

747 Classic

**Flight Handbook
&
Reference Manual**

**Section 2
Hydraulics
To
Powerplant**

Ready for Pushback ... 2nd Generation

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747 Classic Flight Handbook

Hydraulics



General Information

Hydraulic Power is required for:

- All flight controls, including stabilizer trim
- Trailing edge flaps
- Landing gear and brakes
- Nose and body gear steering

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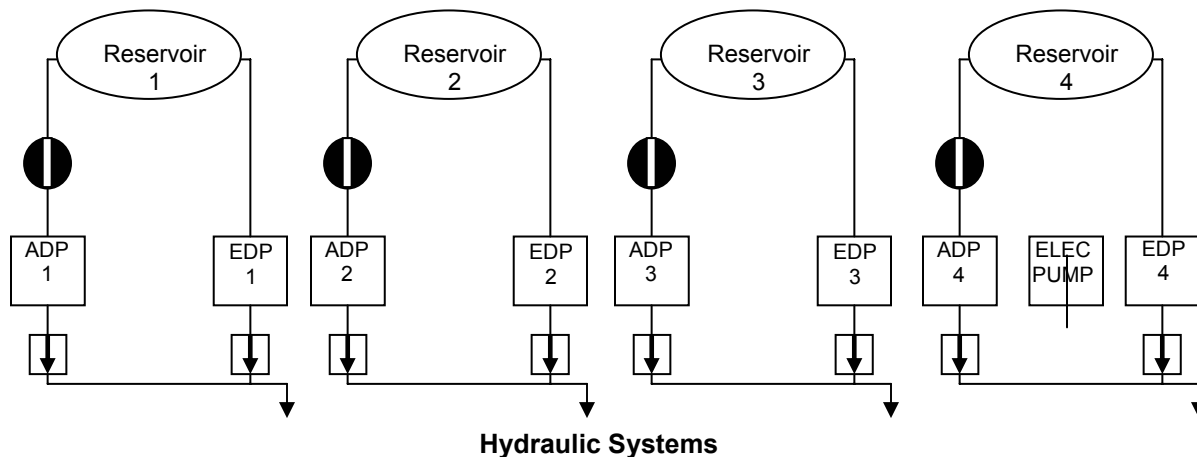
Hydraulic power is provided by four independent systems, identified by engine position and plumbing color code:

- Engine 1: System 1 – Red
- Engine 2: System 2 – Blue
- Engine 3: System 3 – Orange
- Engine 4: System 4 -- Green

Each system has its own reservoir; fluid cannot be transferred between systems. Each system has an engine driven pump (EDP) and an air driven pump (ADP). The pumps are identical. A hydraulic system is not lost because of an inoperative engine. System 4 has an additional electrically driven pump.

Each pump has calibrated leakage for lubrication and cooling. The fluid is drained from the pump case and is routed through a heat exchanger in the respective main fuel tank before being returned to the reservoir.

System pressure is automatically maintained at 3000 psi by an internal regulator in each pump. A relief valve protects each system from pump pressure regulator failures. The relief valve opens at 3500 psi and bypasses excess fluid directly back to the reservoir.



Reservoirs:

A reservoir is located at the aft fairing of each engine pylon. System 1 and system 4 reservoirs contain more fluid than system 2 and system 3 reservoirs to allow for fluid displacement into the landing gear actuators. A sight gage on each reservoir provides a visual indication of fluid quantity. All reservoirs are filled from a central station located at the left body gear wheel well. Each reservoir is pressurized to maintain a positive supply so as to prevent possible malfunction at high altitude. Unregulated pressure is obtained from the airplane's pneumatic system.

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Engine Driven Pump (EDP):

One pump is installed on each engine and is the primary source of pressure for that particular system. A three-position switch on the flight engineer's panel controls each pump. When the switch is in NORMAL regulated pump pressure is provided to the system. Placing the switch into the depressurized (DEPR) energizes a depressurizing solenoid which stops pump output. Fluid is still permitted to Circulate through the pump housing for cooling and lubrication. The supply OFF position of the switch closes the supply valve for that pump. With the valve closed, fluid for pump lubrication and cooling is also shut off.



Air Driven Pump (ADP):

The ADP is the backup for the EDP and also supplements the EDP at high flow rates. The pump is driven by an air turbine, which is powered by air from the Pneumatic system. The pump drive unit also provides speed control and automatic over speed shutdown. Loss of fluid supply increases the chances of over speed shutdown. A three-position switch on the flight engineers Panel controls the pump.

When the switch is AUTO, the ADP starts automatically if EDP pressure drops below approximately 2500 psi. To minimize cycling, the ADP will run 10 to 15 seconds after pressure returns to normal. Placing the switch in the CONTINUOUS position causes the ADP to run continuously regardless of EDP pressure. The OFF position of the switch prevents the ADP from operating



Electrically Driven Pump:

The electrically driven pump pressurizes all of system 4. It has low flow capability and is used primarily to provide brake Pump output pressure can be pressure gauge and on the ACCUMULATOR GAUGE. provided from EXT PWR 1 or



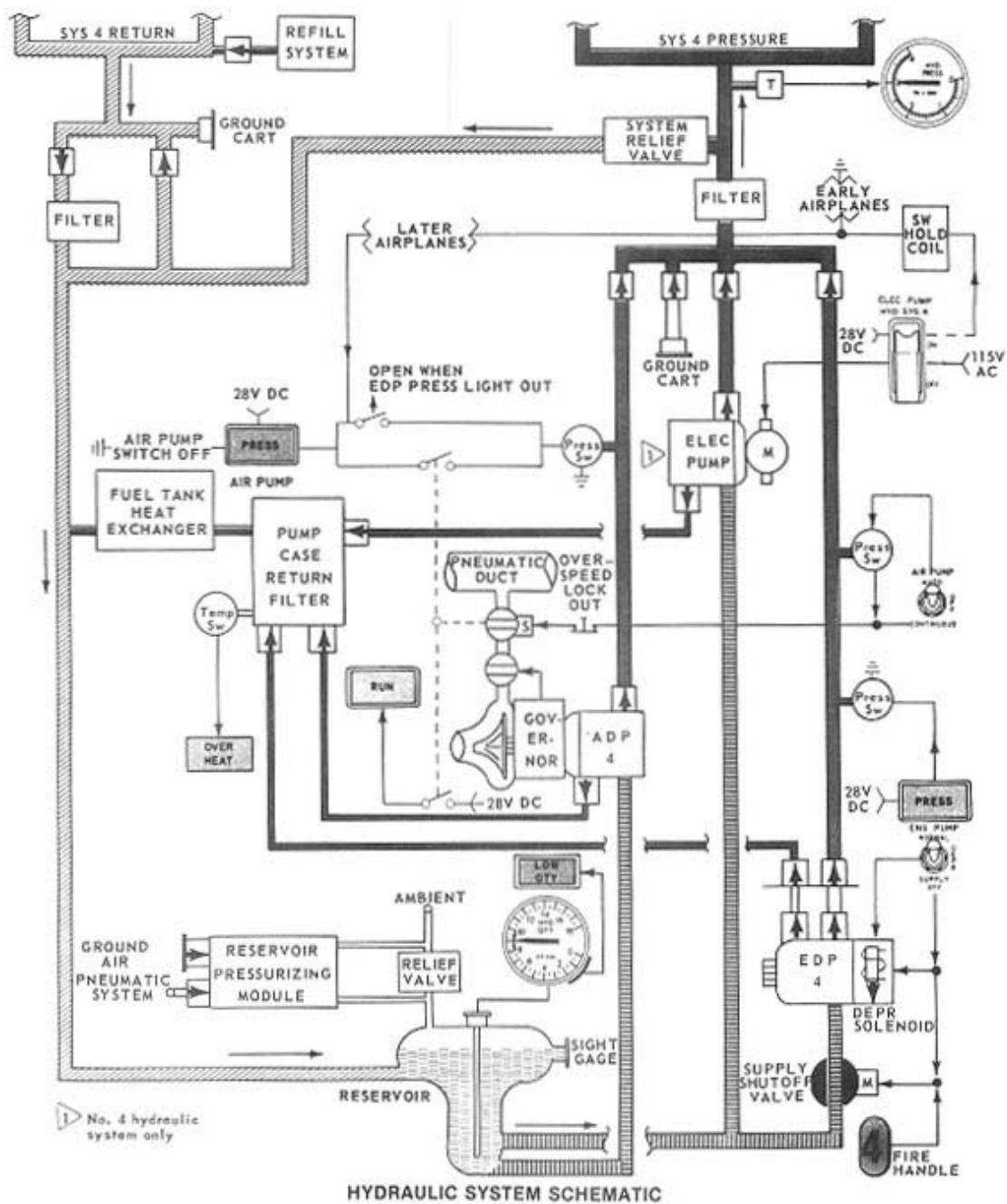
pressure during ground towing. monitored on system 4
NORMAL BRAKE
Electrical power for the pump is APU GEN 1 only.

Pump control is maintained by means of a guarded ON-OFF switch on the flight engineer's panel. The switch is magnetically set; it will drop to OFF is electric power is interrupted to the ground handling bus



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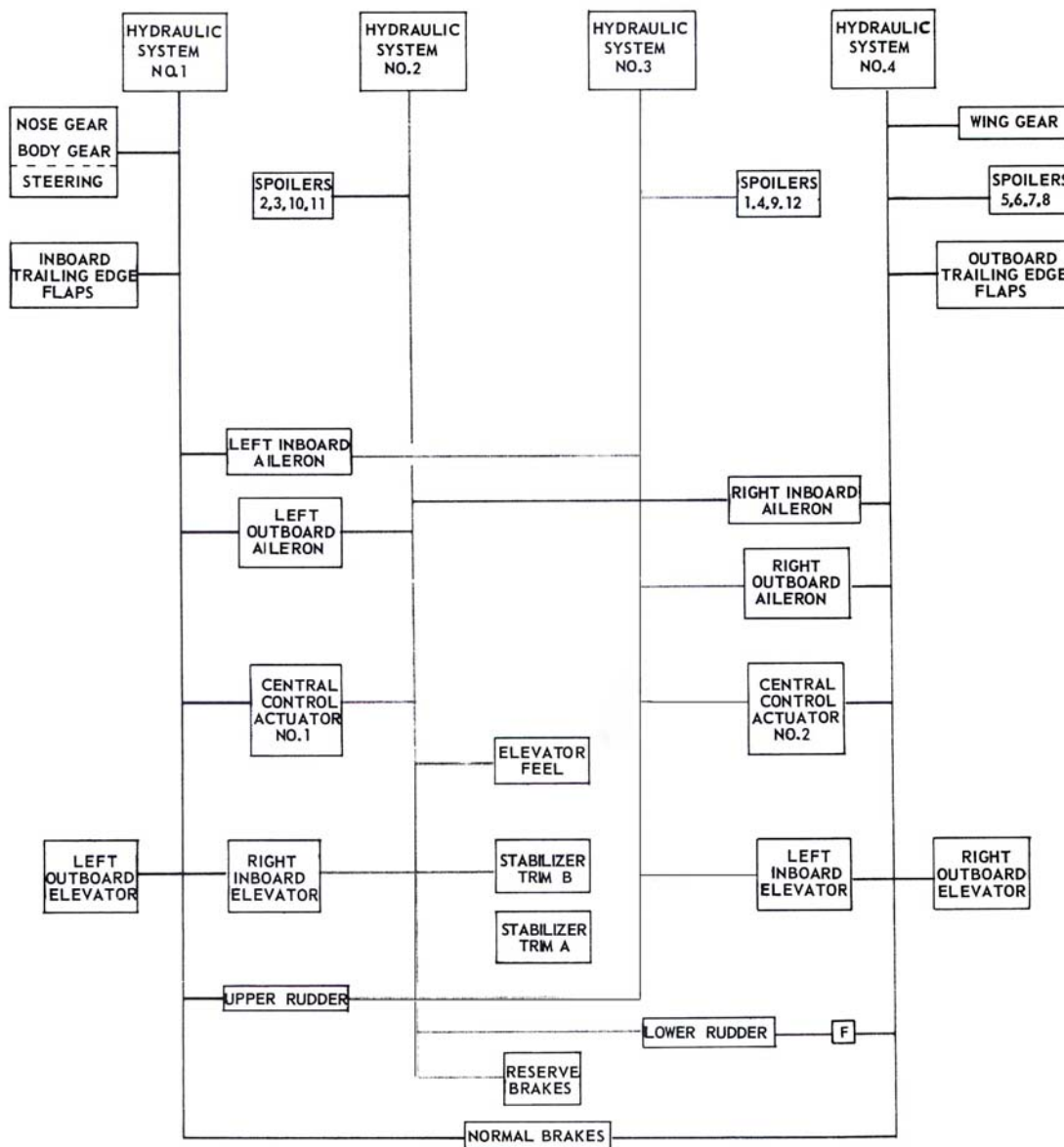
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Hydraulic Power Distribution:

The hydraulic power distribution system has a redundant capability so that loss of one system does not cause complete loss of:

- flight controls
- landing gear, or
- brakes.



HYDRAULIC POWER DISTRIBUTION

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Hydraulic System Controls

Gauge Quantity Test Switch:

Used to verify operation of 4 quantity gauges. When pressed, Hydraulic quantity gauge pointers should decrease to 0 (zero)

Electric Pump Switch:

Controls the electrically driven hydraulic pump. Magnetically held ON.

Drops to OFF if electric power is interrupted to ground handling bus.

ON: Pressurizes all of system 4 including the normal brakes

OFF: Electric pump is deactivated.



Air Pump Switch:

Controls air driven hydraulic pump. Pneumatic air must be available for operation.

AUTO: Pump starts automatically if EDP output drops below 2500 psi.

OFF: Pneumatic air to the drive unit is shutoff. Air pump PRESS light is turned on by the OFF position of the switch

CONTINUOUS: Pump will run continuously regardless of EDP pressure.

Engine Pump Switch:

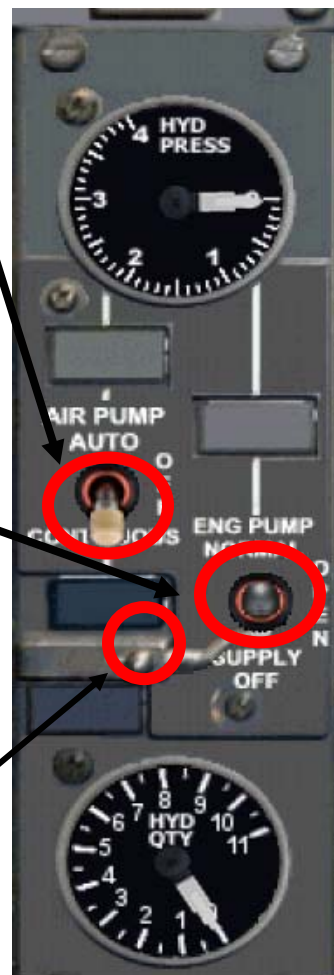
Controls engine pump output to the system.

Engine fire switch overrides all selections of the engine pump switch.

NORMAL: Pump will pressurize system if engine is turning

DEPR: Pump is depressurized; flow to the system is shut off. Fluid is still available for lubrication and cooling.

SUPPLY OFF: All fluid to the pump is shut off. (spring loaded guard must be held to left to permit switch to be placed in SUPPLY OFF . left click to toggle left/right)



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Hydraulic Indicators

Hydraulic Pressure

Gauge:

Indicates system pressure from:

- EDP Output
- ADP Output
- Electric pump output (#4 Gauge only)

Air Pump Low Pressure

Light:

Indicates status of air-driven pump operation

ON:

- AIR PUMP switch is set at OFF
- AIR PUMP RUN light is on but AIR PUMP pressure is below limits
- Air pump is not running when it should be (engine pump pressure light on)

OUT: AIR PUMP operation is normal for existing limits

Air Pump Run Light:

Indicates if pneumatic air is being supplied to the air pump drive unit.

ON: Air pump should be running

OUT: Air pump is not running

Low Quantity Light:

Provides additional alert if fluid quantity is low

ON: Hydraulic quantity gauge indication is low

OFF: Hydraulic quantity gauge indication is normal

Overheat Light:

Monitors temperature of fluid returning from the case of both the EDP and the ADP

ON: Fluid temperature is above limits

OUT: Fluid temperature is normal



Ground

Engine Pump Low Pressure Light:

Monitors Engine pump output pressure

ON: Engine pump pressure below limits

OUT: Engine pump pressure normal.

NOTE: spring loaded guard needs to be pushed to the left to turn the EDP off (single left mouse click toggles guard left then right)

Quantity Gauge:

Indicates fluid quantity.

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Hydraulic System in Normal Operations

Ground Operations

When parked in the terminal area, all hydraulic systems should be depressurized and all ADP switches must be OFF. This is to preclude personnel injury and airplane damage from inadvertent operation of the flight controls. It also reduces noise and allows unrestricted use of the pneumatic system for air conditioning.

Prior to engine start, the flight engineer should obtain clearance from the ground crew and pressurize HYD SYS 4 using the ELEC PUMP switch. Be aware the ELEC PUMP switch will drop to the off position as electric power is transferred. Monitor pressure on the HYD SYS 4 pressure gauge and the NORMAL BRAKE ACCUMULATION gauge. The BRAKE SOURCE LOW PRESS lights remain on with only the electric pump.



During taxi, frequently check the pressure and quantity of the system supplying the brakes. To provide backup for brakes and steering, leave ADP 1, 2 and 4 switches in AUTO until the airplane is parked at the blocks.

Hydraulic Quantity Gauges

Gauge indication is the approved method of verifying hydraulic fluid quantities prior to departure. Always test the gauges when verifying the quantity, both in-flight and on the ground, because needles remain fixed with power off. There is no warning flag.

NOTE: HYD SYS 4 quantity decreases 2-4 gallons when the gear is retracted.

All quantity gauge indications may increase at altitude as trapped air in the lines expands; HYD SYS 1 is especially sensitive. Gauges that increase at altitude should still stabilize at zero during the gauge test; otherwise, the increase in indication is due to system malfunction.

Electric Pump

Power to the electric pump is supplied by EXT PWR1 or APU GEN 1 only. The pump is deactivated in flight. If HYD SYS 4 is pressurized by the EDP or ADP, the electric pump should be turned off if it is operating.



Engine Driven Pump

EDP switches are to be left in the normal position for all normal operation.

Operation time in the DEPR position is unlimited, however, the static fluid in the pump pressure line could overheat at high engine temperatures. If practical, flush the pressure line every hour or so by selecting NORMAL.

CAUTION

Operation in SUPPLY OFF is limited to two minutes. A marginal pump may start deteriorating any time with the supply off. Reenergizing the system after two minutes may contaminate the system.

Air Driven Pump

The ADP is normally operated in AUTO. Pump operation is checked during taxi.

AUTO operation should be checked in routine operating during gear and flap extension and retraction. To minimize cycling, the ADP remains on 10-15 seconds after pressure has returned to normal during AUTO operation.

