Unit 82: Airframe Systems

Unit code: M/6007264
QCF Level 3: BTEC Nationals
Credit value: 10
Guided learning hours: 60

Aim and purpose

This unit will develop learners' understanding of aircraft air, fuel, fire emergency, cabin equipment and protection systems.

Unit introduction

A study of airframe systems is essential for anyone wishing to enter the aerospace industry as a mechanical technician or engineer. This unit provides a thorough introduction to aircraft air, fuel, fire emergency, cabin equipment and protection systems. The aircraft air systems covered include pneumatic power supply, cabin air conditioning and pressurisation systems. The importance of these air systems is apparent when flying at altitude, where there is a need to pressurise the cabin in order to sustain life and prevent the onset of anoxia (total lack of oxygen). The cabin air also needs to be conditioned in order to provide an acceptable environment for passengers and crew.

Aircraft airframe fuel systems are covered, particularly their operation as a heat exchanger for hydraulic oil cooling and during their fuel pressurisation and transfer modes. Aircraft fire protection systems, fixed and portable oxygen systems and associated emergency and cabin equipment systems are also considered, along with other protection systems such as anti-icing and de-icing systems.

The final part of the unit gives learners the opportunity to carry out a number of selected maintenance activities directly associated with airframe systems.

This unit provides some of the knowledge required for learners wishing to progress to the European Aviation Safety Agency (EASA) Part 66 licensing requirements. It will also benefit those seeking employment within the armed forces or the aircraft manufacturing industry.

Learning outcomes

On completion of this unit a learner should:

1 Know the purpose, component function and operation of aircraft pneumatic supply, cabin conditioning and pressurisation systems

2 Know the component and system functions and the layout and operation of aircraft fuel and fire detection and extinguishing systems

3 Know the system functions and the layout and operation of aircraft cabin equipment and protection systems

4 Be able to carry out maintenance activities on pneumatic, cabin conditioning, pressurisation, fuel, fire, cabin equipment and protection systems.

Unit content

1 Know the purpose, component function and operation of aircraft pneumatic supply, cabin conditioning and pressurisation systems

Pneumatic supply: purpose eg aircraft pressurisation, air conditioning, thermal anti-icing, engine starting, hydraulic reservoir pressurisation, potable water tank pressurisation, door and canopy sealing; component function eg piston engine, turbine engine/auxiliary power unit (APU), air compressors, blowers, receivers, reservoirs, ground cart, ducts, louvers, channelling, trunking, check valves, pressure control valves, pitot-static system, sensors, emergency valves, pre-cooler; system operation (supply of air to pre-cooler)

Cabin conditioning and pressurisation: purpose; function of system components eg bleed and ram air, air cycle and vapour cycle cold air units, filters, humidifiers, water separators, trunking, ducting, plenum chamber, diffusers, duct stats, sensors, valves, controllers, temperature control valves, flow control valves, pneumatic and electrical cabin pressure controllers, discharge valves, inwards/outwards relief valves, warning and indicating devices; system operation eg supply of conditioned air to cabin, temperature and humidity control of conditioned air, pneumatic cabin pressure control cycle, electrical cabin pressure control, discharge methods, emergency provision, warnings and indicators

2 Know the component and system functions and the layout and operation of aircraft fuel and fire detection and extinguishing systems

Fuel: purpose; component functions eg tanks, pumps, vents, drains, plumbing, valves, filters, indicators, gauges, warning devices, heat exchangers; layout eg sources of supply, distribution, plumbing, fuel contents/warning sensors and lines, longitudinal balance fuel systems, fuel system component positions; operation eg fuel pressurisation, feed, transfer, dumping, venting, draining, refuel/de-fuel, fuel as heat exchanger

Fire detection: system functions; component functions eg unit detectors, continuous firewire detectors, inertia switches, crash switches, fixed and portable extinguishers, fire warning panel indicators); layout/operation eg engine bay/jet pipe unit detection system, continuous detection system, smoke detection system, on-board fire extinguishing system, pilot/automatic extinguishant actuation system, overheat conditions

