

Unit 16: Heavy Vehicle Transmission Systems

NQF Level 3: BTEC National

Guided learning hours: 60

Unit abstract

This unit will give learners an understanding of the design, constructional details and fundamental operating principles of a range of transmission systems currently fitted to heavy vehicles.

The unit covers the conventional aspects of heavy vehicle transmission systems, their function, principal components and operating principles. This will include a detailed examination of a heavy vehicle's clutch mechanism, its gearbox and the driveline and final drive systems.

Learners will be introduced to recent developments in the use of electronics for the control and operation of transmission systems in a range of heavy vehicles. These developments are frequently integrated into the overall electronic management of the vehicle and can provide significant improvements in terms of driveability, economy and performance. Learners will appreciate the fundamental operating principles of these electronic systems, their integration within transmission systems and their significance in the maintenance of a vehicle's transmission system.

Learners will carry out specific tests and checks to identify transmission system faults such as clutch slip, gearbox linkage problems and failing universal joints. They will use these tests and checks, together with the use of on-board diagnostic equipment to maintain a vehicle's transmission system. This will include maintenance requirements relating to driver/passenger safety and component reliability, whilst ensuring that learners works in a safe manner.

Learning outcomes

On completion of this unit a learner should:

- 1 Understand the construction and operation of a heavy vehicle clutch mechanism
- 2 Understand the construction and operation of a heavy vehicle gearbox
- 3 Understand the construction and operation of a heavy vehicle driveline system and final drive
- 4 Be able to maintain a heavy vehicle's transmission system.

Unit content

1 Understand the construction and operation of a heavy vehicle clutch mechanism

Principal clutch components: pressure plate, disc, flywheel (including bearings and bushes); release bearings; release systems eg production vehicle servo mechanisms, air assisted clutch release mechanism

Types of clutch mechanisms: eg production clutches (coil and diaphragm spring, single plate, multi-plate wet and dry types), automatic clutches (torque converter, fluid flywheel, one way clutch)

Operating principles of clutch: constructional design and use of materials (linings, drive plates and friction surfaces, springs); engagement and disengagement of clutch (single and multi-plate, one way clutches, clutch brakes and automatic clutches); provision for adjustment/self-adjustment; torque calculations and coefficient of friction; power flow; common faults eg wear, misalignment; fault symptoms (slip, drag, judder, overheating); fluid flywheels

2 Understand the construction and operation of a heavy vehicle gearbox

Principal gearbox components: gear design (spur and helical); bearings, shafts, casing, selector and sealing arrangements; gear locking and interlock mechanisms; gear speed synchronisation and engagement mechanisms eg sliding mesh, synchromesh and dog type

Types of gearboxes: eg manual (single stage, double stage, sliding mesh, constant mesh, twin layshaft); auxiliary gearbox, eg splitter gearboxes, range change gearboxes automatic and semi-automatic (epicyclic gear train, hydraulic control systems); layout eg transverse, longitudinal and transaxle

Operating principles of gearbox: manual gearbox – gear ratios, power flow eg constant mesh single and double stage; torque and speed calculations; gear characteristics eg ratio, number of available gears, suitable gear ratios to enable hill climbing ability; gear selection and engagement methods eg synchromesh and dog type, selector forks, interlocks and linkages, remote control mechanisms, automatic gearbox – torque converters (lock-up mechanism); epicyclic gear trains (simple and compound); brake bands; multi-plate and unidirectional clutches; power flow paths; function of key hydraulic components (pump, governor, actuators, servos, regulator and shift valves); electronic control system including mode selection; electronic selection of conventional gear arrangements; lubrication eg method (splash and pump assisted); oil requirements and types (mineral, synthetic); seals and sealing arrangements (static and dynamic types)

3 Understand the construction and operation of a heavy vehicle driveline system and final drive

Principal components of driveline system: propeller shaft arrangement eg single, divided (use of centre bearings); driveline arrangements eg front, rear twin and all wheel drives; universal joints eg Hooke type and rubber; constant velocity joints, sliding joints; drive systems eg two-wheel, four-wheel (transfer box, centre differentials, viscous couplings, differential locks, automatic and manual)

Principal components of final drive: axle types and support arrangements eg live and independent, single and twin-drive axles; final drives eg bevel, spiral, worm and wheel, hypoid and double reduction; differentials eg planetary gears, limited slip systems; axle types eg three quarter, fully floating and double reduction hub arrangements; bearings and drive shaft loadings

Operating principles of driveline: universal joints (Hooke type and rubber); constant velocity joints (angular limitations and conditions required to achieve constant velocity, basic consideration of balance requirements, alignment and torque capacity of hollow and solid shafts); suspension and transmission characteristics giving rise to the requirement for sliding joints and centre propshaft bearings

