HAWK T1/A

ADVANCED TRAINER

OPERATIONS MANUAL

Just Flight

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Please note that Aerofly FS 2 must be correctly installed on your PC prior to the installation and use of this Hawk T1/A simulation.

CONTENTS

INTRODUCTION

The Hawk T1 is an all-metal, low-wing, tandem seat training and weapons training aircraft powered by an Adour Mk 151 turbofan engine.

Aerodynamically, the aircraft is of conventional design with a moderately swept wing with a 2° dihedral and trailing edge double-slotted flaps. A one-piece all-moving tailplane is swept back and has a 10° anhedral.

The fuselage is comprised of three main parts. The front fuselage accommodates two equipment bays and a pressurised cabin containing two cockpits. The centre fuselage contains the engine, a fuselage fuel tank, a gas turbine starting (GTS) system and a ram air turbine (RAT). The rear fuselage houses a jet pipe bay and has an airbrake hinged to its under-surface.

Cockpits

A retractable step and an extending step on the left side of the fuselage give access to the cockpits, each of which is equipped with a rocket-assisted ejection seat. A single, sideways-hinged canopy is fitted. A dividing windscreen, integral with the canopy, protects the occupant of the rear seat.

A cabin pressurisation and air conditioning system uses air supplied from the engine HP compressor via heat exchangers and a cold air unit. The pressurisation and air conditioning system is controlled from the front cockpit.

The layout of each cockpit is similar. Full control of all systems is from the front cockpit but, for appropriate systems, monitoring or over-ride facilities are provided in the rear cockpit. The aircraft is flown solo from the front cockpit. Controls in each cockpit are grouped on consoles and panels as follows:

- Left console – throttle, engine starting, electrical and flying control systems
- Left main panel – weapon selection and radio
- Centre main panel – flight instruments and weapon sighting
- Right main panel – engine instruments
- Right console – avionics equipment

Electrical systems

An engine-driven 9kW DC generator supplies an Essential Services busbar via a Generator busbar. Two batteries provide power for engine starting and, following generator failure, for those services essential for the normal operation of the aircraft; the batteries are individually switched to the Essential Services busbar.

Two static inverters, supplied from the Generator busbar, provide the main AC power requirements. In addition, some equipment is supplied from individual static inverters.

Central warning system

A Central Warning System (CWS) indicates system failures and events which require prompt action. The failures or events are classified and appear as red or amber captions on a Central Warning Panel (CWP) in each cockpit. A light in the head of an engine fire extinguisher push-button illuminates to given an additional warning of fire in the engine bay.

Attention lights, located either side of the centre panel in each cockpit, flash in association with the illumination of any CWP caption. The lights in both cockpits are cancelled when either attention light is pressed. All red warnings are accompanied by an audio tone.

Fuel system

All fuel is carried internally in a flexible fuselage tank and an integral wing tank. Total fuel contents are indicated on a single gauge in each cockpit. Fuel transfers automatically from the fuselage into the wing tank and then into a collector section of the wing tank which houses a booster pump. The aircraft fuel system is pressurised from an engine air bleed.

The booster pump, which has its own electrical inverter, supplies fuel to the engine fuel system and to the fuel system of the GTS.

Engine

The Adour Mk. 151 is a turbofan engine which has a two-stage low pressure (LP) compressor driven by a single-stage LP turbine and a five-stage high pressure (HP) compressor driven by a single-stage HP turbine. In ISA sea-level conditions the engine develops 23.1 kN (5,200lb) static thrust.

The engine, installed in the aft end of the centre fuselage, has an air intake on each side of the fuselage. The engine is started by the gas turbine starting (GTS) system which is operated from the aircraft batteries. The main components of the GTS are a gas turbine air producer and a starter motor. The GTS can also be used to assist in engine relighting.

Hydraulic systems

Two independent hydraulic systems (No. 1 and No. 2), each with an engine-driven pump, supply hydraulic power to tandem actuators in powered flying control units (PFCU) and for general services. A ram air turbine (RAT) extends into the airstream automatically and maintains pressure in the No. 2 system if the No. 2 system pump fails.

One half of each tandem actuator is powered from the No. 1 hydraulic system and the other half from the No. 2 system. If either system fails, the airbrake must be selected in and airspeed must be reduced to ensure control of the aircraft on the power supplied from the remaining system.

The No. 1 system also supplies power for the normal operation of the landing gear, wheelbrakes, flaps and airbrake.

The No. 2 system pump is automatically offloaded to allow an adequate engine windmilling speed to be attained when an airborne engine relight is attempted.

Landing gear

The landing gear consists of two mainwheel units and a nose-wheel unit. The mainwheel units retract inward into wheel bays in the wing and the nose-wheel unit retracts forward into a wheel bay in the front fuselage. There are landing gear selectors and position indicators in both cockpits, but the controlling selector depends on the setting of a control transfer button in the rear cockpit.

The landing gear can be lowered by a nitrogen-operated standby system if the normal system fails.

The mainwheels have hydraulic brakes which are operated by toe pads on the rudder pedals with differential braking action. An anti-skid facility is incorporated in the braking system.

Flying controls

The ailerons and the tailplane are fully power-operated by the two hydraulic systems. The rudder is manually operated. Trimming is provided for all controls.

The flaps can be controlled from either cockpit. From the front cockpit the flaps can be set to Up, Mid or Fully Down. The flaps can be lowered by a nitrogen-operated standby system if the normal system fails.

The airbrake is on the underside of the rear fuselage and can be controlled from either cockpit. To prevent the airbrake from striking the ground when the aircraft is in the landing attitude, an interlock in the landing gear system prevents extension of the airbrake when the landing gear is down. The airbrake is automatically retracted when the landing gear is selected down.

Aircraft specifications

Dimensions

Length (including pitot tube	11.9m (39ft 3in)
Wingspan	9.4m (30ft 10in)
Height (to top of fin)	4m (13ft 2 in)
Wing area	16.7m2 (179.6 ft2)

Engine

Type	Rolls-Royce Turbomeca Adour Mk. 151 twin-shaft turbofan
Thrust rating	23.1 kN (5,200lb)
Starting air supply	Aircraft-mounted gas turbine starter

Weights

Empty weight	3,647kg
Maximum for take-off	5,700kg
Maximum for landing	5,000kg

Performance

Maximum level speed (at 11,000ft)	560kt (645 MPH)
Maximum rate of climb (sea level)	9,300ft/min (2,835m/min)
Service ceiling	48,000ft (14,630m)
Range	1310nm (2,428km)

Paint schemes

The Hawk T1/A is supplied in the following 12 paint schemes:

- Hawk T1 Royal Air Force Early trainer livery, XX241
- Hawk T1 Empire Test Pilots School livery, XX341
- Hawk T1 Royal Air Force Valley, Central Flying Squadron, XX176
- Hawk T1 Royal Air Force Camouflage scheme, XX353
- Hawk T1 Royal Air Force 4 FTS, Welsh Dragon livery, XX172
- RAF 19 Squadron, RAF Leeming – XX329
- Hawk T1 Royal Air Force Red Arrows 2011 livery XX260
- Hawk T1A Royal Air Force 100 Squadron, Black livery, XX331
- Hawk Mk. 51 Finnish Air Force, HW-346
- Hawk Mk. 53 Indonesian Air Force, LL-5320
- Hawk Mk. 63 Royal Saudi Air Force, 79034
- Hawk Mk. 63 Swiss Air Force, U-1252T1

INSTALLATION, UPDATES AND SUPPORT

You can install this Hawk T1/A software as often as you like on the same computer system:

1. Click on the 'Account' tab on the Just Flight website.
2. Log in to your account.
3. Select the 'Your Orders' button.
4. A list of your purchases will appear and you can then download the software you require.

Accessing the aircraft

To access the aircraft:

1. Load Aerofly FS 2 and click the 'Aircraft' tab to open the aircraft selection menu.
2. Use the left and right arrow keys on the keyboard to navigate through the available aircraft until you get to 'Hawk T1/A'.
3. Use the left and right arrow icons above the aircraft to select the paint scheme you wish to use.
4. Press your 'Back' button to return to the main menu and finish setting up your flight in the normal way.

Uninstalling

To uninstall this product from your system, select the appropriate option for your version of Windows from the 'Control Panel':

- 'Add or Remove Programs' (Windows XP)
- 'Programs and Features' (Windows Vista or 7)
- 'Apps & features' (Windows 10 or later)

Select the product you want to uninstall and then select the 'Uninstall' option, following the on-screen instructions to uninstall the product.

Uninstalling or deleting this product in any other way may cause problems when using this product in the future or with your Windows set-up.

Updates and Technical Support

For technical support (in English) please visit the Support pages on the Just Flight website.

As a Just Flight customer you can obtain free technical support for any Just Flight or Just Trains product.

If an update becomes available for this aircraft, we will post details on the Support page and we will also send a notification email about the update to all buyers who are currently subscribed to our Newsletter and emails.

Regular News

To get all the latest news about Just Flight products, special offers and projects in development, sign up for our Newsletter and regular emails.

We can assure you that none of your details will ever be sold or passed on to any third party and you can, of course, unsubscribe from this service at any time.

You can also keep up to date with Just Flight via Facebook and Twitter.

PANEL GUIDE

Note: *Due to the similarities between the front and rear cockpits, only the front cockpit is depicted in this section.*

Configuration panel

This panel is used to configure various options on the Hawk. To open this panel, locate the following switch on the left-hand side of the cockpit:

The available options are:

1. Opens and closes the canopy.
2. This icon will show and hide the control stick so you can get an unobstructed view of the cockpit.
3. Toggles between ‘Cold & Dark’ and being ready to start the engines.
4. Toggles the front pilot in and out of the front cockpit (when viewed externally).
5. Toggles the weapons panel in the front and rear virtual cockpits. Toggles the weapons externally.
6. Toggles the chocks on/off. The aircraft must be on the ground and stationary.
7. Toggles the internally stored pilot ladder.
8. Toggles between T1 and T1/A external appearance.
9. Toggles the rear pilot in and out of the rear cockpit (when viewed externally).
10. Opens and closes the forward storage hatches.

Left console

1. Engine start master switch
2. No. 1 battery switch
3. No. 2 battery switch
4. Fuel booster pump switch
5. Pitot static tube heater switch
6. Cover for tailplane trim standby switch
7. Aileron and rudder trim indicators
8. Aileron and rudder trim switches
9. Throttle damper friction control
10. Throttle lever
11. Anti-skid switch
12. Alternative transmit switch
13. Alternative receiver mute switch
14. Standby UHF switch
15. No. 1 and No. 2 hydraulic system pressure gauges
16. Brakes supply pressure gauge
17. Left and right brake pressure gauges
18. No. 2 hydraulic pump/ram air turbine (RAT) reset button
19. Engine ignition switch
20. Altimeter ground test switch
21. AC 3 reset button
22. DC voltmeter
23. Generator, No. 1 inverter and No 2 inverter reset buttons
24. Landing gear standby lowering system selector
25. Flap standby lowering system selector
26. Landing gear retraction/lowering selector buttons
27. Flap position selector
28. Flap position indicator

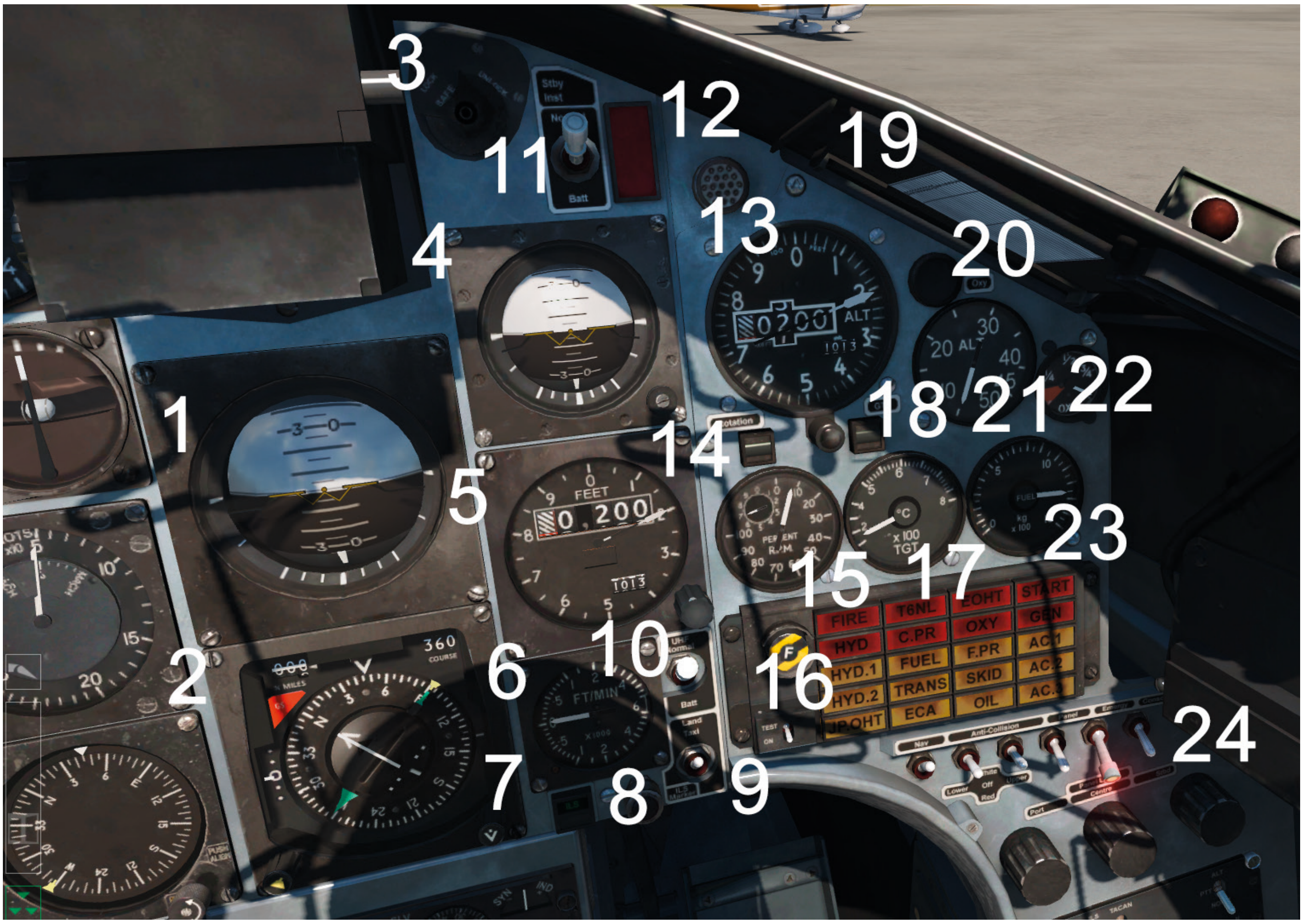
Left panel

1. Missile control panel
2. Left frequency card
3. Weapon control panel
4. UHF transceiver control panel
5. Landing gear unit position indicator
6. CWS attention light
7. Accelerometer
8. Airbrake indicator
9. Turn-and-slip indicator
10. Tailplane position indicator
11. Combined speed indicator (CSI)
12. Directional gyro indicator (DGI)