3 Know the system functions and the layout and operation of aircraft cabin equipment and protection systems

Cabin equipment: emergency equipment functions eg harnesses, belts, seats, slides, parachutes, dropdown oxygen and masks, crew and cabin therapeutic walk round oxygen systems; layout eg cabin, emergency equipment, furnishings, entertainment, galley, waste water systems, toilets, airstairs, cargo handling systems; operation eg seat belts, slides, airstairs, entertainment, therapeutic oxygen, water system supply and distribution

Protection: functions of systems eg de-icing, anti-icing (ice formation, classification and detection, effects of ice and snow), oxygen, windscreen repellents/wipers, probe and drain heating; system layout/operation eg ice detection, anti-icing (such as electrical, hot air, chemical), de-icing (such as pneumatic, chemical, electrical, hot air), oxygen (such as storage, pilot/cabin distribution, regulation, indication and warning, emergency provision, chemical generation, liquid oxygen generation and distribution)

4 Be able to carry out maintenance activities on pneumatic, cabin conditioning, pressurisation, fuel, fire, cabin equipment and protection systems

Pneumatic: following documentation and observing all relevant safety precautions; activity eg check serviceability of aircraft drains, vents, trunking, leak checks, condition of storage bottles, reservoirs, receivers and their associated fixtures and fittings

Cabin air conditioning and pressurisation: following documentation and observing all relevant safety precautions; activity eg leak checks, assist with pressure tests, check condition of system components, fixtures and fittings, check function of system components

Fuel and fire: following documentation and observing all relevant safety precautions; activity eg fuel contamination avoidance procedures, leak checks, refuel/de-fuel operations, fuel tank venting and draining, fuel tank storage, fire wire condition, fire detector condition, testing warning systems, check fire extinguishers for contents and inadvertent operation

Cabin equipment and protection: following documentation and observing all relevant safety precautions; activity eg check seat belts, airstairs, therapeutic oxygen, emergency oxygen for condition/contents, check correct stowage of lift rafts, life jackets and evacuation slides, check operation of seat entertainment systems, windscreen wipers, probe and drain heaters, servicing and draining of water waste system, servicing of toilet system including checking for corrosion, re-apply rain repellent, check operation of blown air, pneumatic, electrical heater, chemical fluid anti-icing/de-icing systems

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 state three purposes for an aircraft pneumatic supply system and give the functions of the piston engine, air compressor and receiver, within the system	**M1** explain how the pneumatic supply systems differ for gas turbine powered aircraft and piston engine aircraft	**D1** explain both the normal and emergency operation of a pneumatically controlled aircraft cabin pressurisation system, throughout the whole of its ground-air-ground cycle
P2 describe how air is supplied to the system pre-cooler from the aircraft's turbine engine/s	**M2** explain how with the use of sensors, duct stats and motor operated valves the temperature of the air supply to the cabin is controlled	**D2** explain the circumstances and the means by which the passenger emergency dropdown oxygen masks are activated and the way that oxygen may be chemically generated.
P3 state the purpose of aircraft cabin conditioning and pressurisation systems, give the function of ram air, bleed air, the air cycle unit and the humidifier and explain how conditioned air is supplied from the intercooler to the aircraft cabin	**M3** explain the operation of an aircraft fuel system for the fuel pressurisation and fuel transfer modes	
P4 state the purpose of the aircraft's fuel system, its fuel, fuel pump and heat exchanger	**M4** explain the circumstances under which the on-board fire extinguishers are automatically operated.	
P5 sketch the layout of the fuel system for a twin-engine aircraft, showing its essential components and describe its operation as a fuel heat exchanger		
P6 state the function of a fire detection and extinguishing system and the functions of inertia switches and fire warning panel indicators		

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:**
P7 sketch the layout of a continuous fire wire aircraft engine detection system, showing all essential components and describe its operation for overheat conditions		
P8 state the function of aircraft cabin harnesses, slides and oxygen provision, sketch the layout and describe the operation of the seat belts and therapeutic oxygen		
P9 state the function of four aircraft protection systems and sketch the layout and describe the operation of an aircraft anti-icing system		
P10 carry out a given maintenance activity on a pneumatic supply system, using given documentation and observing relevant safety precautions [SM3, SM4]		
P11 carry out two given maintenance activities on air conditioning/pressurisation systems, using given documentation and observing relevant safety precautions [SM3, SM4]		
P12 carry out two given maintenance activities on aircraft fuel/fire protection systems, using given documentation and observing relevant safety precautions [SM3, SM4]		
P13 carry out two given maintenance activities on two cabin equipment/protection systems, using given documentation and observing relevant safety precautions [SM3, SM4].		

