2A-28-10: General

The fuel system contains and supplies all the necessary fuel for the two turbofan engines and the Auxiliary Power Unit (APU). There are two integral (wet wing) fuel tanks, each formed by the respective wing's structure. Low pressure fuel is delivered from the tanks to the engine-driven pumps and the APU. See Figure 1 through Figure 3.

The fuel tanks can be fueled by the conventional "over-the-wing" method or from a single-point pressure fueling adapter. Defueling may be accomplished by suction or pumping; any remaining pockets of fuel may then be drained.

Each wing tank contains a fuel hopper as a separate compartment within the tank. Low pressure fuel is pumped from the hopper through a fuel feed line to the engine-driven pumps by fuel boost pumps (two per wing). A hydraulic fluid-to-fuel heat exchanger inside each hopper is used for cooling hydraulic fluid.

An intertank valve in the right fuel hopper allows simultaneous defueling of both tanks. A crossflow shutoff valve in the left hopper allows fuel balance to be adjusted.

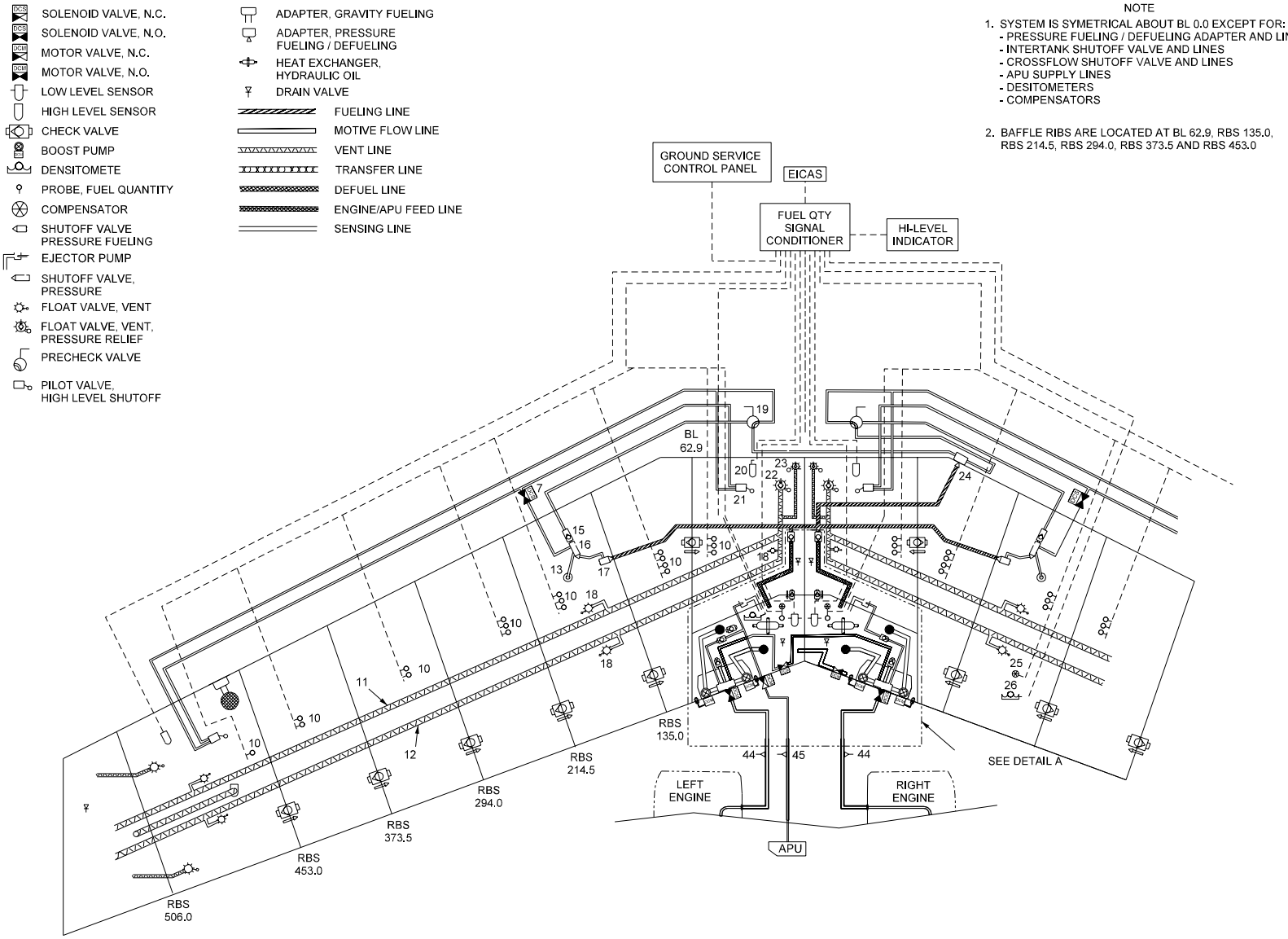
A fuel temperature system provides a signal for cockpit indications of fuel temperature.

A tank vent system provides adequate venting while the aircraft is on the ground. In flight, this same system slightly pressurizes the tanks.

