ROYAL CANADIAN AIR CADETS

PROFICIENCY LEVEL THREE

INSTRUCTIONAL GUIDE

SECTION 5

EO C370.02 – DESCRIBE MATERIALS USED IN AIRCRAFT CONSTRUCTION

Total Time: 30 min

PREPARATION

PRE-LESSON INSTRUCTIONS

Resources needed for the delivery of this lesson are listed in the lesson specification located in A-CR-CCP-803/PG-001, Chapter 4. Specific uses for said resources are identified throughout the instructional guide within the TP for which they are required.

Review the lesson content and become familiar with the material prior to delivering the lesson.

Create slides of figures located at Annexes N to P.

PRE-LESSON ASSIGNMENT

N/A.

APPROACH

An interactive lecture was chosen for this lesson to review, clarify, emphasize and summarize materials used in aircraft construction.

INTRODUCTION

REVIEW

N/A.

OBJECTIVES

By the end of this lesson the cadet shall be expected to describe materials used in aircraft construction.

IMPORTANCE

It is important for cadets to learn about materials used in aircraft construction as it will enhance their understanding of the materials used to build aircraft and why they are chosen.

Unofficial convenience copy of A-CR-CCP-803/PF-001, cached 2026-11-08 from https://app.cadets.gc.ca/cadet-publications/A-CR-CCP-803-PF-001/A-CR-CCP-803-PF-001.pdf.
Verify against the official publication.

Teaching point 1 **Describe Wood and Fabrics Used in Aircraft Construction**

Time: 5 min Method: Interactive Lecture

WOOD

Although wood was used for the first airplanes because of its high strength and low weight, the cost of manpower needed for wood construction and maintenance has caused wood to be almost entirely replaced by other materials, particularly metal.

Species of Wood

If wood is used, it must be carefully selected to meet aviation requirements. Aircraft grade Sitka spruce, sometimes referred to as Airplane spruce, is the preferred reference wood for aviation because of its uniformity, strength and shock-resistance.

Assessment of Wood

If other wood is substituted for aircraft grade Sitka spruce, the replacement wood must meet the same requirements.

Laminated wood is constructed of two or more layers of wood that are bonded together with a glue or resin.

Assessing wood requires the examination of many characteristics such as grain, knots and pitch pockets. A defect might make a piece of wood unusable.

FABRIC

Organic Fabric

Early aircraft were constructed using organic fabrics, such as linen, for the skin of the fuselage and wings. The earliest builders did not use any process to increase the strength of the material. The material was not airtight and it loosened and wrinkled with changes in humidity. Soon, rubberized and varnished coatings came into use to improve the fabric. Later, cotton fibres dissolved in nitric acid were used to make a dope that was worked into the fabric to produce a more durable finish.



Show the cadets the Black Maria, an example of fabric construction, at Annex N.



The Black Maria can be seen today in the National Aviation Museum in Ottawa, ON.

The next step in fabric improvement was to paint enamel over the doped fabric. It cracked and peeled with time, so aluminum powder was blended into the paint. The aluminum powder pigmentation proved very effective in blocking harmful sunlight and reflecting heat away from the fabric.

Other improvements in doping followed, but eventually advances in chemical technology led to new finishes on durable synthetic materials. Although various high grades of cotton are still sometimes used, man-made inorganic fabrics have become the most popular fabric for covering an aircraft.

Unofficial convenience copy of A-CR-CCP-803/PF-001, cached 2026-11-08 from https://app.cadets.gc.ca/cadet-publications/A-CR-CCP-803-PF-001/A-CR-CCP-803-PF-001.pdf.
Verify against the official publication.

Inorganic Fabric

Polyester fibres, woven into cloth with different weights are sold under various trade names. Other inorganic fibres include fibreglass and composites.

CONFIRMATION OF TEACHING POINT 1

QUESTIONS

Q1. Why has wood been used less for modern aircraft?

Q2. What species is the preferred reference wood for aircraft construction?

Q3. What is laminated wood?

ANTICIPATED ANSWERS

A1. Wood construction has high costs for manpower.

A2. The reference species is Sitka spruce.

A3. Laminated wood is constructed of two or more layers of wood that are bonded together with a glue or resin.

Teaching point 2 **Describe Composites Used in Aircraft Construction**

Time: 15 min Method: Interactive Lecture

COMPOSITE CONSTRUCTION



The term composite in this lesson refers to a combination of two or more materials that differ in composition or form. Composite is sometimes used to mean any synthetic building material.

Composite structures differ from metallic structures in important ways: excellent elastic properties, high strength combined with light weight and the ability to be customized in strength and stiffness. The fundamental nature of many composites comes from the characteristics of a strong fibre cloth imbedded in a resin.

Fibreglass

Fibreglass is made from strands of silica glass that are spun together and woven into cloth. Fibreglass weighs more and has less strength than most other composite fibres. However, improved matrix materials now allow fibreglass to be used in advanced composite aviation applications.