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Indicator Lights

A switch in each quantity gauge controls a LOW QTY light. If the light illuminates, fluid quantity should be verified.

The EDP PRESS light illuminates at a considerably lower pressure than the pressure switch that controls the ADP in AUTO. If the EDP switch is placed in DEPR or SUPPLY OFF and the ADP starts, expect up to a 10-minute delay before the EDP pressure light illuminates. This is due to the slow bleed-off of residual pressure through the pump case return.

If either PRESS illuminates, pump operation can be verified on the system pressure gauge by operating the pump isolated.

Hydraulic System Checklist Items:

Preflight

During the interior safety check:

- Check that the ELEC PUMP switch is OFF. If it is not OFF, contact maintenance to find out why.
- Set the four hydraulic AIR PUMP switches to OFF to prevent hydraulic pressure buildup when the pneumatic system is pressurized.



Set the four ENGINE PUMP switches to NORMAL. The eight pump PRESS lights should be illuminated and all other lights should be out.



Test the Hydraulic quantity gauges by pressing the QTY TEST switch. The needles should move toward zero. When the QTY TEST switch is released, the indicators should return to the green band.



Record the hydraulic fluid gauge quantities.

Prestart

The flight engineer will declare that the hydraulic fluid quantity is satisfactory for departure. Normally it should be in the green band or above.

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Start

When convenient, the flight engineer should obtain clearance from the ground crew to pressurize the number 4 hydraulic system.

- Set the ELEC PUMP switch to ON and verify that the switch remains in the ON position.
NOTE: Never place the electric pump on if number 4 hydraulic system is pressurized by the EDP or ADP. The pump can be overloaded and trip a circuit breaker.
- Check that both the system 4 HYD PRESS and the NORMAL BRAKE ACCUMULATOR gauges indicate at least 1800 psi.

Pushback or Tow out

Before releasing the brakes:

- Pressurize hydraulic system 1 with the ADP
- Check ADP in CONTINUOUS: check that the PRESS light is out, the RUN light is illuminated, and that HYD PRESS is normal, then set to AUTO and again check the lights and system pressure.

Taxi

While taxiing:

- Place each hydraulic AIR PUMP switch to CONTINUOUS and verify that the RUN light illuminates and the ADP LOW PRESS light goes out.
- Place the 4 ADP switched to AUTO for flight and check that the RUN light goes out.

In AUTO after the normal check, the ADP RUN and PRESS lights may illuminate if the air valve does not close completely or if the closed-position switch adjustment is marginal. This is an indication problem and is usually corrected after a little vibration occurs.

- Check that ELEC PUMP HYD SYS 4 switch is OFF
- Check that all four system pressure gauges indicate approximately 3000 psi and that all four EDP LOW PRESS lights are out.
- Press the QTY TEST switch and note that all four quantity gauges drive toward zero. Release the switch and check that all gauges return to the green band.

After Takeoff

HYD SYS 4 quantity will drop 2 to 4 gallons with gear up and doors closed.

Landing

The flight engineer should check the hydraulic quantity and pressure on all four systems. HYD SYS 4 quantity will increase 2 to 4 gallons with gear down and doors closed.

Taxi

Frequently check the pressure and quantity for the system supplying the brakes. To provide back-up for brakes and steering, leave ADP 1, 2 and 4 switched in AUTO until the airplane is parked at the blocks.

Blocks

The HYD SYS 2 air pump must be kept running if the airplane is parked using the reserve brake; otherwise the air pumps are shut off.

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Ice and Rain Protection

General Information

Ice Protection

Ice protection is the prevention and removal of ice accumulation (anti-icing and de-icing, respectively). The pneumatic and electrical systems supply the required heat.

Engine bleeds provide hot air for:

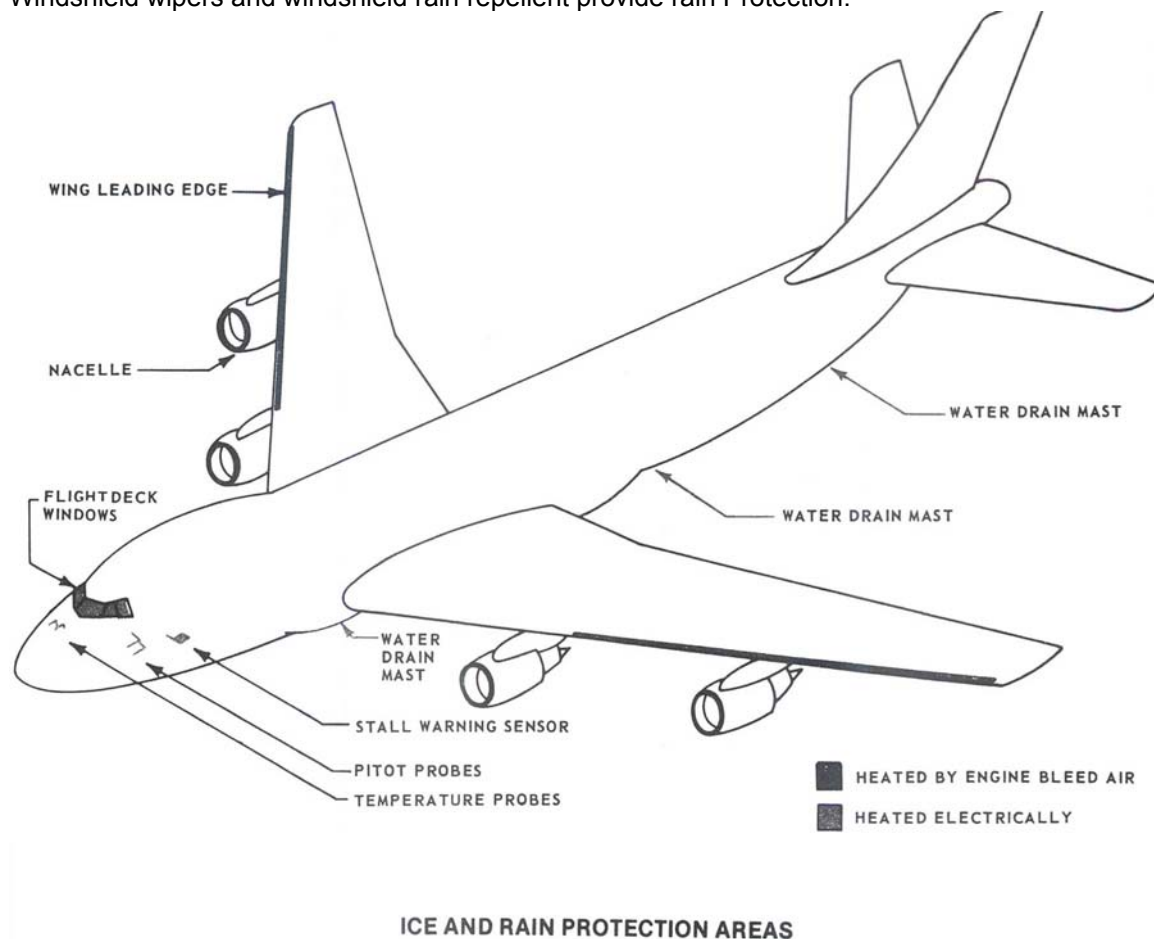
- Wing anti-icing
- Nacelle anti-icing

Electrical power provides heat for

- Flightdeck window anti-icing and defogging
- Pitot probe anti-icing
- Stall warning sensor anti-icing
- Temperature probe anti-icing
- Water drain mast anti-icing

Rain Protection

Windshield wipers and windshield rain repellent provide rain Protection.



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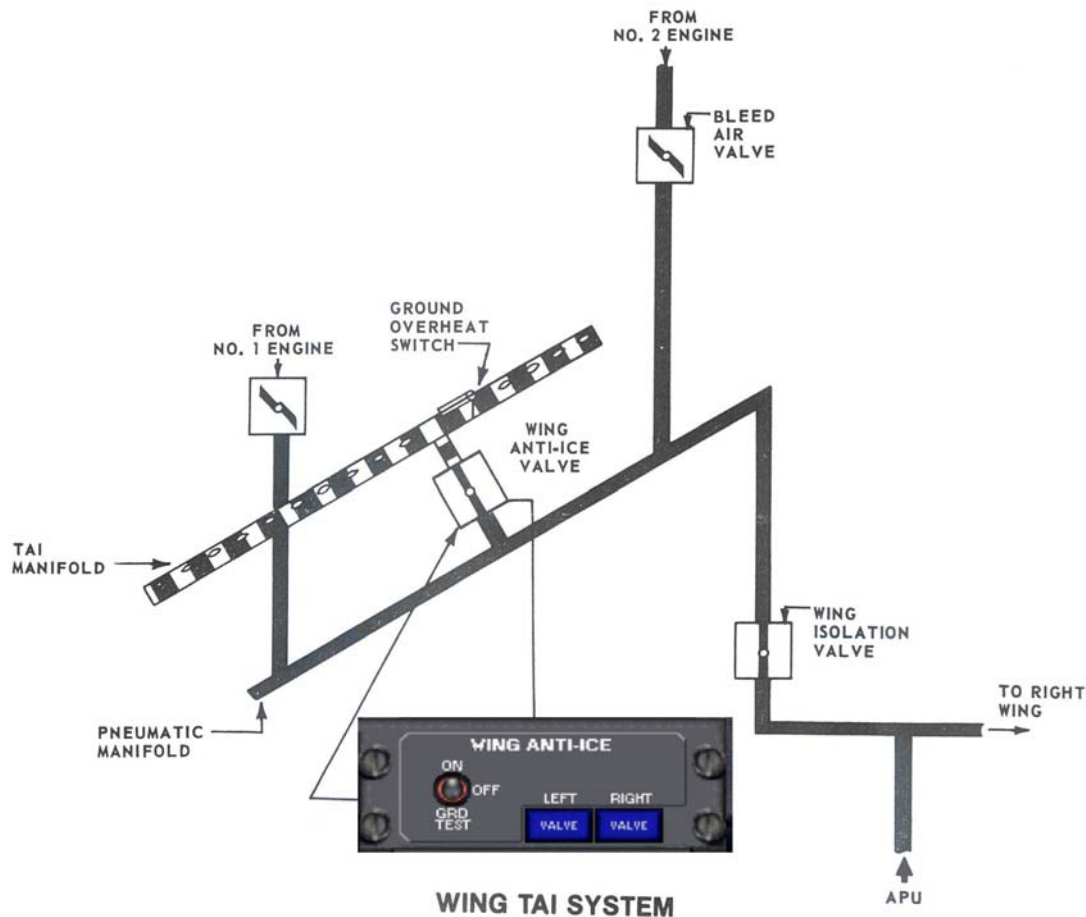
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Wing Thermal Anti-Ice

The wing thermal anti-icing (TAI) system prevents the formation of ice on the leading edge of each wing. The TAI system receives hot air from the pneumatic manifold. Except for ground test, the system is designed for in-flight use only.

A single three-position switch located on the pilots' overhead panel controls airflow. When the switch is placed to the ON position in flight, an anti-ice valve in each wing is opened. The air is then directed to the TAI manifold, which extends from outboard of the inboard engines to the wingtips. A blue VALVE in-transit light shows valve operation. The light is on whenever the valve is in transit or the valve is not in agreement with the switch position.

The TAI system may be tested on the ground by holding the switch in the GRD TEST position. If, during the test, the temperature of a ground overheat switch is exceeded, both wing anti-ice valves are signaled to close. The overheat protection system is not needed in flight.



Nacelle Anti-Ice

General

The nacelle thermal anti-ice (TAI) system prevents ice accumulation on the:

- Nose Cowl,
- Pt2 Probe.

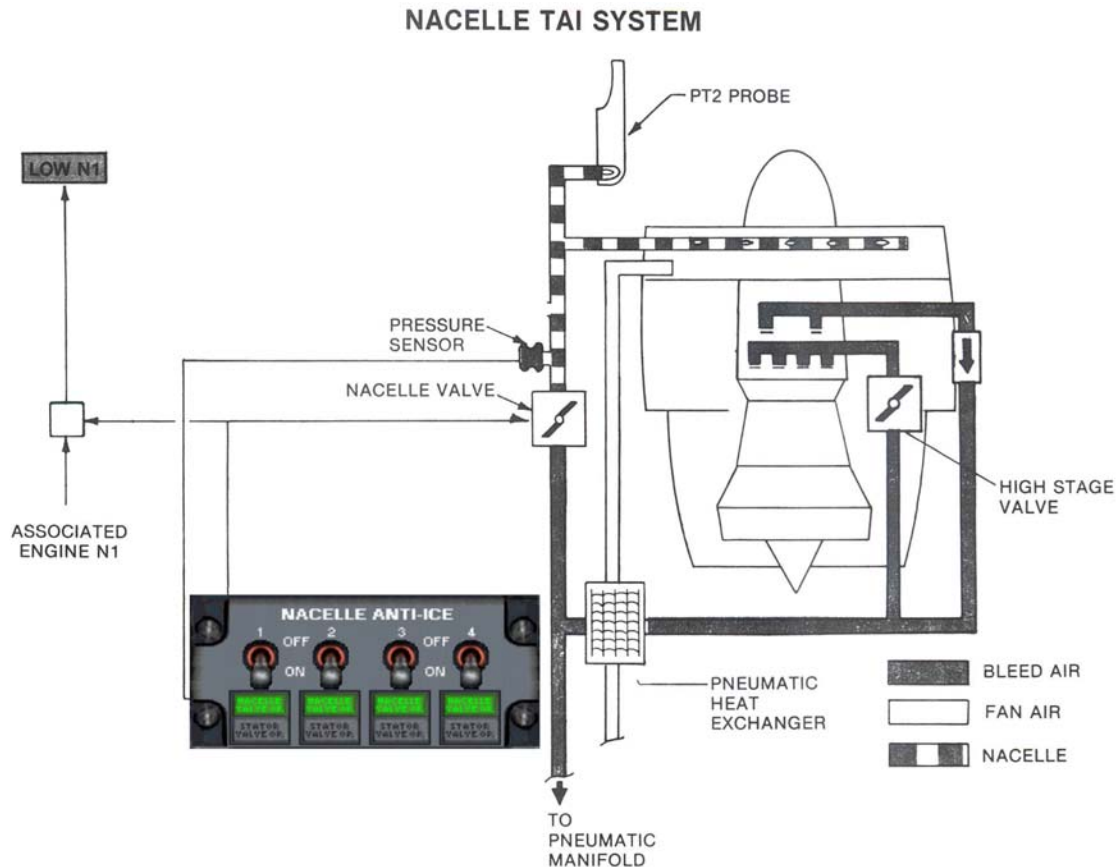
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TAI for the nose cowl and the Pt2 probe is supplied by the same engine bleed delivered to the pneumatic manifold, after being cooled by the pneumatic heat exchanger.

Control

Four NACELLE ANTI-ICE switches provide control, one for each engine. Placing a switch in the ON position arms the nacelle valve on that engine to open, and pneumatic pressure opens them. A pressure sensor illuminates a NACELLE VALVE OPEN light, indicating that the valve is open. Placing a switch in the OFF position removes electrical power and pneumatic pressure closes the valve.



Window Heat

General

Flightdeck windows are electrically heated to provide anti-icing and defogging. Four switches on the pilots' overhead panel control power to an electrically conductive coating within the laminated window. Window heat is regulated by:

Window heat controllers,

- Temperature sensors,
- Thermal Switches.

Conditioned air is also available for window defogging.

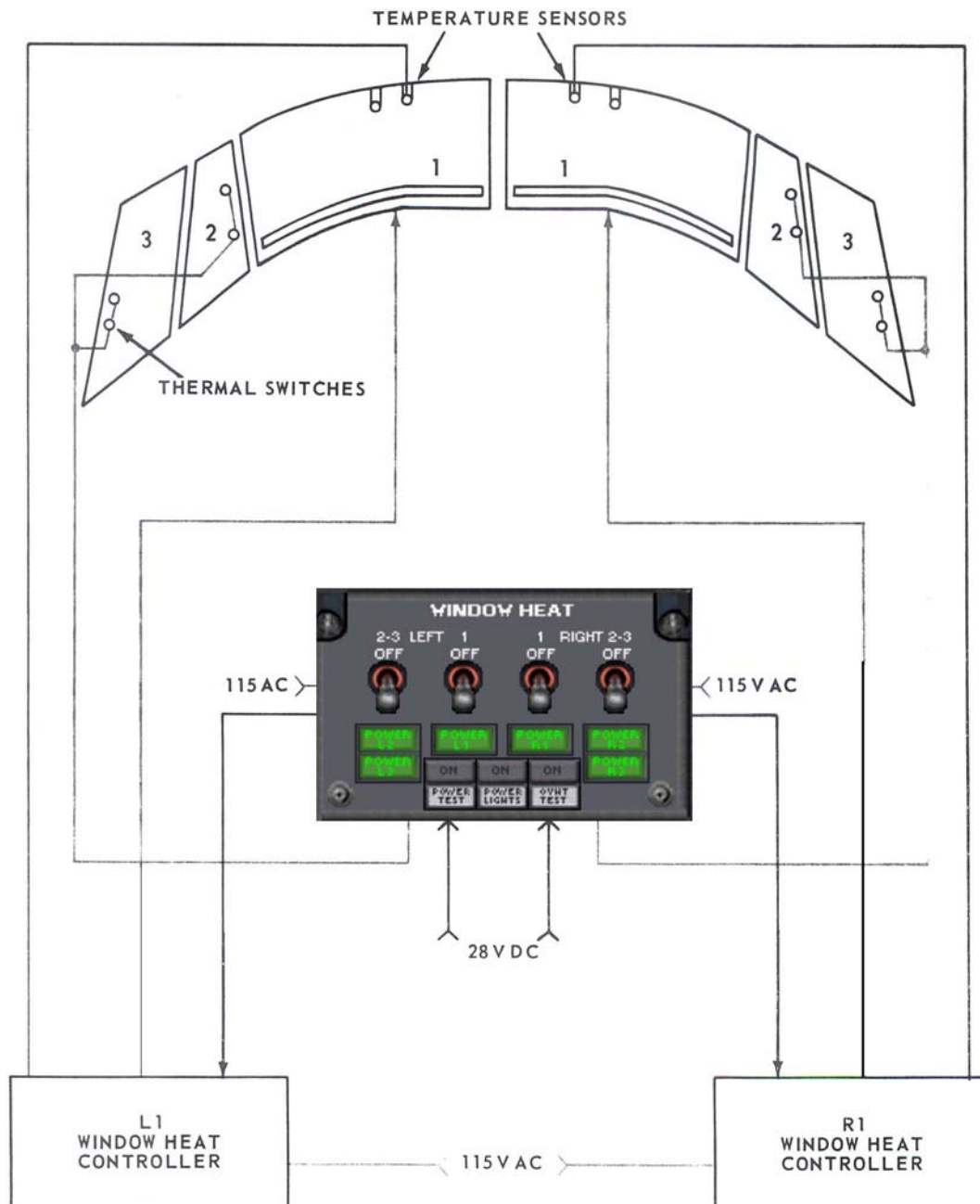
No. 1 Window Anti-Icing

Anti-icing is provided to the No. 1 left and No 1 right windows. Two three-position switches, one for each No. 1 window, are located on the overhead WINDOW HEAT panel. When a switch is placed to the ON position, a window heat controller programs a slow window warm-up and then

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maintains a constant window temperature. These functions are accomplished by programming voltage to the window. A temperature sensor in each window monitors temperature.