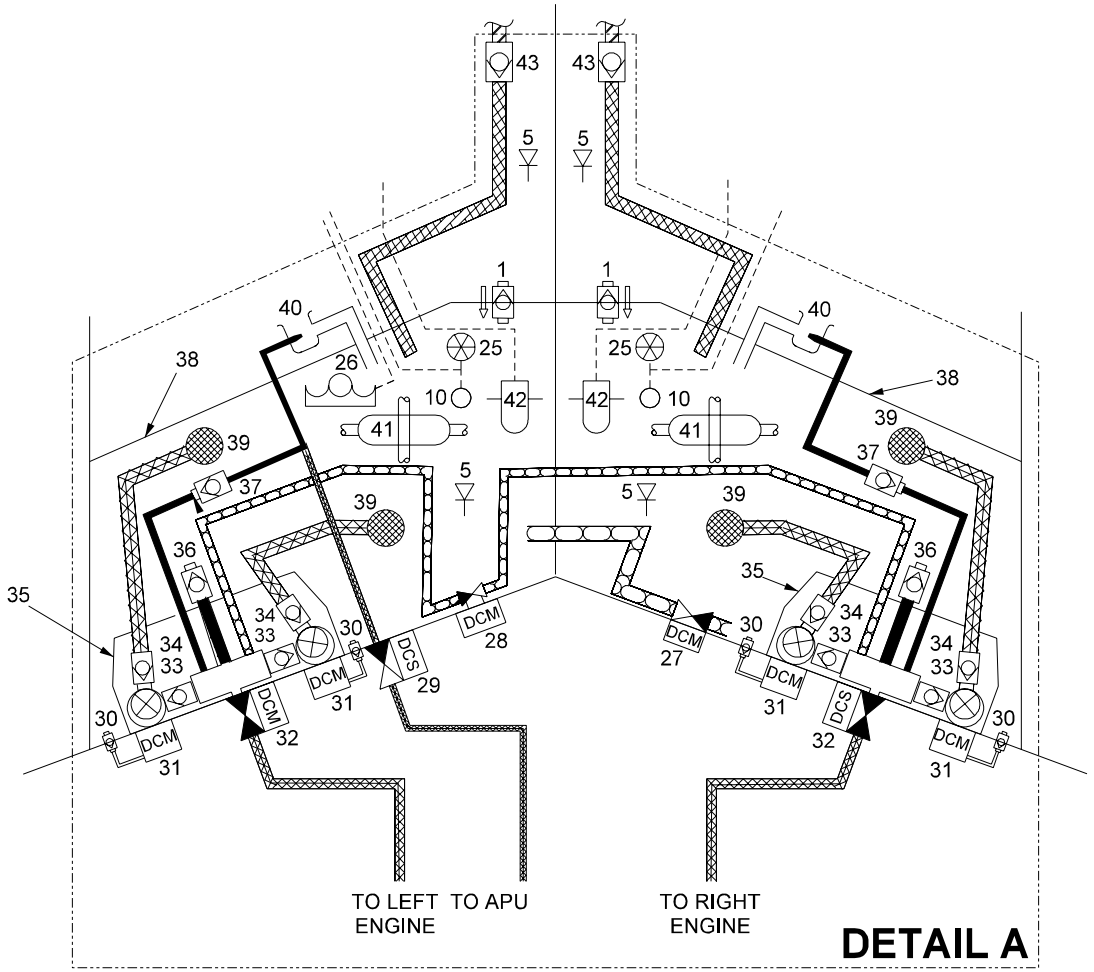
Major advancements in system development for the GV include an automatic refueling system and a heated fuel return system.

The Fuel system is divided into the following subsystems:

- 2A-28-20: Fuel Storage System
- 2A-28-30: Fuel Distribution System
- 2A-28-40: Fuel Indication System



Fuel System Block Diagram (Full Wing View)
Figure 1



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Fuel System Block
Diagram (Hopper View)
Figure 2

INDEX NO.	NOMENCLATURE
1	FUELING CHECK VALVE
2	VENT FLOAT/NON-RELIEVING VALVE (AIR PASSAGE)
3	VENT FLOAT/NON-RELIEVING VALVE (VENT DUCT)
4	OVERBOARD VENT AND RAM AIR INLET
5	WATER/FUEL DRAIN VALVE
6	VENT PLENUM
7	HIGH FUEL LEVEL SENSOR, OUTBOARD
8	PRESSURE FUELING HIGH-LEVEL PILOT VALVE, OUTBOARD
9	GRAVITY FUELING ADAPTER AND SCREEN
10	FUEL QUANTITY PROBES
11	FORWARD VENT DUCT
12	AFT VENT DUCT
13	PRESSURE FUELING AMBIENT PRESSURE PORT
14	PRESSURE FUELING SOLENOID SHUTOFF VALVE
15	PRESSURE SENSING CHECK VALVE
16	PRESSURE SENSING VALVE
17	PRESSURE FUELING SHUTOFF VALVE
18	VENT FLOAT DRAIN VALVE
19	PRESSURE FUELING MANUAL PRECHECK VALVE
20	HIGH FUEL LEVEL SENSOR, INBOARD
21	PRESSURE FUELING HIGH-LEVEL PILOT VALVE, INBOARD
22	VENT FLOAT/PRESSURE RELIEF VALVE, 3-INCH
23	VENT FLOAT/PRESSURE RELIEF VALVE, 1-INCH
24	PRESSURE FUELING/DEFUELING ADAPTER
25	COMPENSATOR
26	DENSITOMETER
27	INTERTANK SHUTOFF VALVE
28	CROSSFLOW SHUTOFF VALVE
29	APU FUEL SHUTOFF VALVE
30	VAPOR RETURN CHECK VALVE
31	FUEL BOOST PUMP
32	ENGINE FUEL SHUTOFF VALVE
33	PUMP DISCHARGE CHECK VALVE
34	PUMP SUCTION CHECK VALVE (HELD OPEN BY PUMP SUCTION PORT)
35	FUEL BOOST PUMP MANIFOLD
36	PUMP SUCTION BYPASS CHECK VALVE
37	FUEL EJECTOR PUMP MOTIVE FLOW CHECK VALVE
38	FUEL HOPPER
39	FUEL BOOST PUMP FILTER SCREEN
40	FUEL EJECTOR PUMP
41	HYDRAULIC FLUID HEAT EXCHANGER
42	LOW FUEL LEVEL SENSOR
43	DEFUELING SUCTION CHECK VALVE
44	ENGINE FUEL LINE DRAIN VALVE
45	APU FUEL LINE DRAIN VALVE

