

# Unit 44: Engineering Maintenance Procedures and Techniques

<b>Unit code:</b>	<b>F/600/0318</b>
<b>QCF Level 3:</b>	<b>BTEC Nationals</b>
<b>Credit value:</b>	<b>10</b>
<b>Guided learning hours:</b>	<b>60</b>

## ● Aim and purpose

This unit will give learners the knowledge and skills needed to plan and carry out maintenance and monitoring techniques on engineering equipment and systems.

## ● Unit introduction

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 introduces learners to a range of commonly used engineering maintenance procedures and monitoring techniques, which may be encountered in any manufacturing, plant or process environment. The unit will also help learners understand 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 for a specific engineering system
- 4 Understand how data gathered from monitoring the performance and condition of engineering plant, equipment and systems can be used.

# Unit content

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## 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 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 Understand 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 collection:* 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

## 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:
<b>P1</b> describe two types of maintenance	<b>M1</b> justify the suitability of particular types of maintenance for specific applications	<b>D1</b> produce a comprehensive plan for the maintenance of a specified engineered system containing all supporting documentation
<b>P2</b> describe the reasons for maintaining a specified engineering system	<b>M2</b> explain how the frequency of maintenance affects production and costs for a specified engineering system	<b>D2</b> analyse given condition monitoring and quality control data to predict specific machinery/plant failure.
<b>P3</b> describe four maintenance activities for a specified engineering system	<b>M3</b> justify planned maintenance for a specified engineered system in terms of system downtime, environmental and health and safety considerations.	
<b>P4</b> identify two items of plant and equipment for a specified engineering system that require maintenance, describing the frequency at which it should be carried out		
<b>P5</b> from a given range of data, calculate the maintenance costs for a specified engineering system in relation to maintenance type, resources and production downtime [IE4]		
<b>P6</b> describe the effects on production of carrying out maintenance on a specified engineering system		

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:
<b>P7</b> produce a basic maintenance plan for a specified engineering system containing supporting documentation with resource and procedure requirements [IE4, SM3]		
<b>P8</b> describe an application of monitoring, the technique used and how the data is collected and interpreted		
<b>P9</b> explain the need to monitor the performance and condition of engineering systems.		

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

<b>Key</b>	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

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## 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 give learners 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.

## 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 demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
<p><i>Whole-class teaching:</i></p> <ul style="list-style-type: none"><li>• introduction to unit content, structure and assessment</li><li>• introduction to methods of working on this unit and basic safety elements of practical work</li><li>• introduction to the range of engineering systems and the concept of a complex engineering system</li><li>• look at a specific example of a complex engineering system.</li></ul> <p><i>Industry visit:</i></p> <ul style="list-style-type: none"><li>• group visits to a small number of different industrial locations to see equipment and systems in use – including at least one example of the specific system looked at in this unit.</li></ul>
Preparation for and carrying out <b>Assignment 1: Types of Maintenance Activities</b> (P1, P2, P3 and M1)
<p><i>Whole-class teaching:</i></p> <ul style="list-style-type: none"><li>• tutor demonstration of simple condition monitoring tools and test equipment.</li></ul> <p><i>Practical activities:</i></p> <ul style="list-style-type: none"><li>• using equipment for data collection.</li></ul> <p><i>Small group work:</i></p> <ul style="list-style-type: none"><li>• analyse the collected data.</li></ul>
Preparation for and carrying out <b>Assignment 2: Maintenance Needs in a Complex Engineering System</b> (P4)
<p><i>Whole-class teaching:</i></p> <ul style="list-style-type: none"><li>• general maintenance planning and the maintenance requirements of the specific example system being studied.</li></ul> <p><i>Small group work:</i></p> <ul style="list-style-type: none"><li>• finding out the maintenance requirements and writing a maintenance plan for the specific engineering system.</li></ul>
Preparation for and carrying out <b>Assignment 3: Costing a Maintenance Schedule</b> (P5, P6 and M2)
<p><i>Whole-class teaching:</i></p> <ul style="list-style-type: none"><li>• explain basic condition monitoring techniques</li><li>• tutor-led demonstration on theoretical maintenance systems.</li></ul> <p><i>Small group work:</i></p> <ul style="list-style-type: none"><li>• making use of captured data to predict potential faults and areas of system failure.</li></ul>
Preparation for and carrying out <b>Assignment 4: Maintenance Planning</b> (P7, M3 and D1)
Preparation for and carrying out <b>Assignment 5: Monitoring Techniques</b> (P8, P9 and D2)
Feedback and unit evaluation.



## 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 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 (P3). Learners would then need to describe the need for maintaining a specific engineering system (P2). The system might be mechanical, fluid power, electrical, process control, or an environmental system. This could be extended to cover M1, for which learners must be able to justify the suitability of particular types of maintenance for specific applications. The work produced for M1 should include total preventative maintenance (TPM), scheduled or condition-based maintenance.

