Unit 3: Vehicle Fault Diagnosis and Rectification

NQF Level 3: BTEC National

Guided learning hours: 60

Unit abstract

Although technological advances have led to increasingly reliable mechanical, electrical and electronic vehicle systems, for a variety of reasons these systems still fail. When a fault develops it is more important than ever from an operational, safety and often a legal standpoint, to carry out a quality repair.

This unit aims to provide learners with the skills, knowledge and understanding needed to recognise fault symptoms, apply fault diagnosis and rectification procedures and confirm system integrity, in a range of vehicle systems.

Learners will be expected to diagnose and undertake work on faults in vehicle mechanical and electrical/electronic systems regardless of the manufacturer or vehicle type (eg light or heavy vehicle, passenger carrying vehicle, motorsport vehicles). Learners will identify, select and use a range of diagnostic tools and equipment, checking that they are in a safe and useable condition before use.

For the purpose of this unit, a fault may be considered to be a component failure or system malfunction relating to mechanical or electrical and electronic systems, individually or in combination.

When diagnosing faults, learners will need to work in a logical manner, working to instructions obtained from appropriate sources. Safe working practices and good house-keeping will be a recurrent theme throughout the unit.

Learning outcomes

On completion of this unit a learner should:

1 Be able to identify vehicle system faults

2 Be able to select and use diagnostic equipment and procedures to identify and confirm faults

3 Understand alternative rectification procedures

4 Be able to rectify faults and confirm system integrity.

Unit content

1 **Be able to identify vehicle system faults**

Mechanical system: systems eg engine (such as pistons, belts, chains, bearings, shafts), ancillary systems (such as fuel, lubrication, cooling), transmission (such as clutch, torque converter, gearbox, rear axle, differential), steering and suspension, braking; faults eg internal engine component failure, failed head gasket, failed seal, fuel blockage, contamination (such as oil, fuel, coolant, hydraulic and pneumatic fluid), non-starting, low/high oil pressure, faulty coolant system, clutch malfunction, damaged clutch linkages, bearing failure (such as engine, clutch, pump, rear axle/differential), selector mechanisms malfunction, gear selection difficult, faulty torque converter hydraulic components, worn gear, worn drive shaft/joint, misalignment (such as drive shafts, steering/suspension), defective steering/suspension components, inoperative braking system (such as faulty caliper, worn disc); symptoms eg unusual sounds, noisy bearings, leaks, smoke, metallic particles in lubricants, loss of power, exhaust gas contamination, misfire, engine overheating/overcooling, water contamination, clutch (such as slip, grab, judder, difficult selection), vibration, unusual tyre wear, poor brake efficiency, brake noise and judder, braking imbalance, excessive brake pedal travel, poor road handling, oversteer, understeer

Electrical/electronic system: systems eg starting, charging, ignition, lighting and auxiliary, control systems (such as electronic, instrumentation, engine); faults eg starting system sluggish or non-operational, battery faults, alternator malfunctioning, diode faults, electronic control not working, fuse problems, damaged or loose wire, inoperative ignition components, ignition timing faults, inoperative systems, headlamp misalignment, instrumentation malfunction, driver information malfunction, engine management malfunction, chassis control system malfunction (such as ABS, stability control, transmission control), security and alarm systems failure; symptoms eg noisy operation, no charge, over charging, short circuit, open circuit, misfire, non-starting, incorrect information, inaccurate displays, confused control

2 **Be able to select and use diagnostic equipment and procedures to identify and confirm faults**

Preparation: regulations eg Provision and Use of Work Equipment Regulations (PUWER) 1998, Control of Substances Hazardous to Health (COSHH) Regulations 2002, Lifting Operations and Lifting Equipment Regulations 1998, Manual Handling Operations Regulations 1992, Personal Protective Equipment at Work Regulations 1992, Confined Spaces Regulations 1997, Electricity at Work Regulations 1989, Control of Noise at Work Regulations 2005, Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) 1995, Health and Safety (First Aid) Regulations 1981, motorsport specific; positioning eg use of ramps, jacks, stands; vehicle protection eg covers, sheeting; component/system access eg removal of bodywork, fairings and covers, removal of excessive oil, dust, grease and dirt, competition/road debris

Diagnostic equipment: mechanical equipment eg dial gauges, micrometers, feeler gauges, pressure gauges, temperature gauges, diagnostic analysers, emission testers, auto transmission test equipment, steering geometry and suspension alignment equipment, wheel balancing and brake testing equipment; electrical and electronic equipment eg meters, multimeters, oscilloscopes, diagnostic analysers, data logging/self-diagnosis equipment, emissions testers, computer systems

Diagnostic procedures: reference to considerations of safety and vehicle/system protection; procedures eg visual, aural, performance monitoring, road and roller tests, procedures used with electrical, electronic and systems diagnostic equipment; assessing vehicle information systems and data in a variety of formats eg workshop manuals, diagnostic information, CD ROMs, IT-based data retrieval systems and fault code analysers