WINDOW HEAT SYSTEM

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Rain Protection

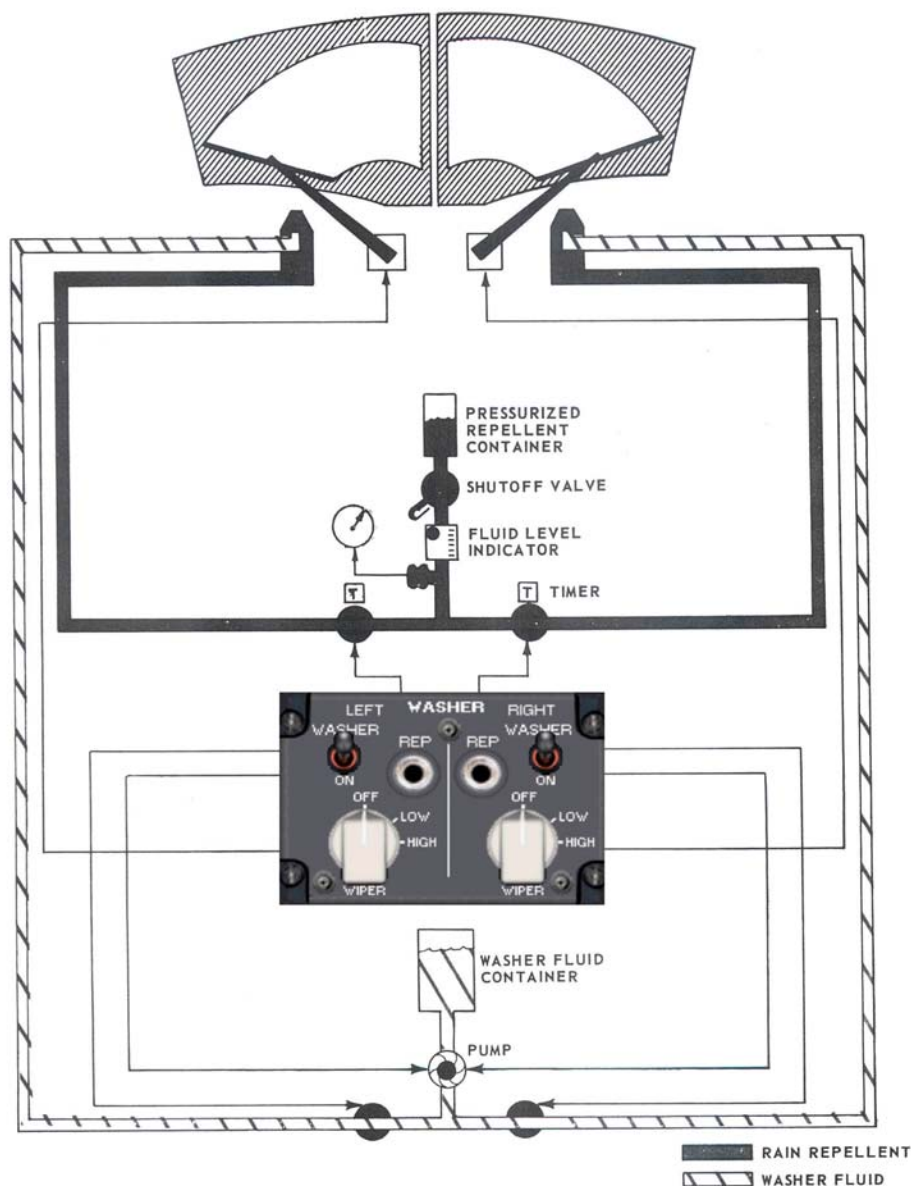
The rain protection system consists of:

- Electrically operated windshield wipers.
- A rain repellent system.

The windshield may be kept clear in moderate or heavy rain by using rain repellent in conjunction with the wipers.

Windshield Wiper System

Windshield wipers are installed on both No. 1 windows. Each wiper is operated by a 28V dc motor and is controlled by a switch with two speed settings, LOW and HIGH. With the switch in OFF, the wiper is parked below the lower edge of the windshield. **NOTE: Although windshield wiper switches are included on the overhead panel, there are no visible, working windshield wipers.**



WINDSHIELD WIPER, WASHER, AND RAIN REPELLENT SYSTEMS

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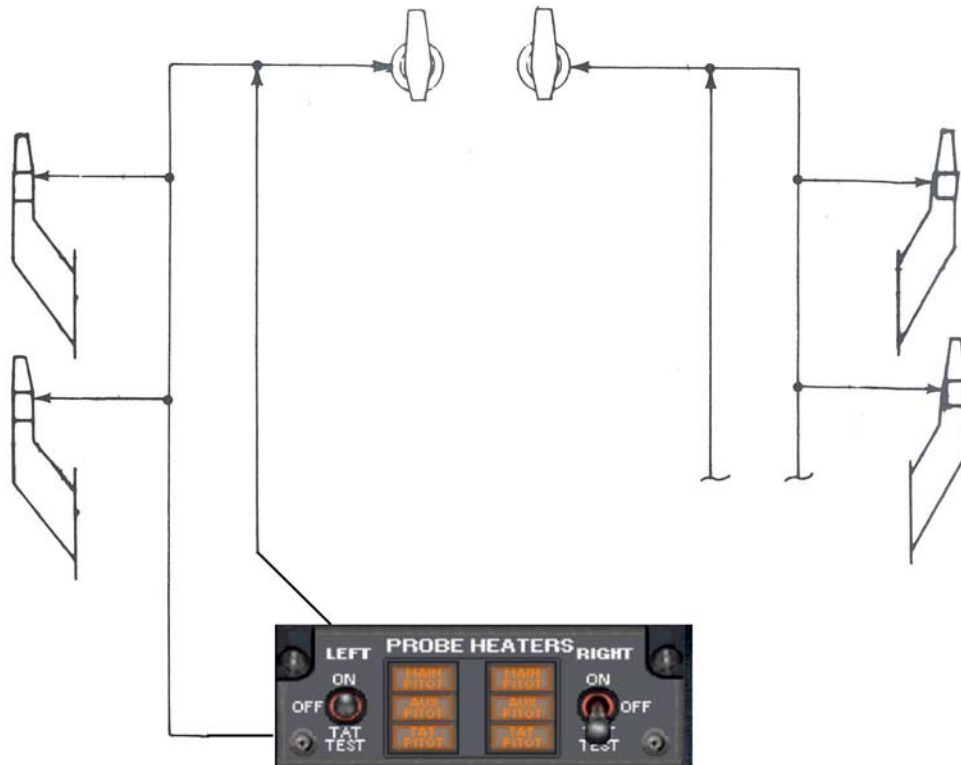
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Probe Heat

The left and right main pitot-static probes, left and right auxiliary pitot-static probes, and the No. 1 and No. 2 total air temperature probes are heated to prevent ice formation that would affect sensing accuracy.

Operation

Probe heat is controlled by two three –position switches, one for the left side and one for the right. These switches are located on the pilots' overhead panel.



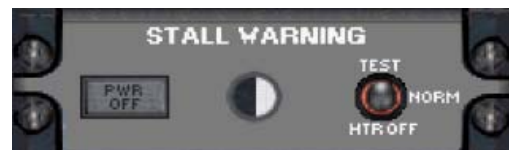
PROBE HEAT SYSTEM

Stall Warning Sensor Heat

The stall warning sensor is a vane located on the left side of the nose and is electrically heated for anti-icing.

Vane heat is controlled by a three position STALL WARNING switch located on the pilots' overhead.

A power off (PWR OFF) light indicates status of both system power and current through the sensor vane.



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Controls and Indications

Wing Anti Ice

Controls airflow to wing TAI system

GRD TEST: Momentary position that opens valves for ground test; valves automatically close when wing anti-ice duct temperature becomes excessive.

OFF: Valves are closed at all times

ON: Valves are closed on the ground; open in flight



Valve in Transit Lights

Confirm Operation of wing valves

ON: Valves are in transit or valve position not in agreement with switch position

OUT: Valve position agrees with switch position

Nacelle Anti-Ice

Nacelle Anti-Ice Switches

Control nacelle anti-ice valves

ON: Arms associated valve to open and arms N1 caution light

OFF: Valves are closed

Nacelle Valve Open Lights

ON: Nacelle anti-ice valves are open

OUT: Nacelle anti-ice pressure no adequate for anti-icing.



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Window Heat

Window Heat Switches

ON: Applies heat to the window area designated by the switch

OFF: Turns off window heat for the window(s) designated by the switch

Window Heat Power Lights

ON: (POWER LIGHTS and WINDOW LIGHTS)

- Heat is being applied in normal cycling operation.
- POWER TEST switch is pressed (L1 and R1 Only)

OFF:

- Window heat switch is off
- Heat is cycling off normally
- POWER LIGHTS switch is off



L1/R1 Power Test Switch

When pressed, tests the L1 and R1

window heat systems when POWER lights are not illuminated with system on.

Overheat Test Switch (normally guarded)

Maintenance Test ONLY, in-flight operation can damage windows

Power Lights Switch

Controls power to the 5 POWER lights

OFF: (unlatched)

- POWER lights cannot illuminate

ON: (latched in; ON legend illuminated)

- POWER lights illuminate when associated window is being heated
- L1 and R1 POWER lights illuminate when POWER TEST switch is pressed provided WINDOW HEAT is on.

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Stall Warning

Power Off Light

ON:

- System power is off.
- Stall warning sensor vane heater inoperative.
- Control switch is in HTR OFF position.

OUT:

- Plane is powered by engine generators
- System is being tested



Stall Warning Switch

NORM:

- Arms stall warning system when the nose gear strut is extended
- Applies heat to sensor vane

HTR OFF:

- Turns sensor heater off (primarily a maintenance function to prevent burns)

TEST:

- Causes control column to shake, indicator to spin, and PWR OFF light to go out.

Windshield

Rain Repellant Switches

Apply one application of fluid to respective No. 1 Window

Windshield Washer Switches

ON: Applies washer fluid to the respective No. 1 Window

Windshield Wiper Switches

OFF: wipers off and parked

LOW: wipers operate at low speed

HIGH: Wipers operate at high speed



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Probe Heat

Probe Heaters Switches

TAT TEST: (momentary)

- On the ground it will override the nose gear air/ground logic and turn the TAT heat on.
- TAT lights should be out

OFF, (on ground)

- Pitot and probe heaters are off
- Pitot lights (4) and TAT lights (2) are on, and
- Probe heat light is on

OFF, (in flight)

- Pitot heaters are on
- PITOT lights (4) are out
- Probe heaters are off, and not armed
- PROBE lights (2) are on, and
- PROBE HEAT light is on.

ON, (on ground)

- PITOT (4), TAT PROBE (2), and PROBE HEAT (1) lights are out.
- Pitots are being heated
- TAT probes are armed and will; automatically be turned on by the nose gear air/ground logic circuits when airborne.

ON, in flight

- PITOT (4), TAT PROBE (2), and PROBE HEAT (1) lights are out, and
- All probes are being heated.



Probe Heat Light

ON: an overhead probe heaters annunciator light is on

OFF: all overhead probe heaters annunciator lights are out



Normal Operations

General

Nacelle Anti-ice

Engine anti-icing must be turned on during all ground or flight operations when icing conditions exist or are anticipated.

Ice may form on fans during taxi; it can be cleared by increasing N1 to 45% - 50% for 10 to 15 seconds every 15 minutes.

In flight, engine ignition is to be on to prevent engine flameout before turning on nacelle anti-ice. Ignition may be turned off after one minute if engine operation is stable.

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After turning on nacelle anti-ice on two symmetrical engines, observe stable engine operation before operating anti-ice on the two other engines.

CAUTION:

Do not use nacelle anti-ice with TAT above +10 C as half resistance of the nose cowl skin will be reduced.

Probe Heaters

Use probe heaters continuously on the ground before takeoff and in flight. Turn off after landing and at the blocks.

Wing Anti-ice

Wing anti-icing may be used either to remove an ice accumulation or to prevent ice from forming on the wing leading edge surfaces. It should be normally used as a deicer.

If icing conditions exist, turn the WING ANTI-ICE switch on before extending the leading edge flaps. When the leading edge flaps are extended, the wing anti-ice is ineffective and should be turned off.

Window Heat

The four WINDOW HEAT switches are placed ON before taxi and remain ON until after landing.

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Landing Gear and Brakes

General Information

The landing gear consists of four main gear and one nose gear. Main gear are identified as L-wing, L-body, R-body, and R-Wing. Each main gear has four wheels while the nose gear has two.

The gear is designed to permit emergency landings with the nose gear and any one main gear on each side down and locked.

Each main gear is equipped with:

- Disc brakes, incorporating an autobraking feature which functions as part of the normal brake system.
- A brake temperature monitoring system
- Antiskid protection.
- Thermal tire deflation fuses

The body gear trucks are steerable. During sharp turns, body gear steering reduces engine thrust requirements and minimizes tire scrubbing. All main gear trucks, when airborne are hydraulically tilted up at the forward end to allow the gear to fit into the wheel wells. All gear are hydraulically positioned as selected by the landing gear lever on the pilots' center instrument panel.

Door and gear sequencing is automatic. The doors open before the gear unlocks, and close after the gear locks in place (up or down)

An alternate extension system uses an electric motor for each gear to unlock the door actuator and release the gear unlock.

A door release handle in each body gear wheel well opens both sets of doors on that side for ground operation. The nose wheel door also has a release handle, located in the nose wheel well.

Hydraulic Power Sources

Hydraulic systems 1 and 4 provide power for the landing gear. Systems 1, 2 and 4 provide power for the brakes.

Hydraulic System 1 supports these functions:

- Body gear retraction, extension, tilt and steering
- Nose gear retraction, extension and steering
- Secondary Pressure source for the normal brake system

Hydraulic System 2 supports these functions:

- Only pressure source for the reserve brake system

Hydraulic System 4 supports these functions:

- Wing gear retraction, extension and tilt
- Primary pressure source for the normal brake system
- Gear up braking

Note: The electrically driven hydraulic pump (EDP) can be used to pressurize system 4 whenever APU gen 1 is operating and field is closed, or external power is plugged into the EXT PWR 1 receptacle.

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Landing Gear

Main Gear Tilt

All main gear trucks are tilted up at the forward end to allow the truck to fit into the wheel well. Trucks are tilted in flight by actuators that are pressurized from each gear hydraulic system. In the ground, aircraft weight overcomes the actuator force and levels the trucks.

The required tilt position is sensed electrically for air-ground logic that is required for various systems. Primary and alternate tilt sensors are used for redundancy.

Nose Gear Air-Ground Logic

When the nose gear strut is not compressed, proximity switches arm stall warning and overrotation warning systems.

Gear Lever

The gear lever controls all gear simultaneously. A lever lock prevents movement from the OFF position to the UP position if any truck is level or either body gear steering actuator is unlocked. This lever-lock can be moved aside manually to raise the handle. This is permitted, providing an alternate procedure confirms normal truck configuration.

Extension and retraction

Each gear is sequenced mechanically with its gear door. Opening of the door is controlled by the gear lever. The gear cannot extend or retract unless the door is open, and the door cannot close unless the gear is locked in the up or down position as selected by the gear lever.

Alternate Extension

The alternate extension system allows the gear to be extended in the event of hydraulic system failure. When the electric motor in each gear uplock has unlocked the door actuator and released the gear uplock, landing gear weight and air loading will extend each gear to the down and locked position. Once started, the electric motor completes the extension cycle and automatically shuts off in the stowed position. If the motor is shut off prematurely during an alternate gear extension, the door actuator remains unlocked, and the door will open when ever the gear lever is placed to OFF.

Steering

Ground steering utilizes the nose and body gear. Nose and body gear steering is pressurized from the No. 1 hydraulic system gear extend line. This prevents wheel movement when the gear is retracted.

Nose Gear Steering

Steering is accomplished by means of steering tillers (NOT IMPLEMENTED in this SIM) located on the captain's and first officer's sidewalls.

Tiller movement of 150 degrees either side of center causes nosewheel movement of 70 degrees either side of center.

If steering hydraulic pressure is lost, the nose gear will caster with asymmetrical thrust or braking.

Body Gear Steering

Body gear steering is controlled by the position of the steering tiller and operates only during medium to sharp turns. Tiller movement of 45 degrees unlocks the body gear steering system. The

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body gear then turns in the opposite direction to the nosewheel movement to a maximum angle of 14 degrees. If steering pressure is lost, mechanical locks in the actuators hold the gear straight.

Brakes

Self-adjusting, multidisc hydraulic brakes that incorporate brake wear indicators are installed on each main landing gear wheel. Two brake systems are provided:

- Normal brakes, which receive pressure from the No. 4 or No. 1 hydraulic system and which incorporate a brake accumulator for parking brakes.
- Reserve brakes, which receive pressure from the No. 2 hydraulic system. There is no accumulator in the reserve braking system.

A NORMAL BRAKE SOURCE SELECT switch on the flight engineer's panel permits selection of the hydraulic power source for the normal brake system.

A RESERVE BRAKE switch on the Captain's instrument panel, when placed to OPEN, permits the No. 2 hydraulic system to pressurize the reserve brake system.

An antiskid system provides optimum braking by modulating the applied brake pressure.

An Autobrake system which is part of the normal brake system, applies pressure evenly to all sixteen brakes.

Manual Brakes

The pilot's brake pedals operate metering valves in the normal and reserve systems simultaneously. When both systems are [pressurized at the same time (reserve brake selected), the system with the highest metered brake pressure will displace shuttle valves and control the brakes.

Antiskid

The aircraft has one antiskid system controlling the normal and reserve antiskid valves. With the ANTISKID switch ON, the system becomes operative when any one main gear is down and locked. Touchdown protection prevents landing with the brakes on and keeps all brakes released until the landing gear tilt logic is satisfied that one main gear on each side is on the ground.

Controlling the deceleration rate of each wheel prevents a skid. Locked wheels due to hydroplaning are prevented by comparing the speed of each wheel to the speed of the other wheels. All of these functions are accomplished by releasing some or all of the pressure applied by the pilot or autobraking system through modulating the antiskid valves.

The normal brake system has an antiskid valve for each wheel. The reserve brake system has an antiskid valve for each side by side pair of wheels, with the wheel most prone to skid signaling skid protection for the pair. The reserve system requires 10% more stopping assistance under maximum braking conditions.

Autobrakes

Autobrakes are part of the normal brake system. Pressure is applied evenly to all sixteen brakes through a single electrically controlled metering valve. The normal antiskid system provides skid protection.

