Unit 12: Applications of Mechanical Systems and Technology

NQF Level 3: BTEC National

Guided learning hours: 60

Unit abstract

Mechanical engineering is a term that covers a wide range of activities. Mechanical systems are found in land, sea and air transport, power generation, manufacturing plant and domestic products. The design, manufacture and maintenance of such systems is the concern of engineers and technicians who must be able to apply a blend of practical and theoretical knowledge to ensure that these systems work safely and efficiently.

Moving parts usually require some form of lubrication and learning outcome 1 examines lubricant types and lubrication systems. Pressurised systems often require seals and gaskets to contain the lubricants and other working fluids. Rotating parts require bearings and mechanical systems incorporate fixing devices to hold the various components in position. A range of seals, bearings and fastenings are examined in learning outcome 2.

A prime purpose of mechanical systems is to transmit motion and power. There are many ways in which this can be achieved and learning outcome 3 examines a range of power transmission systems and components. In the learning outcome 4 learners are introduced to a range of plant equipment and systems. This includes an overview of hydraulic and pneumatic systems, steam plant, refrigeration and air conditioning plant and mechanical handling equipment.

The general aim of this unit is to broaden and extend learners' practical knowledge of mechanical engineering systems and provide a foundation for continuing work in related units.

Learning outcomes

On completion of this unit a learner should:

1 Know about the purposes and uses of lubricants and lubrication systems

2 Know about the uses and applications of a range of engineering components

3 Know about the uses and operation of mechanical power transmission systems

4 Know about the uses and operation of plant equipment and systems.

Unit content

1 **Know about the purposes and uses of lubricants and lubrication systems**

Lubricant purposes and types: purpose eg reduction of frictional resistance, reduction of wear, heat dissipation, prevention of corrosion, prevention of contamination; types eg mineral, vegetable and synthetic oils and greases, graphite, compressed gases, cutting fluids

Lubrication systems and maintenance: operation of lubrication systems eg gravity feed, forced feed, splash lubrication, capillary action, grease cups and nipples, grease packing, compressed air/gas bearings; maintenance eg replenishment and renewal of lubricants, safe storage and handling

Applications: eg automobile engine, automobile transmission, machine tool, pump, compressor

2 **Know about the uses and applications of a range of engineering components**

Seals, packing and bearings: seals eg rotary lip seals, mechanical seals, piston rings; packing eg packed glands, gaskets, shims; bearings eg plain journal, thrust, ball, roller (such as parallel or tapered), needle

Fastenings: screwed fastenings eg metric bolts, studs and set screws, self-tapping screws, locking devices; rivets eg snap head, pan head and countersunk heads, bifurcated and pop rivets

Applications: eg automobile engine, automobile transmission, other automotive sub-system, machine tool, pump, compressor, other mechanical system involving rotation and fluid containment, component assembly, maintenance and replacement

3 **Know about the uses and operation of mechanical power transmission systems**

Cams and linkage mechanisms: cams and followers eg radial plate cams, cylindrical cams, face cams, knife-edge followers, flat plate followers, roller followers; linkage mechanisms eg slider-crank and inversions, four-bar linkage and inversions, slotted link quick return motion, Whitworth quick return motion

Belt, chain and gear drives: belt drives eg flat, V-section, synchronous, tensioning device; chain drives eg roller (such as single, duplex, triplex), morse rocker-joint, tensioning devices; gear trains eg gear types (such as spur, helical, herring bone, bevel, spiral bevel, hypoid), simple, compound, worm, combinations, epicyclic

Transmission shafts, clutches and brakes: transmission shafts and couplings eg sections (such as solid, hollow), flanged couplings, splined couplings, angle couplings (such as Hooke universal, constant velocity); clutches eg dog, flat plate, conical, centrifugal, fluid couplings; brakes eg friction (such as internal expanding, external contracting), disc, dynamometers (such as friction, fluid, electromagnetic)