A second assignment to cover P4 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 assignment covering P5 and P6 could ask learners to calculate from given data the cost of maintenance and describe the effects on production. A further task requiring learners to explain how the frequency of maintenance can affect production and cost would enable M2 to be met.

A well planned, investigative practical assignment could be used to cover criteria P7, M3 and D1. To achieve P7 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 (for example 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 (for example 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 (P9). 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 (P8).

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.

## Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and 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 and M1	Types of Maintenance Activities	Learners need to report to their manager on types of maintenance and maintenance activities and justify particular reasons for maintenance.	Written report relating general maintenance types to specific examples.
P4	Maintenance Needs in a Complex Engineering System	Learners need to write a report on the maintenance of a complex engineering system.	A written report describing the practical needs for maintenance of plant and equipment that also discusses frequency that maintenance is carried out.
P5, P6 and M2	Costing a Maintenance Schedule	Using plant data and a maintenance schedule, learners calculate the cost and effect of maintenance on system production.	A written assessment of the plant maintenance data to identify the costs of maintenance and its impact on production and cost.
P7, M3 and D1	Maintenance Planning	Learners produce a maintenance plan and justify the maintenance programme.	An investigative practical assignment. Evidence includes a written basic maintenance plan for the specified system with accompanying documentation and resource and procedure requirements.  A comprehensive maintenance plan containing all supporting documentation for the specified engineering system.  Additional written evidence justifying the maintenance plan in terms of system downtime, environmental and health and safety considerations.
P8, P9 and D2	Monitoring Techniques	Learners need to describe condition monitoring and how data is used to a new member of staff.	Written explanation of the need for monitoring the performance and condition of engineering systems.  Written or oral description of an application of monitoring, the technique used and how data is collected and interpreted.  Written analysis of given condition monitoring and quality control data to predict specific machinery/plant failure.

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

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following unit titles in the Engineering suite:

Level 1	Level 2	Level 3
		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 to provide learners with access to complex engineered systems or test rigs, relevant data books, manufacturers' specifications, system manuals, functional flow charts and system diagrams. Learners will also need appropriate test equipment and tools and access to maintenance records/documentation from modern factories/plant. Computer software for data logging and self-diagnostics should also be provided.

## Employer engagement and vocational contexts

This unit should be delivered and assessed in a vocational context. Where possible centres should ensure that learners can view real engineering systems in an industrial setting, especially for learning outcome 3.

Further information on employer engagement is available from the organisations listed below:

- Work Experience/Workplace learning frameworks – Centre for Education and Industry (CEI, University of Warwick) – [www.warwick.ac.uk/wie/cei](http://www.warwick.ac.uk/wie/cei)
- Learning and Skills Network – [www.vocationallearning.org.uk](http://www.vocationallearning.org.uk)
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – [www.stemnet.org.uk](http://www.stemnet.org.uk)
- National Education and Business Partnership Network – [www.nebpn.org](http://www.nebpn.org)
- Local, regional Business links – [www.businesslink.gov.uk](http://www.businesslink.gov.uk)
- Work-based learning guidance – [www.aimhighersw.ac.uk/wbl.htm](http://www.aimhighersw.ac.uk/wbl.htm)

## 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

## Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are ...
<b>Independent enquirers</b>	analysing and evaluating data, judging its relevance and use when calculating maintenance costs analysing information when producing a maintenance plan
<b>Self-managers</b>	organising time and resources and prioritising actions in order to calculate resource and procedure requirements.

Although PLTS 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 ...
<b>Creative thinkers</b>	asking questions about the needs for maintenance and trying out alternative solutions to maintenance scheduling problems
<b>Reflective learners</b>	communicating maintenance plans to different audiences to account for different technical knowledge.

## ● Functional Skills – Level 2

Skill	When learners are ...
<b>ICT – Use ICT systems</b>	
Select, interact with and use ICT systems independently for a complex task to meet a variety of needs	gathering and reporting performance data for maintenance of engineering systems
<b>ICT – Develop, present and communicate information</b>	
Enter, develop and format information independently to suit its meaning and purpose including: <ul style="list-style-type: none"> <li>• text and tables</li> <li>• images</li> <li>• numbers</li> <li>• records</li> </ul>	producing maintenance schedules for use in engineering plants and systems
Present information in ways that are fit for purpose and audience	presenting maintenance plans that account for different goals and knowledge of different audiences
<b>Mathematics</b>	
Use appropriate checking procedures and evaluate their effectiveness at each stage	gathering and interpreting performance data and maintenance costs to evaluate cost-effectiveness of different maintenance types
<b>English</b>	
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching maintenance procedures and techniques
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing different types of maintenance and the reasons for their use describing monitoring techniques and explaining the need for monitoring.