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Fuel System Block Diagram (Component Key)
Figure 3

2A-28-20: Fuel Storage System

1. General Description:

The fuel storage system contains all the necessary fuel for the aircraft engines and the Auxiliary Power Unit (APU). It is composed of the following subsystems, units and components:

- Left and Right Wing Fuel Tanks
- Left and Right Fuel Hoppers
- Over-Wing (Gravity) Fueling System
- Gravity Water/Fuel Drain System
- Fuel Ventilation System
- Fuel Filtration System

2. Description of Subsystems, Units and Components:

A. Left and Right Wing Fuel Tanks:

Wing fuel tanks provide the capability to carry the total fuel load. They are formed by the front and rear spars, the upper and lower skins and the closure ribs at Butt Line (BL) 0.0 and Rib Station (RBS) 506.0. The tanks are integral to the wing structure. Using a fuel density of 6.767 pounds per gallon at 60° F, the total usable fuel capacity is 41,300 lb (18,734 kg), for a total of 6,118 US gallons (23,158 liters) This applies to aircraft production numbers 549 and subsequent, and aircraft production numbers 501 through 548 with ASC 50. An inboard portion of each wing tank is divided into a fuel hopper. To prevent a sudden shift in center of gravity due to fuel movement, each wing tank is divided into seven compartments by six baffle ribs. The baffle ribs are sealed except for the following:

(1) Flapper Check Valves:

Flapper check valves prevent fuel flow outboard while permitting the fuel to gravity drain inboard during gravity fueling and engine/APU operation.

(2) Weep Holes:

Quarter-inch (0.25") weep holes, located at the bottom of the baffle ribs between the lower stringers, prevent fuel and water from being trapped between the stringers and the ribs. Fuel and water will move inboard through these weep holes. The water will continue to move inboard to the water/fuel drain valves. Small openings are provided at the top of each baffle rib. These openings allow fuel flow between compartments during pressure fueling.

Weep holes are also provided in the stringers just outboard of the hopper wall. These holes allow fuel and water to move forward and around the hopper wall.

Three water/fuel drain valves are installed in the lower wing skin of each tank for draining water and fuel from the tanks.

B. Left and Right Fuel Hoppers:

The fuel hoppers provide a location to collect fuel from the wing tanks. Fuel in the hoppers is removed by fuel boost pumps and supplied to both engines and the APU. The fuel hopper is an isolated compartment in each wing fuel tank, found on each side of the centerline rib. The capacity of

each hopper is 1283 pounds (190 US gallons / 719 liters).

C. Over-Wing (Gravity) Fueling System:

The over-wing (gravity) fueling system provides an alternate method of fueling the tanks if pressure-fueling equipment is not available. An over-wing (gravity) fueling adapter assembly is installed in each wing fuel tank. Procedures for over-wing (gravity) fueling are presented in Chapter 9: Handling and Servicing.

D. Gravity Water/Fuel Drain System:

The gravity water/fuel drain system drains water/fuel from the tanks through three drain valves located in the lower wing skins.

E. Fuel Ventilation System:

The fuel ventilation system provides air and fuel vapor flow in or out of the fuel tanks. This prevents excess pressure or vacuum in the fuel tanks. In flight, the ventilation system will slightly pressurize each wing tank. The system relieves pressure when necessary by discharging fuel flow overboard.

F. Fuel Filtration System:

The fuel filtration system prevents unwanted objects from entering the wing fuel tanks during gravity fueling and from ingestion into the fuel boost pumps during pump operations. This is accomplished through the use of filter screens installed at the gravity fueling adapters and at the boost pump inlets.

3. Controls and Indications:

A. Crew Alerting System (CAS) Messages:

If the fuel load becomes unbalanced more than 1,000 pounds, a blue FUEL IMBALANCE message will be displayed on CAS.

4. Limitations:

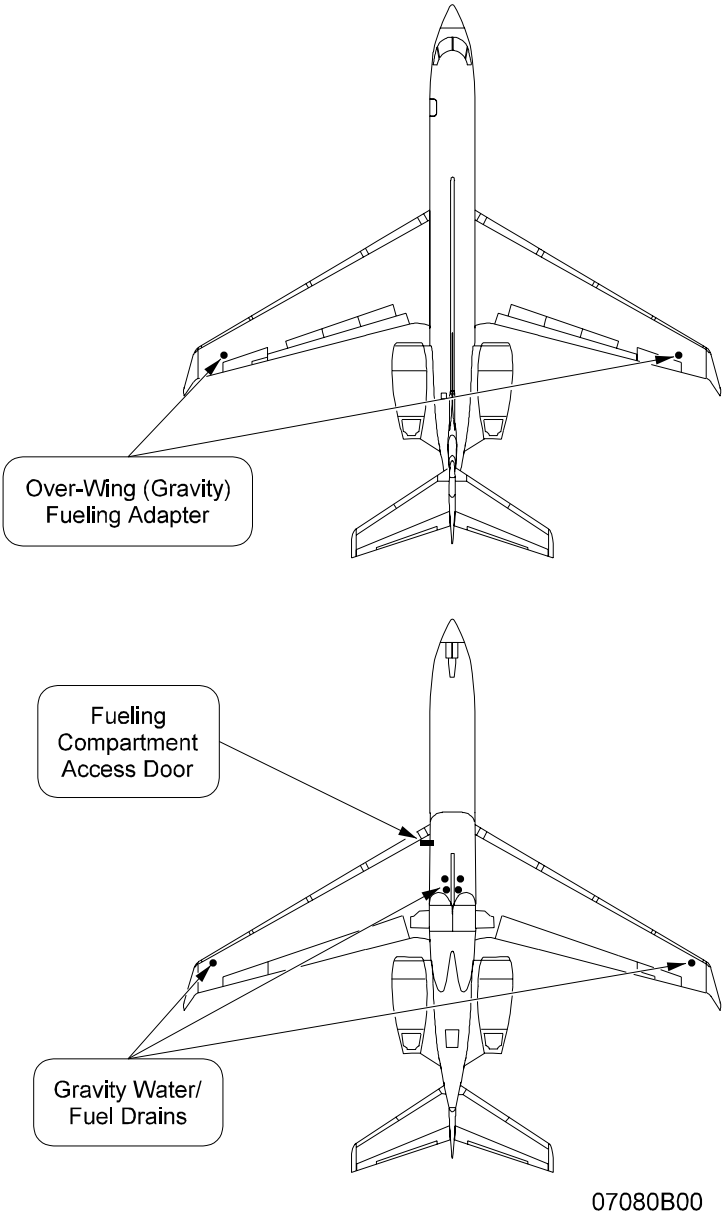
A. Flight Manual Limitations:

