Unit 15: Heavy Vehicle Braking Systems

NQF Level 3: BTEC National

Guided learning hours: 60

Unit abstract

This unit will enable learners to gain an understanding of the operating principles of heavy vehicle braking systems. The unit will develop learners' knowledge and understanding of the specialist braking systems found on heavy vehicles, public service vehicles and plant.

Learning outcome 1 will introduce learners to air compression and storage for heavy vehicle braking systems. This will include the operation of the air supply and storage components, together with the function and operation of pressure protection devices such as pressure regulating valves, switches and sensors.

Learning outcomes 2 and 3 will introduce learners to the actuation, control and operation of heavy vehicle braking and auxiliary braking systems. Learners will gain an in-depth understanding of the function and operation of the components used for these systems.

The final learning outcome will provide hands-on experience of maintaining a heavy vehicle's braking system safety in accordance with legal requirements. This will include familiarising learners with relevant safety precautions such as braking efficiency, brake balance and pressure build-up time. Learners will also be introduced to the legislation and regulations that apply to heavy vehicle braking systems.

Learners will apply maintenance procedures including drum/disc brake adjustment, brake tests, leakage tests, pressure monitoring and the maintenance of appropriate maintenance records.

Learning outcomes

On completion of this unit a learner should:

1 Understand the compression and storage of air for a heavy vehicle braking system

2 Understand the actuation and control of heavy vehicle air brakes

3 Understand the operation and application of a heavy vehicle auxiliary braking system

4 Be able to maintain the safety of a heavy vehicle's braking system in accordance with legal requirements.

Unit content

1 **Understand the compression and storage of air for a heavy vehicle braking system**

Air supply: air filter eg induction manifold, inlet filter; air compressor eg method of drive, single/twin cylinder, liquid/air cooled air compressor, internal unloading mechanisms; air drier eg single/twin tower air drier, purge tanks; electronic air processing system (APS) eg integrated air driers, multi-circuit protection valves, electronic control to adjust reservoir charge pressures; antifreeze system eg alcohol evaporator/injector, heater units on air drier components; safety valve eg location and reasons for fitting; pressure control system eg governor valve and integral un-loader mechanisms in compressor and air drier units, remote un-loader valve

Air storage: number and size of air reservoirs; testing and inspection; factors that affect serviceability

Pressure protection: circuit pressure control and monitoring valves eg single and double check valves, pressure regulating valve, pressure protection valve (single and multi), automatic drain valves; warning devices eg low pressure warning devices, pressure gauges, pressure switches and pressure sensors

2 **Understand the actuation and control of heavy vehicle air brakes**

Actuation system: air brake actuators eg single, double and spring brake units (diaphragm and piston types), methods used to release spring tension in the absence of air pressure; parking brake systems eg remote and integrated spring brake units, application with drum and disc brake units; brake clearance adjustment eg slack adjuster (manual and automatic), foundation brake expander mechanisms (wedge, S-cam, strut (Z-cam), disc brake); auxiliary air valves eg quick release valves, solenoid valves, test couplings, manual release valves, exhaust silencing devices; safety precautions and procedures eg risks associated with compressed gas, trapping hands in actuation mechanisms

Control system: foot valve eg single and dual units, position within the pneumatic circuit; hand control valve eg up-right and inverse pressure types, position within pneumatic circuit; relay valve eg function and operation, single and multi-input relay valves, trailer control valve, trailer emergency relay valve, supply dump valve; pressure protection systems eg brake protection valve (for use with vehicles using load sensing and air suspension); interlock valve eg spring brake-parking protection in the event of parking brake lever set in OFF position on the air pressure build up causing the brakes to release; electronic control of air braking eg principles associated with electronic braking systems (EBS), anti-lock braking system (ABS), electronic stability programmes (ESP) and traction control (anti-spin regulation (ASR))

Full air and air/hydraulic braking systems: full air system eg service and secondary circuits; split and dual braking systems employing upright and inverse air pressure, differential protection systems for drum brakes employing spring brake units; load sensing valves eg mechanically and pneumatically actuated, adjustment and testing; spring brakes applied to trailers (parking brake circuits); anti-jack knife devices eg causes of jack-knifing, methods to reduce the occurrence, controlled fifth wheel coupling, use of anti-lock braking on tractor drive axle; vehicle configuration eg two-axle and multi-axle layouts (including air suspension, pneumatic circuits, convention for port labelling), 2-line drawbar and articulated vehicle systems

