FUEL

2A-28-10: General

1. **Introduction:**

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.

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 bulb installed in the left hopper 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.

2. **Subsystems Within the Fuel 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

3. **Engine Fuel Grades:**

A. **Kerosene Type:**

Fuel conforming to any of the following specifications is approved for use. Fuels conforming to ASTM Specification ES2-74 are also eligible. Mixing of fuels is permissible.

Kerosene Type		
American	**British**	**Canadian**
ASTM D1655-89, Jet A ASTM D1655-89, Jet A-1 MIL-T-83133A, Grade JP-8	DEF STAN 91-87 DEF STAN 91-91	CAN/CGSB-3.23-M86
French	**USSR**	**I.A.T.A.**
Air 3405/C	T-1, TS-1, RT (GOST 10227-86) T-7 (GOST 12308-66)	1988 Kerosene Type

B. **Wide Cut JP-4 Type:**

Fuel conforming to any of the following specifications is approved for use. Fuels conforming to ASTM Specification ES2-74 are also eligible. Mixing of fuels is permissible.

Wide Cut JP-4 Type		
American	**British**	**Canadian**
ASTM D1655-89, Jet B MIL-T-5624N, Grade JP-4	DEF STAN 91-88	CAN/CGSB-3.22-M86
French	**I.A.T.A.**	
Air 3407/B	1987 JP-4	

C. High Flash Point JP-5 Type:

Fuel conforming to any of the following specifications is approved for use. Fuels conforming to ASTM Specification ES2-74 are also eligible. Mixing of fuels is permissible.

High Flash Point JP-5 Type		
American	**British**	**Canadian**
MIL-T-5624N, Grade JP-5	DEF STAN 91-86	CAN 3-GP-24Ma
French		
Air 3404/C		

NOTE:

The use of Wide Cut fuel, as agreed by the Operator, Rolls-Royce and the appropriate Airworthiness Authority, may result in a reduction in HP Fuel Pump life.

4. Fuel Additives:

The following fuel additives (in addition to those included in DEF STAN Specifications) are approved by Rolls-Royce, subject to limitations stated:

A. Corrosion Inhibitor / Lubricity Aids:

Additive:	Concentration Range - Lb 42,035 Gallons (US) / 35,000 Gallons (IMP)	
	Minimum:	**Maximum:**
HITEC 515	4 (11 mg/l)	7.5 (21 mg/l)
APOLLO PRI 19	3 (9 mg/l)	8 (23 mg/l)
TOLAD 245	7.5 (21 mg/l)	12 (34 mg/l)
DUPONT DCI-4A	3 (9 mg/l)	8 (23 mg/l)
HITEC 580	3 (9 mg/l)	8 (23 mg/l)

NOTE:

Minimum requirement is to ensure that sufficient additive is available when it is required to act as a lubricity aid.

B. Anti-Icing Additive:

- DEF STAN 68-252 **or:**
- MIL-I-27686E **or:**
- Any direct equivalent in concentrations not exceeding 0.15 percent by volume

C. Static Dissipater Additive:

- Shell A.S.A. 3 in concentrations of not more than 1.00 parts per million
- Stadis 450 maximum concentration not more than 3.00 parts per million

D. Anti-Microbiological Additive:

(1) Methyl Cellosolve:

Methyl cellosolve may be used. Refer to GIV Maintenance Manual for additive application procedures.

(2) Biobor JF:

Biobor JF may be used. Refer to GIV Maintenance Manual for additive application procedures.

(3) Kathon FP 1.5:

Kathon FP 1.5 may be used. Refer to GIV Maintenance Manual for additive application procedures.

NOTE:

Under certain conditions, solid matter may be precipitated from fuel containing Biobor JF or Kathon FP 1.5 during flight. The fuel differential pressure signals should be carefully monitored in flight immediately following its use in the airplane tanks. Refer to Rolls-Royce Tay Maintenance M-TAY-1RR for recommended procedures to be followed when using Biobor JF or Kathon FP 1.5.

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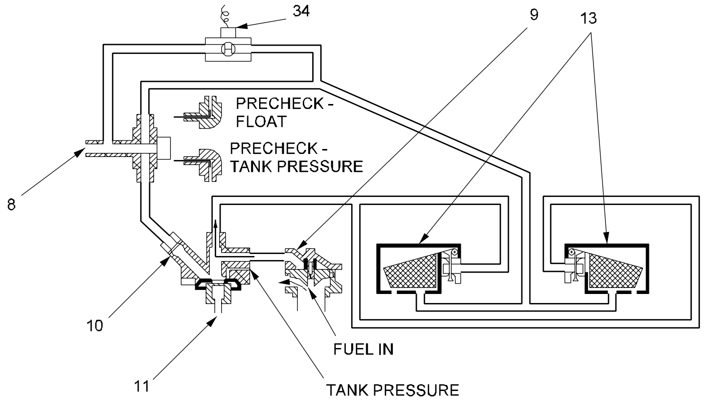
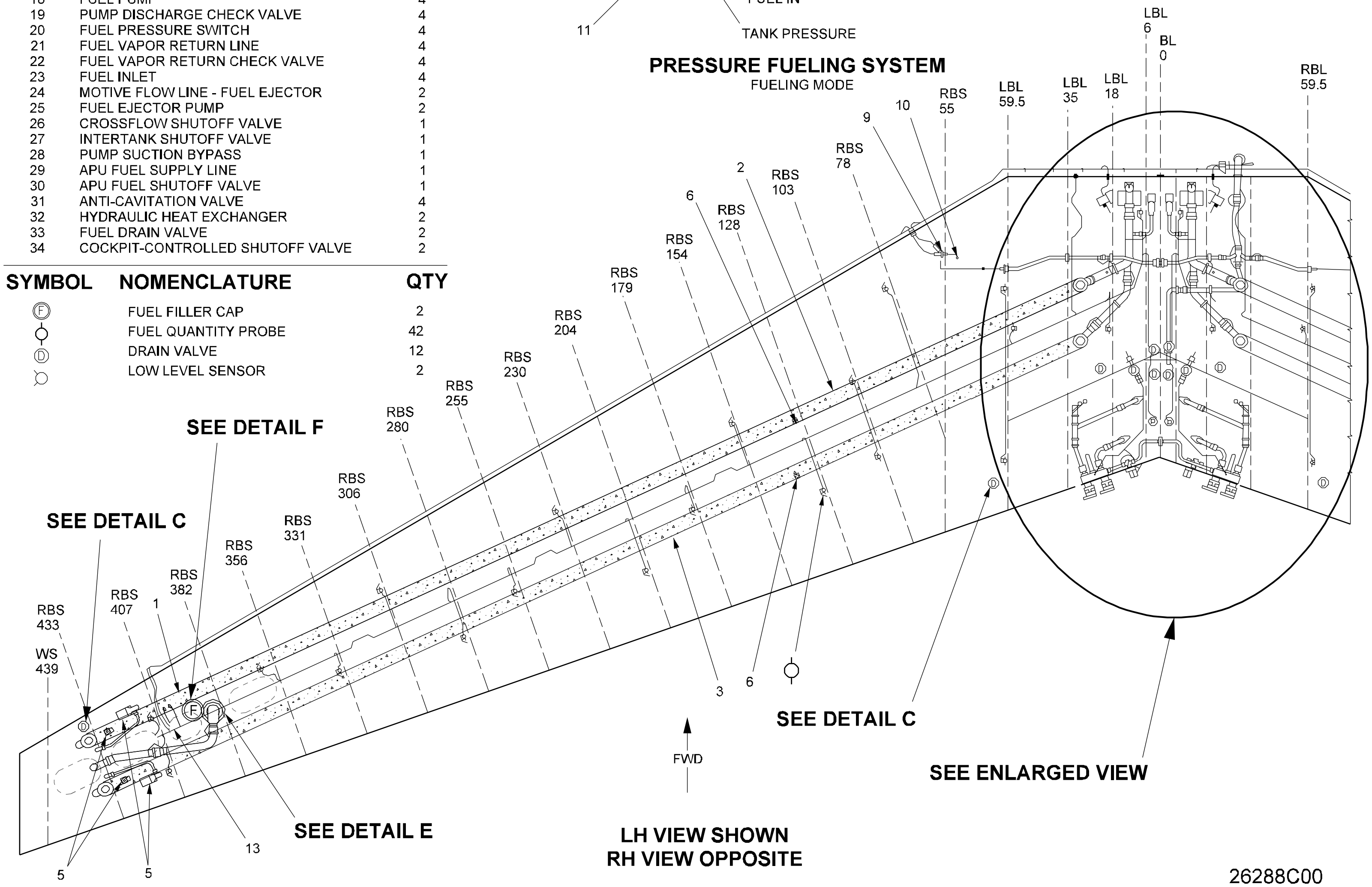
ITEM	NOMENCLATURE	QTY
1	VENT FLOAT / RELIEF VALVE	4
2	VENT LINE - FWD	2
3	VENT LINE - AFT	2
4	VENT - OVERBOARD	2
5	VENT FLOAT / NON-RELIEVING VALVE	8
6	VENT FLOAT / DRAIN VALVE	6
7	PRESSURE FUELING ADAPTER	1
8	PRESSURE FUELING PRECHECK VALVE	2
9	PRESSURE FUELING SHUTOFF VALVE	2
10	PRESSURE FUELING SENSING VALVE	2
11	PRESSURE FUELING AMBIENT PRESSURE PORT	2
12	ENGINE FUEL SHUTOFF VALVE	2
13	PRESSURE FUELING HIGH LEVEL PILOT	4
14	SUCTION DEFUEL VALVE	1
15	SUCTION DEFUEL LINE	1
16	FUEL HOPPER	2
17	FUEL PUMP MANIFOLD	2
18	FUEL PUMP	4
19	PUMP DISCHARGE CHECK VALVE	4
20	FUEL PRESSURE SWITCH	4
21	FUEL VAPOR RETURN LINE	4
22	FUEL VAPOR RETURN CHECK VALVE	4
23	FUEL INLET	4
24	MOTIVE FLOW LINE - FUEL EJECTOR	2
25	FUEL EJECTOR PUMP	2
26	CROSSFLOW SHUTOFF VALVE	1
27	INTERTANK SHUTOFF VALVE	1
28	PUMP SUCTION BYPASS	1
29	APU FUEL SUPPLY LINE	1
30	APU FUEL SHUTOFF VALVE	1
31	ANTI-CAVITATION VALVE	4
32	HYDRAULIC HEAT EXCHANGER	2
33	FUEL DRAIN VALVE	2
34	COCKPIT-CONTROLLED SHUTOFF VALVE	2

