

Unit 9: Understanding and Servicing Mechanical Power Transmission Systems

Unit code:	M/601/4263
QCF Level 3:	BTEC National
Credit value:	10
Guided learning hours:	60

● Aim and purpose

This unit aims to introduce learners to mechanisms and methods of transmitting mechanical power in land based vehicle and machine drivelines and how knowledge of this can be applied in practice. It is designed for learners in centre-based settings looking to progress into the sector or onto further/higher education.

The aim of this unit is for learners to familiarise themselves with mechanisms and methods of transmitting mechanical power in land based vehicle and machine drivelines.

● Unit introduction

The need to maintain land-based machinery in prime operating condition has become increasingly important as profit margins are squeezed and down time becomes a costly, non-recoverable expense. Those working on land-based machinery, either in an engineering or a mechanisation role, must have the necessary knowledge and practical skills to maximise machine life and reliability. They must also minimise down time by carrying out repair and overhaul tasks safely and efficiently.

In this unit learners will develop the knowledge and skills needed to service, maintain, diagnose faults, repair and overhaul the fundamental components common to many land-based machines.

Learning outcome 1 looks at the construction and function of mechanical power transmission systems and components, developing an understanding of their application and function.

In learning outcome 2 learners will develop an understanding of the limitations of the components and how they can fail once these limitations have been exceeded through overload and misuse.

Machines will only continue to provide reliable service if they are maintained regularly to high standards and this is the focus for learning outcome 3. Learners will gain hands-on experience of the range of tasks associated with the maintenance of mechanical power transmission systems.

Learning outcome 4 gives learners the practical skills needed to carry out repair and overhaul tasks effectively following failure. Learners will develop an awareness of contributory factors, outside of the mechanical power transmission component, that may have caused the system to fail. When a machine goes wrong it is essential that the fault is corrected to a high standard and in a safe and efficient manner.

● Learning outcomes

On completion of this unit a learner should:

- 1 Know the types of components used to transmit mechanical drives
- 2 Understand drive system limitations and use
- 3 Be able to service and maintain mechanical drive systems
- 4 Be able to overhaul and repair mechanical drive systems that have failed.

Unit content

1 Know the types of components used to transmit mechanical drives

Construction, function and working principles of the commonly specified mechanical power transmission systems: shafts eg solid, tubular, various cross sections; couplings eg rigid shaft couplings, Hooke's type universal joint (UJ), constant velocity joint; gears eg spur gears, bevel gears, worm and wormwheel, rack and pinion, epicyclic; belts eg 'Vee', wedge, flat, banded 'vee', poly 'vee', toothed, segmented; chains eg roller, rollerless, pintle, hook, cranked link, silent; bushings eg split types, solid or sleeve types, thrust; bearings eg ball, roller, needle roller, radial load, thrust load, radial/thrust load; springs eg open and closed coil, leaf, conical, Belleville, torsion; seals and gaskets eg dynamic seals, radial lip seals, exclusion seals, 'O' rings, face seals, compression packings, static seals for metallic and non metallic gaskets, sealants, sealing tapes; overrun devices eg spragg, inclined plane, centrifugal, roller type; torque limiting devices eg multiplate slip clutch, serrated face clutch, shearbolt; fixings hardware eg keys and keyways, taper locks, circlips, roll pins, split pins, lynchpins; common uses for different types of mechanical power transmission systems; factors affecting choice of mechanical power transmission systems eg cost, reliability, strength

2 Understand drive system limitations and use

Drive system component limitations: component types and causes of failure eg shafts due to bearing failure, couplings due to lack of maintenance, gears due to contaminated lubrication and bearing failure, belts due to lack of tension and overloads, chains due to poor maintenance, bushings and bearings due to seal failure, contaminated lubricant and lack of adjustment, springs due to overheating, wear and being extended beyond their elastic limit, seals and gaskets due to heat, internal pressures and incorrect fitting, overrun devices due to operator engaging power take-off (PTO) at high revolutions per minute (RPM) and allowing machine to idle with PTO engaged, slip clutches due to wear, poor maintenance and continual overloading, fixings hardware due to lack of component security or inappropriate application

3 Be able to service and maintain mechanical drive systems

Health and safety: issues eg dust, heat, sharp edges, contact with machinery, stored energy, heavy loads; relevant, current legislation; risk assessment; personal protective equipment (PPE)

Sources and types of service information: sources eg manufacturers, libraries; types eg maintenance schedules, operator manuals, workshop technical literature

Maintenance tasks: types (inspection, cleaning, lubrication, guarding, component security)