(1) Usable Fuel Capacities – Aircraft Production Numbers 549 and Subsequent, and Aircraft Production Numbers 501 Through 548 With ASC 50:

Left Tank	Right Tank	Total
20,650 lb (9,367 kg)	20,650 lb (9,367 kg)	41,300 lb (18,734 kg)
3,059 gal (11,579 lit)	3,059 gal (11,579 lit)	6,118 gal (23,158 lit)

NOTE:

It is possible to upload fuel in excess of 41,300 lb. This is permitted as long as the maximum ramp weight and/or the maximum takeoff weight is not exceeded, and the loaded aircraft center of gravity is within limits.



Fuel Storage System External Controls
Figure 4

2A-28-30: Fuel Distribution System

1. General Description:

The fuel distribution system contains all the necessary components to control fueling and defueling, and to supply fuel to the engines and the Auxiliary Power Unit (APU). It is composed of the following subsystems, units and components:

- Pressure Fueling/Defueling Control System
- Fueling Shutoff Control System
- Ground Service Control Panel
- Fuel Crossflow and Intertank Transfer System
- Fuel Filtration System
- Engine and APU Fuel Distribution System
- Fuel Boost Pumps
- Heated Fuel Return System

2. Description of Subsystems, Units and Components:

A. Pressure Fueling/Defueling Control System:

The pressure fueling/defueling control system supplies a single point from which the fuel tanks can be fully fueled and/or defueled. This is achieved by the use of a single point pressure fueling/defueling adapter found in the fueling compartment. The fueling compartment is located on the leading edge of the right wing at the wing/fuselage fillet. Procedures for pressure fueling are presented in Chapter 9: Handling and Servicing.

B. Fueling Shutoff Control System:

The fueling shutoff control system provides all the necessary valves, switches, and plumbing to control pressure fueling flow. The system will shut off fueling flow by the following means:

(1) Manually:

- By selection of the L and R REMOTE FUELING SHUTOFF switches to the CLSD position. The switches are located on the COP.
- By placing the AUTO REFUEL switch to OFF, if the system is in the AUTO REFUEL mode. The AUTO REFUEL switch is located on the Ground Service Control Panel (GSCP), on the Left Electronic Equipment Rack (LEER).

(2) Automatically:

- When the tanks are full.
- If a wing overpressure condition is sensed.
- Upon reaching a predetermined desirable fuel level, based on a signal generated by the Fuel Quantity Signal Conditioner (FQSC).

C. Ground Service Control Panel:

The Ground Service Control Panel (GSCP) is located on the Left Electronic Equipment Rack (LEER), on the System Monitor Test Panel. The GSCP allows automatic refueling to a preselected quantity, controlled through the use of a Fuel Quantity Signal Conditioner (FQSC). The FQSC receives a desired input from the GSCP for the amount of fuel required. When the

desired level of fuel is reached the FQSC will send a signal that will automatically stop fueling. Refueling can also be monitored and manually stopped using the GSCP. Power to the GSCP is supplied by the Ground Service Bus. Procedures for automatic refueling are presented in Chapter 9: Handling and Servicing.

D. Fuel Crossflow and Intertank Transfer System:

The fuel crossflow and intertank transfer system allows either fuel tank to simultaneously supply both engines, and allows fuel to flow between each fuel tank.

During normal operations, the left and right fuel manifolds are isolated and each supplies fuel to its respective engine. When necessary, fuel can be distributed from one manifold to the other by opening the crossflow shut off valve through the use of a control switch. The control switch is located on the COP in the FUEL SYSTEM section and is labeled X FLOW.

Likewise, the left and right fuel hoppers are also isolated during normal operations. The tanks can be connected by opening the intertank shutoff valve through the use of a control switch. The control switch is located on the COP in the FUEL SYSTEM section and is labeled INTERTANK.

E. Engine and APU Fuel Distribution System:

The engine and APU fuel distribution system provides the flow of fuel through the aircraft to the engines and APU. Fuel for each engine and APU is removed from the fuel hopper by the fuel boost pumps. It will then flow through fuel feed lines to the APU and the engine low pressure pumps. Ejector pumps, pressurized by the fuel boost pumps, keep the hoppers full of fuel.

Fuel shutoff valves are located in the fuel feed lines between the boost pumps and engines. The valves are controlled by the respective FIRE handle located on the Cockpit Center Pedestal. When the FIRE handle is pulled, the shutoff valve is closed and fuel flow to the respective engine is shut off.

