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INTRODUCTION

Hydraulic power is provided by three independent and isolated systems designated 1, 2 and 3 and operate at a nominal pressure of 3000 psi.

SYSTEM 1 AND 2

Systems 1 and 2 are each powered by an Engine-Driven Pump (EDP), and an AC-Motor Pump (ACMP). The EDPs designated as 1A and 2A are mounted on the respective engine accessory gearbox, and hydraulically power systems 1 and 2 when the engines are operating.

The ACMPs designated as 1B and 2B are used as essential pumps for takeoff, approach, landing and in support of the EDPs in the event of failure. The ACMPs are selectable through switches located on the HYDRAULIC control panel in the flight compartment.

During normal operations, system 1 provides hydraulic pressure to the left side primary flight controls and rudder, left and right flight spoilers, left and right ground spoilers, and the left thrust reverser. System 2 provides hydraulic pressure to the right side primary flight controls and rudder, left and right flight spoilers, main gear assist (left and right main landing gear extension/retraction), right thrust reverser and outboard brakes.

SYSTEM 3

System 3 is powered by two ACMPs designated as 3A and 3B, and are selectable through switches located on the HYDRAULIC control panel in the flight compartment. The ACMPs 3A and 3B provide hydraulic pressure to the primary flight controls (all), left and right ground spoilers, landing gear side brace actuator and doors, inboard and park/emergency brakes, and the nose wheel steering.

Hydraulic pump 3A normally runs continuously while pump 3B is used as an essential pump for takeoff, approach, landing, and in support of the primary pump 3A in the event of failure.