Three deceleration levels are available:

- MIN (minimum): 4 feet per second
- MED (medium): 6 feet per second
- MAX (maximum): 3000 psi is applied to the brakes



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The selection can be changed from one to the other without first selecting OFF.

MIN and MED maintain a constant deceleration rate at all levels of reverse thrust.

The AUTO BRAKE selector is spring-loaded and is held in the MIN, MED and MAX positions magnetically. The system is disarmed by any of the following:

- Brake pedal(s) depressed
- Advancing No. 1 or No. 3 throttle when on the ground
- Antiskid system is not on or fault exists

Parking Brake

To set the parking brake on the simulated 747, use the CTL PERIOD (>) combination. The lights the PARKING BRAKES – PRESS CTL PERIOD (>) TO RELEASE in the lower left of the screen.

Controls and Indications

Landing Gear

Gear down light

ON: all gear down and locked

OUT: all gear not locked and down

Door open light

ON: one or more landing gear doors are open

OUT : All gear doors are closed.

Gear Light

ON:

- Gear lever in down position and primary sensing not indicating gear down
- Gear up and any throttle at idle
- Gear is in transit or not in agreement with gear lever position
- Gear is not locked down and flaps are at 25 or 30

Landing Gear Lever

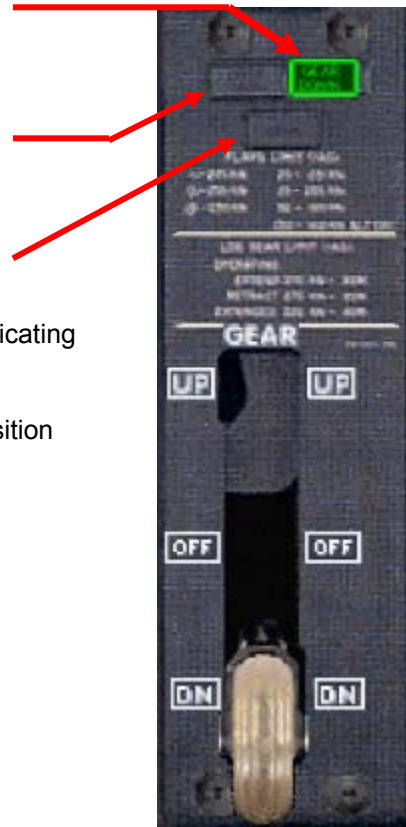
UP: Directs hydraulic pressure to sequence:

- Gear door operation
- Automatic brake application, and
- Gear retraction

OFF: landing gear hydraulic system is depressurized

DN: Directs hydraulic pressure to sequence:

- Gear door operation
- Gear extension, and
- Nose and body gear steering



Use the “G” key to raise/lower gear, or use the mouse and click by

- UP to raise
- DN to lower
- OFF after flaps are up to depressurize brake system

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Alternate Gear Extend Panel

Located on the overhead panel

OFF: disarms alternate gear extension system

ARM: Continues alternate gear extension cycle after cycle was started

EXT: Starts alternate gear extension cycle

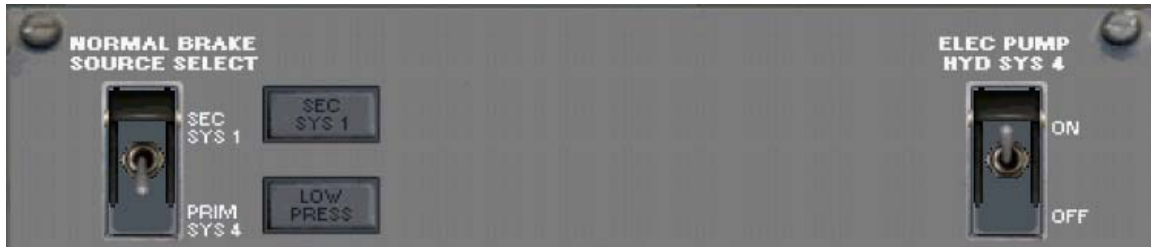


Brakes

Normal Brake Source Selected Switch: Selects hydraulic power source for normal brake system

SEC SYS 1: No. 1 hydraulic system pressurizes brake system

PRIM SYS 4: No. 4 hydraulic system pressurizes brake system



Secondary System 1 Light

ON: No. 1 hydraulic system has been selected to pressurize the brake system.

Brake Low Pressure Light

ON: The hydraulic system pressurizing the brake system has low pressure except that the light remains on when the electric pump is pressurizing the NO. 4 hydraulic system.

Electric Pump Sys 4 Switch

ON: electric pump is pressurizing No. 4 hydraulic system.

Reserve Brakes

Reserve Brake Valve Open Light

ON: Reserve brake valve open

OUT: Reserve Brake valve closed

Brake Source Low Pressure Light

ON or Flashing: the hydraulic system pressurizing the brake system has low pressure except that the light remains on when the electric pump pressurizing the No. 4 hydraulic system.



Reserve Brake Switch

OPEN: opens reserve brake valve to enable No. 2 hydraulic system to pressurize the reserve brake system.

CLOSED: reserve brake system closed

Parking Brakes

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Parking Brake Lever

Click to set, click to unset



Parking Brake Light

Illuminates when brake is set

Anti Skid System

Anti Skid Switch (Located on the overhead panel)

OFF: deactivated

ON: operative when any gear is down and locked



Body Gear Steering Switch

ARM: Permits body gear steering after tiller movement of 45 degrees

DISARM: Disarms the control system

Autobrakes

Autobrake Selector

OFF: Deactivates Autobrake system and extinguishes Autobrake light

DISARM: Autobrake system pressure will release if applied and AUTOBRAKE light will flash

MIN: Autobrake system set for a deceleration of 4 ft/sec

MED: Autobrake system set for a deceleration of 6 ft/sec

MAX: Autobrake system set to apply 3000 psi brake pressure



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Navigation and Communications



Introduction

This section explains the navigation and Communication facilities available on the 747-200 aircraft as modeled in this simulation. The VOR/ADF navigation facilities and communication radio are the standard MSFS 2004 facilities. Included for navigation are:

- VOR radios – VHF Nav
- ADF
- Transponder
- Inertial Navigation System (INS)
- The Microsoft Flight Simulator GPS

The section includes basic help and pointers to information regarding navigation and planning.

VOR, ILS, DME and GPS

General

The VHF navigation systems receive signals from VOR or ILS ground facilities, and present the information received as a visual display of:

- Airplane position with respect to a selected course and station,
- Magnetic bearing and distance to a station, and
- Airplane position with respect to a selected course (or localizer) and glidepath.

In addition the receivers provide VOR/ILS aural identification signals and voice reception. The mode of operation, VOR or ILS, is determined by the frequency selected.

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VOR and ILS

VOR stations transmit a rotating signal and a reference signal oriented to magnetic north. Courses, called radials, are produced by the Phase relationship existing between the two signals. VOR receivers compare the radial the airplane is on against the selected course and send this information to the course deviation bar in the horizontal situation indicators (HSIs). This presents a visual indication of the airplane position relative to the station and the selected course. Magnetic bearing to the station is shown by the VOR/ADF needle on the RMIs when VOR is selected, while the tail of the needles indicates the radial.

ILS receivers compare the relative signal strength of pairs of signals transmitted by course (localizer) and glideslope transmitters. The difference in signal strength moves the course deviation bar and glideslope deviation bar.

When an ILS frequency has been selected, and VOR/ADF selectors are set to VOR, the needles will show a 90-degree relative bearing.

System Sensitivity

With a VOR tuned, the course deviation bar will deviate one dot for a five-degree course deviation.

With an ILS tuned, the course deviation bar will deviate one dot for a 1¼ degree localizer deviation. The glideslope bar will deviate one dot for a ¼ degree glideslope deviation.

System Accuracy

The HIS readability is greater than RMI needle indications due to an expanded scale and possible cumulative errors in the RMI signal chain.

Course deviation bar error limits of +/- 3 degrees are designed to permit maintaining flight within airway tolerances when flying within one degree of the published radial.

Power

Two systems, separate except for common VOR and glideslope antennas, are installed on each airplane. The standby bus powers VOR-1, while No. 2 flight instrument bus powers VOR-2. Both ac and dc power are required.

Switches on each audio control panel permit monitoring of station identification signals.

DME

Distance measuring equipment (DME) displays line-of-sight distances from an airplane to a selected TACAN or VORTAC station. The round-trip time required for the transmission of an interrogating signal to the ground station and receipt of a transmitted reply signal is measured and converted to a digital display of distance. The distance is displayed in the window of a dual indicator installed above the RMI on each pilot's instrument panel. When close to the station and at high altitude, the slant range distance must be considered. For example, at 30,000 feet over the station, the DME will show 5 miles out.

Audio output of the DME system is connected in parallel with the respective VOR audio. The VOR ground station transmits its code identification at 1020 Hz and then pauses. During this interval, the DME transmits its code at 1350 Hz.

Two separate systems are installed in the airplane. Each system requires ac and dc power. The essential radio bus powers DME-1 and No. 2 radio bus powers DME-2.

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GPS

Today, GPS (Global Positioning System) is one of the mainstays of aircraft navigation. It works by accessing signals from 3 or more satellites in stationary orbit around the earth. The GPS receiver can then do the arithmetic necessary to determine the exact latitude and longitude of the receiver, and thus the aircraft. The resolution of modern GPS is a military secret, but thought to be in the one meter (3 feet) range ... more than adequate for pretty exact navigation. Today's aircraft use a combination of laser based Inertial Reference System (IRS), GPS and the tried and true VOR/DME-VOR/DME radar ranging to determine the aircraft's exact location on the planet at any point in time.

The MSFS GPS has been added as a convenience for those who do not wish to be involved in the complexities (or FUN, as many see it) of the INS. The use of the GPS for lateral navigation is fully explained in your MSFS documentation provided on the installation CDs. If you wish to use the MSFS GPS, we suggest strongly that you understand its operation.

Further below in this document, is a flight planning scenario for a flight from London Heathrow to Frankfurt-Main airport. By setting up this plan in the MSFS Flight Planner, you are ready to go with the click of a switch ... to have GPS drive your lateral navigation.

GPS Implementation

When you toggle the NAV/GPS switch to GPS, the aircraft will follow the flight path you have set in the MSFS Flight Planner.



This switch is found on the glareshield above the pilots flight instruments

There are two positions for the switch:

- NAV:** when in the NAV position, the aircraft uses either
- Manual steering
 - Heading Select with the Autopilot
 - INS lateral navigation

Depending on the setting of those switches.

- GPS:** When in GPS mode, the path of the aircraft is directed by the flight plan set up in the MSFS flight planner. The aircraft must be in Autopilot mode to use the GPS.

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VHF NAV Radios

Frequency Indicator

- VOR/LOC 108.00 to 117.95
- Localizer frequency automatically tunes glideslope frequency.
- VOR/LOC frequency automatically tunes a DME frequency.



To tune:

Use dial on right, Click on the right side to increase frequency, on the left to decrease frequency

Click on switch (under Nav1/2) to transfer frequency from RIGHT to LEFT.



Distance Indicators

Located above the RMI, indicate distance in nautical miles and tenths, for their respective DME system.

For example, the aircraft is located at Gate 17 – Ramp Large at Beijing City Airport (ZBAA).

The aircraft is parked approximately 2.1 nautical miles from the Beijing VOR 114.70 PEK. The VOR needle with the dashed line points at the VOR. NAV 2 is tuned to the Duangzhuang VOR 112.7 VYK which is 75km south of the Beijing airport. The needle with the double line is “parked” since NAV 2 cannot pick up the distant signal while on the ground. Shortly after the plane is airborne, the VOR 2 indicator will “come alive”.



VHF NAV Panel Located on Glare Shield

VOR/LOC/DME and Communication Radio frequencies can also be tuned on the tuner dial located on the glare shield. There are three functional components to this panel.

- LEFT/RIGHT toggle switch: Depending on the choice set with the function switch, toggles between the left and right communication radios (COM-1 and COM-2) and the left and right navigation radios (NAV-1 and NAV-2)
- Frequency tuner dial - Click on the right side to increase frequency, on the left to decrease frequency
- Function Selector
 - OFF – the window indicates - - - - -
 - COM – COM-1 or COM-2 frequency (depending on L/R toggle switch) is indicated in the window.
 - NAV – NAV-1 or NAV-2 frequency (depending on L/R toggle switch) is indicated in the window.
 - DME – distance to the DME source as indicated by the frequency in the window, IF it is a NAV-1 or NAV-2 frequency and IF the frequency has DME associated with it.



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ADF System

The automatic direction finder system (ADF), using radio signals in the 190 to 1750 KHz range, provides aural reception and radio bearings to stations.

One ADF is available in this simulation, located on the RMI with the VOR2/ADF switch on the RMI. Each system consists of a control panel, receiver, loop (directional) and sense (non-directional) antennas and pointers. The ADF requires ac and dc power. The ADF is powered by the essential radio bus.

Aural reception is available through the audio selection panel.

ADF Gauge

The ADF gauge has these features

Frequency indicator window – indicated frequency dialed in the range 190 to 1750 KHz. (more below on using the window to dial in the frequency.)

Frequency Dial - Click on the right side to increase frequency, on the left to decrease frequency
ID Switch – click to toggle on/off. Same as clicking on “ADF” button on the audio selector.

When selected, the Morse code for the ADF dialed in will be heard if the ADF transmitter is in range.



Continuing our example from above, sitting on the blocks at Beijing Capital Airport, dialing in 0196.0 for the (Beijing OR) is the outer marker for the Runway 18L ILS approach. Switching the VOR-2/ADF switch to ADF, the “double lined” needle points to the outer marker.



Hint: Tuning the ADF

The ADF Frequency is split into four independently selectable numbers. The first “double digit” has a range of from 1 to 16. The second, third and fourth “single digits” have a range of 0 to 9. Clicking in the space above the number increases the number, clicking below decreases the number. Carefully position the mouse pointer until you see a + sign or - minus sign. A little practice makes this an easy chore.



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Communication Radio

The communication radio, COM 1 is identical to the Nav radios with the exception that it tunes voice communication frequencies from 118.00 to 135.97 MHz.

To use:

- Use dial on right, Click on the right side (+) to increase frequency, on the left (-) to decrease frequency
- Click on switch (under COMM 1) to transfer frequency from RIGHT to LEFT.
- The COMM TEST switch has no function
- The left dial has no function.



Note: If you are flying with MSFS 2004 ATC, the appropriate frequency will be automatically set for you.

Audio Selector

The audio selector is a switch mechanism that allows the pilot to choose which signal is heard in the headset.

Functionality

- CM2 has no function here since there is no COMM2
- BTH will provide COMM 1 audio
- The remaining buttons may be all pushed at the same time
- NV1 and NV2 will provide the Morse code for NAV 1 and/or NAV 2 provided that both are tuned to a VOR station that is in range
- DME will provide the DME Morse code signal for the VOR or ILS tuned on NAV 1 and/or NAV 2 provided that both are tuned to a VOR Station or ILS that is in range, AND that the specified VOR or ILS is also equipped with DME.
- MKR provides audio indication when above the OUTER, MIDDLE and INNER markers on an ILS or other approach.



Note that there are two Audio selectors; both have the exact same functionality.

Transponder

The Air Traffic Control (ATC) transponder system enables the ground radar controllers to positively identify a target on the ground radarscope. An ATC radar-interrogating signal is transmitted from a ground station and received by the airborne transponder that responds by transmitting a series of coded pulses. These return pulses are used as a display on the controller's radarscope to identify the radar indication as a specific aircraft.

In our simulated 747-200, there is a single transponder system installed. In the real aircraft the transponder would be installed in the radio rack. The transponder antenna is located on the fuselage belly forward of the DME antenna. The transponder requires both ac and dc power and is supplied by the essential radio bus and radio bus No. 2.

- The transponder has **no functional switches** with the exception of the frequency window, which is used to both display and set the frequency.
- **Note: If you are flying with MSFS 2004 ATC, the appropriate frequency will be automatically set for you.**



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How to tune:

The Transponder Frequency is split into four independently selectable numbers. The range is from 0000 to 7777. Each digit therefore has a range from 0 to 7.

Clicking in the space above the number increases the number, clicking below decreases the number. Carefully position the mouse pointer until you see a + sign or - minus sign. A little practice makes this an easy chore.



Marker Beacon Lights



The respective light flashes to indicate passage overhead an airways, middle or outer marker beacon.

INS, Inertial Navigation System

The INS automatically solves navigation problems by sensing airplane acceleration, starting from an accurately inserted present position. Acceleration is sensed by accelerometers mounted on a gyroscopically stabilized platform unit. The platform is also the altitude reference for the flight instruments and aircraft systems that require altitude data.

The INS provides steering reference to the autopilot and flight director. All INS data is computed in reference to true north and the great circle route between waypoints.

The INS is programmed with the latitude/longitude pairs that reflect the waypoints of your flight plan. The INS can accommodate up to 9 waypoints at one time, with new waypoints entered as needed to accommodate flights with more than 9 waypoints.

OK, now what do I do?

This is not a flight planning or navigation tutorial. Those topics are covered very well in other places. However, we will attempt to provide the basics and references for you to use.

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Flight Planning and Navigation

If you do not understand the basic concepts of flight planning, you need to acquaint yourself with some of the current tools available on the Internet, and available for free or shareware download.

The key to successful flying is PLANNING, PLANNING, PLANNING then executing the procedures correctly. But how do you plan? AND Do you need to plan to successfully fly the 747-200?? To be successful, you need at least two of the three following.

There are three major components:

- **Weather** – MSFS 2004 includes a real weather feature which allows you to set weather. Many people use the popular “payware” software FS_Meteo or Active Sky 2004. If you are directly connected to the Internet, FS_Meteo will check every 6 minutes in your flight for the closest airport, and download the latest weather, including winds and temperature at altitude. This can provide for a real experience fighting headwinds, tailwinds, and turbulence all set to your personal desires. Go here for further info: <http://www.FSmeteo.com/> or for Active Sky 2004 ... <http://www.hifisim.com/>
- **Weight, balance and fueling** – This software package includes the Classic 747-200 Fuel Planner by Tarek Sharkawy. The fuel planner is easy to use and will ask for distances, alternate airport, and winds aloft. It then calculates total fuel required and displays the suggested distribution of fuel across the tanks.
- **Your flight path from start to finish with alternates.** The INS is programmed with Latitude/longitude pairs that indicate a waypoint in your flight plan. This was very advanced technology for its day. There are three excellent ways (and I am sure many, many more) to generate a flight plan that provides you with the Lat/Lon pairs you need to program the INS.
 - FS Build, <http://www.fsbuild.com/> a very definite “labor of love” provided by Ernie Alston. Easy to use Thousands of plans already done.
 - The RouteFinder flight planning system programmed and maintained on the Internet at <http://www.asalink.net/davideg/rfquery.html> by Davide Giacobello. Easy to use.
 - And of course, the venerable MSFS 2004 Flight Planner. Flight Planner plans can be used to generate INS Waypoints, and of course, “Drive” the Autopilot when using the GPS.
 - Hi Level Enroute Planning charts are published for the continental US by NOAA, and for most of the remainder of the planet, by the US Department of Defense, National Imagery and Mapping Agency (NIMA). Charts might be available at you favorite pilot store.