Leg panel

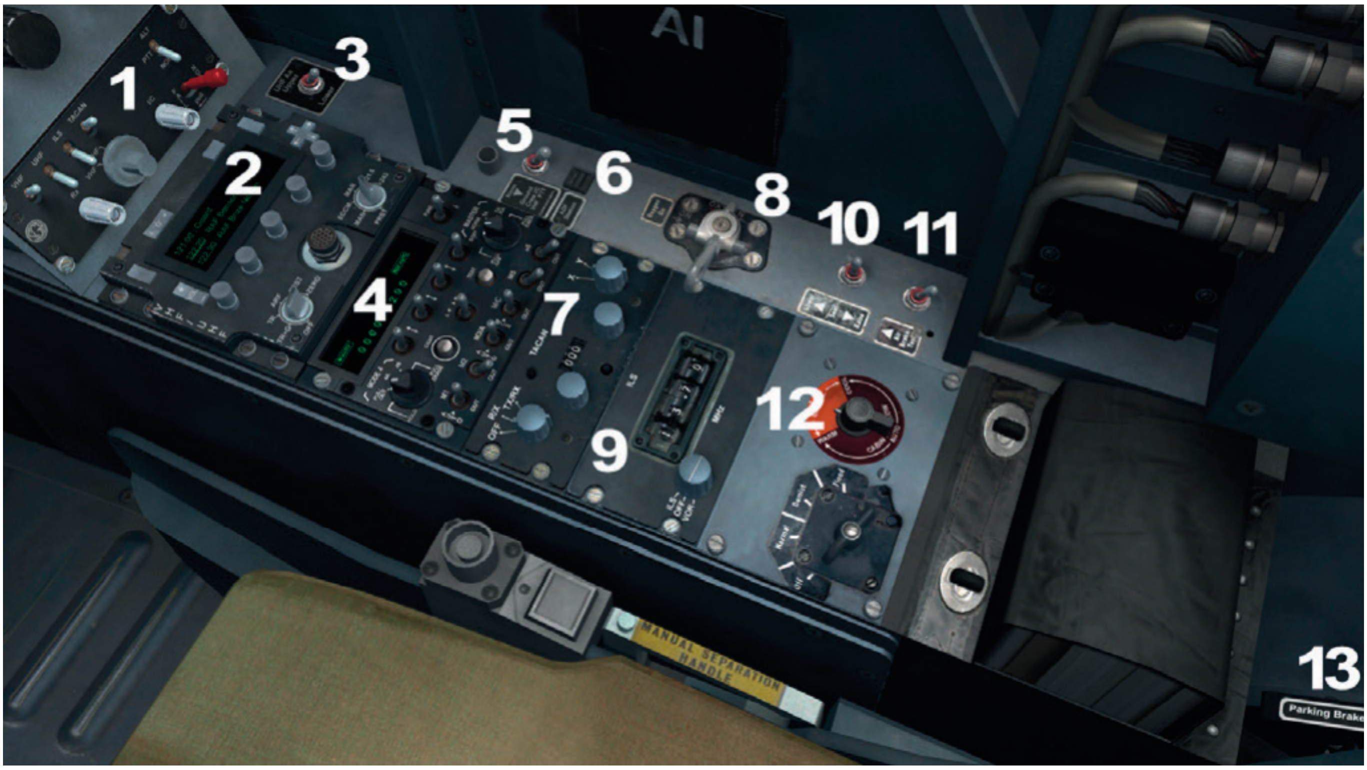
1. AHRS control unit
2. ISIS control unit
3. Rudder bar locking handle

Right panel



1. Attitude indicator
2. Horizontal situation indicator (HSI)
3. Master armament safety switch (MASS)
4. Standby attitude indicator
5. Main altimeter
6. Vertical speed indicator (VSI)
7. Navigation mode selector
8. ILS marker indicator light
9. Landing/taxi lamp switch
10. Communications power switch
11. Flight instruments power switch
12. CWS attention light
13. Standby altimeter
14. Engine LP shaft rotation indicator
15. RPM indicator
16. Central warning panel
17. TGT indicator
18. Air producer start indicator
19. Right frequency card
20. Oxygen flow indicator
21. Cabin altimeter
22. Oxygen supply contents gauge
23. Fuel contents gauge
24. Lighting switches

Right console



1. CCS station box
2. VHF transceiver control panel
3. UHF aerial selector switch
4. IFF/SSR control unit
5. External intercom switch
6. ADF station indicator
7. TACAN control unit
8. Oxygen supply selector
9. ILS control unit
10. Seat pan height adjustment switch
11. Airbrake test switch
12. Cabin conditioning control switch and temperature control switch
13. Parking brake T-handle

FUEL SYSTEM

Fuel is contained in a fuselage bag tank and an integral wing tank, with the option of additional fuel tanks carried on the inner wing pylons. The centre section of the wing tank forms a collector tank, the forward part of which is a negative-G compartment containing a booster pump. The tanks are pressurised to assist the transfer of fuel to the collector tank.

Fuel tanks

The fuselage tank is between and above the engine air intakes. The wing tank extends between the front and rear spar, each side of the centreline. The optional external tanks are carried on the inner wing pylons. The table below shows the capacities of the tanks.

Tank	KG (0.79 SG)	KG (0.77 SG)	Litres	Gallons
Fuselage	645	629	818	180
Wing	627	612	795	175
External Tanks	1365	1331	1728	380
Total	2637	2572	3341	735

Fuel transfer

Fuselage tank to wing tank

Fuel from the fuselage tank is transferred through separate lines to the outer sections of the wing tank. A flap-type non-return valve in each transfer line prevents a reverse fuel flow during aircraft manoeuvres.

Wing tank to collector tank

Fuel transfers from the outer sections of the wing tank into the collector tank via a flap-type non-return valve on each side of the collector tank.

Collector tank to negative-G compartment

Fuel from the collector tank transfers into the negative-G compartment via three flap-type valves, one in each bay of a diaphragm which forms the rear wall of the compartment. The valves prevent an excess of fuel flowing to the rear part of the collector tank when the aircraft attitude is nose high or during acceleration at low fuel states, and thus ensures that fuel is available at the booster pump for delivery to the engine.

Tank air pressurisation

The fuel tanks are pressurised by air from the engine HP compressor. The air enters the system via a filter and a pressure control valve. The pressure control valve incorporates a non-return valve, a reducing valve and a relief valve. The non-return valve prevents reverse air flow to the engine during refuelling and prevents fuel entering the air line, the reducing valve controls the air pressure to the fuselage tank, and the relief valve prevents over-pressure damage and allows the fuel system to function satisfactorily if the reducing valve fails to fully open.
A defuelling air pressure supply connection is on the filter. Datum pressure for the system is taken, at ambient pressure or slightly above, from an air inlet on the fuselage and fed to the pressure control valve, a differential pressure switch and a non-return valve.

The reducing valve, within the pressure control valve, operates to ensure that compressor air pressure to the fuselage tank is slightly above the datum air pressure. The differential pressure switch senses datum pressure on one side and tank pressure on the other. If the tank pressure falls slightly below the datum pressure, the TRANS caption illuminates. If fuel tank pressurisation is lost, the non-return valve allows air to enter the tanks from the datum air source to offset the loss of pressure. The non-return valve also prevents air/vapour or fuel venting to the atmosphere via the datum air source.

Fuel feed

Fuel is supplied to the engine from the negative-G compartment via the booster pump, a bypass valve and an LP cock. A tapping downstream of the LP cock delivers fuel to the GTS.

Booster pump

The booster pump is an immersed, double-entry unit which ensures the engine fuel supply under negative-G conditions. A differential pressure switch, downstream of the bypass valve, senses the pressure rise across the pump. The switch is subjected to collector tank pressure on one side and to LP fuel line pressure on the other. If the pressure rise is low then the switch closes and the FPR caption illuminates.

The booster pump is driven by an integral AC motor which is powered by its own static inverter. Normally the inverter power supply is from the Generator busbar and is controlled by a FUEL PUMP switch. Irrespective of the setting of the fuel pump switch, with the ignition switch to NORMAL the inverter is supplied from the Essential Services busbar while either start/relight button is pressed. The pump continues running from this source until 30 seconds after subsequent GTS shutdown during engine starting or relights. 30 seconds after GTS shutdown, with the fuel pump switch set to ON, the inverter supply reverts to the Generator busbar. With the fuel pump set to OFF the inverter is then de-energised.

Booster pump bypass valve

If the booster pump fails, the bypass valve downstream of the pump opens to allow an engine-driven LP pump to draw fuel directly from the bottom of the negative-G compartment. At the same time, the booster pump delivery line is closed to prevent air being drawn into the engine through either of the pump inlets should they be uncovered.

Fuel flow level warning

Warning of a low fuel state is indicated by the illumination of the FUEL caption and flashing of the attention lights. The warning is triggered by a float switch in the negative-G compartment which closes when the usable volume of fuel falls to 205 litres (160kg).

When the low level float switch closes, activation of the CWS is delayed 10 seconds by a time delay, thereby minimising pilot distraction by intermittent warnings triggered during aerobatics. When the flaps and/or the landing gear are down, a hold-on relay is energised and the FUEL caption, once triggered, remains on regardless of any subsequent position of the float switch. The action of the hold-on relay prevents intermittent triggering of the low fuel level warning during an approach and landing, and thus prevents possible pilot distraction. The hold-on relay is de-energised when the flaps and the landing gear are raised, or when the batteries are switched off.

Controls and indicators

The controls and indicators associated with the fuel system are listed in the table below:

Control/indicator	Marking	Location	Function
LP fuel cock lever	LP FUEL COCK CONTROL – OFF (up) / ON (down)	Left wall, front cockpit	Controls LP fuel cock connecting aircraft fuel system to engine fuel system and to air producer gas turbine
Booster pump switch	FUEL PUMP	Left console, front cockpit	Controls power supply to booster pump
Contents gauge	FUEL kg x 100	Right panel, both cockpits	Indicates usable fuel contents
Fuel low level caption	FUEL	CWP, both cockpits	Indicates approx. 160kg remaining in level flight
Fuel low pressure caption	FPR	CWP, both cockpits	Indicates pressure rise across booster pump or pressure at engine LP filter output is low
Tank air pressure failure caption	TRANS	CWP, both cockpits	Indicates low air pressure in tanks with possible loss of fuel transfer

Gas turbine air producer fuel supply

Fuel for a gas turbine air producer, which is part of the gas turbine starting (GTS) system, is tapped from downstream of the LP cock. It passes through a filter and an electrically operated shut-off valve to a dual fuel/oil pump which delivers the fuel to the distribution block of the gas turbine air producer.

Normal use

Monitor the fuel contents at all stages of flight. The FUEL caption will illuminate when the indicated fuel contents falls to approximately 160kg. When this occurs, check the fuel contents gauge and cross-check against the anticipated time to the 160kg fuel state.

Failures

Tank air pressurisation failure

Failure of the tank air pressurisation system is indicated by the TRANS caption illuminating. Fuel continues to flow to the collector tank by gravity flow. After the fuselage tank has emptied, the lack of pressurisation allows the level of the fuel in the collector tank to fall with that in the outer sections of the wing tank. When the contents of the collector tank falls to approximately 160kg, the FUEL caption is illuminated but the total fuel remaining is more than 160kg, i.e. the fuel in the collector tank plus that in the outer sections of the wing tank. At altitude, maximum power may be limited following the loss of tank pressurisation.

Following the illumination of the TRANS caption, reduce height to below 25,000ft, avoid negative-G manoeuvres and land as soon as practicable. The FUEL caption, if illuminated following tank pressurisation failure, may subsequently go out, indicating an improved fuel transfer rate.

Fuel pressure failure

The FPR caption comes on when the pressure rise across the booster pump or the fuel pressure at the LP filter outlet to the engine HP pump falls below datum. Failure of the booster pump does not seriously affect engine performance in normal flight.

Following the illumination of the FPR caption, reduce power to the minimum practicable and descend as low as practicable. Avoid negative-G manoeuvres and land as soon as possible. When the immediate action has been initiated, check that the FUEL PUMP switch and the LP cock are on. Monitor the apparent rate of fuel consumption throughout the remainder of the flight.

ELECTRICAL SYSTEM

Primary DC power is provided by an engine-driven 9kW DC generator which supplies 28 volts to a Generator busbar. AC power is provided by two static inverters which are connected in parallel to an AC busbar. The inverters are powered from the Generator busbar and each supplies 115 volts, 400Hz to the AC busbar. A third 115 volts, 400Hz static inverter powered from the Generator busbar is connected to an Armament AC busbar. Warnings of generator and inverter failure are given on the central warning panel (CWP).

Two 24-volt batteries provide power for an engine starting system and, following generator failure, for services which are essential for the normal operation of the aircraft. The batteries are connected to individual Battery busbars, each of which is connected by a switch to an Essential Services busbar.

DC system

DC Generator

The 9kW, 28-volt DC generator is below the forward end of the engine and is driven by the engine's external gearbox. Generator output is supplied to the Generator busbar, which is connected to the Essential Services busbar.

Controls and indicators

Item	Marking	Location	Function
Battery switches x2 (front cockpit only)	BATT 1 / BATT 2	Left console	Connect associated battery to Essential Services busbar
DC voltmeter (front cockpit only)	BATT VOLTS	Lower left panel	Indicates voltage at Essential Services busbar
Inverter reset button (front cockpit only)	AC3 RESET	Left console	Brings No. 3 inverter on line
Generator reset button	DC RESET	Left panel	Brings generator on line
Inverter reset buttons x2	AC 1 RESET / AC 2 RESET	Left panel	Brings associated inverter on line
Generator warning caption	GEN	CWP	Indicates voltage at Essential Services busbar is 25 volts or less
Inverter off line caption	AC 1/AC 2/AC 3	CWP	Indicates associated inverter is disconnected from AC busbar / Indicates No. 3 inverter is disconnected from the Armament busbar

Battery supplies

The two 24-volts 18-ampere/hour batteries, No. 1 and No. 2, are in the main equipment bay. The batteries are controlled from the front cockpit by the two-position switches BATT 1 and BATT 2.

Setting a battery switch to ON (forward) connects its Battery busbar to the Essential Services busbar. In this condition the battery is charged by the generator, or if the generator is off line, the battery provides a power supply to the Essential Services busbar. A supply from the Battery busbars is also provided direct to certain services, and in conjunction with the STBY INST and UHF-NORMAL/BATT switches, to standby flight instruments, the radio and communications control system (CCS).

If the generator fails, the services supplied by the Generator busbar are lost, but those services connected to the Essential Services busbar continue to operate from the Battery busbar supply, provided that the battery switches are on. Fully charged batteries should support the Essential Services busbar for approximately 25 minutes. Battery power may be conserved by selective load shedding.

Irrespective of the setting of the battery switches, the following emergency and standby services are powered from the battery supply:

- Landing gear standby lowering
- Flap standby lowering
- Cockpit emergency lighting
- Fire extinguisher
- Crash relay operation

When the UHF-NORMAL/BATT switch is in the NORMAL position, the CCS and the radio are powered from the Essential Services busbar. When the switch is in the BATT position, they are powered from the battery supply.

When the STBY INST-NORMAL/BATT switch is in the NORMAL position, the following instruments in the associated cockpit are powered from the Essential Services busbar. When the switch is in the BATT position they are powered from the battery supply:

- Turn-and-slip indicator
- Standby attitude indicator
- Directional gyro indicator

Voltmeter

The DC voltmeter is connected via a fuse to the Essential Services busbar. The scale of the voltmeter ranges from 21-29 volts and is graduated in two-volt increments.

Concentric with the graduated scale is a coloured scale which extends from 21-24 volts (orange) and from 24-29 volts (green). When the generator is off line with the battery switches set to ON, the battery voltage is indicated. The voltage of each battery can be checked by selecting the switches off and then on in turn.

AC system

AC supplies

AC power is provided by two static inverters (No. 1 and No. 2) which are supplied with DC from the Generator busbar. The output of the inverters (115 volts, 400Hz) is supplied to the AC busbar. The DC input is provided by the generator. Three step-down transformers are connected to the AC busbar, providing 26-volt, 400Hz supplies to associated busbars. A third 115-volt, 400Hz inverter (No. 3) is supplied with DC from the Generator busbar with the output connected to an Armament AC busbar.

Inverters control

The inverter protection circuit trips an inverter off line when certain fault conditions are detected. The fault conditions are grouped into two types: those associated with the input to an inverter and those associated with the output of an inverter.

When an input fault condition has been cleared the inverter is automatically reset, but after an output fault has cleared the inverter must be reset manually. The inverters can be reset manually using the AC1 RESET, AC2 RESET and AC3 RESET buttons.

Inverter failure warning

Warning that an inverter has failed or is off line is indicated by the illumination of an AC 1, AC 2 or AC 3 caption on the CWS.

Normal use

Before flight

Before engine starting on internal batteries:

1. Set both battery switches to ON.
2. Check that the GEN, AC 1, AC 2 and AC 3 captions are illuminated.
3. Confirm that the voltmeter reads a minimum of 23 volts.
4. Check the voltage of the batteries by selecting the BATT 1 and BATT 2 switches OFF and ON in turn. The voltmeter should read a minimum of 23 volts for each battery.

After engine starting on internal batteries:

1. Check that the GEN, AC 1, AC 2 and AC captions are not illuminated.
2. If the GEN caption remains illuminated, press the DC RESET button and check that the caption extinguishes. If an AC caption remains illuminated, press the appropriate AC RESET button and check that the caption extinguishes.
3. Confirm that the voltmeter indicates between 27 and 29 volts.

In flight

In flight the GEN, AC 1, AC 2 and AC 3 captions should remain extinguished and the voltmeter should indicate between 27 and 29 volts.

If either engine start/relight button is pressed the generator is automatically taken off line and the GEN, AC 1, AC 2 and AC 3 captions are illuminated. Following engine relight, press the DC RESET button and check that the GEN caption extinguishes. When the generator output voltage is sufficient to sustain the inverters on line, the AC captions should go out.

After flight

During the shutdown checks, switch off all electrical services and then switch off the batteries.

Failures

DC generator failure

Generator failure is indicated by the GEN caption illuminating and by the voltmeter indicating 25 volts or less. As the Generator busbar voltage falls the inverters are tripped off line and the AC 1, AC 2 and AC 3 captions are illuminated. Press the DC RESET button to bring the generator back on line.

If the fault was transient, the GEN caption should extinguish. Automatic resetting of the inverters should extinguish the AC 1, AC 2 and AC 3 captions but if necessary the inverters can be reset manually. If the generator cannot be reset, switch off all non-essential services and land as soon as possible.

