

Unit 44: Engineering Maintenance Procedures and Techniques

NQF Level 3: BTEC National

Guided learning hours: 60

Unit abstract

The correct maintenance of engineering systems results in improved efficiency and can save organisations time and money in relation to system downtime and stoppages in production. This unit will introduce learners to a range of commonly used engineering maintenance procedures and monitoring techniques, which may be encountered in any manufacturing, plant or process environment. It will also provide an understanding of how the data gathered from monitoring engineering systems can be used.

Learners will examine the consequences of maintenance and maintenance planning in terms of cost and the implications for production, personnel, the environment and safety. They will gain an understanding of engineering maintenance and process planning and develop the skills needed to plan scheduled and preventative maintenance activities on engineering systems.

The unit has been designed to reflect the multidisciplinary nature of maintaining manufacturing plant and process engineering systems, rather than being confined to specialist knowledge of a single discipline. Learners will need to produce a maintenance plan for an engineering system involving two or more interactive technologies from mechanical, electrical, fluid power, process control or environmental systems.

Learners will be required to know about the methods, procedures and documentation that must be completed before handing over maintained systems, and how to confirm that the system is ready to run in a safe and operable condition.

Finally, learners will gain an understanding of the basic techniques of condition monitoring and how computerised maintenance systems can be used to capture data and predict specific failure trends in plant, machinery, equipment and systems.

Learning outcomes

On completion of this unit a learner should:

- 1 Know about the types of maintenance associated with engineering plant, equipment and systems
- 2 Know about maintenance frequency, the cost of maintenance and its effects on production
- 3 Be able to produce a maintenance plan containing resource requirements, appropriate procedures and documentation for a specific engineering system
- 4 Know about monitoring techniques and how data gathered from monitoring the performance and condition of engineering plant, equipment and systems can be used.

Unit content

1 Know about the types of maintenance associated with engineering plant, equipment and systems

Type of maintenance: types eg planned, total preventative maintenance (TPM), breakdown, scheduled, corrective, emergency, post fault, scheduled servicing, modification to equipment, condition-based maintenance; maintenance activities eg visual examination, monitoring, replacement, sensory, testing, checking alignment, making routine adjustments, removing excess dirt and grime, recording results and reporting defects

Reasons for maintenance: issues relating to higher plant reliability and availability eg longer equipment life, improved product quality, greater cost effectiveness, improved safety, legal requirements; issues relating to health and safety eg statutory regulations and standards, company rules, codes of conduct, reduction in environmental damage

Engineering systems, plant and equipment: systems eg process monitoring and control, mechanical, fluid power, electrical, process control, environmental systems (such as fume extraction or air conditioning), medical; plant and equipment eg gearboxes, pumps, engines, compressors, machine tools, lifting and handling equipment, process control valves, mechanical structures, company specific equipment, electrical plant, motors, starters, switchgear and distribution panels, cardiovascular equipment, medical imaging equipment

2 Know about maintenance frequency, the cost of maintenance and its effects on production

Frequency of maintenance: time eg daily/weekly/monthly/yearly; activities eg data logging and checking, adjustments, tests, routine maintenance, fixed-interval overhaul, equipment replacement, use of computerised techniques; methods for determining frequency eg calendar maintenance, hours run meter

Costs: representative data of cost eg maintenance as a proportion of total expenditure, utilisation of operator (frontline maintenance), maintenance labour, maintenance contracting, lost production, levels of spares and consumables in stores, equipment hire/replacement, safety and environmental effects

Effects on production: eg downtime, effects on operating performance, product quality, customer service, financial penalties, effects on associated equipment or plant, higher energy costs, secondary damage

3 Be able to produce a maintenance plan containing resource requirements, appropriate procedures and documentation for a specific engineering system

Maintenance plan: maintenance planning eg methods, sequence and timing, frequency, check lists, planned repairs, use of planning techniques, Gantt and Pert charts, team working, computerised methods; resources eg personnel, supporting equipment, tools, manuals, materials, components, facilities, stores spares and consumables; procedures eg safety procedures, risk assessment, Control of Substances Hazardous to Health (COSHH) and other relevant safety regulations, safe access and working arrangements for the maintenance area, isolation requirements for plant/equipment, disposal of waste, handover procedures, liaison with other departments

Engineering systems: process monitoring and control eg mechanical, fluid power, electrical, process control, environmental systems (such as fume extraction or air conditioning), medical (such as cardiovascular, anaesthetic and ventilation, medical imaging)

Supporting documentation: manufacturers' drawings and maintenance documentation; maintenance logs, databases, records, results and defect reports; plans and schedules; production records; standing instructions; handover documentation

4 Know about monitoring techniques and how data gathered from monitoring the performance and condition of engineering plant, equipment and systems can be used

Monitoring techniques: eg condition monitoring, scheduled overhauls, routine servicing, planning systems, hazard studies, failure mode and effect analysis (FMEA), teamwork, self-diagnostic and computerised systems