Weather

If you do not care about the real weather for your flight, then you will always be at 15C, 29.92 HG or 3013 mb pressure, with no winds. This is perfectly fine. Many people use the Weather generated by MSFS and many use the real weather obtained and inserted in MSFS by Active Sky 2004 or FS_Meteo. The US Government, National Oceanic and Atmospheric Administration (NOAA) supplies aircraft weather data for the whole planet at this site: <http://aviationweather.gov/ifdp/> You can find significant weather and winds aloft for the whole world to use in your flight planning.

Weight and Balance

You can always take the defaults of a full load of passengers and a full load of fuel and understand then why the 747-200 is called the “WHALE”. But for the sake of reality, you should use **Classic Loader** provided with the aircraft to specify the passenger and cargo loads, determining the Zero Fuel Weight - ZFW of the aircraft. Knowing the ZFW, origination and destination airports, and the distance ... you can then use a fuel planner to determine the fuel requirements. Understanding the takeoff weight, you can then plan EPR settings and V1, Vr and V2 settings.

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Your Route

The best way to illustrate how to use the INS and the GPS is to generate a short flight plan and use the data to program the INS. We will have a short flight from EGLL – London Heathrow to EDDF - Frankfurt – Main.

Using the MSFS 2004 Flight Planner, we do step 1, determine the origination:

SELECT AIRPORT

Search for:

Airport name: Airport ID: Airport city:

Search results: (23760 airports found)

Name	ID	City	State / Prov.	Country / Region
Bodmin	EGLA	Bodmin		United Kingdom
London City	EGLC	London		United Kingdom
Denham	EGLD	Denham		United Kingdom
Farnborough	EGLF	Farnborough		United Kingdom
Panshanger	EGLG	Panshanger		United Kingdom
Chalgrove	EGLJ	Chalgrove		United Kingdom
Blackbushe	EGLK	Blackbushe		United Kingdom
Heathrow	EGLL	London		United Kingdom

Filter search results by

Country/Region: State/Province:

City:

Runway/Starting position:

☒ Search default scenery
☐ Search add-on scenery

Then we determine the destination:

SELECT AIRPORT

Search for:

Airport name: Airport ID: Airport city:

Search results: (23760 airports found)

Name	ID	City	State / Prov.	Country / Region
Welzow	EDCY	Welzow		Germany
Schonefeld	EDDB	Berlin		Germany
Dresden	EDDC	Dresden		Germany
Erfurt	EDDE	Erfurt		Germany
Frankfurt/Main	EDDF	Frankfurt/Main		Germany
Munster-Osnabruck	EDDG	Munster-Osnabr		Germany
Hamburg	EDDH	Hamburg		Germany
Tempelhof	EDDI	Berlin		Germany

Filter search results by

Country/Region: State/Province:

City:

☒ Search default scenery
☐ Search add-on scenery

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Next, specify a High Altitude Airway, and IFR Flight Plan

The screenshot shows the 'FLIGHT PLANNER' window with the following settings:

- 1. Choose departure location:** Heathrow (EGLL) - GATE T 16 - GATE HEAVY
- 2. Choose destination:** Frankfurt/Main (EDDF)
- 3. Choose flight plan type:** ☒ VFR (Visual Flight Rules) ☐ IFR (Instrument Flight Rules)
- 4. Choose routing:** ☐ Direct - GPS ☐ Low altitude airways ☒ High altitude airways ☐ VOR to VOR
- 5. Plot flight plan:** Once you've chosen your settings, click "Find Route" below to calculate waypoints for your flight.

Buttons at the bottom: Save..., Load..., Clear, NavLog..., HELP, CANCEL, OK.

Here is the map of your route and the waypoints:



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You may look at your flight plan by clicking on NavLog, print it if you like, then save it as **eglleddf**. Saving your flight plan is like FILING your plan with ATC. When you save your plan in MSFS, you can then use MSFS ATC to direct your flight. You must be careful though ... to match the waypoints generated by the flight plan, with the waypoints programmed into the INS.

To find the Lat/Lon pairs for our London to Frankfurt flight, you need to look in your FS2004 folder, most commonly **C:\MY Documents\Flight Simulator Files**. You will find your plan there as **eglleddf.pln**. Using the Notepad, Textpad, Write or some other text editor, you will see this flight plan.

```
[flightplan]
title=EGLL to EDDF
description=EGLL, EDDF
type=IFR
routetype=3
cruising_altitude=29000
departure_id=EGLL, N51* 28.26', W0* 27.69', +000080.00
departure_position=GATE L 25
destination_id=EDDF, N50* 1.97', E8* 32.12', +000364.00
departure_name=Heathrow
destination_name=Frankfurt/Main
waypoint.0=EGLL, A, N51* 28.26', W0* 27.69', +000080.00,
waypoint.1=EGDVR, V+LOCWAY, N51* 9.75', E1* 21.55', +000000.00,
waypoint.2=EGKONAN, I+LOCWAY, N51* 7.85', E2* 0.00', +000000.00, UG1
waypoint.3=EBKOK, V+LOCWAY, N51* 5.68', E2* 39.10', +000000.00, UL607
waypoint.4=EBURENI, I+LOCWAY, N50* 8.00', E6* 8.33', +000000.00, UJ35
waypoint.5=EDNTM, V+LOCWAY, N50* 0.95', E6* 31.91', +000000.00, UJ35
waypoint.6=EDNOSVA, I+LOCWAY, N50* 1.38', E6* 48.57', +000000.00, UL984
waypoint.7=EDADENU, I+LOCWAY, N50* 1.53', E6* 54.45', +000000.00, UL984
waypoint.8=EDPIMIS, I+LOCWAY, N50* 2.05', E7* 17.97', +000000.00, UL984
waypoint.9=EDRUDUS, I+LOCWAY, N50* 2.75', E7* 57.60', +000000.00, UL984
waypoint.10=EDDF, A, N50* 1.97', E8* 32.12', +000364.00,
```

For INS programming purposes we need to read the waypoint latitude and longitude as follows:

Waypoint 0=EGLL, N51* 28.26' , W0* 27 . 69'

Translates to N51282 and W00276

The latitude format is: N or S + DDMMS with 0 filled in as needed, and only the 1st digit of the "S" or Second field is used. Preceding 0 need not be entered.

The longitude format is : E or W + DDDMMS, with 0 filled as needed, and only the 1st digit of the "S" or Second field is used. Preceding 0 need not be entered.

So, our lat/lon flight path for the INS is as follows

- | | |
|--------------------|---|
| 1. N51282, W00276 | Gate L 25, Heathrow – should be close to current position |
| 2. N51097, E01215 | DVR, the DOVER VOR station |
| 3. N51078, E02000 | KONAN intersection |
| 4. N51056, E02391 | KOK, the KOKSY VOR station |
| 5. N50080, E06083 | URENI intersection |
| 6. N50009, E06319 | NTM, VOR Station |
| 7. N50013, E06485 | NOSVA intersection |
| 8. N50015, E06544 | ADENU intersection |
| 9. N50020, E07179 | PIMIS intersection |
| 10. N50027, E07576 | RUDUS intersection |
| 11. N50019, E08322 | Destination EDDF – Frankfurt – Main |

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Using the Inertial Navigation System (Litton LTN-72)



Quick Programming Guide

- Set the MODE selector (large knob) to **WPT**
- Set the WPT selector to **1**
- Enter the starting waypoint as indicated below. (N51282, W00276)
- Move the WPT selector to **2**
- Enter the next waypoint as indicated below.

NOTE:

Waypoints are usually stated in **N41.46.12** and **W086.19.16** (DD.MM.SS), degrees, minutes, seconds. You will note that when entering these digits manually into the INS, the last digit must not be used.

N41461 and **W08619 1** is the format you must use. Any other format will not work.

Let's enter a couple more Waypoints now, Waypoint 2 is next.

- You will notice on the numeric keypad that the **N, W, S and E** are also designated.
- Press **N** on the keypad. The **N** will be displayed in the left readout window.
- The **INSERT** light should be lighted.
- Press **51097**
- Press **INSERT**
- The **INSERT** light should go out.
- Press **E** and the **INSERT Light** should be lighted and **E** displayed in the right window.
- Press **1215** it is not required that you enter the leading **0**
- The right window should read **001215w**
- Press **INSERT**.
- The **INSERT** light should now be **OFF**.

Move the Waypoint selector to 3

- Press **N** on the keypad. The **N** will be displayed in the left readout window.
- The **INSERT** light should be lighted.
- Press **50178**
- Press **INSERT**
- The **INSERT** light should go out.
- Press **E** and the **INSERT Light** should be lighted and **E** displayed in the right window.
- Press **2000** it is not required that you enter the leading **0**
- The right window should read **002000w**
- Press **INSERT**.
- The **INSERT** light should now be **OFF**

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Follow the above sequence to enter another Waypoint. Continue until you are up to waypoint 9. This is the limit for entry. (Although you will see that we can continue to enter waypoints as soon as we are in flight and moving through our plan.)

Now Let's Get Our First Leg Prepared

All lights should be off on the INS if it is properly programmed.

Let's use the information programmed into the INS.

- We want to fly from Waypoint 1 to Waypoint 2 (i.e. Heathrow to the DOVER VOR).
- Press **TK CHG**
- Select the FROM - TO on the key pad by pressing **1 and 2**
- Press **INSERT**

The Waypoint selection (1 2) will now be displayed in the window. All lights should be OFF.

- Move the small selector to the **AUTO** position. This will allow the **INS** to automatically switch to the next Waypoint.
- Set the large knob to the **DIS TIME** function
- The digital readout should now give you the **Distance** (the distance from the gate to DOVER VOR is 96nm in the left window and the **time** of arrival in the right window. Of course the time cannot be calculated until you are moving.
- Once airborne and settled into your flight make sure the **A/P is ON** and select the **HDG mode**
- Set the **RMT position** on the **INS**.

Other displays available are:

- **POS** = Current aircraft position
- **WPT** = for entering Waypoint information
- **Wind** = Left window is direction and right window is velocity
- **DRSTK/STS** = Desired track displayed in left window. Actual track in right window.
- **TK/GS** = Present track selected and Ground Speed in right window.
- **HDG/DA** = Airplane true heading in left window and drift angle in right window.
- **XTK/TKE** = Cross track distance and track error

Clear Button

The **Clear** Button clears data entered into a readout window before **INSERT** has been pressed.

Hold Button

When in the POS Data Position and your current position is being displayed, pressing the HOLD button will freeze the updating of data.

Clearing a Waypoint from a data window after INSERT is pressed

The only way to clear the waypoints from the readout window once **INSERT** has been pressed is enter a 0 (ZERO) into the window and press **INSERT**.

Alert Light

The ALERT light will light when you are within 3 minutes of your destination waypoint.

NOTE: - The **Litton LTN-72** [only holds 9 waypoints](#). If you are flying to a destination that requires more than 9 waypoints, you will program the used tracks as you fly. For example, when you are on track 7 to 8 you could reprogram tracks 1, 2, 3, 4, 5 and 6. When you are on track 9, monitor closely when it will want to switch. The INS will automatically switch from 9 to 1. When you are on your last track of your trip, switch the INS to the AUTO or MAN position. Keep in mind that this INS is 1970's technology and is not as accurate or as fully featured as today's navigation systems. Several 747-200's were outfitted with a more modern LTN-92 in the late 1980's which supported 99 waypoints.

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NOTE:

The INS tracking method is not designed to follow that of other navigation systems like the FS2004 GPS-500 but is a stand-alone item. If entering a track change does not take the first time, do it again.

Using MSFS 2004 ATC with the Classic 747-200

MSFS ATC really is an excellent addition to your flight sim experience as long as you understand what it does, what it expects and what it is and is not. This is not an ATC tutorial, and you should read the extensive HELP available on flight planning, the GPS and ATC provided on your MSFS installation CDs. We'll supply you enough to get started.

In the real world, most commercial aircraft fly under Instrument Flight Rules – IFR. That's it, that's the way it is. Each country or region on the planet has an Air Traffic Control (ATC) group that controls the airspace above that country or region. The various ATC's cooperate with one another in terms of passing aircraft from one airspace to another at a known altitude and direction.

How do they know these things??? Well that is the purpose of the flight plan and the purpose of the transponder code given to you at the time of Clearance Delivery. The flight plan details the route of flight of the aircraft from departure to destination through the controlled airspace of as many countries and needed. The flight paths are usually known, plotted, already existing routes, very much like the highway systems in every country of the world. Aircraft usually follow these highways from waypoint to waypoint. A waypoint is either a VOR station, an NDB beacon or an Intersection (of two VOR Radials). The transponder is device that transmits the code given by ATC to the pilot. The transponder emits a radio signal and transmits the transponder code. The Air Traffic Control center picks up the signal, displays it on radar scopes and computer screens, and matches it with the filed flight plans. Order is created out of chaos.

If you are confused and want to understand, please refer to the sections above for more info and pointers to the Internet.

As noted above, usually the airlines' dispatch office tries to plot a route (an existing route) from point to point with the most advantageous wind speeds at cruise level. The dispatch office uses all the current meteorological information at its disposal to determine the routing. Again, if you are confused about aviation weather and tools to understand it, go to the Navigation section for many pointers to the Internet.

So, as in the real world, you first need your route planned; as we have done in the section above. Most importantly, you need to have saved the flight plan, which as noted before is the same as FILING the plan with ATC. Your flight plan is the route MSFS ATC expects you to take, and they will do everything in their power to keep you on the route you have planned and to get you safely to your destination, just like in the real world.

For those of you familiar with real air traffic control, it might be helpful to detail some of the differences between real ATC and MSFS ATC

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REAL ATC	MSFS ATC
You can talk to them (obviously)	You make limited choices from a menu
Much of the time you keep them informed	They tell you what to do ... ONLY
Can request diversions, ex., for weather	Must fly through everything
Respond to your descent requests	Tell you when to descend
Acknowledge you're flying a SID or STAR	ATC vectors you to your route, and to the approach, regardless of what you have told the INS.
Is flexible and allows changes and variations to your route within reason, ex., normal step climb requests enroute.	Is inflexible, since you can't talk to them, your planned altitude is what you must fly at, you must not diverge from your route
They will not cancel your IFR flight while you are in it (at least I don't think so!!)	Will cancel your IFR flight if you do not respond to handoffs, if you do not acknowledge flight level directions, if you do not stay on your route, or refuse to rejoin your route ... you usually get "THEE STRIKES"

We must remember that MSFS is a simulation, and that this version of ATC is really pretty good and a very interesting and challenging addition to flying. (Writers's opinion of course).

It is very important to remember that ATC uses vectors, or more easily put, tells you what heading to fly to join your route ... and at the end of your flight, provides descent instructions and heading instructions to provide you a nice intercept angle to the ILS localizer and usually a hundred or two feet below the glide slope intercept. If your flight is to an airport which has no ILS approaches, or if the current wind direction at your destination airport does not support an ILS approach, you will be given vectors which line you up pretty well for a "Visual" approach where you might want to try the "non-precision approach" tools like the VOR or NDB where available ... or if the reciprocal end of an ILS runway, you might try a localizer backcourse, approach.

Refer to the extensive documentation on ATC function provided with your MSFS installation materials. You will find more details of the air traffic control system, and how various parts of it are implemented in MSFS.

NOTES ABOUT: HGHB INS System

This package comes with the HGHB INS System installed and running. This INS System is not a professional type but still offers the look and feel of the real one in many areas. Please consult the manual for detailed instruction concerning the programming and navigation methods available.

If you are experiencing lockups or crashes, the INS data file is most likely corrupt.

In your main aircraft folder, locate and delete a file called rt_ins_mst.gcf

This file will be recreated automatically.

The INS was supplied by HGHB Gauges for Ready for Pushback.

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CIVA INS System

If you have internet access you can download a freeware copy of the CIVA INS. The CIVA Version is very complex and comes very close to duplicating the real world version including multiple installations. It will take some reading and study to learn how to use it.

The link to download the CIVA INS is <http://www.simufly.com/ins/index.htm>

Installation in Ready for Pushback

The panel.cfg file already has the code in place for the use of both versions. The one that is not in use has its lines commented with // which disables the feature. To change from one to the other it is a simple matter of removing the // marks and adding them to the lines of the INS system you will not be using.

In this example below, the CIVA is in use and the HGHB INS has been disabled. Make sure you do a search through the entire file for all instances that are relating to the HGHB and the CIVA INS. They are well marked.

Ready for Pushback offers NO SUPPORT for either version of the INS Systems. The standard MSFS GPS has been included in Ready for Pushback for your convenience and ease of navigation. Many find the INS method too complex to learn and use properly.

Example of changes made to the panel.cfg file

```
// -- HGHB INS Stuff goes here - DO NOT ALTER THIS LINE
//gauge39=../RFP_V2/rt_INS_D, 497, 715, 143
//gauge40=../RFP_V2/rt_INS_D, 866, 714, 143

// -- CIVA INS Stuff goes here - DO NOT ALTER THIS LINE
gauge39=../civa/INS!Config, 0, 0, 0, 0, Vmax742
gauge40=../civa/INS!NavModeTriple, 402, 662, 77
gauge41=../civa/INS!UpdateFlags, 314, 669, 76
gauge42=../civa/INS!Cdu11, 497, 715, 143
gauge43=../civa/INS!Cdu21, 866, 714, 143
```

To change to the HGHB INS you would make it look like this:

```
// -- HGHB INS Stuff goes here - DO NOT ALTER THIS LINE
gauge39=../RFP_V2/rt_INS_D, 497, 715, 143
gauge40=../RFP_V2/rt_INS_D, 866, 714, 143

// -- CIVA INS Stuff goes here - DO NOT ALTER THIS LINE
//gauge39=../civa/INS!Config, 0, 0, 0, 0, Vmax742
//gauge40=../civa/INS!NavModeTriple, 402, 662, 77
//gauge41=../civa/INS!UpdateFlags, 314, 669, 76
//gauge42=../civa/INS!Cdu11, 497, 715, 143
//gauge43=../civa/INS!Cdu21, 866, 714, 143
```

There are several instances throughout the file that you must locate and modify by removing and adding // marks.