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, together with *Unit 80: Aircraft Hydraulic Systems*, will provide learners with a knowledge and understanding of aircraft mechanical systems (other than those associated with aircraft engines and avionics). These two units will be beneficial to anyone pursuing a mechanical pathway in aerospace manufacture or maintenance. The units would, therefore, be best taught in tandem in the second year of a conventional two-year full-time programme.

As a pneumatic supply can be required for thermal anti-icing, hydraulic reservoir pressurisation and aircraft potable water systems, it would be best to teach learning outcome 1 first. The practical assessment activities associated with each system could be undertaken immediately after each system is delivered or, alternatively, as part of a set of practical activities towards the end of the unit's delivery time.

For learning outcome 1, learners should be made fully aware of the purpose of each of the three systems (ie pneumatic supply, cabin air conditioning and pressurisation) and the function of each of the major system components. The operation of each of these systems, under normal and emergency conditions, should also be understood although, with the exception of aircraft pressure controllers and discharge valves, there is no need for learners to understand how the system components themselves operate. However, learners must be made aware of the function of the major components within the system.

For learning outcome 2, learners should be aware of the functions of aircraft fuel and fire detection components and systems and be able to describe the layout of such systems. Tutors should ensure that when explaining the operation of an aircraft airframe fuel system, learners fully understand their operation as a fuel heat exchanger and their operation when pressurising fuel and transferring fuel.

Both fire detection and suppression systems should be covered, with learners being made aware of the properties, function and identification of modern extinguishers. They will as also need to understand the conditions under which aircraft extinguishing systems are automatically activated to suppress an overheat or aircraft fire situation.

For learning outcome 3, emphasis should be placed on the emergency cabin equipment that is most applicable to the learners' vocational area. For example, if the group is primarily concerned with the manufacture and maintenance of civil aircraft then it might be best to emphasise the layout and operation of emergency slides, airstairs and the passenger seats. Alternatively, for learners primarily concerned with military aircraft, it might be best to concentrate on the crew and cabin therapeutic walk round oxygen systems. However both these areas will need to be covered in order to meet the assessment criteria.

Similarly, when dealing with ice and rain protection systems, the items of content selected from the list of examples and the particular type of de-icing and anti-icing system considered may depend on whether the cohort has a civil or military aviation bias.

When it comes to delivering the practical elements in learning outcome 4, the selection of the activities to be carried out will largely be based on access to relevant physical resources. However, learners will be disadvantaged if they cannot gain access to a training aircraft with at least some of the systems and equipment listed on-board. Many of the activities involve physical inspection of system equipment, so at the very least this should be made available off-aircraft to compensate for the lack of equipment being available on-board training aircraft. Visits to air museums, flying clubs and, preferably, aircraft operators or military establishments will need to be arranged for learners with no direct access to aircraft at their centre.

When undertaking the practical activities learners are not expected to reach industry standards of practical competence, other than being able to follow and comply with the relevant safety procedures and aircraft documentation.

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
Whole-class teaching: • explain the purpose of aircraft pneumatic supply systems • describe the main components and their function within the overall system • describe the documentation and relevant safety precautions that need to be followed when working with airframe pneumatic systems. *Practical workshop activities:* • tutor-led demonstration of relevant maintenance activities on pneumatic systems • learners to check condition and serviceability of pneumatic system and components. *Whole-class teaching:* • explain the purpose of the cabin conditioning and pressurisation systems • describe the main components, their function within the overall systems and the operation of the systems. *Practical workshop activities:* • tutor-led demonstration of relevant maintenance activities on pressurisation systems • learners to check condition and function of pressurisation system and components.
Prepare for and carry out **Assignment 1: Aircraft Pneumatic and Pressurisation Systems** (P1, P2, P3, P10, P11, M1, M2, D1).
Whole-class teaching: • explain the purpose of aircraft fuel systems • describe the main components and their function within the system • describe the layout and operation of aircraft fuel systems • explain the function, layout and operation of aircraft fire detection systems and system components • describe the documentation and relevant safety precautions that need to be followed when working with aircraft fuel and fire detection systems. *Practical workshop activities:* • tutor-led demonstration of relevant maintenance activities on fuel and fire detection systems • learners to carry out checks and maintenance activities on aircraft fuel and fire detection systems.
Prepare for and carry out **Assignment 2: Aircraft Fuel and Fire Detection Systems** (P4, P5, P6, P7, P12, M3, M4).

