# Unit 78: Aircraft Propulsion Systems

**Learning hours:** **60**

**NQF level 3:** **BTEC National**

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## Unit abstract

This unit will give learners the underpinning knowledge needed to understand the construction and operating principles of aircraft propulsion systems. Learners will gain an understanding of the major systems associated with aircraft gas turbine engines such as fuel and lubrication systems, engine control and fire/ice detection and protection systems. The unit will emphasise the underlying reasons for these systems and their layout.

The unit covers some of the underpinning knowledge required for those taking module 15: Gas Turbines, of the European Aviation Safety Agency (EASA) Part-66 examinations for certifying staff. The unit also supplies a limited amount of underpinning knowledge across other modules.

## Learning outcomes

**On completion of this unit a learner should**:

1 Understand the function and operation of typical gas turbine fuel systems

2 Understand the function, construction and operation of gas turbine lubrication systems

3 Know about engine control systems

4 Know about the operation and components of engine fire detection and protection systems and the operation of ice detection and protection systems.

## Unit content

1 **Understand the function and operation of gas turbine fuel systems**

*Function and operation*: layout of fuel systems (methods of operation, system equipment and components); fuel systems eg fuel pumps and pressurisation, atomising and vaporising fuel nozzles, pressure control, flow control, bypass valves, fuel filters, fuel heaters, dump valves, cross feed system, hydro-pneumatic fuel controls, electronic (EEC) and manual engine control

*Fuel:* types and grades used in aviation eg Jet-A, Jet A-1 and Jet-B or their military equivalents (Avtur and Avtag); additives eg anti-icing and microbial agents; identification codes eg equipment controls colour, pipe markings and refueler decals; health and safety precautions when working with pressurised fuel systems

2 **Understand the function, construction and operation of gas turbine lubrication systems**

*Function, construction and operation*: operation of gas turbine engine lubrication system types and layout (wet and dry-sump) eg recirculatory pressure relief system, full flow and total loss systems; characteristics and functions of engine lubricants eg types of lubricants, viscosity, flash point, anti-foaming additives, adhesion and cohesion; oil identity codes (type 1 and type 2) and grading system eg Commercial Aviation Number, AN specification (Military), SAE system; requirements for gas turbine engine oil systems; lubrication system components eg oil reservoirs, deaerators, constant displacement oil pumps (gear, vane and gerotor), oil filters, filter ratings, chip detectors (indicating and pulsed), contaminants, relief valve systems, oil jets, vents, check valves, pressure and temperature gauges, oil coolers (hot and cold tank) and scavenge systems

3 **Know about engine control systems**

*Basic engine control systems*: layout of engine control cables eg Teleflex, cable and rod controls, forward and reverse thrust levers, fuel control switches/levers, friction brake, tension regulation, autothrottle regulation; engine control cable rigging eg control pulley box, directional control valves, feedback cables, cable grommets, pressure seals, cable turnbuckles, locking, control cable quick stops, start/thrust cable control drum; fuel shut-off valves; electrical fuel cock actuator; miscellaneous switches eg go-around switch, auto-throttle disengage switch, mode control panel; electronic engine control; flight/ground idle control

4 **Know about the operation and components of engine fire detection and protection systems and the operation of ice detection and protection systems**

*Fire detection and protection systems*: fire protection systems eg classes of fire, requirements for overheat and fire protection systems; main components eg gas turbine engine fire zones, types of fire or overheat detectors, flame resistant materials and fire walls; ground fire protection; extinguishing agents (carbon dioxide, halogenated hydrocarbons); fire extinguishing systems (conventional, high rate discharge); smoke and toxic gas detection systems (carbon monoxide, smoke detectors, light refraction, ionisation and solid state); multi-engine fire protection systems (operation and components); fire extinguishing system inspection and trouble shooting (container pressure check, discharge cartridges and agent containers)

