.

Although not mandatory, it is recommended that learners will have 3 GCSEs, or Scottish Standard Grade/Intermediate in Mathematics, English and a Science based subject.

Level 3 Award in Electric/Hybrid Vehicle System Repair and Replacement
Individuals will already have appropriate vehicle maintenance and repair knowledge and skills at level 3.

Both mandatory units must be completed to achieve the qualification

Unit Ref:	Unit Title & I.D. Number	Unit Level	Guided Learning Hours	Total Qualification Time
EV2.2	Electric/Hybrid Vehicle Routine Maintenance Activities (J/615/7414)	2	14	18
EV3	Electric/Hybrid Vehicle System Repair and Replacement (R/615/7416)	3	20	25

GLH - 34
TQT - 43

LEARNER PROGRESSION

Typical progression routes on completion of this qualification are:

L4 Award in the Diagnosis, Testing and Repair of Electric/Hybrid Vehicles and Components
This qualification is designed for technicians who maintain and repair electric/hybrid high voltage vehicle systems and components. It contains the knowledge and skills required to work on live high voltage vehicle electrical components and associated systems.

On completion, technicians will be able to practically demonstrate that they have the skills required to repair high voltage vehicle electrical components and systems

UNIT REF: EV2.2	UNIT TITLE: ELECTRIC/HYBRID VEHICLE ROUTINE MAINTENANCE AND REPAIR ACTIVITIES

Level: 2	GLH: 14	TQT: 18
Rationale: This unit introduces learners to electric/hybrid (all variations) vehicle technology including, and in particular, the safety requirements of working on these types of vehicles, e.g. whilst carrying out routine vehicle servicing, general repairs that are not related to the high energy electrical system Note: *This unit does not prove that someone is competent to work on the motor vehicle high energy electrical system, and assumes an already good level of electrical understanding. This unit does not cover commercial or domestic electrical installations including charging equipment and cables.*		

LEARNING OUTCOMES The Learner will:	ASSESSMENT CRITERIA The Learner can:
1. Know about electric/hybrid vehicle system components and operation	1.1. Identify the components that make up the high energy electrical drivetrain system 1.2. Describe the construction and function of battery cells and modules 1.3. Describe the construction and function of electric motors 1.4. Describe the basic construction and function of associated high energy electrical components including circuit protection and cabling 1.5. Describe how to identify high energy electrical cabling and associated components 1.6. Identify alternative fuel source vehicles
2. Understand the hazards surrounding electric/hybrid vehicles	2.1 Describe the hazards associated with high energy electricity 2.2 State the levels of current and voltage that present a hazard for both alternating and direct current systems 2.3 Describe the potential hazards that may be present when an electric/hybrid vehicle has been damaged by fire or impact 2.4. Describe the effects of alternating and direct current on humans 2.5. Describe hazards associated with vehicle charging
3. Know how to reduce the risks to yourself and others when working on electric/hybrid vehicles	3.1. Describe the methods that vehicle manufacturers use to provide protection from high energy electrical cabling and components 3.2. Identify the safety precautions to be taken to reduce risks to self and others before carrying out routine maintenance activities 3.3. Describe the specific personal protective equipment required to work on electric/hybrid vehicles 3.4. Describe the precautions required prior to working near high energy electrical components

4. Know how to safely prepare the vehicle when carrying out routine maintenance on electric/hybrid vehicles (**NOT high voltage components or systems**)	4.1. Describe the isolation procedures required to make safe the high energy electrical system before carrying out maintenance and repair activities 4.2. Describe appropriate methods to re-instate vehicles after repairs affecting high energy electrical systems 4.3. Identify additional tools and equipment required to carry out work on electric/hybrid vehicles 4.4. Describe how to connect an external power source to an electric/hybrid vehicle 4.5. Identify vehicle repair and maintenance requirements not related to high voltage components
5. Be able to work safely on an electric/hybrid vehicle (**NOT high voltage components or systems**)	5.1. Use suitable personal protective equipment at all times whilst working on electric/hybrid vehicles 5.2. Select suitable sources of information to support the work being carried out 5.3. Carry out the safe isolation of the high energy electrical system, following the vehicle manufacturer's instructions 5.4. Use the correct methods to safely re-instate the vehicle following the vehicle manufacturer's instructions 5.5. Use the correct procedures to connect an alternative power source to an electric/hybrid vehicle