Note: *If the FPR caption remains illuminated following the resetting of the DC generator, switch the FUEL PUMP switch OFF and then ON to extinguish the caption.*

If the generator cannot be reset, the services which are connected to the Generator busbar are lost:

- AHRS
- Fuel booster pump
- Main altimeter
- Main attitude indicator
- Horizontal situation indicator
- ILS localiser/glideslope receiver
- ISIS control unit
- Navigation mode selector

The services connected to the Essential Services busbar are supplied from the batteries, provided the battery switches are ON.

Following the loss of the generator, voltage decreases immediately to that of the batteries (approximately 24 volts). Set the STBY INST switch and the UHF switch to BATT. The voltage subsequently decreases to 21 volts and then falls rapidly. The battery switches should then be set to OFF. The voltmeter needle then deflects fully to the left and subsequently no attempt should be made to determine battery voltage from the voltmeter.

After generator failure, the life of the batteries may be prolonged by shedding selectable loads on the Essential Services busbar, as listed below. If it should be necessary to isolate the Essential Services busbar, switch off both battery switches. All of the listed services will then be lost:

- Pitot tube heater
- Landing/taxi lamp
- Anti-collision lights
- Cockpit lighting
- Navigation lights
- Radio
- Cabin pressurisation
- IFF
- Anti-skid control
- Landing gear control
- Airbrake control
- Flap control
- Engine start/relight
- Start master switch

Under-voltage and Time Delay Unit failure

Failure of the fuse connecting the under-voltage and Time Delay Unit to the Essential Services busbar causes the GEN caption to be illuminated. If the voltmeter indicates between 27 and 29 volts, failure of the fuse is confirmed and the warning is spurious. The voltmeter must then be monitored at frequent intervals. If the generator subsequently fails, the AC 1, AC 2 and AC 3 captions are illuminated and the voltmeter indicates battery voltage (approximately 24 volts).

Battery failure

An unserviceable battery may cause the generator to be tripped off line and prevent it from being reset. If this occurs, the unserviceable battery must be isolated. Set the battery switches OFF and then ON in turn. If the voltmeter registers an increase when either switch is at OFF, that switch should be left OFF. A single fully charged battery should supply the Essential Services busbar loads for approximately 12 minutes. If necessary, after an unserviceable battery has been isolated, press the DC RESET button to bring the generator on line.

AC failure

Failure of the No. 1, No. 2 or No. 3 static inverter is indicated by the AC 1, AC 2 or AC 3 caption being illuminated. Failure of all three inverters may be caused by failure of the DC generator. If, after resetting the generator, the inverters do not reset automatically, press the AC RESET buttons to bring them on line.

If a single inverter is tripped off line, the associated AC 1, AC 2 or AC 3 caption is illuminated. If the inverter fails to reset automatically, press the associated reset button. If the initial attempt to reset the inverter fails, then further attempts may be made.

Note: *The output of either the No. 1 or No. 2 inverter is sufficient to power all of the loads on the AC busbar.*

If both the No. 1 and No. 2 inverters trip off line, other than following a generator malfunction, attempt to reset one inverter only, using the following procedure. If the attempt fails, the procedure should not be repeated immediately but may be repeated at intervals during the remainder of the flight.

1. Press the AC 1 RESET button.
2. If No. 1 inverter resets, do not attempt to reset No. 2 inverter.
3. If No. 1 inverter fails to reset, press the AC 2 RESET button.
4. If No. 2 inverter resets, do not make a further attempt to reset No. 1 inverter.

If both inverters remain off line, the main attitude indicator, the horizontal situation indicator (HSI) and the AHRS are unreliable. The standby flight instruments continue to operate.

CENTRAL WARNING SYSTEM

The central warning system (CWS) gives warnings of failures or events in the aircraft systems which require prompt action to ensure the safety of the aircraft. The CWS is comprised of a central warning panel (CWP), two attention lights in each cockpit and an audio warning unit.

Indication of an engine fire is given on each CWP and by an integral light in a fire extinguisher push-button on each CWP. The failures and events are classified and appear as red or amber captions on the CWP. Only the red captions are accompanied by audio warning and they indicate more hazardous conditions than those signified by amber captions.

Each caption on the CWP is illuminated by a twin-filament lamp whenever the caption's control circuit is activated by the associated aircraft system exceeding a limitation or deviating from normal operating parameters. When appropriate remedial action is taken the CWS resets itself. It is self-cancelling if activated by transient failures or events. Power for the CWS is supplied from the Essential Services busbar.

Central Warning Panel (CWP)

The CWP is located on the right panel in each cockpit. The captions and their meanings are listed in the table below:

Caption	Indicating	Caption	Indicating
FIRE	Fire in engine bay	T6NL	TGT no NL above approx. 685°C or 108%
EOHT	Engine LP cooling air temperature exceeds 400°C	START	Fire in air producer bay
HYD	Total hydraulic failure	CPR	Cabin altitude exceeds 30,000ft
OXY	Low oxygen pressure in associated cockpit	GEN	Essential Services busbar 25 volts or less
HYD 1	No. 1 hydraulic system pressure 41 bar or less	HYD 2	No. 2 hydraulic system pressure 113 bar or less (remains on with RAT operating)
FUEL	160kg fuel remaining	FPR	Low fuel pressure
AC 1	No. 1 inverter off line	AC 2	No. 2 inverter off line
AC 3	No. 3 inverter off line	JPOHT	Jet pipe bay temperature exceeds 150°C
TRANS	Low air pressure in fuel tanks, possible loss of fuel transfer	OIL	Engine oil differential pressure low
ECA	Failure of either or both amplifier lanes	SKID	ANTI SKID switch off or anti-skid failure or failure of power supply to anti-skid control unit

The layout of the captions on each CWP is similar and, with the exception of the OXY caption, identical captions are lit simultaneously on both panels. The OXY captions operate independently in association with the respective cockpit oxygen system. If the rear cockpit oxygen system is turned off for solo flight, the rear cockpit CWP OXY caption is continuously lit.

A fire extinguisher push-button on each CWP is marked with black and yellow diagonal stripes. Each button has an integral lamp which illuminates a white F on a red background in the head of the button. Pressing a button activates the engine bay fire extinguisher which is energised by supplies from the No. 1 and No. 2 Battery busbars.

A guarded two-position TEST/ON switch is located on each CWP. The switch is spring-loaded from TEST to ON. When set to ON, DC from the Essential Services busbar is supplied to the CWS.

Attention lights

The two attention lights are integrally light spring-loaded red panels which incorporate a cancelling facility. They are located at the top left and right corners of the centre instrument panel in each cockpit. When a CWS control circuit is activated, both attention lights in each cockpit flash. Pressing any of the attention light panels will cancel the attention lights in both cockpits but the caption associated with the fault remains lit. If, after the attention lights have been manually cancelled, the CWS control circuits are activated by another fault condition, the attention lights resume flashing.

Audio warning

The audio warning is provided by a tone generator in the front cockpit, on the lower right side of the seat frame. When a failure of event associated with a red CWP caption activates the CWS control circuits, the tone generator is energised and a continuous ‘whooping’ audio warning sounds. Pressing an attention light panel cancels the audio warning. If a fault condition associated with a red caption subsequently activates the CWS control circuits, the audio tone is re-generated.

Testing the CWS

The CWS is tested when a TEST/ON switch is held at TEST. With the switch at TEST, the lights of all unlit captions on both CWPs come on, the head of each fire extinguisher button is illuminated, the attention lights flash in both cockpits and the warning tone is generated.

When the switch is released, all captions which were not lit before TEST was selected and the fire extinguisher button lights will go out, and the attention lights and the warning tone are cancelled. If, while the switch is held at TEST, an attention light panel is pressed, the attention lights and the audio warning are cancelled.

Normal use

Before starting the engine, when the batteries are switched on, check that the HYD, GEN, HYD 1, FPR, AC 1, HYD 2, TRANS, SKID, AC 2, OIL and AC 3 captions illuminate. Check that when the test switch is held at TEST, all unlit captions on both CWPs illuminate, the attention lights and audio warning tone are activated, and the fire extinguisher button illuminates. When the test switch is released, check that all indications revert to their pre-test state.

Failures

An electrical fault within the CWS can cause the audio warning to sound continuously and in isolation. In this condition the audio warning cannot be cancelled.

HYDRAULIC SYSTEM

Two independent hydraulic systems, designated No. 1 and No. 2, supply hydraulic power for the operation of the powered flying controls. The No. 1 system also supplies power for the normal operation of general services, i.e. landing gear, wheelbrakes, flaps and airbrake. A ram air turbine (RAT) extends into the airstream automatically to supply power to the aileron and tailplane powered flying control units (PFCU) in the event of engine failure or the failure of No. 2 system pressure. The RAT can be re-stowed by use of a push-button in either cockpit. A hand pump in the No. 1 system can be used for pressurising the general services and a wheelbrakes accumulator on the ground when the engine is not running.

Each system contains a reservoir, an engine-driven pump and a flying controls accumulator. A pressure gauge for each system is located in both cockpits. The operating pressure of both systems is 207 bar. Pressure switches initiate warning of pressure failure, which is indicated by the illumination of captions on the CWP. Relief valves in the systems ensure that line pressures do not become excessive.

The No. 1 system powers one half of each PFCU and, when system pressure is 103 bar or more, provides power for the general services. The No. 2 system provides powers for the other half of each PFCU. This arrangement of the hydraulic power supplies ensures that the operation of the flying controls is not affected by the failure of either system. A solenoid-operated bypass valve is associated with the No. 2 system pump. The valve is automatically energised open to offload the pump during engine starting.

The valve is also energised during relighting when the engine RPM falls to 42% or below, provided that both engine start master switches are at ON. The pump can be manually reset from either cockpit when engine RPM are 45% or above.

Controls and indicators

The controls and indicators for the hydraulic systems are similar in both cockpits:

Control/indicator	Marking	Location	Function
No. 2 hydraulic pump/ RAT reset button	HYD 2 RESET	Left console	Resets No. 2 system pump after engine start/relight. Initiates RAT retraction, provided that No. 2 pump pressure is above approx. 130 bar
Pressure gauges (2)	HYD 1 and HYD 2	Left console	Indicates No. 1 system pressure
System low pressure captions	HYD 1 (amber), HYD 2 (amber) and HYD (red)	CWP	Indicates No. 1 system pump output pressure has fallen to 41 bar or below. Indicates No. 2 system pump output pressure has fallen to 113 bar or below (remains on with RAT operating). Indicates total hydraulic failure.

Reservoirs

The reservoir in each system is charged with nitrogen at 3-5 bar. Hydraulic pressure in the systems dissipates slowly after engine shutdown, but it can be dissipated more rapidly by movement of either control column.

Accumulators

The two flying controls accumulators, nitrogen-charged to 76 bar, enable instantaneous demands from the flying controls to be met. An additional accumulator in the No. 2 system, nitrogen-charged to 66 bar, provides power to extend the RAT jack if the No. 2 system pressure falls below 103 bar and maintains pressure to the flying controls whilst the RAT pump is running up. With the RAT extended, both accumulators in the No. 2 system operate to smooth the delivery flow to the flying controls.

A wheelbrakes accumulator, nitrogen-charged to 86 bar, is supplied by the No. 1 hydraulic system pump.

No. 2 system pump bypass valve

The No. 2 system bypass valve solenoid is automatically energised to open the valve during engine starting. With the valve open, the pump output is directed to its suction side and the pump if offloaded. The low output pressure causes the HYD 2 caption to illuminate. When the engine RPM rises through 45%, the bypass valve solenoid can be de-energised and the valve closed by pressing the HYD 2 RESET button.

Subsequently, as No. 2 system pump output pressure rises through approximately 137 bar, the HYD 2 caption extinguishes. Irrespective of the increased pump output pressure following the valve closure, the HYD 2 caption remains illuminated unless the HYD 2 RESET button is pressed. Whenever engine RPM falls through 42%, with both engine start master switches ON, the bypass valve solenoid is automatically energised and the valve opened.

Ram Air Turbine (RAT)

The RAT is an integral part of the No. 2 system and supplies hydraulic power to the flying controls if engine failure occurs. The RAT and its jack are in a bay in the top of the fuselage, forward of the fin. The RAT is maintained in the retracted position by hydraulic pressure on one side of the jack piston and by spring-loading within the jack.

The RAT is automatically extended whenever No. 2 system pressure falls below 103 bar. At this pressure a shuttle valve operates to allow RAT accumulator pressure to the reverse side of the RAT jack piston. Due to the difference in effective areas of the piston head, this pressure extends the jack and raises the RAT into the airstream. Simultaneously, the shuttle valve links the RAT accumulator and the RAT pump output to the No. 2 system flying controls supply line.

A RAT cut-out valve regulates RAT pump output between 169 and 203 bar. Indication that the RAT is functioning is given by the HYD 2 pressure gauge cycling between 160 and 210 bar as control column demands are made. When operating, the RAT pump recharges both its own and the No. 2 system flying controls accumulator.

If engine RPM falls to 42% during relighting, and both engine start master switches are ON, No. 2 system pump bypass valve solenoid is automatically energised and the pump output passes to the suction side of the pump. The reduction in system pressure allows the RAT to extend into the airstream. When RPM increases to 73%, pressing the HYD 2 RESET button causes the solenoid of the bypass valve to be de-energised. At the same time the solenoid of the shuttle valve is energised, allowing No. 2 system pump pressure to be supplied to the shuttle valve and thereby restoring normal operation of the No. 2 system. The HYD 2 caption is subsequently extinguished. With the shuttle reset, hydraulic pressure within the jack is directed to the reverse side of the piston head and the RAT retracts.

The solenoid of the No. 2 system pump bypass valve can be de-energised by pressing the HYD 2 RESET button when engine RPM has risen above 45%. However, the RAT shuttle valve cannot be reset at this RPM since the No. 2 system pump output will be insufficient to assist shuttle valve movement and the output passes to return via the shuttle valve. The RPM required to raise the pump output sufficiently to move the shuttle valve may be as high as 76%.

The output of the RAT pump is dependent on airspeed. At sea level the pump develops maximum output at speeds in excess of 130 knots. At 105 knots the output is reduced to 75% of maximum.

Extension of the RAT can be tested on the ground with the engine running. In flight, with the engine throttled back, the RAT can be tested for functionality. For both tests the No. 2 system hydraulic pressure must be reduced by continuous movement of the control column until the RAT extends. On the ground, with the RAT extended, the HYD 2 pressure gauge shows RAT accumulator pressure. In flight the gauge reading cycles in response to RAT pump cut-out valve action. In flight, depending on the engine RPM used during a test, the HYD 2 caption may extinguish after the RAT has extended and control column movement has ceased.

After a test has been completed and the HYD 2 caption has extinguished, the HYD 2 RESET button must be pressed to retract the RAT.

During engine shutdown, the RAT extends when No. 2 system pressure falls to 103 bar. When pressure has dissipated the RAT is retracted automatically by spring action and its bay doors close.

Normal use

Before flight

After engine start, check control response on HYD 1 system and then press the HYD 2 RESET button. Check that the HYD, HYD 1 and HYD 2 captions are extinguished. Check that the HYD 1, HYD 2 and BRAKES SUPPLY pressure gauges indicate approximately 200 bar.

Before taxiing, check the flying controls for full and free movement and that the HYD 1 and the HYD 2 pressures recover fully after control column movement ceases.

In flight

Check that the pressure in both systems remains at approximately 207 bar. A transient drop in HYD 1 pressure occurs during operation of the landing gear, flaps or airbrake, but pressure should restore when the operation of a service is complete.

With the engine throttled back, RAT functioning can be checked by moving the control column continuously to reduce No. 2 hydraulic system pressure until the HYD 2 caption illuminates and the RAT extends. Functioning of the RAT is indicated by the HYD 2 pressure gauge reading cycling between approximately 160 and 210 bar as the RAT pump cuts in and out. The HYD 2 caption may extinguish depending on the idle RPM used during the test. To retract the RAT, increase engine RPM to above 75% and press the HYD 2 RESET button. Check that the HYD 2 pressure gauge indicates approximately 200 bar.

After flight

During engine shutdown, the RAT extends when No. 2 system pressure falls to approximately 103 bar. It retracts when the system pressure has dissipated.

Failures

In all cases of hydraulic system failure, land as soon as possible.

A non-return valve is in each of the No. 1 and the No. 2 hydraulic system pressure lines to the tailplane PFCU. The valves act to cause a hydraulic lock and prevent a sudden nose-down tailplane runaway if hydraulic failure occurs in extreme conditions of high tailplane loading, i.e. airbrake extended at high speeds.

No. 1 system

If No. 1 system pressure falls to approximately 103 bar, the system pressure is confined to the operation of the PFCU only and:

- The landing gear must be lowered using the standby system
- Flap lowering is dependent on the standby system
- The airbrake, if extended, remains so until blown in by airloads after being selected in
- Wheelbrakes operation is dependent on brake accumulator pressure

If No. 1 system pump output pressure falls below approximately 41 bar, the HYD 1 caption illuminates and the system fails.