SYMBOL	NOMENCLATURE	QTY
Ⓕ	FUEL FILLER CAP	2
	FUEL QUANTITY PROBE	42
Ⓓ	DRAIN VALVE	12
	LOW LEVEL SENSOR	2



PRESSURE FUELING SYSTEM
FUELING MODE



LH VIEW SHOWN
RH VIEW OPPOSITE

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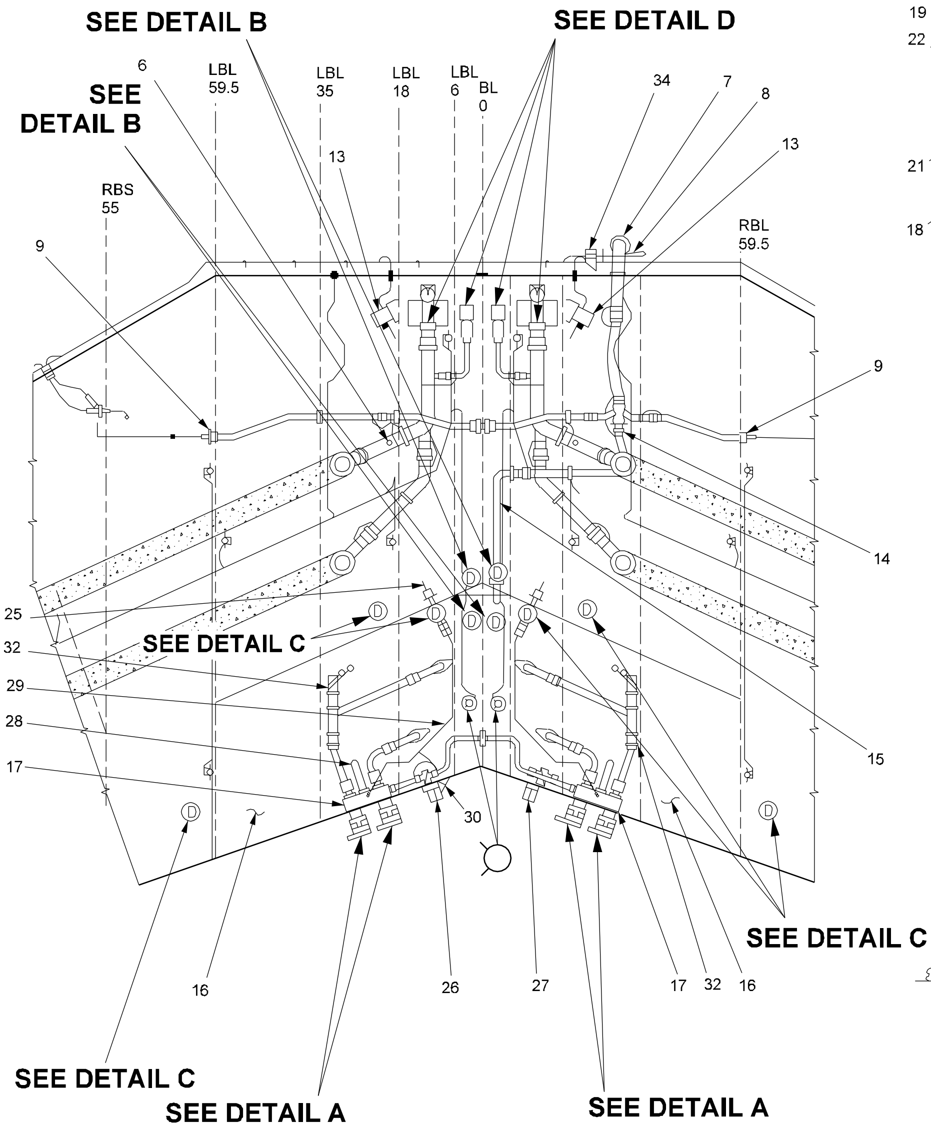
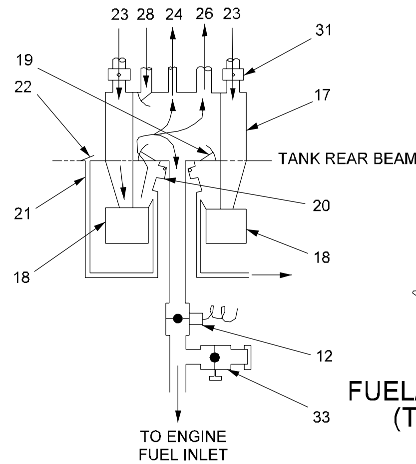
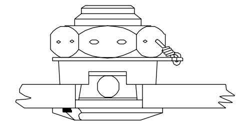
Fuel System Simplified
Block Diagram, Sheet 1 of
2
Figure 1



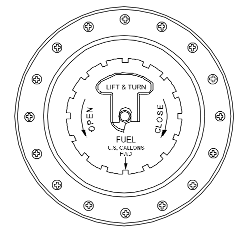
ENLARGED VIEW
LH VIEW SHOWN
RH VIEW OPPOSITE



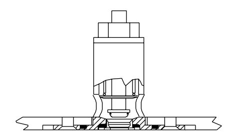
DETAIL A
(TYPICAL 2 PLACES)



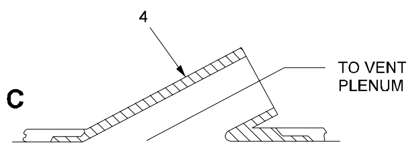
DETAIL B
FUEL/WATER DRAIN VALVE
(TYPICAL 4 PLACES)



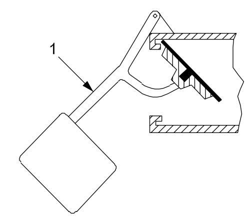
DETAIL F
(TYPICAL 2 PLACES)



DETAIL C
WATER DRAIN VALVE
(TYPICAL 8 PLACES)



DETAIL E
(TYPICAL 2 PLACES)



DETAIL D
(TYPICAL 4 PLACES)

SYMBOL	NOMENCLATURE	QTY
Ⓕ	FUEL FILLER CAP	2
	FUEL QUANTITY PROBE	42
Ⓓ	DRAIN VALVE	12
	LOW LEVEL SENSOR	2

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Fuel System Simplified Block Diagram, Sheet 2 of 2
Figure 2

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:

- Wing Fuel Tanks
- Fuel Hoppers
- Gravity Water / Fuel Drain System
- Fuel Ventilation System
- Over-Wing (Gravity) Fueling System

2. Description of Subsystems, Units and Components:

A. Wing Fuel Tanks:

The integral wing tanks include most of the internal wing structure between the forward and rear spars. The centerline fuselage rib at Buttock Line Zero (BL0) and a sealed rib at Rib Body Station (RBS) 433 form the inboard and outboard edges of each wing tank, while the wing planks form the upper and lower confines.

The external underside of the centerline rib is protected by a non-sparking skeg panel that serves to protect the underside of the aircraft in the event of a gear-up landing.

Partially sealed sheet metal ribs form part of the wing structure and divide each wing tank into five compartments. The ribs act as baffles to prevent fuel sloshing and sudden center-of-gravity changes that could result as fuel moves about a partially filled tank. One-way flapper valves also control fuel movement by opening to allow fuel movement inward while preventing outward movement.

Each wing tank has a fuel filler cap on the upper wing surface near the outboard end of the fuel tank.

B. Fuel Hoppers:

A 190 U.S. gallon (719 liter) fuel hopper in each wing tank extends laterally from the centerline rib to the wing's first structural rib. The hopper's forward wall and the rear wing spar form the forward and aft confines. Flapper valves in the forward wall open to allow hopper refilling during fueling or when the wing fuel tank fuel level is higher than hopper fuel level.

Each hopper supplies its respective engine with fuel. The left hopper also supplies the APU. Each hopper contains the following:

- Fuel pump manifold and associated plumbing
- Fuel tank low level sensor
- Hydraulic fluid heat exchanger
- Fuel quantity probe with compensator
- Motive flow ejector pump

A crossflow shutoff valve in the left hopper allows fuel balance to be adjusted. A fuel temperature bulb provides a signal for cockpit indications of fuel temperature.

Simultaneous defueling of both tanks is provided through a suction defueling line and an intertank shutoff valve inside the right fuel hopper.

A motive flow ejector pump, supplied with motive fuel flow from the fuel pump manifold, transfers fuel from respective fuel tank into the hopper faster than the engine can consume it at maximum cruise power. Excess fuel then overflows the hopper back into the wing tank. With a supply pressure of 25 psig and a maximum motive flow of approximately 750 Pounds Per Hour (PPH) at the ejector pump's inlet, the ejector pump produces a minimum induced flow of approximately 4500 PPH. This assists the boost pumps in maintaining the required fuel pressure at the engine-driven pump inlets.