Evidence Requirements	
You **must be observed by your assessor** completing **all** of the following tasks **on at least one occasion.**	
1.	Carry out the procedure to isolate and re-instate the high energy electrical system
2.	Connect an alternative power source to an electric/hybrid vehicle (high or low voltage system)

Unit Content	Assessment Criteria
Identification of the components that make up the electric/hybrid propulsion system could include: a. batteries/ stack, pod, module. b. motors c. cabling; d. relays/control units e. charger and charging points f. isolators g. inverter h. battery management interface i. ignition/key-on control switch j. driver display panel k. multi-battery server unit Identification of ancillary electric/hybrid components could include a. heating and air conditioning system components b. starter generator Battery modules could include: a. types i. lead-acid ii. sodium-nickel chloride iii. lithium-ion derivatives iv. nickel-ion (Ni-Fe) v. nickel-metal-hydride b. operational temperature ranges c. capacities; primary/secondary cells; power density; energy density d. housings; materials used e. reactive materials; positive/ negative potential f. connections; shape; material; position g. charging process; fast/slow charge; higher and lower voltages h. location and effects on cooling, ease of maintenance, space, weight transfer; removing and refitting. An overview of electric motors could include: a. principle of DC/AC types i. permanent magnet ii. induction iii. brushed/ brushless iv. single/three phase b. connections; screwed; push; integrity; security c. power rating/output d. housing materials/insulation e. armatures/rotor f. windings/stator g. principle of regenerative braking The function of associated electrical components could include: a. cabling; materials; colour coding; routing; insulation; cross-sectional area b. circuit protection; fuses; thermal cut outs; insulation c. relay/control units; battery management interface; inverter; d. distribution units e. electrical symbols and terminology; circuit protection methods. f. circuit theory; interaction between voltage, current, resistance (Ohm`s law); power equation to calculate power dissipated in a circuit g. conductors, insulators; earth return, insulated return Definition of voltages used for motor vehicle high energy systems: ECE R100 (relating to vehicle regulations) paragraph 2.14 clearly defines high voltage: “High Voltage means the classification of an electric component or circuit, if its working voltage is >	1.1-1.6

60 V and ≤ 1500 V DC or > 30 V and ≤ 1000 V AC root mean square (rms)." NOTE: This is different to definitions in commercial and domestic use which are: i. Extra Low Voltage <50 V rms AC and <120 V DC ii. Low Voltage 50-1000 V rms AC and 120-1500 V DC iii. High Voltage >1000 V rms AC and >1500 V DC Examples of the typical voltages used for a range of electric / hybrid vehicles 40-1000V DC Alternative fuel systems could include a. Hydrogen b. methanol Hazards associated with vehicle charging (plug in) could include: a. cable selection b. cable routing – reducing trip hazards c. signage and safety precautions d. current rating of charging components and charge points e. damaged components affecting vehicle charging	
The hazards that are associated with high energy vehicle electrical systems a. fire b. explosion c. arc flash d. gases/fumes e. chemicals f. vehicle operation ie. automatic start / stop systems, quietness of operation g. high voltage h. high current i. EMF – for example pacemaker, insulin pumps and other medical devices Resulting injuries to include a. fatality b. electric shock and cardiac arrest c. burns from chemical and fire d. falling from height or being thrown due to electric shock e. manual handling injuries from lifting heavy components f. eye injuries g. skin damage from burns h. breathing difficulties and complications from fumes i. EMF – for example pacemaker, insulin pumps and other medical devices j. residual magnetic energy stored in high energy components The hazards that may be present in the event of a damaged vehicle or when charging to include: a. Increased risk of exposure to the hazards listed above b. Surrounding conditions including precautions when charging in the presence of water – i.e. rain, valeting etc. c. Incorrect use of extension leads when charging d. suitability of power supply used when charging Safety precautions to be taken before approaching and interacting with electric / hybrid vehicles a. risk assessment b. awareness of damaged components c. dealing with leakage d. isolation of high energy electrical system e. safe connection when charging f. workplace procedures for driving electric/hybrid vehicles (no sound) g. workplace procedures for the use of signage and barriers when people are working on electric / hybrid vehicles h. types of signage in use in and around electric/ hybrid vehicle repair i. risks to health when working around electric /hybrid vehicles i.e., pacemakers and other medical equipment possibly affected	2.1-2.5

