Unit 70: Aircraft Materials and Hardware

Unit code: A/600/7199

QCF Level 3: BTEC Nationals

Credit value: 15

Guided learning hours: 90

Aim and purpose

This unit will develop learners' knowledge and understanding of the materials and hardware used in the construction, maintenance and repair of aircraft.

Unit introduction

An understanding of aircraft materials and hardware is a fundamental requirement for those wishing to practice as aircraft engineering technicians, no matter what their chosen specialisation.

This unit will provide learners with an understanding of the processing, identification, microstructure, properties and use of ferrous and non-ferrous metals, as well as composite materials. In particular, steels and light alloys are considered in detail, as are polymers and polymer matrix composites, since it is these materials that are most widely used in aircraft construction. The mechanical testing of steels and light alloys is considered, as a way of determining their properties. The nature of corrosion and the recognition of the types of corrosion that may occur on aircraft metallic structures, are also covered.

A general electro-mechanical approach has been adopted with respect to the types of hardware covered in the unit. Aircraft fastening and locking devices are first covered, followed by fluid plumbing, riveting, transmission and aircraft mechanical controls hardware. Then finally, a further outcome is devoted to understanding the types, construction, characteristics, identification methods and use of aircraft electrical cables and connectors.

This unit covers part of the knowledge required for those taking the European Aviation Safety Agency (EASA) Part 66 examinations.

Learning outcomes

On completion of this unit a learner should:

1 Know the methods of producing and treating ferrous and non-ferrous metals and alloys

2 Understand the effect of microstructure on the macroscopic properties of ferrous and non-ferrous metals and alloys

3 Know the nature of corrosion and how the properties of ferrous and non-ferrous materials are determined using testing techniques

4 Know about the structure and properties of non-metallic materials

5 Know the types, characteristics and applications of aircraft fasteners and general hardware

6 Understand the construction, characteristics and applications of aircraft electrical cables and connectors.

Unit content

1 Know the methods of producing and treating ferrous and non-ferrous metals and alloys

Ferrous metals and alloys: iron and plain carbon steel production eg blast furnace, open hearth, basic oxygen, and electric-arc process; heat treatments eg annealing, normalising, hardening, tempering, case hardening, surface hardening (such as flame, induction, nitriding) iron-carbon diagram; steel alloys and properties eg with chromium, molybdenum, manganese, vanadium, tungsten, nickel; identification methods eg SAE classification, MIL-Spec, part number, colour code; applications eg engine rotary and static parts, engine mounts, landing gear struts, axles and bearings, flap and slat track mechanisms, heat shields, hinges, fasteners

Non-ferrous metals and alloys: aluminium production (Bayer process bauxite to alumina, smelting process); heat treatment and processing eg annealing, solution treatment, anodising, precipitation treatment, age hardening, cold working (such as rolling, cladding, drawing, forging); alloying and properties eg aluminium with copper, manganese, silicon, magnesium, zinc, lithium, chromium, nickel; other non-ferrous metals and alloys such as (titanium, tungsten, copper, magnesium and nickel); identification eg SAE, AMS, BS, DTD, ASN specifications, aluminium association incorporated alloy group series method, non-heat treatable and heat treatable codes; applications eg flying control surfaces, fuselage structure and skin, empennage structure and skin, cabin floors, cowlings, panels, fixtures and fittings

2 Understand the effect of microstructure on the macroscopic properties of metals and their alloys

Macroscopic properties: mechanical properties eg density, strength, stiffness/elasticity, specific strength, specific stiffness, plasticity, toughness, hardness, brittleness, ductility, malleability; other properties eg heat resistance, expansivity, conductivity, resistivity, durability, passivity, ease of fabrication and manufacture

Microstructure: atomic lattice packing (body-centred cubic (BCC), face centre cubic (FCC), closed packed hexagonal (CPH)); features of grain structure eg formation, boundary, size, crystal defects (such as point, line or dislocation, planar), slip planes; effect of grain structure, lattice packing and alloying on eg ductility, brittleness, toughness, fracture toughness, hardness and strength, of parent material

3 Know the nature of corrosion and how the properties of ferrous and non-ferrous materials are determined using testing techniques