3 **Understand alternative rectification procedures**

Rectification procedures: eg

- dismantling, inspection and assessment: comparison against specifications (manufacturer, vehicle data, auto data, computer-based systems), factors influencing rectification choice (operational, cost, safety and legal requirements)
- adjustments: associated with the range of vehicle systems, manufacturers' specifications (tolerances, operational limits), safety, performance and legal considerations
- replacement: using new, overhauled and factory or third party reconditioned components and units
- repair: in-house or third-party specialist repair options, comparison of cost of replacement/repair including consideration of service life expectancy, reliability and warranty status
- substitution/alteration: use of adapted, redesigned or re-engineered components and/or units and effects of substitution (based on comparisons of specifications, manufacturers' bulletins, safety and service recommendations)

4 Be able to rectify faults and confirm system integrity

Rectify faults associated with mechanical systems: eg engine and ancillary systems, transmission, steering, wheels and tyres, suspension and braking systems

Rectify typical faults associated with electrical/electronic systems: eg starting, charging, ignition, lighting and auxiliary systems, vehicle instrumentation, driver information, engine management, chassis control (such as ABS, stability control, transmission control), security and alarm

Equipment: hand tools; MOT equipment; product specific equipment; for mechanical systems eg measuring equipment, analysers, on-board diagnostics, alignment equipment, balancing equipment; for electrical/electronic systems eg scanning equipment meters

Documentation to confirm system integrity: carry out testing and compare results against manufacturers' specifications and data; legal requirements; performance test data

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 identify faults on four different systems (two mechanical and two electrical), on each of two different vehicles from given symptoms P2 select, prepare and use appropriate diagnostic equipment and procedures to diagnose faults on four different systems (two mechanical and two electrical) on each of two different vehicles P3 describe a different rectification procedure for each of two different faults, one fault on each of two different mechanical systems P4 describe a different rectification procedure for each of two different faults, one fault on each of two different electrical/electronic systems	M1 justify the use of the equipment chosen to diagnose selected system faults with reference to the expected accuracy of the results obtained M2 describe the advantages and disadvantages of two diagnostic procedures including the use of dedicated test equipment M3 justify the selection of a rectification procedure in terms of safety, cost, performance and legal considerations.	D1 analyse a system's test results and recommend actions needed to rectify problems D2 review one vehicle diagnostic and rectification procedure carried out and make recommendations for improvement.

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:**
P5 carry out rectification procedures on two different faulty mechanical systems, conforming with manufacturers' specifications and safety and legal requirements P6 carry out rectification procedures on two different faulty electrical/electronic systems, conforming with manufacturers' specifications and safety and legal requirements P7 use appropriate equipment, procedures and documentation to confirm system integrity.		

Essential guidance for tutors

Delivery

Learners will need an understanding of the purpose, function, and principles of operation of specific vehicle components and systems before starting this unit. Tutors will need to consider this level of prior knowledge and skills carefully considered before starting to deliver this unit.

The delivery approach used should be sufficiently varied to provide learners with the underpinning knowledge and skills needed to assist with fault-finding operations on any vehicle type.

Emphasis should be placed on developing practical diagnostic and rectification skills. Videos, simulations and rigs will be effective learning aids, since provision of 'live' examples of the range of system faults is likely to be impracticable. Learners should be given opportunities to compare the advantages and disadvantages of alternative procedures. It is therefore strongly recommended that most of the unit is delivered in a relevant workshop environment using practical investigation and appropriate equipment, rigs, units, components and vehicles.

The four learning outcomes are ordered logically and could be developed sequentially through practical demonstration and practice. This will help learners understand the logic and routine behind effective fault-finding and rectification procedures before attempting to diagnose and rectify the faults themselves.

The best way for learners to develop fault identification and diagnostic skills is to practise the procedures involved. Although an understanding of rectification procedures is needed for learning outcome 3 it may be best to develop this understanding through practical use. This may mean that the majority of time is devoted to the practical requirement of learning outcomes 1, 2 and 4.

Although the unit content attempts to range faults and symptoms it is appreciated that in some cases faults will actually be symptoms and in some cases symptoms will be faults. If this is explained during delivery if it then occurs during assessment learners will feel confident about what they are doing.

The use of 'eg' is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Assessment

This unit is likely to be assessed through a combination of assignments and practical workshop investigations. These will develop learners' investigative skills and can provide opportunities to develop key skills.

It is expected that learners will have carried out practical work on vehicles to support the underpinning knowledge. Evidence will include test data, printouts and records of the diagnostic procedures carried out. These records may be witness statements/observation records supplemented by annotated photographs.

The emphasis in this unit is on developing practical fault diagnostic and rectification skills across a range of mechanical and electrical/electronic vehicle systems. Learners should be given opportunities to diagnose typical faults, recommend repair strategies and carry out fault rectification, based on diagnostic information and other criteria such as safety, cost and operational and legal requirements. It is expected that learners will be given opportunities to use and compare alternative diagnostic procedures and equipment in practical situations.

To achieve P1, learners should identify faults on two mechanical and two electrical systems, on each of two different vehicles from given symptoms. It is likely that only one symptom for each fault will be sufficient. However it may be beneficial to learners if more symptoms can be given or arranged. This means there will be a total of eight faults to identify.

