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CHAPTER 12

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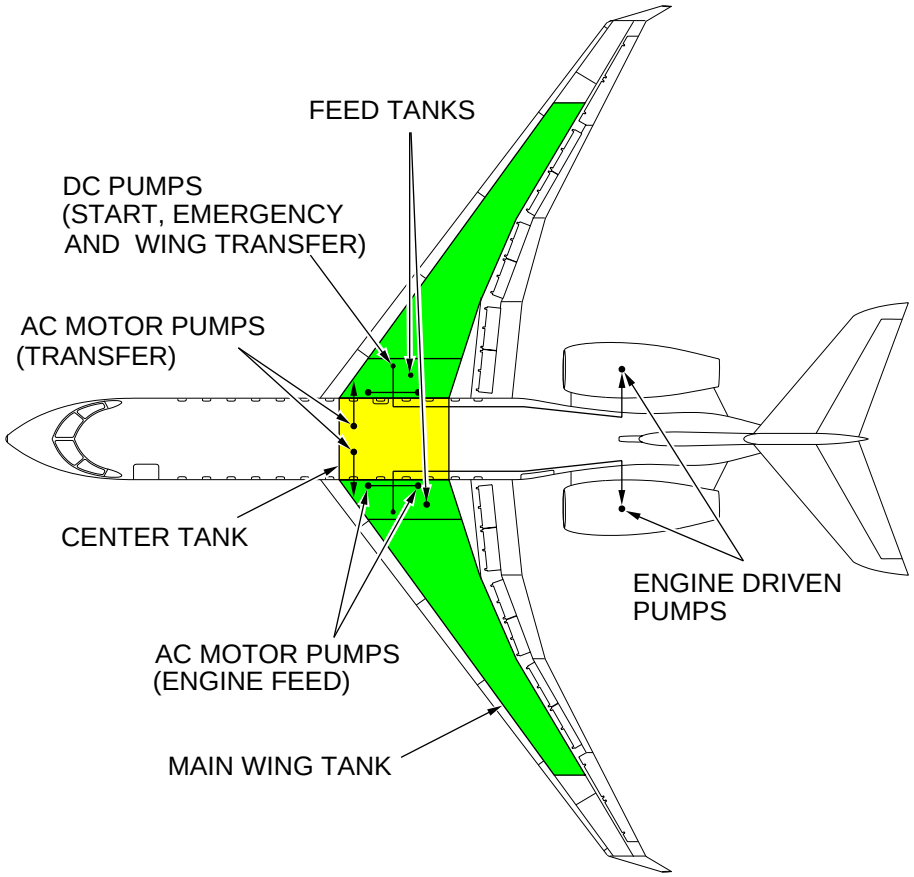
GENERAL

Fuel is contained in a wet wing box structure, which is sealed to form three main separate wing tanks (left wing, right wing and center wing). 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) back up boost pump. The transfer system maintains the feed tanks full during all attitudes and provides automatic transfer of fuel from the center 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 tank.

GENERAL (CONT'D)

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
- Refuel/defuel
- Fuel recirculation

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.

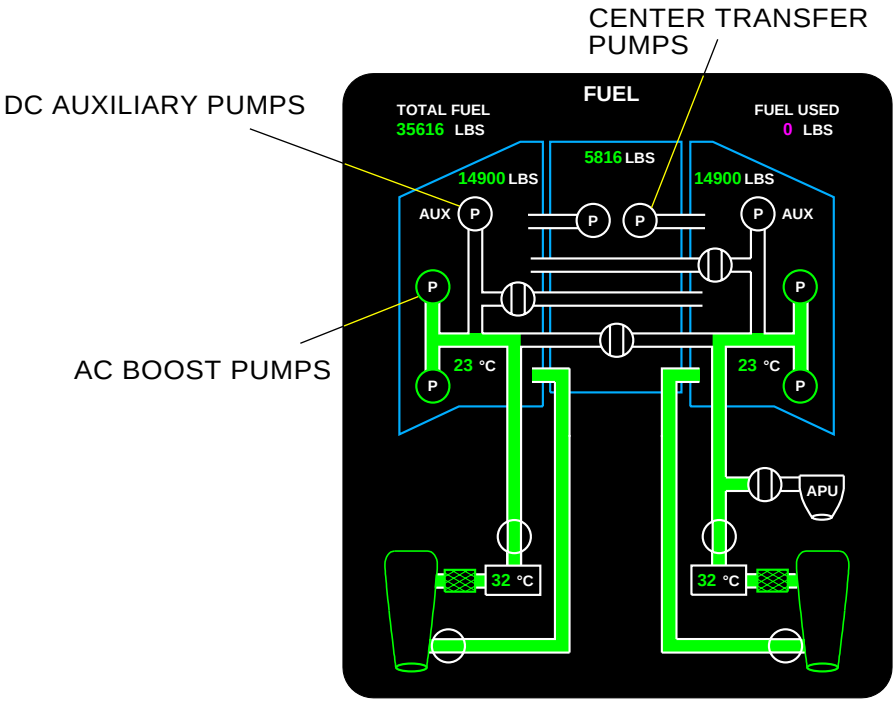
FUEL SPECIFICATIONS

For information on fuel additives, temperature limitations and approved fuels, refer to Airplane Flight Manual (AFM) CSP 700−5000−1 − LIMITATIONS Chapter.

Fuel remaining in a tank when the appropriate fuel quantity indicator reads zero is not usable. Refer to the AFM CSP 700−5000−1 for exact tank and total fuel quantity.

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.



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).

FUEL SYSTEM SYNOPTIC PAGE (CONT'D)

Center Transfer Pumps

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

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 in combination with certain EICAS messages, which represent the panel configuration or failure within a given system.

WING XFEED switch

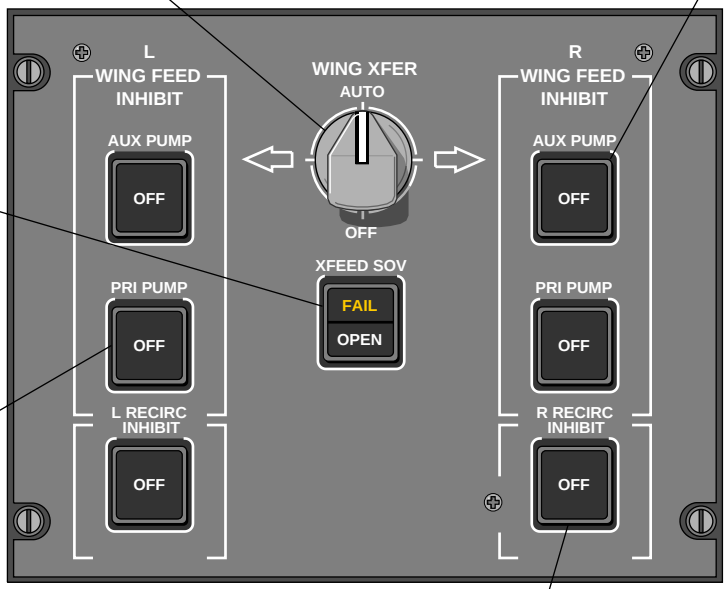
- **AUTO** selection − Provides a means of transferring fuel from one wing to the other. Controlled by the FMQGC.
- **<− or −>** selection − A left to right or a right to left selection, provides a means of transferring fuel (in the direction of the arrow) from one wing tank to the other.
- **OFF** selection − Provides a method of inhibiting wing to wing transfer.

AUX PUMP switch

- **OFF** light − Indicates that the right auxiliary pump has been disarmed. The left AUX PUMP has similar logic.

XFEED SOV switch

- **FAIL** light − Will come on when the valve does not go to the commanded position.
- **OPEN** light − When the switch is selected, the crossfeed valve opens and interconnects the engine feed lines.



PRI PUMPS Switch

- **OFF** light − Indicates that both left wing primary pumps have been disarmed. The right PRI PUMPS switch has similar logic.

RECIRC INHIBIT switch

- **OFF** light − Indicates that the FRTT valve is closed when commanded by the flight crew.