F. Fuel Boost Pumps:

Four fuel boost pumps, two main pumps and two alternate pumps, are provided to deliver fuel to the APU and the engine low pressure fuel pumps. One main pump and one alternate pump is installed external to each hopper. They are accessible from the respective main landing gear wheel well. Fuel for each engine and the APU is removed from the fuel hopper by the boost pumps. The fuel is then routed through fuel feed lines to the APU and the engine low pressure fuel pumps.

NOTE:

Fuel boost pump configuration must be manually set by the flight crew. There is no “Auto Change” feature.

G. Heated Fuel Return System:

The heated fuel return system provides fuel from the engines to heat fuel tanks during high altitude flying and cold weather conditions to decrease fuel viscosity caused by cold-soaked wing tanks. A heated fuel control valve is located in the fuel line between the spill diverter valve in the Fuel Management Unit (FMU) and the Fuel-Cooled Oil Cooler (FCOC) inlet. The

control valve is a solenoid-controlled, two-position, three-port valve which switches the flow path from the FCOC inlet to the return-to-tank plumbing. This valve is controlled by the Full Authority Digital Engine Control (FADEC) based on temperatures sensed in each fuel hopper.

A second valve is installed in the fuel line to serve as a cockpit-controlled shutoff valve. This valve is controlled by a two-position switch located on the COP, labeled FUEL RETURN. This switch has two positions: AUTO (light out) and OFF (amber light). Placing the switch to AUTO opens the shutoff valve. Once the system is armed, the return flow will be automatically controlled by the FADEC through the heated fuel control valve.

To provide adequate fuel heating without overheating, the temperature switch opens and closes based on sensed fuel temperatures: opening at approximately 0° C and closing at approximately +10° C. Returned fuel temperature is approximately +50° C.

3. Controls and Indications:

(See Figure 5 and Figure 6.)

A. Circuit Breakers (CBs):

The fuel distribution system is protected by the following CBs:

Circuit Breaker Name:	CB Panel:	Location:	Power Source:
L MAIN PUMP CONT	LEER	A-3	L ESS DC Bus
L MAIN FUEL PUMP	Left PDB	N/A	L ESS DC Bus
R MAIN PUMP CONT	REER	A-14	R ESS DC Bus
R MAIN FUEL PUMP	Right PDB	N/A	R ESS DC Bus
L ALT PUMP CONT	LEER	A-2	L MAIN DC Bus
L ALT FUEL PUMP	Left PDB	N/A	L MAIN DC Bus
R ALT PUMP CONT	REER	A-15	R MAIN DC Bus
R ALT FUEL PUMP	Right PDB	N/A	R MAIN DC Bus
FUEL X-FLO VLV	LEER	B-2	L ESS DC Bus
FUEL INTER-TANK VLV	LEER	C-3	L ESS DC Bus
R FUEL S/O	REER	B-14	R ESS DC Bus
L FUEL S/O	LEER	B-3	L ESS DC Bus
L FUELING S/O	LEER	A-16	GND SVC Bus
R FUELING S/O	LEER	C-16	GND SVC Bus

B. Crew Alerting System (CAS) Messages:

CAS messages associated with the fuel distribution system are:

Area Monitored:	CAS Message:	Message Color:
Alternate Fuel Boost Pumps	L-R ALT PUMP FAIL	Amber
Boost Pump Logic	BOOST PUMP	Amber
Main Fuel Boost Pumps	L-R MAIN PUMP FAIL	Amber
Intertank Valve	FUEL INT TANK OPEN	Blue
Heated Fuel Return	L-R FUEL RETURN FL	Blue
Crossflow Valve	FUEL XFLOW OPEN	Blue

4. Limitations:

A. Flight Manual Limitations:

(1) Fuel Load Balancing:

(a) Maximum Fuel Imbalance For Takeoff:

Maximum fuel imbalance for takeoff is 1,000 lb.

(b) Maximum Fuel Imbalance In Flight:

Maximum fuel imbalance in flight is 2,000 lb.

(c) Fuel Load Balancing Criteria:

Proceed with fuel load balancing before the imbalance exceeds 1,000 lb.

(2) Boost Pumps:

(a) Operation:

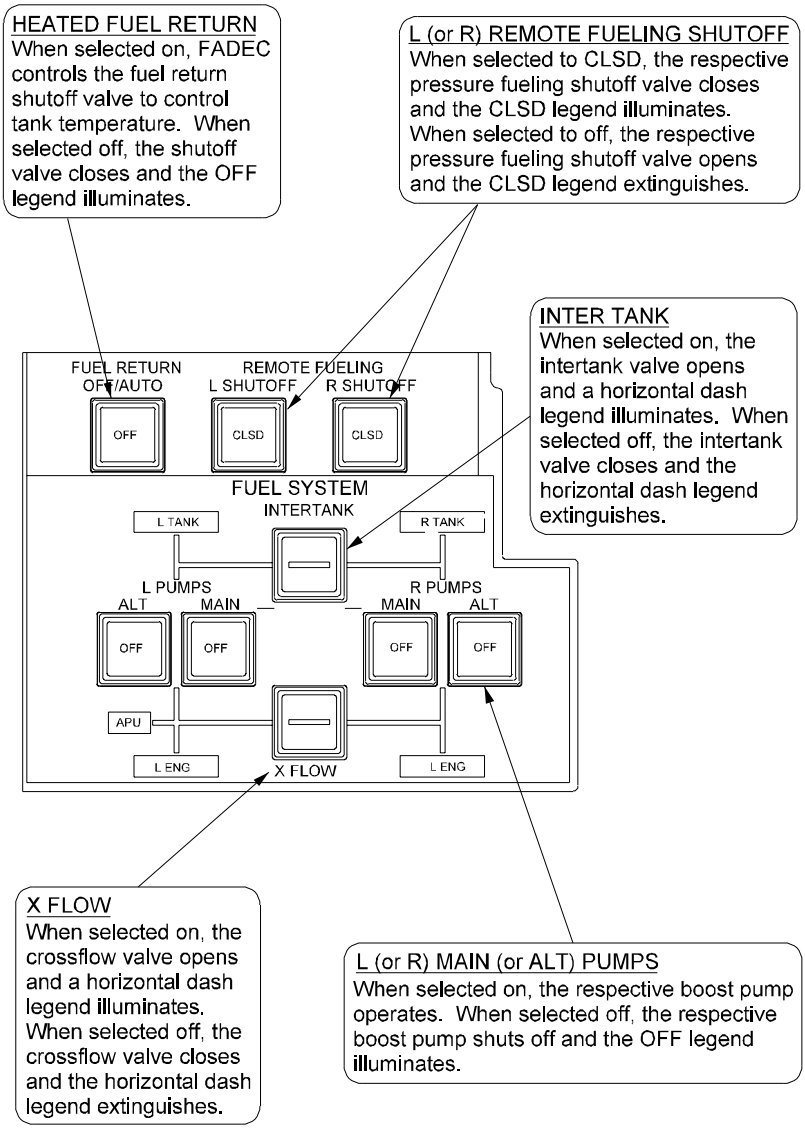
All operable boost pumps must be selected ON for all phases of flight unless fuel balancing is in progress.