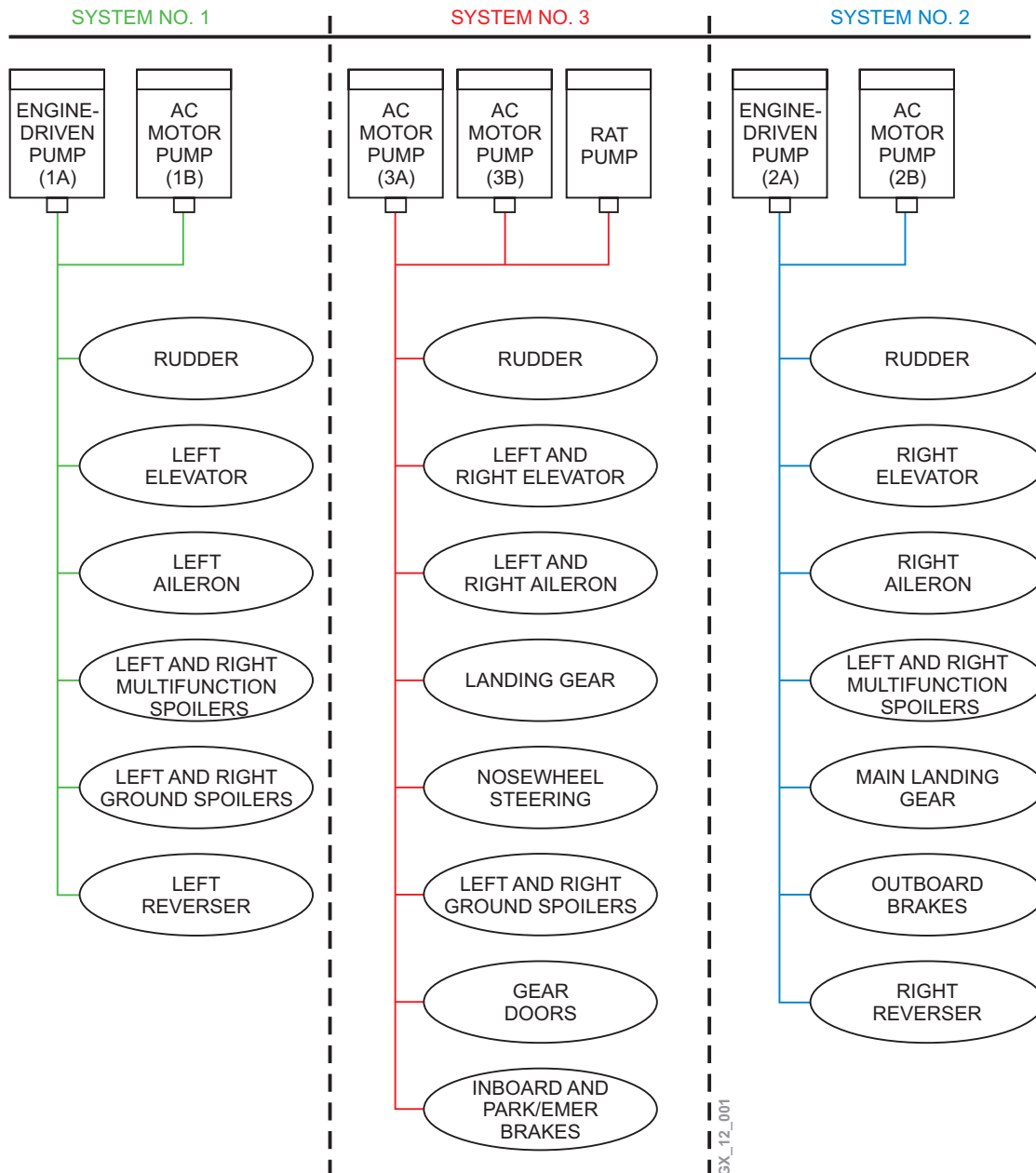
EMERGENCY HYDRAULIC POWER

In the event that all normal electrical power is lost, a Ram Air Turbine (RAT) is deployed and will power an independent hydraulic pump for system 3.