The illumination of the HYD 1 caption when the landing gear is selected up may indicate a leak in the No. 1 hydraulic system. Selecting the landing gear down immediately may prevent the loss of fluid from the system. Do not attempt to reselect the landing gear up.

No. 2 system

If No. 2 system pump output pressure falls to approximately 113 bar, the HYD 2 caption illuminates. If the pressure continues to fall to approximately 103 bar, the RAT extends. The No. 2 system pressure then increases and the pressure indication cycles between approximately 160 and 210 bar.

If the failure is transient, for example because of excessive control column movement at low engine RPM, the HYD 2 caption should extinguish when control movement ceases or when the engine RPM is increased. Set a minimum of 76% RPM and press the HYD 2 RESET button to retract the RAT.

If the failure is caused by loss of hydraulic fluid or of reservoir nitrogen pressure, the RAT is inoperative and there will be no cycling of the HYD 2 pressure indication.

No. 1 and No. 2 systems

Failure of both engine-driven pumps is indicated by the illumination of the HYD 1 and the HYD 2 captions and by pressure gauge readings. The RAT should extend when No. 2 system pressure falls to approximately 103 bar. Functioning of the RAT is indicated by the HYD 2 pressure indication cycling between approximately 160 and 210 bar as control column demands are made. The lowering of the landing gear and flap are dependent on the standby lowering systems and wheelbrake operation is dependent on brake accumulator pressure.

Total hydraulic failure

If failures of the hydraulic systems occur progressively, the HYD caption (red) illuminates and is accompanied by audio warning when the third system failure occurs, i.e. total hydraulic failure, irrespective of the sequence in which the systems fail. Following total hydraulic failure, the aircraft should be abandoned before the flying controls accumulators are exhausted.

Accumulators

The complete loss of nitrogen from the No. 1 or No. 2 system accumulator results in the loss of damping of high-pressure hydraulic pulses and is indicated by pressure fluctuations on the associated pressure gauge.

FLIGHT CONTROLS

The flight controls are comprised of ailerons, an all-moving tailplane, a rudder, flaps and an airbrake.

The ailerons and tailplane are fully power-operated with no reversion to manual control, and the rudder is manually operated. Trimming facilities are provided for the ailerons, tailplane and rudder.

The flaps and airbrake are power-operated and a flaps standby lowering system is provided.

The dual control columns, which are interconnected, are linked by push-pull rods to hydraulically operated powered flying control units (PFCU), one at each aileron and one at the tailplane. In each cockpit a pair of rudder pedals is carried on a rudder bar. The rudder bars are interconnected and linked by push-pull rods to the rudder.

Hydraulic power for the operation of the aileron and tailplane PFCU is provided by the No. 1 and the No. 2 hydraulic systems. Hydraulic power for the flaps and the airbrake is from the No. 1 hydraulic system.

Controls and indicators

The controls and indicators for the ailerons, tailplane and rudder are listed below:

Control/indicator	**Marking**	**Location**	**Function**
Aileron trim switches	AILERON TRIM	Left console	Control aileron trim actuator
Aileron trim indicator	AILERON	Left console	Indicates aileron trim setting
Tailplane main trim switches	Unmarked	Top of control column	Control tailplane actuator main motor
Tailplane standby trim switch covers	LIFT FOR STANDBY, CLOSE FOR MAIN	Left console	Cover, when raised fully, operates integral switch to isolate trim actuator main motor, and exposes standby trim switches
Tailplane standby trim switches	Unmarked	Left console	Control tailplane trim actuator standby motor
Tailplane position indicator	TAILPLANE	Centre panel	Indicates tailplane setting
Rudder trim switch	RUDDER TRIM	Left console	Controls rudder trim tab setting
Rudder trim indicator	RUDDER	Left console	Indicates rudder trim tab setting
Rudder bar lock handle (front cockpit only)	Unmarked (red)	Right side of leg panel	Engages/disengages rudder system lock

Powered Flying Control Units (PFCU)

Each PFCU is comprised of an actuator, which has two cylinders and two pistons in tandem and which is anchored at one end to the aircraft structure. The pistons are connected to a ram which is linked to a control surface operating lever. Each half of the actuator has a control valve, operating simultaneously in the same sense, to direct hydraulic fluid under pressure to one side or the other of the associated piston depending on the direction of control column movement. One half of each actuator is supplied, via its control valve, from No. 1 hydraulic system. The other half is similarly supplied from No. 2 hydraulic system. If one hydraulic system fails, the control valve in the associated half of the PFCU operates to allow fluid to be displaced freely as the piston moves, thus preventing a hydraulic lock. The failure does not affect operation of the flying controls.

The pistons move relative to the actuator body and deflect the control surface via the ram and the operating lever. The ram has a mechanical feedback linkage which centralises the control valve when the control surface reaches the demanded position. When control column movement ceases, the control valves close to effect a hydraulic lock which prevents further movement of the pistons and therefore the control surface.

Control surfaces – range of movement

Aileron – the range of aileron movement is approximately ±12°.

Tailplane – the range of tailplane movement is +6.6° (nose down) to -15° (nose up), relative to the fuselage datum. Tailplane position is shown on the TAILPLANE position indicators by a pointer which moves against a scale graduated at 1° intervals from +7° to -17°. The scale has major graduations at 5° intervals.

Rudder – the range of movement of the rudder is 20° left and right. The rudder trim tab has a range of movement of 9° left and right, relative to the rudder.

Trimming

General

Control column or rudder pedal forces are trimmed out using the aileron, tailplane or rudder trim switches which control a power supply to the motors of associated trim actuators. The tailplane can be trimmed using either the main or standby trim switches which control the main or the standby motor of the tailplane trim actuator. The power supply for the trim actuator motor is from the Essential Services busbar via the trim switches.

Aileron trim

The aileron trim actuator operates to bias the aileron spring feel unit. Operation of the actuator is controlled by the AILERON TRIM switches. The amount of trim applied is shown on the AILERON trim indicator by a pointer which moves against an un-numbered arc from 270°, through 0° to 90°. The range of trim afforded by the aileron trim actuator is governed by limit switches and by mechanical stops. The time required to trim from stop to stop is approximately seven seconds.

Tailplane trim

The maintain motor of the tailplane trim actuator is controlled by two switches on the control column in each cockpit. The standby motor of the actuator is controlled by two switches in the front cockpit and by a single switch in the rear cockpit. The standby trim control switches are under the LIFT FOR STANDBY, CLOSE FOR MAIN cover. When either cover is raised the main motor is isolated and tailplane trimming, using the exposed switches, is then effected by the standby motor. In the front cockpit the two standby control switches must be operated together to effect operation of the standby motor. The range of trim (+3° to -5°) afforded by the tailplane trim actuator is governed by limit switches and by mechanical stops. The time required to trim from stop to stop is approximately four seconds.

Rudder trim

The rudder is trimmed by a rotary actuator which moves a trim tab on the rudder. The actuator is controlled by the RUDDER TRIM switch. The degree of trim is shown on the RUDDER trim indicator by a pointer which moves against an unnumbered arc from 315°, through 0° to 45°. The range of trim afforded by the rudder trim tab is governed by limit switches only. The time required to trim over the full range is between 16 and 22 seconds.

Rudder bar lock

The rudder bar lock handle, located in the front cockpit only, enables the rudder pedals, the control linkage and the rudder to be locked in the central position. The handle is moved to the locked position by it rearwards and upwards to the horizontal where it obstructs the right rudder pedal.

The lock is disengaged by rotating the handle downwards and forwards until the handle is in its unlocked position against the right side of the cockpit leg panel.

Flaps

General

A double-slotted trailing edge flap is on each side of the wing. Each flap is supported by hinges which are offset below the wing to give increased wing area when the flaps are lowered. The flaps are hydraulically operated by a single centrally mounted jack, powered by No. 1 hydraulic system. A high pressure nitrogen standby system is provided for lowering the flaps if No. 1 hydraulic system fails.

Controls and indicators

The flaps are controlled by a three-position UP/MID/DOWN selector on the left panel in the front cockpit and by a similar UP/PUPIL/DOWN selector in the rear cockpit. Each cockpit has a FLAP x 10 (degrees) position indicator above the flaps selector. A T-handle, marked F on the left panel in each cockpit, operates the flap standby lowering system.

Operation

Operation of the flaps is via an electro-hydraulic selector valve which is electrically controlled by the cockpit selectors. With the rear cockpit flap selector at PUPIL, flap selection is controlled from the front cockpit.

Standby lowering system

High pressure nitrogen for lowering the flaps by the standby system is stored in a bottle behind the rear cockpit bulkhead. The bottle is charged to 207 bar. If the No. 1 hydraulic system fails, the flaps are lowered to fully down when the T-handle is pulled out. When the handle is pulled, the flap selector valve is de-energised and a cartridge is electrically detonated to release the nitrogen which is directed via a shuttle valve, to the down side of the jack, causing the up-side fluid to be dumped overboard via a jettison valve. The flaps lower and subsequently cannot be raised. The standby lowering system operates irrespective of flap setting and of which cockpit has flap control.

Power supplies

The power supply for normal flap operation is from the Essential Services busbar. The power supply for operation of the flaps using the standby system is from the battery supply. Normally a voltage of at least 14 volts is required to activate the system.

Airbrake

The airbrake, located on the underside of the rear fuselage, is hydraulically operated by a jack which is powered by No. 1 hydraulic system. The airbrake can be operated from either cockpit and is electrically controlled via an electro-hydraulic selector valve. Full extension of the airbrake is approximately 60°.

There is sufficient ground clearance for full extension at the normal ground attitude of the aircraft. However, to ensure that an extended airbrake cannot strike the ground when the aircraft is in the landing/take-off attitude, an interconnect circuit automatically retracts the airbrake and isolates the airbrake selection switch when the landing gear is selected down by normal selection. If the landing gear standby lowering system is used, the airbrake automatic retraction facility does not operate.

Controls and indicators

An AIR BRAKE – IN/OUT switch, spring-loaded to the centre off position, is located on the top of each throttle lever handle. An AIRBRAKE magnetic indicator is on the centre panel in both cockpits. The indicator is de-energised to show black when the airbrake is fully retracted or when the electrical supply is not established. The indicator is energised to show white when the airbrake is not fully retracted. A spring-loaded AIR BRAKE TEST switch, located on the front cockpit right console, enables the airbrake operation to be tested on the ground. The electrical supply for the airbrake system is from the Essential Services busbar.

Operation

In flight, operating an AIR BRAKE switch extends or retracts the airbrake, provided that the landing gear is up. If the airbrake is in the extended position when the landing gear is lowered by a normal down selection, the airbrake is automatically retracted.

Testing

On the ground, holding the AIR BRAKE TEST switch forward bypasses the landing gear interconnect circuit, allowing the airbrake to be operated using the AIR BRAKE – IN/OUT switch. When OUT is selected the airbrake moves to full extension. When IN is selected the airbrake retracts.

Normal use

Before flight

Release the rudder lock and confirm free movement.

After starting the engine, check the flying controls for full and free movement and that the hydraulic pressures recover fully after control movement ceases. During the check of full and free tailplane movement, check that the full range of +6.6° (nose down) to -15° is displayed on the tailplane position indicator in each cockpit.

Make the following checks:

Rudder trim – check that the rudder trim functions over its full range and check the indicator. Set the trim to neutral.

Aileron trim – check that the aileron trim functions over its full range and check the indicator. Set the trim to neutral.

Tailplane trim (main) – check that the tailplane trim functions over its full range using the main trim switches and check the indicator.

Tailplane trim (standby) – lift the cover of the tailplane standby trim switches. Check that the standby trim functions over its full range and check the indicator. Return the trim to neutral. Lower the switch cover and check that the main trim is again functioning.

Flaps – for solo flight the rear cockpit flaps selector must be set to PUPIL. Check the operation of the flaps over the full range and check the indicator. If appropriate, return flap control to the front cockpit by setting the front cockpit selector to the same setting as the rear cockpit selector and then set the rear cockpit selector to PUPIL.

Airbrake – hold the AIR BRAKE TEST switch forward and check the operation of the airbrake and the magnetic indicator independently from both cockpits. Check the rear cockpit over-ride facility by making simultaneous but opposite selection in both cockpits. Check that the rear cockpit selection prevails.

In flight

Periodically check the hydraulic pressures. Although the airbrake is automatically retracted when the landing gear is selected down normally, the airbrake should be selected in before the landing gear is selected down.

Failures

If a HYD 1 or HYD 2 caption illuminates, the airbrake is not to be extended. If, in the event of a HYD 1 or HYD 2 caption illuminating, the airbrake is extended it should be immediately selected in.

LANDING GEAR, WHEELBRAKES AND ANTI-SKID

The landing gear consists of left and right mainwheel units and a fully castering nose-wheel unit. Hydraulically operated wheelbrakes are fitted to the mainwheels.

The landing gear is normally operated by hydraulic power from the No. 1 hydraulic system, but if this system fails the landing gear can be lowered using a high-pressure nitrogen standby system. An emergency retraction facility is provided.

The mainwheel units retract inward into wheelbays in the wing, forward of the spar. Fairing doors on each main unit leg retract with the unit. Wheelbay doors are hydraulically sequenced to close after the legs retract. The reverse sequence occurs on lowering and the wheelbay doors remain open with the landing gear down.

The nose-wheel unit retracts forward into a fuselage bay which is closed by three doors mechanically linked to the unit leg. The doors remain open with the nose-wheel unit down. A cam, integral with the oleo leg of the nose-wheel unit, self-centres the nose-wheel when the oleo extends during take-off.

Hydraulically operated three-plate wheelbrakes, incorporating a selectable electro-hydraulic cross-coupled anti-skid system, are fitted to the mainwheels. The brakes are operated by toe pads on the rudder pedals. Differential braking is provided.

Landing gear

Controls and indicators

The controls and indicators for the landing gear system are listed below:

Control/indicator	Marking	Location
Retraction selector button (with emergency retraction facility)	UP	Left panel, both cockpits
Lowering selector button	DOWN	Left panel, both cockpits
Selection control transfer button	Red	Left panel, rear cockpit
Unit position indicator	Unmarked	Left panel, both cockpits
Standby lowering selector T-handle	U/C	Left panel, both cockpits

Position indicator

The electro-mechanical position indicator has three windows, one for each unit of the landing gear, through which the following indications are given:

- Green – unit locked down
- Red – unit unlocked or no electrical supply to the indicator
- UP (in white on black background) – unit locked up

Operation

Operation of the landing gear is controlled via an electro-hydraulic selector valve by the UP and DOWN selector buttons. Each UP button has a solenoid-operated safety lock which prevents inadvertent up selection when the aircraft is on the ground. The solenoids are energised from the Essential Services busbar via the contacts of a ‘weight-on-wheels’ microswitch on the oleo of each mainwheel leg. As the oleos extend after take-off the microswitches close. The solenoids are then energised and withdraw the button safety lock to allow an UP selection to be made.

Selection control transfer button

The selection control transfer button is below the DOWN selector button in the rear cockpit. When the transfer button is depressed, landing gear selection is controlled from the front cockpit and the rear cockpit UP and DOWN buttons are automatically set to the out position.

When an UP or a DOWN selection is made in the rear cockpit, the transfer button is released and full control of the landing gear, including the emergency retraction facility, is transferred to the rear cockpit. The front cockpit selector buttons are then electrically isolated and remain in the last selected position.

Control of landing gear selection is returned to the front cockpit when the transfer button is again depressed. However, a solenoid-operated safety lock in the transfer button ensures that this transfer can only be achieved when the setting of the front cockpit UP and DOWN selector buttons corresponds with the setting of the rear cockpit buttons. The transfer button must be depressed for solo flight.

Standby lowering system

High-pressure nitrogen from a storage bottle is used to lower and lock the landing gear if No. 1 hydraulic system fails.

The standby system is operated by pulling a U/C T-handle outwards after pressing a locking button integral with the handle. The system operates irrespective of the landing gear selector buttons. Pulling the U/C T-handle in either cockpit de-energises the landing gear selector valve and electrically detonates a cartridge which operates a release valve to allow nitrogen from the storage bottle to be directed, via shuttle valves, to the down side of the landing gear jacks. After the landing gear has been lowered using the standby system it cannot subsequently be retracted.

The landing gear can be raised in an emergency by rotating either landing gear selector UP button clockwise and then pressing the button. The facility is available from both cockpits when landing gear normal control is from the front cockpit (rear cockpit transfer button depressed) or from the rear cockpit alone when normal control is from that cockpit. The emergency retraction facility is inoperative if the landing gear has been lowered by the standby system or the No. 1 hydraulic system has failed.