Levels of current and voltage that may present hazards a. contact time b. AC/DC current and voltage levels c. factors affecting resistance to current flow The effect of different AC and DC electrical currents passing through the human body. a. IEC 60479 b. IEC 479-2	
Unit Content	**Assessment Criteria**
Safety precautions to be taken before carrying out any maintenance and repair procedures on high voltage vehicles could include: a. appropriate PPE as described by manufacturer's instructions b. precautions when using electrical equipment; differentiating between low/high energy c. disposal of waste materials; recycling obligations d. dealing with leakage from battery packs e. isolation of high energy electrical system; vehicle shut down procedures f. risk assessment The identification of high energy cabling and associated components should include: a. using wiring diagrams b. wiring colour c. wiring size/cross-sectional area d. warning signs The precautions required when working with high energy vehicle components: a. awareness of highly magnetic components and strong magnetic fields b. medical conditions that may be affected by high energy or magnetic fields c. checking voltage prior to working near or on high energy systems	3.1-3.4
The possibility of the electric/ hybrid vehicle drive train system affecting repairs on other vehicle systems should include: a. connections to other systems (mechanical or electric) b. electro-magnetic interference c. interlink between low and high energy sources d. residual magnetism The procedures required to deactivate the high energy vehicle system before carrying out repair activities could include: a. identification of isolation switches / high voltage service disconnect b. preparing vehicle for isolation/shut down c. following manufacturer's set procedures d. observation and data confirmation displays The precautions taken prior to removing and replacing high energy components could include: a. check system is made safe/isolated/shut down b. check voltage free prior to starting work c. make others aware of work being carried out/warning signs Appropriate methods to re-instate vehicles after repairs affecting high energy vehicle systems could include: a. re-connection of high energy battery b. use of fault diagnostic equipment c. on board displays Additional tools and equipment required to carry out work on electrical/hybrid vehicles could include a. insulated hand tools	4.1-4.5

b. diagnostic and code reading equipment c. specialist tools e.g. manufacturer specific software d. electrical meters e.g. voltmeter rated to a minimum 1000V (CAT. III) or 600V (CAT.IV) An awareness of when and how to connect an additional external power source to a High Voltage vehicle (where appropriate for jumping or charging a vehicle) and could include: a. identification of connections b. correct connection methods c. awareness of current draw capability of vehicle d. use of correct cables e. correct use of PPE f. awareness of short circuits and component damage g. confirmation of charging procedure and awareness and identification of charging fault / failure to charge	

UNIT REF: EV3	UNIT TITLE: ELECTRIC/HYBRID VEHICLE SYSTEM REPAIR AND REPLACEMENT

Level: 3	GLH: 20	TQT: 25
Rationale: This unit enables learners to demonstrate, in a practical way, their knowledge of electric/hybrid vehicle technology and repair procedures. The unit also ensures that the learner is aware of the effect that electric/hybrid vehicle technology has on other vehicle systems. Note: *This unit only provides the knowledge and skills required to work on non-live high energy electrical components and associated systems. It does not enable a learner to dismantle 'live' components, e.g. battery packs, and assumes an already good level of electrical understanding. This unit does not cover commercial or domestic electrical installations including charging equipment and cables.* *The unit should also only be undertaken after completion of Unit EV2*		