A matrix is any material that sticks other materials together.

There are different types of glass used in fibreglass: E-glass, which has a high resistance to electric current, and S-glass, which has a higher tensile strength, meaning that the fabric made from it resists tearing.

Aramid

Aramid is a polymer. A polymer is composed of one or more large molecules that are formed from repeated units of smaller molecules.

Unofficial convenience copy of A-CR-CCP-803/PF-001, cached 2026-11-08 from https://app.cadets.gc.ca/cadet-publications/A-CR-CCP-803-PF-001/A-CR-CCP-803-PF-001.pdf.
Verify against the official publication.



Ask the cadets to name all the applications they are aware of for Kevlar® .

The best-known aramid material is Kevlar®, which has a tensile strength approximately four times greater then the best aluminum alloy. This cloth material is used in many applications where great strength is needed: canoes, body armour and helicopter rotors. Aramid is ideal for aircraft parts that are subject to high stress and vibration. The aramid's flexibility allows it to twist and bend in flight, absorbing much of the stress. In contrast, a metal aircraft part would develop fatigue and stress cracks sooner under the same conditions.

Carbon/Graphite

The term carbon is often used interchangeably with the term graphite; however, they are not quite the same material. Carbon fibres are formed at 1315 degrees Celsius (2400 degrees Fahrenheit), but graphite fibres are produced only above 1900 degrees Celsius (3450 degrees Fahrenheit). As well, their actual carbon content differs – but both carbon and graphite materials have high compressive strength and stiffness.

Carbon molecules will form long strings that are extremely tough (this is what makes diamonds so strong). These minute hair-like strands of carbon (a very common and inexpensive element) are, per unit of weight, many times stronger than steel. Individual carbon fibres are flexible, rather than stiff, and bend easily despite having high tensile strength. To stiffen the fibres, cross-directional layers are immersed in a matrix material such as epoxy plastic.



The term epoxy refers to a substance derived from an epoxide. An epoxide is a carbon compound containing an oxygen atom bonded in a triangular arrangement to two carbon atoms. So, an epoxy matrix is itself carbon-based, as are the fibres that it binds.



Show the cadets Figure 17O-1.

The passenger cabin of airliners must be pressurized so that passengers will not have to wear oxygen masks during flight. The large two-level cabin of the A380 Airbus requires a bulkhead (wall) to keep this pressurized air from leaking into the unpressurized tail section. Airbus' facility in Stade, Germany specializes in the design and production of carbon fibre reinforced plastic (CFRP) components and the A380 rear pressure bulkhead was produced there.

Ceramic

Ceramic fibre is a form of glass fibre designed for use in high temperature applications. It can withstand temperatures approaching 1650 degrees Celsius (3000 degrees Fahrenheit), making it effective for use around engines and exhaust systems.



Show the cadets Figure 17O-2.

Unofficial convenience copy of A-CR-CCP-803/PF-001, cached 2026-11-08 from https://app.cadets.gc.ca/cadet-publications/A-CR-CCP-803-PF-001/A-CR-CCP-803-PF-001.pdf.
Verify against the official publication.

Ceramic's disadvantages include both weight and expense, but sometimes no other known material will do the job. One of the most famous applications of ceramic is the Thermal Protection System used on the space shuttle. The properties of aluminum demand that the maximum temperature of the shuttle's structure be kept below 175 degrees Celsius (350 degrees Fahrenheit) during operations. Heating during re-entry (in other words, heating caused by friction with the air) creates surface temperatures high above this level and in many places will push the temperature well above the melting point of aluminum (660 degrees Celsius or 1220 degrees Fahrenheit).



Underneath its protective layer of tiles and other materials, the space shuttle has an ordinary aluminum construction, similar to many large aircraft.



Show the cadets Figure 17O-3.

A space shuttle's Thermal Protection System is very complex and it contains highly sophisticated materials. Thousands of tiles of various sizes and shapes cover a large percentage of the space shuttle's exterior surface. There are two main types of silica ceramic tiles used on the space shuttle:

- **Low-Temperature Reusable Surface Insulation (LRSI).** LRSI tiles cover relatively low-temperature areas of one of the shuttles, the Columbia, where the maximum surface temperature runs between 370 and 650 degrees Celsius (700 and 1200 degrees Fahrenheit), primarily on the upper surface of fuselage around the cockpit. These tiles have a white ceramic coating that reflects solar radiation while in space, keeping the Columbia cool.



Show the cadets Figure 17O-4.

- **High-Temperature Reusable Surface Insulation (HRSI).** HRSI tiles cover areas where the maximum surface temperature runs between 650 and 1260 degrees Celsius (1200 and 2300 degrees Fahrenheit). They have a black ceramic coating, which helps them radiate heat during re-entry.

Both LRSI and HRSI tiles are manufactured from the same material and their primary difference is the coating.