Ready for Pushback ... 2nd Generation

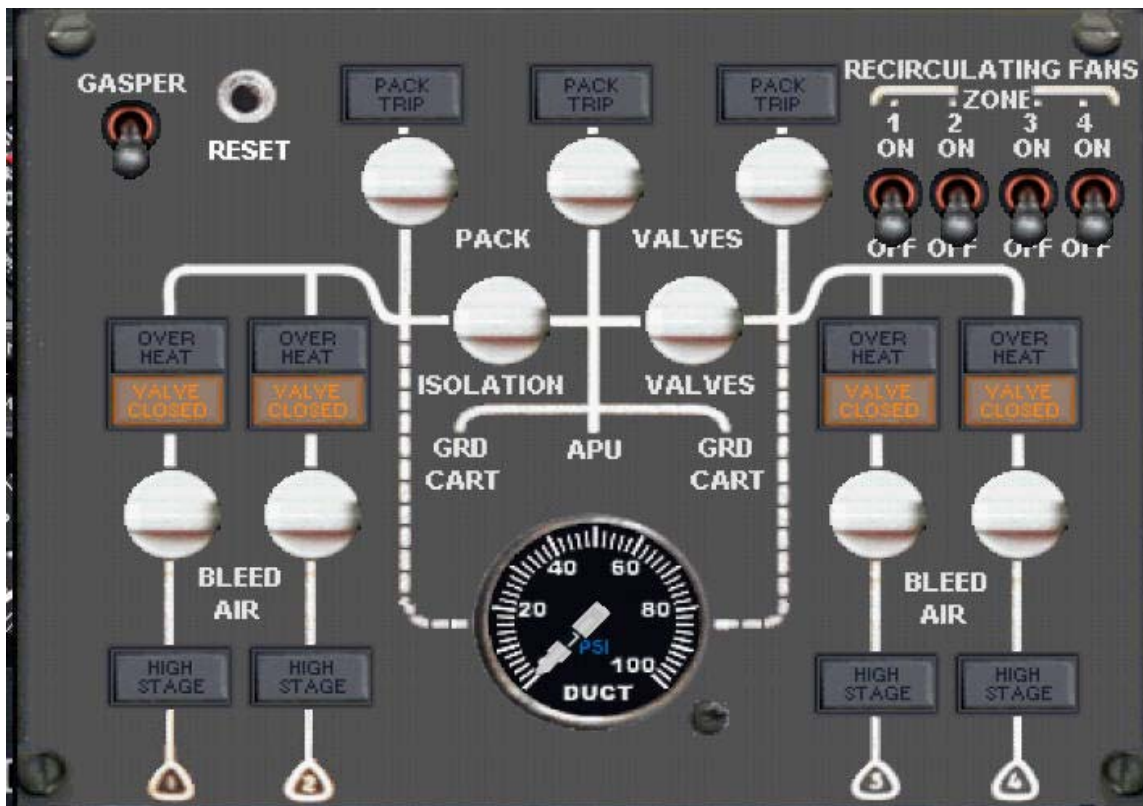
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Remember that this package comes with the HGHB INS System installed and working. The CIVA INS is not included and is only available through the internet as a free download. We are not authorized to include it with Ready for Pushback.

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Pneumatics



General Information

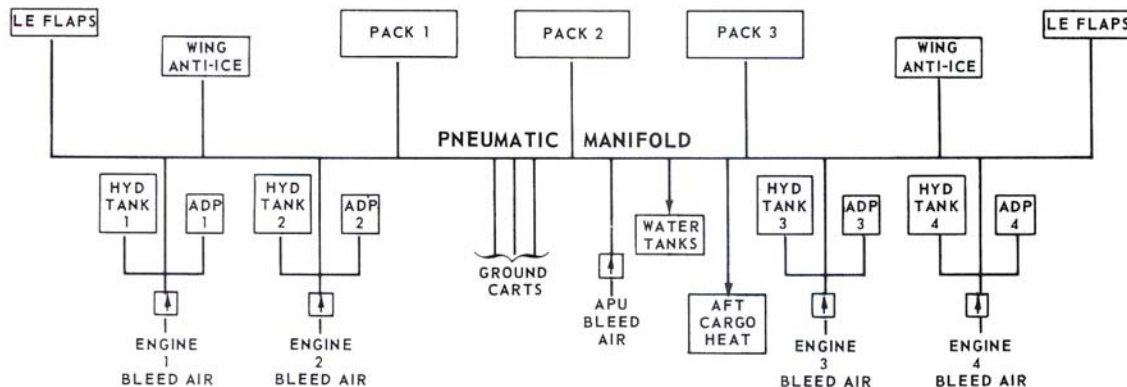
The pneumatic system provides compressed air for:

- engine starting,
- air conditioning pack operation,
- pressurizing fuselage compartments, hydraulic reservoirs, and potable water tanks;
- leading edge flap positioning,
- air driven hydraulic pump (ADP) operation,
- wing anti-icing, and
- aft cargo compartment heat.

The pneumatic manifold can be pressurized with engine bleed air, by the APU or from ground carts. The following diagram depicts the pneumatic system.

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Bleed Air Distribution

Engine Bleed Air

Air is bled from the N2 Compressor of each engine at two stages:

- Mid, or eighth stage, and
- High, or fifteenth stage.

Mid-Stage Bleed

A check valve in the outlet prevents reverse flow into the engine.

High-Stage Bleed Air Valve

- is a pneumatically operated pressure regulator, opening when high stage pressure drops below a preset minimum, and
- controls flow to maintain a scheduled downstream pressure.

Automatic operation is independent of electric power. The BLEED AIR switch provides override control to close the high-stage valve. The engine ignition switch also energizes the valve closed during engine starting. The valve is armed to open if electric power fails.

Pressure Relief Valve

The pressure relief valve protects the engine ducts from high-stage over-pressure and exhausts into the cowling. Relief valve opening can be detected by a rise on the related NACELLE TEMPERATURE gauge.

Precooler

The precooler controls the temperature of the bleed air delivered to the pneumatic manifold. It consists of an engine-mounted heat exchanger, using fan air for cooling. A pneumatic temperature control sensor, located in the pylon, positions two parallel exit doors to regulate the flow of cooling air through the heat exchanger. No flight deck control is provided.

Pylon Bleed Air Valve

This valve has four functions:

- shutoff valve,
- pneumatically operated pressure regulator to limit the temperature of air entering the pneumatic manifold if the precooler malfunctions. It will modulate toward closed to limit airflow as required by the cooling capacity of the Precooler. It will go to full closed if necessary.
- Reverse flow check valve to prevent reverse flow if duct pressure exceeds engine pressure.

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The engine ignition switch overrides the check valve feature to allow reverse flow for engine starting. The BLEED AIR switch must be open for this function. Automatic operation is independent of electric power. The BLEED AIR switch and engine fire handle provide override control to close the pylon bleed air valve. The valve is armed to open if electric power fails.

Overheat Warning

An overheat switch located downstream of each pylon bleed air valve senses the temperature of the air. When temperature exceeds a preset limit, the switch lights an amber OVERHEAT light on the flight engineer's panel.

Isolation Valves

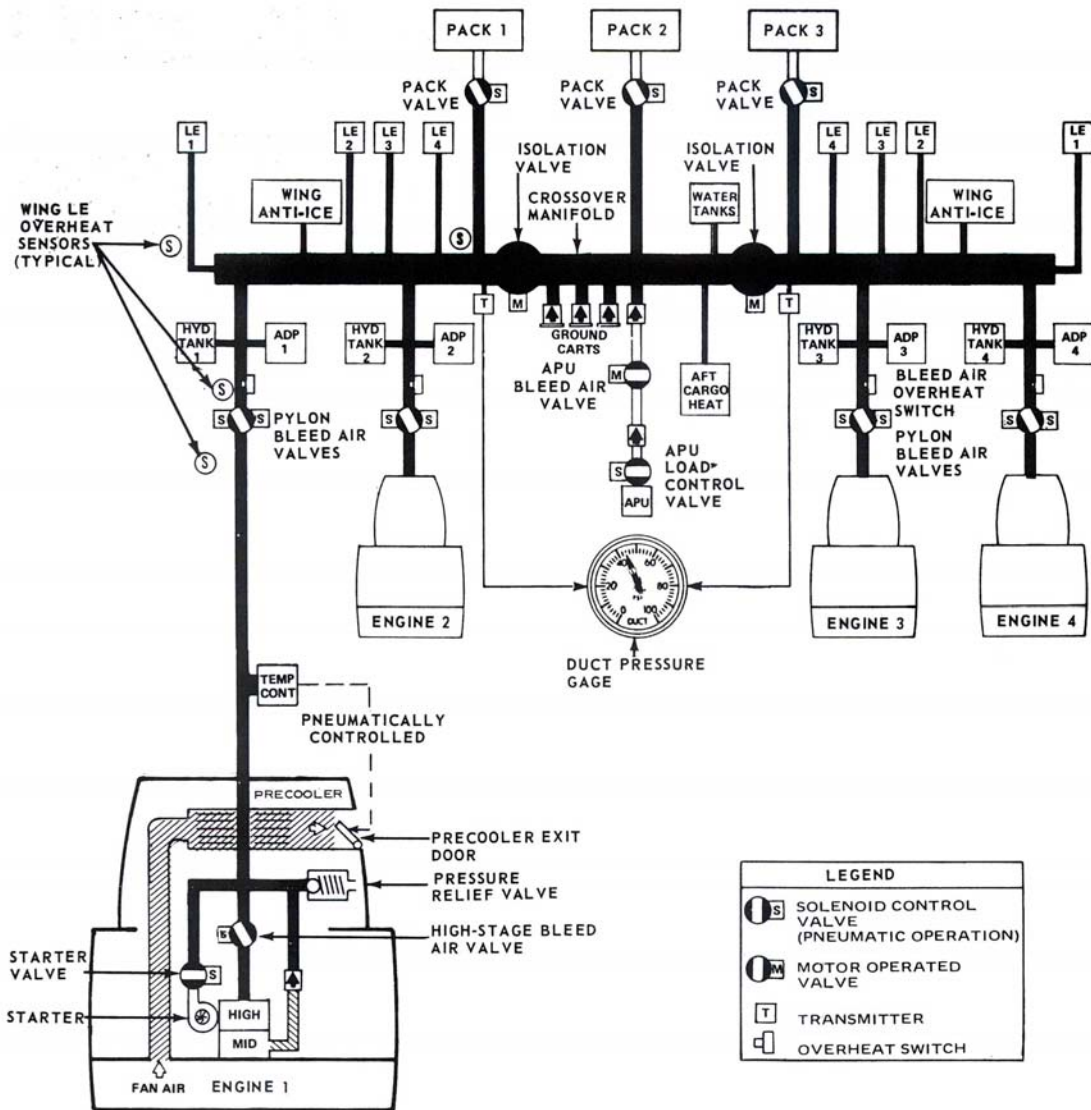
Two isolation valves permit isolation of the crossover manifold from individual wing sections of the pneumatic manifold. The valves are motor operated and controlled by the ISOLATION VALVES switches.

Duct Pressure Gauge

This is a single gauge with two needles, labeled L and R. With the isolation valves open, both needles should indicate the same pressure.

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PNEUMATIC SYSTEM

Ground Carts

Air supplied by ground carts can be used by all systems. Three connectors are provided on the underside of the fuselage. Two carts are required for engine starting and for operating one air conditioning pack.

APU Bleed Air

- At sea level, the output of the APU is sufficient to operate:
- three air-conditioning packs simultaneously, or
- one air conditioning pack while simultaneously starting one engine.

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APU Load Control Valve

Located on the APU, this valve

- operates as a shutoff or modulating control valve. It is armed by the APU BLEED AIR switch on the flight engineer's panel.
- maintains APU EGT at 620 degrees C maximum by modulating to reduce airflow as required.

APU Bleed Air Valve

This electrically controlled on-off valve is located on the aft wall of the left body gear wheel well. It is controlled by the APU BLEED AIR switch on the flight engineer's panel. In the closed position, the valve protects against loss of cabin pressure if the APU duct in the wheel well ruptures.

APU Duct Protection

Thermal switches are installed adjacent to the APU duct. A duct rupture triggers the adjacent switch and automatically shuts down the APU.

Wing Leading Edge Overheat System

The Wing leading edge overheat system provides a warning to prevent overheating of the fiber-glass paneling on the upper side of the leading edge and also the leading edge flaps.

The system consists of a series of thermal switch sensors adjacent to the pneumatic duct in the pylon and in the wing leading edge. A ruptured duct triggers one of the adjacent thermal switches and illuminates the related WING OVHT light on the flight engineer's panel. The panel also contains a three-position switch.

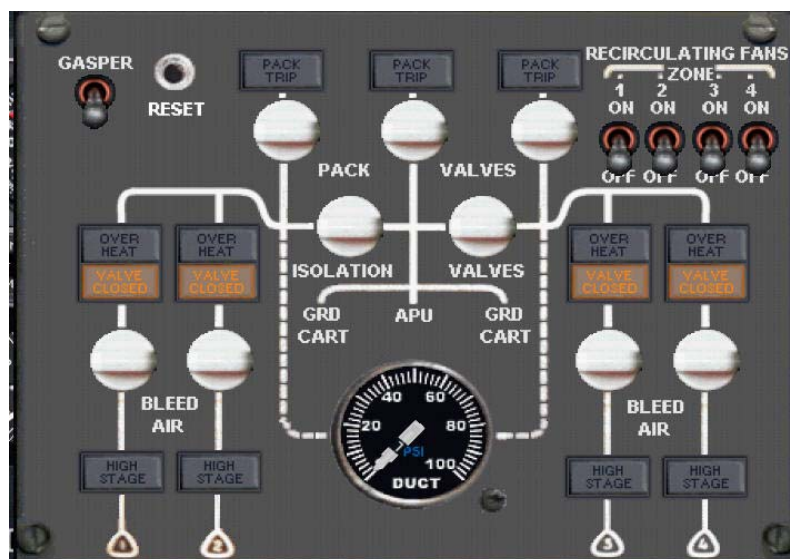
Flight Engineers Panel

Bleed Air Switch

Controls flow of engine bleed air to pneumatic duct. Arms both high-state and pylon bleed air valves:

OPEN: Valves are armed to open; both control solenoids are de-energized

CLOSE: Pneumatic air or spring pressure closes both valves; control solenoids are energized



Isolation Valve Switch

Isolates wing duct from rest of pneumatic system; normally open

Overheat Light

Backup for temperature regulators in Precooler and pylon bleed air valve
ON: Indicated engine bleed air temperature is above limits

Duct Pressure Gauge

Indicates left and right pneumatic duct pressure. L and R needles should show the same pressure with both isolation valves open

Valve Closed Light

Monitors position of pylon bleed air valve.

ON: Pylon bleed air valve is closed and engine bleed air to pneumatic system is shut off.

OUT: Pylon bleed air valve is open and engine bleed air is supplying pneumatic duct.

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High Stage Light

Monitors position of high stage valve.

ON: High stage valve is open and supplying air. Normal at low engine power.

OUT: High stage valve is closed. Normal at high engine power.

APU Bleed Air Switch

Controls flow of APU bleed air to pneumatic duct

OPEN: Opens APU bleed air valve directly; arms load control valve to open

CLOSE: Closes APU bleed air valve directly and disarms the load control valve.



Pneumatics Checklist and Monitoring Items

General

Normal Indications

The four BLEED AIR valves and the two ISOLATION valves are left open for all normal operations: engine starting, during taxi, and in flight. Normal indications are:

OVERHEAT lights out at all times.

HIGH STAGE light on at low engine powers and out at high engine powers. Ignore indications with engine shutdown.

VALVE CLOSE light on whenever DUCT pressure exceeds engine output. VALVE CLOSED light may come on with asymmetrical thrust.

DUCT pressure gauges indicating 15 to 45 pso, depending on altitude and engine power.

Wing Leading Edge Overheat

Monitor WING LE OVHT panel lights. Either light on indicates a pneumatic duct leak in the respective wing or in the engine struts on that side

APU Bleed Air

- Do not use APU bleed air during taxi. This improves install margin for the engines.
- Turn one pack off if duct pressure drops below 14.
- Never connect engine to APU bleed air together in flight. For takeoff with APU supplying No 2 pack, both wing isolation valves must be closed. After takeoff, APU bleed air must be shut off before the wing isolation valves are opened.

Preflight

Normally to pressurize the pneumatic manifold:

- The APU is operated,
- The APU BLEED AIR switch is OPEN,
- The four engine BLEED AIR switches should be open, and
- The two wing isolation valves must be open.

With the engines shut down, the HIGH STAGE and VALVE CLOSED lights may be illuminated or out. All other lights should be out.

When the APU bleed air valve is OPEN, check that the DUCT pressure gauge indicates 40-50 psi (packs off).

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Test the WING LE OVERHEAT system:

- Place the switch to TEST A. The LEFT and RIGHT WING OVHT lights should illuminate
- Place the switch to TEST B. The lights should illuminate again.

NOTE: Test B is not required on –212B aircraft.

Start

The desired DUCT gauge pressure for starting is 30-40 psi. When using APU air, leave one pack on if DUCT gauge pressure remains above 30 psi with the start valve open.

When using ground start carts or engine bleed air, turn all packs, all ADPs and aft cargo heat off.

The HIGH STAGER and VALVE CLOSED lights should be out while cranking. Both lights should illuminate when the engine IGNITION switch is released. The VALVE CLOSED light normally goes out again as the engine approaches idle speed.

Cruise

Since the pneumatic system is fully automatic, the primary task is system monitoring. Monitor the system, including the WING LE OVHT lights. DUCT pressure in flight will vary from 15 to 45 PSI depending on pneumatic load.

Descent

Test the WING LE OVHT system.

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Powerplant



Engine Description

General

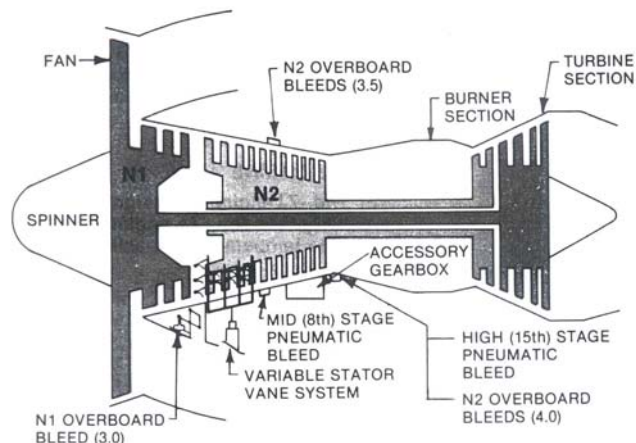
The 747 aircraft is powered by four engines. Three manufacturers provided engines for the 747-200 model:

- Pratt and Whitney – JT9D in many variants and thrust ratings
- General Electric – CF6-50
- Rolls Royce – RB211 in a number of variations

This simulation models the Pratt and Whitney JT9D, twin-spool, fan engine. There were numerous P&W JT9D sub-models certified for the 747-200 series, with thrust ratings from 43,500 pounds to 48,630 pounds.

Two compressors (N1 and N2) are connected to their respective turbine assemblies by means of shafts. The N1 and N2 compressor-turbine assemblies are mechanically independent of each other.

N1 consists of a single fan and three-stage compressor driven by a four-stage turbine. A spinner is located on the front of the fan. There are no inlet guide vanes. N2 consists of an eleven-stage compressor, driven by a two-stage turbine.



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The compressors are designed to achieve maximum efficiency at cruise thrust. During starting and at low thrust conditions, an automatic overboard compressor bleed system provides stable operation.

Each engine is equipped with a pneumatically actuated thrust reverser on the fan section. There is no reversing provided for the turbine section.

