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INTRODUCTION

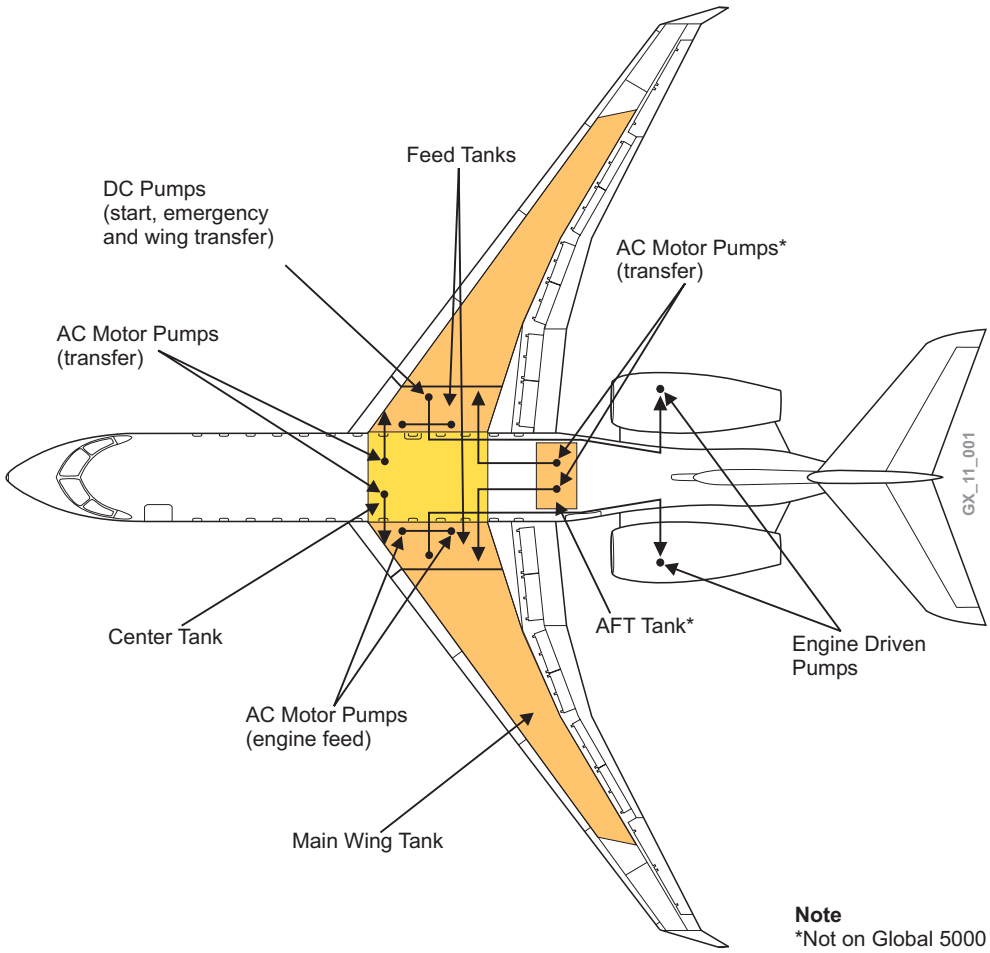
This chapter describes the fuel system for the Global Express aircraft.

Appendix 1 at the end of this book has a description of the Global 5000 fuel system. If you operate a Global 5000, do not read this chapter, proceed directly to the appendix.

Fuel is contained in a wet wing box structure, which is sealed to form the three main separate wing tanks, and a smaller quantity of fuel is carried in a separate aft fuselage tank. The tanks are vented to atmosphere and slightly pressurized by an air scoop located on the lower surface of each wing. A scavenge pump purges fuel from the vent lines and a climb vent, located in each main wing tank, provides ventilation when the airplane is in a nose up attitude.

Each engine is supplied with fuel from its respective feed tank which contains two alternating current or AC primary pumps, and one Direct Current (DC) backup (or Aux) electrical boost pump. The transfer system maintains the feed tanks full during all attitudes, and provides automatic transfer of fuel from the center tank and aft tank to the main wing tanks.

Lateral balance between left and right main tanks is controlled automatically by the Fuel Management and Quantity Gauging Computer (FMQGC), or manually through switch selections in the flight compartment.



Flight deck control is provided on the overhead panel, and fuel quantity and warnings are displayed on EICAS.

A single point pressure refuel/defuel adapter is provided which is connected to a manifold containing shutoff valves. Pressure refueling can be done either automatically or manually. Gravity filling is provided for each wing tank and for the center tank.

A dual channel FMQGC continuously monitors the following:

- Fuel quantity indicating
- Left, right engine and APU feed
- Wing to wing balance (wing XFER)
- Center tank transfer
- Aft tank fuel transfer
- Refuel/Defuel

Any fault detected by the fuel system computer is annunciated on Engine Indication and Crew Alerting System (EICAS) in the form of a visual and/or aural alert, and/or maintenance diagnostics.

FUEL TANKS

All fuel is carried in three integral tanks (left wing, right wing and center wing) and a smaller aft fuselage tank (contained in a structurally enclosed bladder).

The inboard section of each wing is designated as a feed tank, from which each engine draws its fuel. Fuel flows from the outboard sections of each wing tank, into the feed tank (by gravity), through swing check valves in the baffles of each main tank. The check valves allow fuel flow in the inboard direction only. This will restrict large fuel movements, and limit center of gravity shifts in airplane changes of attitude. Fuel is also transferred into the feed tanks, from the center fuselage and aft fuselage tanks by the transfer system.

DESCRIPTION

FUEL SPECIFICATIONS

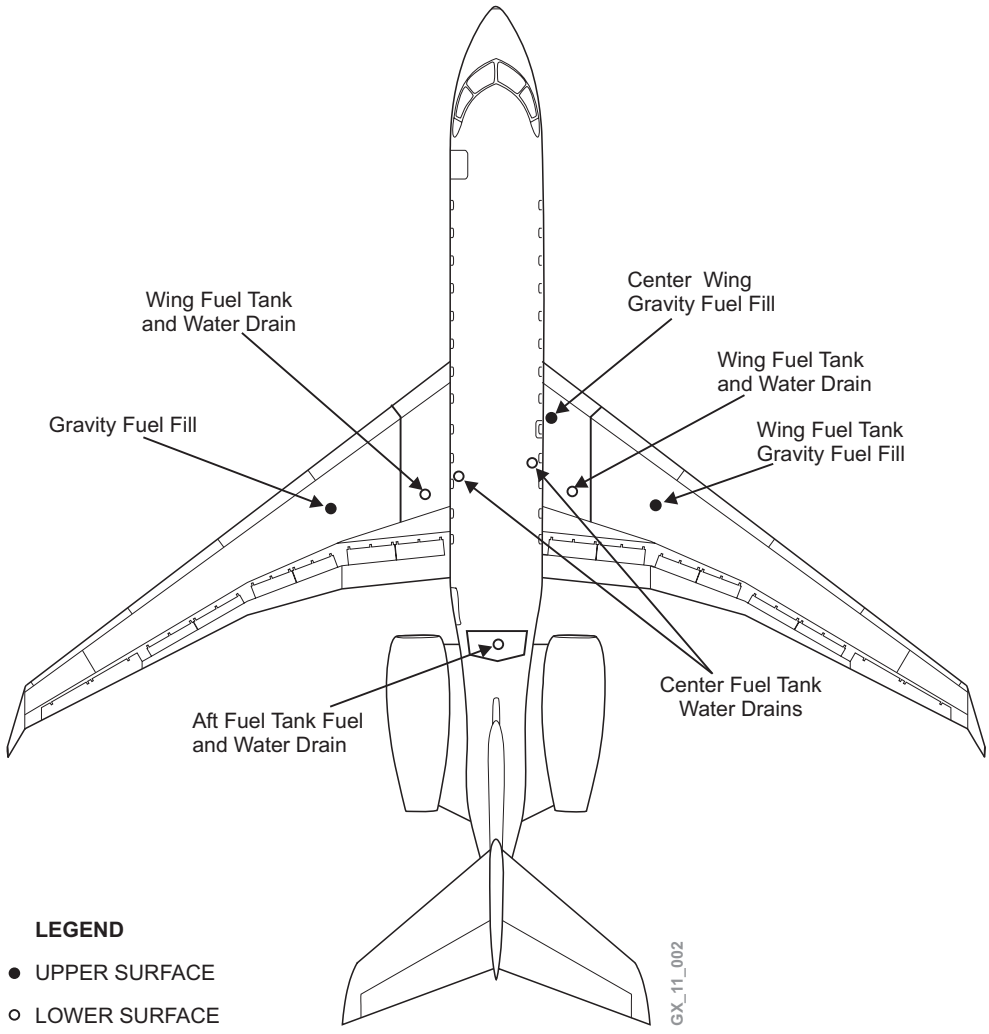
For information on fuel additives, temperature limitations and approved fuels, refer to AFM - LIMITATIONS Chapter 2.

Fuel remaining in a tank when the appropriate fuel quantity indicator reads zero is not usable. Based upon a fuel density of 6.75 lb/U.S. gallon, the maximum usable fuel load for each fuel tank is given below:

PRESSURE REFUEL (+0 / -1%)				
	Tank Volume		Fuel Mass †	
Left main tank	8,435 liters	2,229 U.S. gal	6,825 kg	15,050 lb
Right main tank	8,435 liters	2,229 U.S. gal	6,825 kg	15,050 lb
Center tank	6,265 liters	1,655 U.S. gal	5,075 kg	11,150 lb
Aft tank	1,275 liters	337 U.S. gal	1,025 kg	2,300 lb
Total	24,410 liters	6,450 U.S. gal	19,750 kg	43,550 lb
† based on a fuel density of 0.809 kg/liter (6.75 lb/U.S. gal), rounded to the nearest 25 kg or 50 lb. Fuel Mass is provided for reference only and should not be considered limiting.				

GRAVITY REFUEL (AIRPLANE LEVEL)				
	Tank Volume		Fuel Mass †	
Left main tank	7,760 liters	2,050 U.S. gal	6,275 kg	13,850 lb
Right main tank	7,760 liters	2,050 U.S. gal	6,275 kg	13,850 lb
Center tank	6,245 liters	1,650 U.S. gal	5,050 kg	11,150 lb
Aft tank	not available	not available	not available	not available
Total	21,765 liters	5,750 U.S. gal	17,600 kg	38,850 lb
† based on a fuel density of 0.809 kg/liter (6.75 lb/U.S. gal), rounded to the nearest 25 kg or 50 lb. Fuel Mass is provided for reference only and should not be considered limiting.				

FUEL AND WATER DRAINS



All tanks have flush self-closing water drain valves, installed at various low points, to permit draining of any accumulated water or residual fuel. They are located at the low point of each wing. Three gravity fill caps are provided for wing and center tank gravity refueling.

AC BOOST PUMPS

Two AC boost pumps, also referred to as primary boost pumps, are located in each feed tank. They normally supply fuel to the engines in all airplane ground and flight mode operations. Each pump is capable of maintaining an engine (fuel demand) in all modes of engine operation. The two pumps are continuously on, whenever the engine is operating and AC power is available. Both boost pumps (two on each side) may be inhibited by selection of one of the individual switches on the fuel control panel. The boost pumps are controlled automatically through the Alternating Current Power Center (ACPC), when a fuel command is received.

DC AUXILIARY PUMPS

DC powered auxiliary pumps (AUX pumps) one in each feed tank, are used for the following:

- APU starting
- Wing to wing transferring of fuel
- Engine feed in the event of an AC boost pump failure
- During takeoff and landing with at least one of the following:
  Flaps > 0°, landing gear down and in flight, or low wing fuel condition (600 pounds each wing)

Each AUX pump may be inhibited by selecting off a switch on the fuel control panel. The pumps are automatically controlled by the Secondary Power Distribution Assembly (SPDA).

NOTE

When an AUX pump is used for wing transfer mode of operation and an AC pump fails, priority is given to the engine feed system and the automatic wing transfer operation will be inhibited. Manual override of the automatic selection is possible via the fuel control panel.

CENTER TRANSFER PUMPS

Two center transfer pumps (controlled by the FMQGC) are used to transfer fuel from the center tank to the main wing tanks. There is no manual selection available to transfer fuel from the center tank to the wings.

AFT TRANSFER PUMPS

Two aft transfer pumps and associated shutoff valves are used to transfer fuel from the aft fuel tank to the wing tanks. Transfer is scheduled by the fuel computer or by a switch selection on the fuel control panel.

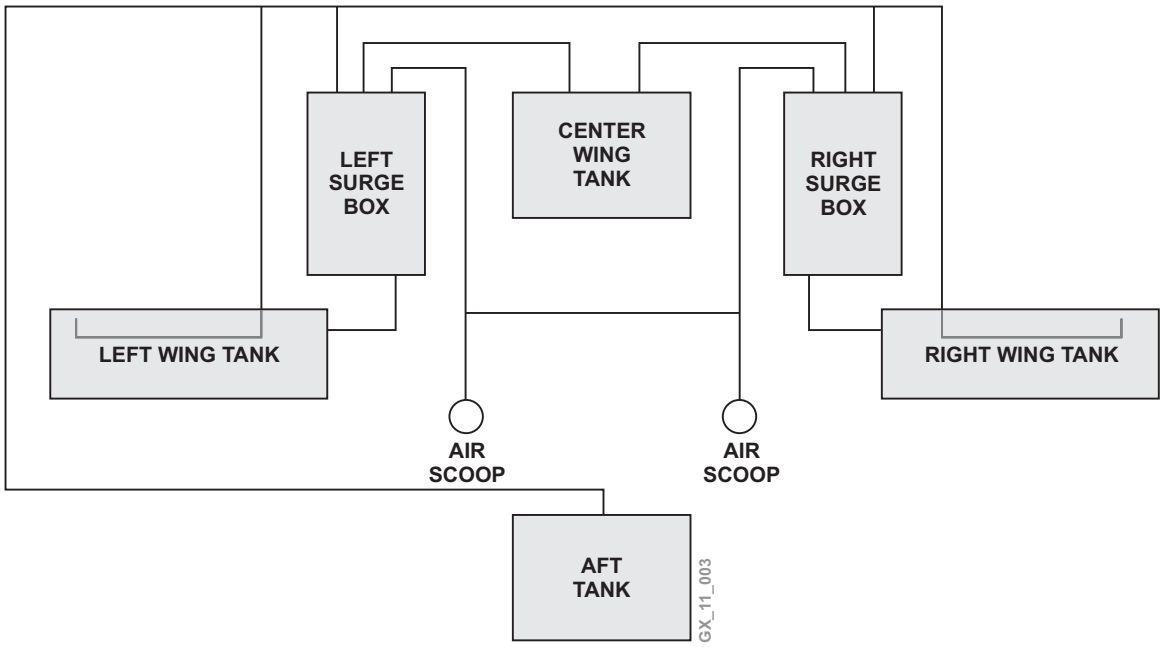
VENT SYSTEM

An open vent (no float valves or flame arrestors) system is used to control the pressure in the fuel tanks. It consists of vent line tubing and ram air inlet/outlet scoops, to ensure adequate venting of all fuel tanks. The vent lines connect the two air scoops to the fuel tanks, and the fuel tanks to each other. The lines are drained of fuel which is returned to the feed tanks during operation. The low point of the main vent line is continuously scavenged by a jet pump.