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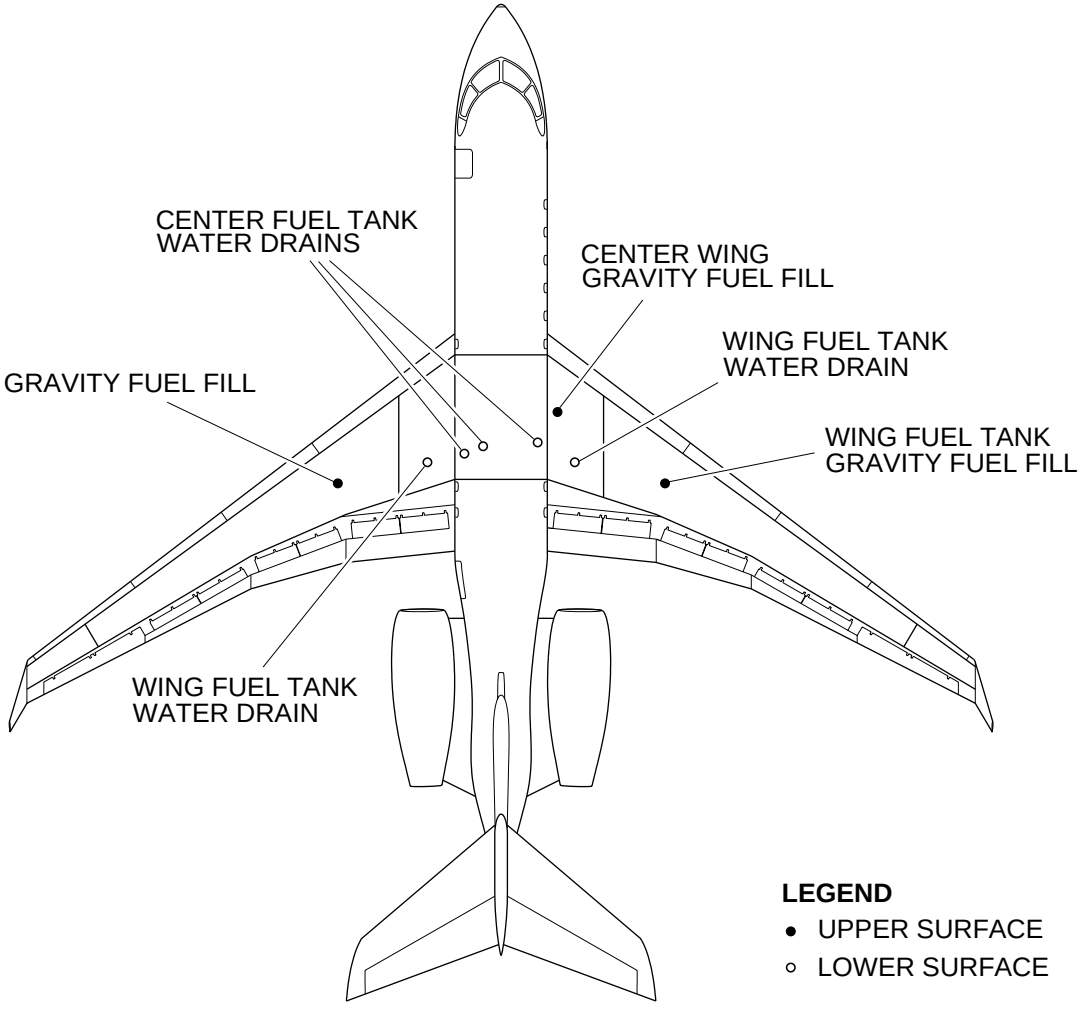
FUEL TANKS

All fuel is carried in three integral tanks (left wing, right wing and center wing).

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 wing tank by the transfer system.

SERVICE POINTS



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.

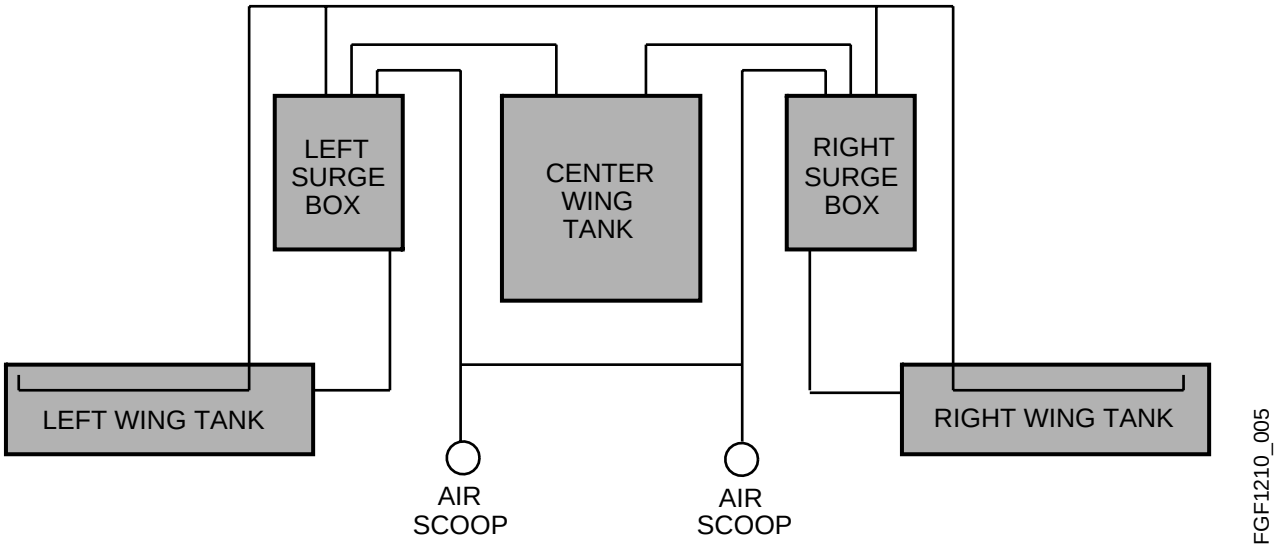
VENT SYSTEM

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 outlets (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 and center tanks.

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

VENT SYSTEM SCHEMATIC



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 and center tanks.

TRANSFER SYSTEM

Fuel contained in the center 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.

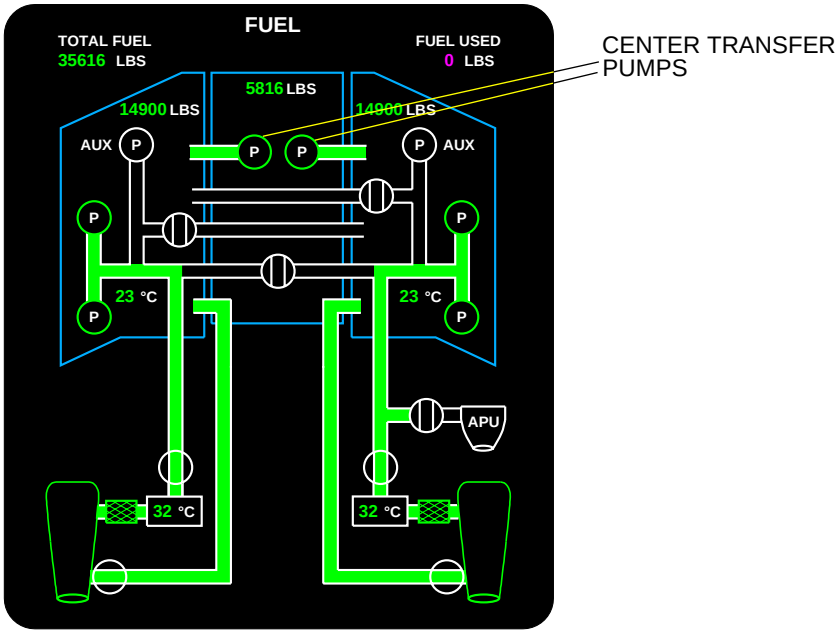
After depletion of center tank fuel quantity, no further transfer of fuel is required, since all remaining fuel is contained in the wing tanks.

Control of fuel transfer from the center tank is normally under control of the fuel computer. 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 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.

TRANSFER SYSTEM (CONT'D)

Auto Wing Transfer

The auto wing transfer mode is only enable when the slat/flap handle is in the In the wing transfer automatic 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 SOV's 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.

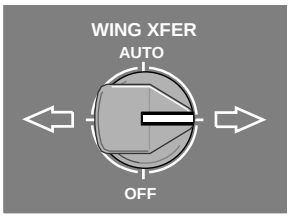
In the event of a center tank transfer pump failure, fuel will be transferred from the operating center tank transfer pump to its respective wing tank. The automatic wing transfer system will maintain lateral fuel balance, to ensure that fuel contained in the center tank is available to both engines.

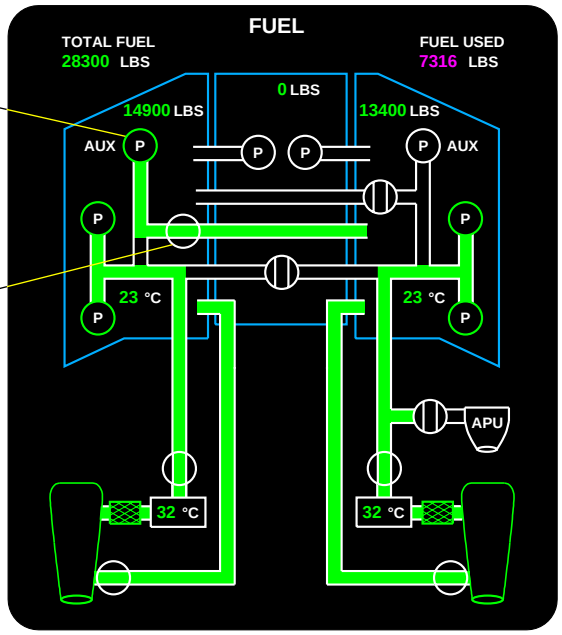
Manual Wing Transfer

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.

DC Auxiliary Pump
In wing transfer demand, commanded on by the FMQGC.

Wing Transfer Shutoff Valve
Commanded on by the FMQGC or manually by the switch on the fuel control panel.





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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 enable 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.