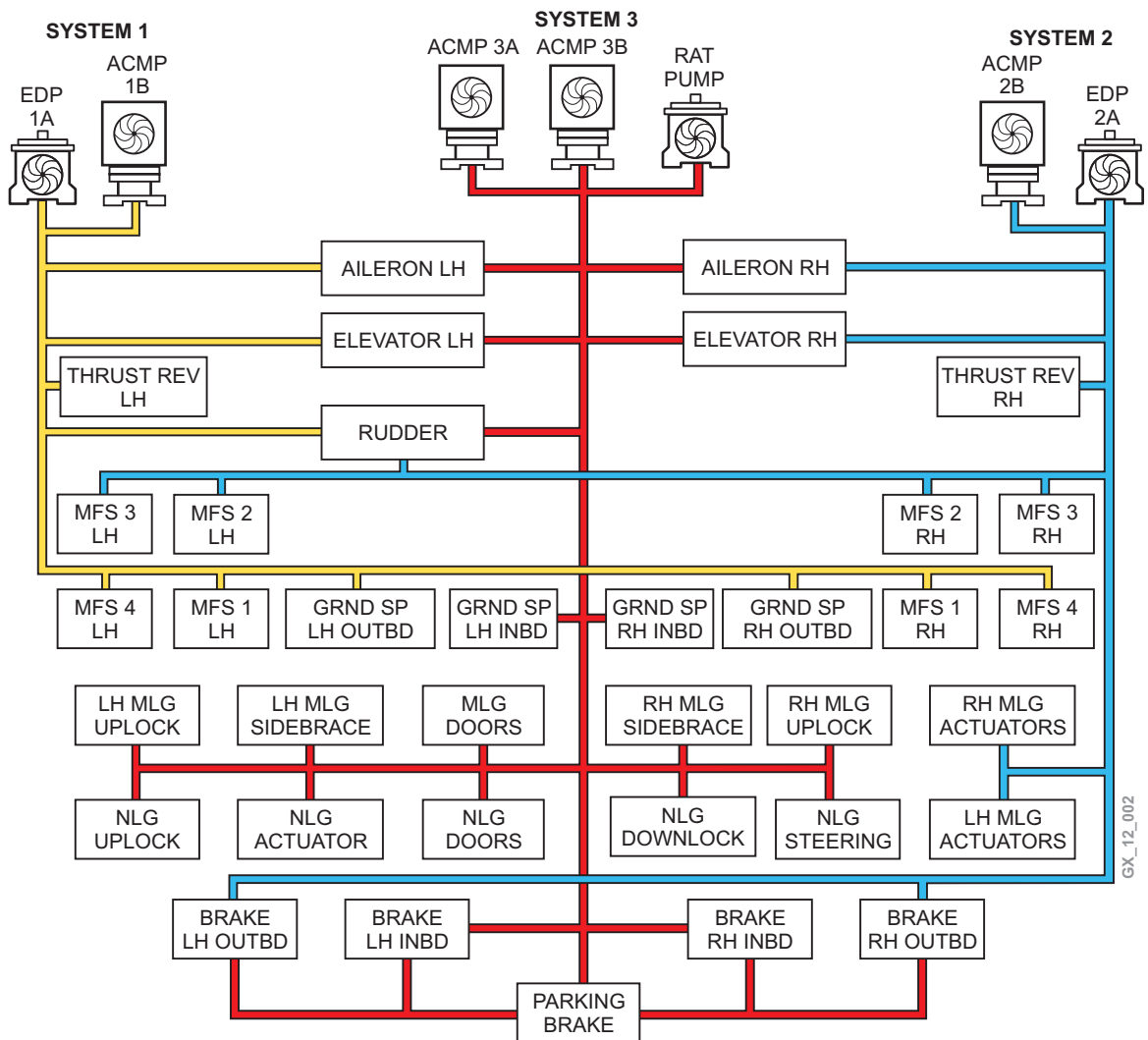
HYDRAULIC ACCUMULATORS

The RAT uses an accumulator to maintain pressure at the reservoir during RAT deployment. Two additional hydraulic accumulators are installed on the airplane and are used by the brake control system. One is used for brake system 2, and the other for brake system 3 emergency operation.