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • explain the function, operation and layout of cabin emergency equipment • explain the function, operation and layout of protection systems • describe the documentation and relevant safety precautions that need to be followed when maintaining cabin equipment and protection systems. *Practical workshop activities:* • tutor-led demonstration of relevant maintenance activities on cabin equipment and protection systems • learners to carry out maintenance on cabin equipment and protection systems.
Prepare for and carry out **Assignment 3: Cabin Equipment and Protection Systems** (P8, P9, P13, D2).
Feedback on assessment and unit evaluation.

Assessment

A theoretical assignment or a formal written assessment might be the best way to assess the criteria associated with learning outcome 1 (P1, P2, P3, M1, M2 and D1). However, it may be appropriate, depending on the progress of the cohort, to split the pass criteria from the merit and distinction criteria and use two separate forms of assessment.

Evidence for P1 and P2 could come from questions that require learners to demonstrate their understanding of the pneumatic supply from piston engine aircraft (P1) and then the supply from a turbine engine aircraft to the pre-cooler (P2).

For P3, learners need to demonstrate an understanding of the way in which engine bleed air, ram air and the cold air unit are used to provide correct temperature air to the cabin and the use of humidifier equipment to ensure the air moisture content is appropriate for passenger comfort.

For M1, learners will need to explain the significant differences in the air supply systems on piston and turbine engine aircraft. For M2 they will need to explain how the temperature of the air supplied to the cabin is controlled. An accurately labelled diagram could be produced to support the explanation.

To satisfy D1, learners need to demonstrate their knowledge of the operation of the pneumatic controller/discharge valve combination. In particular this will need to include its operation from the ground to the aircraft operating altitude, its operation at altitude when maximum cabin differential has been met and its use on the descent to control cabin pressure changes within suitable limits.

P4, P5, P6, P7, M3 and M4 cover learning outcome 2. In order to meet P4, P5, P6 and P7 learners only need to answer questions of a descriptive nature, in which they show an awareness of the function of aircraft airframe fuel systems and fire detection/extinguishing systems and their major components. They will also need to sketch the layout and describe the operation of a typical fuel system and continuous fire wire detection system for a modern aircraft.

For M3 learners must explain the operation of fuel systems when used in their pressurisation and fuel transfer modes. For M4 they will need to explain the circumstances under which the on-board fire extinguishers are automatically operated (ie during fire emergency and crash emergencies). They should also be aware of the means of electrically signalling and firing the bottles.

A formal written or theoretical assignment would also be an appropriate method of assessing the criteria that cover learning outcome 3 (P8, P9 and D2). This assignment should include written questions that cover the functions and layout of aircraft cabin harnesses, slides and oxygen provision, together with other questions that require learners to describe the operation of seat belts and walk round therapeutic oxygen bottles.

For P9 learners should state the function of most (four) of the protection systems mentioned in the unit content. They should also be able to describe the operation of an aircraft anti-icing system, whether this is hot air, chemical or electrical.

Assessment of D2 should give learners the opportunity to explain the circumstances needed for automatic activation of the passenger cabin dropdown masks and the mechanism used to achieve this. Learners will also need to explain in detail (probably with the aid of a diagram) the way in which typical chemical oxygen generators produce the required oxygen once activated.

P9, P10, P11 and P12 cover learning outcome 4. As mentioned above, the assessment of these practical skills could take place either at the end of each related learning outcome or as part of a final overall unit assessment, and centres should decide when to gather this evidence. Appropriate documentation should be made available and learners will need to demonstrate that they can follow the guidance given in the documentation and follow all relevant safety procedures.