The vent line distribution is to a high point in the fuselage, preventing fuel from reaching either of the two ram outlets and spilling overboard. If any fuel passes the high point, it is collected by the surge box and is drained back to the tank before it reaches the outlet. Each surge box vent line tubing runs vertically along the fuselage side wall, and is coupled to the wing, center and aft tanks.

The vent system is fully redundant, such that any single blockage does not affect the venting capability.

VENT SYSTEM SCHEMATIC



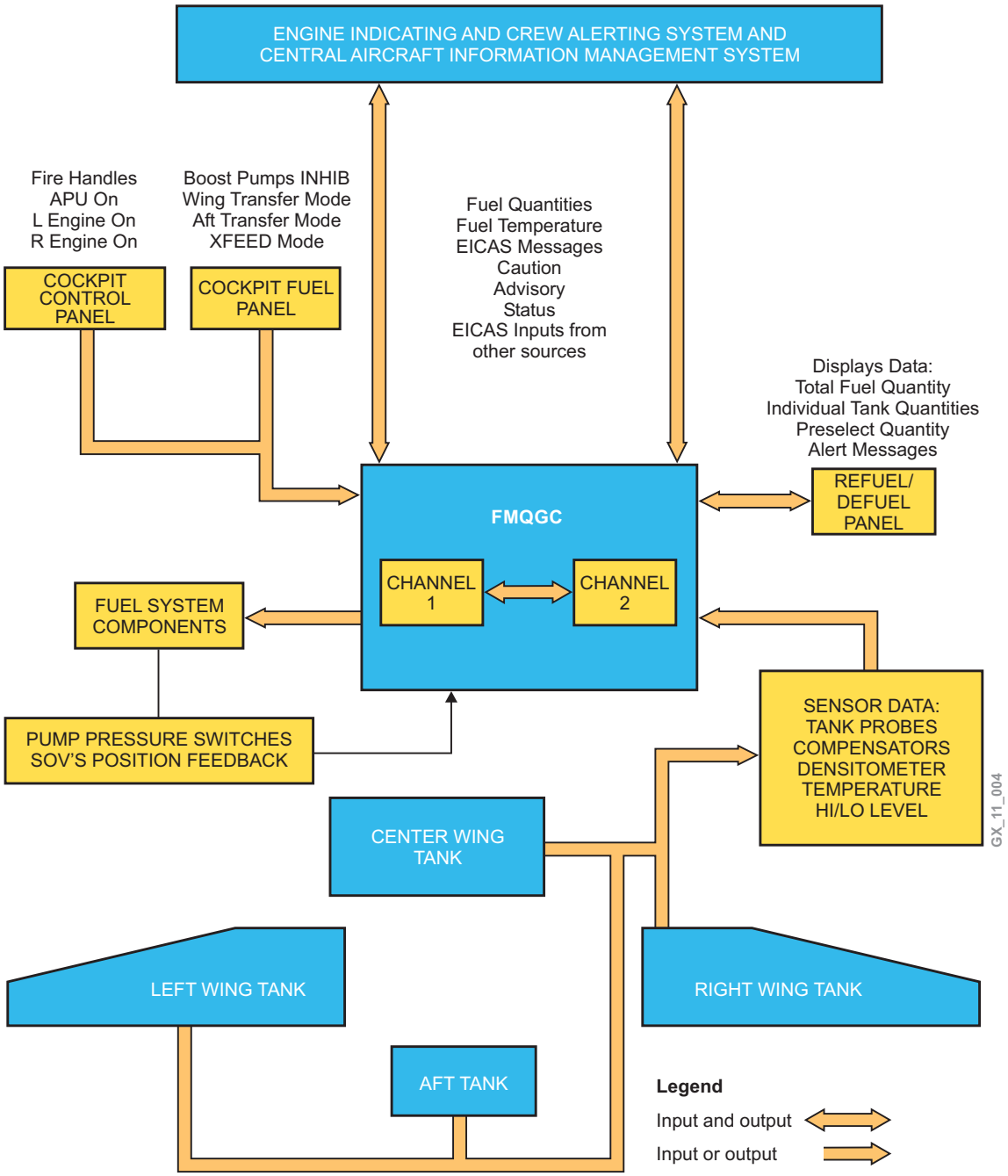
PRESSURE RELIEF VALVES

Relief valves are used to protect the tanks from over pressurization, in the case of failure of the vent system and/or refuel shutoff valve. They are located in the wing, center and aft tanks. The aft tank relief valve has a similar function as the center and wing tank relief system, but also incorporates a negative-pressure relief feature which can activate in an emergency descent.

FUEL MANAGEMENT QUANTITY GAUGING COMPUTER (FMQGC)

The FMQGC consists of a dual channel computer with BITE, utilizing capacitance type probes in each tank to continuously measure the quantity of usable fuel. The fuel computer performs all digital processing related to the system control and indication and performs computations associated with fuel gauging system requirements. The following schematic represents inputs and outputs of various components and systems operations.

FMQGC SCHEMATIC

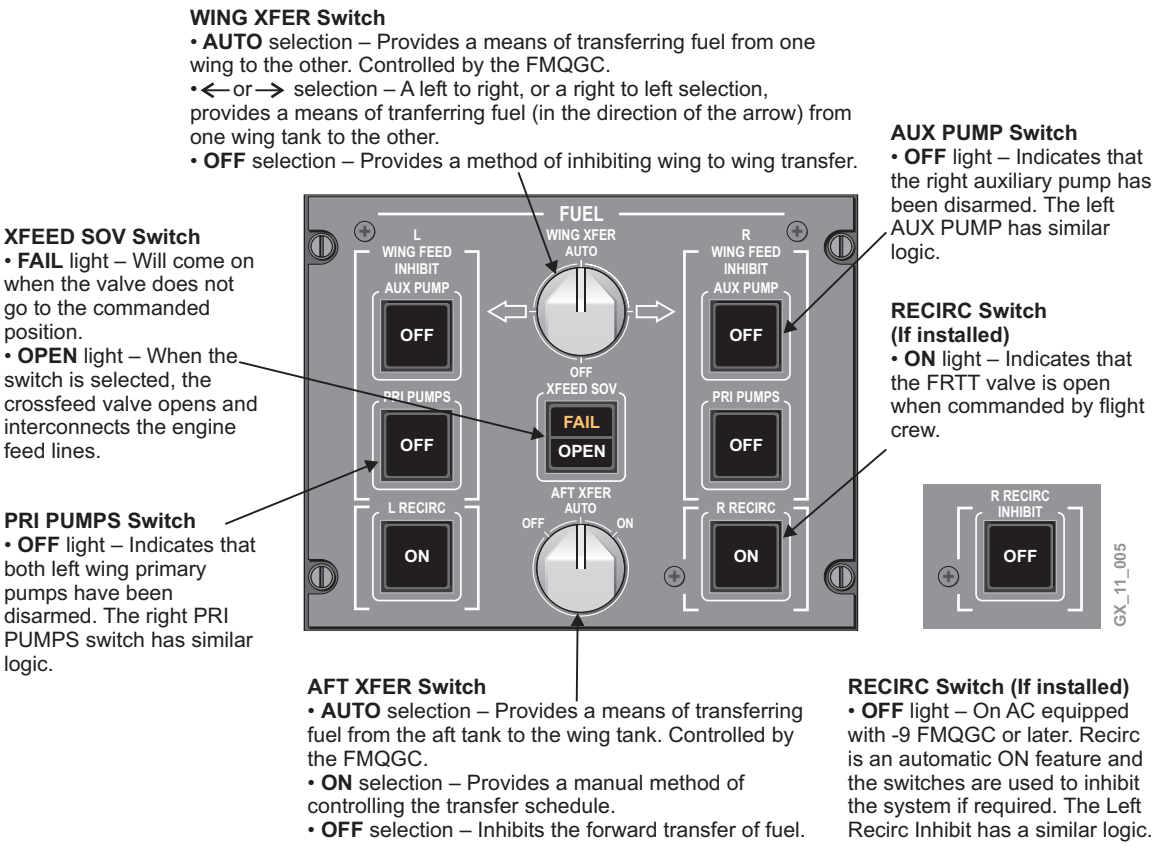


FUEL CONTROL PANEL

The fuel control panel is located on the overhead panel in the flight compartment. The fuel control panel defines the operational modes, component controls, and component inhibits.

The fuel control panel has switches, which when selected, override the automatic control of certain components within the fuel system. Switch selections from this panel are sent to the ACPC. The ACPC will then control the system from the inputs received from the panel. The switch lamps come on when selected in combination with certain EICAS messages, which represent the panel configuration or failure within a given system.

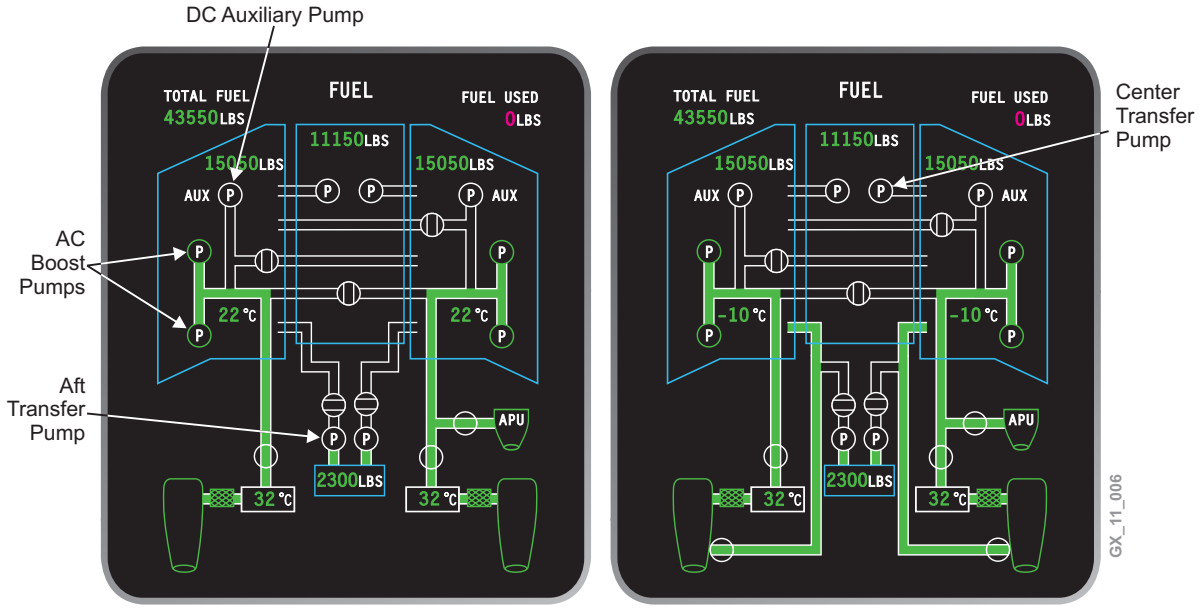
FUEL CONTROL PANEL



FUEL SYSTEM SYNOPTIC PAGE

The FUEL synoptic page provides an overview of system status, as represented below with both left and right engines running and no transferring of fuel taking place.

FUEL SYNOPTIC PAGE



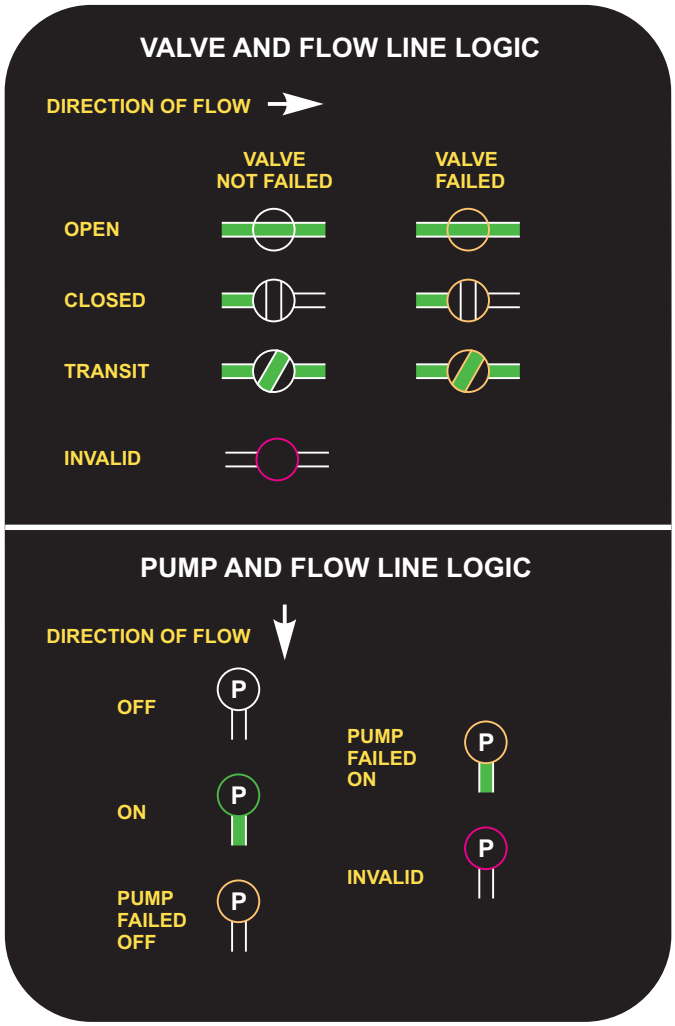
Without Fuel Recirculation **With Fuel Recirculation**

NOTE

For the remainder of this chapter, the synoptic page with recirculation shown will be used as a default.