DISTRIBUTION TABLE SCHEMATIC



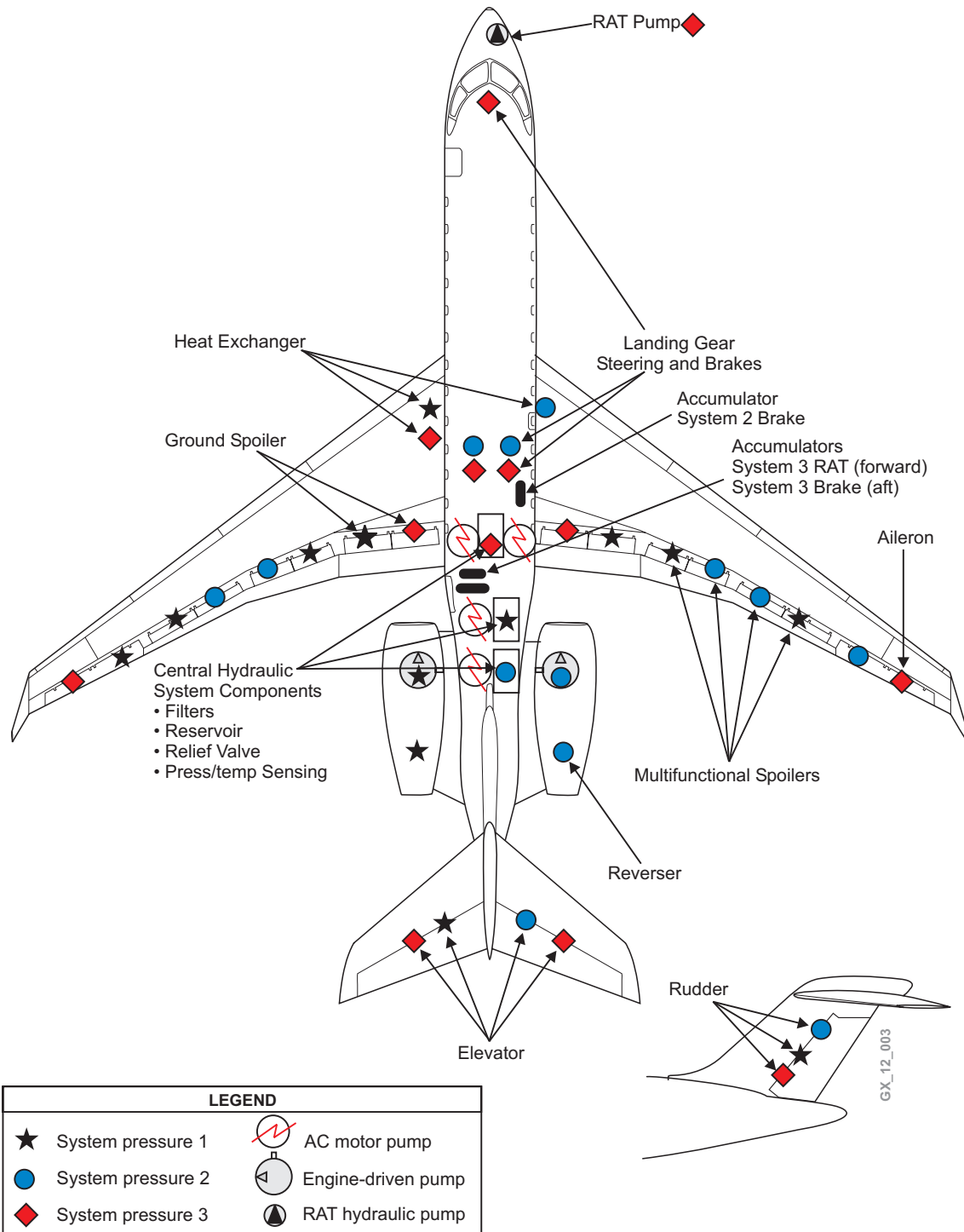
HYDRAULIC SYSTEM DISTRIBUTION SCHEMATIC



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Note:
MFS = Multifunction Spoiler