LEARNING OUTCOMES The Learner will:	ASSESSMENT CRITERIA The Learner can:
1. Be able to work safely on an electric/hybrid vehicle	1.1. Use suitable personal protective equipment throughout all vehicle inspection activities 1.2. Work in a way which minimises the risk of damage to the vehicle and its systems, other people and their property
2. Be able to use information to carry out the task	2.1. Select suitable sources of technical information to support electric/hybrid vehicle repair activities 2.2. Use suitable sources of technical information to support electric/hybrid vehicle repair activities
3. Be able to use appropriate tools and equipment	3.1. Select and use appropriate tools and equipment to carry out electric/hybrid vehicle repairs 3.2. Ensure that equipment has been calibrated to meet manufacturer's requirements
4. Know how to carry out repairs on high energy electrical systems	4.1. Explain the correct procedures required prior to removing and replacing high energy electrical system components 4.2. Explain how to isolate and re-connect live high energy electrical supplies correctly
5. Be able to carry out repairs on high energy electrical systems	5.1. Make the high energy electrical system safe to work on prior to carrying out any work 5.2. Use the correct procedures to disconnect and reconnect an isolated high energy battery 5.3. Use the correct procedures to remove and refit high energy electrical vehicle system components 5.4. Use appropriate procedures to reinstate the vehicle and confirm repairs successfully carried out 5.5. Reset vehicle systems post-repair
6. Be able to record information and make suitable recommendations	6.1. Complete records accurately, in the format required 6.2. Make suitable recommendations based on the results of post replacement inspections

Evidence Requirements	
You **must be observed by your assessor** completing **all** of the following tasks **on at least one occasion.**	
1.	Disconnecting and reconnecting a high energy system battery
2.	Removing and refitting a high energy system component

Unit Content	Assessment Criteria
The correct procedures required when removing and replacing electric/hybrid vehicle drive train system vehicle components could include: a. observation of H & S b. correct use of PPE c. correct use of tools and equipment d. correct use of tools and equipment e. following repair procedures f. following workplace procedures g. referral to manufacturer specific information The knowledge of disconnecting high energy supplies correctly should include: a. batteries b. motors c. cabling d. control units e. relays f. switches g. charging system h. circuit protection i. associated connectors j. auxiliary system components k. inverter Make the system safe prior to carrying out repairs should include: a. isolate/disconnect high energy system following manufacturer's instructions b. carry out appropriate checks following manufacturer's recommendations to ensure isolated system is safe (allowing discharge time for capacitance in disconnected circuits). High energy components that may be disconnected could include: a. high energy battery pack/modules b. charger c. battery management interface d. inverter e. air brake compressor f. power steering motor g. electric heating / air conditioning h. electric motor assemblies Low energy components that may be disconnected could include: Appropriate procedures to confirm repairs successfully carried out could include: a. on vehicle testing b. checking fault codes c. voltage/current checks d. use of specialist equipment e. wiring and cable routing integrity f. on road testing/drive cycling g. additional colleague / supervisor sign off (where required) Demonstrate the correct methods to reset vehicle systems post-repair could include: a. use of scan tools b. on board diagnostics c. use of specialist equipment d. driver display module e. instrument information/warning information	4.1-4.2

Records to be completed accurately, in the format required could include: a. manufacturer's set procedures b. job cards c. warranty records d. on line data transfer e. workplace internal records as a means of monitoring research and development Comparison of inspection and test results with suitable data could include: a. wiring diagrams b. repair instructions c. bulletins d. torque settings e. technical data f. research and development data Suitable recommendations based upon the results of carrying out the replacement activities could include: a. recommendations for further investigation and repairs b. recommendations for further replacement c. no further action required d. recommendations for customer Isolate and re-connect live high energy electrical supplies correctly e.g. batteries, capacitors and motors Reset vehicle systems post-repair e.g. clear fault codes	