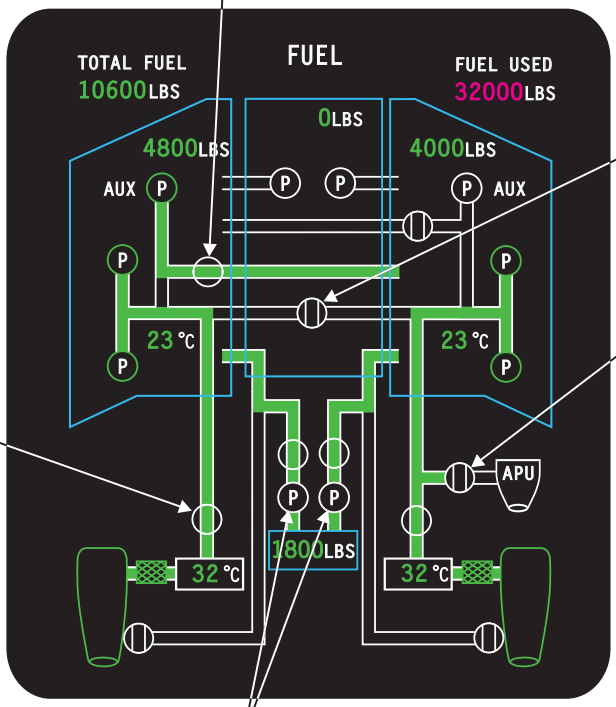
EICAS PHILOSOPHY

The following represents the EICAS symbols and flow line logic for the fuel synoptic page. The symbols are shown in serviceable and failure conditions.



FUEL SHUTOFF VALVE DISPLAYS

WING Transfer SOV
Controlled by the FMQGC or the WING XFER switch on the fuel control panel.



Fuel Crossfeed SOV
Controlled by the switch on the Fuel Control Panel. It is used to interconnect the engine feed lines.

APU Feed Shutoff Valve
- Activated by the RUN position switch on the APU control panel.
- Also controlled by the APU FIRE DISCH handle.

Engine Feed Shutoff Valve
- Applicable engine FIRE DISCH handle

.

NOTE: The engine run switches activate the HPSOV located in the FMU not these shut-off valves. These are only activated by the “FIRE DISCH” handle.

AFT Tank Transfer Valve
Controlled by the FMQGC or the AFT XFER switch on the fuel control panel.

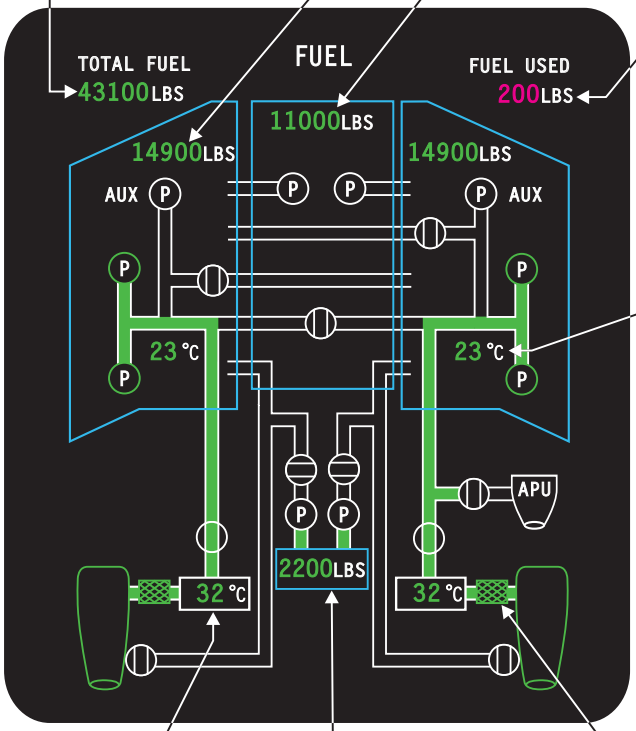
FUEL FILTER, QUANTITY AND TEMPERATURE READOUT

Wing Fuel Quantity
Indicates fuel quantity, in the respective wing tank, in pounds (lbs).

Total Fuel Quantity
Indicates fuel quantity, in all fuel tanks, in pounds (lbs).

Fuel Quantity Readout (Center Fuselage Tank)
Indicates fuel quantity, in the center tank, in pounds (lbs).

Fuel Used Quantity Readout
Indicates fuel quantity burned.



Bulk Fuel Temperature Readout
Prior to -9 FMQGC
- **Green** – Temperature of fuel in tanks is between -35°C and +43°C.
- **Amber** – Temperature of fuel in tanks is lower than -35°C or greater than +43°C.

Fuel Recirculation system is ON:
- **Green** – Temperature of fuel in tanks is between -35°C and 0°C.
- **Amber** – Temperature of fuel in tanks is lower than -35°C or greater than 0°C.

Bulk Fuel Temperature Readout
-9 FMQGC or later
- **Green** – Temperature of fuel in tanks is between -35°C and +54°C.
- **Amber** – Temperature of fuel in tanks is lower than -35°C or greater than +54°C.

Fuel Recirculation system is ON:
- **Green** – Temperature of fuel in tanks is between -35°C and 10°C.
- **Amber** – Temperature of fuel in tanks is lower than -35°C or greater than 10°C.

Engine Inlet Fuel Temperature
- **Green** – Engine fuel temperature is ≥ 5°C.
- **Amber** – Engine fuel temperature is < 5°C.

Fuel Quantity Readout (Aft Tank)
Indicates fuel quantity in the aft tank, in pounds (lbs).

Fuel Filter Flow Line
- **Green** – Indicates normal fuel flow to the engine.
- **Amber** – Fuel pressure drop exists across the filter, flow line from the filter to the engine turns amber.

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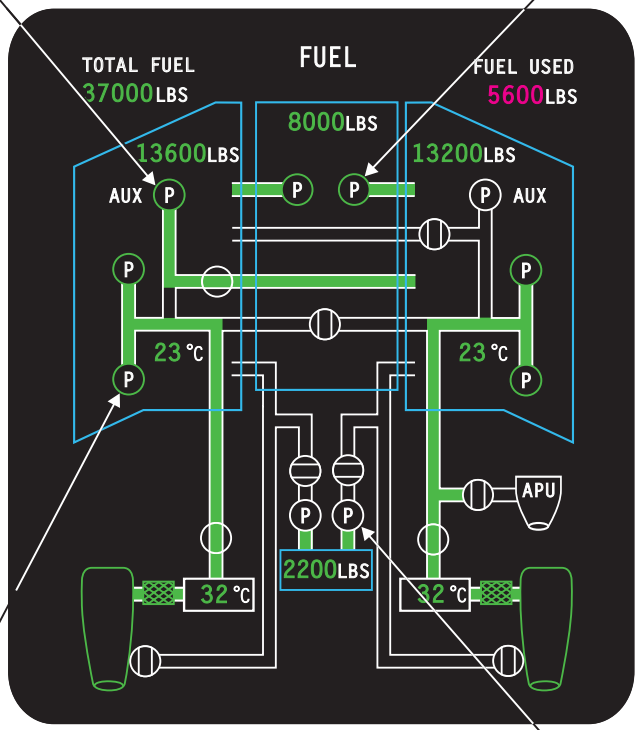
FUEL PUMP DISPLAYS

L or R DC Auxiliary Pumps
• **ON** – For takeoff and landing, primary pump failure, and wing transfer of fuel.

NOTE: The AUX PUMP cannot be used to support the engine feed system and wing transfer at the same time. In auto, engine feed will have priority over wing transfer. Manual overide is always possible.

• **OFF** – When commanded by the switch on the Fuel Control Panel.
– When both primary pumps are on and no wing transfer is required.

Center Transfer Pumps
Controlled by the FMQGC and transfers center tank fuel to the wing tanks. No manual control.



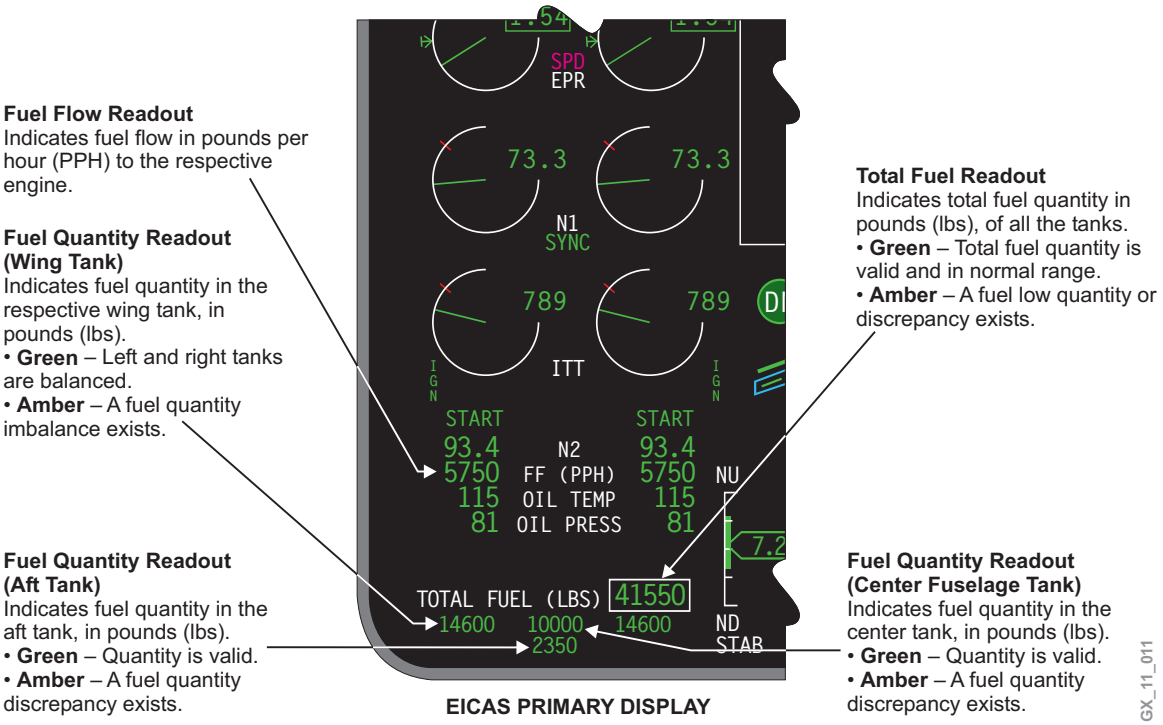
L or R AC Boost Pumps
• **ON** – At all times with the engines running.
• **OFF** – When commanded by the switch on the Fuel Control Panel.

AFT Transfer Pumps
• **ON** – When requested by the computer or selected on the Fuel Control Panel.
• **OFF** – When commanded by the switch on the Fuel Control Panel.
– When commanded by the FMQGC in AUTO mode.

FUEL QUANTITY AND INDICATION

The fuel quantity gauging system is an ac-type capacitance system. Fuel quantity probes, compensators, densitometers, temperature sensors and high level detectors are inputs received by the FMQGC. The FMQGC uses this acquired data to compute the fuel quantity for each tank and total fuel quantity remaining on board the airplane.

The FMQGC outputs the computed individual fuel tank, total quantity and fuel temperature for EICAS display. The fuel system computer corrects for airplane pitch attitude and presents the corrected information of individual tank quantities, and total fuel quantity displayed on EICAS. The FMQGC can display quantity in either pounds (standard) or kilograms (optional). The primary EICAS page displays fuel quantity in all fuel tanks, and total fuel in the airplane.



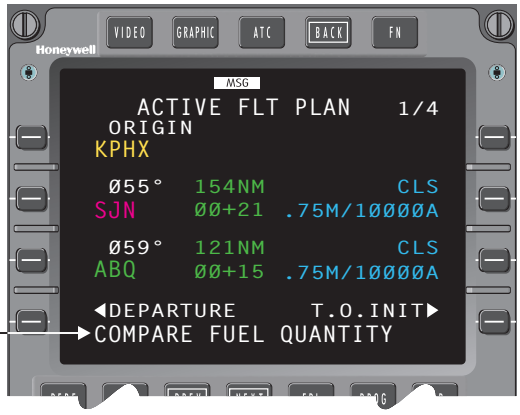
EICAS PRIMARY DISPLAY

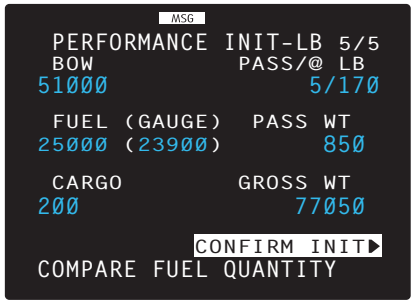
FLIGHT MANAGEMENT DISPLAY

When both engines are started, the Flight Management System (FMS) fuel quantity switches from Fuel Quantity Gauge System (FMQGC) to FMS computed fuel quantity, based on fuel flow data from the engines and APU.

Fuel quantity information to the FMS is used for monitoring and sensing, to assist in determining a fuel leak. When a fuel leak is detected, a crew alert ("MSG" on the Primary Flight Display) will be displayed and a message will appear on the scratchpad of the FMS CDU.

COMPARE FUEL QUANTITY
Displays when the gauge fuel weight and the FMS fuel weight differ by more than 2% of the Basic Operating Weight (BOW).





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ENGINE FEED SYSTEM

Fuel is provided to each engine from the two AC boost pumps. In normal operation, both boost pumps are continuously on, and provide all engine fuel flow once the engine is started. The AC pumps are located in the inboard section of each wing (feed tank), and each AC pump is powered by a separate bus.

Loss of pressure at any AC boost pump causes the DC pump to come on, to provide a back up of the remaining boost pump. The DC pumps also come on automatically for takeoff, based on flaps/slats position and weight on wheels logic.

The engine fuel burn schedule is automatically controlled by the FMQGC to ensure correct distribution for all airplane configurations.