Wheelbrakes and anti-skid

Wheelbrakes

Hydraulically operated wheelbrakes, incorporating a selectable electro-hydraulic cross-coupled anti-skid system, are fitted to the mainwheels. The brakes are operated by toe pads on the rudder pedals and differential braking is provided. A parking brake is in the front cockpit only.

Pressure on the toe pads generates hydraulic pressure in a brake master cylinder attached to the front of each pedal. This pressure is then transmitted via a hydraulic line to a twin brake control valve. The hydraulic lines from each master cylinder are independent of each other and of the No. 1 and No. 2 hydraulic systems. The brake control valve regulates pressure from No. 1 hydraulic system (or the wheelbrake accumulator) to the brake unit. The toe brakes can be operated independently for differential braking or together for uniform braking.

A pressure-sensitive bypass valve and a restrictor in each brake pressure line minimises brake response time and improves the operation of the anti-skid system. When a pressure-sensitive valve is open, pressure can be rapidly applied to the associated wheelbrake. When the applied pressure reaches a pre-set value the valve is automatically closed. Pressure from the brake control valve can then only pass through the restrictor which allows a gradual rate of application of pressure at the brake, and so provides for smooth operation of the anti-skid system by reducing the possibility of rapid wheel deceleration.

A brakes SUPPLY pressure gauge, located on the left console in each cockpit, indicates the brakes accumulator pressure. When the accumulator is fully charged the supply gauge indicates between 195 and 210 bar. If the No. 1 hydraulic pump fails, a fully charged accumulator provides a reserve of power which is sufficient to provide a reserve of power which is sufficient to bring the aircraft to a braked stop, with anti-skid protection, after landing.

Two brake pressure gauges, PORT and STBD, adjacent to the SUPPLY pressure gauge, indicate the pressure applied at the respective brake. The gauges are graduated from 0-140 bar in increments of 10 bar. With the brakes fully applied, the highest pressure indicated is between 85 and 100 bar. When the brakes are released, a residual pressure of up to 10 bar may be indicated on the gauges.

Parking brake

A PARKING BRAKE T-handle is aft of the right console in the front cockpit. The wheelbrakes can be applied and locked on by pulling up the T-handle.

When the parking brake is on, an initial brake pressure of between 85 and 100 bar should be indicated for each mainwheel, provided the wheelbrakes accumulator pressure is above this range.

Anti-skid

The anti-skid system provides automatic protection against mainwheel skidding. The main components of the anti-skid system are a control unit, two solenoid-operated electro-hydraulic control valves and a speed sensor in each mainwheel.

The power supply for the system is from the Essential Services busbar, via a fuse, and is controlled by an ANTI SKID switch on the left console in each cockpit. The system operates automatically, provided that the ANTI SKID switch in each cockpit is selected ON. A SKID caption on the CWP is illuminated if either the ANTI SKID switch is OFF or if the anti-skid system fails.

Normal use

Before flight

During the initial cockpit checks, in the front cockpit check that the landing gear selector DOWN button is in. In the rear cockpit check that the control transfer button (red) is in and that the UP button and the DOWN button are both out. In both cockpits check that the UP selector button has not been rotated to its emergency setting. For solo flight, check that the ANTI SKID switch in the rear cockpit is ON and that the landing gear control transfer button is in.

During the internal checks, apply the parking brake and check that brake pressure at each mainwheel is between 85 and 100 bar.

When the chocks have been removed after engine starting, release the parking brake and allow the aircraft to roll forward gently, and then check the action of the brakes. While taxiing, check the differential action of the brakes. Before take-off select ANTI SKID on and then check that the SKID caption is extinguished and that braking is normal.

In flight

After take-off with the landing gear selected UP, check that the unit position indicators show UP.

After lowering the landing gear, check that the unit indicators show green and that the DOWN selector is fully in. Check that the wheelbrakes accumulator pressure gauge registers 195 to 210 bar and the residual pressure is below 10 bar.

Landing

Normal braking is unlikely to activate the anti-skid system.

After landing

After landing but before taxiing, select ANTI SKID off and then check that the brakes accumulator pressure is approximately 200 bar and that braking is normal.

Failures

Landing gear

If the landing gear fails to lower when DOWN is selected, check that HYD 1 pressure is normal and check the position of the selector in the rear cockpit. Below 200 knots with the flaps up make further landing gear selections from both cockpits if possible. If the landing gear still fails to lower, select DOWN and then operate the landing gear standby system by pressing the central knob and pulling the handle.

If the No. 1 hydraulic system fails, the normal landing gear lowering system is inoperative. Select DOWN and lower the landing gear using the standby system.

Wheelbrakes

If the No. 1 hydraulic system fails, the wheelbrakes are served by the brakes accumulator only. Do not test the brakes during the downwind checks. After touchdown, set the throttle lever to HP OFF. When the mainwheels and the nose-wheel are firmly on the ground, apply the brakes progressively. During the landing run, pulling the control column fully aft increases load on the mainwheels. After the aircraft has been stopped, do not taxi.

When the brakes accumulator pressure drops below approximately 120 bar, the brakes function with decreasing effectiveness. When the supply gauge indicates 100 bar it is unlikely that further braking will be possible.

Anti-skid

Malfunctioning of the anti-skid system, including failure of the fuse in the control unit DC supply line, is normally indicated by the SKID caption illuminating. Select the anti-skid system OFF. The caption remains illuminated and braking without anti-skid protection is then available.

AIR CONDITIONING AND PRESSURISATION

The front and rear cockpits are contained in an air conditioned pressure cabin. Air, tapped from the final stage of the engine HP compressor, is ducted to a cabin pressurisation and air condition (ventilation and temperature) system. Compressor air flows through the duct to the cabin via a pressure regulating and shut-off (PRSO) valve and a cold air unit/heat exchanger unit. On the ground, and when air conditioning is switched off in flight, the cabin is ventilated by ram air.

Controls and indicators

The controls and indicators associated with air conditioning and pressurisation are listed below:

Control/indicator	Marking	Location	Function
Cabin conditioning control switch	OFF/NORMAL/DEMIST/FLOOD – guarded at OFF. A catch to the right of the switch must be pushed outboard before the switch can be set to OFF from NORMAL	Right console, front cockpit	OFF – closes PRSO valve, ram air valve open. NORMAL – selects air conditioning on. Ram air valve and an inducer valve controlled automatically via landing gear microswitches. DEMIST – increases flow of conditioned air to canopy. FLOOD – boosts conditioned air mass flow and increases its temperature.
Rotary temperature control switch	CABIN AIR TEMP – MANUAL FIXED/AUTO sectors AUTO sector extremities – WARM/COOL	Right console, front cockpit	MANUAL FIXED – for setting temperature control valve manually AUTO – permits automatic operation of temperature control valve
Cabin altimeter	ALT	Right panel, both cockpits	Indicates cabin pressure in terms of altitude
Cabin altitude caption	CPR (red)	CWP, both cockpits	Indicates cabin altitude exceeds 30,000ft

Pressure regulating and shut-off valve

The PRSO valve combines the functions of a pressure regulator and an ON/OFF valve. A valve-operating solenoid is energised to close the valve when the cabin conditioning control switch is at OFF. At all other settings of the switch the solenoid is de-energised and the valve is open and operates to keep the pressure of the ducted engine HP compressor air within a set range.

Air conditioning system

The air conditioning system receives and cools a proportion of the air tapped from the engine HP compressor. The remainder bypasses the system. The air flowing to the air conditioning system is directed into a primary heat exchanger where it is cooled. It then passes through the compressor of a cold air unit which delivers it to a secondary heat exchanger. The cooled air then flows to drive the turbine of the cold air unit and in the process its temperature is further lowered. The temperature of the air is then modified by the addition of engine HP compressor air which has bypassed the cold air unit and heat exchangers. The conditioned air finally passes via a water extractor to the cabin.

In flight, ram air is used in the heat exchangers to cool the air from the engine HP compressor. When the volume of ram air passing through the intakes is low, i.e. during ground running or in flight at low speeds with the landing gear down, air is drawn into the ram air intakes and through the heat exchangers under the influence of cooling air inducers in the exhaust duct of each heat exchanger. Engine HP compressor air is injected into the exhaust duct where the inducer creates a Venturi effect which causes a greater volume of cooling air to be drawn through the heat exchanger.

A solenoid-operated shut-off valve controls the injection of air into the inducers. The valve is energised closed when the cabin conditioning control switch is at OFF. At other settings of the switch the valve is automatically controlled through the operation of the up-lock microswitch on the right mainwheel leg. When the landing gear is lowered the microswitch opens, the shut-off valve solenoid is de-energised and the valve opens. The solenoid is energised and closes the valve when the landing gear is locked up.

Cabin ventilation

Conditioning air

Conditioned air passes into the cabin and is distributed by body and canopy vents. Ventilation pipes on each side of both cockpits distribute the air through fixed foot and head vents and body vent louvres. A vent/demist change-over valve, controlled by the cabin conditioning control switch, regulates the proportion of conditioned air supplied to the body and canopy vents. When the switch is at NORMAL, about 60% of the conditioned air is directed to the body vents and the remainder goes to the canopy vents. When DEMIST or FLOOD is selected the proportions are reversed. Selection of FLOOD also increases the mass flow by about 50% and raises its temperature by adding HP compressor air to the conditioned air supply.

Ram air

When the aircraft is on the ground, or if the cabin conditioning system is switched off in flight, cabin ventilation is by ram air from a duct in the nose of the aircraft. An inlet and an outlet valve are controlled by a solenoid-operated ram air control valve which is in series with compression microswitches on the main landing gear oleos. On the ground the solenoid is energised and closes the control valve. The inlet and outlet valves then open to ventilate the cabin. In flight, when the compression switches open the control valve opens and engine HP compressor air closes the inlet and outlet valves. Pressurisation of the cabin then takes place.

Temperature control

A temperature control valve regulates cabin temperature by scheduling the mixing of compressor air which has bypassed the air conditioning unit with the cold air delivered from the air conditioning unit. The control valve is operated either automatically or manually according to the setting of the temperature control switch.

In the automatic mode the switch setting, together with inputs from sensors, cabin temperature and conditioned air delivery temperature, are fed into a control circuit to operate either a cool demand relay or a warm demand relay. The contacts of the operated relay close and the valve is motored in the appropriate direction.

The temperature control switch can be set to any position within the AUTO sector, the extremities of which are marked COOL and WARM, to set a variable resistor. The temperature control valve is then adjusted automatically to maintain the selected cabin temperature. In the MANUAL FIXED sector, rotating the switch towards either COOL or WARM progressively closes or opens the valve. When the switch is released it returns to the 12 o’clock position under the influence of a spring. The valve remains in its new position.

Pressurisation

With the cabin sealed, the cabin is pressurised by controlling the rate of discharge of conditioned air. A pressure controller receives inputs of cabin pressure and ambient pressure (from the pitot-static system) and controls the discharge of conditioned air to maintain a cabin differential pressure at a value which is related to aircraft altitude. A warning of excessive cabin altitude is given by a CPR caption on the CWP.

The pressure controller, on the front pressure bulkhead, automatically regulates cabin pressure by opening and closing two discharge valves, one integral with the controller and one on the rear seat frame. The forward valve discharges conditioned air into the forward equipment bay. The aft valve discharges air into the fuselage aft of the cabin.

Pressurisation commences at about 5,000ft. As altitude is increased the controller regulates the discharge of air until a differential pressure of 0.276 bar is reached at about 40,000ft, above which the differential pressure is maintained constant.

Cabin pressure altimeter

The cabin pressure altimeter indicates cabin pressure in terms of altitude. Corresponding normal values of aircraft and cabin altitude (when pressurised) are shown in the table below.

Aircraft altitude (feet)	Cabin altitude (feet)
10,000	7,800
20,000	12,700
30,000	16,800
40,000	20,100

Cabin altitude warning

A pressure switch is in the rear cockpit, aft of the right console. If cabin altitude reaches 30,000ft, the switch closes. The CPR caption on the CWP and the attention lights come on and the audio warning is activated.

Normal use

Before flight

Before starting the engine, check that the canopy is locked and that the cabin conditioning control switch is at NORMAL. To minimise the possibility of ice forming in the cabin conditioning system as engine RPM are increased for take-off, set the CABIN AIR TEMP switch to not colder than the six o'clock position in the AUTO sector. On the ground at idle RPM the cabin conditioning system is not very effective. When stationary, increasing RPM to between 60-70% provides effective cabin conditioning.

In flight

After take-off adjust the CABIN AIR TEMP switch as required for comfort. Prior to descending from medium and high altitudes, set the cabin conditioning control switch to DEMIST.

Failures

If the cabin is under-pressurised above an aircraft altitude of 8,000ft, the failure can only be detected by comparing aircraft and cabin altimeter readings. If a discrepancy is observed, check the setting of the cabin conditioning switch.

If the cabin altitude exceeds 30,000ft the CPR caption comes on and the attention lights and audio warning are activated. The validity of the warnings should be checked against the cabin altimeter. Descend to the lowest possible altitude and land as soon as practicable.

OXYGEN SYSTEMS

A gaseous oxygen system provides both occupants with a common supply from two 1,400-litre cylinders behind the rear cockpit bulkhead.

An outlet from the cylinders is routed through a combined pressure-reducing valve and relief valve before dividing to provide a separate supply line to each cockpit. In each cockpit the main oxygen flow reaches the seat via a shut-off valve, a flow indicator transmitter and a low-pressure switch. At the seat the supply is connected at a pull-off bayonet connector and then flows via a coupled pressure demand regulator/PEC and the PEC tube to the face mask.

The endurance of the supply is approximately seven hours.

Controls and indicators

The oxygen system controls and indicators, which are similar in each cockpit, are listed in the table below:

Control/indicator	Marking	Location
Supply selector (two-position rotary control)	OXYGEN – ON/OFF	Right console
Supply contents gauge	OXY	Right panel
Flow magnetic indicator	OXY	Right panel
Oxygen supply low pressure caption	OXY	CWP

Supply selector

The supply selector operates the shut-off valve which controls the oxygen supply to the associated seat. The valve is open when the selector is pointing forward.

Supply contents gauge

The supply contents gauge is a direct reading gauge showing cylinder pressure in terms of contents. The gauge scale is graduated in eighths from full (F) and has major markings at quarter intervals. Below 1/8 the scale is coloured red. When the needle registers in the red sector the system is empty.

Supply flow indicator

The oxygen flow magnetic indicator in each cockpit functions in respect of the oxygen supply. The indicator in each cockpit is electrically operated by a flow transmitter in the supply line to the associated seat. An indicator is de-energised and shows black when no oxygen is flowing or there is no electrical supply. It is energised to show a white vertical bar when oxygen flows. When the oxygen system is in operation the indicator should give alternating black and white bar indications in time with the user's breathing.

Supply low pressure warning

The supply low pressure warning is controlled by the low pressure switch which closes to illuminate the OXY caption when the system pressure to the associated seat is below 3 bar. The caption and attention lights illuminate and the audio warning is activated.

Normal use

Before flight

Check that the OXY flow indicator shows a white bar when the supply selector is switched on.

In flight

The system is selected on before engine start and should remain on throughout the flight. Periodic checks should be made of the oxygen contents and of the operation of the flow indicator.

After flight

Before leaving the aircraft, turn off the oxygen system in both cockpits.

Failures

Indication of oxygen system malfunction can be given by illumination of the OXY caption or by the flow indicator. The flow indicator may continue to indicate normal flow when the system pressure is below the minimum required by the user, therefore the illumination of the OXY caption must always be regarded as genuine unless, by a process of cross-checking, it is proved to be spurious.

If a system malfunction is indicated, make sure the system is selected ON and the contents are sufficient.

FLIGHT INFORMATION DISPLAYS AND INSTRUMENTS

A primary flight instrument display, on the centre panel in each cockpit, is comprised of a combined airspeed indicator/machmeter (CSI), a main altimeter, a main attitude indicator, a turn-and-slip indicator, a vertical speed indicator (VSI) and a horizontal situation indicator (HSI).

Each cockpit also has a standby attitude indicator and a directional gyro indicator (DGI) on the centre panel, a standby altimeter on the right panel and a standby magnetic compass on the canopy centre line.

An attitude and heading reference system (AHRS) provides pitch and roll information to the main attitude indicators and gyromagnetic compass heading or directional gyro (DG) heading to the HSI in each cockpit. ILS glideslope and localiser information and TACAN (VOR) range and bearing information is presented on each HSI by selection at a navigation mode selector in the front cockpit. Power for either system is from the AC busbar. If this supply fails, a display of attitude and of direction is provided by the standby attitude indicator and the DGI respectively. The CSI, HSI, main altimeter, main attitude indicator, VSI and DGI have integral lighting.

Pitot-static system

An aerodynamically-compensated pitot-static tube is on the nose of the aircraft. The tube is shaped in the vicinity of the static holes so as to induce, locally, a static pressure equal and opposite to that caused by the aircraft's presence. An outer sheath on the tube has a heater element which is supplied with 28 volts DC from the Essential Services busbar. The power supply is controlled by a two-position PITOT HT switch at the aft end of the left console in the front cockpit.