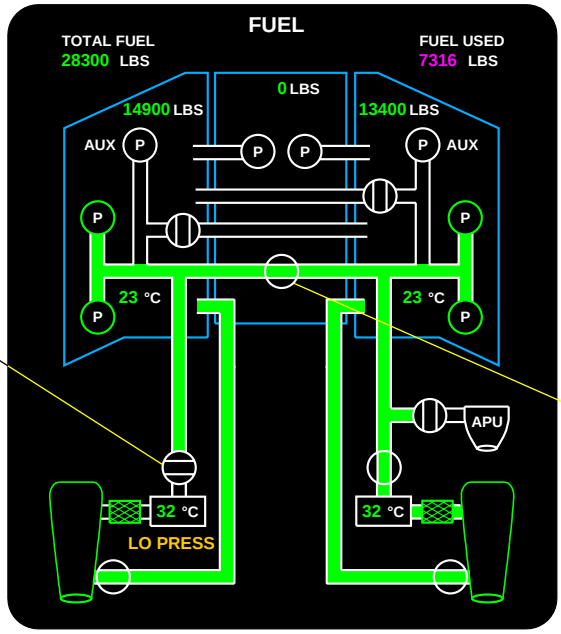
TRANSFER SYSTEM (CONT'D)

Crossfeed (Cont'd)

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.

Engine Feed Shutoff Valve

Commanded off when the fire handle is pulled.



Crossfeed Shutoff Valve

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

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The FUEL synoptic page 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 backup to the wing transfer system) is to provide means of correcting lateral C of G imbalances, by temporarily inhibiting the flow fuel from the light side of the airplane. Fuel will then be supplied to both engines from the heavy side until lateral fuel imbalance 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.

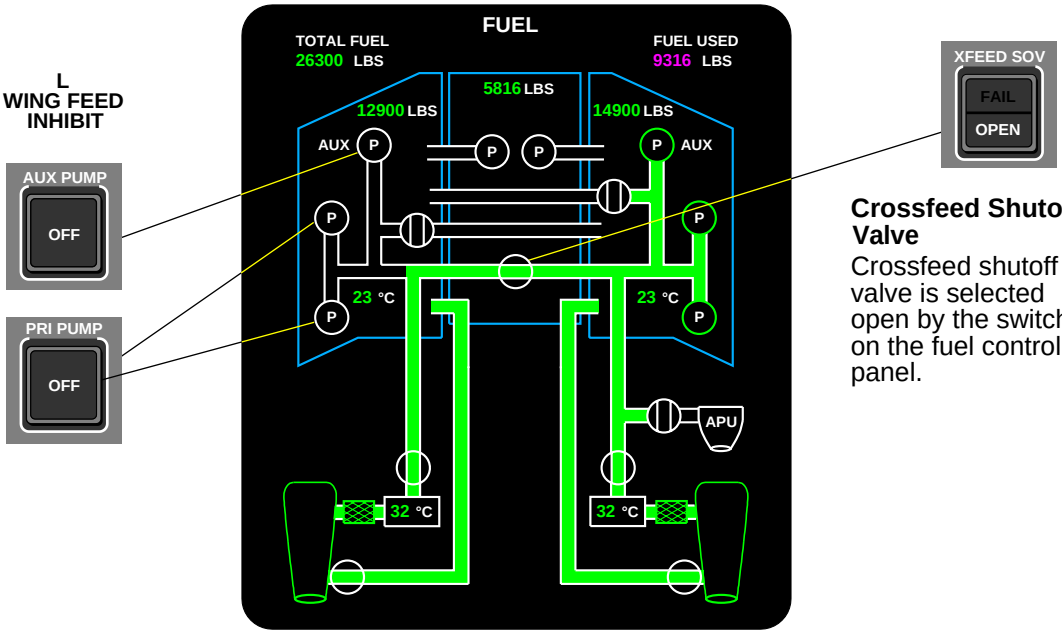
NOTE

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

TRANSFER SYSTEM (CONT'D)

Crossfeed (Cont'd)

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



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

FGF1210_009

The FUEL synoptic page 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 pumps inhibited and both engines running.

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 take-off, based on flaps/slats position and weight on wheels logic.

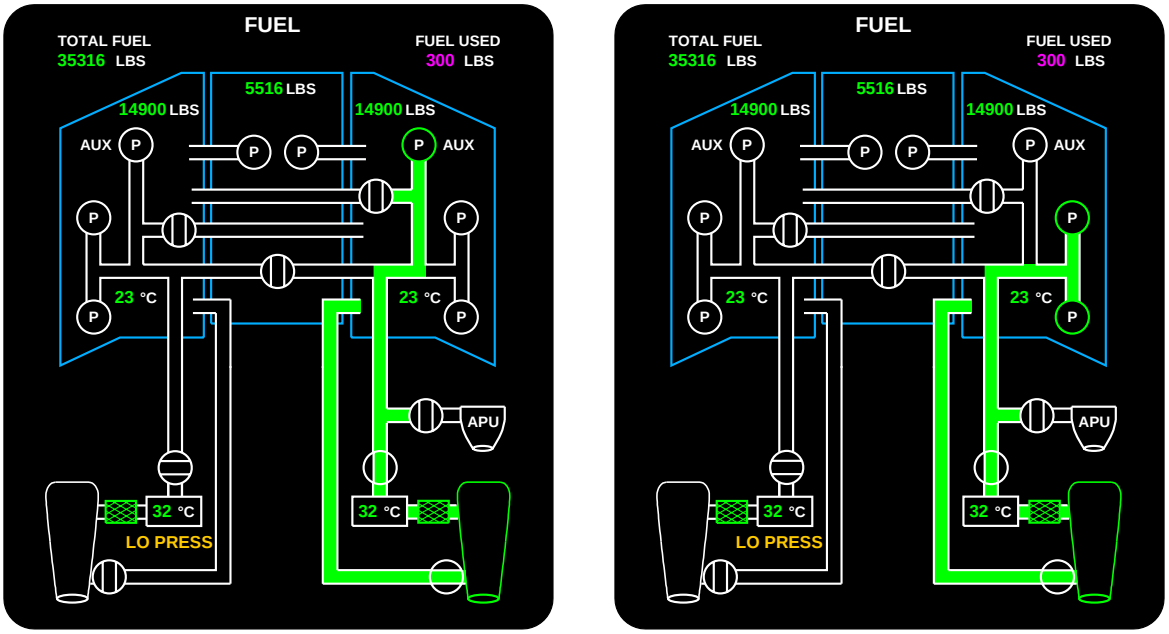
The engine fuel burn schedule is automatically controlled by the FMQGC to ensure correct distribution for all airplane configurations.

The engine fuel burn sequence is as follows:

- Fuel from the wing tanks will be consumed 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.

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.



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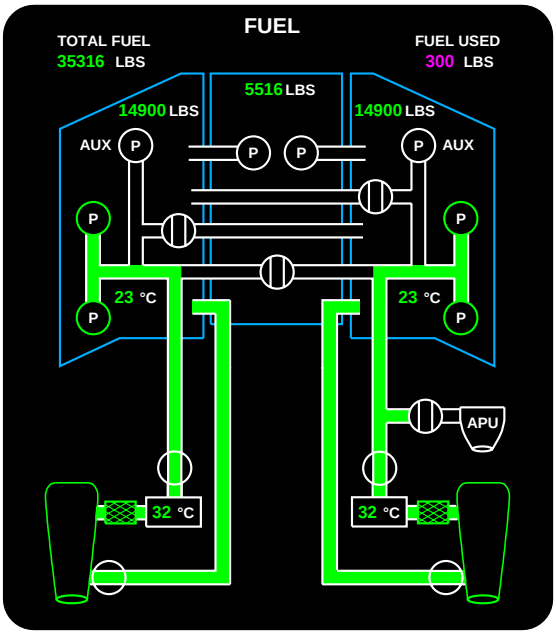
ENGINE FEED SYSTEM (CONT'D)

Engine Feed System Indication (Cont'd)

The FUEL synoptic display below represents airplane configuration with the APU shutdown, both engines on speed, AC pumps running and the DC pumps on standby.



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APU FUEL FEED

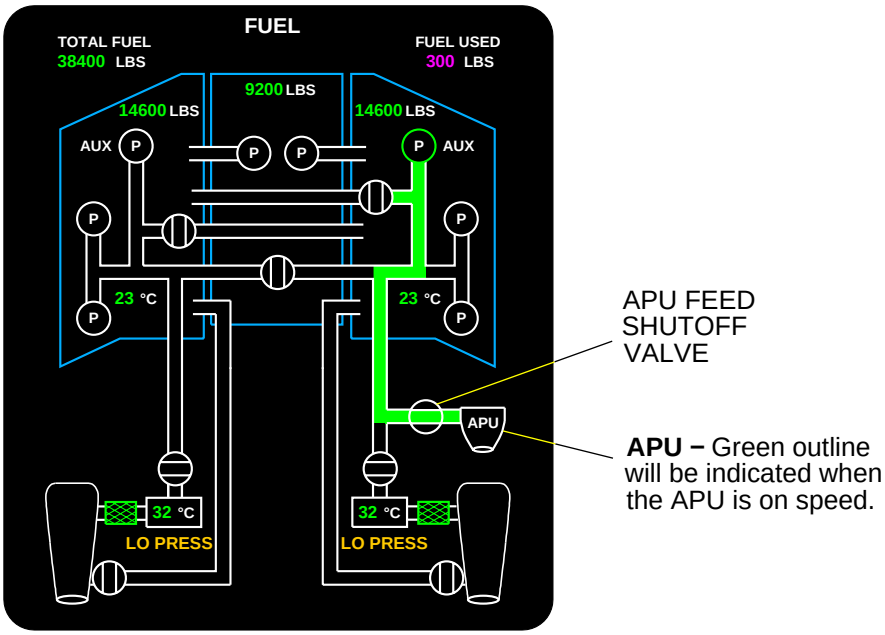
The APU start capability is normally provided by the DC AUX pump(s). The fuel supplied to the APU is taken from the right engine feed line. The APU can also be fed from the left engine feed line using the left DC AUX pump (powered by DC ESS bus) and opening the crossfeed shutoff valve (BATT bus). A motor 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 starting with the right 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 start in progress, left and right engines are off.



