

Unit 86: Aircraft Gas Turbine Engine and Propeller Maintenance

Unit code:	F/600/7303
QCF Level 3:	BTEC Nationals
Credit value:	10
Guided learning hours:	60

● Aim and purpose

This unit will introduce learners to the equipment and fittings found in aircraft engine bays that need to be considered when installing aircraft engine assemblies (power plant) into the aircraft.

● Unit introduction

This unit will give learners an understanding of the procedures needed for selected engine maintenance tasks, enabling them to safely carry out or assist with maintenance tasks such as engine start-up, ground runs and boroscope monitoring checks.

The second half of the unit aims to give learners an understanding of the theory, construction, control and protection of aircraft propellers and propeller systems. Learners will acquire a thorough knowledge of the procedures needed to maintain propellers and turbo-propeller engine aircraft, in a safe and efficient manner, in accordance with laid down standards.

This specialist unit has been designed to extend the knowledge that learners will have already gained from their study of *Unit 81: Aircraft Propulsion Systems* and *Unit 83: Aircraft Gas Turbine Engines*, in order to fully cover the knowledge requirements of modules 15 and 17 of the EASA Part-66 syllabus. The additional knowledge provided by this unit is thus essential for those wishing to become mechanical licensed aircraft maintenance engineers and will also be of considerable value to those in training or who are currently practicing in the armed forces, as aircraft maintenance technicians.

● Learning outcomes

On completion of this unit a learner should:

- 1 Understand the configuration of power plant bays and the requirements for installing power plant into the aircraft
- 2 Be able to assist with selected aircraft engine maintenance tasks
- 3 Understand propeller theory and propeller construction, control and protection
- 4 Know the procedures that must be followed in order to maintain aircraft propellers and propeller systems fitted to turboprop aircraft.

Unit content

1 Understand the configuration of power plant bays and the requirements for installing power plant into the aircraft

Power plant bay configuration: function and familiarity with the arrangement of parts (such as fire wire, firewalls, cowlings, acoustic panels, engine mounts, antivibration mounts, hosepipes, feeders, connectors, wiring looms, control cables and rods, lifting points and drains)

Installation requirements: pre-installation checks for serviceability of power plant bay parts; handling precautions and procedures for eg fire wire, hosepipes, wiring looms, control rods and cables, fuel and oil feeds, slinging and hoisting equipment

2 Be able to assist with selected aircraft engine maintenance tasks

Engine monitoring: carry out or assist with engine monitoring tasks, safely following correct procedures eg interpretation of engine power output or other performance parameters, trend analysis (such as oil analysis, vibration analysis, boroscope monitoring)

Ground operations: carry out or assist with ground operations tasks, safely following correct procedures eg engine start up, engine ground running, compressor washing/cleaning, engine and component inspection, in accordance with laid down criteria, tolerances and manufacturers' data

Storage: carry out or assist with storage tasks eg engine or component preservation, engine or component de-preservation, engine inhibiting, in accordance with laid down maintenance documentation

3 Understand propeller theory and propeller construction, control and protection

Theory: fundamental terms (high/low/reverse blade angle, angle of attack, rotation speed, torque, slip, relative airflow, blade vibration resonance); blade element theory and blade forces (aerodynamic, centrifugal, thrust/lift)

Construction: blade types (fixed pitch, variable pitch, constant speed); construction methods and materials eg wood, composite, metal blades, blade parts (such as blade leading edge/face, blade shank, blade back, hub assembly)

Control and protection: control methods eg speed control, mechanical pitch change, electronic pitch change, feathering and reverse pitch, synchronising and synchrophasing equipment; protection methods (fluid and electrical de-icing equipment and operation)

4 Know the procedures that must be followed in order to maintain aircraft propellers and propeller systems fitted to turboprop aircraft

Propeller maintenance: information sources and procedures for blade damage assessment and treatment/repair (such as erosion, corrosion, impact damage, blade blending, re-coating); propeller storage and preservation

Propeller system maintenance: information sources and procedures and related safety precautions for eg propeller installation, spinner installation, static and dynamic balancing, blade tracking, propeller engine running