(b) When Fuel Tank Temperature Is Less Than 0° C:

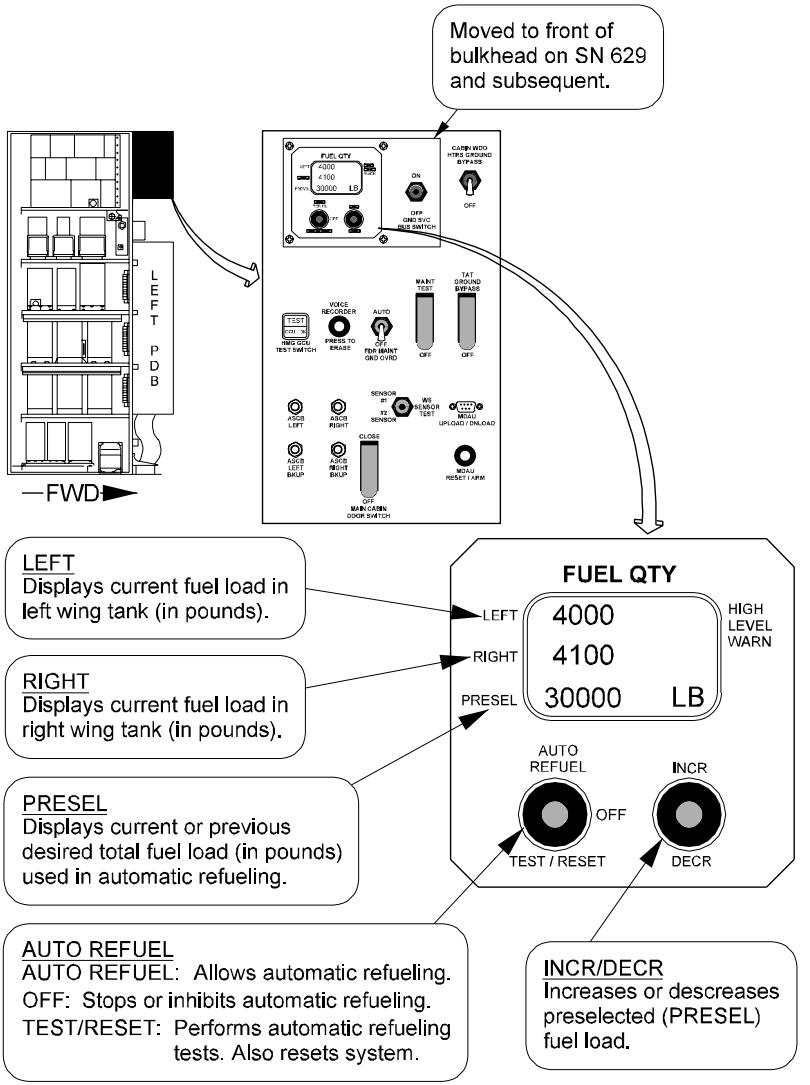
When fuel tank temperature is less than 0° C, all boost pumps shall remain ON. If fuel load balancing is required when fuel tank temperature is less than 0° C, comply with Section 01-03-80, Fuel Load Balancing.

CAUTION

THE ENGINE WILL ONLY RUN ON SUCTION FUEL FEED AT OR BELOW 20,000 FEET. ABOVE 20,000 FEET, THE ENGINE WILL RUN ERRATICALLY AND FLAME OUT IF THE CROSSFLOW IS NOT OPEN WITH AT LEAST ONE BOOST PUMP ON.



Fuel System Control Panel
Figure 5



Ground Service Control Panel
Figure 6

2A-28-40: Fuel Indication System

1. General Description:

The fuel indication system provides the flight crew with continuous indication of the amount of fuel in each wing fuel tank (left and right) and the total fuel (left and right wing fuel tanks combined). The system also provides continuous indication of left and right wing fuel tank temperature. The fuel indication system is composed of the following subsystems, units and components:

- Fuel Quantity Indication System
- Fuel Temperature and Pressure Sensing and Indication System

2. Description of Subsystems, Units and Components:

A. Fuel Quantity Indication System:

Fuel quantity is measured by two independent transistorized, capacitance-type systems, one for each tank. Each system is composed of a series of probes, sensors, compensators, and densitometers. The Fuel Quantity Signal Conditioner (FQSC) receives capacitance values from both systems and supplies output signals to the Engine Instrumentation and Crew Alerting System (EICAS). Fuel quantity is then shown in pounds on EICAS, appropriate synoptic pages and, when necessary, the Radio Frequency Management Unit (RFMU).