The pitot-static system supplies the following cockpit instruments:

- Main altimeter (repeater in the rear cockpit)
- Standby altimeters
- VSI
- CSI

Main altimeter

A Mk 3B servo-type altimeter in the front cockpit gives indications of altitude on a counter and by a single pointer. The altimeter, which uses inputs of static pressure, has a range of operation from -2,265 feet to 50,000 feet. The instrument is electrically driven and provides electrical outputs to a Mk 3C repeater-type altimeter in the rear cockpit.

On both altimeters the pointer makes one full rotation for each thousand feet of altitude. Each altimeter has a 4-drum, 5-digit counter which indicates altitude in increments of 50 feet. Between zero and 9,950 feet, the tens of thousands of feet digit is obscured by a black and white striped flag. Below zero feet, however, the digit is obscured by a red and white flag. Altitude below zero feet is calculated by adding the indicated height to minus 10,000ft, e.g. a true pressure altitude of minus 150ft is indicated by the red and white flag obscuring the tens of thousands of feet digit with the altimeter display reading 9,850ft (minus 10,000ft + 9,850ft).

Both the Mk 3B and the Mk 3C altimeters have a pressure datum setting control, at the lower right-hand corner, for adjusting the millibar scale of a 4-digit pressure setting indicator in the face of the instrument. The controls of the front and rear cockpit altimeters are not interconnected.

A two-position switch, spring-loaded to off, and marked ALTIMETER TEST, is at the forward end of the left console in the front cockpit. A similar switch on the centre panel in the rear cockpit is similarly marked. The front cockpit switch, which is collectively marked GROUND USE ONLY with the ignition switch enables the operation of the electrical parts of both altimeters to be tested. The rear cockpit switch enables the Mk 3C altimeter servo to be tested in isolation from the Mk 3B servo.

When the front cockpit switch is held on, with power applied to the altimeters, the altitude indication on both altimeters should progressively increase by a fixed value, irrespective of the setting of the millibar scale. The value increases with increasing instrument altitude above sea level. At sea level the value is 5,000ft and at 5,000ft AMSL it is 5,400ft. When the switch is released the altimeters should progressively return to their previous indication. When the rear cockpit switch is held on, the rear cockpit altimeter indication should progressively increase until a value of 11,100ft is indicated. The front cockpit altimeter indication remains unaltered. While the altimeters are running up to or down from the test values, the altitude counter is obscured by a red and black striped bar. If the rear cockpit switch is held on while the front cockpit switch is at on, the rear cockpit indication should then increase to 11,100ft. The altimeter test switches must not be operated in flight.

Both altimeters are supplied with AC from the No. 3, 26 volts AC busbar. If the power supply fails or if the servo mechanism runs away, the altitude counter is obscured by the red and black striped bar. The front cockpit altimeter has, at the centre of its face, a window in which a black flag is displayed when a 28-volt fuse-protected supply from the Generator busbar is present at the instrument. If the DC supply fails, the black flag is replaced by a white flag with black letters 'PE'. This has no effect on the serviceability of the front cockpit altimeter but causes the red and black striped bar to obscure the altitude counter of the rear cockpit altimeter, rendering it unusable.

Standby altimeter

A Mk 19F altimeter is on the right panel in each cockpit and can be used as a standby if the Mk 3B or 3C altimeters are unserviceable.

Height is indicated by two pointers and by a black and white disc which is viewed through a spiral slot and replaces the third pointer of other altimeters. The longer pointer makes one rotation for each 1,000 feet and the shorter pointer makes one rotation for each 10,000 feet. The leading edge of the white sector of the disc indicates total height as it moves through the slot. The slot, which covers the height range zero to 60,000ft, is marked with un-numbered increments representing 10,000ft to 50,000ft (in 10,000ft increments). The amount of white visible is proportional to the tens of thousands of feet and the slot is completely filled at 60,000ft. A millibar setting control is provided.

Vertical speed indicator

The VSI is calibrated in thousands of feet per minute and registers positive and negative vertical speed to a maximum of 6,000ft per minute.

Combined speed indicator

The CSI gives indication of airspeed and Mach number derived from pitot and static pressure.

Airspeed is indicated by a pointer which moves against a scale graduated from 50 to 550 knots (VNE) in 10-knot increments. Mach number is shown on a scale which is displayed in a window and read against the airspeed pointer. The scale is calibrated from 0.3 to 1.2 in increments of 0.02M. The Mach number scale moves independently of the airspeed pointer and the scale window to maintain the correct relationship between airspeed and Mach number.

Standby flight instruments power switch

A two-position switch, STBY INTL – NORMAL/BATT, is on the centre panel in each cockpit. When the switch is set to NORMAL, a 28-volt DC supply from the Essential Services busbar provides power for the turn-and-slip indicator, the standby attitude indicator and the DGI. When the switch is set to BATT, these instruments are powered by supplies from No. 1 and No. 2 Battery busbars.

Main attitude indicator

The main attitude indicator in each cockpit is of the moving ball type. It receives pitch and roll attitude signals from the AHRS displacement gyroscope assembly. The attitude indicators and the vertical gyro unit form the attitude indication system.

The moving ball has a grey top half with black pitch attitude marking representing the area above the horizon, and a black bottom half with white pitch attitude markings representing the area below the horizon. A white line between the two halves represents the horizon. Pitch attitude is indicated by division lines marked on both halves of the ball parallel to the horizon line at 5° intervals, read against a fixed yellow aircraft symbol. The division lines are numbered at 30° intervals from the horizon line to show 30°, 60° and 90° of climb or dive. The words CLIMB and DIVE are marked at the 45° division lines on the grey and black halves respectively.

Roll attitude in each direction is measured by movement of an index against a fixed semi-circular scale which has 30° divisions up to 90° and 10° subdivisions to show bank angles up to 30°.

A spring-loaded button marked ERECT is on the AHRS control unit in the front cockpit. Momentary operation of the button increases the rate at which the AHRS vertical gyro erects. To ensure that the vertical gyro has attained a sufficiently high rotation speed before fast erection is initiated, the button must not be operated until 60 seconds have elapsed from the AHRS being switched on. Thereafter, the button should only be used in unaccelerated flight conditions. A two-position switch, spring-loaded to off and marked ATT FAST ERECT, is on the centre panel in the rear cockpit. The switch offers similar facilities and should be used in the same way as the ERECT button.

The main attitude indicators and the AHRS are powered by a 115 volts, 400Hz supply from the AC busbar and a 28 volts DC supply from the Generator busbar. Failure of either supply to a main attitude indicator or failure of a valid signal from the AHRS is indicated by the appearance of a red and black striped warning flag across the bank scale on the lower right of the indicator.

Turn-and-slip indicator

Each turn-and-slip indicator has a pointer which indicates direction and rate of turn and a ball which indicates slip or skid. The rate scale is graduated, left and right of a centre mark, with marks to indicate rate 1 and rate 2 turns. A warning flag appears in the presentation when the DC supply is interrupted or when the rotational speed of the gyro drops to a level whereby accuracy is impaired.

A static inverter within each turn-and-slip indicator is powered from either the Essential Services busbar or from supplies from No. 1 and No. 2 Battery busbars, depending on the setting of the STBY INST switch. After the application of power, the gyro requires three minutes to spin up to its operating speed. Do not use the instrument within this period.

Standby attitude indicator

The standby attitude indicator is smaller than the main attitude indicator but is similar in appearance and presents similar information.

The erection system is pneumatic; the air pressure being generated by a radial compressor machined into the gyro wheel itself. Control is by a gravity sensitive pendulum mechanism with roll and pitch acceleration cut out at 0.25G (14.5° bank). The normal erection rate is nominally 3° per minute.

To cage the instrument a caging knob at the lower right corner of the instrument face should be pressed until all motion has ceased and the instrument has settled in the caged position. A red flag is displayed on the left side of the bank scale, between the 30° and 60° divisions, while the caging knob is pressed in.

The standby attitude indicator has an integral static inverter which provides AC to drive the gyro. The inverter is powered from either the Essential Services busbar or from supplies from No. 1 and No. 2 Battery busbars, depending on the setting of the STBY INST switch. If the power supply to the indicator fails, a red and black striped flag is displayed at the top of the instrument face. After the application of power, the gyro requires three minutes to spin up to its operating speed.

Directional gyro indicator

The DGI has a rotating compass card graduated at 5° intervals and with alpha-numeric markings at 30° intervals. DG heading is indicated by a fixed white index above the top of the compass card. Pushing in and rotating a control knob, marked PUSH ALIGN and PULL V, on the lower right-hand corner of the indicator face, aligns the compass card to a desired heading. When the knob is pulled out and rotated, a yellow set heading index is moved round the edge of the compass card which remains in a fixed position. When the knob is released, the set heading index is locked to and rotates with the card as the aircraft changes heading. The DGI is provided as a standby instrument for use if the compass function of the HSI fails.

The DGI contains a static inverter which is powered from either the Essential Services busbar or from supplies from No. 1 and No. 2 Battery busbars, depending on the setting of the STBY INST switch. If the static inverter fails, a red and black striped warning flag is displayed on the lower left-hand part of the compass card.

Attitude and Heading Reference System (AHRS)

The AHRS supplies heading signals to the HSI and TACAN, and pitch and roll signals to the main attitude indicators. The heading reference part of the system can be operated in either a slaved or a DG mode. The AHRS consists of a displacement gyroscope assembly (DGA) and an electronics control amplifier in the main equipment bay, a detector unit in the fin and an AHRS control unit on the leg panel in the front cockpit.

The DGA is an all attitude device. It contains a vertical gyro to provide pitch and roll information to the main attitude indicators via the electronics control amplifier and a directional gyro (DG) to provide a stable heading reference to the electronics control amplifier.

When the AHRS is switched on the vertigo gyro is automatically fast erected in pitch and roll so as to be within 0.25° of the local vertical within 1.5 minutes of power being applied. If power to the AHRS is subsequently interrupted for longer than 40 seconds, the initial fast erection of the vertical gyro is automatically carried out when power is re-applied. It is essential therefore that the aircraft is in straight and level unaccelerated flight when power is re-applied and for 1.5 minutes afterwards to ensure that the vertical gyro is erected to the correct datum, otherwise erroneous data is presented on the main attitude indicator. The normal erection rate of the vertical gyro is 1° per minute but a manually initiated fast erection facility erects the gyro at 29° per minute.

In the DG mode, the DG operates as an earth rate corrected free gyro, heading compensated for transport rate at a fixed ground speed of 350 knots. In the slaved mode the DG is slaved to magnetic heading signals from the detector unit. The normal slaving rate is 1.5° per minute. Automatic fast synchronisation of the DG to detector unit heading takes place when the AHRS is switched on following fast erection of the vertical gyro and when the AHRS is switched from the DG mode to the slaved mode provided the aircraft is in straight and level unaccelerated flight. In flight, slaving errors can be eliminated by manually initiating fast synchronisation at a PUSH TO SYNC control on the AHRS control unit.

The control should only be operated when the aircraft is in straight and level unaccelerated flight. If the aircraft is not in straight and level flight and manual fast synchronisation is initiated, the DG is synchronised to erroneous magnetic heading signals from the detector unit. Heading signals from the AHRS to the HSI and the TACAN are incorrect. Automatic and manually initiated fast synchronisation takes place at a rate of greater than 30° per second. If power to the AHRS is interrupted (HSI power failure warning flag displayed) for less than 40 seconds, the system enters a free gyro mode and, unless extreme manoeuvres have been carried out in this mode, will remain erect. If the accuracy of the system is suspected, then straight and level unaccelerated flight should be achieved and manual fast erection and fast synchronisation initiated.

The AHRS control unit has the following controls and indicators:

Heading mode selector

The heading mode selector is a three-position rotary switch marked OFF/DG/SLV. It selects either power off to the system (OFF), the directional gyro (DG) or the slaved (SLV) mode of operation.

Synchronisation indicator

The synchronisation indicator, marked SYN IND, has a centre zero movement with a pointer which is displaced left (-) or right (+) of centre to indicate the direction in which the DG is desynchronised from magnetic heading in the slaved mode. A three-quarters to full scale deflection indicates a synchronisation error of 5°. When the pointer is displaced in the slaved mode it can be re-centralised, indicating that the DG is synchronised, by pressing the PUSH TO SYNC control. In the DG mode the pointer is parked in the upright position.

Synchronisation and Set Heading control

The synchronisation and set heading control is a push-to-turn control marked PUSH TO SYNC.

In the slaved mode fast heading synchronisation at greater than 30° per second is initiated when the control is pressed. Two arrowheads are above the control and are marked – and +. In the DG mode the heading outputs are aligned to a desired heading when the control is pressed and turned. Rotation of the control in the anti-clockwise (-) or the clockwise (+) direction results in a negative or a positive heading change respectively. The rate of heading change depends on the amount the control is turned. In the slaved and DG modes the HSI and the main attitude indicator power failure warning flags are displayed while the PUSH TO SYNC control is pressed. The warning flags are also displayed in the slaved mode while fast synchronisation is taking place. A synchronisation repeater marked COMPASS SYNC is on the right console in the rear cockpit.

Latitude control

The rotary latitude control, marked LAT, is preset to the latitude of operation to establish a correction for apparent drift of the directional and vertical gyros due to earth's rotation. The control also establishes a correction for transport rate drift of the DG.

Fast erection button

A button type switch, marked ERECT, causes the vertical gyro to be erected at 29° per minute when pressed. When the AHRS is in the fast erection mode, the main attitude indicator and the HSI power failure warning flags are displayed.

Horizontal Situation Indicator (HSI)

An HSI, located on the centre panel in each cockpit, combines the compass system and radio navigational displays. The HSI displays the following information:

Heading

Heading is indicated by a rotating compass card read against a fixed 'V' lubber mark above the card. The card is graduated at 5° intervals and is marked alpha-numerically at 30° intervals.

Heading index

A yellow heading index registers against the outside edge of, and rotates with, the compass card. The index can be manually set relative to the compass card by a select heading knob, marked with a symbol representing the heading index, at the lower left-hand corner of the HSI face.

Compass select flag

When the AHRS control unit mode selector is set to DG, a white flag with DG in black letters is displayed on the lower right side of the compass card.

Track index and counter

A track index which is on a centre display assembly registers against the inside edge of, and rotates with, the compass card. The index can be manually set relative to the compass card by a selector knob at the lower right-hand corner of the front cockpit HSI only. The rear cockpit selector knob is inoperative. The reciprocal of the track set is indicated by a track index tail on the centre display assembly. A three-digit display of the selection is given on a track (COURSE) counter at the top right of each HSI face. Operation of the front cockpit selector knob positions the index and the counter of both the front and rear HSI. The selector knob is marked with a symbol representing the track index.

Deviation bar

A deviation bar and a fixed scale of two dots on either side of a centre index are on the centre display assembly. The bar moves left or right of the centre index to indicate deviation from the selected track when TACAN information is selected at the navigation mode selector or from an ILS localiser when ILS information is selected at the navigation mode selector. When operating in the ILS mode, the HSI track deviation display is more readily interpreted if the track index is set to the QDM of the localiser.

TACAN bearing

The magnetic bearing to a TACAN (VOR) ground beacon is indicated by a green pointer head when read against the compass card. The reciprocal is indicated by the tail of the pointer. The bearing is also displayed when ILS information is selected at the navigation mode selector.

To/from indication

Two triangular indicator windows, ‘to’ and ‘from’, are on the centre display assembly. The ‘to’ window is adjacent to the track index and the ‘from’ window is adjacent to the tail of the track index. With the navigation mode selector set to TACAN, a TACAN radial set on the track index and the bearing pointer locked on to a TACAN beacon, a white flag is displayed in the ‘to’ or the ‘from’ window. The ‘to’ flag is displayed whenever the bearing from the TACAN is less than 90° from the selected radial. Conversely, the ‘from’ flag shows white whenever the bearing from the TACAN beacon is 90° or more from the selected radial.

TACAN range

Range to a TACAN ground beacon, in nautical miles, is shown on a three-digit counter marked N MILES at the upper left corner of the HSI face. A yellow bar obscures the counter when range information is invalid. The range is also displayed when ILS information is selected at the navigation mode selector.

Glidepath deviation pointer

A pointer, to the left of the compass card, moves over a fixed vertical scale consisting of two dots above and two dots below a circle (representing the aircraft). The pointer is driven by the ILS equipment and indicates the vertical position of the ILS glidepath relative to the aircraft, e.g. if the pointer is above the circle on the scale, the aircraft is below the glidepath. The pointer is only driven when ILS information is selected at the navigation mode selector.

Glidepath warning

A red flag, with ‘GS’ in white letters, appears above the glidepath deviation scale when the glidepath information is invalid.

ILS localiser or TACAN bearing warning

A red flag, with ‘NAV’ in white letters, appears bellows the COURSE counter when the ILS localiser or the TACAN bearing information is invalid.