Adjustments to manufacturers' recommendations: types eg belt and chain tension, bearing preload and endfloat, spring tension and compression, torque limiter settings

4 Be able to overhaul and repair mechanical drive systems that have failed

Health and safety: issues eg dust, heat, sharp edges, contact with machinery, stored energy, heavy loads; relevant current legislation; risk assessment; PPE

Technical information: types eg workshop manuals, operator manuals, technical specification sheets

Repair and overhaul tasks: tasks (inspection, stripping down, assessing component failure, rebuilding, adjusting and testing)

Repair and overhaul strategies: strategies eg replacement, repair, re-manufacture; factors affecting choice of strategy eg economic, serviceability of related components, cause of original component failure

Assessment and grading criteria

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

Assessment and 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 function of a given range of mechanical transmission components [IE, CT, SM]	M1 for a selected range of mechanical power transmissions find an alternative and report on the strengths and weaknesses of both	D1 evaluate different overload protection devices used to protect mechanical transmission components, for their effectiveness and their usability
P2 identify any faults or wear areas on a range of mechanical transmission components [IE, CT, TW, SM]		
P3 select from the range of components, items that would make up a complete mechanical drive system and describe how the system operates [IE, CT, SM]		
P4 from a selected range of mechanical transmission systems, state the possible factors resulting in the manufacturers choosing that system [IE, CT, SM]		
P5 explain the limitations of different types of mechanical drive systems [IE, CT, SM]	M2 report on how chosen mechanical drive systems have changed for chosen land based operations over the last 50 years and why	
P6 compare reasons as to where different systems are suited and unsuitable [IE, CT, SM, RL]		

Assessment and 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 carry out an assessment of possible risks prior to performing service and maintenance tasks to the mechanical drive systems on land-based vehicles and machines [IE, CT, SM]</p>	<p>M3 discuss why it is important to record details of all service and repair work done to the mechanical drive systems on land based vehicles</p>	<p>D2 evaluate the costs (lost time and lost production) to the end user of servicing and repairing mechanical drive systems on at least three different land based vehicles.</p>	
<p>P8 following manufacturer's guidelines, carry out periodic maintenance and adjustments on mechanical transmission systems [IE, CT, SM]</p>			
<p>P9 produce service tasks to suit the transmissions maintained detailing all critical adjustments and measurement data [IE, CT, SM]</p>			
<p>P10 report on possible implications due to incorrect maintenance and adjustments to each system</p>			
<p>P11 produce a plan of work to outline the procedure to be adopted for the removal of a mechanical transmission unit from a land-based vehicle or machine in preparation for overhaul or repair</p>			<p>M4 evaluate whether any repairs made could have been prevented by a different service regime or use of different mechanical drive systems.</p>
<p>P12 produce a risk assessment prior to performing practical removal, overhaul or repair procedures to a transmission unit</p>			
<p>P13 carry out a removal, overhaul and repair task on a mechanical land-based transmission unit and check the integrity of the unit on completion [IE, CT, SM, TW]</p>			

Assessment and 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:
P14 report the overhaul and repair process, specialised tools, equipment and materials used. [IE, CT, SM, RL, EP]		

PLTS: This summary references where applicable in the pass criteria, in the square brackets, the elements of the personal, learning and thinking skills. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers CT – creative thinkers	RL – reflective learners TW – team workers	SM – self-managers EP – effective participators
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Essential guidance for tutors

Delivery

Delivery of this unit will involve practical assessments, written assessment, visits to suitable collections and will link to industrial experience placements.

Tutors delivering this unit have opportunities to use as wide a range of techniques as possible. Lectures, discussions, seminar presentations, site visits, supervised mechanical power transmission practicals, research using the internet and/or library resources and the use of personal and/or industrial experience would all be suitable. Delivery should stimulate, motivate, educate and enthuse learners.

Work placements should be monitored regularly in order to ensure the quality of the learning experience. It would be beneficial if learners and supervisors were made aware of the requirements of this unit before any work-related activities, so that naturally occurring evidence can be collected at the time. For example, learners may have the opportunity to carry out servicing, maintenance, repair and overhaul tasks and they should be encouraged to ask for observation records and/or witness statements to be provided as evidence of this. Guidance on the use of observation records and witness statements is provided on the Edexcel website.

Visiting expert speakers could add to the relevance of the subject for learners. For example, land-based vehicle technicians or workshop managers could talk about their work, the situations they face and the methods they use.

Whichever delivery methods are used, it is essential that tutors stress the importance of carrying out maintenance and repair tasks safely and the need to manage the resource using legal methods.