Low fuel level warning is supplied by low level sensors installed in each wing fuel tank hopper. The sensors supply a capacitance value to the FQSC when a low fuel level exists. The FQSC will then send a signal that will cause a message to be displayed on EICAS.

High-level fuel warning is supplied by high level sensors installed in the outboard section of each wing tank. These sensors supply a capacitance value to the FQSC when a high fuel level exists. The FQSC will then send a signal that will cause a the high-level fuel warning light on the fueling compartment door to illuminate. If refueling is being conducted in the automatic fill mode, a signal will also shut off pressure fueling in the event that the high-level pilot valves do not shut off pressure fueling flow.

B. Fuel Temperature and Pressure Sensing and Indication System:

Fuel temperature is sensed by a fuel temperature bulb installed in each hopper. Changes in temperature cause a change in resistance within the temperature bulb. This is sensed by the resistance bridge in the associated Data Acquisition Unit (DAU). The DAU sends voltage signal that is converted and displayed on EICAS and appropriate synoptic pages as the fuel tank temperature. When sensed fuel tank temperature is outside the minimum or maximum temperature parameters, a signal is sent to alert the flight crew by display of an appropriate message on EICAS.

Fuel pressure is sensed by a pressure switch located on each fuel boost pump. When sensed fuel pressure is below minimum established pressure, a signal is sent to alert the flight crew by display of an appropriate message on CAS and the ENGINE START synoptic page.

3. Controls and Indications:

(See Figure 7 through Figure 9.)

NOTE:

A full description of the FUEL synoptic page can be found in Section 2B-03-00: Engine Instruments and Crew Alerting System Description.

A. Circuit Breakers (CBs):

The fuel indication system is protected by the following CBs:

Circuit Breaker Name:	CB Panel:	Location:	Power Source:
L FUEL QTY (AIR)	REER	B-15	RT EMER BATT Bus
R FUEL QTY (AIR)	REER	B-16	RT EMER BATT Bus
L FUEL QTY (GND)	REER	C-14	GND SVC Bus
R FUEL QTY (GND)	REER	C-15	GND SVC Bus

B. Crew Alerting System (CAS) Messages:

CAS messages associated with the fuel indication system are:

Area Monitored:	CAS Message:	Message Color:
Fuel Boost Pumps	L-R FUEL PRESS LOW	Red
Wing Tank Hoppers	FUEL TANK TEMP	Red
Fuel Quantity	L-R FUEL LEVEL LOW	Amber
Fuel Quantity Measurement	FQMS MAINT REQD	Blue
Fuel Quantity Signal Conditioner	L-R FQSC CH FAIL	Blue

4. Limitations:

A. Flight Manual Limitations:

(1) Maximum Fuel Tank Temperature:

Fuel temperatures of +54° C or greater will cause a red FUEL TANK TEMP message to be displayed on CAS.

(2) Minimum Fuel Tank Temperature:

(a) Caution Range:

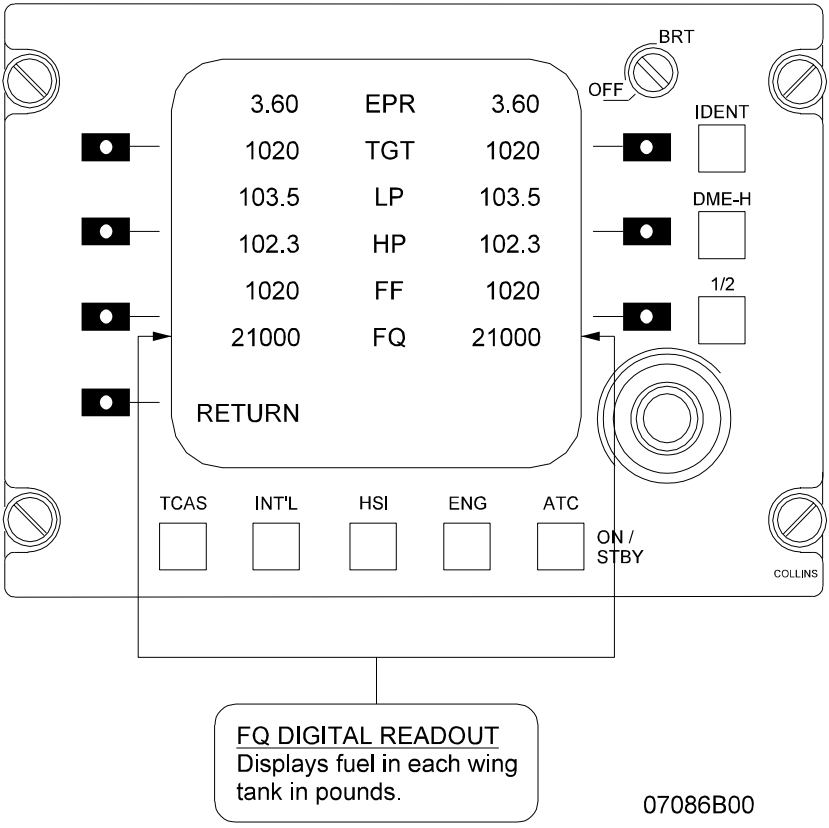
Fuel temperatures of -35° C to -36° C will cause an amber FUEL TANK TEMP message to be displayed on CAS.

