Unit 7: Engine Electrical Charging and Starting Systems

NQF Level 3: **BTEC National**

Guided learning hours: 60

Unit abstract

The application of electrical technology in modern motor vehicle systems is under constant development. This has resulted in an ever-increasing electrical load being placed on a vehicle's charging and starting systems. This unit aims to develop learners' understanding of the processes and technology that support vehicle electrical systems. The unit will give learners the opportunity to determine faults in a vehicle's battery, charging and starting systems, identify and confirm the specific component that has failed and undertake suitable rectification procedures.

Learners will investigate the chemical process within a battery and understand how to specify a battery for a particular vehicle. They will also gain an understanding of the operation and conversion of energy within the charging and starting systems of a modern motor vehicle. The unit will enable them to apply this knowledge to both charging and starting systems and undertake diagnostic and rectification work on a range of vehicles.

Learning outcomes

On completion of this unit a learner should:

1 Be able to specify a battery for a given motor vehicle application

2 Understand a vehicle's starting system

3 Understand a vehicle's electrical charging system

4 Be able to diagnose and rectify engine electrical system faults on a vehicle's charging and starting systems.

Unit content

1 Be able to specify a battery for a given motor vehicle application

Chemical processes of lead acid batteries: chemical to electrical conversion, water to electrolyte process eg charge and discharge cycles, use of chemical symbols, changes to specific gravity and components chemical state; health and safety eg gases produced, acid content

Battery performance and construction: performance eg cold cranking amperage, amp/hour rating (10/20 rating); construction eg casing, plates (lead dioxide and spongy lead), separators; connections eg series/parallel, vehicle earthing, corrosion protection; electrolyte eg sulphuric acid, distilled water; battery calculations eg amp/hour system requirement, cold cranking usage, plate area, maximum load; battery specification eg manufacturer's recommendations, type, make, performance; specify battery by comparing system calculations/performance tests to battery capabilities

2 Understand a vehicle's starting system

Function of starting system: energy conversion eg electrical to mechanical rotation, rotational to linear translation; starter solenoid eg provide mechanical movement by use of electro-magnetic application; ignition key/push button switch eg provide timely electrical supply to starting system; principles of starter, motor eg conversion of electrical energy to mechanical movement, creation and use of magnetic effect to create mechanical movement (Fleming's left hand rule)

Starting system components: electrical supply (battery); circuit protection methods eg fuse, immobiliser, key recognition, relay; ignition switch eg key or manual operation; wiring looms; warning system eg visual and audible; solenoid; starter motor assembly eg casing, magnets, armature, brush box, gear, roller clutch drive

Circuit diagrams: switched supply system; permanent feed system; recognition of circuit components/circuit symbols; types of circuit diagrams eg use of workshop manuals, manufacturer's diagrams, wiring diagrams and schematics

3 Understand a vehicle's electrical charging system

Voltage generation, rectification and regulation: function of generator eg alternator to create electro-motive-force using Fleming's right hand rule; system components eg stator, rotor, rectifier, voltage regulator, slip ring, brushes, bearings, cooling fan; warning device; bridge rectifier; drive belts eg single- or multi- 'V' design

Multi-phase electrical output: principles of three-phase electricity eg excitation, magnetic inductance, sinusoidal pattern, full wave rectification; use of oscilloscope to observe wave patterns; AC-DC voltage conversion

4 **Be able to diagnose and rectify engine electrical system faults on a vehicle's charging and starting systems**

Battery tests and faults: testing eg relative density, battery capacity, condition testing; equipment eg hydrometer, multimeter, dedicated test equipment, inductive amp clamp; typical battery faults eg dead cell, shorting out, low specific density, failing under heavy discharge, physical damage (overcharged causing heat distortion, corrosion/degradation, mechanical damage/defects)

Starting system tests and faults: system operation; circuit testing eg continuity, feed, voltage drop; component test eg ignition switch, solenoid operation, starter motor operation and internal components (armature, brushes, windings, circuit protection eg relays, overload relay, immobiliser); use of test equipment eg multimeter, dedicated test equipment, oscilloscope, inductive amp clamp; typical starting system faults eg internal short on armature, failed solenoid operation, inhibitor switch failed

Charging *system tests and faults*: system operation; circuit testing eg continuity, feed, voltage drop; component test eg diodes, bearings, rotor, windings; output test eg voltage, current, waveform; typical charging system faults eg diode failure (indicator light on), faulty voltage control (overcharging), bearing fault (noisy or excessive free play), faulty brush box/rotor (no charge); use of test equipment eg multimeter, dedicated test equipment, oscilloscope, inductive amp clamp

Grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all of the learning outcomes for the unit. The criteria for a pass grade describes the level of achievement required to pass this unit.

Grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 explain the chemical processes of a lead acid battery P2 perform calculations to select a battery, based on performance and construction, for a given motor vehicle application P3 explain the function of the components and operating principles of a vehicle's starting system P4 use a circuit diagram to identify the electrical components of a vehicle's starting system P5 explain the process of voltage generation and regulation for a given vehicle application P6 describe the application of multi-phase electrical output in relationship to a vehicle's charging system	M1 compare the performance characteristics of two different batteries M2 justify the choice of starting system diagnostic tests and rectification methods M3 justify the choice of charging system diagnostic tests and rectification methods.	D1 evaluate the engine electrical systems of two different vehicles in terms of the ease of carrying out diagnostic and rectification procedures.

Grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P7 carry out diagnostic tests to identify two different vehicle battery faults P8 carry out diagnostic tests and rectification of two different vehicle starting system faults P9 carry out diagnostic tests and rectification of two different vehicle charging system faults.		

Essential guidance for tutors

Delivery

Before starting this unit learners should, ideally, have an understanding of the fundamentals of each system to be considered. This may have come from previous study (eg BTEC First Diploma Unit 2: Vehicle Electrical and Electronic Principles) or hands-on experience within the industry. Learners should at least be able to identify the components of the systems covered (battery, starting system, charging system) and have an appreciation of the need to carry out diagnostic and repair procedures to rectify system faults. Where learners do not have this level of understanding centres will need to ensure that sufficient underpinning knowledge is provided before delivering the unit content.

The unit would be best delivered using a practical, hands-on approach. For example, a laboratory demonstration of the chemical processes within a battery for learning outcome 1 and the evaluation of changes in the electrolyte and the state of charge within each cell. Most of the delivery of the unit will rely on the use of rigs or vehicles to aid learners' understanding of both starting and charging systems. This is particularly important with such concepts as mechanical movement created by magnetic influence on components, commutation applications and flawed actuation as a direct result of a failed component.

All practical work should reflect both current industry practice and also consider the benefits of covering a range of industry applications (eg 6/12/24 volt systems) for specific groups.

Learners will be required to apply some mathematical and scientific skills throughout the unit. Therefore when planning the delivery of this unit, tutors may need to consider the timing of delivery with respect to other units that support the skills required.

Assessment

Assessment evidence is most likely to be gathered from practical work on vehicles and test rigs. Tutors will need to provide or simulate a range of system faults on vehicles to ensure authenticity of individual evidence for large groups of learners. Work-based evidence of the application of theory and fault-finding skills would also be acceptable.

P1 and P2 are linked and should be assessed together. For P1, learners will need to explain the chemical processes of a lead acid battery. In particular this should consider the chemical to electrical conversion, water to electrolyte process and relevant health and safety issues when working with a battery.

P2 requires learners to be able to consider the performance and construction of a battery for a given or chosen vehicle application. When considering performance, learners should typically look at the impact of cold cranking, other draws on the power of the battery (eg the demand from modern computer and security systems when the vehicle is idle) and issues such as amp/hour rating. When looking at construction, learners should be considering the battery's casing, plates and separators. They will also need to include how connections are achieved and electrolyte is used. The essential aspect of this criterion will be the learners' ability to perform the required battery calculations and establish the required battery specification for the application. It is expected that learners will draw from and make suitable references (eg manufacturer's recommendations, types, makes and performance capabilities) when specifying the battery and use their system calculations/performance tests to determine battery capabilities.

The assignment used for P1 and P2 could be extended to cover M1. This will require learners to compare the performance characteristics of two different batteries. One of the batteries used could be the one already dealt with for P2 and compared against another (completely different) battery.

A second assignment could be used to cover P3 and P4. This will require learners to explain the function of the components and operating principles of a vehicle's starting system (P3). The components to be covered include the battery, circuit protection methods, ignition switch, wiring looms, warning system, solenoid, starter and motor assembly. The explanation should consider the relevant energy conversion methods (eg electrical to mechanical rotation, rotational to linear translation), the operation of the starter solenoid and ignition key/push button switch and the operating principles of the starter motor. In explaining the function of components learners could also identify them using a circuit diagram in order to achieve P4.