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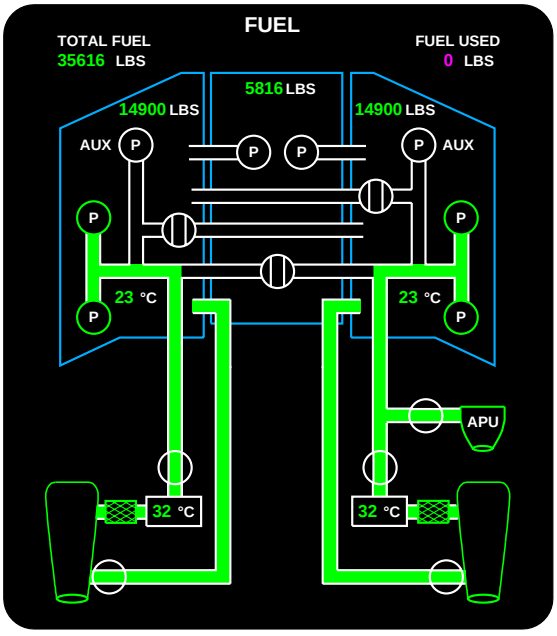
LOWER VIEW

NOTE

APU on speed, left and right engines on and AC electrics established.



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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 provide inputs to the FMQGC. The FMQGC uses these acquired data to compute the fuel quantity for each tank and total fuel quantity remaining on board the airplane.

The FMQGC provides 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.

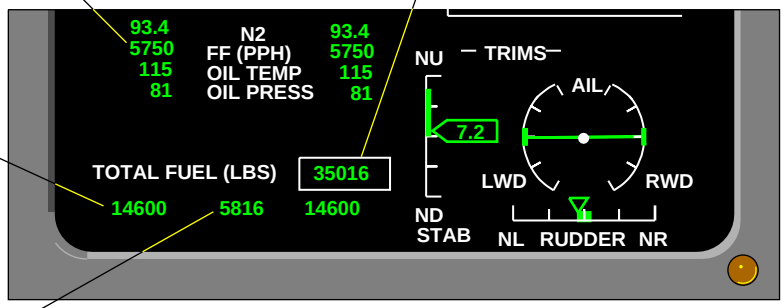
Fuel FLow Readout
Indicates fuel flow in pounds per hour (PPH) to the respective engine.

Total Fuel Readout
Indicates total fuel quantity in pounds (lbs), of all the tanks.

- Green − Total fuel quantity is valid and in normal range.
- Amber − The fuel quantity is low.
- Dashed − Fuel quantity is not valid.

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

- Green − Left and right tanks are balanced.
- Amber − A fuel quantity imbalance exists or applicable tank is less than 600 lbs (272 KG).
- Dashed − Fuel quantity is not valid



EICAS PRIMARY DISPLAY

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

- Green − Quantity is valid.
- Dashed − Fuel quantity is not valid.

FGF1210_014

The FMQGS can display fuel quantity in either LB (standard) or KG (optional). The primary EICAS page displays fuel quantity in all fuel tanks and total fuel in the airplane.

FLIGHT MANAGEMENT DISPLAY

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

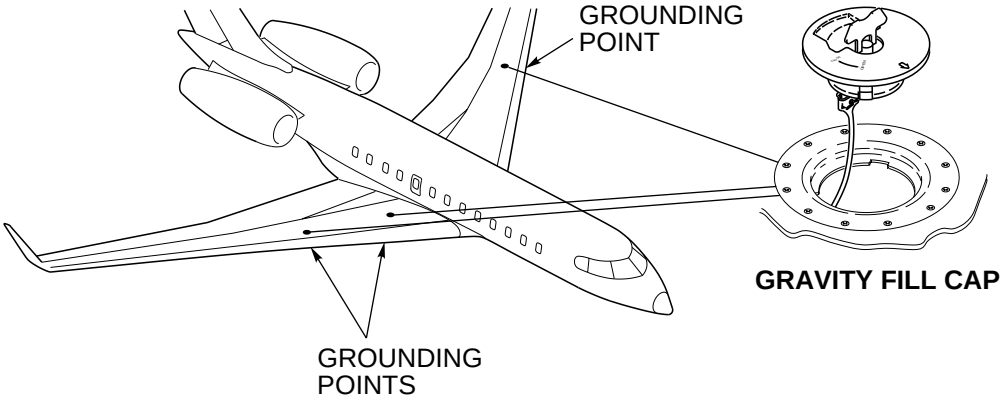
Compare Fuel Quantity
Displays when the gauge fuel weight and the FMS fuel weight differ by more than 2% of the Basic Operating Weight (BOW).

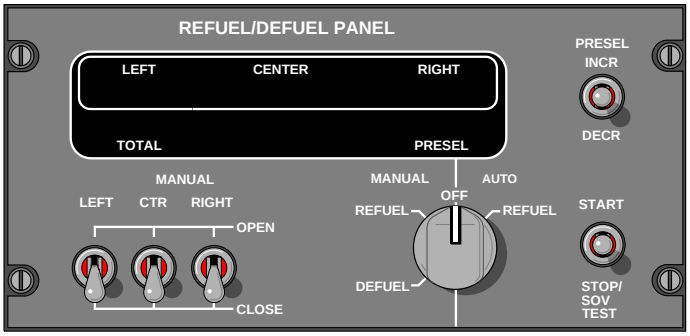
GF1210_017a

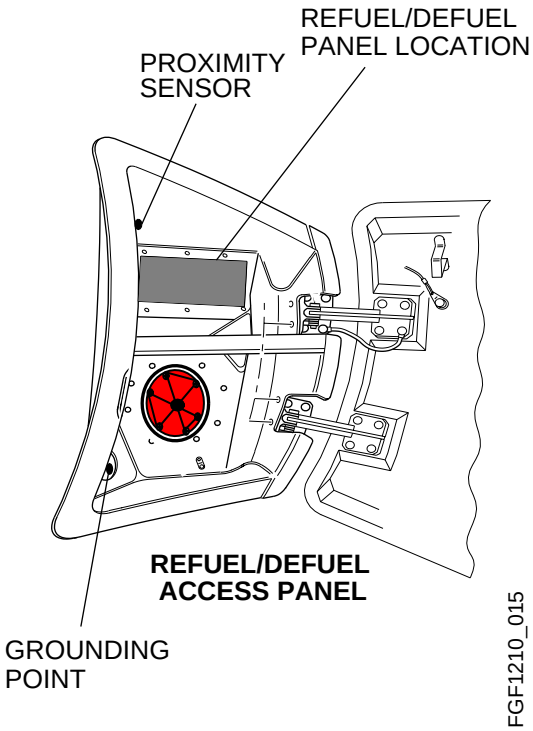
Fuel quantity information to the FMS is used for monitoring and sensing, to assist in determining a fuel leak. When a fuel leak is detected, a crew alert ("**MSG**" on the primary flight display) will be displayed and a message will appear on the scratchpad of the FMS CDU.

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.







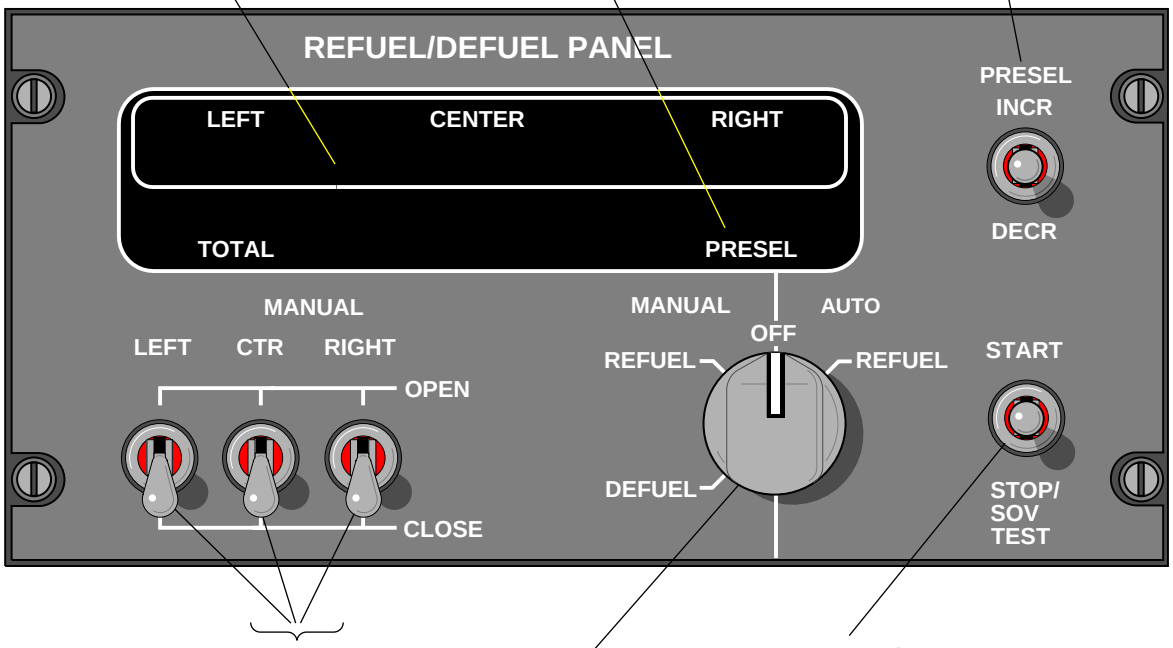
Gravity filling via a filler point is also provided for the wing and center wing tanks.