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 arrangement of fire wire, fire wire components, acoustic panels and engine feeds in a typical turbojet aircraft and explain the functions of these components	M1 explain the need for the handling precautions and procedures that must be followed before, during and after using slinging and hoisting equipment for power plant installation	D1 under supervision carry out a trend analysis task, using the correct information sources and following laid down procedures, and interpret engine performance parameters
P2 describe the pre-installation checks and handling precautions that must be followed for engine bay cable looms, control rods, fuel and oil feeds	M2 under supervision and following correct procedures, carry out an engine component inspection and assess for serviceability using laid down criteria, tolerances and manufacturers' data	D2 under supervision and following correct procedures, carry out an engine start and low rpm ground run, using a ground simulator or on a live gas turbine powered aircraft.
P3 assist with one engine monitoring task, one ground operations task and one storage task, following correct procedures and under close supervision [TW1, TW5, SM3, SM4]	M3 explain one control method used to synchronise propellers and describe the equipment and explain the operation of an electrical propeller de-icing system	
P4 define the fundamental terms associated with aircraft propellers and using elementary blade theory explain how aerodynamic, centrifugal and lift forces are created and how they vary along the length of the blade	M4 using the correct information sources detail the procedure and explain the need and related safety considerations for the static and dynamic balancing of propellers.	
P5 explain the relative advantages and disadvantages of fixed pitch, variable pitch and constant speed propellers		

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:
P6 describe the construction methods used for the manufacture of a composite blade and explain why a different material is often used for the blade leading edge		
P7 explain the control method used for controlling propeller speed and the fluid de-icing system used to protect the blade during icing conditions		
P8 describe the information sources and detail one general procedure for the treatment of blade erosion and the storage and preservation of a propeller blade		
P9 describe the information source, procedure and related safety precautions for the installation of a propeller spinner [IE4].		

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.

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

Essential guidance for tutors

Delivery

This unit is primarily concerned with the maintenance procedures and practice associated with aircraft gas turbine engines and propellers. As such, access to gas turbine power plant and associated systems is essential. When delivering the practical aspects of learning outcome 2, learners will also need supervised access to either live turbine powered aircraft or a modern ground training simulator. Centres should be aware of these essential resource requirements when considering the delivery of the unit and will need to plan for this access accordingly.

A variety of delivery methods should be used for this unit appropriate to each of the learning outcomes. These may include lectures, tutor-lead demonstrations, visits to aircraft maintenance establishments or even delivery of the unit on the premises of a 'Part-147' training establishment, an armed forces training establishment or with an airline operator.

Learning outcome 1 concentrates on the configuration of components and equipment in typical gas turbine power plant bays and the installation of aircraft engines in these bays (including auxiliary power unit (APU) bays). It is therefore essential when delivering this outcome that learners have access to such bays or at the very least be able to study detailed photographs of power plant bay configurations. A hands-on approach, via a visit to an aircraft operational establishment will enhance learning and is the recommended method of delivering this outcome. Learners will also need access to related maintenance documentation where the procedures and safety considerations applicable to engine installation and bay equipment may be found.

Learning outcome 2 aims to give learners an understanding of maintenance procedures and associated safety considerations in order to be able to perform (under supervision) a number of practical activities associated with engine monitoring, ground operations and engine storage and preservation tasks. Therefore, it is even more important that when delivering this outcome, learners have access to operational gas turbine engines and gas turbine powered aircraft or an engineering ground simulator, as well as the associated documentation and all other necessary sources of information. If part or all of this equipment is not available at the centre, a working visit to a suitably equipped aircraft engineering training centre or operator will be needed to enable learners to undertake the practical tasks needed to meet the grading criteria.

Learning outcome 3 introduces learners to propeller theory, construction, control and protection. The theory should emphasise the forces that act on the blade and how they vary with changing angle of attack, relative airflow and rotational speed, and how lift is equalised along the length of the blade from the hub to tip. Blade element theory need only be used to show the relationship between the forces acting at points along the blade. The problems of resonance and supersonic tip speeds should also be emphasised when delivering the theoretical aspects of this outcome. Construction methods involving metals and composite materials need to be covered and the methods of controlling propeller speed and pitch also need to be emphasised. A propeller rig, complete with a pitch change facility would be a useful training aid for the delivery of this learning outcome.

The final learning outcome will give learners an understanding of the propeller and propeller systems maintenance procedures that need to be adhered to when assessing damage, repairing or installing propellers and their associated equipment. A training rig could again be used to bring these procedures to life, with all necessary documentation and information sources also available.