An accessory gearbox is located at the bottom of the engine and is driven by N2. All engine accessories and engine-driven aircraft accessories are mounted on the gearbox except the N2 RPM sensor, which is mounted on the fan case.

Compressor Overboard Bleeds

Air discharged through various engine bleeds increases airflow across the compressor blades to prevent stall. The N1 compressor has one overboard bleed referenced to as the 3.0 bleed. It is positioned fully opened or closed by fuel pressure from the engine fuel pump. When open, this bleed exhausts N1 air into the fan duct.. The N2 compressor has one set of overboard bleeds referred to as the 3.5 bleeds. The 3.5 bleeds are normally closed in flight. These bleeds are closed by the 15th stage air pressure. When open, the bleeds exhaust air overboard through the engine cowling.

During reverse thrust, the N1 bleed and one 3.5 automatically open to minimize stall. This is known as the reverse actuated bleed system.

Pneumatic System Bleeds

Air to supply the aircraft pneumatic system is bled from the N2 compressor at two stages:

- Mid (8th stage)
- High (15th stage)

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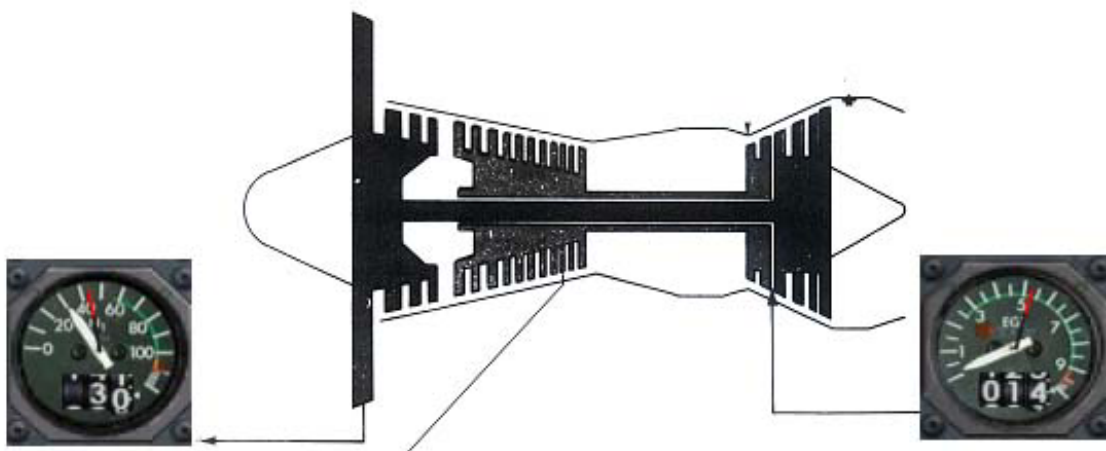
Analog Engine Indicators

ENGINE INDICATORS



ENGINE PRESSURE RATIO (EPR) GAGE

- Indicates the ratio of exhaust gas pressure (Pt7) to inlet air pressure (Pt2).
 $EPR = Pt7/Pt2$.
- Setting knob: sets bug and digital scale to target EPR.



N1 TACHOMETER

- Indicates N1 compressor rpm in percent.
- Fan blades passing a sensor located in the fan case provide the rpm indication. Otherwise, same as N2 tachometer.



N2 TACHOMETER

- Indicates N2 compressor rpm in percent.
- Indication is displayed by a pointer and by digits in the window.
- Gage has a limit needle which is moved by the pointer if it passes the red line. Limit needle indication is retained until manually reset.
- Powered by a tachometer generator, driven by the accessory gearbox.

EXHAUST GAS TEMPERATURE (EGT) GAGE

- Indicates turbine exhaust gas temperature between second and third-stage turbines, in degrees centigrade.
- Gage has a limit needle that is moved by the pointer if it passes the red line. Limit needle indication is retained until manually reset.
- An amber alert light comes on approximately 10°C before the red line limit to alert crew to monitor EGT.
- Sensing is by probes located between N1 and N2 turbine sections.

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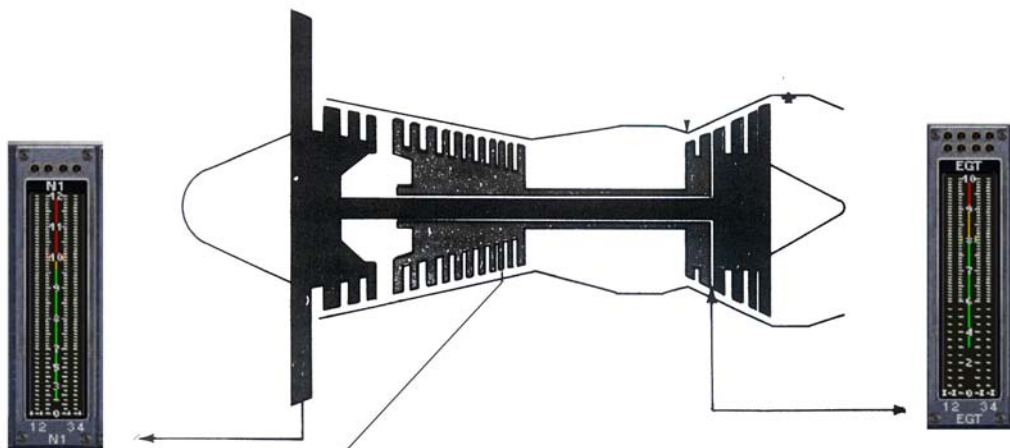
Tape Engine Indicators



ENGINE INDICATORS

ENGINE PRESSURE RATIO (EPR) GAGE

- Indicates the ratio of exhaust gas pressure (Pt7) to inlet air pressure (Pt2).
 $EPR = Pt7/Pt2$.
- Setting knob: sets bug and digital scale to target EPR.



N1 TACHOMETER

- Indicates N1 compressor rpm in percent.
- Fan blades passing a sensor located in the fan case provide the rpm indication. Otherwise, same as N2 tachometer.



N2 TACHOMETER

- Indicates N2 compressor rpm in percent.
- Indication is displayed by a pointer and by digits in the window.
- Gage has a limit needle which is moved by the pointer if it passes the red line. Limit needle indication is retained until manually reset.
- Powered by a tachometer generator, driven by the accessory gearbox.

EXHAUST GAS TEMPERATURE (EGT) GAGE

- Indicates turbine exhaust gas temperature between second and third-stage turbines, in degrees centigrade.
- Gage has a limit needle that is moved by the pointer if it passes the red line. Limit needle indication is retained until manually reset.
- An amber alert light comes on approximately 10°C before the red line limit to alert crew to monitor EGT.
- Sensing is by probes located between N1 and N2 turbine sections.

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Start and Ignition System

General

The engine start system provides a means of rotating the N2 compressor to an RPM at which a successful start can occur when ignition and fuel are supplied. The system is also used to provide in-flight starts when required.

The ignition system initiates fuel combustion during ground and in-flight starting and is used for flameout protection when required.

Start System

The start system consists of the following:

- An air driven starter,
- An electrically controlled, pneumatically operated starter valve, and
- A pressure switch to operate a starter VALVE OPEN light.

Ignition switches on the pilot's overhead panel control the operation of the start system.

On the ground, the engines can be started from any one the following three separate air sources:

- APU
- Ground carts
- Crossbleed from an operating engine

Placing an ignition switch to the GND START position supplies electrical power to:

- Open the pylon bleed air valve
- Open the starter valve
- Close the high stage bleed air valve

Electrical power for all four start systems is 28V dc.

Starter valve operation is indicated by the starter VALVE OPEN light coming on when the valve opens, and then going out when the valve closes. An increase in duct pressure does not indicate that the starter valve has closed. Closure of the pylon bleed air valve will increase duct pressure.

Ignition System

The normal ignition system consists of the following for each engine:

- Two ignition switches
- A start-lever operated ignition microswitch
- Two ignition exciter boxes
- Two igniters

There is also a single STANDBY IGNITION switch located on the pilot's overhead panel that permits energizing either igniter in all engines at the same time.

Ignition Switches

There are two engine ignition switches for each engine. They are labeled SYS1 and SYS2. Each switch has the following three positions:

- GND START, which is momentary and must be held
- OFF
- FLT-START which is self-holding.



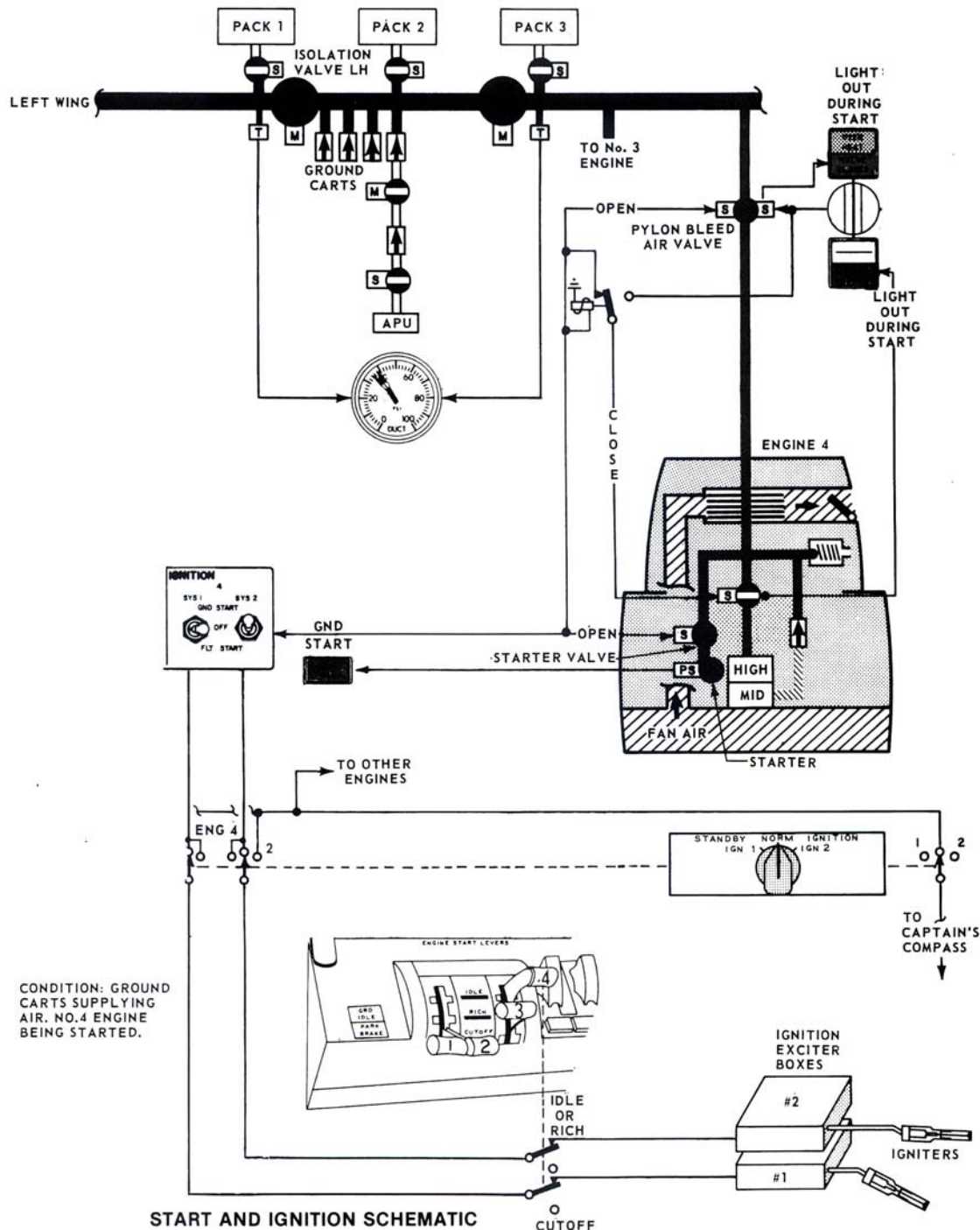
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With the switches in GRND START, in addition to opening the starter valve, the start lever operated ignition microswitch is armed. Moving the start lever out of CUTOFF closes the switch, providing power to the ignition exciter(s) and energizing the igniter(s).

With the switches in FLT-START, the ignition system operates the same as for the GND START switch position, however the starter circuit is not engaged.

The FLT START position is selected whenever continuous ignition is required.



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Standby Ignition Switch

This switch is a three-position switch, named IGN 1, NORM and IGN2. In the NORM position, ignition is controlled through the respective normal ENGINE IGNITION switches. The other positions of the STANDBY IGNITION switch are used in the event of a loss of normal AC power. The selection of IGN1 or IGN2 powers the respective igniter system on all engines from the standby AC bus, provided the start levers are in other than the CUTOFF position.

Start and Ignition System Controls and Indicators

Standby Ignition Switch

Controls IGN1 and IGN2 AC power sources and bypasses normal ignition switches when selected. When positioned to:

NORM: All IGN 1 and IGN2 systems are on normal AC power source; control is through the normal ignition switches.

IGN 1: All IGN 1 system transferred to standby AC. IGN 2 systems operate as selected by associated ENGINE IGNITION switch.

IGN 2: All IGN 2 system transferred to standby AC. IGN 1 systems operate as selected by associated ENGINE IGNITION switch.



Valve Open Light

Indicates position of starter valve:

ON: valve is open.

OUT: valve is closed

Engine Ignition Switches, SYS-1 and SYS-2

Each switch controls its respective normal ignition system for the engine. Either switch controls start air. When positioned to:

GND START: Switch must be held in this position. Pylon Bleed air valve and starter valve signaled to open, and high stage valve is signaled to close. Start levers armed to provide ignition from associated system.

OFF: Normal ignition is off; start air system off.

FLT START: Engine start lever armed to provide ignition from associated system



Start Lever

Electronically controls the fuel control unit, engine fuel shutoff valve, and normal and standby ignition systems using microswitches in the pedestal.

CUTOFF: Closes engine fuel shutoff valve and signals fuel control unit to shut of. Disarms normal and standby ignition.

RICH: Selection is valid only when selected from the cutoff position. Opens engine fuel shutoff valve and signals fuel control unit to open. Increases normal start fuel schedule to about 100pph, reverts to normal as the engine speed reaches idle. Arms the normal and standby ignition.

IDLE: Opens engine fuel shutoff valve and signals fuel control unit to open. Arms the normal and standby ignitions and arms flight-idle circuits.



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Engine Fuel System

General

The engine fuel system delivers fuel to the engine at the flow rates required to obtain the desired thrust output.

Fuel Shutoff Valve

An electrically operated fuel shutoff valve for each engine is located in the associated fuel tank. The location of these valves protects against fuel loss from pylon/engine fuel leaks. The valve is actuated by the respective:

- ENGINE VALVE switch on the flight engineer's panel
- Start lever
- Engine fire handle

A "close" signal from any of these sources overrides any "open" signal .



Engine Fuel Pump

The engine fuel pump has a centrifugal first stage and two parallel gear stages. The fuel heater and filter units are between the first stage and the two gear stages. If the first stage fails, fuel bypasses this stage, as well as the heater and filter to maintain engine operation.

Fuel Filter

The fuel filter traps ice crystals or other foreign matter as fuel flows through it. If the filter becomes clogged, a bypass valve opens to allow continued operation with unfiltered fuel. When a preset pressure differential exists across the filter as a result of clogging, a pressure switch illuminates an ICING light on the flight engineer's panel.

Fuel Heater

The fuel heater is used to melt ice crystals trapped in the fuel filter. Turning on the associated FUEL HEAT switch opens a solenoid control shutoff valve. Opening the valve permits the 15th stage air to flow through the heater, raising the temperature of the fuel entering the filter, which in turn, causes the ice crystals to melt.

Fuel Control Unit Freezing

Fuel control unit freezing is different from fuel filter clogging. A clogged fuel filter illuminates the ICING light and fuel heat can be used to melt the ice and clear the fuel filter. Fuel control freezing occurs because fuel heat has been used and the water (melted filter ice) entering the fuel control adheres to the numerous internal linkages and takes a long time to flush out. When fuel heat is turned off, the temperature of the fuel control drops below freezing in approximately 12 to 15 minutes (when engine temperature is -5 C and colder.) When water on the linkages freezes, the only indication will be the engine spinning down or running away to a high power; there is no icing light indication. The ten-minute fuel heat cycle is used on engines No. 1 and No. 4 when engine fuel temperature is -5C or colder, and departure airport OAT (outside air temperature) was warmer than +5C, to insure that the temperature of the fuel control remains above freezing.

Fuel Control Unit

The fuel control unit meters the flow of fuel to the engine to:

- Prevent a "rich blow-out" and minimize N2 surge during acceleration.
- Prevent a "lean die-out" during deceleration.
- Maintain a constant turbine inlet temperature at a fixed throttle setting (at a constant ram air temperature).
- Directly and indirectly control bleed and vane operation.

To accomplish these functions, the fuel control unit uses the following inputs:

- Throttle position – Pilot command input. (Increasing throttle increases fuel flow)

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- Burner pressure (Pb) – A reference of air mass to establish fuel flow requirements (increasing burner pressure increases fuel flow).
- N2 ROM – Reference N2 to throttle command signal, (increasing N1 RPM decreases fuel flow until a steady state exists).
- Engine inlet temperature (Tt2) – Adjust acceleration and deceleration fuel schedule to TAT (total air temperature). Cold TAT increases fuel schedule.

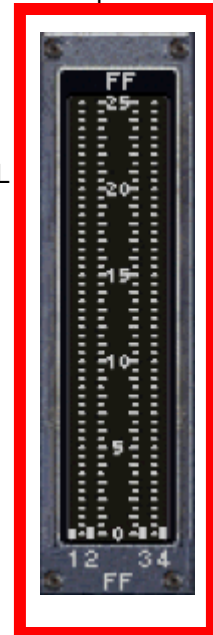
A condition actuator mounted on the fuel control unit is electrically operated by the start lever and accomplishes the following:

- Positions the fuel control unit to deliver fuel for starting.
- Provides additional fuel flow when starting in cold temperatures (RICH position of the start lever).
- When airborne (and for several seconds after touchdown) provides additional idle fuel flow, with a corresponding engine speed increase of about 8% N2 at sea level when the flaps are at 25 to 30.

Fuel Flowmeter



The fuel Flowmeter measures the rate of fuel flow in pounds per hour (pph). The flow rated is transmitted to the respective fuel flow gauge on the center instrument panel and to the FUEL USED gauge on the flight engineer's panel.



Oil Cooler

The oil cooler used a heat exchanger principle. The fuel being delivered for combustion flows through the cooler and absorbs the oil's heat,

Pressurizing valve

The pressurizing valve distributes fuel flow to the primary and secondary manifolds according to the rate of fuel flow. Low fuel flow utilizes only the primary system.

Fuel Nozzles

The fuel nozzles are externally mounted and extend into the combustion chamber. The nozzles have primary and secondary fuel spray outlets.