C. Gravity Water / Fuel Drain System:

Two types of manually operated drain valves allow fuel sampling, draining of accumulated water and gravity draining of the wing tanks and fuel hopper. The majority of the drain valves are located on the bottom of the wing, adjacent to the fuselage centerline. Each fuel tank also has a drain valve near the rear spar at the wing root and another valve in the vent plenum near the wing tip.

The four valves closest to the fuselage centerline are protruding type valves and are placarded as fuel / water low point drains. Pushing the valve up with a Phillips screwdriver, then rotating the valve 90° locks the valve open, allowing draining to occur. Rotating the valve stem 90° (or more if necessary) in the opposite direction reseats and closes the valve.

The remaining valves are flush type valves. They are opened by pushing the valve inward with an appropriate tool and rotating the valve stem 90°. Rotating the valve stem 90° (or more if necessary) in the opposite direction reseats and closes the valve.

D. Fuel Ventilation System:

The fuel ventilation system is an open vent system that slightly pressurizes the fuel during flight and prevents tank over-pressurization during fueling operations. Operation of the system is fully automatic.

Two vent ducts attached to the inside of the upper wing surface run from a Y-pipe assembly near the wing center section to the vent plenum in the wingtip. The Y-pipe assembly connects to a float-operated vent / relief valve that allows tank venting and prevents tank over-pressurization during refueling by venting the inboard part of the tank through the vent ducts to the vent plenum. Float-operated vent valves, downstream of the Y-pipe assembly, drain the fuel vent system.

A non-relieving float-operated vent valve connects each vent duct to the vent plenum. Two smaller float valves provide additional venting for the vent valves. A flush vent then connects the vent plenum to the atmosphere through a flush NACA-type vent on the wing's lower surface. In flight, the NACA duct slightly pressurizes the wing tank.

E. 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. The adapter has a standpipe filler neck that limits wing tank capacity to approximately 2,185 gallons (8,271 liters). This equates to approximately 14,750 pounds (6,690 kg) total per tank.

During gravity fueling, fuel is allowed to travel inboard, through the ribs, to the aircraft centerline. This path fills the aircraft from the centerline rib, including the hopper, outboard.

A grounding wire receptacle is incorporated in to the wing leading edge so that the gravity fueling nozzle may be grounded during fueling. Gulfstream recommends gravity fueling take place over the leading edge of the wing, rather than the trailing edge. Procedures for over-wing (gravity) fueling are presented in Chapter 9: Handling and Servicing.

3. Limitations:

A. Usable Fuel Capacities:

Left Tank	Right Tank	Total
14,750 lb (6,690 kg)	14,750 lb (6,690 kg)	29,500 lb (13,380 kg)
2,185 gal (8,271 L.)	2,185 gal (8,271 L.)	4,370 gal (16,542 L.)

NOTE:

It is possible to upload fuel in excess of 29,500 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.

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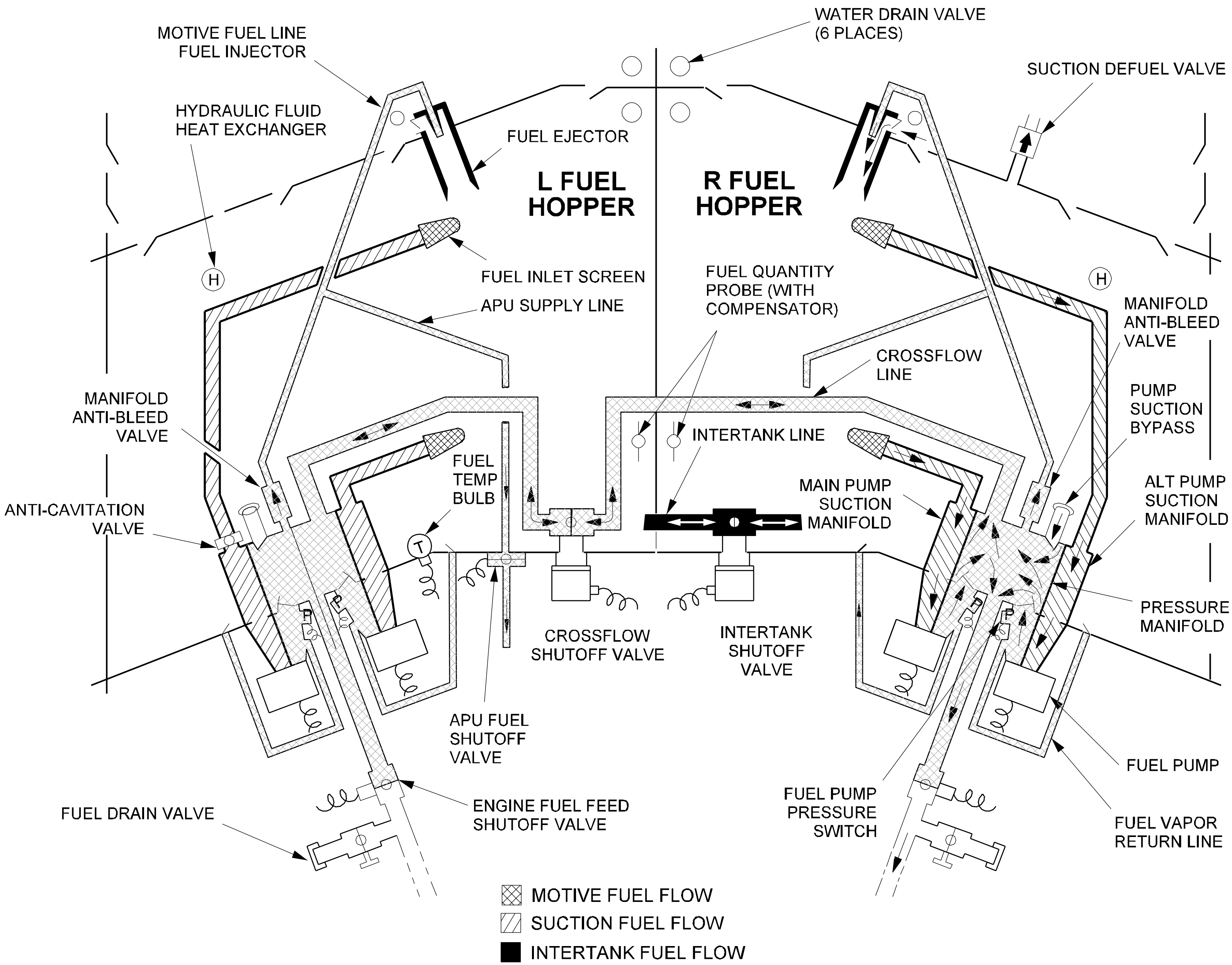


Fuel Hopper Simplified
Block Diagram
Figure 3

2A-28-30: Fuel Distribution System

1. **General Description:**

   The fuel distribution system moves fuel from the wing fuel tanks to refill the hoppers and delivers fuel under pressure from the hoppers to the engines and APU.

   Additionally, the fuel distribution system allows fueling and suction defueling through a single-point pressure fueling adapter. Defueling can also be accomplished using the boost pumps, drains or a combination of all three methods.

   The fuel distribution system is composed of the following subsystems, units and components:

   - Pressure Fueling System
   - Defueling System
   - Fuel Boost Pumps
   - Fuel Ejectors
   - Fuel Shutoff Valves

2. **Description of Subsystems, Units and Components:**

   A. **Pressure Fueling System:**

   The single-point pressure fueling system, shown in Figure 1 and Figure 4, is a hydromechanical system. It is capable of control from the cockpit (by solenoid valves) or from the adapter (by manual shutoff means). Components of the system include:

   - Pressure fueling adapter
   - Two precheck valves
   - Two shutoff valves
   - Two sensing valves
   - Four high-level pilot valves
   - Two fuel shutoff solenoid valves

   (1) Connection and Commencement:

   The fueling adapter is located underneath the right wing leading edge wing-to-fuselage fillet. After connecting the fuel nozzle to the fueling adapter, opening the nozzle supplies fuel at 35 to 55 psig (optimum for adequate prechecks) to the pressure fueling shutoff valve. Fuel pressure against the shutoff valve forces the poppet open, allowing fuel to flow to the tanks. Once fueling commences, system prechecks are completed.

   (2) Precheck Selector To FLOAT:

   With a tank's precheck selector in FLOAT, fuel flows through sense lines into the inboard and outboard high-level pilot valve float chambers. Flow is such that it flows into the chambers faster than it can drain through openings in the bottom of the chambers. As pilot valve fuel level rises, the float in each valve rises until it closes the valve's poppet. The resulting back pressure in the inboard and outboard sense lines overcomes fuel pressure against the shutoff valve, which then closes to stop fueling. This sequence indicates a successful test.

(3) Precheck Selector To TANK PRESS:

Placing the precheck selector to TANK PRESS directs fuel to the tank pressure sense valve. Back pressure in the sense line then overcomes fuel pressure against the shutoff valve, which then closes to stop fueling. This sequence indicates a successful test.

(4) Precheck Selector To FUEL:

Placing the precheck selector to FUEL between each test sequence enables continued testing. After completion of the tests, placing the precheck selector to FUEL resumes normal fueling.

(5) Full Load Fueling:

As the fuel level rises, the inboard high-level pilot valves fills through the opening in the bottom of its chamber and closes before the outboard high-level pilot valve. Fueling continues while the outboard high-level pilot valve is still open. When the fuel level reaches full, the outboard high-level pilot valve closes and the resultant back pressure in the outboard sense line closes the shutoff valve. Fueling stops.