Data collecting: collected at identified points; data eg types, operational characteristics, output quality, throughput, environmental operating conditions; interpreting data eg electronic-based data, data recording and presentation

Need for monitoring: physical aspects eg improve safety, reduce environmental hazards, extend equipment life, ensure accurate equipment performance; cost-related aspects eg improve product quality, reduce downtime, reduce costs; other aspects eg produce comprehensive computer database, better communications

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:
<p>P1 describe two types of maintenance and explain the need for maintaining a specified engineering system</p> <p>P2 describe four maintenance activities for a specified engineering system</p> <p>P3 identify two items of plant and equipment for a specified engineering system that require maintenance and describe the frequency at which it should be carried out, giving reasons why maintenance is needed</p> <p>P4 from a given range of data, calculate the maintenance costs of a specified engineering system in relation to maintenance type, resources and production downtime</p> <p>P5 describe the effects on production of carrying out maintenance on a specified engineering system</p>	<p>M1 justify the selection and suitability of particular types of maintenance for specific applications</p> <p>M2 explain how the frequency of maintenance affects production and costs for a specified engineering system</p> <p>M3 justify planned maintenance for a specified engineered system in terms of system downtime, environmental and health and safety considerations.</p>	<p>D1 produce a comprehensive plan for the maintenance of a specified engineering system containing all supporting documentation, handover procedure, resources, health and safety and environmental considerations</p> <p>D2 analyse given condition monitoring and quality control data to predict specific machinery/plant failure.</p>

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>P6 produce a basic maintenance plan for a specified engineering system containing supporting documentation with resource and procedure requirements</p> <p>P7 describe an application of monitoring, the technique used and how the data is collected and interpreted</p> <p>P8 explain the need to monitor the performance and condition of engineering systems.</p>		

Essential guidance for tutors

Delivery

This unit could be delivered using tutor-led demonstrations, case studies, assignments and practical collection and interpretation of data from engineering systems. Industrial visits to see sophisticated computerised maintenance planning equipment in use would be extremely beneficial.

The unit can be delivered in an electronic, electrical, mechanical or instrumentation context. However, it would be better to choose a system that involves combined areas of engineering, as this is more likely to be encountered in the workplace. The system used for practical work should be complex enough to allow learners to produce a comprehensive maintenance plan. The following examples of engineering systems could be used:

- a fluid power system
- an electrical/electronic system
- a CNC machine tool
- a position/speed/process control system
- a system controlled by a programmable controller/computer
- an environmental control system such as dust/fume extraction or refrigeration/air conditioning system
- a material transfer system.

Learners will require instruction in the use of simple condition monitoring tools and test equipment, such as equipment for monitoring temperature, physical and electrical effects. It should be possible to place data obtained from the system in a software context and undertake analysis.

The delivery approach used will be best determined through analysis of learners' needs and consideration of the range of industries that centres are working with or preparing their learners for. Whichever approach is taken should be sufficiently varied to provide learners with a knowledge of engineering system maintenance planning and monitoring in most industrial settings.

Because a structured approach is required for the maintenance of modern industrial machinery, equipment and systems, learners should be made aware of the importance of maintenance planning. Learners should achieve this through formulating a maintenance plan for a specified engineering system and identifying the range of spares for both routine maintenance and fault conditions.

Finally, learners should be taught about basic condition monitoring techniques and how computerised maintenance systems can be used to capture data and predict specific failure trends in plant, machinery, equipment and systems.

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

Evidence of achievement could be obtained from investigative assignments, reports of workshop activities or through learners building a portfolio from maintenance operations carried out in the in the workplace.

The unit could be assessed through a mixture of written assignments and practical tasks. Assuming that the learning outcomes are delivered in order, a first assignment with a series of written tasks could be used to cover the criteria associated with learning outcomes 1 and 2. The first task could ask learners to describe two types of maintenance (P1) and four maintenance activities (P2) and explain the need for maintaining engineering systems. Such a system might be mechanical, fluid power, electrical, process control, or an environmental system. This could be extended to cover merit criterion M1. To achieve this learners must be able to justify the selection and suitability of particular types of maintenance for specific applications and should include total preventative maintenance (TPM), scheduled or condition-based maintenance.

A second task to cover P3 could ask learners to identify items of plant and equipment that require maintenance and the frequency at which maintenance should be carried out. They will also need to give reasons for carrying out maintenance, for example longer equipment life, improved product quality, greater cost effectiveness, improved safety or legal requirements. The task also needs to ensure that learners cover timing, activities carried out and methods of determining the frequency. It should also ensure that learners have opportunities to give reasons for the required maintenance covering plant reliability/availability and issues relating to health and safety.