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">• introduction to unit content, scheme of work and methods of assessment• describe arrangement and function of aircraft power plant bay parts• explain the pre-installation checks and handling precautions applicable to engine installation and bay equipment. <p><i>Practical workshop activities:</i></p> <ul style="list-style-type: none">• practical investigation of gas turbine power plant bays and components. <p><i>Individual learner activities:</i></p> <ul style="list-style-type: none">• research maintenance documentation and procedures for installing power plant into aircraft.
Prepare for and carry out Assignment 1: Power Plant Bay Configuration and Installation (P1, P2, M1)
<p><i>Whole-class teaching and demonstration:</i></p> <ul style="list-style-type: none">• describe the safety precautions and procedures that must be followed when carrying out aircraft maintenance• explain and demonstrate a range of engine monitoring tasks, ground operations tasks and storage tasks. <p><i>Practical workshop activities:</i></p> <ul style="list-style-type: none">• in groups and under supervision, learners to assist with a variety of aircraft maintenance tasks.
Prepare for and carry out Assignment 2: Aircraft Engine Maintenance (P3, M2, D1, D2)
<p><i>Whole-class teaching:</i></p> <ul style="list-style-type: none">• explain how the different forces act on propeller blades, the problems resonance and supersonic tip speeds• describe the different types of propeller blade and the construction methods and materials used• using a propeller rig where available, explain the methods used to control speed and pitch and for synchronising and synchrophasing propellers and describe the protection methods used. <p><i>Individual learner activities:</i></p> <ul style="list-style-type: none">• research project and quiz on propeller theory and construction.
Prepare for and carry out Assignment 3: Propeller Construction, Control and Protection (P4, P5, P6, P7, M3)
<p><i>Whole-class teaching:</i></p> <ul style="list-style-type: none">• explain the information sources and procedures used for propeller blade damage assessment and maintenance and methods of correct storage• explain the information sources and procedures for propeller systems maintenance. <p><i>Individual learner activities:</i></p> <ul style="list-style-type: none">• find and use relevant information sources.
Prepare for and carry out Assignment 4: Aircraft Propellers and Propeller Systems Maintenance (P8, P9, M4).
Feedback on assessment and unit evaluation.

Assessment

Assessment evidence can be obtained from written assessments, research assignments and from practical exercises carried out in centre workshops or in a real or simulated aircraft maintenance engineering environment.

To achieve P1 and P2, learners must have a detailed knowledge of aircraft engineering bay components and the associated installation checks and safety precautions to be followed during engine change unit (ECU) removal and fitting. This knowledge may best be assessed using evidence from either a formal written assessment or theoretical assignment.

For P3, learners not only need a detailed knowledge of procedures and associated safety but also the information sources and type of documentation required to assist with engine monitoring, ground operation and storage/preservation maintenance tasks. Assessment evidence for P3 will most likely come from tutor observation or written reports on the learner's ability to assist with these tasks in a competent manner, demonstrating that they are fully aware of the information sources and documentation that must be used.

Assessment evidence for P4 and P5 might best be obtained from some form of formal written assessment. In the case of P4, answers to questions would include illustrations of the forces acting on the blade profile at varying angles of attack.

Learners must also have knowledge of the purpose and types of material used for propeller blade manufacture and the methods of manufacture used for the production of composite blades (P6) as well as understanding the methods used for controlling blade speed and protecting against ice build-up (P7). The illustrated answers to questions set in a written assessment or investigative assignment, would provide appropriate evidence.

For P8 and P9, learners need to demonstrate a knowledge of the sources of information, procedures and related safety precautions, associated with propeller maintenance tasks. A theoretical assignment, that involves selecting information from the appropriate sources, would provide the necessary evidence.

To achieve a merit, learners must be able to explain the need for and nature of, the special handling precautions associated with slinging and hoisting aircraft power plant and equipment (M1). Verbal questioning, set using the lifting/hoisting equipment as a prop, would be an appropriate way of obtaining the necessary evidence to meet this criterion. Learners also need to carry out (under supervision) an engine component inspection and assess the component for serviceability (M2). Assessment evidence for this criterion is likely to be obtained from learners' answers to verbal questions and tutor observation during the task.