(6) Partial Load Fueling:

The preferred method for partial load fueling requires Essential DC bus power in order to use the L and / or R REMOTE FUELING SHUTOFF switches (cockpit overhead panel) to control fuel flow, and the standby fuel quantity indicator (copilot's flight panel) to monitor fuel quantity. When the desired amount of fuel has been uploaded into the wing tank(s), the REMOTE FUELING SHUTOFF switch(es) are selected to CLSD. This supplies 28 VDC to the respective fuel shutoff solenoid valve. The valve opens and the resultant back pressure against the pilot valve float system stops fuel flow to the tank(s).

NOTE:

Before fueling, it is recommended that the aircraft be positioned with the wings laterally level and with the nose gear at the low portion of the ramp.

NOTE:

The amber L-R FUEL LEVEL LOW caution Crew Alerting System (CAS) messages are prompted for display at approximately 650 lb (295 kg). These messages may erroneously appear at greater fuel loads when the boost pumps are not operating. Proper operation should resume when the boost pumps are selected on.

B. Defueling System:

The aircraft may be defueled by suction defueling or pumping. If necessary, after defueling, any remaining pockets of fuel may be removed by wing draining.

Suction defueling takes place through either the fueling adapter or main wheel well fuel drains. Suction defueling through the fueling adapter is basically the reverse of the fueling process: fuel is drawn from the fuel tanks through the fueling lines. Suction defueling through the main wheel well fuel drains requires connecting drain hoses to the drain valves. With the appropriate equipment, a fuel truck drains the tanks. Neither suction method will result in completely empty tanks. Approximately 150 gallons will remain, primarily in the left tank. This can be removed by the pumping method, if desired.

Defueling by pumping is a method whereby fuel from the wing tanks is forced through main wheel well fuel drains by the boost pumps. This method leaves much less fuel remaining than the suction methods, however, caution is required to ensure the boost pumps are not run dry for more than three minutes, to prevent pump damage.

Regardless of the defueling method, opening the INTER TANK valve (cockpit overhead panel) allows fuel to gravity flow from the left hopper to the right hopper as the right hopper level drops during defueling.

Once defueling is completed, the FUEL LOW LEVEL circuit breaker must be pulled to prevent damage to the system with power applied to the aircraft.

C. Fuel Boost Pumps:

(See Figure 3 and Figure 5.)

Two electric motor-driven boost pumps are mounted on the rear spar in each main wheel well. All four pumps are identical and interchangeable, but for the purposes of identification, the inboard pumps are designated as main pumps and the outboard pumps are designated as alternate pumps. The pumps are capable of operation for as long as fuel is available.

Each pump consists of a fuel-cooled 28 VDC motor that drives a low-pressure impeller. When operating, each pump supplies fuel at 22 psi (minimum) at a maximum flow rate of 8,000 PPH. The inlet and discharge ports of the pumps extend through the rear beam into the pump manifold. Spring-loaded flapper valves on the manifold’s inlet and discharge ports close to allow pump removal without defueling the fuel tank. Operating pressure opens the discharge port flapper valve; installing the pump opens the inlet port flapper valve.

(1) Fuel Pump Manifold:

The fuel pump manifold, located in the rear of the fuel hopper, is composed of two suction chambers and a single pressure chamber. Each suction chamber connects to separate suction line with an inlet screen. An anti-cavitation float valve in each suction line prevents pump cavitation by supplying fuel through the valve if an inlet screen clogs. From the inlet screen, the pump draws fuel from the bottom of the hopper into the suction chamber, then through the suction port flapper valve, into the pump. Rotation of the pump impeller pressurizes the fuel and delivers it at low pressure through a discharge port flapper valve into the pump manifold pressure chamber.

From the pressure chamber, fuel flows at low pressure to the following components:

(a) An engine fuel feed lines to its respective engine. Fuel flow through the line is controlled by a normally open shutoff valve installed between the boost pumps and engine-driven pumps.

(b) A crossflow line interconnected to the opposite side pump manifold. Fuel flow through the line is controlled by a normally closed shutoff valve located in the left fuel hopper.

(c) A motive flow line connected to the fuel ejector. Fuel for the APU is tapped from the left side motive flow line.

(d) Pump suction bypass lines which extend down to the bottom of the hoppers. These lines are fitted with a check valve normally held closed by boost pump pressure. If both boost pumps should fail, the engine can draw fuel directly from the hopper, using the suction bypass lines, bypassing the inoperative pumps.

(2) Pump Operation:

Depressing a MAIN PUMPS switch (cockpit overhead panel, FUEL SYSTEM section) supplies 28 VDC from the Essential DC bus to the associated pump's power relay. The relay then closes to supply 28 VDC operating power from the Essential DC bus to the pump's inverter. The inverter then supplies AC power to the pump motor. The amber OFF legend in the switch extinguishes.

Similarly, depressing an ALT PUMPS switch supplies 28 VDC from the Right Main DC bus to the associated pump's power relay. The relay then closes to supply 28 VDC operating power from the Right Main DC bus to the pump's inverter. The inverter then supplies AC power to the pump motor. The amber OFF legend in the switch extinguishes.

(3) Pump Malfunctions:

If a boost pump fails to develop 16 psi after switch selection, a pump pressure switch energizes a fuel boost pump relay. The relay then triggers the associated amber L-R MAIN FUEL FAIL or L-R ALT FUEL FAIL caution message on CAS.

If fuel pressure at the engine-driven high pressure fuel pump inlet is less than 15 psi, or both boost pumps on one side are selected OFF (or should fail) with the crossflow (X FLOW) valve closed, a pressure switch at the high pressure fuel pump inlet triggers the associated red L-R FUEL PRESS LOW warning message on CAS and on the ENGINE START system page. A respective red L / R FUEL PRESS annunciator also illuminates on the Standby Warning Lights Panel (SWLP), if installed. This message can occur regardless of engine speed and output pressure of the engine-driven low pressure fuel pump. In addition to serving as a warning to check and set the FUEL SYSTEM panel configuration, this message could serve as an early predictor of a fuel leak, in which case the flight crew should be alert for erratic fuel flow indications.

(4) Autochange Circuit:

Should an operating boost pump on one side fail, an autochange circuit is incorporated to automatically select the other pump on that side. The autochange circuit is powered by the Essential DC bus and consists of two parts: control monitor relays and transfer relays.

The first part of the autochange circuit incorporates a control monitor relay for each boost pump. If the selected pump loses power or its power circuit breaker opens, the control monitor relay automatically selects the opposite boost pump on by energizing that pump's power relay. If a boost pump's power circuit breaker opens, an amber CB legend will illuminate in that pump's control switch.

The other part of the autochange circuit incorporates a transfer relay for each boost pump. If a boost pump is selected on but fails to develop 16 psi output, the transfer relay automatically selects the opposite boost pump on by energizing that pump's power relay. The amber OFF legend will illuminate in the failed pump's switch.

Whenever the autochange system activates a boost pump other than the one selected, the switch corresponding to the now-operative boost pump must be selected on by the flight crew. The switch corresponding to the now-inoperative boost pump should be selected to OFF.

Restated in summary, the autochange circuit will automatically select the opposite boost pump on the same side if:

- A main boost pump fails, even with the alternate boost pump not selected on
- A main boost pump power circuit breaker opens with the pump running due to actuation of the main pump control monitor relay
- An alternate boost pump fails, even with the main boost pump not selected on
- An alternate boost pump power circuit breaker opens with the pump running due to actuation of the alternate pump control monitor relay

D. Fuel Ejectors:

A fuel ejector (often referred to as an ejector pump or jet pump and shown in Figure 6) is a simple device that has no moving parts. It resembles and operates like a venturi tube. It uses high pressure / low volume fluid as an operating force to move a large volume of low pressure fluid in the desired direction.

Each fuel hopper has a fuel ejector on the forward face of the forward wall with the outlet projecting into the hopper. With a boost pump operating, high pressure / low volume fuel flowing through the motive flow fuel line from the pump manifold enters the ejector's motive flow inlet.

As the motive flow fuel rushes out of the nozzle and enters the throat of the venturi, it creates a low pressure area that in turn draws a large volume of fuel from the wing tank and moves it at low pressure into the fuel hopper through the ejector's outlet. This induced fuel flow ensures the hopper remains full at all times as the engines consume fuel. Any excess fuel in the hopper overflows through the top of the hopper wall back into the wing tank.

E. Fuel Shutoff Valves:

Shutoff valves are incorporated in the fuel distribution system to control movement of fuel about the wing tanks, hoppers and to the engines. All shutoff valves receive power from the Essential DC bus. The valves are shown in Figure 3 and described as follows:

(1) Engine Fuel Feed Shutoff Valve:

An engine fuel feed shutoff valve is installed in each engine's fuel feed line. Each valve is normally open to allow passage of low pressure fuel to the respective engine-driven low pressure fuel pump. The valve is closed by pulling the respective FIRE handle, located on the left and right forward sides of the cockpit center pedestal.

(2) Crossflow Valve:

The fuel crossflow line is pressurized with fuel from the fuel pump manifold pressure chamber. The fuel then waits in the crossflow line at the normally-closed crossflow valve. Selection of the X FLOW switch (cockpit overhead panel, Figure 8) opens the valve, allowing fuel from the fuel pump manifold pressure chamber on one side to flow to the chamber on the other side, enabling both engines to be operated from one tank system. With the X FLOW switch selected open, a horizontal bar in the switch capsule illuminates. In addition, a blue FUEL XFLOW OPEN advisory message is displayed on CAS. When selected closed, the bar extinguishes and the CAS message is removed.