Corrosion: chemical fundamentals eg the corrosion cell, rust reactions, dry corrosion, formation by galvanic action, microbiological mechanisms and stress, the redux table and metal potential, active and passive materials, material susceptibility to corrosion; types of corrosion, their recognition and cause eg microbiological, hydrogen embrittlement, mercury contamination, surface, crevice, exfoliation, inter-granular, bimetallic, pitting, fretting, stress and fatigue corrosion

Testing techniques and properties: tensile test (strength, ductility and stiffness; hardness test eg brinell, vickers pyramid, Rockwell, shore scelerscope; impact tests eg charpy, izod; fatigue tests (toughness) eg rotary machine, full fatigue rig (S/N curve, fatigue limit, endurance limit)

4 Know about the structure and properties of non-metallic materials

Structure: microstructure of polymers (thermoplastics, thermosets, elastomers); structural make-up and use for plastic, Perspex, glass fibre reinforced plastic (GFRP), ceramic matrix composite (CMC), polymer matrix composite (PMC) and metal matrix composite (MMC) materials

Properties: of eg composite material reinforcing fibres, matrix and core materials (such as strength, stiffness/elasticity, specific strength and stiffness, toughness, ductility, fatigue resistance)

Characteristics of polymers and composites: eg directional and non-directional strength and stiffness in tension, compression, shear and bending, cost, environmental degradation, weathering, ageing, reaction to ultra-violet light, heat and chemical attack

Use and identification: of eg reinforcing fibres and cloths (such as glass cloth, aromatic-polyamide aramid/ Kevlar, boron, ceramic fibres), matrix materials (such as thermosets, thermoplastics, metals) and core materials (such as paper and metal honeycomb, balsawood, Styrofoam, methane foam, pvc foam, cellulose acetate)

5 Know the types, characteristics and applications of aircraft fasteners and general hardware

Aircraft fasteners: eg screws, nuts, wing nuts, bolts, studs, (type, thread form, markings, identification codes, dimensions), rivets (such as materials, dimensions, tolerances, allowances, spacing and pitch, solid, chobert, avdel, jo-bolts, blind), locking devices (such as lock nuts, tab and spring washers, friction devices, specialist fasteners (such as lock wired devices, quick release, toggle, bayonet)

Aircraft general hardware: eg

- fluid plumbing hardware (such as solid and flexible pipes, unions, olives, fittings, bayonet and threaded connectors)
- transmission hardware (such as springs, bearings, belts, chains, pulleys, sprockets)
- flexible control cables (such as aircraft control cables, bowden cables, teleflex cables, swaged, bolted and pinned end fittings, swaging methods and checks for integrity, turnbuckles, turn barrels, handling)

6 Understand the construction, characteristics and applications of aircraft electrical cables and connectors

Aircraft electrical cables: eg performance, current and voltage rating, construction, classification, insulation, screens, types (such as nyvin, tersial, fepsil, kapton, high-tension, co-axial), coding, crimped terminations, cable sleeves, cable supports, clamps, blocks, grommets)

Aircraft electrical connectors: eg terminal blocks, high density module blocks, pins, ground/earth points, threaded and bayonet multi-pin couplings, plugs, rack and panel connectors

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 production process of plain carbon steel and a heat treatment after production that will add hardness to the surface of this steel	**M1** compare the mechanical and other properties of steel alloys, titanium alloys and magnesium alloys and give two examples of the best use of each of these alloys in aircraft production	**D1** compare the properties and characteristics of aluminium-lithium alloys and polymer matrix composites and explain their use and effectiveness for aircraft construction
P2 use a given sample and a given identification method to identify the type of an alloy steel and give two aircraft structural applications for this material	**M2** explain what is meant by a passive material and for two different passive metallic materials used on aircraft, explain how this property is advantageous	**D2** choose appropriate metallic and/or non-metallic materials for the sandwich construction of an aircraft floor panel and give reasons for your choice.
P3 describe the production process for aluminium and a heat treatment process that may be used to return the aluminium to a malleable state after cold working	**M3** explain the effect on the microstructure and therefore the parent metal of cold-working and alloying	
P4 identify the type of an alloy using a given sample and the alloy group series method, and give two aircraft structural applications for this material	**M4** explain the significance of the S/N curve with respect to the measurement and testing of fatigue and discuss the differences between fatigue limit and endurance limit.	
P5 describe the mechanical properties and other properties of two metal alloys that make them suitable for fuselage structure and skin		
P6 explain how BCC, FCC, and CPH lattice packing and features of grain structure affect the ductility and brittleness of parent metallic materials		