Operating principles of final drive: gear ratio, speed reduction and torque multiplication in the final drive; final drive arrangements for transaxles; driving thrust and torque reaction; differential (effects on torque/speed at the driven wheels, limited-slip differentials); lubrication methods (final drive and rear axles); oil requirements and types (mineral, synthetic); oil seals and sealing arrangements (static and dynamic)

4 Be able to maintain a heavy vehicle's transmission system

Transmission system faults: eg clutch (slip, drag, judder, loss of drive, excessive noise, wear, misalignment, operating mechanism faults), gearbox (gear selection, oil leaks, linkages and fittings), driveline and final drives (prop/drive shafts, universal and constant velocity (CV) joints, bearings, gaiters and seals), use of on-board diagnostic (OBD) equipment, reporting methods (inspection records, oral report to supervisor)

Maintenance operations: working to manufacturers' maintenance and service procedures eg manuals, job cards, direct supervision; maintenance operations eg clutch adjustments/alignment, gearbox oil change, gear selection linkage repair, driveshaft gaiter condition check/replacement, security of mountings and fittings; context of the maintenance operations eg routine maintenance, repair or adjustment due to a system failure, alternative service procedures for adverse condition (vehicles operating in dry, dusty environments and vehicles working in extreme temperature environments)

Critical safety considerations: procedures relating to maintenance operations carried out eg materials handling (protection against dust, oil and chemical exposure), vehicle and system protection (application of four-wheel drive diff locks, lifting and supporting vehicles), personal protective equipment (PPE), control of substances hazardous to health regulations (COSHH), component and environmental waste disposal

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 and describe the function of the principal components of two different types of clutch mechanism	M1 compare two different heavy vehicle clutch types in terms of their principal components and operating principles	D1 justify the use of a specific clutch type for two different heavy vehicle applications in terms of purpose, function and performance
P2 explain the operating principles of one type of clutch	M2 explain the advantages and disadvantages of increasing the number of available gears in a heavy vehicle's gearbox	D2 justify the use of a specific type of driveline and final drive arrangement for two different heavy vehicle applications in terms of purpose, function and performance.
P3 identify and describe the function of the principal components of one type of gearbox	M3 compare two different heavy vehicle driveline and final drive arrangements.	
P4 explain the operating principles of two different types of gearbox		
P5 identify and describe the principal components in a heavy vehicle driveline and final drive		
P6 explain the operating principles of a heavy vehicle's driveline and final drive arrangement		

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:
<p>P7 inspect a heavy vehicle's transmission system, report faults and attribute symptoms to the faults identified</p> <p>P8 carry out a maintenance operation on a heavy vehicle's transmission system</p> <p>P9 explain and apply critical safety considerations relating to the inspection and maintenance of a heavy vehicle's transmission system.</p>		

Essential guidance for tutors

Delivery

This unit can be delivered in the context of learners' chosen areas (eg heavy vehicle or passenger vehicle), although a generic approach would be equally suitable. The term 'maintenance' in this unit is used in a generic way and can be taken to mean either routine maintenance (a regular service) or less routine work (a repair due to a component failure or adjustment to correct a misalignment).

Delivery of this unit would ideally be a balance of theoretical and practical study. Whatever approach is taken, learners' experience should be sufficiently varied to provide them with the knowledge and skills needed to perform routine heavy vehicle workshop operations. In addition, learners need to develop the skills and understanding needed to diagnose transmission system faults in an industrial setting. Health and safety considerations should be emphasised whenever learners undertake practical activities.

The learning outcomes could be delivered in the order they are listed. In this way, learners will gain a progressive understanding of the function and operating principles of the relevant parts of the power train from the clutch (through the gearbox and driveline) to the final drive.

Learners should be introduced to a range of clutches used on modern heavy and passenger carrying vehicles. However, centres may wish to focus on a specific clutch type to meet local needs and cover the others in a more general way. The approach taken with clutches could be replicated with gearboxes, driveline and the final drive. However, centres should ensure that learners gain a sufficient understanding of all types and delivery should not be limited to just the one or two required to meet the assessment criteria.

For the final learning outcome learners will need access to heavy vehicles and workshop facilities. The delivery of this part of the unit could consist of lectures to introduce the transmission system and likely faults, learner-led research into the maintenance requirements followed by practical application on vehicles in the workshop. Again, learners should experience a range of routine maintenance operations in line with those suggested in the unit content.

During practical work, the critical safety aspects of each operation should be emphasised. Learners should be encouraged to recognise and explain these aspects of safety during their practical workshop activities on the various parts of the transmission systems to reinforce the importance to themselves and to others.

The use of a record of practical work carried out during the delivery phase of the unit should be standard practice. This is likely to be in the form of a workshop logbook. This will enable learners to capture and reflect on their experience and will provide support and guidance during the activities chosen for the final assessment.