REFUEL/DEFUEL PANEL

LEFT/RIGHT/CTR/TOTAL
Displays the current fuel quantity in each tank and the total quantity in all tanks. Quantities are displayed in 50 lb (25 KG) increments.

PRESELECT TOTAL QTY DISPLAY
Displays the fuel quantity target for automatic refueling. Set in 100 lb (50 KG) increments.

PRESEL INCR/DECR
Increases or decreases the preselect quantity for AUTO refueling.



FUEL SOVs
Allows tanks to be refueled or defueled manually.

START−STOP/SOV TEST
- START − Initiates refueling.
- STOP/SOV TEST − Stops automatic refueling or enables testing of the refuel SOVs and circuitry during fueling.

AUTO MODE
- AUTO REFUEL − Enables automatic refueling.

MODE SELECTOR
- MANUAL REFUEL − Enables manual refueling using the fuel SOVs.
- MANUAL DEFUEL− Enables manual defueling using the fuel SOVs.

OFF POSITION
- OFF − Removes power form the panel.

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REFUEL/DEFUEL PANEL (CONT'D)

Normal Fuel Loading

The normal fuel loading logic as planned by the FMQGC is as follows:

- Wing tanks only if the required fuel load is equal to or less than the wing tank capacity.
- Any fuel in excess of the wing tank capacity is placed in the center tank.

NOTE

The fuel computer always strives to keep between 0 and 400 lb maximum lateral imbalance, however, the software allows the imbalance to reach 1100 lb before shutting down and going into INHIB mode.

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.

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. SOV FAIL will be displayed in the tank window for the failed shutoff valve, alternating display of the tank quantity.

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 center tank. If the center tank is used, it 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.

REFUEL/DEFUEL PANEL (CONT'D)

Pressure Refueling (Cont'd)

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.

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.

Suction Defueling

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

Fault Reporting

Fault reporting is in the form of error messages which will appear in the display windows of the refuel/defuel panel. In the event of a fuel computer failure, a FMQGC" will be displayed in the TOTAL window and FAILURE in the PRESEL window. An example of fault reporting is illustrated below:

REPEATER
This indicates that two panels are powered on.

FGF1210_017

Error Messages

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

REFUEL/DEFUEL PANEL (CONT'D)

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 valid, 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 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.

REFUEL/DEFUEL PANEL (CONT'D)

Refueling Distribution

Refer to Refuel/Defuel 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 refueling.

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

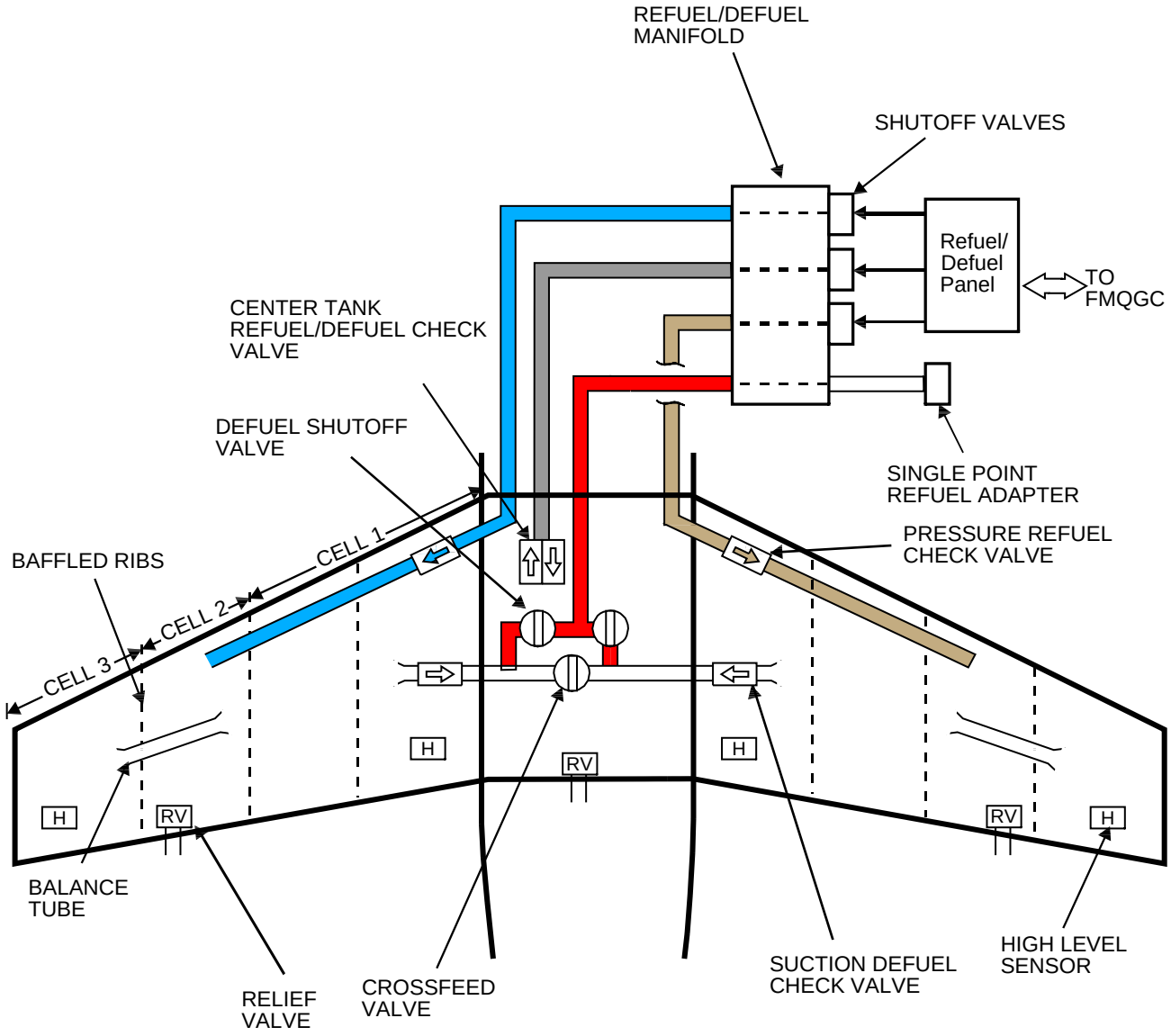
The filling sequence of the wing compartment during pressure refueling is as follows:

- 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.

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.

REFUEL/DEFUEL SCHEMATIC



FUEL RE-CIRCULATION SYSTEM

The fuel re−circulation system is designed to prevent the bulk fuel temperature from reaching the freezing point by re−circulating heated fuel to the wing fuel tanks. 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.

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. 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). The recirculation line is fitted with a check valve to prevent crossflow or fuel propagation due to a ruptured line.