For P2, learners will need to prepare two vehicles for diagnostic checking and identify the faults prior to rectification. Learners should be able to select and access sources of data to help with the fault diagnosis and also select, prepare and use the appropriate diagnostic equipment to carry out the tasks.

To achieve P3 and P4, learners need to describe rectification procedures for different faults on two mechanical systems and two electrical/electronic systems. Although the rectification procedures described for the two electrical/electronic systems or two mechanical systems need to be different, procedures described for P3 can be used again in P4. The rectification strategies described could relate back to the different faults identified for P2.

For P5 and P6, learners will apply their knowledge by carrying out the rectification process, conforming with the manufacturer's specifications, safety and legal requirements, for two different mechanical and two different electrical/electronic systems.

When confirming system integrity for P7, the equipment that could be used is ranged within the unit content under learning outcome 4, although other equipment, such as that listed under learning outcome 2 as diagnostic equipment, is also appropriate. Confirmation of system integrity should include comparing results against manufacturers' specifications and data, legal requirements and performance test data.

Throughout the assignments it is expected that each of the faults will be on different systems and may be on different vehicles at different times. The vehicles could, however, be of the same type (eg both goods vehicles or motorsports vehicles if this is appropriate) or different types. The intention is to give learners experience of a diverse range of vehicle system faults across different vehicles so that they have the opportunity to satisfy all the grading criteria with sufficient depth and rigour.

To achieve M1, learners should justify the use of the equipment selected to diagnose system faults, with reference to the expected accuracy of the results obtained.

This should demonstrate learners' ability to progress from knowing how to select and use the equipment to justifying the reasons for using the correct equipment and possible consequences of not doing so. A task to do this could be set after the activities for P1 and P2 have been carried out.

For M2, learners should identify and describe the advantages of alternative diagnostic procedures, including the use of dedicated test equipment within the context of the fault diagnosis being carried out. Opportunities for this could be provided after P2 has been achieved. Learners should also be able to justify the selection of a rectification procedure (M3) in terms of safety, cost, performance and legal considerations. Again a task could be set after P3, P4 and P5 have been carried out. All responses to tasks set for the merit criteria are likely to be in the form of written outcomes.

To achieve a distinction, learners should analyse test results and recommend actions needed to rectify the problems associated with systems and components (D1). Learners will also need to review a diagnostic and rectification procedure and make recommendations for improvement (D2). These criteria can be met through responses to written tasks after all pass criteria have been carried out and data obtained from the practical tasks for D1.

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

This unit supports, and can be linked with, any of the practical systems-based units in the qualification.

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

- Unit AE 4: Diagnose and Rectify Engine Electrical Faults
- Unit AE 6: Diagnose and Rectify Auxiliary Equipment Electrical Faults
- Unit MR 6: Inspect Vehicles
- Unit MR 7: Diagnose and Rectify Vehicle Engine and Component Faults
- Unit MR 8: Diagnose and Rectify Vehicle Chassis System Faults
- Unit MR 11: Overhaul Mechanical Units
- Unit MR 13: Diagnose and Rectify Vehicle Transmission and Drive Line System Faults
- Unit MR 58: Setting up Motorsport Vehicles
- Unit MR 59: Carrying out Motorsport Vehicle Inspection During Competition
- Unit MR 62: Removing and Refitting Suspension Systems on Motorsport Vehicles
- Unit MR 63: Removing and Refitting Braking Systems on Motorsport Vehicles

- Unit MR 64: Removing and Refitting Steering Systems on Motorsport Vehicles
- Unit MR 65: Removing and Refitting Chassis Sub Assemblies and Components on Motorsport Vehicles
- Unit MR 66: Removing and Refitting Fuel Systems on Motorsport Vehicles
- Unit MR 67: Carrying out Fault Diagnosis and Rectification Activities on Motorsport Vehicles
- Unit MR 69: Removing and Refitting Electrical/Electronic Equipment on Motorsport Vehicles.

Essential resources

A range of vehicle types and equipment are needed for the delivery of this unit. This will include manufacturer/vehicle-specific equipment (eg for engine management, ABS, security and other advanced systems) and non-manufacturer/vehicle-specific equipment (eg meters, oscilloscopes). A variety of data sources will also be required to support the range of vehicles, systems, equipment and procedures used.

Indicative reading for learners

Bonnick A — *Vehicle Electronic Systems and Fault Diagnosis* (Butterworth-Heinemann, 2004) ISBN 0340706309

Chowanietz E — *Automotive Electronics* (Butterworth-Heinemann, 1995) ISBN 0750618787

Hillier V A — *Fundamentals of Automotive Electronics, 2nd Edition* (Nelson Thornes, 1996) ISBN 0748726950

Nunney M J — *Light and Heavy Vehicle Technology* (Butterworth-Heinemann, 2006) ISBN 0750680377

Whipp J — *Transmission, Chassis and Related Systems* (Thomson Learning, 2001) ISBN 186152806X

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.

Problem solving Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• using appropriate equipment, procedures and documentation to confirm system integrity.	PS3.3 Apply agreed methods to check if the problem has been solved, describe the results and review your approach to problem solving.