Health and safety issues relating to working with power driven machinery must be stressed and reinforced regularly, and risk assessments must be undertaken before practical activities. Adequate PPE must be provided and used following the production of suitable risk assessments.

Tutors should consider integrating the delivery, private study and assessment for this unit with other relevant units and assessment instruments learners are taking as part of their programme of study.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan gives **an indication of the volume of learning it would take the average learner** to achieve the learning outcomes. It is **indicative and is one way of achieving the credit value**.

Learning time should address all learning (including assessment) relevant to the learning outcomes, regardless of where, when and how the learning has taken place.

Topic and suggested assignments/activities and/assessment
Component limitations.
Wearing components.
Construction of LBVTS.
Assignment 1: Construction Function, Use and Protection of Land-based Vehicle Transmission Systems (P1, P2, P3, P4, P5, P6, M1, M2, D1)
Assignment 2: Servicing of LBVTS (P7, P8, P9, P10, M3)

Topic and suggested assignments/activities and/assessment

Assignment 3: Removal, Repair and Reinstatement of LBVTS Components (P11, P12, P13, P14, M4, D2)

Evaluation of repairs and servicing.

Unit review.

Assessment

For P1, P2, P3 and P4, learners must identify components of selected mechanical power transmission systems and describe their construction and function. Learners should identify at least one component in each of the types listed in the unit content. Tutors should identify the systems or agree them through discussion with learners.

Learners must also describe the working principles of selected mechanical power transmission systems and components. Learners are expected to cover one example in each type of system and component listed in the unit content. These may be the same as those used to provide evidence for other grading criteria.

Learners must select from a minimum of three mechanical power transmission system and identify their components. They must state the factors that influence manufacturer choice of these selected mechanical power components to make complete transmission systems for a variety of applications. Where possible, task size and complexity should be the same for all learners.

P1, P2, P3 and P4 could be assessed directly by the tutor during practical activities. If this format is used then suitable evidence from guided activities would be observation records completed by learners and the tutor, and accompanied by appropriate work logs or other relevant learner notes. If assessed during a work placement, witness statements should be provided by a suitable representative and verified by the tutor. Alternatively, evidence could take the form of a pictorial presentation with notes (possibly using appropriate software or an overhead projector), an annotated poster or written assignment.

P5 and P6 require learners to explain the limitations of component parts which are commonly at fault when selected mechanical power transmission systems fail. Learners are expected to provide evidence for at least five mechanical power transmission systems. These may be the same as those used to provide evidence for other grading criteria. Learners are required to suggest the component part most at risk when the power transmission system fails.

Learners must compare the factors that make selected mechanical power transmission systems suitable and unsuitable for a variety of applications. Where possible, the task size and complexity should be the same for all learners. Learners are not expected to evaluate all the mechanical power transmission systems listed in the unit content but their evidence must cover bearings, chains, belts and torque limiting devices. Evidence could be in the same form as for P1.

P7, P8, P9 and P10 require learners to carry out routine inspection, maintenance, servicing and adjustment tasks, in accordance with recommendations made by the manufacturers, to selected mechanical power transmission systems.

A full written risk assessment must be carried out before any physical is carried out.

Learners must produce a work sheet detailing all service tasks, adjustments and data collected. This could be recorded as a log sheet or a service book.

Learners are also required to report on any possible implications resulting from poor maintenance and/or adjustment. It is expected that learners will provide evidence covering at least five different mechanical power transmission systems (which may be the same as those used to provide evidence for other grading criteria).

Tutors should identify the systems or agree them through discussion with learners. Where possible, to ensure fairness of assessment the size and complexity of the tasks should be the same for all learners. Learners are not expected to maintain and adjust all the mechanical power transmission systems listed in the unit content. However, evidence that they have carried out maintenance and adjustments on at least five mechanical power transmission systems, in accordance with manufacturers' recommendations, is required.

Learners should ensure they cover bearings, chains, belts and torque limiting devices. This could be assessed directly by the tutor during practical activities. If this format is used then suitable evidence from guided activities would be observation records completed by learners and the tutor, and accompanied by appropriate work logs or other relevant learner notes. If assessed during a work placement, witness statements should be provided by a suitable representative and verified by the tutor.

P11, P12, P13 and P14 require learners to plan and carry out routine repair and overhaul tasks to selected mechanical power transmission systems to meet given objectives. Tutors should identify the systems or agree them through discussion with learners. These may be the same as those used to provide evidence for other grading criteria. A full written report must be produced covering the exact process, tools, equipment and materials used. Where possible, to ensure fairness of assessment the size and complexity of the tasks should be the same for all learners. Learners are not expected to repair and overhaul all the mechanical power transmission systems listed in the unit content. However, evidence that they have carried out repair and overhaul tasks on at least five mechanical power transmission systems, in accordance with manufacturers' recommendations, is required.