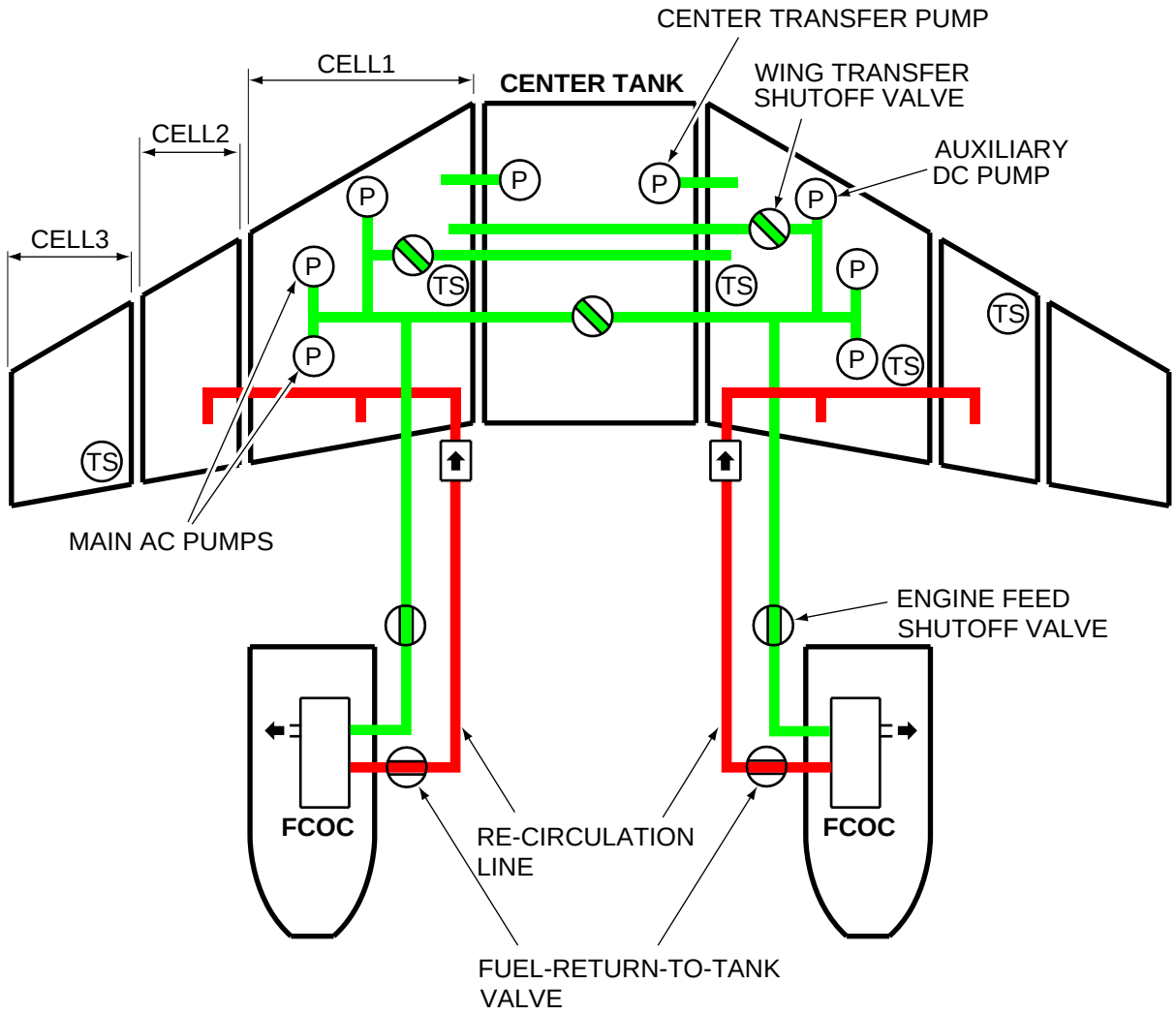
The wing fuel tanks are fitted with many fuel temperature sensors; the left wing has two and the right wing has three. With the Fuel Recirculation OFF, the Fuel Management and Quantity Gauging Computer (FMQGC) reads all temperature sensor but will display only the lowest temperature. When the Fuel Recirculation 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. Finally, the **L (R) FUEL RECIRC OFF** status message will be displayed when the crew selects system off.

The **FUEL HI TEMP** caution message is posted when the bulkhead fuel temperature exceeds 54°C when the Fuel Recirculation System is inoperative. To prevent the system from operating above the freezing level, the set point has been reduced to 10°C when the system is selected on.

FUEL RE-CIRCULATION SYSTEM (CONT'D)



The FRTT valves are powered by their dedicated circuit breakers on DC BUS 1 and 2.

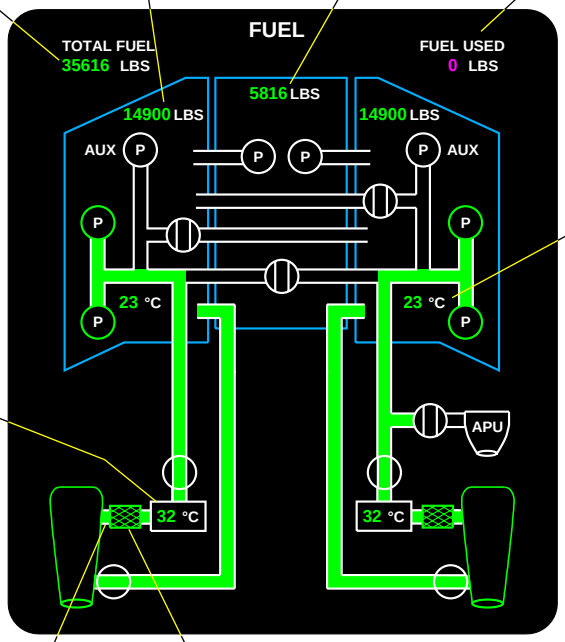
FUEL FILTERS, QUANTITY AND TEMPERATURE READOUTS

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

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

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

Fuel Used Quantity Readout
Indicates fuel quantity burned.



Bulk Fuel Temperature Readout

- 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.

With Fuel Recirculation System 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 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.

Fuel Filter

- Green − Indicates normal fuel flow through the filter.
- Amber − Fuel pressure drop exists across the filter.

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FUEL PUMP DISPLAYS

L or R DC Auxiliary Pumps

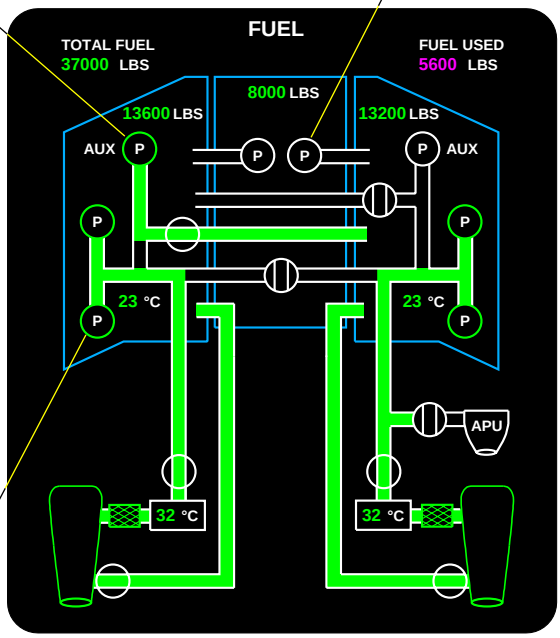
• ON − For engine starting, take−off and landing, primary pump failure and wing transfer of fuel.

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 override 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 centre tank fuel to the wing tanks. No manual control.



L or R AC Boost Pumps

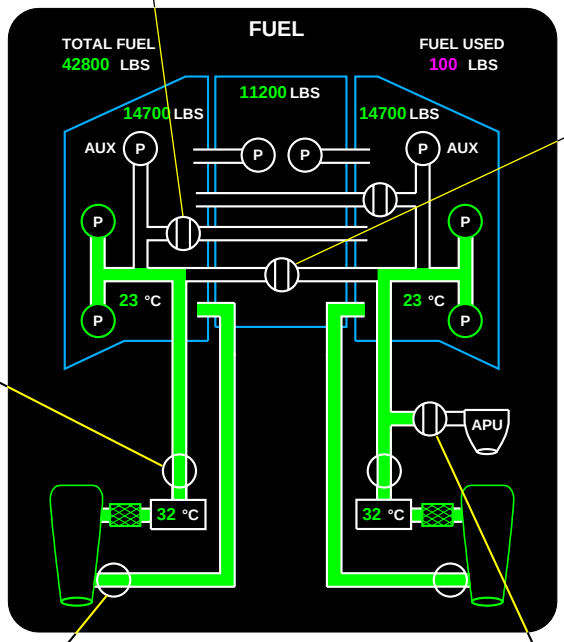
• ON − At all times with the engines running.

• OFF − When commanded by the switch on the Fuel Control Panel.

FGF1210_022

FUEL SHUTOFF DISPLAYS

Wing Transfer Shutoff Valve
Controlled by the FMQGC or the WING XFER switch on the Fuel Control Panel.



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

Engine Feed Shutoff Valve
Applicable engine FIRE DISCH handle.

NOTE
The engine run switches activate the HPSOV located in the FMU not these shutoff valves. These are only activated by the FIRE DISCH handle.

Fuel Return To Tank (FRTT) Valve
Activated by the FMQGC.