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 describe the action of a corrosion cell that occurs between rivets and the aircraft skin and explain the circumstances under which corrosion is accelerated		
P8 identify three types of corrosion with the aid of pre-prepared illustrations [IE1]		
P9 explain why inter-granular corrosion is considered dangerous in aircraft metallic structures		
P10 carry out a tensile test using standard steel and aluminium alloy test pieces and determine the strength and ductility properties of these alloys from test results [IE1, SM3]		
P11 describe the differences in the microstructure of thermosets, thermoplastics and elastomers and describe the structural makeup of GFRP, CMC, PMC, and MMC materials		
P12 describe the properties and characteristics and explain the use and methods of identification, for two reinforcing fibres, two matrix materials and two core materials used in the production of aircraft composite structures		
P13 use an approved method to identify each of a range of given aircraft standard and specialist fasteners, rivets and locking devices, detail their characteristics and give an example of the use for each		

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:**
P14 use an approved method to identify each of a range of given aircraft fluid plumbing, transmission, control cable and fittings hardware, detail their characteristics and give an example of the use for each [IE1, IE4]		
P15 identify the cable type of a range of given aircraft electrical cables, state their current and voltage rating and give an aircraft circuit use for each type [IE1, IE4]		
P16 explain the importance of aircraft earthing and the care and safety precautions necessary for aircraft earthing points and electrical connectors.		

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 has been designed to provide learners with an understanding of the materials and hardware used in the construction and repair of aircraft. The knowledge provided by this unit is considered the minimum for all technicians engaged in aerospace manufacture, maintenance or repair, irrespective of their chosen specialist field. This unit could be delivered in the first year of the programme in tandem with *Unit 69: Aircraft Workshop Principles and Practice*, where a limited amount of the theory presented in this unit is put into practice. Elements of the content of this unit will also act as a crucial foundation for further study of both mechanical and avionic units.

When delivering the content of learning outcome 1, only a small amount of time needs to be given over to the production of steel and aluminium. Learners only need to be able to identify and differentiate between different forms, for example wrought and cast iron or wrought and cast aluminium. In addition a very brief study of the iron-carbon diagram and aluminium-copper diagram along with pictorial views of the phase, will help learners understand the effects of the heat treatment of these metals and alloys. When delivering the content on heat treatments and processing, a general descriptive approach should be adopted, with the property changes resulting from the treatments and the subsequent use of the metal/alloy being emphasised. There is no need for any in-depth study of for example, time-temperature-transformation (TTT) diagrams, when considering the effects of heat treatments. When delivering the content on identification methods, the needs of the cohort and possibly the needs of local employers should be considered. In addition the group series method of identification devised by the aluminium association incorporated should be taught when considering identification methods for aluminium and its alloys.

When delivering the content on the macroscopic properties of ferrous and non-ferrous metals and alloys in learning outcome 2, it may be helpful to also determine some of these properties practically, by delivering the content in tandem with the materials testing element in learning outcome 3. As well as emphasising the strength, stiffness, toughness and hardness properties of metallic materials, the specific strength and stiffness or structural efficiency and fatigue properties of the light alloys should also be emphasised, these properties being of particular importance when considering materials for aeronautical applications. When considering the microstructure of metallic materials the relationship between the types of lattice packing, the subsequent number of slip planes, alloying and dislocation density needs to be clearly related to the ductility, brittleness, toughness and hardness of the parent material, as appropriate.

Whole class teaching with well prepared visual aids and where possible physical examples, may well be the most appropriate method of delivering the content on corrosion for learning outcome 3. The action of the galvanic cell and the significance of the potential values set out in the redux table needs to be well understood with, for example, cell theory being illustrated by different potential materials being used for aircraft rivets and skin, that may form a corrosion cell. The types of corrosion and the potential threat posed by these types of corrosion to the aircraft structure and components should be well understood. The provision of physical examples of a variety of these corrosion types will most certainly enhance learning.

Learning outcome 4 is mainly concerned with the structure, properties, characteristics and use of non-metallic composite materials. Delivery should also look at the structure of polymers and the characteristics and advantages afforded by a range of common composites. Emphasis should be placed on polymer matrix composites (PMC), as this is the most common form of non-metallic material used for aerospace applications. By emphasising the properties and characteristics of the reinforcing fibres, matrix and core materials that make up composite materials, learners can identify the aerospace applications that make best use of these properties and characteristics.