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Throttle System

General

The throttle system consists of throttles and reverse levers connected by cables and linkage to each engine's fuel control unit and reverser mechanism.



For This VIRTUAL Aircraft:

You have a number of options available for using the throttles:

Keyboard:

F4	Full Throttle
F3	Increase throttle
F2	Decrease throttle
F2	Hold down key to activate reversers
F!	Idle engines

NumPad 9	Increase throttle
NumPad 3	Decrease throttle

On some computers:

SHIFT NumPad 9	Increase throttle
SHIFT NumPad 3	Decrease throttle

Things you can buy to enhance your sim experience:

- Joystick with throttle lever
- Flight Sim Yoke with throttle lever
- Rudder Pedals

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NOTE: Analog Engine Gauge Description



The engines gauges are an excellent replica of what is used on the real aircraft.

Order:

- Top Row = EPR
- Second Row = N1
- Third Row = EGT
- Bottom Row = Fuel Flow

There are two windows within the EPR gauge.

- Top Window = EPR Preset
- Bottom Window = Current EPR

The EPR is connected to the FFRATS. Pulling a knob at the lower right corner of the EPR gauge allows it to be set manually. To the right and left of the knob you should see a + and – sign when moving the mouse. When the knob is pulled out left clicking on either side of the knob will adjust the red reference pointer to

your target EPR. The knobs on all 4 EPR gauges are independent and may be set separately. The knobs default on loading to the pulled position.

Pushing the knobs in selects the FFRATS Auto Limiter mode. To engage the FFRATS Limiter at least 3 of the 4 knobs must be pushed in. To simplify that, 3 or all 4 knobs must be in before the Limiter will work. This allows in real life for one knob to be INOP and still retain the use of the FFRATS on all 4 engines. When a knob is pushed in the red reference pointer will rotate to the FFRATS Limiter EPR. All other sequences for using the Auto Limiter and FFRATS are identical to the Tape Gauges.

The second rows of gauges are N1

The window with rolodex style readouts shows the N1 value. There is a fine red pointer that indicates the max value that this gauge has reached since a MAX IND RESET was performed.

The third row of gauges are EGT

The window with the rolodex style readouts displays the current Exhaust Gas Temperature. The small red pointer moves to the highest temperature that has been reached since a MAX IND RESET. There is also an amber warning lamp that will light when the temperature reaches 905° F. When first loading the aircraft in FS2004 this lamp will illuminate for 3 seconds as a lamp test.

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The Fourth row of gauges are the Fuel Flow

The window with the rolodex display shows the current fuel burn in KGPH.

Placing the mouse over any of the 16 engine related gauges will automatically display the tool tips window. These windows will give you a wealth of information.

For example the EPR tool tips will display current EPR, Manual or FFRATS Mode, preset EPR and more.

Quick Engine Start Guide

There are certain requirements to start from Cold and Dark that very closely matches the real aircraft.

The items I am showing below are not a complete item by item listing as required in real life but shows the basics only that you will need in FS2004 and Ready for Pushback.

A "checklist" is exactly what those words means. It is a list of items to check and see if you have done things correctly and is not a substitute for knowing the order of setup for panels.

Cold & Dark (engines not running)

Open Overhead Panel

GRD CREW CALL Button

Request Ext Power

Close Overhead

Open ELECT Panel

Battery ON

Wait for EXT PWR Lights 1 and 2 to illuminate - about 2 minutes

GRD Switch for both connections to ON position - 2 Green Lights illuminated

Close Electrical Panel

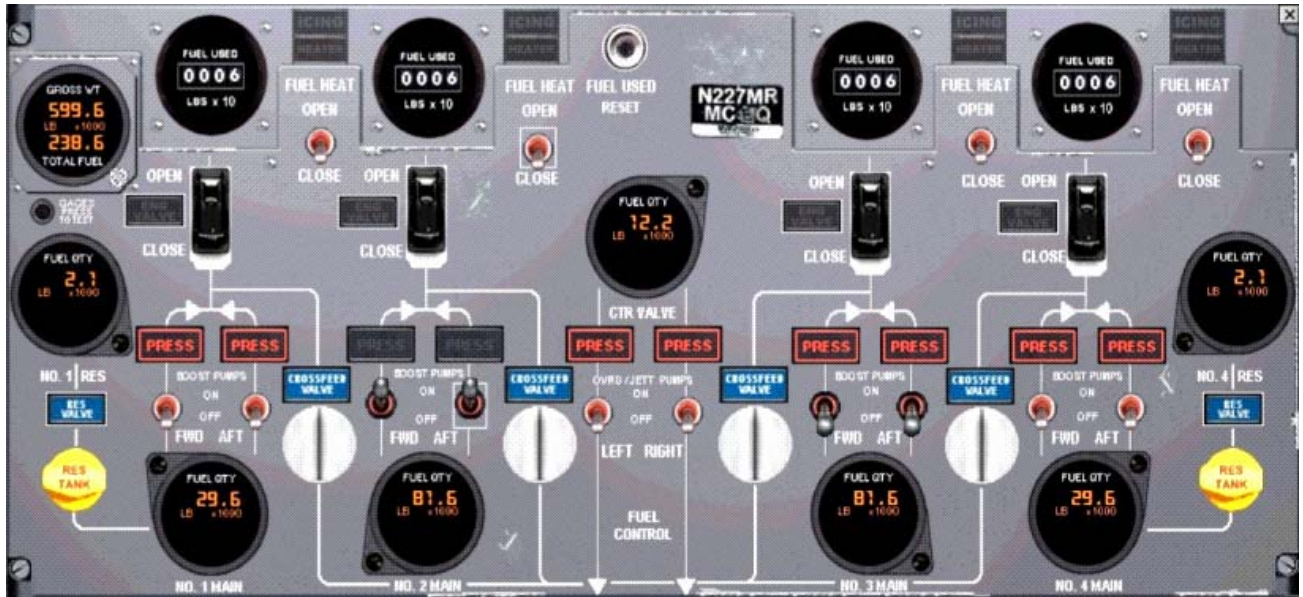
Open Fuel Panel

All Crossfeed Valves OPEN

Number 2 Main Tank Boost Pumps ON.

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In this configuration, Main No. 2 is feeding fuel to and is pressurizing the Fuel Manifold. All engines and the APU are receiving their fuel from No.2 Main Tank through the Fuel Manifold.

Open Electrical Panel

APU Switch to ON Position

Wait for APU Door to open

Blue light out

APU Switch to START

Wait for APU to spool up to 99 or 100% RPM

APU BLEED AIR Open

On the AUX Panel section:

4 APU Switches to CLOSE Position

This will trip the GRD PWR to OFF

Close the 4 BUS TIE switches

Connect the 4 CONSTANT SPEED DRIVES

Close ELECT PANEL

OPEN Overhead Panel

Cancel EXT PWR

Close OVERHEAD

Open HYDR Panel

Make sure the 2 Isolation valves are horizontal

Make sure that the 4 engine bleed air valves are vertical

Make sure the 4 Air Driven Pumps are in AUTO Position

You should have pressure on all 4 HYD PRESS Gauges

Duct Pressure should read over 40 psi

Close HYDR Panel

Make sure Parking Brake is set.

Program the INS

Pushback – Engines are normally started while the aircraft is being pushed back from the gate.

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Open Overhead Panel

Start No.4

Open Throttle Panel

Fuel On at 20% N2 for engine No. 4

Close Throttle Console

Open HYDR Panel

Verify that the engine driven hydraulic pumps are in the NORMAL Position

You will have HYDR Pressure still available to the aircraft.

Close HYDR Panel

Open ELECT Panel

Close No. 4 Generator Field

Close No. 4 Generator

This will trip OFF the APU Generator from the right side.

Now that No.4 is running you should have the idea of how to start the other 3 engines.

Remember the start order is always 4, 1, 2, 3

No. 4 is the primary source for Hydraulics and is required for Brakes, flaps and other items.

I did not cover the use of pack settings and other items as that is all in the manual and in order to enjoy this simulation to its fullest reading the manually thoroughly is mandatory.

NOTE: FS2004 Auto Start

The traditional <CTRL E> Auto Start feature has been disabled to further enhance the realism of Ready for Pushback.

When an Auto Start is attempted you will see a message displayed in the FS2004 ATIS display bar.



The only way to start the engines is by correctly configuring the aircraft and using the manual starters.

Refer to the AOM for complete details.

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NOTE: Reduced Thrust Takeoff

For the majority of takeoffs, the use of full takeoff thrust would produce better aircraft performance than is actually required. Normal operating procedures use reduced thrust for takeoffs. The advantage is lower engine maintenance and improved engine reliability.

The FAA and DOT approved method for determining reduced thrust settings is called the "*Assumed Temperature Method*" and it matches the aircraft performance to that required by regulations. This method determines the highest ambient temperature at which takeoff is permissible (at the actual takeoff weight) and then this temperature is used to select the takeoff EPR.

As a conservative measure, an airlines procedure is based on the actual takeoff weight plus 30,000 lbs when determining the Assumed Temperature from the Weight Limitation chart. If a tail wind exists, an additional 5,000 lbs per knot tailwind component is added to the TOW.

Another aspect of the Assumed Temperature Method that seems to increase the margin is the fact that V1 (TAS) is lower than that of the elevated temperature which translates into shorter accelerate - stop distance.

Since the maximum temperature in the 747 certified takeoff data is +39 degrees C, assumed temperature will not exceed IAS + 39 degrees C. In addition, the -3A powered aircraft are further restricted to a maximum of 46 degrees C. This eliminates bleed air problems which are encountered if less than 1.33 EPR is used for take-off.

Low barometric pressures are encountered for by adding a further 2,500 lbs to the weight margin for every 0.10 inch of altimeter setting below 29.92 in. Hg.

There will be no credit taken for headwind when computing reduced take-off thrust.

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Computing Reduced Thrust Takeoff EPR

- Using a runway in use chart and check the Flaps 10 takeoff weight plus 30,000 lbs (+5,000 lbs per knot if a tailwind exists and +2,500 lbs per 0.10 inch of altimeter setting below 29.92) and read the OAT. This is the assumed temperature.
- Find the take-off EPR for this assumed temperature.

Example - TO data Calculation

Conditions:

- (JT9D-3A Engines)
- YUL - Runway 28 (wet, no standing water)
- Takeoff weight: 513,000 lbs
- OAT: 20 degrees C
- Barometric Pressure: 29.76 in. HG.
- Tailwind Component: 4 knots
- Center of Gravity: 21%

Is Reduced Thrust Procedure Permitted?

- Take-off Weight : 513,000 lbs
- Add: 30,000 lb Margin
- Add Tailwind Margin (5,000 lbs x 4 knt component) = 20,000 lbs
- Add press. correction (29.92 - 29.76) = 0.16 (round up to 0.20) @ 2500 lb/.1 in. Hg.
= 5,000 lbs
- Weight Used to determine Assumed Temperature is 568,000 lbs.

Enter the weight limitation chart (YUL 747/3A, runway 28, 10 Flap) and obtain the temperature opposite 568,000 lbs., or the next higher weight, which in this case

gives 36 degrees opposite 571,000 lbs. If the temperature is odd, subtract 1 degree C to make it even. In this case the final assumed temperature is higher than the actual temperature and therefore a reduced thrust take-off is permitted.

T/O EPR Calculation:

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Enter TAKE-OFF EPR Table from the bottom and proceed vertically to either the assumed temperature or the actual pressure altitude, whichever comes first. (If actual pressure altitude falls between two of the listed altitudes, use the higher altitude.)

In this case, obtain EPR of 1.38 opposite 34 degrees C.

T/O Speed Calculation:

Enter the Take-off & Flap Retraction Speeds (KIAS) - 10 Flap Table at the actual take-off weight (513,000 lb); interpolate to the nearest knot and obtain V1 = 124, VR = 130, V2 = 141, 5 Flap = 155, 1 Flap = 194 and 0 Flap = 211 knots (if a 1/2 or more is involved, round up to the next higher whole number).

T/O Distance Check:

Enter the Take-off Distance (ft) - 10 Flap Table. Initially do not interpolate but use the exact or next higher listed values of the actual take-off weight, actual pressure altitude, and the assumed temperature. Obtain take-off distance and correct for tailwind if one exist. Confirm the resultant required distance is not greater than the runway available and enter on T/O data chit. In the unlikely event that entering the table at next higher weight, altitude and temperature gives a runway length required exceeding that available, interpolate for the parameter which will have the most effect. When the S/O requests the cross check of his determination of the take-off data he must verbally advise what wind condition he used and whether or not interpolation was required.

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EXAMPLE: - TAKE-OFF DATA CALCULATION:

- At 500 ft., 35 degrees C and 520,000 lbs read: 6050
- Tailwind correction: 600 (next higher)
- Required Length: 6,650

On T/O Data Form enter 6650 for T/O distance and 7,000 for available

Charts Required

Take-Off Distance (FT) 10 Flap

GTOW

OAT °C	740	720	700	680	660	640	620	600	580	560	540
0	12,200	11,300	10,450	09,700	09,000	08,300	07,700	07,200	06,700	06,200	05,800
5	12,400	11,500	10,650	09,900	08,450	07,800	07,300	07,300	06,800	06,300	05,850
10	12,600	11,700	10,850	10,050	09,300	08,600	07,950	07,450	06,900	06,400	05,950
15	12,800	11,900	11,000	10,200	09,450	08,750	08,100	07,550	07,000	06,550	06,050
20	13,000	12,050	11,200	10,400	09,650	08,900	08,250	07,600	07,150	06,650	06,150
25		12,500	11,550	10,700	09,950	09,200	08,500	07,900	07,350	06,850	06,400
30		13,250	12,250	11,350	10,500	09,700	08,950	08,250	07,650	07,100	06,600
35			13,050	12,100	11,200	10,300	09,500	08,800	08,100	07,500	06,950
40				12,950	11,950	11,000	10,150	09,350	08,600	07,950	07,350
45					12,800	11,800	10,850	10,000	09,200	08,450	07,800

Take-Off EPR

OAT °C	EPR
20	1.48
22	1.48
24	1.47
26	1.46
28	1.45
30	1.44
32	1.43
34	1.42
36	1.41
38	1.40
40	1.39
42	1.39
44	1.38
46	1.37
48	1.36

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Included on the CD and available as a download is a very easy to follow Take-off calculator program that uses real world data to compute all the information required, automatically by simply entering a few numbers. The above information shows you how to do manually but the program supplied by us takes out the guess work and the hard pencil pushing.

The screenshot shows a Windows-style application window titled "Classic 742 Takeoff Calculator Version 1.0". The interface is divided into several sections for inputting takeoff data. At the top left, a mouse cursor points to the "TDC" logo. The "TAKE-OFF CONDITIONS" section includes input fields for GTOW (0 lbs), Tailwind (0 Knots), and Barometric Pressure (29.92 in.HG). To the right of this section is a small graphic of a 747 aircraft with the text "Classic 747-200" and "Ready for Pushback". Below the input fields are buttons for "Calculate", "Reset", "Print", and "About". The "NORMAL THRUST TAKE-OFF" section has fields for Current OAT (0 C), Normal Takeoff Distance (0 ft), and Normal EPR (0). The "REDUCED THRUST TAKE-OFF" section has fields for Assumed OAT (0 C), Derated Takeoff Distance (0 ft), and Derated EPR (0). The "TAKE-OFF SPEEDS (Knots)" section features a row of six input fields for V1, VR, V2, 5 Flap, 1 Flap, and 0 Flap, all currently set to 0. To the right of these are "PITCH" and "TRIM" sections, each with a "+" sign and a "0" input field.

TAKE-OFF CONDITIONS		
GTOW	0	lbs
Tailwind	0	Knots
Barometric Pressure (Only enter if < 29.92)	29.92	in.HG

Buttons: Calculate, Reset, Print, About

NORMAL THRUST TAKE-OFF		
Current OAT	0	C
Normal Takeoff Distance	0	ft
Normal EPR	0	

REDUCED THRUST TAKE-OFF		
Assumed OAT	0	C
Derated Takeoff Distance	0	ft
Derated EPR	0	

TAKE-OFF SPEEDS (Knots)					
V1	VR	V2	5 Flap	1 Flap	0 Flap
0	0	0	0	0	0

PITCH	
+	0

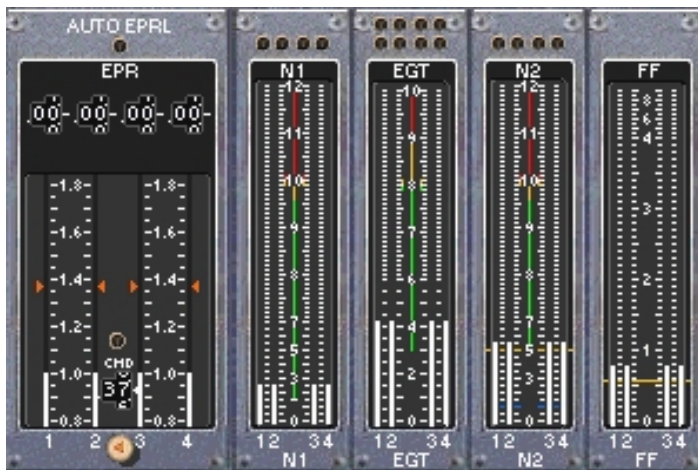
TRIM	
	0

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Special Feature

Tape Engine Gauges



ENGINE PRESSURE RATIO INDICATOR

Tape and digits indicate Pt7/Pt2 ratio. Tape readout from 1.80 down to 0.80 EPR is directly opposite graduations. With electrical power loss to instrument or tape servo drive the OFF flag appears and the counter reads .50.

N1 RPM INDICATOR

Tape indicates percent of N1 compressor RPM. Green, Yellow and Red range markings are provided. An amber light on top of each scale illuminates when its tape goes into the red range until extinguished by pushing the max. Indication reset switch. OFF flags appear on each tape with electrical power loss to instrument or to tape servo drives.. Tape goes to zero with signal loss.

We have made every attempt to make these gauges as realistic and true to the real ones as we felt was possible. The information included for their use and function is not contrived but is a direct quote from the Aircraft Operations Manual.

FUEL FLOW INDICATOR

Tape indicates metered flow to engines in kilograms per hour. OFF Flag appears for each tape with electrical power loss. A line at 545 kg/h denotes maximum flow during engine start.

N2 RPM INDICATOR

Tape indicates percent of N2 compressor RPM. Green, yellow and red range markings are provided. A line at 50% RPM denotes "Starter Off" point. An amber light on top of each scale illuminates when its tape goes into the red range until extinguished by pressing the max. Indication reset switch.

EXHAUST GAS TEMPERATURE INDICATOR

Tape indicates degrees C EGT as sensed between N2 and N1 turbines. Green, yellow and red range markings are provided. OFF flags appear on each tape with electrical power loss to instrument or to tape servo drive. Amber and red lights are installed on top of each scale:

- Steady Amber above 915 degrees C.
- Flashing Red between 920 and 940 degrees C.
- Steady red above 94- degrees C.
- Steady lights require reset, flashing resets automatically as temperature drops.