(b) Warning Range:

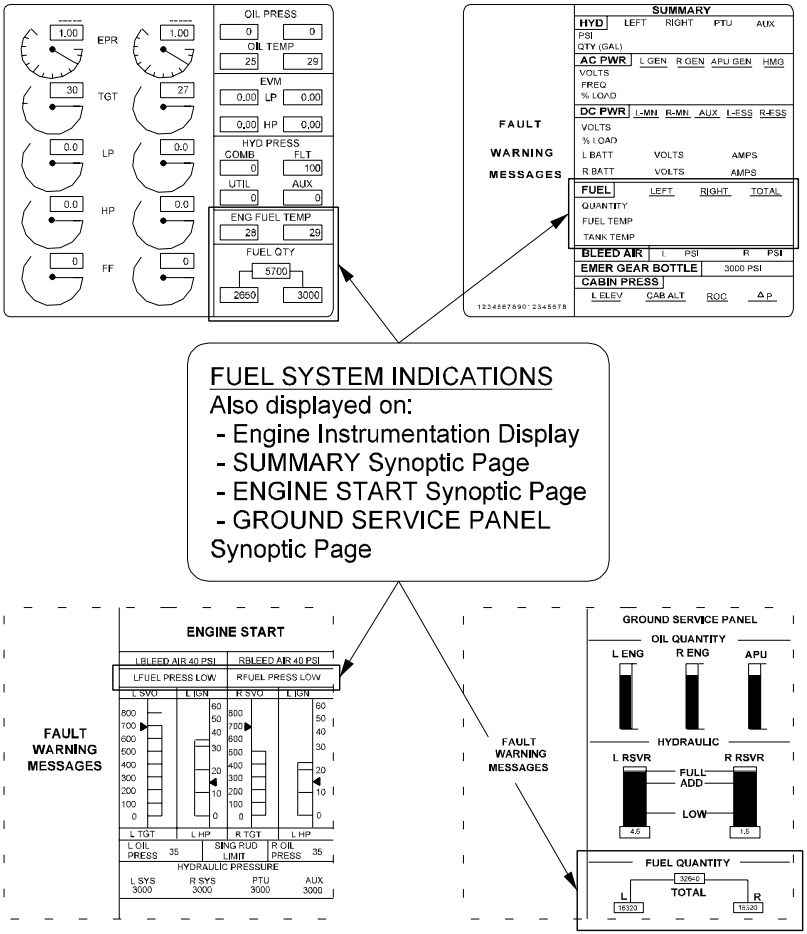
Fuel temperatures less than or equal to -37° C will cause a red FUEL TANK TEMP message to be displayed on CAS.

(3) Inflight Fuel Tank Temperature at or Below -30°C With Less Than 5,000 Lb Total Remaining:

When fuel tank temperature is at or below -30°C in flight with less than 5,000 lb of total fuel remaining, the aircraft shall be descended to an altitude where Static Air Temperature (SAT) is -60°C or warmer and maintain a minimum speed of Mach 0.80.



Radio Frequency Management Unit Display
Figure 7



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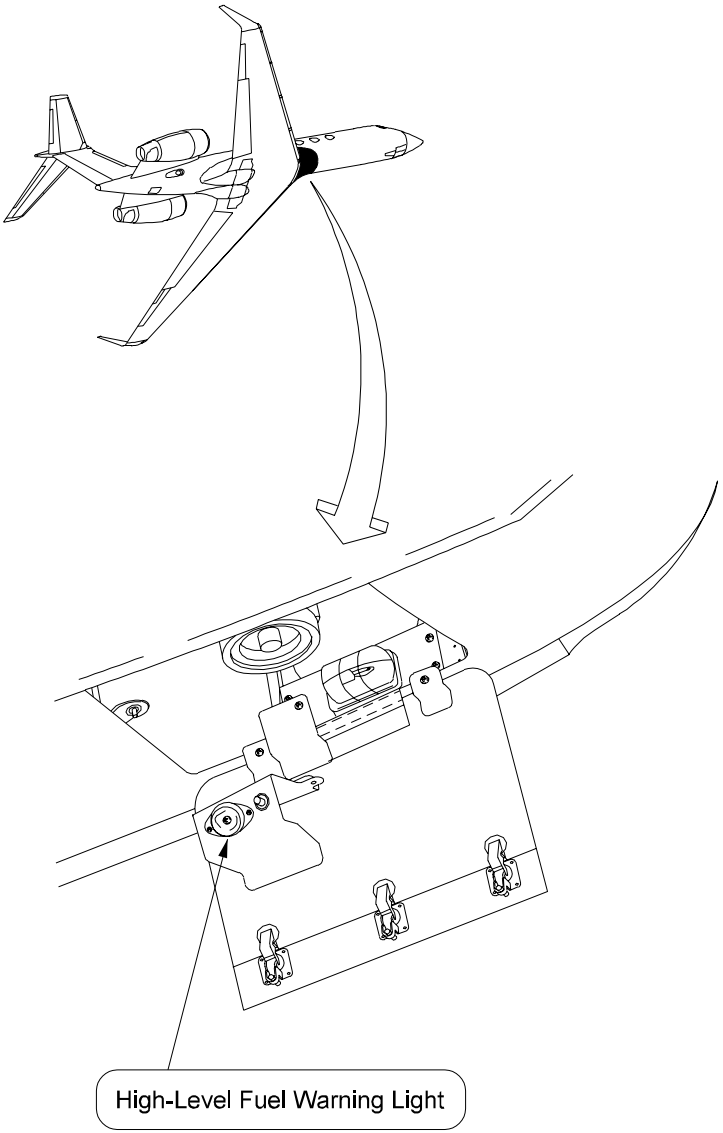
Engine Instrumentation and Synoptic Page Displays
Figure 8



Fueling Compartment Access Door
Figure 9