The crossflow valve is also opened for fuel balancing in accordance with the limitations set forth in Section 1 of the GIV Airplane Flight Manual.

(3) Intertank Valve:

The intertank valve is opened to combine the left and right hoppers. Located in the right fuel hopper, the intertank valve is controlled by the INTER TANK switch (cockpit overhead panel, Figure 8). When selected open, a horizontal bar in the switch capsule illuminates. In addition, a blue FUEL INT TNK OPEN advisory message is displayed on CAS. When selected closed, the bar extinguishes and the CAS message is removed.

F. Fuel Balancing Procedure:

If fuel balancing is required (either one or both engines operating), proceed as follows:

(1) When fuel tank temperature is above 0° C or fuel contains an anti-icing additive:

(a) Select both boost pumps ON for the side having the higher fuel state.

(b) Select the crossflow valve OPEN.

(c) Select both boost pumps OFF for the side having the lower fuel state.

(2) When fuel tank temperature is below 0° C or fuel contains no anti-icing additive:

(a) Select all four boost pumps ON.

(b) Select the intertank valve OPEN.

(c) Establish a small sideslip (½ ball) in the appropriate direction.

(3) After fuel is balanced:

(a) Ensure all four boost pumps are ON.

(b) Select the crossflow valve CLOSED.

(c) Select the intertank valve CLOSED.

(d) Return to normal cruise operations.

CAUTION

THE INTERTANK VALVE IS USED FOR SUCTION DEFUELING AND IS NOT TO BE USED IN FLIGHT EXCEPT AS DESCRIBED IN THE PRECEDING PROCEDURE, GIV OPERATING MANUAL SECTION 05-16-20: FAILURE OF TWO FUEL BOOST PUMPS ON ONE SIDE OR GIV AIRPLANE FLIGHT MANUAL SECTION 3: FAILURE OF TWO FUEL BOOST PUMPS ON ONE SIDE.

G. Fuel System Check:

Test Conditions:

(1) Ensure the L and R REMOTE FUELING SHUTOFF switches are OPEN (extended). Verify the CLSD legend is extinguished.

(2) Ensure the crossflow valve is CLOSED.

(3) Ensure the L MAIN boost pump is ON.

(4) Ensure the intertank valve is CLOSED.

(5) Ensure the L FUEL PRESS LOW warning message is not displayed on CAS.

(6) Ensure the R FUEL PRESS LOW warning message is displayed on CAS.

Perform the following steps:

(7) Select the L and R REMOTE FUELING SHUTOFF switches CLOSED (depressed). Verify the CLSD legend is illuminated.

(8) Select the L and R REMOTE FUELING SHUTOFF switches OPEN.

(9) Simultaneously select the crossflow and intertank valves OPEN.

(10) Verify the following:

(a) Horizontal bar in crossflow valve switch capsule illuminates.

(b) Horizontal bar in intertank valve switch capsule illuminates.

(c) FUEL XFLOW OPEN advisory message is displayed on CAS.

(d) FUEL INT TNK OPEN advisory message is displayed on CAS.

(11) Verify the R FUEL PRESS LOW warning message is not displayed on CAS.

(12) Select the L MAIN boost pump OFF.

(a) Select the L ALT boost pump ON.

(b) Verify the L FUEL PRESS LOW and R FUEL PRESS LOW warning messages are momentarily displayed on CAS, then are removed.

(13) Select the L ALT boost pump OFF.

(a) Select the R MAIN boost pump ON.

(b) Verify the L FUEL PRESS LOW and R FUEL PRESS LOW warning messages are momentarily displayed on CAS, then are removed.

(14) Select the R MAIN boost pump OFF.

(a) Select the R ALT boost pump ON.

(b) Verify the L FUEL PRESS LOW and R FUEL PRESS LOW warning messages are momentarily displayed on CAS, then are removed.

(15) Simultaneously select the crossflow and intertank valves CLOSED.

(16) Verify the following occurs simultaneously:

(a) Horizontal bar in crossflow valve switch capsule extinguishes.

(b) Horizontal bar in intertank valve switch capsule extinguishes.

(c) FUEL XFLOW OPEN advisory message is removed from CAS.

(d) FUEL INT TNK OPEN advisory message is removed from CAS.

(17) Verify the L FUEL PRESS LOW warning messages is displayed on CAS.

(18) Select the L MAIN boost pump ON.

(19) Verify the L FUEL PRESS LOW is removed from CAS.

(20) Select the R ALT boost pump OFF.

(21) Verify the R FUEL PRESS LOW is displayed on CAS.

3. Controls and Indications:

A. Circuit Breakers (CBs):

Circuit Breaker Name:	CB Panel:	Location:	Power Source:
ALT PUMP CONT	PO	D-4	Right Main DC Bus
FUEL INTERTANK V	PO	B-4	Essential DC Bus
FUEL PUMP IND	PO	A-4	Essential DC Bus
FUEL PUMP LOGIC (1)	PO	C-4	Essential DC Bus
FUEL X FLOW V	PO	D-2	Essential DC Bus
L ALTN BOOST PUMPS	PDB	RIGHT DC	Right Main DC Bus

Circuit Breaker Name:	CB Panel:	Location:	Power Source:
L FUEL S/O	PO	A-2	Essential DC Bus
L FUELING S/O	PO	A-3	Essential DC Bus
L MAIN BOOST PUMPS	PDB	ESS DC	Essential DC Bus
MAIN PUMP CONT	PO	A-1	Essential DC Bus
R ALTN BOOST PUMPS	PDB	RIGHT DC	Right Main DC Bus
R FUEL S/O	PO	B-2	Essential DC Bus
R FUELING S/O	PO	B-3	Essential DC Bus
R MAIN BOOST PUMPS	PDB	ESS DC	Essential DC Bus

NOTE(S):

(1) Aircraft having SPZ-8000.

B. Warning (Red) Messages and Annunciations:

CAS Message:	SWLP Indication	Cause or Meaning:
L-R FUEL PRESS LOW	L FUEL PRESS R FUEL PRESS	Fuel pressure at inlet to high pressure fuel pump is less than 15 psi, or both fuel BOOST PUMPS on one side have been selected to OFF with CROSSFLOW valve CLOSED.

C. Caution (Amber) Messages and Annunciations:

CAS Message:	Cause or Meaning:
L-R ALT FUEL FAIL	Indicated alternate fuel boost pump has failed.
L-R MAIN FUEL FAIL	Indicated main fuel boost pump has failed.

D. Advisory (Blue) Messages and Annunciations:

CAS Message:	Cause or Meaning:
FUEL INT TANK OPEN	Fuel intertank valve is open.
FUEL XFLOW OPEN	Fuel crossflow valve is open.

4. Limitations:

A. Flight Manual Limitations:

(1) Boost Pumps:

During cruise, one (1) boost pump per side may be selected OFF provided:

- The fuel contains an anti-icing additive, **or:**
- Fuel tank temperature is above 0° C

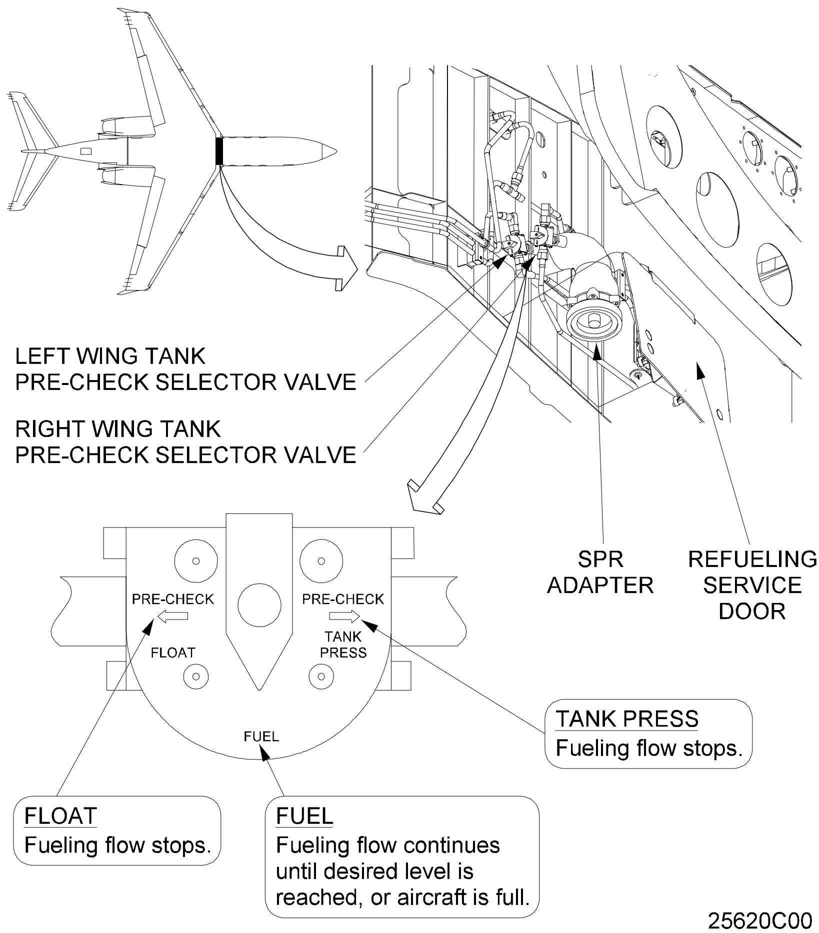
See Section 01-12-30, Engine Fuel Grades.