The engine fuel burn sequence is as follows:

- Fuel from the wing tank will burn first
- When the wing tanks get below 93%, fuel transfers from the center tank to the wing tank until it is at or above 97%
- When the center tank empties, fuel from the wing tanks continue to burn
- When either wing tank reaches 5,500 pounds, fuel transfers from the aft tank
- Once the aft tank is empty, the wing tanks will continue to burn the remaining fuel

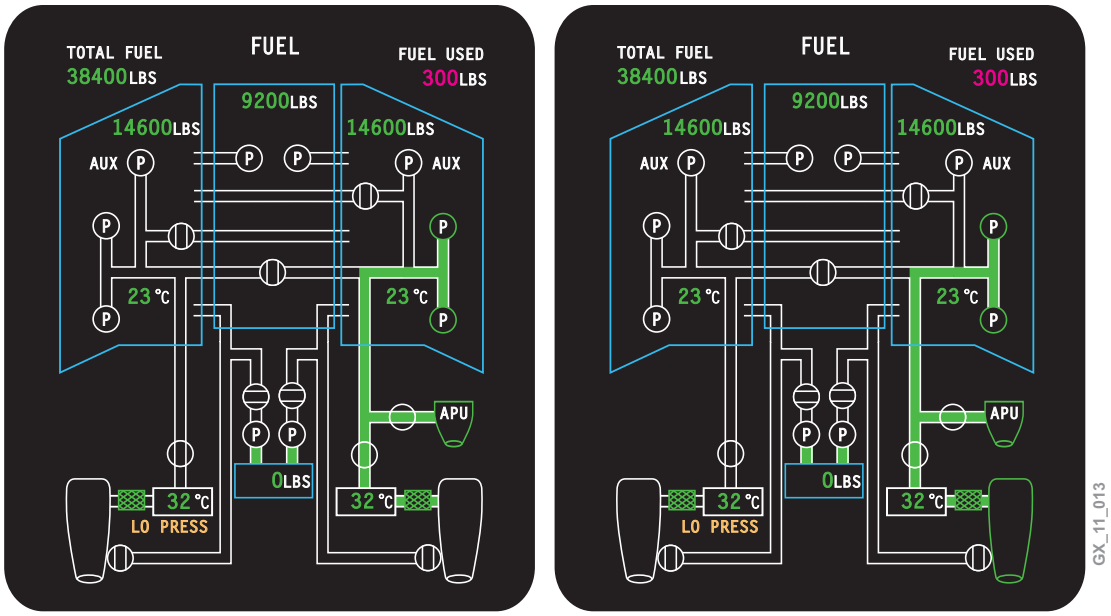
Airplanes which do not incorporate fuel recirculation.

The engine fuel burn sequence is as follows:

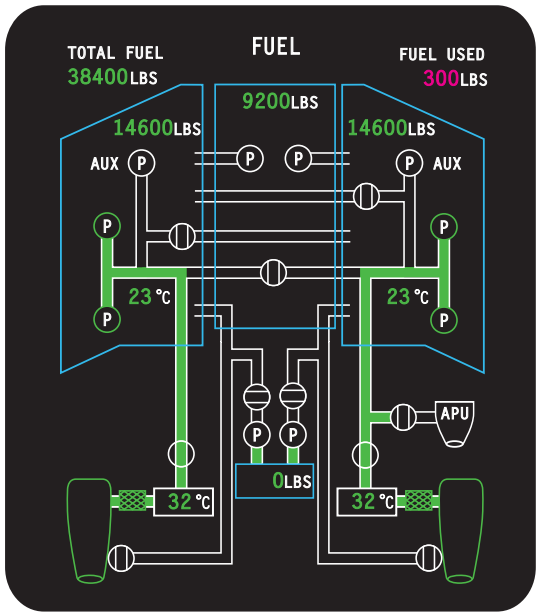
- Fuel from the wing tanks will burn first
- When the wing tanks get below 93%, fuel transfers from the center tank to the wing tank until it is at or above 97%
- When the center tank empties, wing tank continue to burn
- When either wing tank reaches 4,000 pounds, fuel transfers from the aft tank
- Once the aft tank is empty, the wing tanks will continue to burn the remaining fuel

Engine Feed System Indication

The left FUEL synoptic page below represents the normal engine start mode of operation. The right engine is started using the Auxiliary Power Unit (APU) as the source of electrical power and left engine is off. The right Fuel synoptic display represents the right engine on speed.



The FUEL synoptic page below represents airplane configuration with the APU shut down, both engines on, the AC pumps running, and the DC pumps on standby.



TRANSFER SYSTEM

Fuel contained in the center tank and the aft fuselage tank cannot be fed directly to the engine, but must be first delivered to the feed tanks by the transfer pumps. The normal sequence of fuel usage is to transfer center tank fuel into the wings as required, to keep the wings full during climb and cruise while holding the aft fuselage tank full.

After depletion of center tank fuel quantity, fuel continues to be burned from the wing tanks until 5,500 lb. of fuel remains in either wing tank, at which point, transfer of fuel from the aft tank to the feed tanks is initiated. The transfer from the aft tank is then continuous until the aft tank is empty. When the aft fuselage tank fuel is depleted, no further transfer of fuel is required, since all remaining fuel is contained in the wing tanks.

Airplanes which do not incorporate fuel recirculation.

The engine fuel burn sequence is as follows:

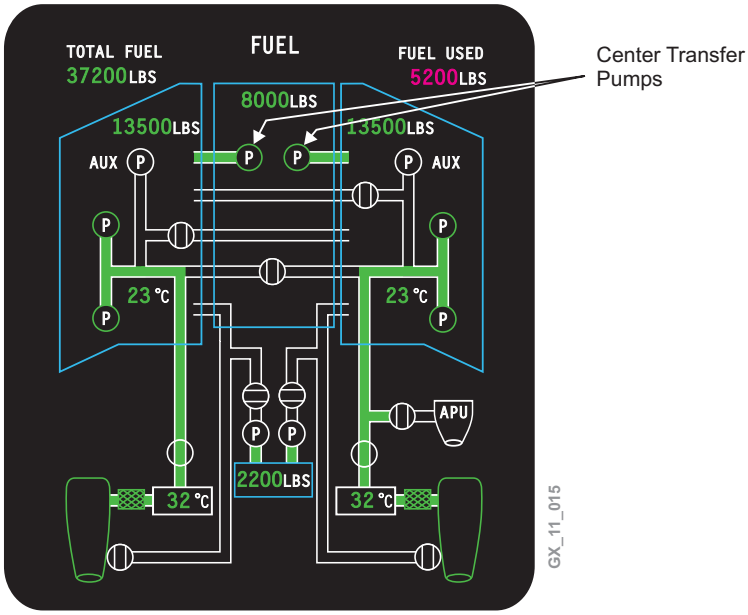
After depletion of center tank fuel quantity, fuel continues to be burned from the wing tanks until 4,000 pounds of fuel remains in either wing tank, at which point, transfer of fuel from the aft tank to the feed tanks is initiated. The transfer from the aft tank is then continuous until the aft tank is empty. When the aft fuselage tank fuel is depleted, no further transfer of fuel is required, since all remaining fuel is contained in the wing tanks.

Control of fuel transfer from the center and aft tanks is normally under control of the fuel computer. Manual override is provided to command transfer of aft tank fuel into the feed tanks via the fuel control panel. There is no manual override for the center tank transfer system.

CENTER TRANSFER

Fuel transfer from the center tank to wing tank is completely automatic through the control of the FMQGC. The FMQGC monitors the fuel level and quantities in the wing tank (using fuel probes, compensators, densitometers, and temperature sensors) to control fuel transfer from the center tank to the wing tanks. Fuel will be transferred from the center tank and delivered to the wing feed tanks, through the use of two center transfer pumps.

The FMQGC will start the applicable center transfer pump(s) when each individual wing tank reaches approximately 93% of its fuel tank capacity. The FMQGC will automatically stop the center transfer pump(s) when the respective wing tank reaches greater than 97%, of its fuel tank capacity.



The FUEL synoptic page represents the center tank transfer system in operation, with both engines running.

WING TRANSFER

The wing transfer system permits fuel to be pumped from either side of the airplane to the other, using the DC auxiliary pumps and motor operated shutoff valves.

The wing transfer system provides a means of correcting lateral fuel imbalance. It may be used in automatic mode via FMQGC, or manual mode as selected by the cockpit fuel control panel. Fuel imbalance at a predetermined value will be annunciated on the EICAS display in the form of a caution message.

AUTO WING TRANSFER

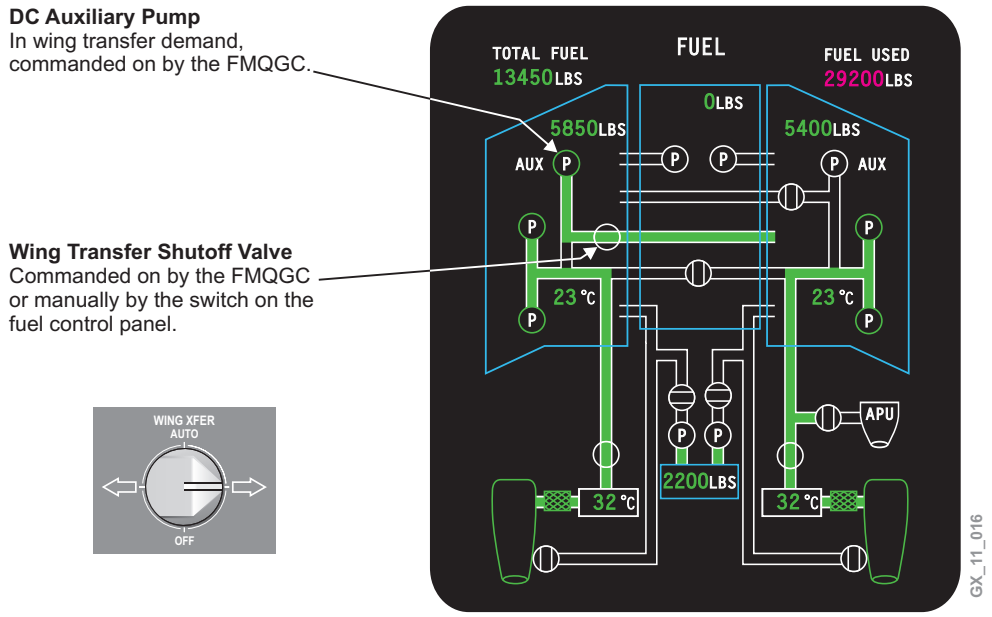
The auto wing transfer mode is only enabled when the slat/flap handle is in the in/zero position. In this mode, the FMQGC will correct lateral fuel imbalances of 400 pounds on ground and in flight. The FMQGC will control and operate the DC auxiliary pumps and wing transfer SOVs as necessary, to pump fuel from the feed tank into the opposite wing. Once commanded on, the wing transfer system remains on until lateral fuel imbalance is zero.

In the event of a center tank transfer pump failure, fuel will be transferred from the operating center tank transfer pump to its respective wing tank. The automatic wing transfer system will maintain lateral fuel balance, to ensure that fuel contained in the center tank is available to both engines.

MANUAL WING TRANSFER

In manual mode, the wing transfer system is controlled using the fuel WING XFER switch. Once selected, the wing fuel transfer continues until the WING XFER switch is selected off on the fuel control panel.

The FUEL synoptic page represents the left to right wing transfer mode of operation with both engines running.



CROSSFEED

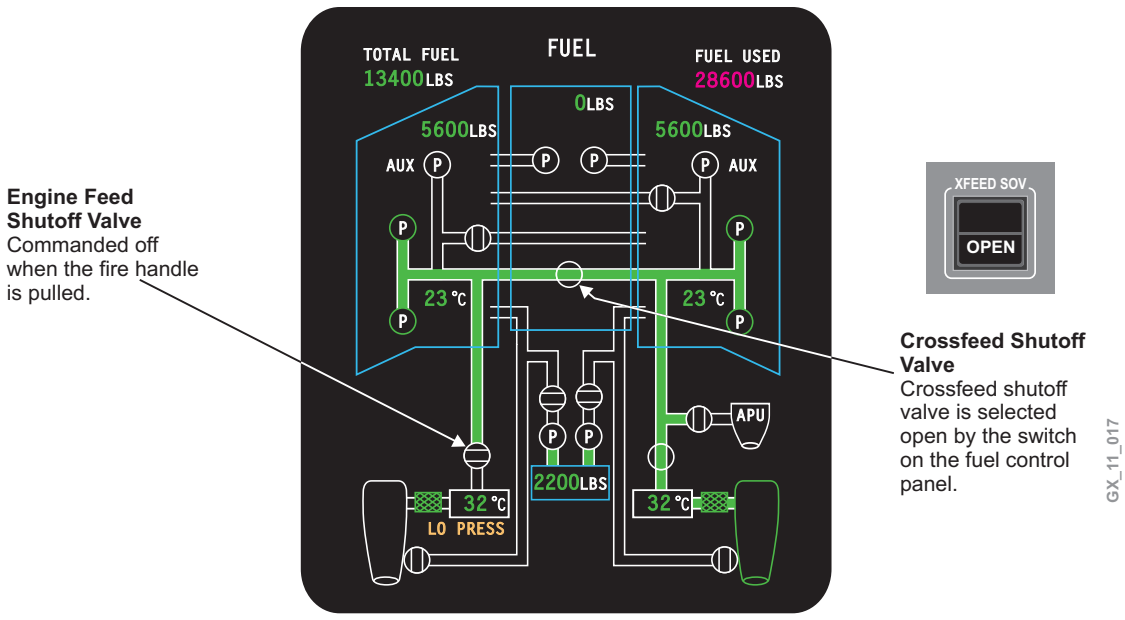
The crossfeed system permits interconnection between the left and right engine feed lines, using a shutoff valve. This will enable both engines to be fed by either feed tank, or alternatively, enabling a single engine to be supplied from both feed tanks.

For normal airplane operations, the crossfeed shutoff valve is closed, isolating the feed lines and ensuring that each engine is supplied fuel only from its own side of the airplane. Opening the crossfeed shutoff valve interconnects the feed lines, enabling fuel to flow from one engine feed line to the other.

No automatic means of controlling the crossfeed SOV is provided, and selection has to be made using the XFEED SOV switch on the fuel control panel.

In single engine operating mode, with the crossfeed shutoff valve opened, fuel flows from both feed tanks via the AC primary pumps to the single engine, and fuel flow rates from both sides of the airplane are considered essentially the same. Therefore the airplane can be flown indefinitely without developing any significant lateral fuel imbalance.