Power failure warning

An orange flag, with black diagonal stripes, appears at the lower left-hand side of the compass card when the power to the HSI has failed or when the AHRS generates an invalid signal.

Accelerometer

An accelerometer calibrated from -5 G to +10 G is located on the centre panel in each cockpit. Each accelerometer has three concentrically mounted pointers; one pointer indicates instantaneous G and the other two indicate maximum positive and negative values experienced. On the front cockpit instrument the latter two pointers can be reset by pressing a PUSH TO SET knob on the instrument face.

Standby compass

An E2C standby compass is on the canopy centre line in each cockpit, one just aft of the front windscreen and the other just aft of the rear windscreen. The compass has integral lighting which is controlled by a COMPASS switch on the right panel.

Normal use

Before flight

DGI

With the battery switches on, check that the warning flag clears. Set the compass heading on the DGI, checking that the heading index moves with the compass card. Set the heading index as required by pulling out and rotating the control knob. Check that the index moves independently and that the compass card does not rotate.

Turn-and-slip indicator

Three minutes after the batteries are switched on, check that the under-speed warning flag clears. Whilst taxiing, check the instrument for correct indications.

Accelerometer

In the front cockpit reset the accelerometer. In the rear cockpit check that the accelerometer has been reset.

Altimeter – main

Check that the warning bar clears from the altitude counter when power is applied to the instrument. Set QFE on the millibar scale and check that the altimeter pointer indicates zero feet. Set the appropriate barometric pressure.

Altimeter – standby

Set QFE on the millibar scale and check that the altimeter indicates zero feet. Set the millibars scale as required.

AHRS

With AC power on line check that the mode selector is set to SLV and that the correct latitude is set at the control unit. Check the heading indicated by the HSI compass card against the E2C compass. If necessary, synchronise the DG by pressing the PUSH TO SYNC control.

Attitude indicators – main

With DC and AC power on line and the AHRS mode selector set to SLV, check that the warning flag clears. If necessary, operate the fast erect system but not until 60 seconds have elapsed from switch-on.

Attitude indicators – standby

With the battery switches on, check that the warning flag clears. If fast erection is required, press the caging knob. Check that the red warning flag is displayed whilst the knob is pressed.

HSI

With AC power on line and the AHRS control unit mode selector set to SLV, check that the power failure flag clears. Using the select heading knob, check that the select heading index moves freely relative to the compass card and then set as required. Using the select track knob on the front cockpit HSI, check that the track index moves freely relative to the compass card on both the front and rear cockpit HSIs and that the track (COURSE) counters indicate correctly, and then set as required.

In flight

Periodically check that the AHRS remains synchronised. Achieve straight and level unaccelerated flight before selecting the slaved mode from the DG mode. If power to the AHRS is interrupted and then re-applied, and manual synchronisation becomes necessary, establish the aircraft in straight and level unaccelerated flight, cross-check the attitude indicator, natural horizon and the turn-and-slip indicator, and then with the slip ball trimmed to the centre, press the PUSH TO SYNC control.

Failures

Standby instruments

If the power failure warning flag on either the standby attitude indicator or the DGI is displayed, set the STBY INST switch to BATT. If a warning flag then remains displayed, the associated instrument is unserviceable and the switch should be returned to NORMAL. If the warning flag on both instruments appears a power supply failure is indicated. Select the alternative power source by setting the switch to BATT.

If the warning flag is displayed on the turn-and-slip indicator, the turn indications are unreliable and must not be used. The slip ball indications are unaffected. If the warning flag is displayed in association with the warning flag on the standby attitude indicator and on the DGI, select the alternative power source by setting the STBY INST switch to BATT.

Main altimeters

If the DC supply to the front cockpit main altimeter fails, the PE warning flag is displayed on the front cockpit altimeter and the altitude counter on the rear cockpit altimeter is obscured by the red and black striped bar. The front cockpit altimeter remains serviceable but in the rear cockpit the standby altimeter must be used.

AHRS

If the main attitude indicator information is unreliable when cross-checked against the standby attitude indicator and the main attitude indicator power failure flag is not displayed, achieve straight and level unaccelerated flight and then press and hold pressed the ERECT button until the main attitude indicator display is erected. When the display is erected, release the ERECT button and monitor the performance of the main attitude indicator against the standby attitude indicator.

If, when operating in the SLV or DG mode, the main attitude indicator or the HSI power failure flag is displayed, check the HSI or the attitude indicator respectively for a display of its power failure flag. If the check shows that both the attitude indicator flag and the HSI power failure flag are displayed, then consider the AHRS as unreliable and use the standby attitude indicator and E2C compass/DGI. If only the attitude indicator or the HSI power failure flag is displayed, then consider the indicator which displays the failure flag as having a power failure and do not use it. Use the appropriate standby instrument(s).

If, when operating in the SLV mode with the HSI power failure not displayed, the HSI heading is incorrect when compared with the E2C compass and the AHRS cannot be synchronised, select the DG mode and align the HSI heading with the E2C heading. If unsatisfactory heading performance is obtained in the DG mode, use the E2C as the heading reference.

GENERAL EQUIPMENT

Cockpit entry and exit

Entry to, or exit from, the front and rear cockpit is by either:

- An extending footstep, a toe-in step and a retractable step which are integral with the left side of the fuselage
- An access ladder

Canopy

The sideways-opening canopy operates about four hinges on its right side. The canopy is manually operated and its weight is counterbalanced by a torque tube arrangement on its right edge.

A combined pneumatic damper and locking strut controls the rate at which the canopy can be opened or closed and enables the canopy to be locked in the open position. The damper/locking strut, which can secure the canopy in any desired position, is controlled by canopy operating levers via Teleflex cable. The strut is on the front cockpit right wall and is secured to the cockpit floor by a quick release pin. If a fault occurs in the strut or the controlling cable which prevents the canopy from being opened normally, the quick release pin should be removed to free the strut.

Two interconnected levers on the canopy frame, one at the left side of each cockpit, operate four interlocked canopy locking pins. The levers are spring-loaded to the forward position. The canopy is locked when the levers are fully forward and unlocked when the levers are moved aft. A thumb-operated spring-loaded safety catch in the front cockpit prevents inadvertent movement of the levers from the canopy locked position. The safety catch is linked to a thumb-operated catch in the rear cockpit and to a push-button integral with an external lock/unlock handle.

When either the front or the rear cockpit catch is pressed outboard, both levers are free to move. An UNLOCKED label in each cockpit is positioned such that when the canopy is locked, each safety catch totally obscures the word UNLOCKED. If any part of the word is visible the canopy is not locked. When either safety catch is pressed the canopy seal is deflated. An arrowhead is marked on the left side of the front windscreen arch. A second arrowhead on the canopy forward edge is marked with CANOPY LOCKED ARROWS MUST BE IN LINE. When either lever is fully held aft, the canopy swings partially open and the locking strut allows the canopy to be manually positioned. When the level is released the locking strut holds the canopy in the selected position. In the front cockpit, a grab handle on the canopy frame forward of the lever may be used to position the canopy.

Aircraft lighting

Aircraft lighting is controlled from the lighting panel below the CWP on the lower-right side of the cockpit, and an additional switch to the lower left of the CWP.

1. Landing/taxi light
2. Navigation lights
3. Anti-collision light lower
4. Anti-collision light upper
5. Panel light
6. Emergency panel light

Internal lighting is controlled in an on/off manner via the ‘Panel’ switch (5). If battery power is available, the lighting can be turned on in an emergency situation (6).

Navigation lights on both wings can be turned on/off using the ‘Nav’ switch (2).

Anti-collision lights can be turned on using switches 3 and 4. Up turns on the white lights, down turns on the red lights and the middle position turns the lights off.

COMMUNICATION SYSTEM

The communication system provides multi-channel VHF communications. Associated with it are a TACAN installation, Instrument Landing System (ILS) equipment and an IFF/SSR installation.

Although radios are fitted to the aircraft, Aerofly does not support these features.

A Communications Control System (CCS) provides overall control of the elements of the communications system. The CCS integrates the VHF transmit facilities and the audio signals from this equipment and from the ILS and TACAN receivers. It also integrates the audio tone of the tone generator in the Central Warning System.

Power supplies

Power for the communications system and associated equipment is provided as follows:

Essential Services Busbar

- CCS
- VHF
- IFF/SSR
- ILS marker light test
- VOR

Generator Busbar

- ILS

AC Busbar

- TACAN

When the communications power switch marked UHF – NORMAL/BATT is at BATT, power for the CCS and the main UHF (VHF) is from the supplies from No. 1 and No. 2 Battery busbars.

Navigation mode selector

With the ILS or TACAN switched on, a navigation mode selector on the centre panel in the front cockpit is used to select a HSI display of either ILS-derived glidepath and localiser information or TACAN-derived range, bearing and steering information.

The selector is a spring-loaded oblong button which is marked with an upper and lower caption, ILS and TACAN respectively. At any one time either the upper or the lower caption is lit by integral lights to indicate the mode acquired and display. If the desired mode is not displayed, pressing the button selects the alternative display and its associated caption is illuminated. A flag-type mode-selected indicator on the centre panel in the rear cockpit repeats the indication given on the mode selector. The mode selector is powered from the Generator busbar. When the Generator busbar is live an indication is given on the selector and the repeater irrespective of whether or not the ILS and/or TACAN is switched on.

Aerials

A VHF aerial is on top of the aircraft fin. A UHF aerial is on the underside of the front fuselage; an additional UHF aerial is on top of the fuselage aft of the rear cockpit. Either the upper or the lower aerial can be manually connected to the UHF transceiver using an aerial selector switch in the front cockpit. UHF aerial selection may also be made from the rear cockpit.

Communications Control System (CCS)

The CCS is comprised of two similar station boxes, one in each cockpit, and a communications junction box (JB) in the front cockpit. Control of the communications system is effected by selector switches, the majority of which are on the station boxes.

A station box on the right panel in each cockpit provides for selection and control of the UHF (main and standby) and VHF receiver audio outputs, and the associated facilities comprising TACAN identification audio and ILS audio. Each station box contains switching circuits incorporating a normal and a standby microphone amplifier. Amplifier selection is by a NORM/FAIL switch on the station box.

Each station box has the following controls and switches:

Function selector

A two-position rotary selector, marked VHF/UHF, selects which radio unit is currently in operation. The VHF setting will select the VHF unit on the left side of the cockpit panel, and the UHF setting will select the modern UHF/VHF unit on the right console.

Receiver audio switches

Four two-position switches (up for on), marked VHF, UHF, ILS and TACAN, each select the audio output from its associated receiver. The output of one or more receivers can be selected.

Receiver volume control

A rotary control, marked RX, controls the level of the receiver audio signals. This is non-functional due to simulator limitations.

Press-to-transmit selector

A two-position selector, marked PTT- ALT/NORM selects either a normal or an alternative transmit switch for use with the selected transmitter. This is non-functional due to simulator limitations.

Intercom volume control

A rotary control, marked I/C, controls the level of the intercom audio signals. This is non-functional due to simulator limitations.

Amplifier selector

A two-position selector, marked NORM/FAIL, selects either a normal or a standby microphone amplifier. This is non-functional due to simulator limitations.

A two-position receiver mute switch, marked MUTE/NORMAL, is located on the left console inboard of the throttle quadrant. The switch is spring-loaded to the NORMAL position. When the switch is operated, audio signals from the VHF, TACAN and ILS receivers are muted.

Instrument Landing System (ILS)

The ILS installation is comprised of a localiser and glideslope receiver and a marker receiver.

The localiser and glideslope receiver, which has the system's control on its front panel, is on the right console in the front cockpit. ILS frequencies in the range 108.00 to 119.95 can be selected.

The marker receiver is in the front cockpit on the left side of the seat frame. When the navigation mode selector is set to ILS, deviation from the localiser centre line and from the glideslope of the selected ILS ground installation is shown on the HSI. Marker audio signals are fed into the CCS. If the glideslope signal is weak or inaccurate the GS warning flag is displayed on the HSI. If the localiser signal is weak or inaccurate the NAV flag is displayed on the HSI. Sensible localiser and glideslope indications may be obtained out to 25 NM and 10 NM respectively at 2,000ft AGL.

Controls and indicators

The ILS system has the controls and indicators listed in the table below:

Controls/marking	**Function**
Three-position rotary mode selector	OFF – power off ILS – connects the power supply to the system VOR – inoperative
Four rotary frequency selector thumb-wheels and digital indicators	MHz – from left to right, the knobs are used to manually change localiser receiver frequency in steps of 10, 1, 0.1 and 0.05 MHz. The selected frequency is shown on four digital indicators. A fixed digit '1' to the left of the tens digit indicates one hundred.
Marker indicator light	ILS MARKER – located on the centre panel in each cockpit. When the marker receiver generates a marker signal, the light comes on momentarily. The filament of each light can be tested by pressing the light. Power for the test is from the Essential Services busbar.

ENGINE SYSTEMS

The Adour Mk. 151 is a turbofan engine which has a two-stage low pressure (LP) compressor driven by a single-stage LP turbine and a five-stage high pressure (HP) compressor driven by a single-stage HP turbine. The LP and HP shafts are concentric but mechanically independent. In ISA sea level conditions the engine developers 23.1 kN (5,200lb) static thrust.

An external gearbox, driven from the HP shaft, is located at the forward end of the engine below the compressor section. The gearbox provides drives for:

- LP fuel pump
- HP fuel pump
- Engine oil pumps
- HP shaft tacho-generator
- DC generator
- Hydraulic pumps (x2)

The Adour engine is started by a gas turbine starting (GTS) system in which air from a gas turbine air producer powers a starter motor which drives the HP shaft through the engine external gearbox. Following flame-out, the engine may be relit with or without the use of the GTS system.

Fire detection and warning systems are provided for the engine bay and air producer bay. An overheat detection and warning system is provided for the jet pipe bay. A fire extinguishing facility is provided in the engine bay only.

Controls and indicators

Control/indictor	**Marking**	**Location**	**Function**
Ignition switch (front cockpit only)	IGNITION –NORMAL/ ISOLATE	Left console	Controls power supply to the engine ignition units
LP fuel cock lever (front cockpit only)	LP FUEL COCK CONTROL – OFF/ON	Left wall	Controls LP fuel cock connecting aircraft fuel system to engine fuel system and to air producer gas turbine
Start master switch	ENG START – OFF/ ON/START	Left console	Controls power supply to the GTS system and provides an emergency shutdown facility for the GTS system
HP cock/throttle lever	Idle position indicated by mark on quadrant	Left console	Controls HP fuel shut-off valve and throttle valve/engine speed
Idle stop lever	Unmarked	Throttle lever	Withdraws retractable idle stop to permit movement of HP cock from idle to HP off
LP shaft rotation indicator (black/green)	ROTATION	Right panel	Black – indicates LP shaft speed below 100 RPM or rotating in wrong direction, or starting sequence completed or cancelled Green – indicates LP shaft speed greater than 100 RPM and in correct direction of rotation. It also shows green whilst start/relight button is pressed.
Air producer start indicator (black/green)	GTS	Right panel	Black – indicates air producer shutdown or speed below datum Green – indicates air producer speed at or above datum
Start/relight button	RELIGHT	Throttle lever	When pressed with start master switch at ON, ignition switch at NORMAL and the throttle level in the range HP off to idle: 1. Initiates start sequence 2. Energises igniter plugs 3. Offloads DC generator in flight 4. At any throttle position, transfers booster pump to Essential Services busbar for duration of GTS system operation and for 30 seconds after shutdown of GTS

TGT indicator	°C x 100 TGT	Right panel	Indicates turbine exhaust gas temperature
RPM indicator	PERCENT RPM	Right panel	Indicates HP shaft speed as a percentage (when shaft speed exceeds approximately 11%)
TGT/NL over-limit caption	T6NL	CWP	Indicates if TGT reaches 685°C or LP shaft speed (NL) exceeds 108%
LP cooling air overheat caption	EOHT	CWP	Indicates if LP cooling air temperature exceeds approximately 400°C
Oil low pressure caption	OIL	CWP	Indicates if differential pressure is low
Fuel low pressure caption	FPR	CWP	Indicates pressure rise across booster pump or pressure at engine filter outlet is low
Engine control amplifier lane failure caption	ECA	CWP	Indicates failure of either or both amplifier lanes or of a fault in amplifier controlling circuits
Jet pipe bay overhead caption	JPOHT	CWP	Indicates if jet pipe bay temperature exceeds 150°C

Airflow

Two intakes, one on each side of the fuselage, pass air directly to the LP compressor. Beyond the compressor the air divides into two approximately equal streams. One flows through an annular bypass duct, while the other passes through the HP compressor, an annular combustion chamber and the HP and LP turbines. The two streams meet in an exhaust mixer section and flow through a jet pipe to discharge through a fixed propelling nozzle. Tappings at the HP compressor outlet supply air for engine and aircraft systems.