CAUTION

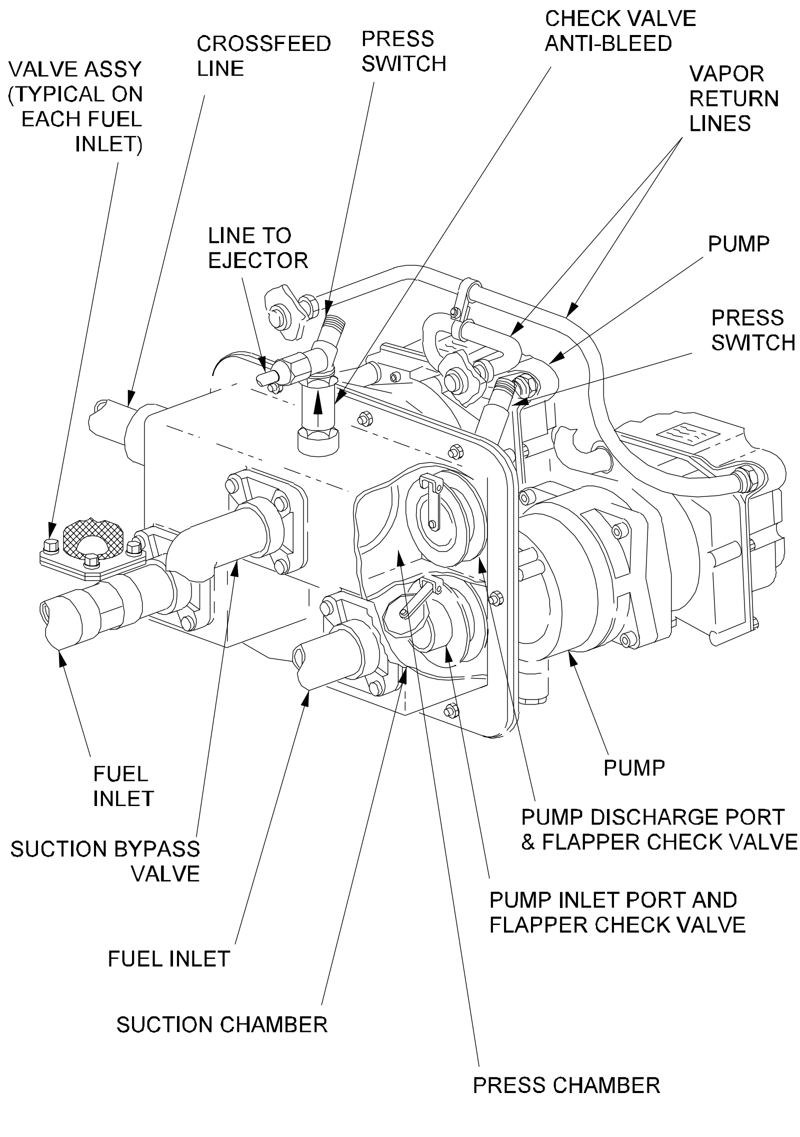
THE ENGINE WILL RUN ON SUCTION FUEL FEED ONLY AT OR BELOW 20,000 FEET. ABOVE 20,000 FEET, THE ENGINE WILL RUN ERRATICALLY AND FLAME OUT IF THE CROSSFLOW VALVE IS NOT OPEN WITH AT LEAST ONE BOOST PUMP ON.

B. Other Limitations:

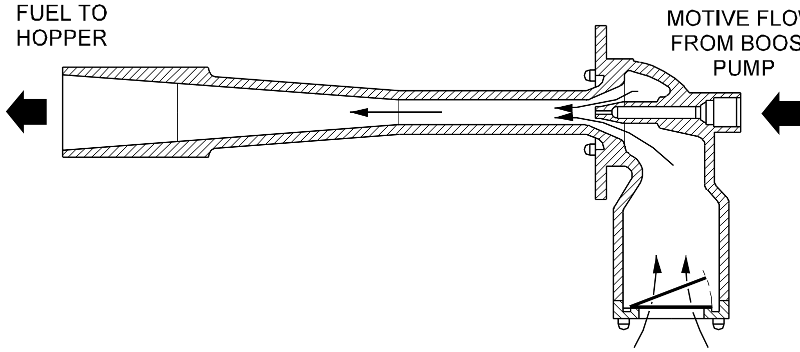
Normal operation of the fuel system is from tank to respective engine. For takeoff and landing, all operable boost pumps are selected on.



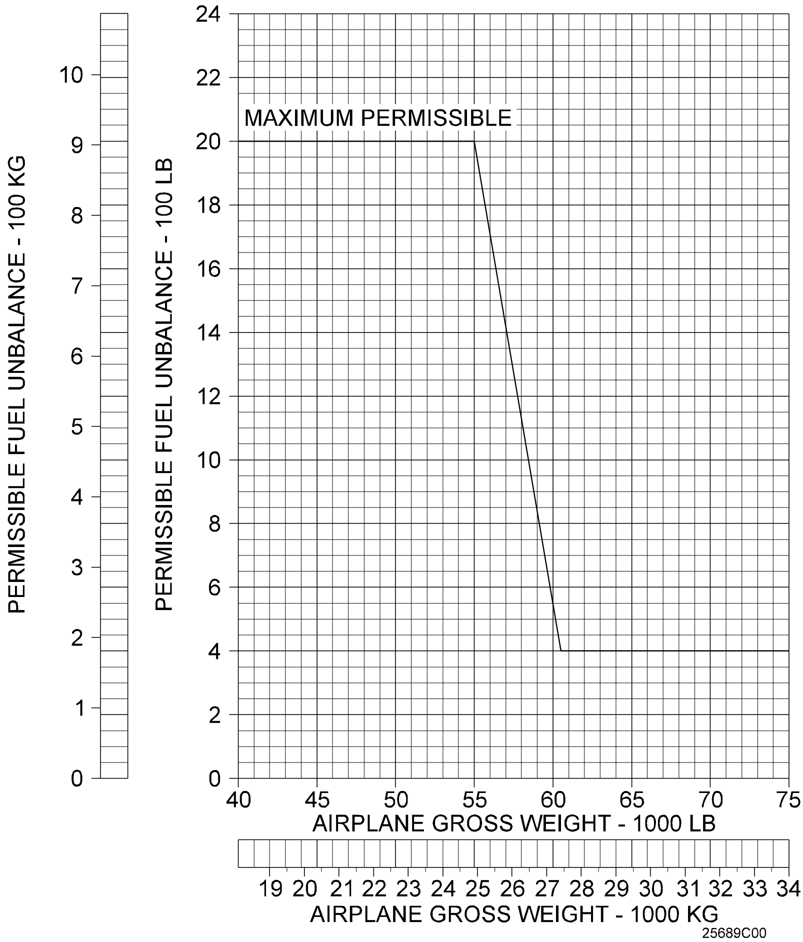
Refueling Adapter and Precheck Controls
Figure 4



Fuel Boost Pump
Figure 5



Fuel Ejector
Figure 6



Permissible Fuel Unbalance For All Flight Operations
Figure 7

2A-28-40: Fuel Indication System

1. General Description:

The fuel indication system provides the flight crew with continuous indication of fuel quantity and warns of a low fuel level. Continuous indication of fuel tank temperature is also provided. The fuel indication system is composed of the following subsystems, units and components:

- Fuel Quantity Indication System
- Fuel Low Level Warning System
- Fuel Temperature Indication System

Fuel flow and engine fuel temperature indications are described in Section 2A-73-

10, Engine Fuel System.

2. Description of Subsystems, Units and Components:

A. Fuel Quantity Indication System:

(See Figure 8 through Figure 10.)

(1) General:

A set of 21 parallel-wired, capacitence-type fuel probes extend into various parts of each wing tank to provide an accurate measurement of tank fuel quantity. The two sets of probes are identical and independent. Each set connects to a signal conditioner through a signal junction box. The signal conditioner, powered by the Essential DC bus, uses the composite readings to drive the standby fuel quantity indicator and to provide driving signals to Data Acquisition Units (DAUs) No. 1 (left side) and No. 2 (right side) for display on the Engine Instrument and Crew Alerting System (EICAS).

(2) EICAS Fuel Displays:

Fuel quantity appears in the lower right corner of the EICAS engine instruments display as FUEL QTY. The Left (L) and Right (R) displays show fuel quantity in the respective wing in 50 lb increments, ranging from 0 lb to 15,000 lb. The Total (T) display shows the combined fuel quantity of both wings in 50 lb increments, ranging from 0 lb to 30,000 lb. The FUEL system page on CAS displays the identical information. Under normal conditions, EICAS fuel quantity data is displayed white in color. If a low fuel condition in one wing is detected, the respective quantity display digits change to amber. If a low fuel condition in both wings is detected, the entire FUEL QTY display changes to amber. If a DAU fails, the associated side’s display digits are replaced with amber dashes.

(3) Standby Fuel Quantity Indicator:

Located on the copilot’s flight panel, the standby fuel quantity indicator contains three 4 digit displays: LEFT, RIGHT and TOTAL. Values shown on each display are in pounds to be multiplied by ten (LBS $\times$ 10). Above the LEFT and RIGHT displays are associated amber LOW FUEL warning lights which illuminate when approximately 650 pounds (295 kg) of usable fuel remains in the respective hopper.