Learners must carry out a risk assessment for selected maintenance, service or adjustment activities on selected mechanical power transmission systems. Learners are expected to provide evidence for three different activities. Tutors should identify the activities or agree them through discussion with learners. The activities may be the same as those used to provide evidence for other grading criteria. Where possible, to ensure fairness of assessment the size and complexity of the tasks should be the same for all learners. Evidence should be in a format that is recognised within the industry and by the Health and Safety Executive

This could be assessed directly by the tutor during practical activities. If this format is used then suitable evidence from guided activities would be observation records completed by learners and the tutor, and accompanied by appropriate work logs or other relevant learner notes. If assessed during a work placement, witness statements should be provided by a suitable representative and verified by the tutor. Alternatively, evidence could take the form of a pictorial presentation with notes (possibly using appropriate software or an overhead projector), an annotated poster or written assignment

For M1, learners to find and report on alternatives to power transmission components currently used in land-based systems. At least five alternative systems should be looked at, with their strengths and weaknesses highlighted. Tutors should identify the systems or agree them through discussion with learners. Their report could take the form of a pictorial presentation with notes (possibly using appropriate software or an overhead projector), an annotated poster or written assignment.

For M2, learners need to report on why and how machinery design for a set operation has changed, also understanding that the principles stay relatively the same. They need to compare three different operations and how they are carried out now and 50 years ago, Tutors should identify the systems or agree them through discussion with learners. The report can be presented in the same way as for M1.

For M3, learners need to discuss why it is important to record details of all service and repair work, including how it can be used at a future date and any risk assessment carried out. Three recording systems should be looked at and evaluated. Tutors should identify the systems or agree them through discussion with learners.

M4 carries on from M3 by looking at an actual service regime and evaluating whether using a different regime could have avoided a breakdown. Examples of three service schemes and breakdowns should be supplied by the tutor. The report can be presented in the same way as for M1.

For D1, learners need to evaluate different overload protection devices used to protect mechanical transmission components for their effectiveness and their usability. Five different overload devices must be looked at either chosen by the tutor or in discussion with the tutor. The report could take the form of a pictorial presentation with notes (possibly using appropriate software or an overhead projector), an annotated poster or written assignment.

D2 is a continuation of D1, looking at the cost involved in servicing and repairing land-based transmission components. These costs could be in terms of down time from breakdowns, lost production, the degradation of crops or lost time. Operation costs need to be known or worked out. The report can be presented in the same way as for D1.

Programme of suggested assignments

The following table shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, P3, P4, P5, P6, M1, M2, D1	Construction Function, Use and Protection of Land-based Vehicle Transmission Systems (LBVTS)	You are designing a transmission system. Select relevant components to build these systems, specifying their function, cost and performance. Highlight the limitations of the components, and evaluate available protection systems. Discuss how these components have evolved over the past 50 years.	Written report. Diagrams. Presentation.
P7, P8, P9, P10, M3	Servicing of LBVTS	Using three supplied transmissions, following manufacturers' guidelines, carry out periodic maintenance and full services. It is essential that a risk assessment is carried out before each task and recorded in the usual manner.	Service report sheet. Written risk assessment.
P1, P12, P13, M4, D2	Removal, Repair and Reinstatement of LBVTS Components	Remove, overhaul and repair selected transmission components. Before removal, a full plan of work should be produced, along with a written risk assessment. Once repaired, an evaluation of whether the breakage and/or wear could have been prevented should be made, along with the costs of repair and servicing (or not as the case may be) the LBVTS.	Practical. Written evaluation. Written risk assessment.

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

This unit forms part of the BTEC land-based sector suite. This unit has particular links with:

Level 2	Level 3
Land Based Engineering Operations – Applying Mechanical principles	Understanding and Working with Land-based Vehicle Engine Technology
Service and Repair Mechanical Transmissions on land based equipment	Service and Repair Powershift, Hydrostatic and/or CVT Transmissions on Land based Equipment

Essential resources

- Learners will need access to:
- transmission components
- complete transmissions
- workshop manuals, service manuals
- service consumables, and waste disposal facilities
- selection of relevant tooling.