Bleed valve

A bleed valve at the final stage of the HP compressor prevents compressor stall during engine starting by bleeding off HP air into the bypass duct. The valve operates automatically in response to signals from a fuel differential pressure switch.

Before the engine is started the bleed valve is open. It remains open during engine starting and closes when the HP shaft speed reaches 61%. Thereafter the valve normally remains closed under all conditions at or above idle, re-opening only when the RPM falls to approximately 45%. However, it may reopen during the shutdown checks when the fuel pump switch is selected off before the throttle is selected to HP OFF. Closing of the bleed valve is indicated by an increase in idle RPM of approximately 3% and a decrease in TGT of approximately 50°C.

HP compressor bleeds

Air is tapped from the compressor section for cooling bearing housings and turbine discs, and for pressurising oil and air seals. Some of the air enters the LP shaft and passes forward to provide continuous anti-icing of the LP compressor nose fairing. Surplus air from inside the shaft is dumped overboard through an outlet containing a temperature switch. If the air temperature reaches approximately 400°C, the switch closes and the EOHT caption illuminates.

Two tappings at the final stage of the HP compressor bleed air for aircraft services. One tapping supplies the cabin air conditioning system, the anti-G system and the cockpit canopy seal. The other supplies air to pressurise the aircraft fuel system.

Turbine gas temperature (TGT) indicators

Thermocouples, downstream of the LP turbine, sense exhaust gas temperature and provide an input to the turbine gas temperature (TGT) indicators and to an engine control amplifier (ECA).

Throttle levers

The throttle levers in the front and rear cockpits control a HP shut-off valve and a throttle valve. The levers are quadrant-mounted and interconnected. The range of throttle movement is from HP OFF (fully aft) through an idle position, which is indicated by a mark in each quadrant, to maximum (fully forward).

A retractable idle stop in the front cockpit quadrant allows free forward movement of the throttle levers but prevents inadvertent rearward movement past idle. The idle stop is withdrawn to permit rearward movement of the throttle to HP OFF, by lifting a spring-loaded idle stop lever on either throttle.

Engine fuel system

Fuel from the aircraft fuel system is supplied via an LP pump and filter to an HP pump, both pumps being engine-driven. During normal running the HP pump supplies fuel to spray nozzles in the combustion chamber via a throttle valve and the HP shut-off valve in a fuel control unit (FCU) and a fuel-cooled oil cooler (heat exchanger). An additional flow from the HP pump bypasses the throttle valve. It passes to the spray nozzles via an idle bypass and a sub-idling fuel control unit (SIFCU) which provide the control of fuel flow during engine starting and idling.

Automatic limitation of fuel flow is effected by an LP shaft speed (NL) limiter and a TGT limiter which operate through the ECA to regulate a fuel trim valve. Limitation of RPM is provided by a hydro-mechanical governor integral with the HP fuel pump. At certain low altitude/high speed conditions, when air intake pressure exceeds a specific value, the engine is fuel-flow-limited by a flow control unit.

LP fuel supply

The LP pump maintains fuel pressure at the HP pump inlet to prevent cavitation within that pump. A pressure switch in the supply line downstream of the LP filter closes to illuminate the FPR caption if the pressure falls below 2.4 bar.

HP fuel supply

The multi-plunger, variable-stroke HP pump supplies fuel at high pressure to the FCU and SIFCU. Pump stroke is controlled by servo pressure derived from the pump itself. The servo pressure is modulated to increase or decrease pump output by changing the pump stroke in response to signals from the flow control unit and the hydro-mechanical governor.

The hydro-mechanical governor functions to reduce pump output if RPM rises to the permitted maximum (104%). Thus, for a particular throttle valve setting the pump servo pressure modifies HP pump output to give a corresponding fuel flow (and hence RPM). The pump output is further modified to take account of changes in airspeed and altitude.

Fuel control unit

The throttle valve consists of a sleeve which moves to control a fuel flow orifice in response to throttle lever movement. A dashpot assembly incorporated in the throttle acts as an acceleration control to prevent over-fuelling as the throttle is opened. It has no effect on engine deceleration.

The flow control unit modifies HP pump output in response to throttle valve position, fuel trim valve position, airspeed and altitude.

The fuel trim valve functions to maintain NL and TGT within limits. The valve reacts to inputs from the ECA and, through the fuel control unit, effects a reduction in pump output.

The HP valve is a shut-off valve controlling the fuel supply to the spray nozzles. The valve is interconnected with, and controlled by, the throttle lever. With the lever set to HP OFF, the valve is closed and fuel circulates to the LP side of the fuel system. Fuel remaining in the spray nozzles then drains to atmosphere through an outlet beneath the fuselage. When the lever is set to idle the valve is fully open.

Sub-idling fuel control unit

The SIFCU automatically controls the fuel flow required during engine starting and acceleration to idle. A diaphragm within the unit is subjected on one side to hydro-mechanical governor pressure and on the other side to LP fuel pressure. The difference between these pressures is proportional to RPM. Movement of the diaphragm, in response to pressure changes, actuates a fuel metering mechanism.

Engine control amplifier

The ECA receives signals of NL and TGT and provides:

- Maximum TGT control
- Maximum NL control
- Excessive TGT or NL warning signal
- Warning of ECA failure
- LP shaft correct rotation signal

Reference values of the normal permitted TGT and NL are stored in the ECA. When either a TGT of 660°C or an NL of 104% is approached, the ECA energises the solenoid of the fuel trim valve. The amplifier then maintains the fuel trim valve in the position required to hold TGT or NL at the limiting value. Only one of the reference parameters can be in control at any one time.

If the ECA fails to control TGT or NL at the normal permitted reference values and they reach 685°C or 108% respectively, the T6NL caption comes on.

Control of TGT and NL is effected by one of two circuits in the ECA, lane 1 or lane 2. The lanes are similar but one is dominant and initially effects control. The lanes are monitored within the amplifier and, if a malfunction occurs in the controlling lane, automatic change-over to the other lane takes place. Failure of either lane or of the amplifier is indicated by the ECA caption illuminating.

LP shaft speed sensing probes supply signals to the ECA. When, during engine starting, the LP shaft speed reaches 100 RPM in the correct direction, a relay in the ECA closes to connect a DC supply to the ignition units and to energise the rotation indicators which change from black to green. The indicators remain green until the starting cycle is completed or cancelled, when they revert to black. The indicators also show green whenever a start/relight button is pressed.

Engine oil system

An oil tank is located beneath the aft end of the bypass duct. The tank has pressure and gravity replenishing points.

A pressure pump draws oil from the tank and delivers it, through a fuel-cooled oil cooler and a filter, to the engine and to the external gearbox. A pressure relief valve protects the system and a cooler bypass valve ensures the circulation of an adequate supply of oil at low temperatures or if the cooler is blocked. Three scavenge pumps return the oil through associated filters to the tank.

A differential pressure switch monitors the pressure difference between feed oil pressure and the scavenge oil pressure at an internal gearbox. If the differential falls below 0.7 bar the switch closes to light the OIL caption. To eliminate transient low pressure warnings caused by manoeuvres involving negative G, activation of the caption is delayed for a nominal 10 seconds.

Engine ignition system

The engine ignition system has two igniter plugs in the combustion chamber. Each plug is energised by an associated ignition unit. The ignition units are supplied with DC during starting and relighting provided that the ignition switch is set to NORMAL. With the throttle lever at HP OFF, the ISOLATE position of the switch allows the engine to be turned without the ignition units being energised. The ignition units are inhibited when the throttle is opened beyond the idle position. Therefore, to achieve light up, it is essential that during and relighting the throttle is held in the idle position (against the idle stop).

Engine starting system

The GTS system is used for engine starting on the ground and can be used for relighting in flight. The system is comprised of a gas turbine air producer and a free turbine starter motor. The air producer is at the top of the fuselage, forward of the ram air turbine. It supplies air via a solenoid-operated start valve, when a dump valve is closed, to the starter motor which is fitted to the engine external gearbox and drives the HP shaft through the gearbox. Until the dump valve is closed the air is exhausted overboard. To prevent shock loading the starter motor clutch, a speed switch inhibits operation of the start valve to prevent engagement of the starter when engine RPM are above 20%.

The air producer uses fuel from the aircraft fuel system but has its own ignition system, fuel pumping and control system. The air producer and the starter motor each have independent lubrication systems.

Air producer

The air producer is comprised of a centrifugal compressor driven by a two-stage turbine. It is rotated to self-sustaining speed by a DC motor. Air is drawn into the compressor through a grille on the top of the fuselage. A DC-powered dual fuel/oil pump draws fuel from the aircraft tanks and supplies it to nozzles in a combustion chamber containing two igniter plugs. Power for the DC motor and igniter plugs is from aircraft batteries via the Essential Services busbar.

When the air producer is at or above its under-speed datum the GTS indicators shown green. The GTS system is automatically shut down when engine RPM reach 45% during starting or relighting. When this occurs the GTS indicators show black.

Protection circuits within the starting system automatically shut down the GTS in the event of certain failures after a start/relight button has been pressed.

Starter motor

The starter motor is a centripetal free turbine driven by air ducted from the air producer. The motor drives the engine HP shaft via the external gearbox and provides assistance until approximately 45% RPM have been achieved, when the starting system is automatically shut down.

Engine starting operation

With the battery switches set to ON, the LP cock lever at ON, the throttle lever at HP OFF, both start master switches at ON and the ignition switch at NORMAL, the air producer is started by pressing momentarily a start/relight button. The rotation indicators show green and the engine ignition units are energised for the duration of the press. The air producer accelerates to idle and, as the under-speed datum is passed, the GTS indicator shows green. This should occur within 20 seconds of the start/relight button being pressed.

When the GTS indicator shows green, momentarily setting a start master switch to START opens the start valve and air flows from the air producer to the starter motor. The dump valve closes and the air producer accelerates to full power. The starter motor rotates and drives the engine HP shaft which induces an airflow through the engine to rotate the LP shaft. When the LP shaft speed reaches 100 RPM in the correct direction of rotation, a relay in the ECA closes to energise the rotation indicators (which show green) and the engine ignition units.

When the rotation indicator shows green and 15-20% RPM are indicated, setting the throttle lever to the idle position fully opens the HP shut-off valve and fuel, scheduled by the SIFCU, is fed to the spray nozzles in the combustion chamber. Engine light up should normally occur within 10 seconds of idle being selected. The engine should accelerate to reach starter cut-out speed, approximately 45% RPM within 22 seconds of selecting idle. At starter cut-out speed the fuel to the air producer is cut off and it shuts down. Simultaneously, the GTS and rotation indicators change to black and the ignition units are de-energised. The engine continues to accelerate and should stabilise at approximately 52% RPM within 30 seconds of selecting idle.

After the RPM have stabilised, the throttle should be opened slowly to accelerate the engine through approximately 65% to close the bleed valve, after which the throttle should be returned to idle. With the bleed valve closed, the engine idle RPM should be approximately 3% higher and the TGT approximately 50°C lower than when idling with the bleed valve open. T the idle speed may vary, however, depending on engine loading, air bleeds and ambient conditions. As the engine warms up, the idle RPM increases and should be 55% before take-off.

During engine starting the start cycle can be discontinued by setting the throttle lever to HP OFF. The GTS continues running and, following a wet start, may be used to carry out a dry crank. However, if it is intended to terminate the GTS starting cycle, the start master switch must be set to OFF. Subsequently the three-minute interval must be observed before a further start is attempted.

Dry cranking

The engine may be dry cranked by following a procedure similar to that for a normal start except that when the GTS indicator shows green, the ignition switch must be set to ISOLATE before the start master switch is set momentarily to START. The throttle lever should be retained at HP OFF throughout. The air producer automatically reverts to idle after 45 seconds. If a dry crank is initiated from an air producer idling condition the start master switch must not be selected to START until engine RPM are below 20%.

Relighting

General information

The engine relighting system allows a flamed-out engine to be relit using an immediate relight, a cold relight (assisted) or a cold relight (unassisted) procedure.

In the immediate relight and the cold (unassisted) relight procedures the GTS is activated and may run up to idle but it is not used. In the cold relight (assisted) procedure the GTS is activated and used when the aircraft is below 20,000ft, but the windmilling RPM must be below 20% before making the relight because starter engagement is inhibited above that RPM.

For all relight procedures the throttle must be set to HP OFF. Except in the case of an immediate relight, the bleed valve should be open (45% RPM or below) before relighting is initiated. As the engine runs down following flame-out, No. 2 hydraulic pump is automatically offloaded as RPM falls through 42%, provided that both start master switches are at ON. The RAT automatically extends and provides pressure to the No. 2 hydraulic system after offloading has occurred.

When a start/relight button is pressed, the engine igniter plugs are energised (provided the throttle is at idle), the DC generator is offloaded and the booster pump is powered from the Essential Services busbar. At stabilised idle RPM following a successful relight, the throttle should be opened slowly to maximum and a check made that the bleed valve closes by 61% RPM. As the throttle is opened, cross-check RPM and TGT for surge-free engine operation.

If the GTS system has been activated, it will normally be running at idle (GTS indicator green) after a successful immediate or cold relight (unassisted) procedure. Regardless of the GTS indication, shut the system down by setting either of the start master switches to OFF for a minimum of five seconds and then resetting it to ON.

Immediate relight

An immediate relight may be attempted at any airspeed and altitude, provided the engine RPM are not too low (below 30%).

With the start master switch at ON and the throttle at HP OFF, an immediate relight is carried out by pressing a start/relight button and simultaneously advancing the throttle to idle. If a relight is not obtained within 30 seconds of selecting idle, the throttle must be returned to HP OFF to prevent over-fuelling. A further 30 seconds should be allowed to elapse to drain the engine and cool the GTS system starter motor before initiating a cold relight. After a successful relight, shut down the GTS system.

Cold relight – assisted

The aircraft should be below 20,000ft at an IAS between 165 and 250 knots, with the throttle at HP OFF, both start master switches at ON and the ignition switch at NORMAL.

The relight is initiated by pressing the start/relight button to start the air producer which runs up to idle. The rotation indicator shows green and the engine igniter plugs are energised. When the GTS indicator shows green, and with the RPM less than 20%, momentarily setting a start master switch to START causes the GTS to run up to full speed to accelerate the engine, at which point the throttle should be moved to idle.

When the engine has accelerated to 45% RPM, the GTS system shuts down, the engine igniter plugs are de-energised and, after a 30-second delay, the booster pump is restored to the Generator busbar. To prevent over-fuelling, the throttle must be returned to HP OFF if a relight is not achieved within 45 seconds of selecting START.

Cold relight – unassisted

An unassisted relight is carried out below 25,000ft at a minimum of 250 knots with both start master switches at ON and the throttle lever at HP OFF. When the RPM falls below 45%, a start/relight button is pressed to energise the engine igniter plugs (the rotation indicator shows green) whilst the throttle is simultaneously advanced to the idle position. The button should be released when the engine lights up.

Approximately 30 seconds after 45% RPM have been exceeded, the booster pump is restored to the Generator busbar. After a successful relight, shut down the GTS system.

Fire protection systems

The fire protection systems detect and give warning of fire or overheating in the engine bay and the air producer bay, and of overheating in the jet pipe bay. An extinguishing facility is provided in the engine bay only.

The controls and indicators associated with the fire protection systems are on the CWP and are listed below.

Control/indicator	Marking
Fire warning caption	FIRE
Fire extinguisher push-button and light	F
Air producer bay fire warning caption	START

Fire detection and warning

The fire detection system consists of two sets of fire-wire elements of the automatic resetting type. Each set of elements forms a continuous loop which is connected to a control unit. One set of fire-wire elements encircles the engine and the other encircles the air producer. The system is powered from the Essential Services busbar.

The fire-wire elements are temperature-sensitive and the current flow in them increases as temperature rises. If the engine fire-wire reaches a critical temperature, current flow increases sufficiently to close a relay in the control unit which supplies DC to illuminate the head of the fire extinguisher push-buttons and the FIRE captions. If the air producer fire-wire is activated, a relay in the control unit closes and DC is supplied to illuminate the START captions. If the temperature in the affected bay falls below the critical value, the warning lights go out and the detection system is automatically reset. Resetting may take up to 45 seconds.

The jet pipe bay has temperature sensors which activate the JPOHT caption when the bay temperature exceeds 150°C.

Fire extinguishing

An extinguisher bottle in the fuselage is discharged through a spray ring into the engine bay when an extinguisher push-button is pressed. The system is supplied with DC from the No. 1 and No. 2 Battery busbars and is operable irrespective of the setting of the battery switches.

Test facility

The fire detection and warning system is tested when a switch on the CWP is held at TEST. A serviceable system is indicated by the FIRE, START and JPOHT captions, together with all other unlit captions on the CWP in both cockpits and the lamp in the fire extinguisher push-buttons, illuminating.

The fire detection and warning system should not be tested in flight. The system should be tested before engine start-up and again after flight (during engine shutdown).

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