*Ice detection and protection systems:* de-icing and anti-icing systems eg bleed air, electrical, pressure control (constant, manual and cyclic); ice detection and indication systems

## 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 sketch the layout and describe the basic function and operation of typical components used in a given gas turbine fuel system<br>P2 describe the different types of fuel used in gas turbines (military or civil) and identify their colour codes and identification markings<br>P3 describe the precautions necessary when working with aviation fuels and pressurised fuel systems<br>P4 describe the operation of a lubrication system for a typical gas turbine engine<br>P5 describe the characteristics of lubricants used in gas turbines and state why they are suitable for the requirements of gas turbine engines<br>P6 sketch the layout and describe the basic functions of the main components found in a given gas turbine lubrication system<br>P7 identify and describe the basic engine controls of a gas turbine engine | M1 explain the operation of a typical gas turbine engine fuel control system<br>M2 explain the differences between a wet and dry sump lubrication system<br>M3 compare the operational requirements for two given gas turbine fire detection and protection systems. | D1 compare and evaluate the fuel and lubrication systems for two main types of gas turbine engine<br>D2 analyse the causes and effects of engine fires and how they are detected and contained. |

| **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**: |
| P8 identify and describe the main components of a given type of gas turbine engine fire detection and protection system and describe the principles of operation<br><br>P9 describe the principles of operation of an engine ice detection and protection system. | | |

## Essential guidance for tutors

### Delivery

This unit should be delivered using a mixture of lectures, tutor-led demonstrations, case studies, visits to aircraft factories and practical collection of data from a chosen type of gas turbine engine. Delivery should, where possible, include a comparison of different types of gas turbine engines including turbojet, turbofan, turboshaft and turboprop. It would be advantageous to then focus on a particular type of gas turbine and relate the fuel and lubrication systems to the chosen engine. This allows delivery to be tailored to learners' requirements and the most appropriate form of gas turbine application.

Learners will need access to a gas turbine engine together with the fuel components, lubrication, fire and ice protection and controls systems. However where learners are employed they should be encouraged to use the resources available at their workplace. A practical approach could be used for parts of the unit, particularly where centres have access to small gas turbine engine test rigs, for example to monitor oil temperature and pressure, or the use of engine controls and servicing, although this is not essential.

If possible visits should be made to an engine manufacturer, airline and/or aircraft maintenance facility where installation, commissioning or maintenance of gas turbine engines takes place. Learners should be encouraged to take an investigative approach throughout and to use an appropriate engine to identify the main components.

For learning outcome 1, learners will need to know about the layout of the main components of a gas turbine fuel system and understand the function, operation and contribution of each main component to the fuel system as a whole. They should learn about the types of fuel used, including the main additives and the reasons for those additives, their identification codes and the equipment colour markings used for gas turbine engines. These markings can then be compared to those used for reciprocating engine fuels used in aviation such as Avgas 80/100/100LL or the military equivalents to ensure that learners are aware of the differences of each type of fuel system. Learners must also be made aware of the health and safety implications of high pressure fuel systems.

In learning outcome 2 learners must understand the layout, function and operation of the main components which make up a typical gas turbine lubrication system and which can be related to any of the four main types of engine application whether civil or military.

Learners should understand the types and characteristics of lubricants used in gas turbines and why synthetic oils are used almost exclusively in preference to mineral oils and also have a basic understanding of why they should not be mixed. They should be aware of the different types of synthetic oils used, such as type 1 and type 2, and the basic differences between them. They will have a knowledge of the grading system and be able to recognise either the commercial aviation number or the AN specification (military) and relate these to the SAE system, as appropriate to the learner.

Learning outcome 3 is concerned with engine controls, their layout, function and operation. Learners should understand how the basic controls are built up from their components parts to control a relevant and typical gas turbine engine. While it is not necessary for learners to understand Full Authority Digital Engine Control (FADEC) in this unit, it is an ideal opportunity to introduce it in very basic terms so that learners are aware of its existence.