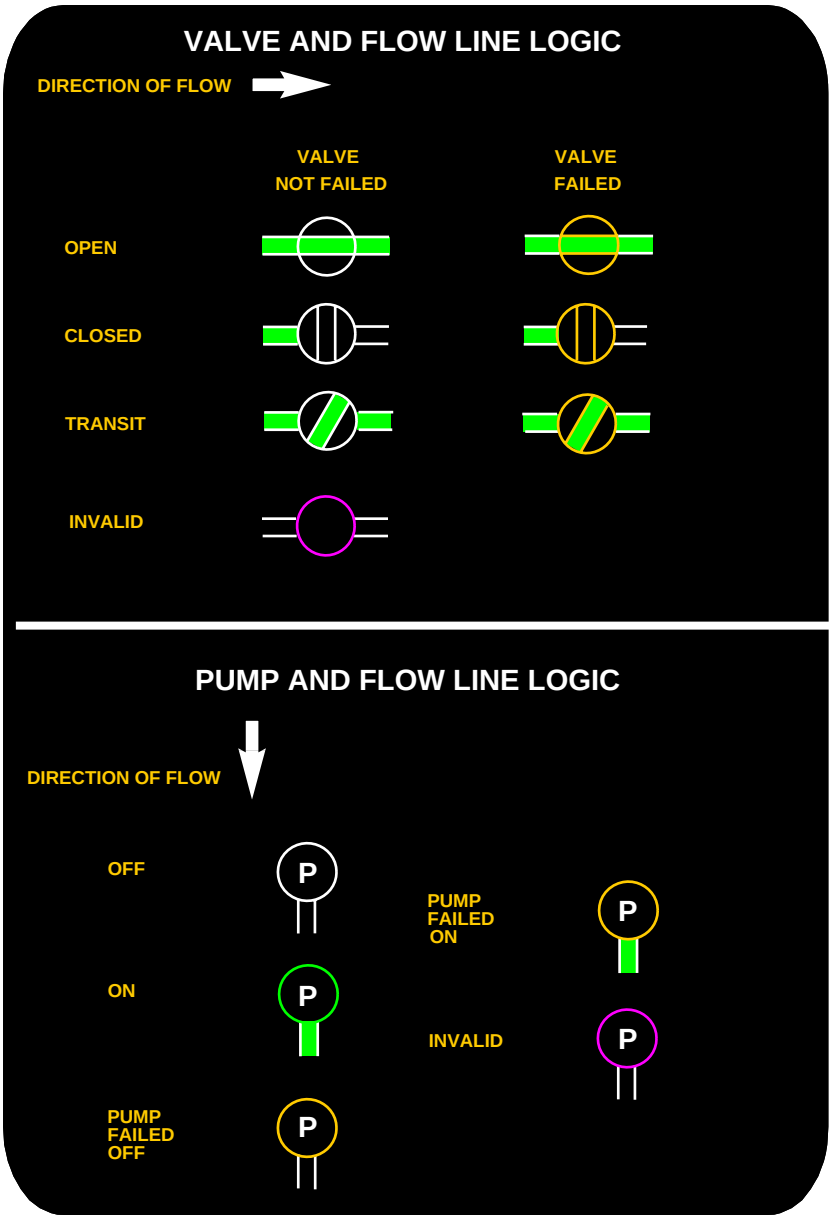
APU Feed Shutoff Valve
- Activated by the RUN position switch on the APU Control Panel.
- Also controlled by the APU FIRE DISCH handle.

FGF1210_023

FUEL SYNOPTIC PAGE SYMBOLS

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

EICAS Philosophy

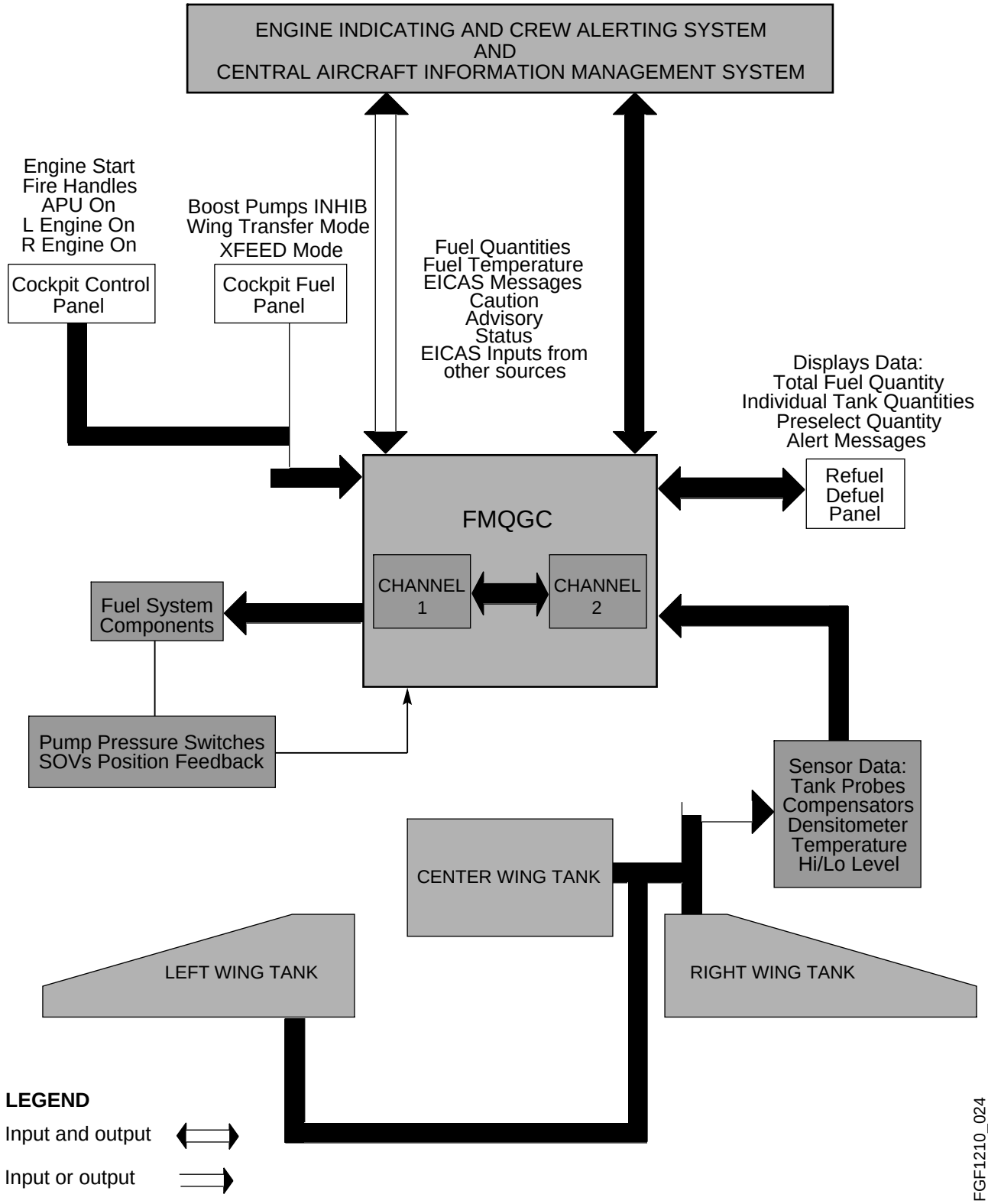


GF1210_029

FUEL MANAGEMENT QUANTITY GAUGING SYSTEM (FMQGS)

The FMQGS 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



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 Take-off / Approach configuration.

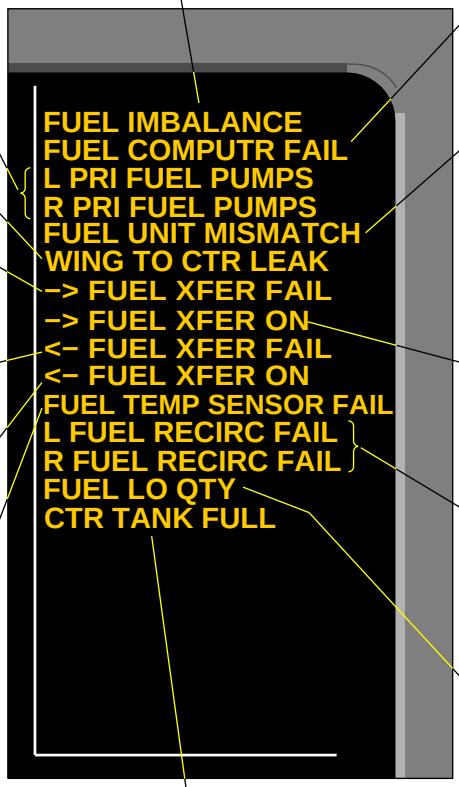
L (R) PRI FUEL PUMPS
Indicates that the forward and aft primary AC pumps on the affected side have failed to operate when requested.

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

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

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

–> 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.

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

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

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

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

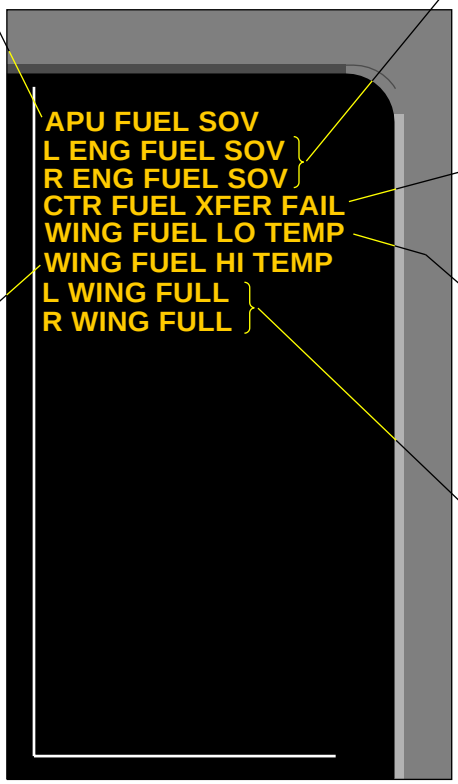
CTR TANK FULL
Center tank has reached or exceeded its computer controlled maximum capacity of 6100 lbs.

FGF1210_025

EICAS MESSAGES (CONT'D)

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 LO TEMP
Indicates that either the left or right wing fuel bulk temperature is at or below −35°C.

WING FUEL HI TEMP
If Fuel Re-Circulation system is On:
Indicates that the left or right wing fuel bulk temperature is greater than 10°C.

If Fuel Re-Circulation system is Off:
Indicates that the left or right wing fuel bulk temperature is greater than 54°C.