4 **Know about the uses and operation of plant equipment and systems**

Actuation and handling systems: pneumatic and hydraulic actuation systems eg system layout for automated plant and process operations, system components; safety and maintenance; mechanical handling systems eg belt conveyers, roller conveyers, workshop gantry cranes, workstation jib cranes

Steam, refrigeration and air conditioning plant service systems: steam power generation plant eg system layout for power generation and process operations, system components, feed water treatment, safety and maintenance; refrigeration systems eg system layout for vapour compression and absorption systems, refrigerants, system components, safety and maintenance; air conditioning systems eg system layout for full summer and winter cycle air conditioning, system components, safety and maintenance

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 describe the level of achievement required to pass this unit.

Grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 explain the purpose and application of three different types of lubricant P2 describe the operation and maintenance of three different lubrication systems P3 describe the operation of one seal, one type of packing and two different types of bearing with a typical application for each one P4 describe two different types of screwed fastening and two different types of rivet giving a typical application for each one P5 describe the operation of two different types of cam and follower and two different types of linkage mechanism	M1 compare and contrast the operation and uses of flat plate clutches, centrifugal clutches and fluid couplings in mechanical power transmission systems M2 compare and contrast the operation and use of pneumatic and hydraulic actuation systems.	D1 justify the use of a particular lubricant and lubrication system in a given engineering application D2 justify the choice of engineering components in a given engineering application.

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:**
P6 describe the arrangement and operation of two different kinds of belt drive, two different kinds of chain drive and two different kinds of gear train P7 describe the arrangement and operation of two different kinds of transmission shaft and coupling, two different kinds of clutch and two different kinds of brake P8 describe with the aid of diagrams the general layout and operation of a pneumatic actuation system, a hydraulic actuation system and a mechanical handling system P9 describe with the aid of diagrams the general layout and operation of a steam power generation plant, a refrigeration system and an air conditioning system.		

Essential guidance for tutors

Delivery

The learning outcomes of this unit can be delivered in any order, although it may be best to leave learning outcome 4 until last. When delivering learning outcome 1 it would be appropriate to start with an overview of the reasons for lubrication in mechanical systems. Some time can then be spent on lubricant types, their origins, additives, uses and classification. When explaining the function and maintenance of lubricating systems it will be useful to present items of equipment and view their applications in motor vehicles or workshop machinery if available. Much useful trade literature is available from the major oil companies and equipment suppliers.

A similar approach can be adopted when delivering learning outcome 2. Initial overviews of the purpose and uses of seals, packing, bearings and fastenings can be followed by an examination of exemplar items. Time can then be spent in explaining their specific function and applications. If facilities are available, practical assembly and replacement exercises can enhance understanding of component use.

The content of learning outcome 3 is quite wide ranging and the order of delivery is a matter of personal preference. Coverage of cam types, followers and input and output motions should be qualitative. It is not necessary to enter into cam profile design procedures as these are time consuming and may be covered in other units. The emphasis should be on the identification of the different types and their typical applications. The same applies to the delivery of linkage mechanisms which are covered in detail in *Unit 11: Further Mechanical Principles and Applications*.

The range of transmission shafts, shaft couplings, clutches, brakes, belt, chain and gear drives is quite extensive but, wherever possible, explanation of their functions and applications should be accompanied by the presentation of exemplar items of equipment. Descriptive printed material will be of value in the delivery of this outcome, reinforced by the viewing of typical applications in motor vehicles, workshop equipment and video footage where possible.

When delivering the pneumatic and hydraulic system content for learning outcome 4 the emphasis should be on system layout, major system components and the comparison of operation and usage. It is not necessary to enter into the detailed description of components such as valve types and their symbolic representation. Similarly, with mechanical handling systems and steam, refrigeration and air conditioning plant the emphasis should be on function and layout. An industrial visit will be of value to reinforce delivery of this outcome.