The FUEL synoptic page below represents the fuel crossfeed mode of operation, with the crossfeed shutoff valve selected open, left engine shut down, left engine feed shutoff valve closed, and the right engine running.



A secondary use of the crossfeed system (as a back-up to the wing transfer system) is to provide means of correcting lateral C of G imbalances, by temporarily inhibiting the flow of fuel from the light side of the airplane. Fuel will then be supplied to both engines from the “heavy” side until lateral fuel balance is within desired limits.

CAUTION

The possibility of engine flameout could occur if the crossfeed valve is not opened prior to inhibiting the fuel pumps.

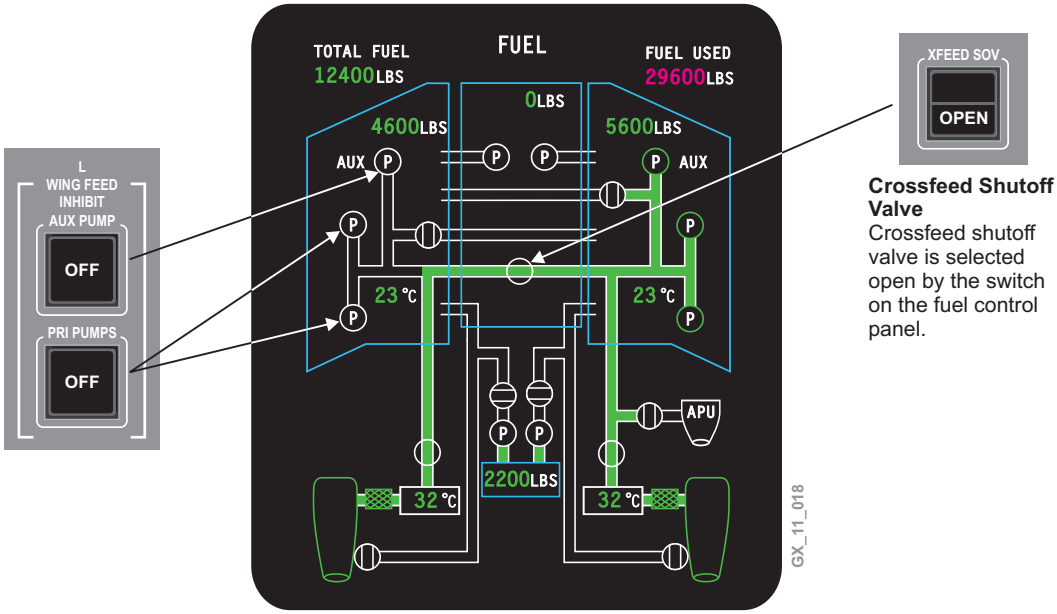
In this operating mode, the crossfeed valve is selected open via the XFEED SOV switch on the fuel control panel. The fuel pumps on the light side of the airplane are turned off, using the applicable AUX PUMP and PRI PUMP switches. Fuel will then be supplied from the heavy side of the airplane only, thereby correcting the lateral fuel imbalance. Crossfeed continues in this mode until the crew deselects the switches after lateral balance is achieved.

NOTE

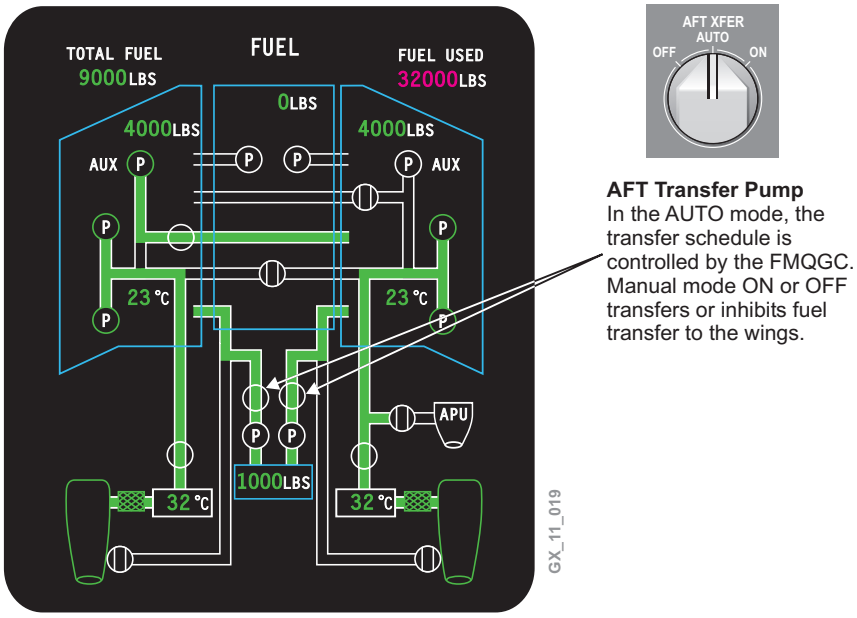
It is important that the crew monitor system operation in this mode, since crossfeed will continue until manually deselected.

In the event that a lateral fuel imbalance occurs outside design limits, it will be annunciated on EICAS, prompting the crew to take action.

The FUEL synoptic page below represents the fuel crossfeed mode (backup) of operation. The system is shown with the crossfeed shutoff valve selected open, left auxiliary pump inhibited, left forward and aft boost pumps inhibited, and both engines running.



Crossfeed Shutoff Valve
Crossfeed shutoff valve is selected open by the switch on the fuel control panel.



AFT TRANSFER

Fuel contained in the aft tank is retained until late in the flight, in order to maintain a favorable aft center of gravity (C of G).

The aft transfer schedule is normally controlled automatically by the FMQGC. Fuel can also be transferred or inhibited manually from aft tank to wing tank, using the AFT XFER switch on the fuel control panel, if desired.

Aft transferring of fuel is achieved using the two AC boost pumps and two shutoff valves. Each of the two transfer pumps in the system has sufficient capacity to maintain the transfer schedule in the event of a failure of one of the pumps.

When the aft transfer system is commanded to operate, the aft tank refuel transfer valve and the aft transfer pump come on. Fuel is then pumped by the aft transfer pump, into its respective feed tank.

The FUEL synoptic page above represents the fuel aft transfer mode of operation, with both engines running. The system is shown transferring fuel from the aft tank bladders to their respective wing tanks.

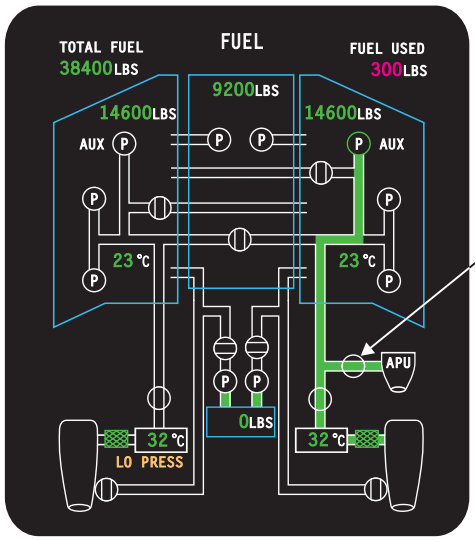
APU FUEL FEED

The APU start capability is normally provided by the DC AUX pump(s). The fuel supplied to the APU is taken from the right engine feed line. The APU can also be fed from the left engine feed line using the left DC AUX pump (powered by DC ESS bus) and opening the crossfeed shutoff valve (BATT bus). A motor operated fire shutoff valve is used in the APU feed line, in order to isolate the flow of fuel to the APU in case of a fire or rotor burst.

The FUEL synoptic page top view represents the APU during the starting sequence, with the DC pump running and battery power only as the single source of electrical power. In the lower view, the APU is fed from the right engine feed line using the AC pumps.

TOP VIEW

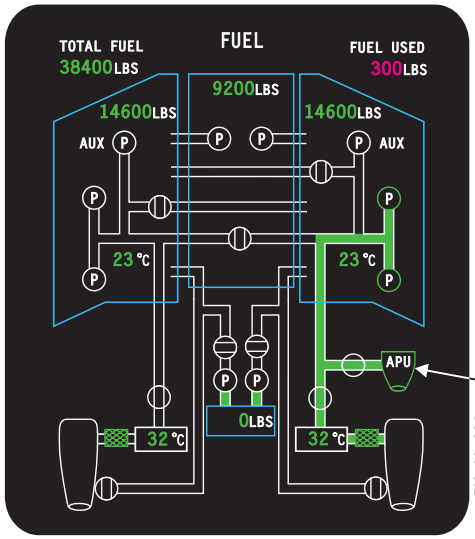
Note: APU starting and left and right engines are off.



APU Feed Shutoff Valve

LOWER VIEW

Note:
APU on speed and AC electrics established.



APU – green outline indicates on-speed.

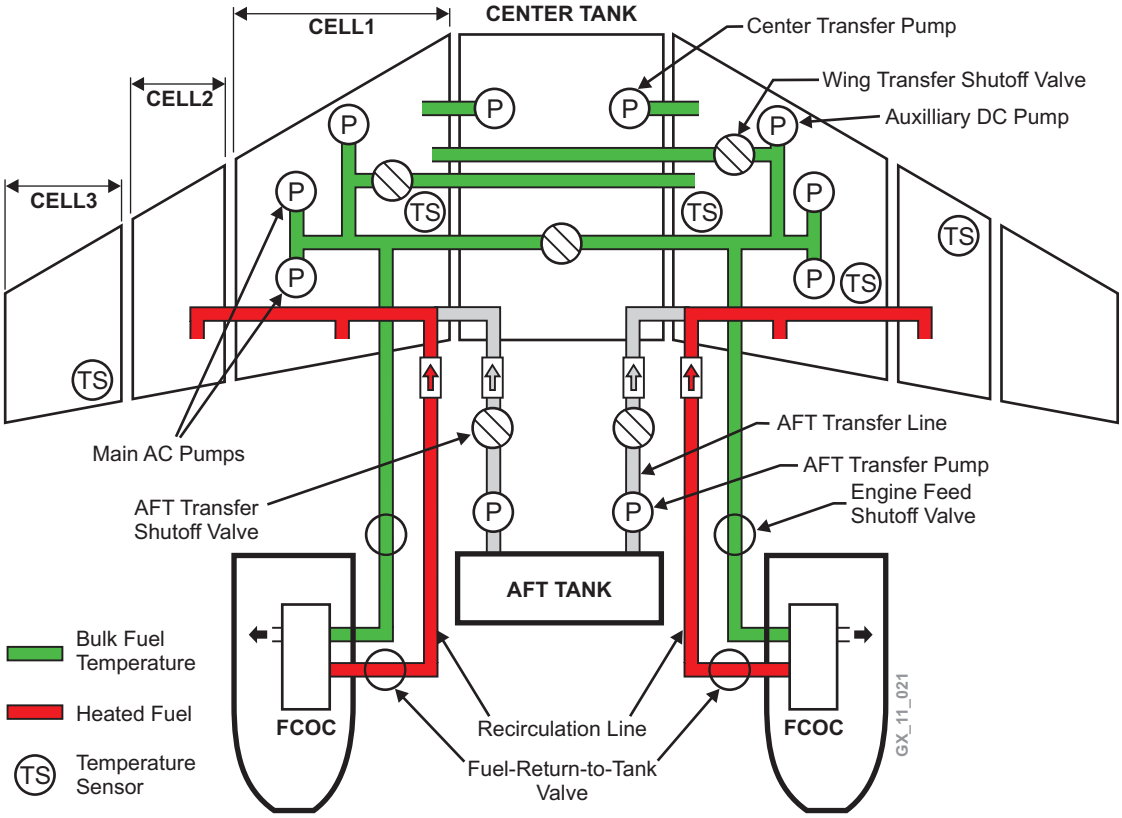
FUEL RECIRCULATION SYSTEM

The Fuel ReCirculation system is designed to prevent the bulk fuel temperature from reaching the freezing point by recirculating heated fuel to the wing fuel tank. The system is operated through the L and R RECIRC switches on the Fuel Control panel for aircraft equipped with FMQGC models prior to -9.

On -9 FMQGC models and later, recirculation is an automatic ON function. The FMQGC will turn on recirc when the altitude is > 34,000 feet, AND the bulk temperature drops below – 20°C, or average temperature drops below – 9°C, and turn off recirc when the bulk temperature reaches 5°C or altitude is < 33,800 feet, or either engine is turned off. It will turn both sides on or off at the same time.

Heat is generated by the engine oil cooling system. Cold fuel circulated through the Fuel Cooled Oil Cooler (FCOC) where the heat from the engine oil is transferred to the fuel. The Fuel Return To Tank (FRTT) valve allows the heated fuel to return to the wing fuel tank.

When the FRTT valve is open, fuel returns to the wing tank through the recirculation line. The recirculation line joins the aft tank transfer line. This slightly decreases the transfer rate of the aft tank to the feed tanks. Heated fuel is then distributed to the number 1 and 2 cell of the wing fuel tank. No fuel is distributed to the number 3 cell as it will have emptied before the local fuel temperature reaches – 40°C (F). Both the recirculation line and the aft tank transfer line are fitted with a check valve to prevent crossflow or fuel propagation due to a ruptured line.



The wing fuel tanks are fitted with many fuel temperature sensors; the left wing has two and the right wing has three. With the Fuel Recirculation OFF, the Fuel Management and Quantity Gauging Computer (FMQGC) reads all temperature sensors but will display only the lowest temperature. When the Fuel Recirculation system is ON, the FMQGC computer reads the inboard temperature sensor as it will be the one who reads the highest temperature.

Operation of the Fuel Recirculation System is allowed only during cruise flight above 34,000 feet.