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

Assessment

This unit provides opportunities for assessment evidence to be generated from a combination of assignments, projects and practical work. Centres may wish to devise some written tests that require learners to explain, compare or justify as required by the criteria. However, although the pass criteria require learners to identify and explain by providing descriptive evidence, it is not expected that centres will only use tests to achieve this. The unit lends itself to an investigative, practical approach and this should be reflected in the assessment strategy wherever possible. The range of evidence presented could include notes, diagrams, investigative test data, the records of the maintenance and diagnostic procedures carried out plus tutor observation and oral questioning.

Proving authenticity and guarding against plagiarism can be a problem, particularly with open, written assignments. The assessment of P1 to P6 is particularly suited to, and could be carried out through, either 'on-the-job' oral questioning/observation, or through a written time constrained assessment. Both of these methods can assure high levels of authenticity. P7, P8 and P9 require individual practical work and as such are less problematic when it comes to authenticity. Centres should note however, that whichever method is chosen, they will need to ensure that each criterion and its related content is met in full.

To achieve a pass, learners will need to identify and describe the function of the principal components of two different types of heavy vehicle clutch mechanisms (P1), one type of gearbox (P3) and a heavy vehicle's driveline and final drive (P5). In addition, learners need to explain the operating principles of one of the clutches (P2), two types of gearbox (P4) and one heavy vehicle's driveline and final drive (P6).

The content for each of these areas (clutches, gearboxes, driveline/final drives) provides a range of choices through the examples listed. For clutches, this includes production single and multi-plate and automatic, and within these groupings there are further examples. Centres are expected to cover as wide a range of these as possible during delivery of the unit but need only select the one or two of these, as indicated by the criteria, for assessment purposes. This will enable centres to concentrate on a specific specialisation as the main focus of assessment (eg computer-aided gear changing).

Where a criterion identifies that learners must consider two types this is to ensure that the learning process is sufficiently wide. For example, whilst a centre may specialise in goods vehicles it is important that learners are equally aware of a light commercial vehicle's clutch. The purpose is to make sure that learners' employment potential is not limited. The range of choices available should mean that for any one group, each learner could be considering the function of the principal components for a different type of vehicle and clutch type. This can be beneficial when considering the issues that surround authenticity of evidence.

P7 and P8 would be best assessed through investigation and practical examination of a live vehicle layout and configuration. P9, the explanation of critical safety considerations, should be an integral part of the assessment for P7 and P8. It is strongly recommended that the 'explain' part of P9 is assessed before learners start work on either P7 or P8. The assessment evidence for P9 could be in two forms. Firstly, a written assessment of the critical safety considerations relating to the inspection and maintenance operation to be carried out followed by oral questioning to ensure an understanding of the dangers associated with the task before starting work.

A suitable transmission system fault may need to be simulated for P7 and learners provided with the typical symptoms of the fault, as would be reported by a driver of the faulty vehicle. Assessment of this criterion is likely to be in three parts: a written inspection record completed by learners at the time of the inspection, a verbal report back to the supervisor/customer (tutor record of oral questioning/observation) and tutor observation of the process (eg use of logical and efficient diagnostic techniques, safe working).

A similar approach could be taken with P8 and it would be sensible to link these two criteria together - identify the fault and carry out the maintenance operation to effect the necessary adjustment or repair.

The main assessment evidence for P8 is the final product – the completed maintenance task. However, a record of tutor observation will also be necessary to cover the process aspects of the task (eg working to the manufacturer's procedures, correct and safe working). The final link is with P9 and the application of critical safety considerations relating to the maintenance operation being carried out. For example, tutors will need to observe the learner handling materials correctly, using relevant system protection, using appropriate PPE, working to COSHH regulations and correctly disposing of waste, as required by the task undertaken.

To achieve a merit, learners need to compare the constructional differences of two different clutch types (eg production diaphragm spring and a coil spring type). The two clutches could be the same as those considered for P1, or if centres wish to encourage learners to have a wider experience then one or two completely different clutches could be used. The focus of the comparison should be based on the understanding developed through P1 and P2. Learners must also be able to explain the requirement of multiple gear ratio applications (eg splitter gear box and range change gearboxes giving multiple ratios, 8 speed versus 10 speed) to provide the necessary hill climbing ability. Finally, they need to compare two different heavy vehicle driveline and final drive arrangements (eg longitudinal, in line versus transverse or rear engine, rear wheel drive versus rear engine four-wheel drive). Again, one of these could be the driveline and final drive considered for P5 and P6.

To achieve a distinction, learners need to justify the use of a specific clutch type (D1) and justify the use of a specific type of driveline and final drive arrangement (D2) for two different heavy vehicle applications in terms of purpose, function and performance. Once again, these could be the same clutches, driveline and final drives that the learner worked with through the pass and merit criteria.