SYSTEMS OVERVIEW SCHEMATIC

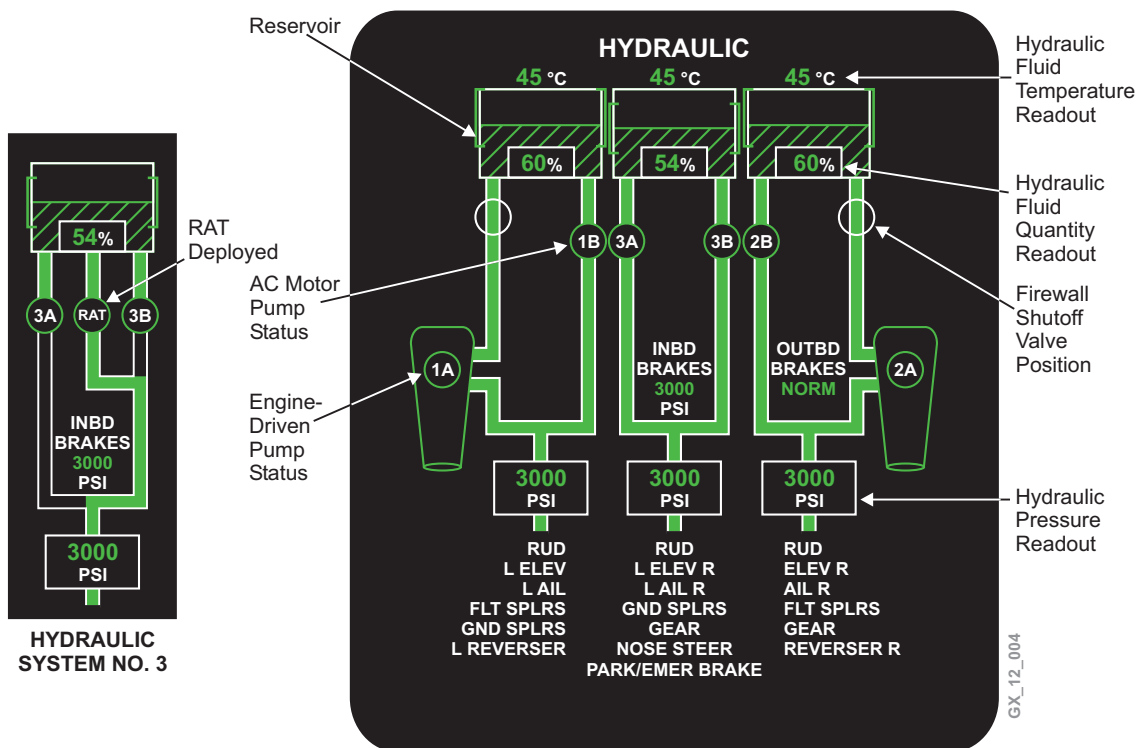


HYDRAULIC SYSTEM INDICATION

The HYDRAULIC synoptic page provides an overview of normal system status, and RAT deployment as represented below.

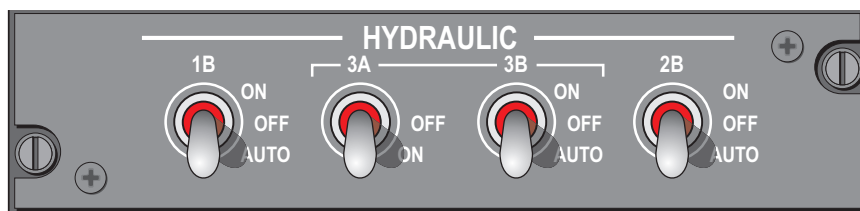
Hydraulic reservoirs, valve positioning, and pump operations are pictorially displayed. System temperatures, fluid quantities and pressures are represented digitally. Flow lines connect components and legends display system status.

HYDRAULIC SYNOPTIC PAGE



The synoptic page is displayed in detail later in this chapter.

HYDRAULIC CONTROL PANEL

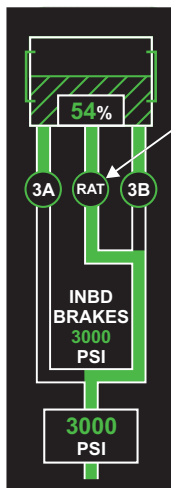


The hydraulic control panel is located on the overhead panel in the flight compartment. There are four switches which control electrically operated pumps for each system. The function of each switch is described later in this chapter.

HYDRAULIC SYNOPTIC PAGE (Cont)

Hydraulic RAT Pump
Displays RAT pump deployed and powering system No. 3. The pump symbol and flow lines only appear when the RAT is deployed.