Learning outcome 4 looks at fire and ice protection systems, and learners will need to understand how these systems work. Learners should know the main fire zones, how fires can start and how they are detected and dealt with to stop them from

spreading. Ice detection and protection requires an understanding of the differences between de-icing and anti-icing and the main areas that need particular protection.

**Assessment**

Assessment evidence can be collected from assignments and practical activities undertaken either in the laboratory or in the workplace.

To achieve a pass, learners must have a basic knowledge and understanding of the principles of aircraft propulsion systems. Learners must be able to sketch and describe the basic layout of a fuel system and the components that are used to make up that system (P1). They should also be able to describe the types and grade of fuel used and should also be able to recognise the colour codes used to identify the markings for these fuels either Military or Civil (P2). Learners must also demonstrate a clear understanding of the dangers of dealing with pressurised fuel systems (P3).

Learners should be able to sketch and describe a typical lubrication system both wet and dry (P4, P5, P6) and understand the difference between the two (M2). Learners will need to describe a basic system that includes, for example, pumps, filters, deaerators, oil reservoirs and other components within the system. They will need to understand the types and characteristics of lubricants used in gas turbines, the reasons why synthetic oils are used almost exclusively in preference to mineral oils and why they should not be mixed. They should also be aware of the different types of synthetic oils used, such as Type 1 and Type 2, and the basic differences between each type.

Learners must demonstrate a basic understanding of engine controls by identifying and describing their basic function (P7).

Ice and fire detection and protection systems should be identified and described at component level to show that learners understand how they form a system (P8, P9).

To achieve a merit, learners must be able to explain how the fuel is controlled in a typical gas turbine engine. M1 is developed from P1, P2, P3 and P7. For the lubrication system and its components, M2 requires an understanding of the system's operation and should focus on an engine and system relevant to the learner, while demonstrating an understanding of the other systems available. This should be shown in the differences between wet and dry sump systems. Learners should also be able to compare the operational requirements for both fire detection and protection (M3).

To achieve a distinction Learners must demonstrate an understanding of both fuel and lubrication systems and compare and evaluate two main types of gas turbine engines for these systems (D1). They must also analyse the causes and effects of fires, how they are detected and contained (D2). They must also understand how fires are dealt with using a variety of different methods.

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

This unit has strong links with other BTEC units in the programme, particularly *Unit 72*: *Principles and Applications of Aircraft Mechanical Science* and *Unit 76: Aircraft Maintenance Practices*. The unit is also designed to contribute essential evidence for an aircraft Modern Apprenticeship.

The unit has a strong link to *module 15: Gas Turbines* for EASA part 66 and the license examinations and to a lesser extent some of the science for *module 2:Physics*.

**Essential resources**

This unit is intended to provide learners with a practical introduction to gas turbine engines. The intention is to focus on the techniques, skills, methods and documentation used, particularly planning and quality control which are applicable to all areas of maintenance, installation and commissioning.

For these reasons it is essential that learners have access to:

- an aircraft gas turbine engine
- data books and manufacturers' specifications
- AP manuals
- the internet
- appropriate textbooks.

**Indicative reading for learners**

Eastop, M — *Applied Thermodynamics for Engineering Technologists* (Longman,1996) ISBN 0582091934

Rogers, M — *Engineering Thermodynamics – Work and Heat Transfer* (Longman, 1992) ISBN 0582045665

Sherwin K and Horsley, M — *Thermofluids* (Chapman and Hall, 1996) ISBN 0412598000

## 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 skills 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 the operation of a lubrication system for a typical gas turbine engine lubrication system<br>• describing the characteristics of lubricants used in gas turbines and state why they are suitable for the requirements of gas turbine engines<br>• sketching the layout and describing the basic functions of the main components found in a given gas turbine lubrication system. | C3.3 Write **two** different documents about complex subjects. One piece of writing should be an extended document and include at least **one** image. |