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

This unit provides some of the knowledge and understanding for the Level 3 National Occupational Standards in Vehicle Maintenance and Repair, particularly:

- Unit MR 13: Diagnose and Rectify Vehicle Transmission and Driveline System Faults
- Unit MR 13HV: Diagnose and Rectify Commercial Vehicle Transmission and Driveline System Faults.

The unit also builds on the knowledge gained from *Unit 1: Operation of Vehicle Systems* and supports *Unit 3: Vehicle Fault Diagnosis and Rectification*.

Essential resources

Learners will need access to a range of transmission types (clutches, gearboxes and driveline/final drives) and their components for this unit. A variety of information and data sources specific to the transmission systems will also be required. The necessary special tools and equipment will be needed for the investigations and routine maintenance operations on the selected transmission systems as defined in the unit content and grading criteria.

Indicative reading for learners

Denton T – *Advanced Automotive Fault Diagnosis* (Butterworth-Heinemann, 2006)
ISBN 0750669918

Heisler H – *Advanced Vehicle Technology* (Butterworth-Heinemann, 2002)
ISBN 0750651318

Hillier V – *Hillier's Fundamentals of Motor Vehicle Technology* (Nelson Thornes, 2004) ISBN 0748780823

Nunney M J – *Light and Heavy Vehicle Technology* (Butterworth-Heinemann, 1998)
ISBN 0750638273

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.

Application of number Level 3	
When learners are:	They should be able to develop the following key skills evidence:
<ul style="list-style-type: none"> researching information on the range of gear ratios used on a typical heavy vehicle gearbox using vehicle data to carry out multi-stage calculations to verify the gear ratio steps using geometric progression formulae interpreting the results of their calculations and presenting findings and justifying their methods. 	<p>N3.1 Plan an activity and get relevant information from relevant sources.</p> <p>N3.2 Use this information to carry out multi-stage calculations to do with:</p> <ul style="list-style-type: none"> a amounts or sizes b scales or proportion c handling statistics d using formulae. <p>N3.3 Interpret the results of your calculations, present your findings and justify your methods.</p>
Communication Level 3	
When learners are:	They should be able to develop the following key skills evidence:
<ul style="list-style-type: none"> selecting materials and researching information on vehicle transmission systems (eg safety, maintenance and diagnostic data) explaining the operating principles of vehicle clutches, gearboxes, drivelines and final drives. 	<p>C3.2 Read and synthesise information from at least two documents about the same subject.</p> <p>Each document must be a minimum of 1000 words long.</p> <p>C3.3 Write two different types of documents each one giving different information about complex subjects.</p> <p>One document must be at least 1000 words long.</p>

Information and communication technology Level 3	
When learners are:	They should be able to develop the following key skills evidence:
<ul style="list-style-type: none"> • searching for information on specific heavy vehicle transmission systems • preparing and presenting technical reports on the various aspects of heavy vehicle transmission systems and their components and arrangements • completing maintenance documents and records. 	<p>ICT3.1 Search for information, using different sources, and multiple search criteria in at least one case.</p> <p>ICT3.2 Enter and develop the information and derive new information.</p> <p>ICT3.3 Present combined information such as text with image, text with number, image with number.</p>
Improving own learning and performance Level 3	
When learners are:	They should be able to develop the following key skills evidence:
<ul style="list-style-type: none"> • researching, planning and carrying out diagnostic and maintenance procedures • evaluating maintenance, diagnostic and repair strategies. 	<p>LP3.1 Set targets using information from appropriate people and plan how these will be met</p> <p>LP3.2 Take responsibility for your learning, using your plan to help meet targets and improve your performance</p> <p>LP3.3 Review progress and establish evidence of your achievements</p>

Problem solving Level 3	
When learners are:	They should be able to develop the following key skills evidence:
<ul style="list-style-type: none"> carrying out diagnostic procedures and attributing symptoms to faults. 	<p>PS3.1 Explore a problem and identify different ways of tackling it.</p> <p>PS3.2 Plan and implement at least one way of solving the problem.</p> <p>PS3.3 Check if the problem has been solved and review your approach to problem solving.</p>
Working with others Level 3	
When learners are:	They should be able to develop the following key skills evidence:
<ul style="list-style-type: none"> researching, planning and carrying out diagnostic and maintenance procedures with colleagues and supervisors reviewing maintenance, diagnostic and repair strategies with colleagues and supervisors. 	<p>WO3.1 Plan work with others.</p> <p>WO3.2 Seek to develop co-operation and check progress towards your agreed objectives.</p> <p>WO3.3 Review work with others and agree ways of improving collaborative work in the future.</p>