Air over hydraulic braking systems: eg hydraulic circuit interfaced with air pressure circuits, hydraulically operated expander mechanism, hydraulic tandem master cylinder with air assistance, hydraulic load sensing valves, arrangement of parking brake, use of remote spring brake and application compliance with trailers using full air braking systems

3 **Understand the operation and application of a heavy vehicle auxiliary braking system**

Engine auxiliary brake: exhaust manifold and engine compression types; operational cycle, construction (method used to cut fuel injected), effectiveness

Transmission auxiliary brake: hydraulic retarder eg remote and integral construction with gearbox, control system, arrangements for cooling; friction retarder and provision for cooling; electric retarder eg principles (using eddy current braking with reference to Lenz's law), control system, effects of heat generation on the operational efficiency, method used to dissipate heat energy

4 **Be able to maintain the safety of a heavy vehicle's braking system in accordance with legal requirements**

Safety precautions: braking efficiency eg definition, calculation of braking efficiency from data (service, secondary and parking brake test); brake balance eg definition from testers' manual, calculation of brake balance from data obtained under test; pressure build-up time eg definition, test procedure, likely causes of poor build-up performance

Legal requirements: major legal documents affecting heavy vehicle braking standards eg Motor Vehicles (Construction and Use) Regulations (including community directives), Goods Vehicles (Plating and Testing) Regulations, Public Service Vehicles (Condition of Fitness, Equipment, Use and Certification) Regulations

Maintenance: drum/disc brake adjustment; brake test eg roller brake testers, use of retardation meter under road test conditions; leakage test eg pressure loss over set time, use of leak detection device/fluids; pressure monitoring eg checking load sensing valve settings, pressure balance on dual footbrake valves, operation of the trailer control valve dump function, trailer relay emergency valve operation; maintenance records eg legal requirements to keep and store records, paper-based records, use of wall charts, service sheets, defect notices, prohibitions, computer-based service and maintenance logging

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 describe the operation of the air supply and storage components of a heavy vehicle high pressure braking system P2 describe the function and operation of the pressure protection components within a heavy vehicle's pressure storage system P3 describe the function and operation of the components used for the actuation and control of a full air braking system P4 describe the function and operation of a braking system using air/hydraulic control P5 explain the operation of an engine auxiliary braking system P6 explain the operation of a transmission auxiliary braking system	M1 describe the construction of the air supply and storage components of a high pressure braking system for a heavy vehicle M2 compare and contrast the construction, operation and application of a heavy vehicle full air braking system with that of an air/hydraulic system M3 compare and contrast the application and effectiveness of an engine-activated auxiliary braking system with that of a transmission type auxiliary braking system.	D1 evaluate data derived from a braking system test and identify the required maintenance procedure D2 explain the effect that two different wear or maladjustments may have on the effectiveness and legality of a heavy vehicle's braking system.

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 explain the safety precautions and legal requirements for a heavy vehicle brake system P8 describe the main requirements for heavy vehicle braking systems maintenance P9 carry out and record the results of a drum/disc brake adjustment and one other heavy vehicle braking system maintenance procedure.		

Essential guidance for tutors

Delivery

It is expected that learners will have a working knowledge of general vehicle systems, such as the theory associated with vehicle braking and various foundation brake configurations including leading, trailing, twin leading and disc brakes. It is important that learners understand the methods used to operate the major braking systems used on vehicles. They also need an understanding of heavy vehicle suspension and steering systems so that they appreciate the connection between the applications of air braking technology and air suspension.

It is recommended that this unit is delivered using a balance of theoretical and practical study. Learners should have access to manufacturers' technical information that uses the current port numbering convention. Systems and operating principles are best demonstrated using a combination of vehicles, air brake demonstration rigs and components.

Tutors will need to ensure that learners have an appreciation of the safety and legal aspects relevant to compressed air braking systems.

Practical workshop sessions should develop learners' ability to carry out accurate brake testing and to deal with combinations of system faults which may affect more than one system on the same vehicle. More complex system faults, including air-braking systems that use electronic control and computer-based fault diagnosis could be introduced where practical, or possibly be demonstrated through the support of a vehicle manufacturer or main dealer.

The order in which the learning outcomes are delivered is largely dependent on the level of prerequisite knowledge of various related topics. However, most centres are likely to consider the compression and storage of air first. Included within this section are aspects of air brake technology associated with servicing and maintenance. Examples include air driers, alcohol injection systems, reservoir charging times and predominant charging of specific circuits. The legal requirements imposed on heavy vehicle systems can also be covered in part.

It is anticipated that most learners will have access to live heavy vehicles to work with or to at least observe the basic charging process. Where centres do not have access to running vehicles then it may be possible to organise a group demonstration with a local vehicle dealer or operator.