Indicative reading for learners

Textbooks

Hathaway L and Riney L – *Bearings and Seals, (Fundamentals of Science Series) 5th Edition* (John Deere Publishing, 1992) ISBN 0866912274

Hathaway L and Riney L – *Belts and Chains, (Fundamentals of Science Series) 5th Edition* (John Deere Publishing, 1994) ISBN 0866911995

Hathaway L and Riney L – *Identification of Parts Failure, (Fundamentals of Science Series) 4th Edition* (John Deere Publishing, 1991) ISBN 0866911340

Hathaway L and Riney L – *Power Trains, 6th Edition* (John Deere Publishing, 1991) ISBN 0866911634

John Nix – *Farm Management Pocketbook* (The Anderson Centre) ISBN-10: 0954120140

Journals

Farmers Guardian

Farmers Weekly

Profi International

Websites

www.bagma.com

www.defra.gov.uk

www.howstuffworks.com

www.hse.gov.uk

www.iagre.org

www.lantra.co.uk

British Agricultural and Garden Machinery Association

Department for Environment, Food and Rural Affairs

HowStuffWorks

Health and Safety Executive

Institution of Agricultural Engineers

Lantra Sector Skills Council

Delivery of personal, learning and thinking skills (PLTS)

The following table identifies the PLTS opportunities that have been included within the assessment criteria of this unit:

Skill	When learners are ...
Independent enquirers	planning servicing and repair task efficiently analysing and evaluating construction of LBVTS
Creative thinkers	asking questions to extend their thinking during lectures and practical sessions exploring alternatives or new solutions to the construction of LBVTS identifying design ideas over time
Reflective learners	assessing their servicing/repair activities presenting findings of their evaluation of LBVTS reviewing progress in practical tasks and coursework
Team workers	working with others to carry out Servicing and repairs reaching clear agreements regarding who is carrying out which tasks during practicals
Self-managers	allocating enough time to carry out and clear up after practicals ensuring correct tooling and consumables are available
Effective participators	discussing issues of concern when servicing and repairing LBVTS identifying improvements to service records.

Although PLTS opportunities are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are ...
Independent enquirers	planning and carrying out research activities related to the unit evaluating and carrying out extended thinking
Creative thinkers	asking questions to extend their thinking during lectures and practical sessions trying out alternatives or new solutions to design and construction adapting ideas as circumstances change eg changes to health and safety legislation
Reflective learners	identifying opportunities for their own achievements setting goals for themselves eg planning practicals correctly reviewing progress in practical tasks and coursework
Team workers	working with others to report findings from servicing practicals reaching clear agreements regarding who is carrying out which tasks during practicals
Self-managers	showing initiative and commitment with machinery management, service and operation dealing with pressures in an emergency repair managing tool use and resource management correctly
Effective participators	discussing how poor maintenance can be improved or prevented.

● Functional Skills – Level 2

Skill	When learners are ...
ICT – Use ICT systems	
Select, interact with and use ICT systems independently for a complex task to meet a variety of needs	reporting activities from assessments to service reports
Use ICT to effectively plan work and evaluate the effectiveness of the ICT system they have used	producing work schedules and plans
Manage information storage to enable efficient retrieval	storing and retrieving assessments
Follow and understand the need for safety and security practices	recording risk assessments
Troubleshoot	using manufacturers' software and online manuals to diagnose problems
ICT – Find and select information	
Select and use a variety of sources of information independently for a complex task	finding online service procedures
Access, search for, select and use ICT-based information and evaluate its fitness for purpose	using manufacturers' software to find information
ICT – Develop, present and communicate information	
Enter, develop and format information independently to suit its meaning and purpose including: <ul style="list-style-type: none"> • text and tables • images • numbers • records 	producing service reports, LBVTS condition reports and vehicle health checks
Bring together information to suit content and purpose	producing assessments
Present information in ways that are fit for purpose and audience	producing reports
Evaluate the selection and use of ICT tools and facilities used to present information	computer, projector, large Monitor, Can-interaction tool, relevant software
Select and use ICT to communicate and exchange information safely, responsibly and effectively including storage of messages and contact lists	emailing written tasks.

Skill	When learners are ...
Mathematics	
Understand routine and non-routine problems in a wide range of familiar and unfamiliar contexts and situations	calculating mechanical advantage
Identify the situation or problem and the mathematical methods needed to tackle it	using mechanical advantage
Select and apply a range of skills to find solutions	Engineering, communication skills
Use appropriate checking procedures and evaluate their effectiveness at each stage	comparing to manufacturers' specification
Interpret and communicate solutions to practical problems in familiar and unfamiliar routine contexts and situations	presenting alternative solutions to repairs
Draw conclusions and provide mathematical justifications	evaluating the efficiency of LBVTS
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	verbally assessing LBVTS
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	using manufacturers' service/workshop manuals
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	writing and communicating assessments producing notes.