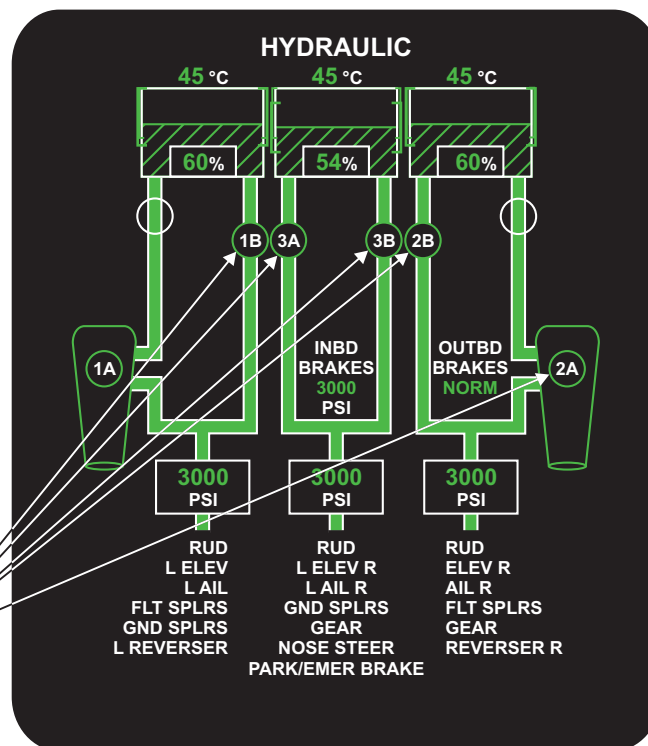
HYDRAULIC SYSTEM #3



Hydraulic Pumps 1A, 2A, 1B, 2B, 3A, 3B and RAT

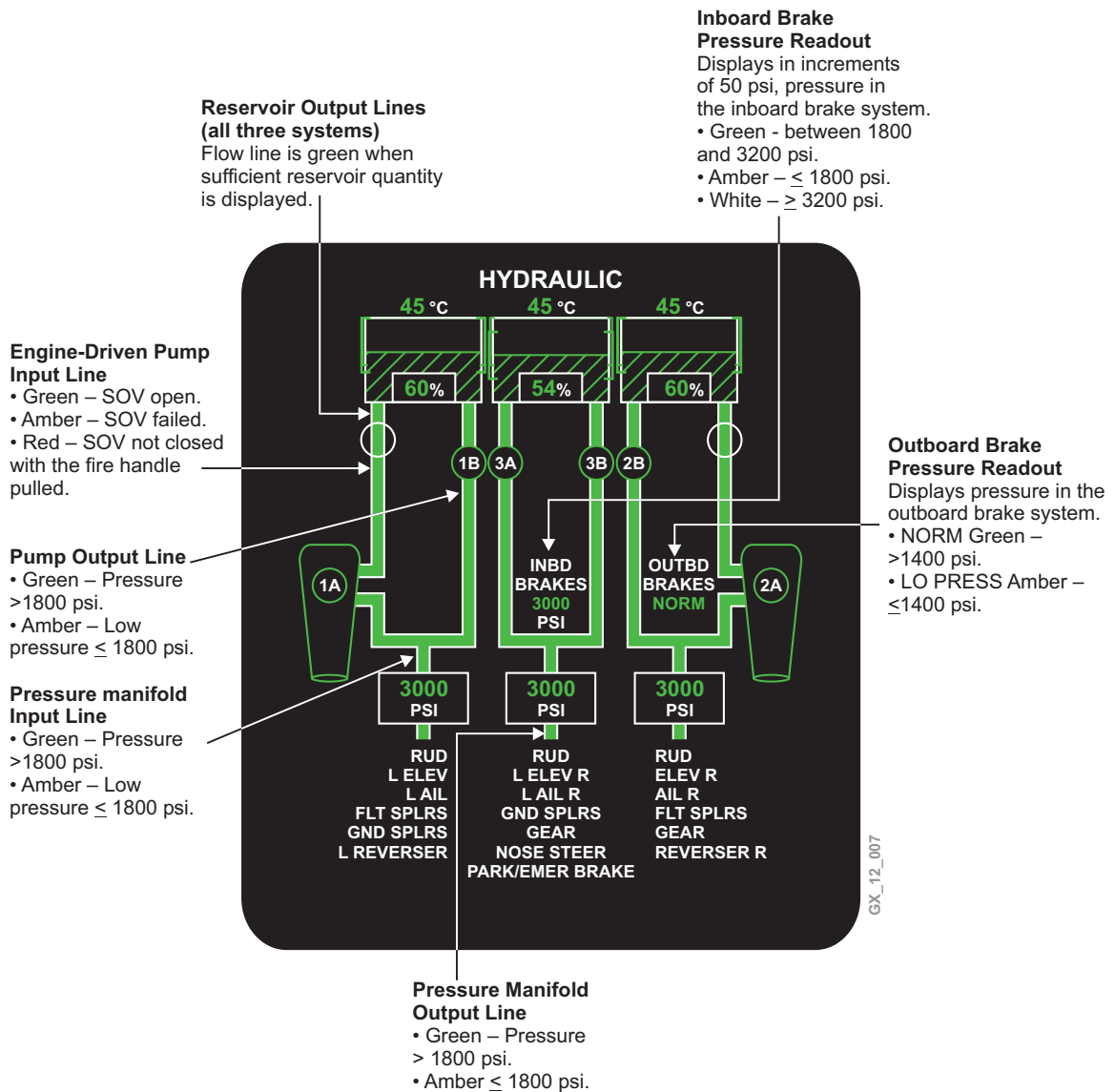
Displays the condition of each of the hydraulic pumps.

- **Green** – Pressure >1800 psi.
- **Amber** – Hydraulic supply to system inoperative ≤ 1800 psi.
- **White** – Hydraulic pump is not commanded to operate.