A third task to achieve P4 and P5 could ask learners to calculate from given data the cost of maintenance and describe the effects on production. A fourth task requiring learners to explain how the frequency of maintenance can affect production and cost would enable the merit criterion M2 to be met.

A well planned, investigative practical assignment could be used to cover criteria P6, M3 and D1. To achieve P6 learners need to produce a basic maintenance plan for a specified system with accompanying documentation with resource and procedure requirements.

This basic maintenance plan should include at least the following:

- identification of the plant/equipment/machinery to be maintained
- identification of the person with overall responsibility for the maintenance process
- the maintenance procedures to be adopted
- timescales for preparation and implementation of the maintenance activities
- a list of the physical resources required for the maintenance activities (eg lifting equipment, tools, test and measuring equipment)
- details of the administrative support that is to be provided for the maintenance work
- details of the maintenance documentation systems to be provided.

This then needs to be built on in order to achieve D1, where a comprehensive maintenance plan containing all supporting documentation needs to be produced for a specified engineering system. The comprehensive maintenance plan should contain the entire basic plan together with at least the following:

- health and safety procedures
- identification of appropriate types of maintenance compatible with production requirements
- identification of who is to carry out the maintenance (eg in-house labour, contractors, specialists)
- lists of sub-assemblies and spare parts to be held
- the quality control procedures that need to be followed during maintenance activities, together with maintenance tools/equipment control and test instrument calibration
- environmental considerations such as the procedures to be adopted for the disposal of all types of waste material arising from the maintenance activity including the safe disposal of toxic and/or hazardous materials if relevant
- handover documentation.

To achieve M3 the practical activity could be supported by written evidence showing that learners are able to justify the maintenance plan in terms of system downtime, environmental and health and safety considerations.

The criteria associated with learning outcome 4 could be assessed through a written assignment. Learners need to explain the need for monitoring the performance and condition of engineering systems(P8). This should include the physical aspects, cost related aspects and other aspects as outlined in the unit content. Systems do not need to be given as the task should be tackled as a generic response outlining the need in systems in general. The task also needs to ask learners to describe an application of monitoring, the technique used and how data is collected and interpreted (P7).

To achieve D2 learners need to carry out an in-depth analysis of given condition monitoring and quality control data to predict specific machinery/plant failure. An example would be data produced by vibration analysis for a large motor bearing. The data could come from computer analysers, inspection and test, SPC (Statistical Process Control), or from general product quality control.

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

This unit links to Unit 45: Monitoring and Fault Diagnosis of Engineering Systems.

The unit can contribute towards the evidence requirements of the following units in the Level 3 NVQ in Engineering Maintenance:

- Unit 4: Handing Over and Confirming Completion of Maintenance Activities
- Unit 9: Carrying Out Planned Maintenance on Mechanical Equipment
- Unit 10: Carry Out Condition Monitoring on Plant and Equipment
- Unit 15: Carrying Out Planned Maintenance on Electrical Equipment

- Unit 21: Carrying Out Planned Maintenance on Fluid Power Equipment
- Unit 24: Maintaining Mechanical Equipment within an Engineered System
- Unit 25: Maintaining Electrical Equipment within an Engineered System
- Unit 26: Maintaining Fluid Power Equipment within an Engineered System
- Unit 27: Maintaining Process Controller Equipment within an Engineered System
- Unit 28: Carrying Out Planned Maintenance on Engineered Systems.

Essential resources

In order to deliver this unit centres will need access to:

- actual complex engineered systems or test rigs
- data books and manufacturers' specifications
- system manuals, functional flow charts and system diagrams
- computer software for data logging and self-diagnostics
- appropriate test equipment and tools
- maintenance records
- access to maintenance records/documentation from modern factories/plant
- computer-based training systems with interactive hardware and software
- Relevant standards eg BS 6548
- IEE Electrical Maintenance (Code of Practice).

Indicative reading for learners

Textbooks

Kelly A – *Maintenance Systems and Documentation* (Butterworth-Heinemann, 2006)
ISBN 0750669942

Kelly A – *Strategic Maintenance Planning* (Butterworth-Heinemann, 2006)
ISBN 0750669926

Mobley R K – *Maintenance Fundamentals* (Butterworth-Heinemann, 2004)
ISBN 0750677988

Snow D – *Plant Engineer's Reference Book* (Butterworth-Heinemann, 2001)
ISBN 0750644524

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.

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"> producing a plan for the maintenance of a specified engineered system including supporting documentation, resources and relevant health and safety issues calculating maintenance costs in relation to resources (including labour, materials, consumables, and parts), production downtime and maintenance type. 	<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.
Communication Level 3	
When learners are:	They should be able to develop the following key skills evidence:
<ul style="list-style-type: none"> describing two types of maintenance and explaining the need for maintaining a specified engineering system describing four maintenance activities for a specified engineering system. 	<p>C3.3 Write two different types of documents each one giving different information about complex subjects. One document must be at least 1000 words long.</p>