To achieve learning outcome 5, learners need to understand a range of typical aircraft fasteners and general mechanical hardware, while for learning outcome 6 they need a similar understanding of aircraft electrical cables and connectors. During delivery of these two learning outcomes tutors should emphasise one or more parts of the unit content, depending the requirements of the cohort being taught. In any event an understanding of both types of hardware will be necessary both as a co-requisite for the practical application of the electrical hardware contained in *Unit 69: Aircraft Workshop Principles and Practice* and as pre-requisite knowledge for the mechanical applications contained in *Unit 71: Inspection and Repair of Airframe Components and Structures*. Apart from understanding the types, characteristics and use of the hardware, learners must be able to clearly identify the specific item from the correctly labelled packaging and where appropriate from the marking on the item itself. Correct identification of aircraft hardware and spare parts is an essential skill in ensuring the safe construction of aircraft assemblies and the maintenance of airframes that require replacement hardware, to return the aircraft to a serviceable state. Tutors should ensure that learners are proficient in the use of these identification methods.

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: • introduction to unit content, scheme of work and assessment strategy • using visual aids/video footage, explain the production of pig iron and cast iron and the basic microstructure of cast iron and wrought iron, together with a brief explanation of plain carbon steel production, using for example, the open hearth process or electric arc process (the microstructure of the products of these processes may also be studied at this time, including the iron-carbon equilibrium diagram) • explain the effects and uses of alloying steel with elements such as chrome, vanadium, tungsten and nickel. Explain heat treatments and processing • explain the identification methods and classification systems used to identify a range of alloy steels. *Individual activity:* • multiple-choice quiz on ferrous metals and alloys (production, heat treatment and identification methods). *Whole-class teaching:* • using visual aids/video footage to briefly explain aluminium production, such as the Bayer process. Explanation of the effects and use of aluminium alloyed with elements such as copper, silicon, lithium, manganese, magnesium, chromium and nickel • workshop teaching to explain and possibly demonstrate examples of heat treatments and processes such as, annealing, solution treatment, hardening and cold working. Show and explain the nature of the most common identification methods, particularly the aluminium association incorporated alloy group series method • explain the composition and aircraft use of metals and metal alloys, other than steels and aluminium alloys such as copper, titanium, tungsten and magnesium. *Individual activities:* • a multiple-choice quiz on aluminium and its alloys • produce a written description of the aircraft applications for ferrous and non-ferrous metals.
Prepare for and carry out **Assignment 1: Production, Identification, Heat-treatment and Application of Ferrous and Non-ferrous Metals and Alloys** (P1, P2, P3, P4).

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • in a materials laboratory environment explain the mechanical and physical properties attributed to ferrous and non-ferrous alloys and the use of these properties in aerospace applications • explain the microstructure of metals and the effect that the different microstructures have on the parent metal. *Individual activity:* • multiple-choice quiz on metal microstructure and its effect on the macroscopic properties and characteristics of the parent material.
Prepare for and carry out **Assignment 2: Macroscopic Properties and Microstructure** (P5, P6, M1, M2)
Whole-class teaching: • explain, with laboratory examples where possible, the fundamentals of corrosion such as the reaction of a corrosion cell, rust reaction, galvanic action, passivity, dry corrosion and the significance of the redux table with respect to metal potential and the cell electrodes • using examples or appropriate photographs, explain the action and cause of common types of corrosion that may be found on aircraft. *Individual activity:* • multiple-choice quiz on corrosion. *Whole-class teaching:* • explain the use and demonstrate the procedures for testing ferrous and non-ferrous alloys (such as tensile test, hardness test and simple rotary fatigue tests). *Individual activity:* • analyse pre-prepared or real test data to ascertain properties of metals and alloys.
Prepare for and carry out **Assignment 3: Corrosion and Metallic Materials Testing** (P7, P8, P9, P10, M3, M4)
Whole-class teaching: • with the aid of suitable illustrations and physical examples, explain the microstructure and structural make-up of polymers and GFRP, CMC, PMC and MMC materials • explain the characteristics of polymers and composites • with the aid of physical examples and illustrations, identify and explain the properties and use of composite reinforcing fibres, matrix and core materials and the characteristics of polymers and composite aircraft structure *Individual activity:* • multiple-choice quiz or class work on non-metallic materials.
Prepare for and carry out **Assignment 4: Non-metallic Materials** (P11, P12, D1, D2) (Note: evidence for successful completion of criteria D1 and D2 may be gathered here as part of this assignment or a separate investigative assignment could be set).