P5 and P6 can also be linked with learners covering both the processes involved in voltage generation, rectification and regulation and the application of multiphase output. For P5, learners will need to provide suitable explanations of the function of a generator, relevant system components and the related drive belts. P6 requires learners to describe the application of multi-phase electrical output in relationship to a vehicle's charging system. This should include the general principles of multi-phase electrical output, the use of an oscilloscope to observe wave patterns (screen shots or sketches may be used to evidence the patterns observed under specific conditions), and the application of AC-DC voltage conversion in a vehicle setting. The assessment evidence for P6 should be firmly linked back to the task set for P5 to enable the learner to cover.

P7, P8 and P9 will require learners to demonstrate their practical skills with respect to diagnostic tests and rectification for batteries, starter and charging systems. P7 requires learners to carry out diagnostic tests to identify two different vehicle battery faults. Assessment of rectification is not required as this would simply mean replacing the faulty battery. However P8 and P9 will require learners to carry out both diagnostic tests and rectification of two different vehicle starting system faults and two different vehicle charging systems.

The assessment of P7 could be linked back to P1 and P2. Typical battery faults might include dead cell(s), shorting out, low specific density, failing under heavy discharge or physical damage. Learners will need to select and use suitable equipment when carrying out the diagnostic tests.

For P8 and P9, the diagnostics tests should consider the respective system operation, appropriate circuit testing and component tests. The rectification procedures should be completed and systems checked to confirm integrity. Appropriate work records should also be completed.

It is likely that relevant observation records/witness statements will form the evidence of learners using a range of equipment for each system to confirm diagnosis before undertaking rectification. A short report (or logbook entry) outlining the details of the diagnostic procedures carried out would also be expected. The report does not have to be a full technical report but should reflect industry practice of reporting back to supervisor/customer. To ensure authenticity centres will need to provide a variety of faults so that each learner is able to carry out a series of diagnostic and rectification procedures unique to them.

The practical activities carried out for P8 and P9 will link directly with M2, M3 and D1.

To achieve M2 and M3, learners must be able to justify the choice of starting and charging system diagnostic tests and rectification methods used (on each of the of the two different vehicle system faults for each criterion), respectively.

For D1, learners should be able to evaluate the engine electrical systems of two different vehicles in terms of the ease of carrying out diagnostic and rectification procedures. The systems considered could be the same ones used for P8 and P9.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

The unit provides some of the knowledge and understanding associated with the Automotive Skills Level 3 National Occupational Standards in Vehicle Maintenance and Repair, particularly:

- Unit MR06: Inspect Vehicles
- Unit MR07: Diagnose and Rectify Vehicle Engine and Component Faults
- Unit MR11: Overhaul Mechanical Units.

This unit supports, and is supported by *Unit 1: Operation of Vehicle Systems*, *Unit 3: Vehicle Fault Diagnosis and Rectification* and *Unit 6: Vehicle Electrical and Electronic Principles*.

Essential resources

Learners will need to be given access to suitable motor vehicle workshop facilities. This should include equipment for working with dangerous acids, voltage generation equipment and test equipment including oscilloscopes. A range of components and vehicles should be provided as well as a variety of data sources and technical information.

Indicative reading for learners

Denton T — *Automobile Electrical and Electronic Systems* (Butterworth-Heinemann, 2004) ISBN 0750662190

Hillier V and Coombes P — *Hillier's Fundamentals of Motor Vehicle Technology* (Nelson Thornes, 2006) ISBN 0748780998

Key skills

Achievement of key skills is not a requirement of this qualification but it is encouraged. Suggestions of opportunities for the generation of Level 3 key skill evidence are given here. Tutors should check that learners have produced all the evidence required by part B of the key skills specifications when assessing this evidence. Learners may need to develop additional evidence elsewhere to fully meet the requirements of the key skills specifications.

Communication Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• selecting materials and researching information (eg safety, maintenance and diagnostic data) • explaining operating principles and functions of vehicle electrical systems and components.	C3.2 Read and synthesise information from at least **two** documents about the same subject. Each document must be a minimum of 1000 words long. C3.3 Write **two** different types of documents each one giving different information about complex subjects. One document must be at least 1000 words long.
Problem solving level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• undertaking diagnostic procedures and attributing symptoms to faults.	PS3.1 Explore a problem and identify different ways of tackling it. PS3.2 Plan and implement at least one way of solving the problem. PS3.3 Check if the problem has been solved and review your approach to problem solving.