To achieve M3 and M4 learners must be able to fully explain how propeller synchronisation may be achieved and how an electrical propeller de-icing system operates, down to component level. In addition, learners need to be fully aware of the information sources, procedures and related safety aspects that need to be considered when carrying out the static and dynamic balancing of aircraft propellers. Evidence for M3 and M4 might best be obtained from questions in an investigative style assignment.

To achieve a distinction, learners will need to successfully complete practical maintenance activities under supervision, selecting and following the correct laid down procedures (such as those detailed in maintenance manuals). For D1, learners will need to carry out a trend analysis activity and interpret engine performance parameters. For D2, learners will need to carry out an engine start under strict supervision, and then bring the engine up to fast idle speed, sufficient to bring power on-line, using a ground simulator or live gas turbine engine powered aircraft or rig. Evidence for the successful achievement of D1 and D2 will most likely come from answers to verbal questions and tutor observation during the tasks.

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, M1	Power Plant Bay Configuration and Installation	A technician has been asked to explain to a new apprentice the arrangement and pre-installation checks and handling precautions when working on power plant bay.	Written assignment.
P3, M2, D1, D2	Aircraft Engine Maintenance	A technician needs to assist with a range of aircraft engine maintenance tasks.	Portfolio based on practical activities supported by annotated photos and observation records.
P4, P5, P6, P7, M3	Propeller Construction, Control and Protection	A technician needs to produce a report on propeller construction, control and protection.	Written assignment.
P8, P9, M4	Aircraft Propellers and Propeller Systems Maintenance	A technician needs to work with a new apprentice to show and explain the relevant information sources, procedures and safety precautions for the installation of propeller.	Written assignment.

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:

Level 1	Level 2	Level 3
		Aircraft Propulsion Systems
		Aircraft Gas Turbine Engines

This unit has strong links with the other propulsion units in the programme, particularly *Unit 78: Aircraft Propulsion Systems* and *Unit 83: Aircraft Gas Turbine Engines*, both of which are prerequisites for this unit. Collectively, the prerequisite units and this unit cover all the necessary knowledge requirements of the EASA Part-66 Module 15 and module 17. In addition this unit will contribute to the essential evidence required by those undertaking aerospace apprenticeship programmes and will also be useful for those in training with the armed forces.

The unit can also contribute towards Level 3 NVQ in Aeronautical Engineering, especially *Unit 153: Carrying out Tests on Aircraft Engines and Systems*.

Essential resources

Learners will need to be given the opportunity to undertake limited practical maintenance activities on aircraft gas turbine engines and propellers and it is therefore essential that learners have access to:

- aircraft gas turbine engines
- operational aircraft/ground engineering simulators
- aircraft propellers or propeller rig
- data books and manufacturer, specifications
- maintenance manuals or air publications
- associated documentation civil or military.

Employer engagement and vocational contexts

Much of the work for this unit can be set in the context of learners' work placements or be based on case studies of local employers. 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/
- Learning and Skills Network – www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk
- National Education and Business Partnership Network – www.nebpn.org
- Local, regional Business links – www.businesslink.gov.uk
- Work-based learning guidance – www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

Apart from the essential manuals and documentation listed above and centre training notes, access to the following textbooks would be useful:

Hunecke, Klaus – *Jet Engines: Fundamentals of Theory, Design and Operation* (Crowood Press, 1997)
ISBN 9781853108341

Wagtendonk, W – *Principles of Helicopter Flight* (Aviation Supplies & Academics, 2007) ISBN 9781560276494

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 ...
Independent enquirers	analysing and evaluating information sources and procedures relating to propellers and propeller systems maintenance
Team workers	collaborating with others to work towards common goals when assisting out engine monitoring tasks, ground operations tasks and storage tasks taking responsibility when assisting with gas turbine maintenance tasks and showing confidence in themselves and their contribution
Self-managers	organising time and resources, prioritising actions and anticipating, taking and managing risks when assisting with gas turbine maintenance tasks.

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 ...
Reflective learners	Setting goals with success criteria for the development and work.

● Functional Skills – Level 2

Skill	When learners are ...
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	describing the configuration of power plant bays, propeller construction and maintenance procedures
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching and investigating aircraft gas turbine and propeller maintenance
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing the configuration of power plant bays, propeller construction and maintenance procedures