Actuation and control of air braking systems are best covered using an integrated approach of theory and practice. Testing of individual valves and components on training rigs will help learners identify the main characteristics. Integrated theory and practice sessions will enable a step-by-step approach for learners to assemble complete air braking circuits.

The use of training rigs, where learners have to connect valves and pipes to assemble the circuit, is probably the most effective method to assimilate the circuit and valve configuration. During these practice sessions it would be appropriate to demonstrate simple faults and fault-finding techniques that relate closely to basic servicing and maintenance. For example, air leaks from pipes and unions or air leaks from exhaust ports on an operating valve.

Factors that affect vehicle stability and control (such as jack-knifing) can be demonstrated by using simple vehicle models, locking axles or individual wheels and observing their behaviour when rolling down a slight gradient. The task can be made into a simple learner exercise which reinforces the more abstract concepts associated with stability of rigid and articulated vehicles.

An introduction to the operating principles of vehicle retarders, such as the eddy current type, can be covered by practical observation of the effects of eddy current formation on a non-ferrous disc rotating within an electromagnetic field. This can be extended to observe the effects of increasing the current flowing through the electromagnet. Learners should then progress onto an actual retarder, relating the theory associated with Lenz's law and the retarder's operation. Engine braking, hydraulic and friction retarders can similarly be explained in terms of the principles providing the retarding forces and the requirements to dissipate substantial heat energy once in operation.

Where centres do not have access to a roller type vehicle brake tester then they are advised to arrange a visit to a test station, local vehicle dealer or operator for a demonstration. This will significantly help to reinforce the concept of vehicle braking efficiency to stated minimum legal limits.

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

A range of assessment methods can be used and it likely that evidence will be collected from a combination of activities/assignments, investigative projects and practical work.

Assignments and projects should be designed to develop learners' basic knowledge of braking systems and provide opportunities to assess their understanding of system testing. Centres may also consider the use of periodic short tests. These could comprise short answer questions or set-piece workshop tasks that enable learners to demonstrate specific aspects of the required practical skills. A variety of assessment strategies should be used to give learners the opportunity to demonstrate their full ability and to add diversity to the subject and learning environment.

Learners should be encouraged to carry out research and use a range of resource materials during their investigations. Tutors should provide guidance on how material can be referenced and used as part of learners' own work so as not to infringe guidelines on authenticity of evidence.

For P1, learners should describe the operation of the main components used for the compression and storage of air. This can be achieved with the aid of suitably labelled circuit/component diagrams and/or copies of manufacturers' diagrams (whether redrawn/sketched by the learner or electronically copied). Electronically copied diagrams are acceptable provided learners have annotated the work adequately, the source of the information is acknowledged and they are used to aid learners' own description.

Having achieved P1 learners could extend their description of the operation of a high pressure braking system to include the system's construction to meet the requirements M1.

P2 can be linked with P1, as learners need to describe the function and operation of the pressure protection components within a heavy vehicle's pressure storage system. The braking/storage system could be the same for both criteria. Learners should describe the circuit pressure control, monitoring valves and warning devices that apply to the system being considered. The description should include a clear indication that learners have understood the need to use a pressure protection system. In particular, learners must appreciate that failure of one circuit or device might result in the loss of pressure and so adversely affect the level of vehicle safety.

P3, P4, P5 and P6 relate to the different heavy vehicle braking systems. This section is likely to form the core of the unit assessment strategy and provide most of the underpinning knowledge and understanding needed for the other criteria.

For P3, learners need to describe the function and operation of the components used for the actuation and control of a full air braking system (service and secondary circuits). Learners should make use of circuit and component diagrams to support their description of full air braking systems (including trailers). They should also draw from the actuation and control system components listed in the unit content, as appropriate to the system considered. The operation of the major control valves should include reference to how the progressive control of braking is obtained. Descriptions of multi-function valves should include both normal operation and situations where failure of individual circuit(s) may occur.

For P4, learners need to describe the function and operation of an air/hydraulic control braking system. This should include a clear description of how air pressure is used to generate large hydraulic pressure at the wheel cylinders plus the operation of the parking brake using air/hydraulic systems.

There is an opportunity to link the work carried out at pass level with the merit criteria. To achieve M2, learners need to use their understanding from P3 (a full air braking system) and P4 (an air/hydraulic system) to compare and contrast the construction, operation and application of the two systems as used on heavy vehicles. The comparison should consider aspects such as the types of compressor, internal and external un-loading methods, air driers including the electronic controlled air processing systems (APS) and the storage arrangements for each system.