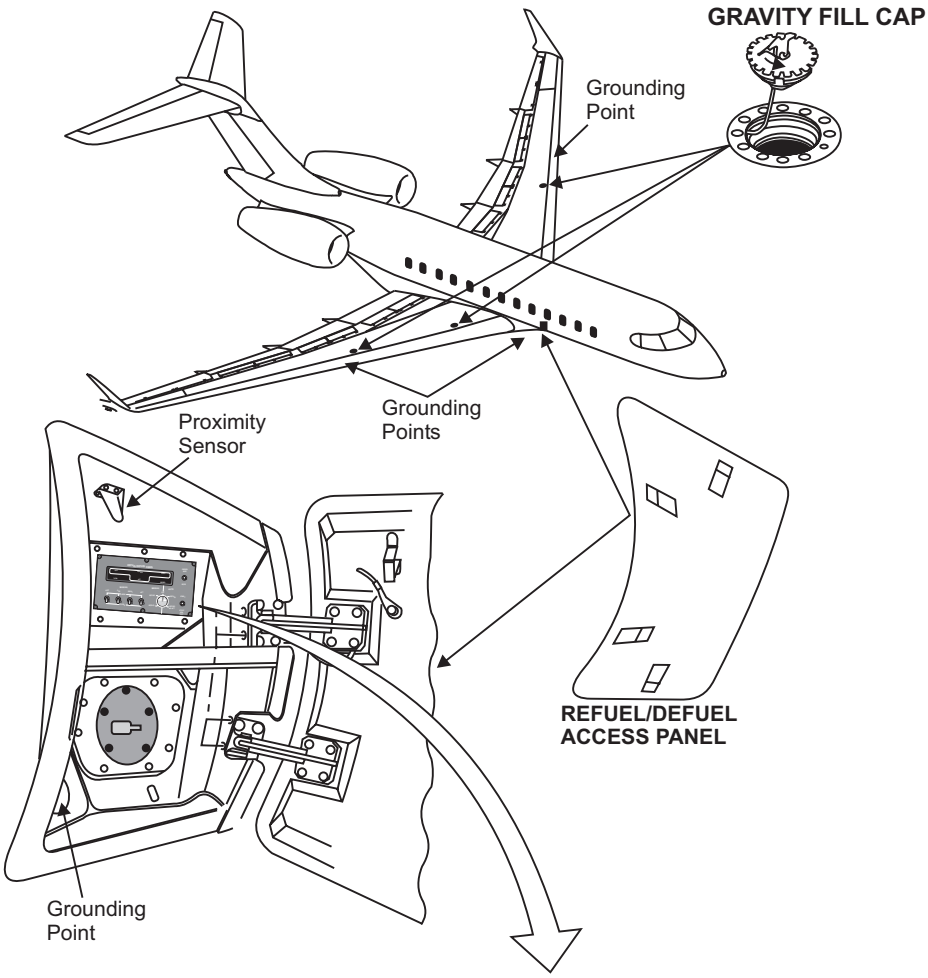
Display of system status is provided through EICAS messages. A L (R) FUEL RECIRC FAIL caution message will be displayed on the EICAS status page when the FRTT valve is not in the commanded or allowed position. The L (R) FUEL RECIRC ON status message will be displayed when the system operates properly and within specification on aircraft equipped with FMQGC prior to -9. Aircraft equipped with FMQGC -9 or later have a L (R) FUEL RECIRC OFF status message associated with PBA as the recirc function is automatic.

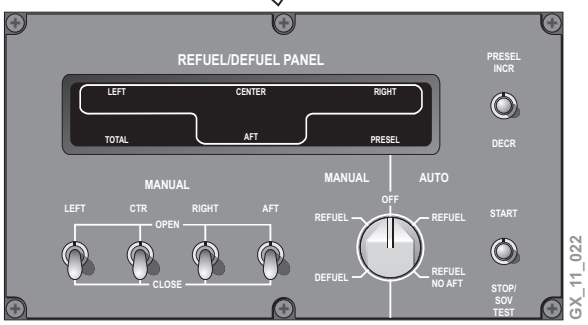
The FUEL HI TEMP caution message is posted when the bulk fuel temperature exceeds 43°C (FMQGC prior to -9), (+54°C -9 FMQGC and later) when the Fuel Recirculation System is OFF. To prevent the system from operating above the freezing level, the set point has been reduced to 0°C (FMQGC prior to -9), (+10°C -9 FMQGC and later) when the system is selected on.

REFUEL/DEFUEL SYSTEM

Pressure refueling/defueling operations are controlled from the refuel/defuel control panel. Pressure refueling can be accomplished in “MANUAL” or “AUTO” mode of operation.

Gravity filling via a filler point is also provided for the wing and center tanks.





REFUEL/DEFUEL PANEL

REFUEL DISTRIBUTION

Refer to Refuel Schematic for component location, recognition, and operation.

All fuel tanks can be refueled either automatically (by the FMQGC) or manually (by the refuel/defuel panel). The recommended pressure is 50 psig for pressure fueling.

A balance line in each tank is used during refueling to transfer fuel to the most outboard section of the wing.

The filling sequence of the wing compartment during pressure refueling is as follows:

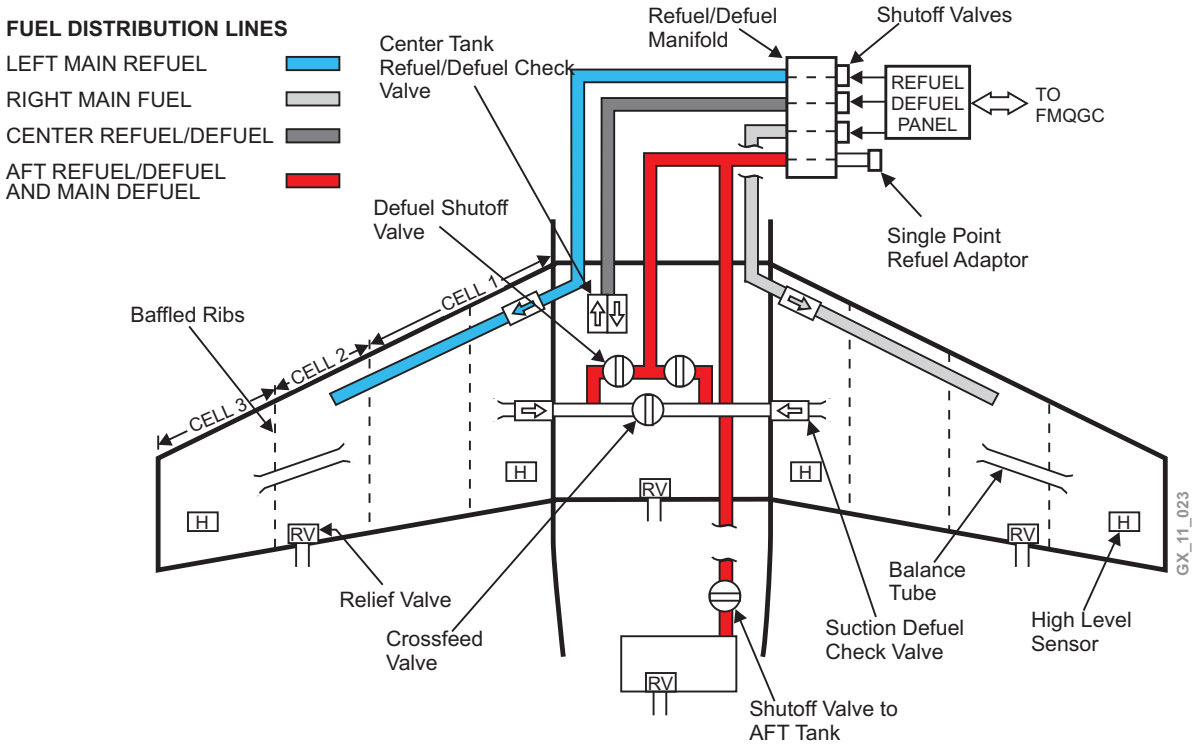
- Cell 2 is filled directly by the refuel system, fuel flows inboard by gravity into
- Cell 1, which is the inboard section including the feed tank. After inboard cells 1 and 2 are completely filled
- Cell 3 is filled to capacity by overflow of cell 2 fuel through the balance tube connecting cells 2 and 3

The aft and center tanks will be refueled simultaneously (automatically by the FMQGC) to maintain center-of-gravity (C of G) limits.

High level sensors installed in each tank automatically close the refuel/defuel SOVs, if the maximum fuel level capacity is reached. Relief valves augment the normal vent system to prevent overpressure in case of overfilling a tank.

As with the wing tanks, automatic refueling of the center tank is controlled by the FMQGC, with automatic shutoff commanded by the high level sensor. Automatic refueling of the aft tank is controlled by the FMQGC, with automatic shutoff commanded by the high level sensor.

REFUEL/DEFUEL SCHEMATIC



NORMAL FUEL LOADING

The normal fuel loading logic as planned by the FMQGC is as follows: Note that when the refuel process starts, fuel flows to all of the tanks at the same time until they reach the planned amount.

- Wing tanks only if the required fuel load is equal to or less than the wing tank capacity
- Wing tanks full and the remainder in the aft tank if the required fuel load is greater than the wing tank capacity but less than or equal to the combined capacity of the wing and aft tanks
- Any fuel in excess of the combined capacity of the wing and aft tanks is placed in the center tank

NOTE

The fuel computer always strives to keep between 0 and 400 lb maximum lateral imbalance, regardless of what FMQGC version we have.

For FMQGC (pre-5), the logic was set to stop fuel loading and display inhib on the fuel panel as soon as the lateral imbalance reached 400 lb. Since -5 FMQGC, the software now allows the imbalance to reach 1100 lb before shutting down and going into inhib mode.

An additional switch position on the refuel/defuel panel allows auto refueling without adding fuel to the aft tank.

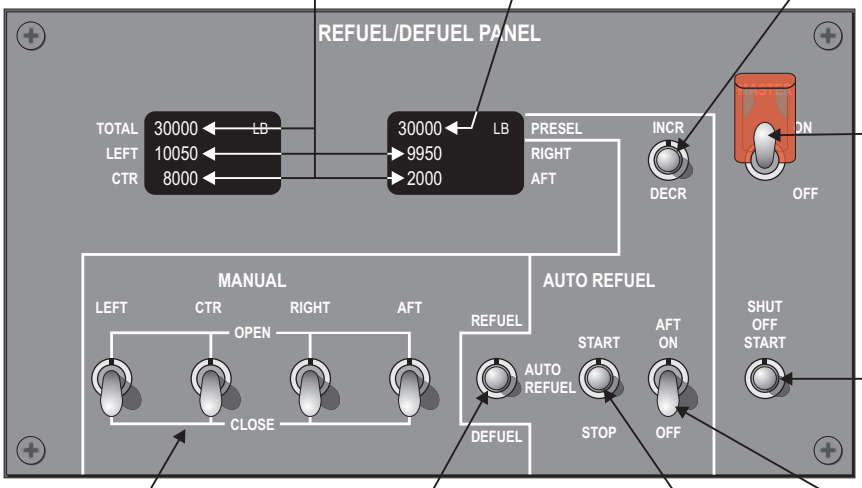
If the aft tank fueling is inhibited by use of this switch, then the refuel sequence is as follows:

- Wing tanks only if the required fuel load is equal to or less than the wing tank capacity
- Wing tanks full and the remainder in the center tank if the required fuel load is greater than the total wing capacity

Fuel Imbalance Limitations

WING TANK FUEL LOAD	GROUND/CONFIGURED FOR TAKEOFF/LANDING	FLIGHT - CLEAN CONFIGURATION
Less than 19,450 lb	1,100 lb	1,100 lb
19,450 to 20,250 lb	1,100 to 600 lb	1,100 lb
Greater than 20,250 lb	600 lb	1,100 lb

REFUEL/DEFUEL PANEL



FUEL QUANTITY Displays
Displays current tank quantities.

PRESELECT Display
Indicates preselected total quantity.

INCR/DECR Switch
Increases or decreases PRESEL quantity for AUTO refueling

MASTER Switch
Applies APU battery power to refuel/defuel system.

SHUT OFF TEST Switch
Performs test of the automatic shutoff system.

LEFT/CTR/RIGHT/AFT MANUAL Switches
Manually controls valves open or closed.

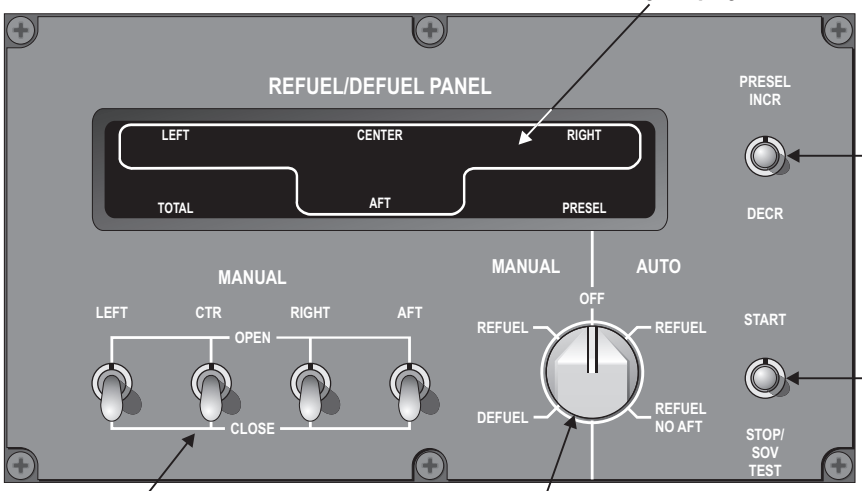
MODE SELECTOR Switch
REFUEL – Enables manual refueling.
AUTO REFUEL – Enables auto refueling.
DEFUEL – Enable manual defuel.

START/STOP Switch
Starts or stops automatic refueling.

AFT ON/OFF Switch
Enables/disables automatic refueling of the aft tank.

EARLIER VERSION

Quantity Displays



PRESEL INCR/DECR Switch
Increases or decreases the preselected quantity for AUTO refueling

START/STOP/SOV TEST Switch
START – Starts automatic refueling
STOP/SOV TEST – Stops automatic refueling and performs SOV test.

LEFT/CTR/RIGHT/AFT MANUAL Switches
Manually controls valves open or closed.

MODE SELECTOR
OFF – No power to panel
AUTO / REFUEL – Selected when aircraft to be fueled automatically to a preselected fuel load.
AUTO / REFUEL NO AFT – Selected when no fuel required in aft tank during AUTO refueling.
MANUAL / REFUEL – Selected when fuel tanks filled manually by operator.
MANUAL /DEFUEL – Selected when defueling aircraft by manually opening tank SOV's.

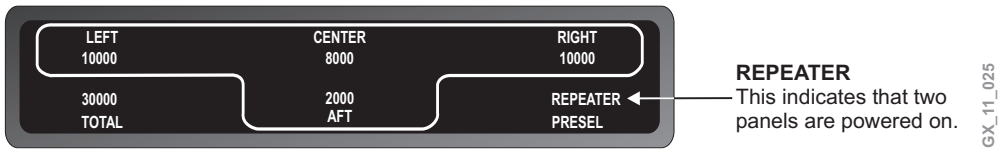
LATER VERSION

GX_11_024

FAULT REPORTING

Fault reporting is in the form of error messages which will appear in the display windows of the refuel/defuel panel.