To the right of the TOTAL display is a three-position, momentary-action TEST switch, used to test both the standby fuel quantity indication system and / or the EICAS fuel quantity indication system. Switch positions are “D” (for standby fuel quantity indicator display testing only), off (the spring-loaded center position) and “T” (for testing the entire fuel quantity indication system). Holding the TEST switch in “D” results in the standby fuel quantity indicator’s three displays showing all eights (8888); EICAS is not tested in this mode. Holding the TEST switch in “T” results in the standby fuel quantity indicator and EICAS FUEL QTY display showing 7000 pounds in each wing and 14,000 pounds total. (If the No. 21 probe compensator is not covered, the EICAS FUEL QTY display will show 9000 pounds in each wing and 18,000 pounds total.) The EICAS

FUEL QTY display will also be amber. During the test, the amber LOW FUEL warning lights on the standby fuel quantity indicator will flash for approximately 30 seconds and then illuminate steady. In addition, the amber L-R FUEL LEVEL LOW caution messages will be displayed on CAS. With the test completed, releasing the TEST switch returns the displays to indicating actual fuel quantity and extinguishes the amber LOW FUEL warning lights.

A switchlight, labeled FUEL QTY IND, is installed immediately to the right of standby fuel quantity indicator. When depressed, standby fuel quantity indicator display is inhibited. When extended, normal display is available. The FUEL QTY IND switchlight legend is blue in color and is always illuminated.

Power for the standby fuel quantity indication system is provided by the Essential DC bus. It remains functional all the way down to, and including, Emergency Battery (E-BATT) operation.

B. Fuel Low Level Warning System:

The fuel low level warning system (Figure 11) consists of a temperature-sensitive thermistor in each hopper, a dual-circuit control unit and two amber LOW FUEL lights on the standby fuel quantity indicator. The system receives power from the Essential DC bus.

When the hoppers are full, fuel covers the thermistor and the control units maintains its two warning relays in the energized position. No warnings are displayed in this state.

If a hopper’s fuel level drops below approximately 650 pounds (295 kg), it exposes the thermistor to air. Because there is always a difference between fuel temperature and air (or fuel / air vapor) temperature, resistance changes in the thermistor. The control units senses this change in resistance and de-energizes the respective warning relay. When the relay is de-energized, it provides a signal to the fuel quantity signal conditioner.

The signal conditioner, in turn, flashes the respective amber LOW FUEL light on the standby fuel quantity indicator for 30 seconds to alert the flight crew, then reverts to steady illumination. The signal conditioner also provides a signal to EICAS to display the appropriate cautions. An amber L-R FUEL LEVEL LOW message is displayed on CAS; the respective FUEL QTY display changes to amber. If a low fuel condition in both wings is detected, the entire FUEL QTY display changes to amber.

C. Fuel Temperature Indication System:

A resistance-type temperature bulb in the left fuel hopper provides a signal to DAU No. 1. DAU No. 1 then sends the signal to EICAS for display on the FUEL system page as fuel tank temperature (FUEL TANK TEMP). Fuel tank temperature is displayed in 1° C resolution within a normal operating range of -40° C to 54° C.

Depending on fuel temperature, the EICAS displays the temperature reading with either white or red digits, as listed in the **Limitations** portion of this section.

3. **Controls and Indications:**

A. **Circuit Breakers (CBs):**

Circuit Breaker Name:	CB Panel:	Location:	Power Source:
FUEL LOW LEVEL	PO	B-1	Emergency Battery Bus
L FUEL QTY	PO	C-1	Essential DC Bus
R FUEL QTY	PO	D-1	Essential DC Bus

B. **Caution (Amber) Messages and Annunciations:**

CAS Message:	Cause or Meaning:
L-R FUEL LEVEL LOW	Fuel level in hopper is below approximately 650 lb (295 kg).

Annunciation:	Cause or Meaning:
LOW FUEL light(s) (amber) illuminated on standby fuel quantity indicator.	Fuel level in respective hopper is below approximately 650 lb (295 kg).

4. **Limitations:**

A. **Flight Manual Limitations:**

Fuel Tank Temperature (FUEL TANK TEMP):

- 54° C and above: red digits
- -40° C to 54° C and above: white digits
- Less than -40° C: red digits

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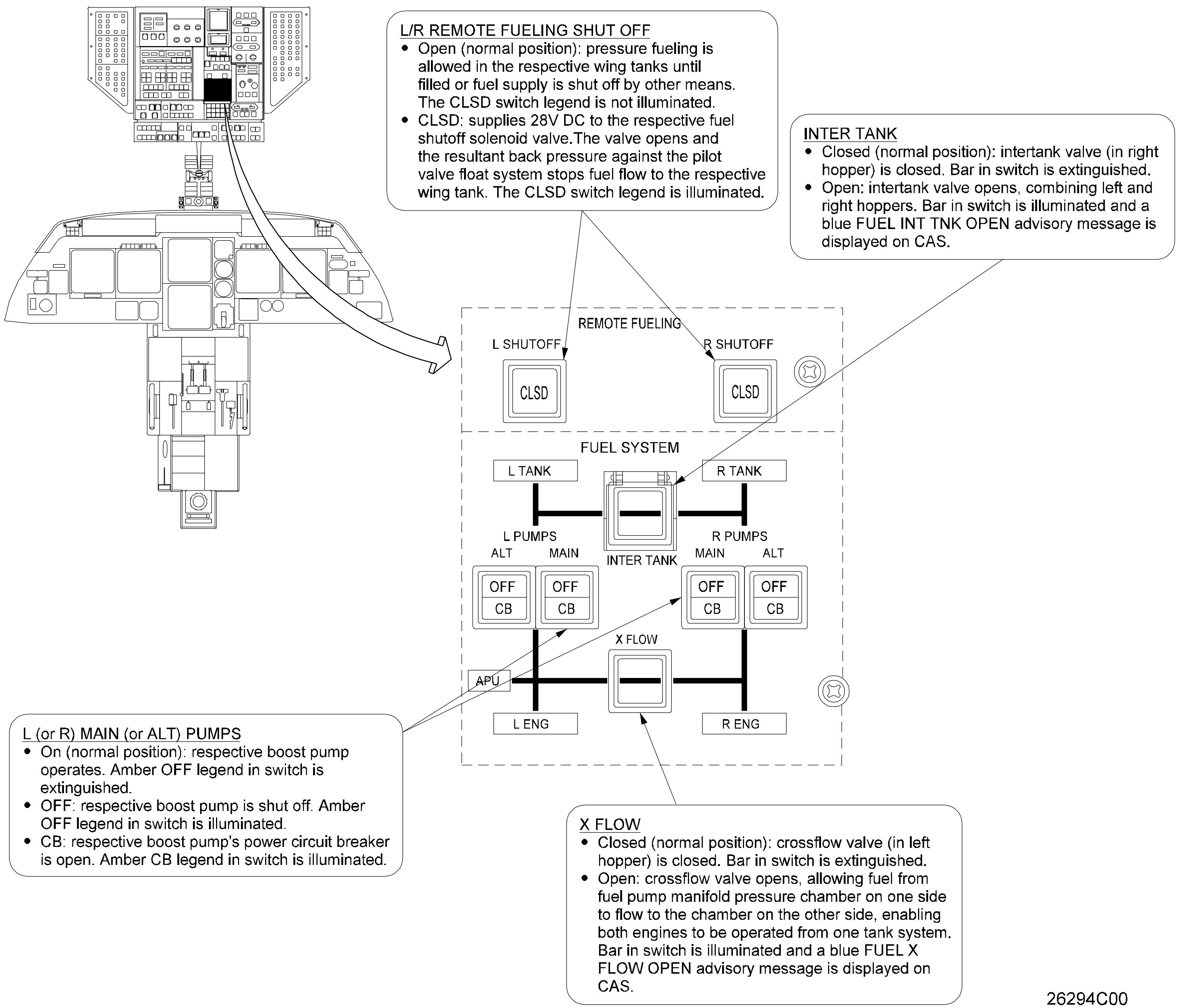

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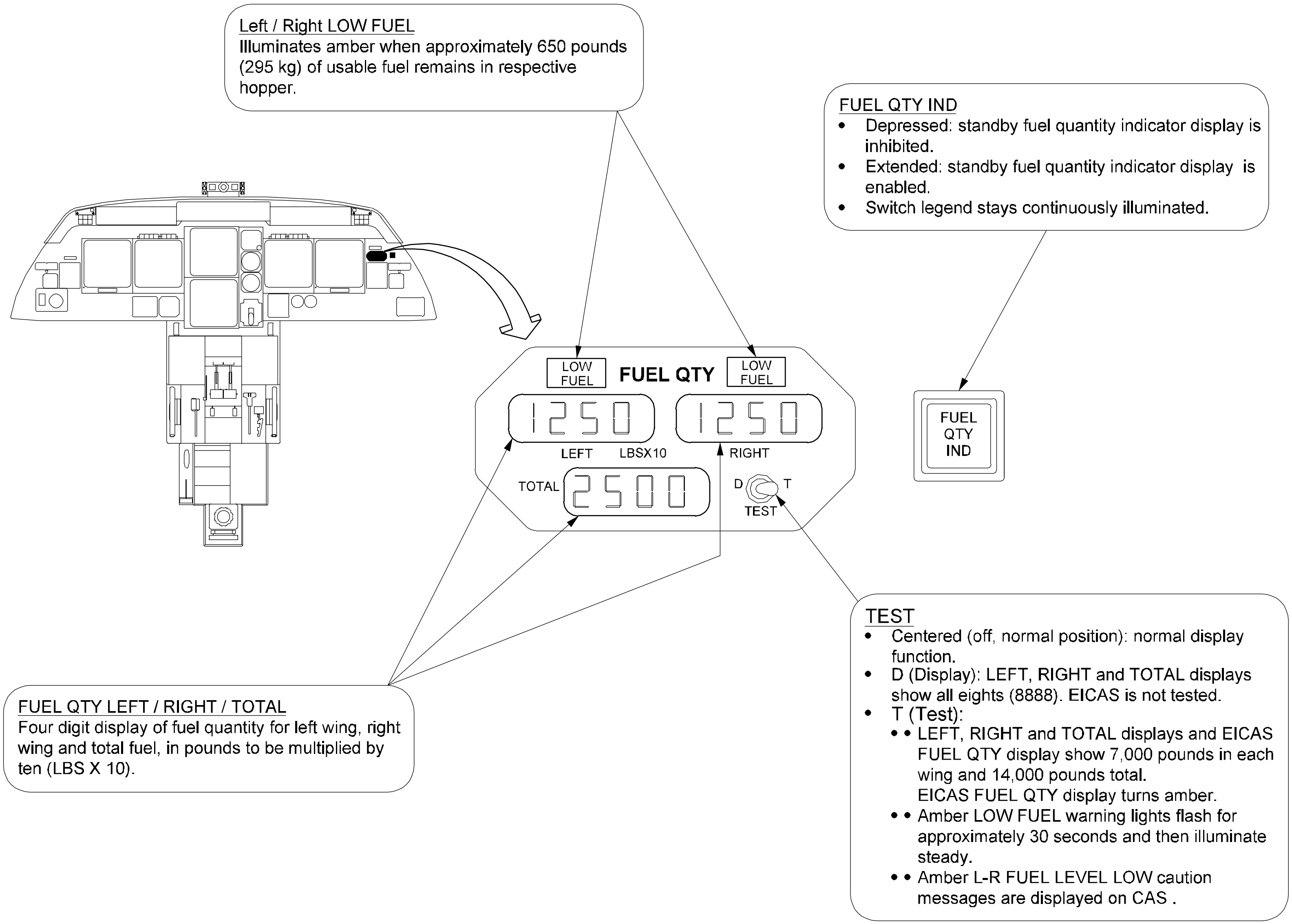
Fuel System Controls and Indications
Figure 8