For P5, learners need to explain the operation of an engine auxiliary braking system. It is expected that they will be able to comment on the manner in which the vehicle energy of motion is converted by the engine to provide a retarding force.

To achieve P6, learners need to explain the operation of a transmission auxiliary braking system, including the method of energy absorption and dissipation. Learners should provide an explanation of a system's hydraulic retarder, friction retarder or electric retarder and any related provision for cooling/heat dissipation for a given or chosen system.

Learners could extend the work done for P5 and P6 by comparing the application and effectiveness of an engine-activated auxiliary braking system with that of a transmission type auxiliary braking system, in order to meet the requirements of M3.

For P7, learners need to explain the safety precautions and legal requirements for a heavy vehicle braking system. They must identify the major legal documents affecting the vehicle relating to the braking system being considered. It is expected that the work for this criterion will be linked to that undertaken when considering the braking systems in P3, P4, P5 and P6.

It is expected that P8 and P9 will be linked. Learners should first describe the requirements for heavy vehicle braking systems maintenance, before carrying out and recording the results of a drum/disc brake adjustment and one other braking system maintenance procedure. The second procedure should be selected from those listed in the unit content — a brake test, leakage test or pressure monitoring.

Evidence for both criteria is likely to be the learner's log of the procedures carried out together with a description of the system's maintenance requirements. The work will also require verification by a competent assessor, whether carried out in the learner's workplace or the centre's workshop. This verification will provide further evidence of learners' achievement and is likely to be in the form of a record of observation. Annotated photographic evidence can also be used to record the stages of the maintenance procedure, tools, environment, etc.

Both distinction criteria link with the last three pass criteria, particularly the practical aspects of P9. However, learners will need to draw on their understanding of all the pass criteria to achieve D1 and D2. Learners should evaluate data derived from a braking system test and identify the required maintenance procedure to meet the requirements of D1.

For D2, learners must explain the effects that two different maladjustments or excessive wear faults can have on the effectiveness and legality of a heavy vehicle braking system.

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

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

- Unit MR 06: Inspect Vehicles
- Unit MR 08HV: Diagnose and Rectify Commercial Vehicle Chassis System Faults.

The unit also supports the following units in the Level 3 SEMTA National Occupational Standards in Automotive Engineering:

- Unit 4: Assembling Sub-Assembly Units to Vehicles
- Unit 8: Assembling Braking Systems to a Vehicle
- Unit 45: Conducting and Monitoring Static Tests on Vehicles
- Unit 52: Fitting Pipework Systems to Commercial and Passenger Carrying Vehicles.

The unit can be linked to *Unit 1: Operation of Vehicle Systems*, *Unit 3: Vehicle Fault Diagnosis and Rectification* and *Unit 17: Heavy Vehicle Steering and Suspension Systems*.

Essential resources

Centres will need to provide learners with access to vehicle workshop facilities equipped to deal with heavy vehicles. A range of heavy vehicle braking components and rigs will also need to be available.

Indicative reading for learners

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

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

The Stationery Office — *Road Vehicles (Construction and Use) Regulations* ISBN 0110670787

The Stationery Office — *The Goods Vehicles (Plating and Testing) Regulations* ISBN 011087478

The Stationery Office — *The Public Service Vehicles (Condition of Fitness, Equipment, Use and Certification) Regulations* ISBN 011016257

Vehicle and Operator Services Association (VOSA) — *Vehicle Testing Manuals and Guides:*

- *HGV Inspection Manual*
- *Preparing Your HGV for Brake Tests — A Best Practice Guide*

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:**
• planning how to capture results from heavy vehicle braking system maintenance procedures, take measurements and record results • carrying out calculations to determine braking efficiency and brake balance • interpreting and present braking efficiency and brake balance data.	N3.1 Plan an activity and get relevant information from relevant sources. N3.2 Use this information to carry out multi-stage calculations to do with: a amounts or sizes b scales or proportion c handling statistics d using formulae. N3.3 Interpret the results of your calculations, present your findings and justify your methods.
Communication Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• researching the function and operation of the range of braking systems • reading maintenance manuals to plan maintenance procedures • describing the function and operation of the range of braking systems • recording the results of brake tests, maintenance procedures and reporting findings.	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.

Information and communication technology Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• researching, developing and presenting reports, projects or assignments on the functions and operation of braking systems • preparing maintenance procedure reports.	ICT3.1 Search for information, using different sources, and multiple search criteria in at least one case. ICT3.2 Enter and develop the information and derive new information. ICT3.3 Present combined information such as text with image, text with number, image with number.