Note that the use of ‘eg’ in the content 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

Criteria P1, P2 and D1 could be achieved through an individual assignment. This should contain tasks to explain the purpose and application of three different types of lubricant (P1) and the operation and maintenance of three different lubrication systems (P2). To achieve D1, learners should be able to fully justify the use of a particular lubricant and lubrication system in a given engineering application. This might be the lubrication system of a vehicle engine or transmission, a machine tool, pump or compressor. Alternatively, a mechanical system required to operate in a hostile service environment such as extremes of temperature may be considered.

A second assignment could be used to assess P3, P4 and D2. This would require learners to describe the operation and application of one type of seal, one type of packing and two different types of bearing (P3). Another task would need to cover two different types of screwed fastener and two different types of rivet (P4). The applications should be general, rather than product specific, to demonstrate an understanding of purpose. Diagrams and sketches could be used to complement the descriptions. To achieve D2 learners should be able to fully justify the choice of bearings, seals, packing and fastenings in a given engineering system. This again might be a sub-system of a vehicle, a machine tool or any mechanical system where rotation and the containment of fluid is involved.

Criteria P5 and P6, which relate to learning outcome 3 on mechanical power transmission systems, could be achieved through a third assignment. This should require learners to describe methods of transmitting/converting motion from one form to another by means of two different types of cam and follower and two different linkage mechanisms. It will also need to include two different kinds of belt drive, two different kinds of chain drive and two different kinds of gear train. As with the previous assessment, learners should be encouraged to illustrate the descriptions with diagrams and freehand sketches.

Criteria P7 and M1 relate to learning outcome 3 and could be achieved through a fourth assignment. This should contain tasks requiring learners to describe the arrangement and operation of two different kinds of transmission shaft coupling, two different kinds of clutch and two different kinds of brake (P7). To achieve M1, learners should compare and contrast the operation of manually operated and automatic friction clutches and fluid couplings. The comparisons should be of a general nature, although they may be accompanied by typical applications to illustrate usage.

A final time-constrained assignment could be used to assess P8, P9 and M2. This should contain tasks requiring learners to describe, with the aid of diagrams, the general layout and operation of pneumatic and hydraulic actuation systems (P8), a steam generation plant, a refrigeration system and an air conditioning system (P9). Learners will also need to provide a reasoned comparison of the operation and use of pneumatic and hydraulic actuation systems to achieve merit criterion M4. As with the previous assessment, the comparison should be general in nature but may be accompanied by typical applications to illustrate usage.

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

This unit has close links with Unit 6: Mechanical Principles and Applications, *Unit 11: Further Mechanical Principles and Applications* and *Unit 15: Electro, Pneumatic and Hydraulic Systems and Devices*.

The unit provides some of the underpinning knowledge for the SEMTA Level 3 NVQ in Mechanical Manufacture, Level 3 NVQ in Engineering Maintenance and Level 3 NVQ in Engineering Technical Support.

Essential resources

Centres should have access to a range of engineering components, demonstration equipment and engineering and motor vehicle workshops.

Indicative reading for learners

Textbooks

Darbyshire A — *Mechanical Engineering BTEC National Option Units* (Newnes, 2003) ISBN 0750657618

Neale M J — *Lubrication and Reliability Handbook* (Newnes, 2000) ISBN 0750651547

Smith E H — *The Mechanical Engineer's Reference Book* (Butterworth-Heinemann, 1998) ISBN 0750642181

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. Staff should check that learners have produced all the evidence required by part B of the key skills specifications when assessing this evidence. Learners may need to develop additional evidence elsewhere to fully meet the requirements of the key skills specifications.

Communication Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• describing, with the aid of diagrams, the general layout and operation of a pneumatic actuation system, a hydraulic actuation system and a mechanical handling system • describing, with the aid of diagrams, the general layout and operation of a steam power generation plant, a refrigeration system and an air conditioning system.	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.