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • use available hardware to identify types, characteristics and usage of aircraft fasteners, rivets and locking devices • use available hardware and/or photographs to explain the types, characteristics, identification methods and use for a range of fluid plumbing, transmission and manual flight control hardware. *Individual activity:* • multiple-choice quiz on aircraft fasteners and general mechanical hardware. *Whole-class teaching:* • use available aircraft cables and fittings and/or photographs to explain the types, construction, characteristics, identification methods, use and handling precautions for a range of aircraft electrical cables and connectors.
Preparation for and carry out **Assignment 5: Aircraft Mechanical and Electrical Hardware** (P13, P14, P15, P16).
Feedback on assessment and unit review.

Assessment

It is expected that a range of assessment methods will be used for this unit. Evidence may be gathered from written responses to assignments and formal timed assessments. Evidence from laboratory reports and observation records will also be appropriate particularly in order to achieve the assessment criteria associated with the materials testing element of learning outcome 3.

Five assignments could be used to assess this unit, although opportunities exist to combine or split the suggested assessment activities, as centres see fit.

The first assignment could consist of written tasks that require learners to describe the production of steel (P1) and aluminium (P3) and relate these production methods to a qualitative understanding of the microstructure obtained in the material as a result of the production processes and any subsequent heat treatments (P3). Learners must also demonstrate an understanding of the identification methods used for steel and aluminium and their associated alloys, as well as the aerospace uses to which these materials may be put (P2, P4).

The second assignment is also likely to consist of formal written tasks. Learners must be able to describe the properties associated with two metal alloys that make them suitable for fuselage and aircraft skin production (P5). Their description must mention the structural efficiency properties that make these alloys suitable for this application. They must be able to relate and explain how the different forms of lattice packing, the associated number of slip planes and the nature of the grain structure impact on the ductility and brittleness of the parent metallic material (P6). To achieve the related merit criteria learners need to build on their knowledge of material properties and microstructure in order to be able to compare the properties of steel, titanium and magnesium alloys and provide appropriate examples in aircraft production (M1). They must also be able to explain the meaning of passive metallic materials and detail the uses to which this advantageous property may be put, during aerospace manufacture and maintenance (M2).

A third assignment could cover P7, P8, P9, M3 and M4. To achieve P7, learners must understand the mechanisms and necessary components that produce a corrosion cell and relate this understanding to a real life application where an aircraft skin is riveted using two materials of differing potential. Learners must identify three types of corrosion from pre-prepared drawing or actual physical examples (P8) and explain the dangers associated with inter-granular corrosion within aircraft structures (P9). They must be able to carryout a standard tensile test on both an aluminium and steel alloy test piece and be able to establish the alloys' strength and ductility properties from the test itself and from the test results (P9).

M3 and M4 require further tasks enabling learners to explain the effect on the microstructure and therefore the parent material of cold working and alloying (M3). In particular mention must be made of the increases in dislocation density and strain energy within and around the grains that results in increased hardness and strength in the parent material. With respect to the results of a series of fatigue tests and/or fatigue data collected from live aircraft, learners must be able to explain the significance of the S/N curve produced and the meaning of the parameters identified on the curves, including fatigue limit and endurance limit, related to different metallic materials (M4).

A fourth assignment could be used to assess P10, P11, D1 and D2. Learners must describe the differences in microstructure between thermoplastic and thermoset polymers and elastomers and describe the structural make-up of the most common composite materials (P10). They must also describe the properties and characteristics and explain the use and methods of identification for two reinforcing fibres, matrix materials and core materials, used in the production of aircraft composite structures (P11). It is suggested that learners are steered towards two different variants of PMC, when making their choice on suitable reinforcing fibres, matrix materials and core materials.

The two distinction grade criteria can also be built into this assignment and would require learners to compare and contrast the properties and characteristics of aluminium-lithium alloys and polymer matrix composites and be able to debate (set up an argument) for their use and effectiveness in aircraft construction (D1). They must also be able to assess the mechanical and physical properties and characteristics required of an aircraft composite material floor panel and argue for the choice of appropriate materials for its construction based on the materials ability to meet the required properties and so be fit for purpose (D2).