The following illustration represents one example of fault reporting:



ERROR MESSAGES

The following messages may be displayed on the refuel/defuel panel if a fault exists:

INHIBIT
In manual refuel or defuel mode, displayed when a tank switch is in the OPEN position. In pressure defuel mode, displayed when an engine is on (no fire handles pulled). In auto mode, displayed when the preselected fuel quantity is invalid, airplane is in CAIMS maintenance mode, or the SOV shutoff test fails.

FULL
Displayed when the high level shutoff has been activated.

LOAD ERROR
In auto refuel mode, displayed when an invalid fuel distribution is selected. Example, one tank contains more fuel than the target quantity assigned by the automatic distribution.

IMBAL
Displayed when a predetermined fuel quantity imbalance exists between the left and right wings.

REPEATER
Displayed in the PRESEL window of the external Refuel/Defuel Panel when two panels are powered ON. The panel located in the flight compartment is in control and the outside panel provides quantity display only.

_ _ _ _ _ _
Dashes will be displayed for a fuel quantity if the computed value is invalid.

FAILED
Displayed in the PRESEL window if the Refuel/Defuel Panel is not functional.

FMQGC - FAILURE
FMQGC will be displayed in the TOTAL window and FAILURE in the PRESEL window if the Refuel/Defuel Panel is not communicating with the fuel computer.

PRESSURE REFUELING

Pressure refueling is accomplished through the single point refuel/defuel adapter, located in the right hand wing root, and is controlled by the refuel/defuel control panel. An optional duplicate refuel/defuel control panel can be installed in the flight compartment.

NOTE

A SHUTOFF TEST must be carried out prior to all refueling operations.

If the test is successful, a SOV PASS is displayed in the PRESEL window. If the test fails, a SOV FAIL is displayed in the PRESEL window.

Pressure refueling may be performed in either “automatic” or “manual” mode. The airplane does not have a fuel jettison system.

A preselect fuel quantity is used during automatic refueling of the airplane. This method will allow the airplane to be filled automatically to the desired fuel state selected.

NOTE

The preselect quantity is the desired final total fuel quantity in the tanks, and not the quantity to be added.

The computer determines the required distribution of fuel into each of the aircraft tanks to achieve the preselected value and controls each refuel valve accordingly. The refuel schedule (planning only) will fill the wings first, then the aft tank, then the center tank. If the aft or center tanks are used each will be fueled to a minimum of 500 pounds to ensure pump priming. The shutoff point, for each tank, is “anticipated” by the computer by monitoring the refueling rate to determine the correct shutoff point for each individual refueling operation.

When auto refueling is terminated by the computer, the quantity showing in the TOTAL window is equal to that in the PRESEL window.

Auto refueling can be interrupted at any time by moving the START/STOP switch to the STOP position. Individual tank quantities can be seen in the other two windows of the display.

The AFT ON/OFF switch allows auto refueling to take place with or without fuel being placed in the aft tank.

EARLIER VERSION RDCP REFUEL/DEFUEL PROCEDURES

NOTES

1. The maximum refueling pressure is 50 psig.
2. The Tank Pressure Relief Valves must be tested for proper function prior to refueling by manually operating the three external pull handles.
3. Maximum fuel imbalance of 400 pounds/1100 pounds (depending on FMQGC software version, see NORMAL FUEL LOADING section) is allowed between the two main tanks, following which, the tank quantity window on the RDCP flashes an IMBAL message alternating with the tank quantities every two seconds.
4. A SHUTOFF TEST of the system must be conducted during each refueling.

AUTO REFUEL

The procedure for auto refuel is as follows:

- Open the RDCP access panel
- Place the MASTER switch in the ON position
- Allow the FMQGC to conduct BITE test until tank quantities are displayed steady in all windows

NOTE

If a system fault is detected, the windows will display dashed lines or error message(s) in the individual tank windows instead of quantities. Do not proceed without investigating and rectifying fault.

- Verify no error messages are displayed in any of the individual tank quantity windows
- Verify all MANUAL tank switches are in the CLOSE position
- Place the MODE SELECTOR switch in the AUTO REFUEL position
- Note the quantities in the TOTAL and PRESEL windows. They should be the same
- Place the AFT switch in the ON or OFF position as required
- Hold the PRESEL switch in the INCR position until the PRESEL window displays the desired total fuel quantity
- Connect the refuel tender to the single point adapter and adjust the tender pressure as desired but not to exceed 50 psig

- Place the START/STOP switch in the START position and release it
- Verify tank quantities show increase
- Place the spring-loaded SHUTOFF TEST switch in the TEST position and hold it.
- Verify the PRESEL window displays SOV TEST
- Verify all tank quantities stop increasing to confirm the refuel valves have closed
- Verify the PRESEL window displays SOV STOP alternating with the preselected value and does not display SOV FAIL
- Release the SHUTOFF TEST switch and verify tank quantities resume showing increase with the preselected quantity showing steady in the PRESEL window
- The FMQGC shall control the fueling sequence automatically within the required loading sequence
- When all tank quantities stop registering an increase, verify that the displays in the TOTAL and the PRESEL window are the same and no error message is displayed in any of the windows. Each tank window should display the quantity in it as distributed by the FMQGC in the automatic mode and should add up to the TOTAL displayed
- Disconnect the tender as required and return the RDCP MASTER switch to the OFF position
- Secure RDCP access panel

MANUAL REFUELING

In “manual” mode, it permits the operator to select and control the fuel quantity to be added in each tank through the refuel/defuel panel. In this mode, the high level sensors automatically close the refuel/defuel SOVs, if the maximum fuel level capacity is reached.

MANUAL REFUEL

The procedure for manual refuel is as follows:

- Open the RDCP access panel
- Place the MASTER switch in the ON position
- Allow the FMQGC to conduct BITE test until tank quantities are displayed steady in all windows

NOTE

If a system fault is detected, the windows will display dashed lines or error message(s) in the individual tank windows instead of quantities. Do not proceed without investigating and rectifying fault.

- Verify no error messages are displayed in any of the individual tank quantity windows
- Verify all MANUAL tank switches are in the CLOSE position
- Verify MODE SELECTOR switch is in the mid position marked AUTO REFUEL
- Note the quantities in the TOTAL and PRESEL windows. They should be the same
- Move the MODE SELECTOR switch up to the position marked MANUAL REFUEL
- Verify the PRESEL window displays the message MANUAL instead of quantity
- Connect the refuel tender to the single point adapter and adjust the tender pressure as desired but not to exceed 50 psig
- Select the desired tank MANUAL switches to the OPEN position
- Verify that the selected tank quantities show increase
- Place the spring loaded SHUTOFF TEST switch in the TEST position and hold it
- Verify the PRESEL window displays SOV TEST
- Verify all tank quantities stop increasing to confirm the refuel valves have closed
- Verify the PRESEL window displays SOV STOP alternating with MANUAL and does not display SOV FAIL
- Release the SHUTOFF TEST switch and verify tank quantities resume showing increase with MANUAL showing steady in the PRESEL window
- When the desired fuel quantity for the selected tank is displayed on the tank window, return the MANUAL switch to the CLOSE position to terminate the fueling operation
- Return the MODE SELECTOR switch to AUTO REFUEL
- Disconnect the tender as required and return the RDCP MASTER switch to the OFF position
- Secure RDCP access panel

GRAVITY REFUELING

The wing tanks may be refueled through over wing gravity fill adapters located on top of both left and right wings. It is not possible to completely fill either wing tank by gravity fueling, since the fill adapters are located outboard and below the maximum fuel level.

The center tank may be refueled through a gravity fill adapter located on top of the right hand wing.

Gravity fueling of the aft tank is not possible therefore; no fill adapter is provided.

SUCTION DEFUELING

Suction defueling of the fuel tanks is carried out by applying suction (recommended pressure of -8 psig) to the single point refuel/defuel adapter, using the refuel/defuel control panel.

WING TANK

Suction defueling of the wing tanks is accomplished by opening a valve which connects the refuel/defuel manifold to the engine feed line. This allows fuel to be drawn out of the tank through the suction defuel check valve in the feed tank.

CENTER TANK

The center tank is defueled through the refuel/defuel shutoff valve.

AFT TANK

The aft tank may be suction defueled, using the same line and shutoff valve used for pressure refueling of the tank.

SUCTION DEFUEL

The procedure for suction defuel is as follows:

- Open the RDCP access panel
- Place the MASTER switch in the ON position
- Allow the FMQGC to conduct BITE test until tank quantities are displayed steady in all windows

NOTE

If a system fault is detected, the windows will display dashed lines or error message(s) in the individual tank windows instead of quantities. Do not proceed without investigating and rectifying fault.

- Verify no error messages are displayed in any of the individual tank quantity windows
- Verify all MANUAL tank switches are in the CLOSE position
- Verify the AUTO REFUEL switch is in the mid position marked AUTO REFUEL
- Note the quantities in the TOTAL and PRESEL windows. They should be the same
- Move the MODE SELECTOR switch to the position marked MANUAL DEFUEL
- Verify the PRESEL window displays the message DEFUEL

- Connect the refuel tender to the single point adapter and adjust the tender pressure to negative 8 psig (suction) maximum
- Select the desired tank MANUAL switches to the OPEN position
- Verify tank quantities show decrease
- When the desired fuel quantity for the selected tank is displayed on the tank window, return the MANUAL switch to the CLOSE position to terminate the defueling operation
- Move the MODE SELECTOR switch to AUTO REFUEL
- Disconnect the tender as required and return the RDCP MASTER switch to the OFF position
- Secure RDCP access panel

PRESSURE DEFUELING

Pressure defueling of the fuel tanks is accomplished through the fuel shutoff valves and single point adapter. Pressure defueling is identical to suction defueling, except that primary defueling flow is provided by the AC boost pumps or DC auxiliary pump in each feed tank.

NOTE

AC or DC electrical power is required to operate the airplane pumps for this procedure.

Direct pressure defueling of the wing tank is accomplished using the AC boost pumps or DC auxiliary pump in each feed tank.

Direct pressure defueling of the center tank is not possible. Center tank fuel may however be transferred to the wing tanks using the center tank transfer pumps. From there, it may then be defueled via the wing tank.

Direct pressure defueling of the aft fuselage tank is not possible. Aft fuselage tank fuel may however be transferred to the wing tanks using the aft transfer pumps. From the wing tank, it may then be defueled via the wing tank.

LATER VERSION RDCP REFUEL/DEFUEL PROCEDURES

Differences in Later Refuel/Defuel Panel are as follows:

- The MODE SELECTOR switch is now rotary and includes the aft tank control switch
- The START/STOP switch now includes the SOV test function
- The master ON/OFF switch is part of the mode selector switch

EICAS MESSAGES

FUEL IMBALANCE
Indicates that a fuel quantity imbalance exists between the left and right wing tanks of:
– More than 1100 lbs (499 kg) in flight
– Between 600 lbs (272 kg) and 1100 lbs (499 kg) on ground or in Takeoff / Approach configuration.

AFT XFER OFF SCHED
Indicates that fuel transfer from the aft tanks to the wings is unable to keep pace with the optimum aft transfer schedule.

FUEL COMPUTR FAIL
Indicates that both channels of the fuel system computer have failed.

FUEL LO QTY
Indicates fuel in the left or right wing tank is less than 600 lbs (272 kg).

L (R) FUEL RECIRC FAIL
Indicates that the FRTT valve is not in the commanded or allowed position.

FUEL UNIT MISMATCH
The refuel/defuel panel and EICAS indications are correct but in different units of measurements.

→ FUEL XFER FAIL
Transfer from the left wing to the right wing has been requested and failed.

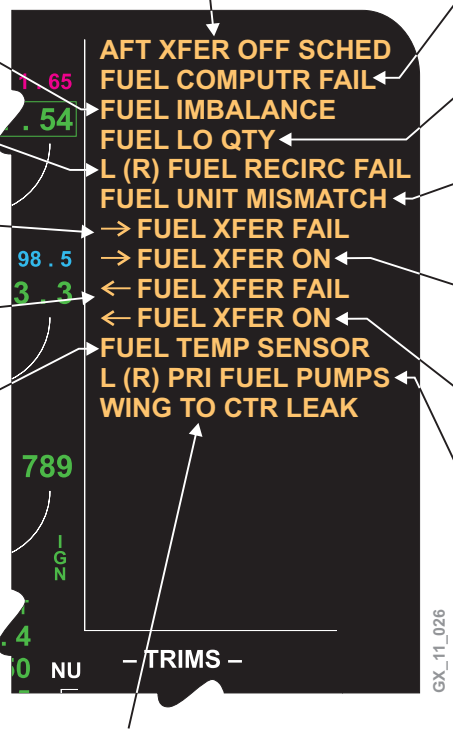
→ FUEL XFER ON
Indicates that fuel is being transferred from the left wing tank to the right wing unrequested.

← FUEL XFER FAIL
Transfer from right wing to left wing has been requested and failed.

← FUEL XFER ON
Indicates that fuel is being transferred from the right wing tank to the left wing unrequested.