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

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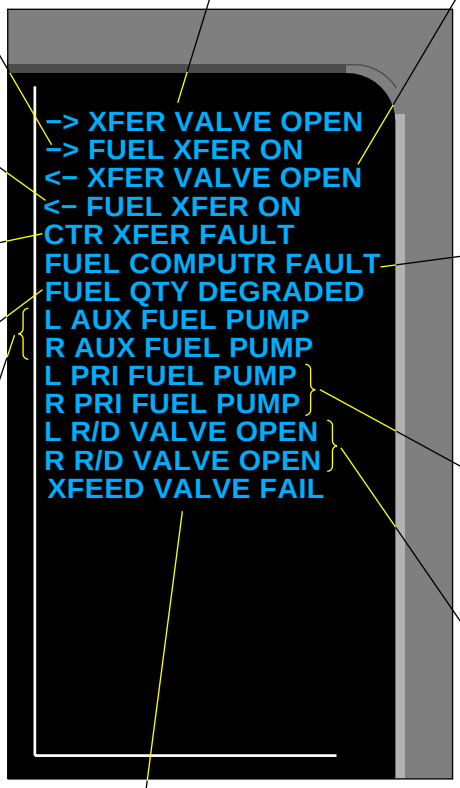
EICAS MESSAGES (CONT'D)



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

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

<– 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 right to left transfer system is in the AUTO mode of operation.

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

FUEL COMPUTR FAULT
Indicates that either channel of the computer has failed.

FUEL QTY DEGRADED
Indicates that the fuel computer detects a loss of fuel gauging accuracy.

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

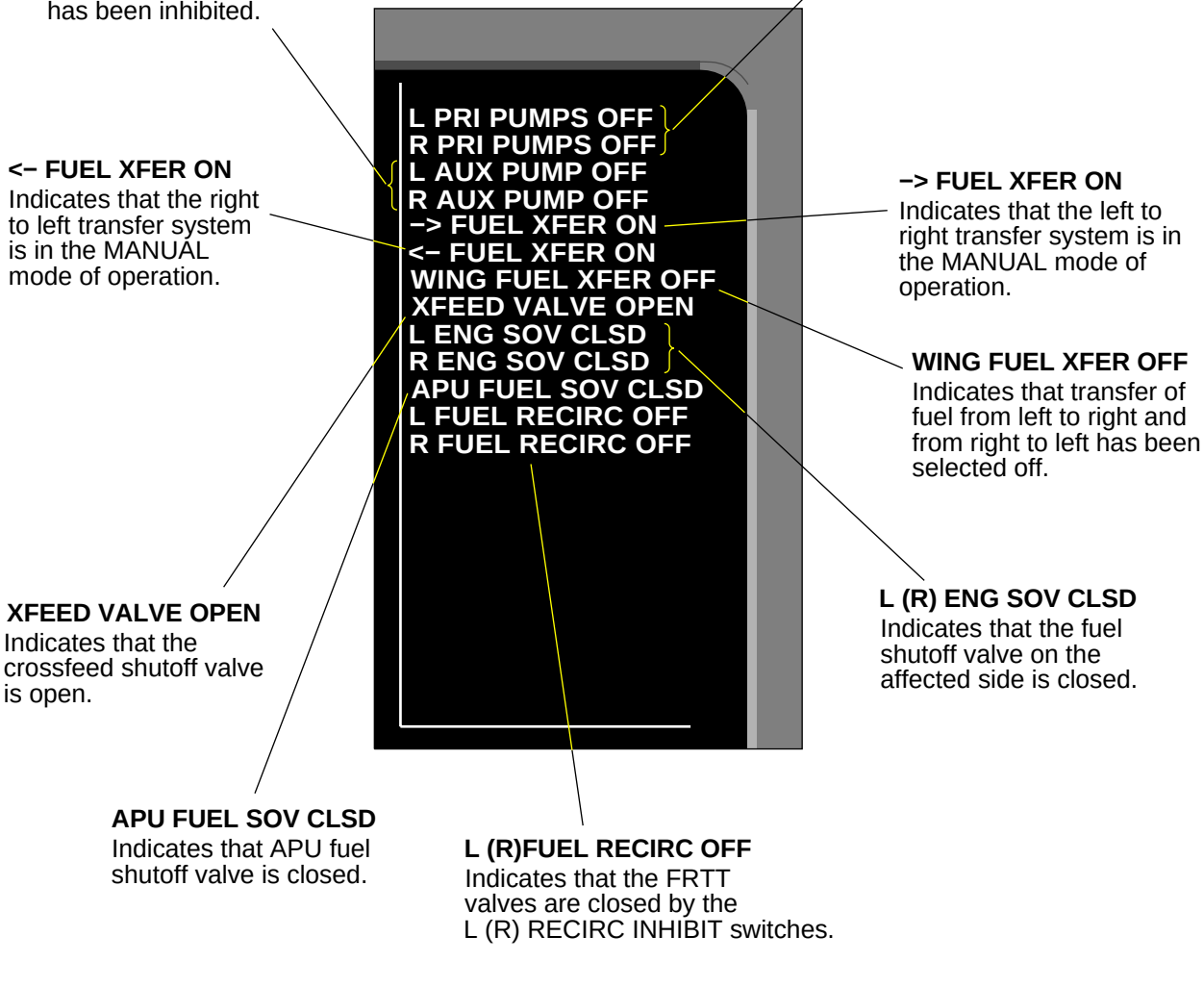
L (R) AUX FUEL PUMP
Indicates that the auxiliary fuel pump on the affected side has failed to operate when requested.

L (R) R/D VALVE OPEN
Indicates that the left and right refuel/defuel valves have failed to close (after refuel/defuel operation) when requested.

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

FGF1210_027

EICAS MESSAGES (CONT'D)



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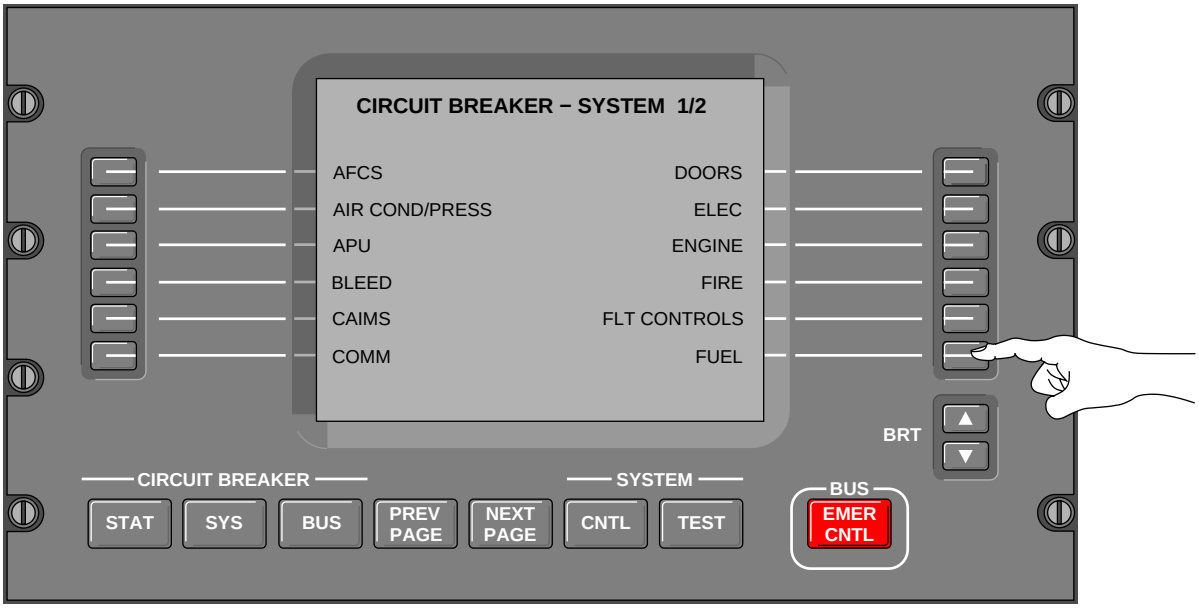
CB - FUEL SYSTEM



CB − FUEL SYSTEM 1/5			
→ XFER SOV C	DC ESS		IN
→ XFER SOV O	DC ESS		IN
← XFER SOV C	BATT		IN
← XFER SOV O	BATT		IN
APU FIRE SOV	DC EMER	DCPC	IN
FUEL COMPUTR CH A	BATT		IN

CB − FUEL SYSTEM 2/5			
FUEL COMPUTR CH B	DC ESS		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 3/5			
L ENG FUEL SOV	DC EMER	DCPC	IN
L FUEL RECIRC VLV	DC 1		IN
L FWD PRI PUMP	AC 2		IN
R AFT PRI PUMP	AC 4		IN
R AUX PUMP	BATT		IN
R CTR XFER PUMP	AC 4		IN

CB − FUEL SYSTEM 4/5			
R ENG FUEL SOV	DC EMER	DCPC	IN
R FUEL RECIRC VLV	DC 2		IN
R FWD PRI PUMP	AC 3		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 5/5			
R/D SOL VALVES	APU BATT	ASCA	IN
XFEED SOV C	BATT		IN
XFEED SOV O	BATT		IN

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

FGF1220_001

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