A fifth assignment could cover the aircraft hardware learning outcomes. Learners must be able to detail the characteristics and identify a range of mechanical fasteners, locking devices and rivets, using an approved method. This may include but not be exclusively confined to the reading of part numbers and other codes on correctly labelled packaging and being able to confirm from features of the give codes or numbers, that the correct hardware is contained within the packing (P12). Learners must also be able to carryout a similar identification exercise for a given selection of fluid plumbing, transmission, control cables and fittings and electrical cables and as before, they must be able to detail their characteristics (P13, P14). Learners must finally be able to explain the importance of aircraft earthing and detail the care and safety precautions necessary to maintain earth points and fittings in a serviceable condition (P15).

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, P4	Production, Identification, Heat-treatment and Application of ferrous and non-ferrous metals and alloys	A formal assignment requiring learners to respond to written tasks.	Written responses to set written tasks carried out under controlled conditions.
P5, P6, M1, M2	Macroscopic Properties and Microstructure of Metallic Materials	A formal assignment requiring learners to respond to written tasks.	Written responses to set written tasks carried out under controlled conditions.

Criteria covered	Assignment title	Scenario	Assessment method
P7, P8, P9, M3, M4	Corrosion and Metallic Materials Testing	A two-part assignment, consisting of set written tasks followed by a metallic materials testing exercise.	Written responses to set tasks, carried out under controlled conditions and a written laboratory report resulting from materials testing.
P10, P11, D1, D2	Non-metallic Materials	A formal assignment requiring learners to respond to written tasks (*Note*: evidence for successful completion of criteria D1 and D2, may be gathered here as part of this assignment or a separate investigative assignment could be set).	Written responses to set written tasks carried out under controlled conditions. (If suggestion as per note is followed, then a written report resulting from the investigation could be used to provide evidence).
P12, P13, P14, P15	Aircraft Mechanical and Electrical Hardware	A two-part assignment consisting of a multiple-choice test and an oral identification exercise.	Written response to multiple-choice test questions and oral response to identification exercise given under controlled conditions.

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 Workshop Principles and Practice
		Inspection and Repair of Airframe Components and Structures
		Airframe Structural Concepts and Construction Methods

This unit has been mapped against the EASA Part-66 examinations and provides some of the necessary knowledge for Module 6 Aircraft Materials and Hardware. This unit also contribute knowledge towards Module 7 Aircraft Maintenance Practices. This unit also contributes knowledge towards SEMTA Level 3 National Occupational Standards in Aeronautical Engineering, particularly:

- Unit 8: Installing Aircraft Mechanical Fasteners into Composite and/or Metallic Components
- Unit 12: Installing Aircraft Mechanical Controls
- Unit 13: Repairing Airframes and Structures
- Unit 62: Installing Aircraft Cable Forms/Looms.

Essential resources

The following resources are considered the minimum required to effectively deliver the unit content:

- a bench or other type of tensile test machine
- example of aircraft metallic and composite materials and structural components
- good quality illustrations of different types of corrosion, identified on aircraft or preferably some physical examples of corrosion types
- a good range of aerospace fasteners, locking devices, rivets, transmission, fluid plumbing and manual control cables and fixtures hardware
- a good selection of electrical cables, cable looms and electrical connectors and ancillary fittings.

Although not essential, access to a chemistry laboratory to investigate the nature of corrosion and additional testing machines such as hardness testers, Izod and/or Charpy impact and some form of rotary bench mounted fatigue tester would most definitely encourage interest and enhance the learning experience.

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

Black B – *Workshop Processes, Practices and Materials* (Newnes, 2004) ISBN 0750660732

Bolton W – *Materials for Engineering* (Newnes, 2000) ISBN 0750648554

Crane D – *Airframe Volume 1: Structures* (Aviation Supplies and Academics, 2008) ISBN 1560277122

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	identifying questions to answer and problems to resolve when identifying types of corrosion and carrying out tensile tests analysing and evaluating information when identifying aircraft hardware.
Self-managers	organising time and resources when carrying out tensile tests to determine the strength and properties of steel and aluminium alloys.

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 ...
Creative thinkers	setting goals with success criteria for their development and work.

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 the properties and applications of aircraft materials and hardware
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	explaining the properties and applications of aircraft materials and hardware.