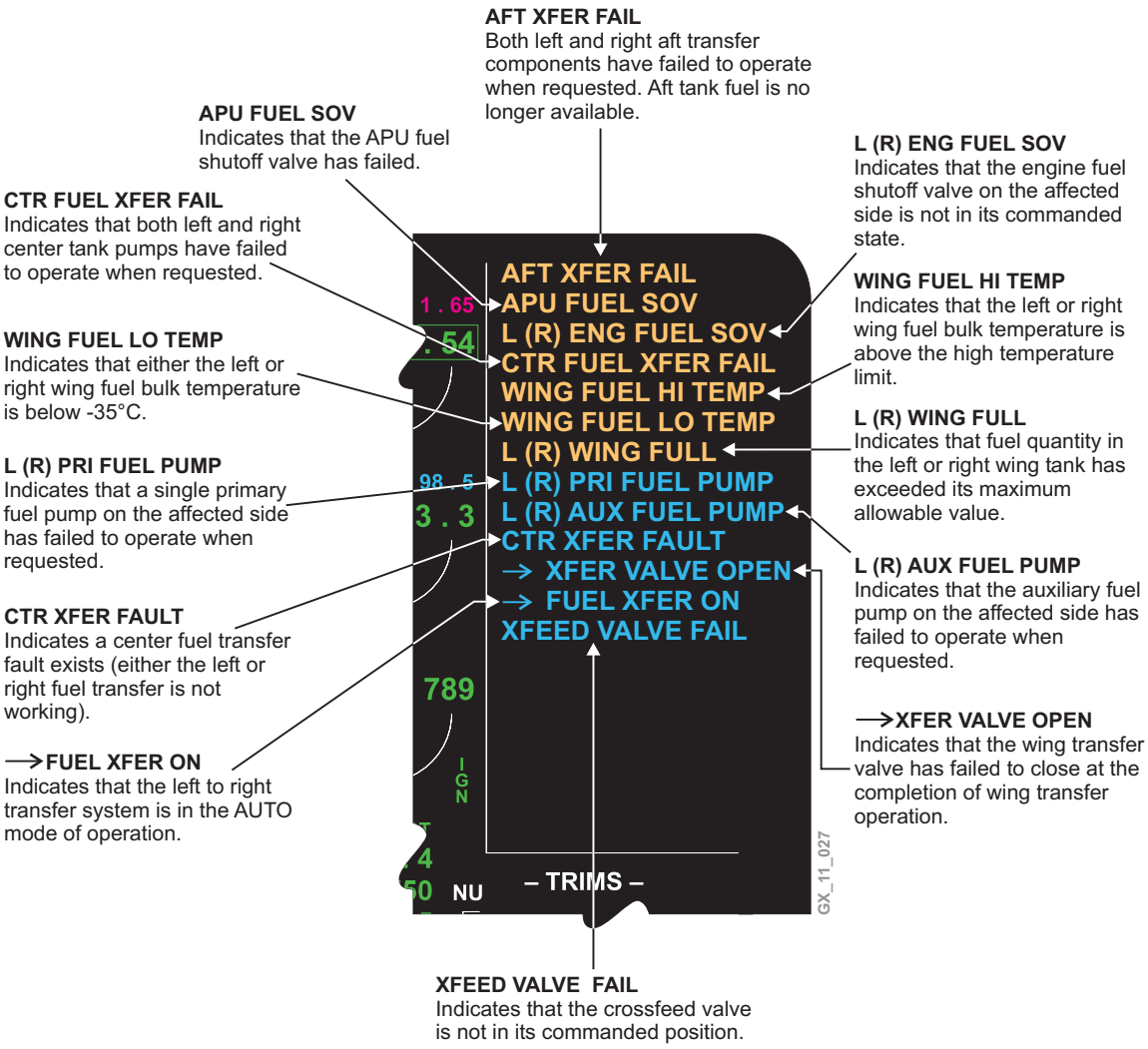
FUEL TEMP SENSOR
On ground, indicates that a fuel temperature sensor is failed. With flaps deployed, will be posted only if the failure requires corrective action.

L (R) PRI FUEL PUMPS
Indicates both left or both right forward and aft primary AC pumps have failed to operate when requested.



WING TO CTR LEAK
Indicates that the fuel level in the center tank has increased by 600 lbs or more.

EICAS MESSAGES (Cont)



AFT XFER FAIL
Both left and right aft transfer components have failed to operate when requested. Aft tank fuel is no longer available.

APU FUEL SOV
Indicates that the APU fuel shutoff valve has failed.

L (R) ENG FUEL SOV
Indicates that the engine fuel shutoff valve on the affected side is not in its commanded state.

CTR FUEL XFER FAIL
Indicates that both left and right center tank pumps have failed to operate when requested.

WING FUEL HI TEMP
Indicates that the left or right wing fuel bulk temperature is above the high temperature limit.

WING FUEL LO TEMP
Indicates that either the left or right wing fuel bulk temperature is below -35°C.

L (R) WING FULL
Indicates that fuel quantity in the left or right wing tank has exceeded its maximum allowable value.

L (R) PRI FUEL PUMP
Indicates that a single primary fuel pump on the affected side has failed to operate when requested.

L (R) AUX FUEL PUMP
Indicates that the auxiliary fuel pump on the affected side has failed to operate when requested.

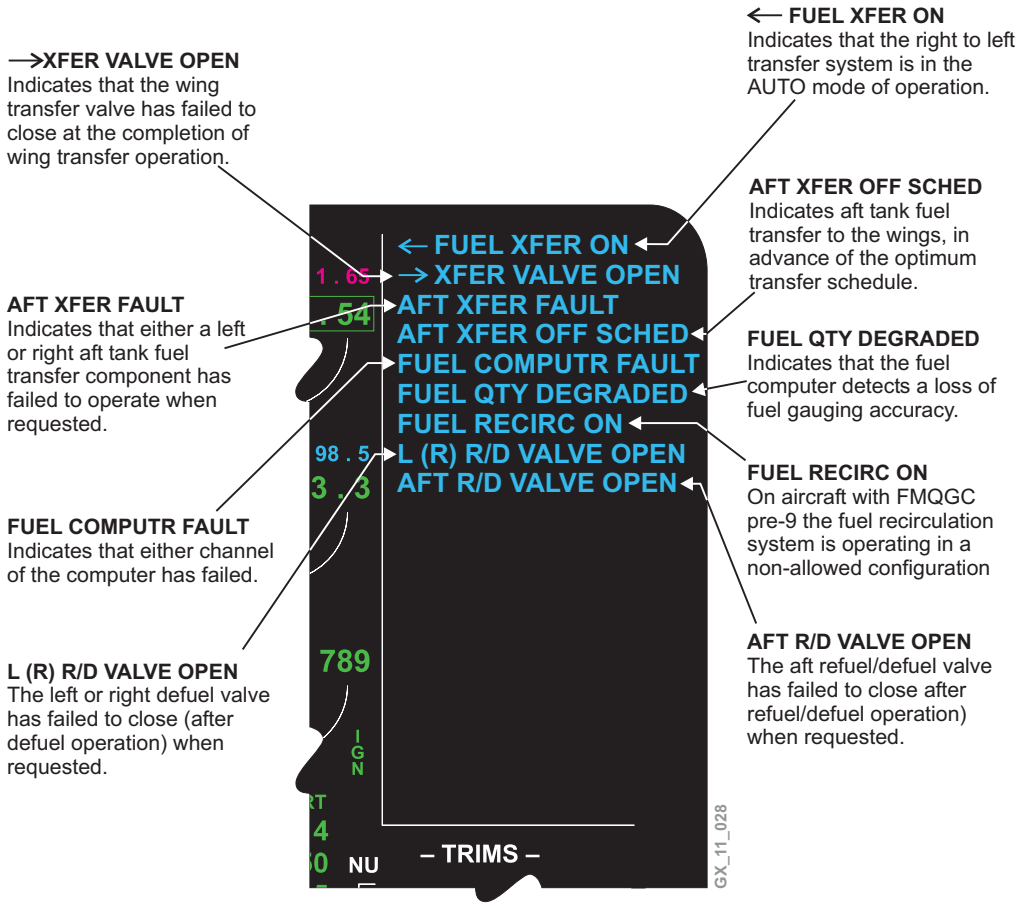
CTR XFER FAULT
Indicates a center fuel transfer fault exists (either the left or right fuel transfer is not working).

→XFER VALVE OPEN
Indicates that the wing transfer valve has failed to close at the completion of wing transfer operation.

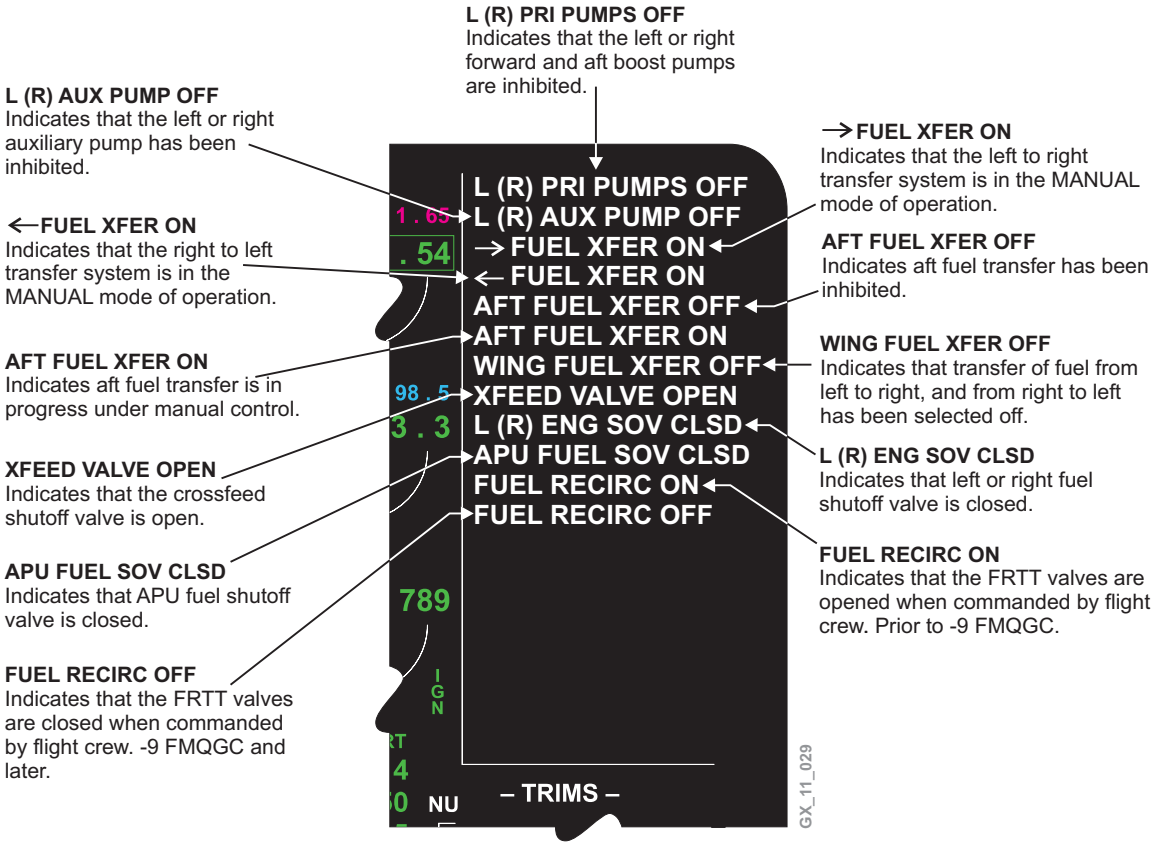
→FUEL XFER ON
Indicates that the left to right transfer system is in the AUTO mode of operation.

XFEED VALVE FAIL
Indicates that the crossfeed valve is not in its commanded position.

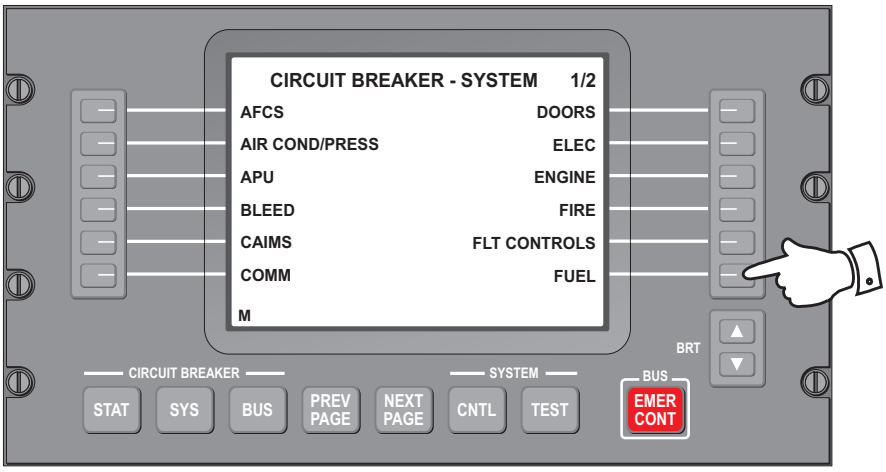
EICAS MESSAGES (Cont)



EICAS MESSAGES (Cont)



EMS CIRCUIT PROTECTION



CB - FUEL SYSTEM 1/6			
XFER SOV C	DC ESS		IN
XFER SOV O	DC ESS		IN
XFER SOV C	BATT		IN
XFER SOV O	BATT		IN
AFT TANK L PUMP	AC 2		IN
AFT TANK L SOV C	DC 1		IN

CB - FUEL SYSTEM 2/6			
AFT TANK L SOV O	DC 1	X	IN
AFT TANK R PUMP	AC 3	X	IN
AFT TANK R SOV C	DC 2	X	IN
AFT TANK R SOV O	DC 2	X	IN
APU FIRE SOV	DC EMER	DCPC	IN
FUEL COMPUTR CH A	BATT		IN

CB - FUEL SYSTEM 3/6			
FUEL COMPUTR CH B	DC ESS	X	IN
FUEL R/D CH A	APU BATT	ASCA	IN
FUEL R/D CH B	APU BATT	ASCA	IN
L AFT PRI PUMP	AC 1		IN
L AUX PUMP	DC ESS		IN
L CTR XFER PUMP	AC 1		IN

CB - FUEL SYSTEM 4/6			
L ENG FUEL SOV	DC EMER	DCPC	IN
L FWD PRI PUMP	AC 2	X	IN
L FUEL RECIRC VLV	DC 1	X	IN
R AFT PRI PUMP	AC 4	X	IN
R AUX PUMP	BATT	X	IN
R CTR XFER PUMP	AC 4	X	IN

CB - FUEL SYSTEM 5/6			
R ENG FUEL SOV	DC EMER	DCPC	IN
R FWD PRI PUMP	AC 3	X	IN
R FUEL RECIRC VLV	DC 2	X	IN
R/D MOTOR VALVES	APU BATT	ASCA	IN
R/D PANEL COCKPIT	APU BATT	ASCA	IN
R/D PANEL EXT	APU BATT	ASCA	IN

CB - FUEL SYSTEM 6/6			
R/D SOL VALVES	APU BATT	ASCA	IN
X FEED SOV C	BATT		IN
XFEED SOV O	BATT		IN

GX_11_030

NOTE: The fuel recirculation protection is not active, TBD by flight test.

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