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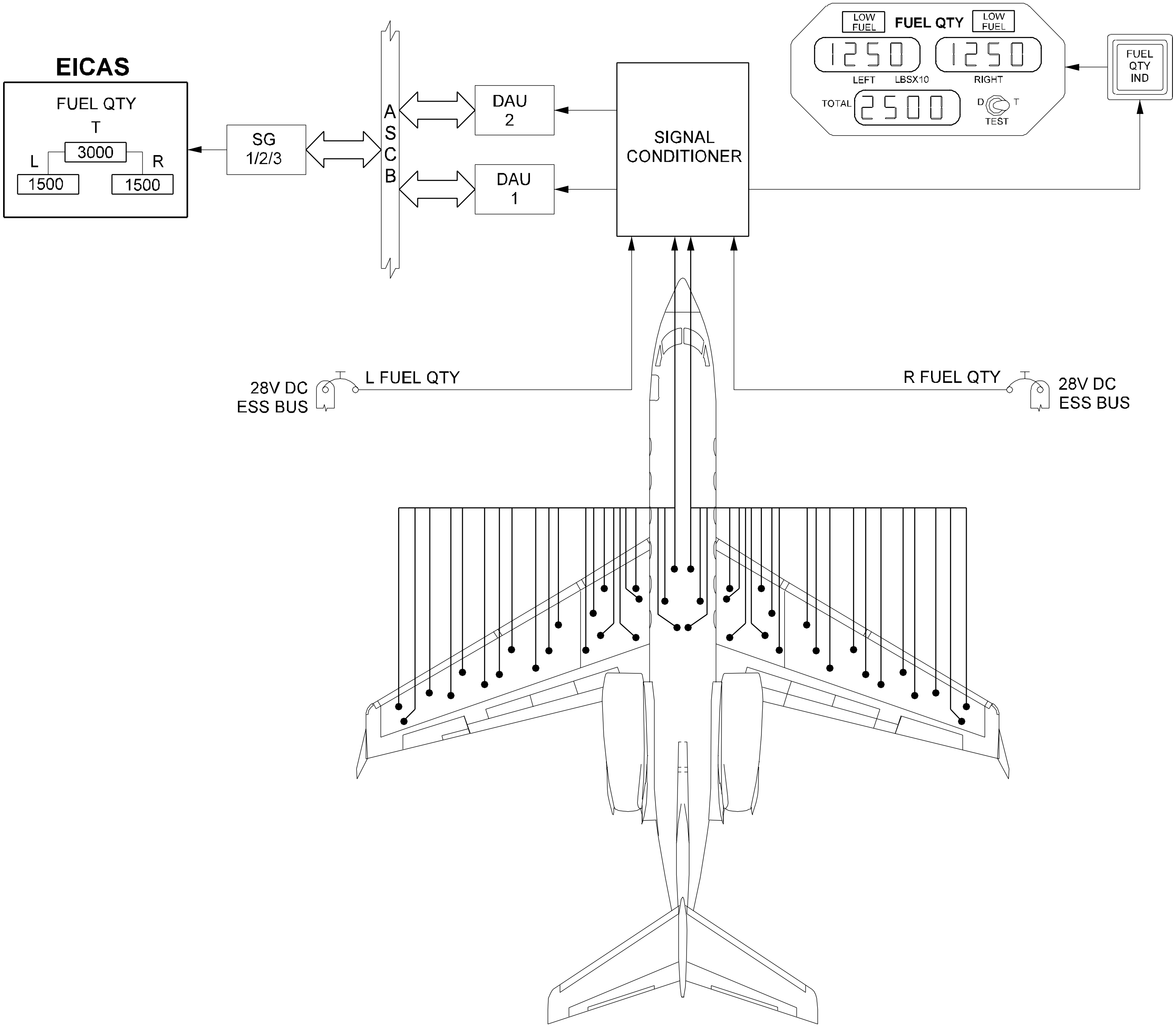
Standby Fuel Quantity System Controls and Indications
Figure 9



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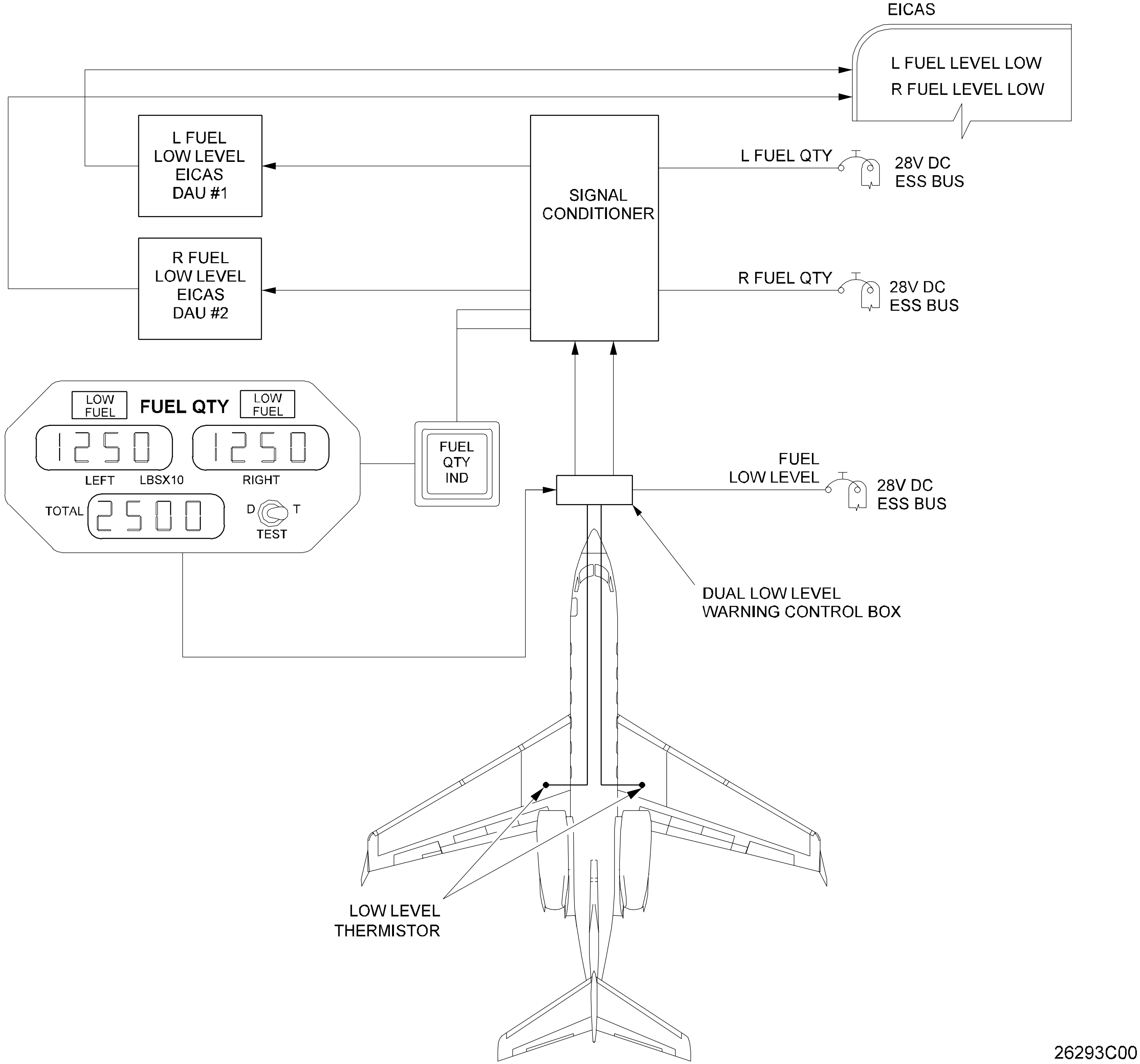
Fuel Quantity System
Simplified Block Diagram
Figure 10



Fuel Low Level System
Simplified Block Diagram
Figure 11