Most of the practical activities require a limited amount of skill to complete them satisfactorily, so the fact that learners adopt the correct approach and strictly adhere to procedures and all related safety considerations should be the primary factor used to assess learner competence. For all the practical tasks witness statements/ observation records and annotated photographs and documentation are likely to be the best form of evidence.

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, P10, P11, M1, D1	Aircraft Pneumatic and Pressurisation Systems	A technician needs to show and explain the function, operation and maintenance requirements of aircraft pneumatic and pressurisation systems to a new member of staff.	A two part assignment, consisting of written tasks requiring learners to describe/explain aircraft pneumatic and pressurisation systems and a practical maintenance task evidenced through tutor observation and photos.
P4, P5, P6, P7, P12, M3, M4	Aircraft Fuel and Fire Detection Systems	A technician needs to show and explain the function, operation and maintenance requirements of aircraft fuel and fire detection systems to a new member of staff.	A two part assignment, consisting of written tasks requiring learners to describe/explain aircraft fuel and fire detection systems and a practical maintenance task evidenced through tutor observation and photos.
P8, P9, P13, D2	Cabin Equipment and Protection Systems	A technician needs to show and explain the function, operation and maintenance requirements of aircraft cabin equipment and protection systems to a new member of staff.	A two part assignment, consisting of written tasks requiring learners to describe/explain aircraft cabin equipment and protection systems and a practical maintenance task evidenced through tutor observation and photos.

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 Hydraulic Systems

This unit provides some of the skills and understanding associated with the SEMTA Level 3 National Occupational Standards in Aeronautical Engineering, particularly:

- Unit 43: Installing Aircraft De-icing Systems
- Unit 44: Installing Aircraft Fuel Systems
- Unit 45: Installing Aircraft Environmental Systems
- Unit 55: Testing Aircraft Pneumatic Systems
- Unit 56: Testing Aircraft Environmental Systems
- Unit 57: Testing Aircraft De-icing Systems
- Unit 147: Removing and Replacing Components of Aircraft Pneumatic and Vacuum Systems
- Unit 148: Removing and Replacing Components of Aircraft Environmental Systems
- Unit 150: Removing and Replacing Components of Aircraft Cabin Systems, Equipment and Furnishings
- Unit 155: Carrying Out Tests on Aircraft Fuel and Storage Systems.

This unit covers some of the systems knowledge and understanding contained in Module 11 of the EASA Part 66 syllabus for those wishing to qualify as category A and B1 Aircraft Licensed Mechanics and Technicians.

Essential resources

As a minimum, centres should provide learners with access to an airliner or military aircraft and their associated airframe systems equipment. The aircraft should be equipped with as many of the following systems as possible:

- pneumatic
- cabin conditioning
- pressurisation
- fire protection
- airframe fuel
- de-icing/anti-icing
- cabin systems equipment that enables learners to assess the condition of some of these systems.

Access may be via the centres own aircraft or through pre-arranged visits to aircraft airline operators or military establishments where some of the practical activities detailed in learning outcome 4 can be undertaken. In addition to the above (particularly for those centres that do not have access to their own suitable training aircraft), centres should have a selection of airframe system components and systems rigs, suitable not only for explaining their function and operation, but also for assessing system component condition and system layout and operation.

Indicative reading for learners

Textbooks

Moir I and Seabridge A – *Aircraft Systems: Mechanical, Electrical and Avionic Sub-Systems Integration* (Wiley-Blackwell, 2008) ISBN 0470059966

Specialist texts

Air Publications – 101 Series of manuals and Air Publications (Military)

ATA – 100 Series, specialist textbooks and publications from the Joint Aviation Authority and sanctioned by the European Aviation Safety Agency (Civil)

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 ...
Self-managers	organising time and resources, prioritising actions and anticipating and managing risks when carrying out maintenance activities on aircraft airframe systems.

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 ...
Independent enquirers	analysing and evaluating information, judging its relevance and value when researching different airframe systems
Team workers	collaborating with others when working in small groups to carry out maintenance activities on airframe systems.

Functional Skills – Level 2

Skill	When learners are ...
English	
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	Researching and investigating aircraft airframe systems and system components
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing and explaining the purpose, function and operation of aircraft airframe systems and system components.