A different and even more sophisticated material, Reinforced Carbon-Carbon (RCC), is used for the nose cone and leading edges of the space shuttle. It is a composite material consisting of carbon fibre reinforcement in a matrix of graphite, often with a silicon carbide coating to prevent oxidation.

CONFIRMATION OF TEACHING POINT 2

QUESTIONS

Q1. What type of glass is used in fibreglass strands?

Q2. What is best known aramid material?

Q3. What method is used to stiffen carbon fibre materials?

Unofficial convenience copy of A-CR-CCP-803/PF-001, cached 2026-11-08 from https://app.cadets.gc.ca/cadet-publications/A-CR-CCP-803-PF-001/A-CR-CCP-803-PF-001.pdf.
Verify against the official publication.

ANTICIPATED ANSWERS

A1. Silica glass.

A2. Kevlar®.

A3. Immersing cross-directional layers of carbon fibres in a matrix compound such as epoxy plastic.

Teaching point 3 **Describe Metals Used in Aircraft Construction**

Time: 5 min Method: Interactive Lecture

METALS USED IN AIRCRAFT CONSTRUCTION

Aluminum

Pure aluminum lacks sufficient strength to be used for aircraft construction. However, its strength increases considerably when it is alloyed or mixed with other compatible metals. For example, when aluminum is mixed with copper or zinc, the resultant aluminum alloy is as strong as steel, with only one-third the weight. As well, the corrosion resistance possessed by the aluminum carries over to the newly formed alloy.

Alclad®

Most external aircraft surfaces are made of clad aluminum. Alclad® consists of a pure aluminum coating rolled onto the surface of heat-treated aluminum alloy. The thickness of the aluminum coating is approximately five percent of the alloy thickness, on each side of the alloy sheet. This clad surface greatly increases the corrosion resistance of the aluminum alloy. However, if the aluminum coating is penetrated, corrosion can attack the alloy within.

Magnesium

Magnesium is one of the lightest metals with sufficient strength and suitable working characteristics for use in aircraft structures. In its pure form it lacks sufficient strength, but like aluminum, mixing it with other metals to create an alloy produces strength characteristics that make magnesium useful.

Titanium

Titanium and its alloys are lightweight metals with very high strength. Pure titanium weighs only half as much as stainless steel and is soft and ductile. Titanium’s alloys have excellent corrosion resistance, particularly to salt water.



Show the cadets Figure 17P-1 and Figure 17P-2.

Stainless Steel

Stainless steel is a classification of corrosion-resistant steel that contain large amounts of chromium and nickel. It is well suited to high-temperature applications such as firewalls and exhaust system components.

Unofficial convenience copy of A-CR-CCP-803/PF-001, cached 2026-11-08 from https://app.cadets.gc.ca/cadet-publications/A-CR-CCP-803-PF-001/A-CR-CCP-803-PF-001.pdf.
Verify against the official publication.

CONFIRMATION OF TEACHING POINT 3

QUESTIONS

Q1. Why is pure aluminum unsuitable for use in aircraft components?

Q2. What three characteristics make titanium useful for aircraft components?

Q3. What two metals are mixed with steel to make stainless steel?

ANTICIPATED ANSWERS

A1. Pure aluminum lacks sufficient strength.

A2. Titanium alloys have high strength, are lightweight and are resistant to corrosion.

A3. Steel is mixed with chromium and nickel.

END OF LESSON CONFIRMATION

QUESTIONS

Q1. What species is the reference wood for aircraft construction?

Q2. What is the name used to commonly identify aramid material?

Q3. What two metals are mixed with steel to make stainless steel?

ANTICIPATED ANSWERS

A1. The reference wood is Sitka spruce.

A2. Aramid is commonly called Kevlar®.

A3. Steel is mixed with chromium and nickel.

CONCLUSION

HOMEWORK/READING/PRACTICE

N/A.

METHOD OF EVALUATION

N/A.

CLOSING STATEMENT

Materials used in aircraft construction have evolved and improved since the earliest construction and the rate of change is accelerating. Advances in associated technologies are continually integrated with aircraft construction as aircraft become larger, more powerful and more complex.

INSTRUCTOR NOTES/REMARKS

N/A.

Unofficial convenience copy of A-CR-CCP-803/PF-001, cached 2026-11-08 from https://app.cadets.gc.ca/cadet-publications/A-CR-CCP-803-PF-001/A-CR-CCP-803-PF-001.pdf.
Verify against the official publication.

REFERENCES

C3-136 (ISBN 0-88487-207-6) Sanderson Training Systems. (2001). *A&P Technician Airframe Textbook*. Englewood, CO: Jeppesen Sanderson Inc.

Unofficial convenience copy of A-CR-CCP-803/PF-001, cached 2026-11-08 from https://app.cadets.gc.ca/cadet-publications/A-CR-CCP-803-PF-001/A-CR-CCP-803-PF-001.pdf.
Verify against the official publication.