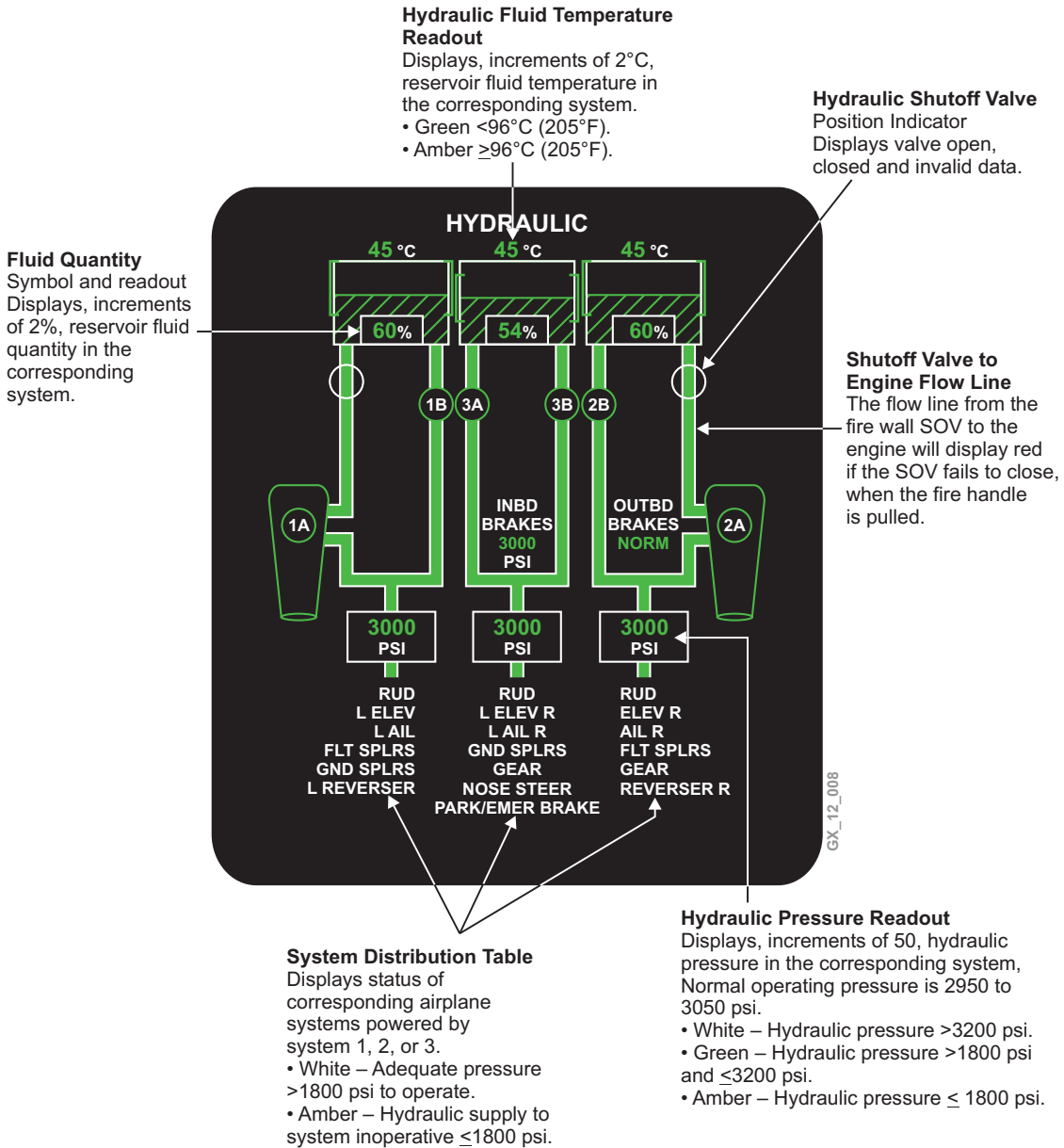


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HYDRAULIC SYNOPTIC PAGE (Cont)



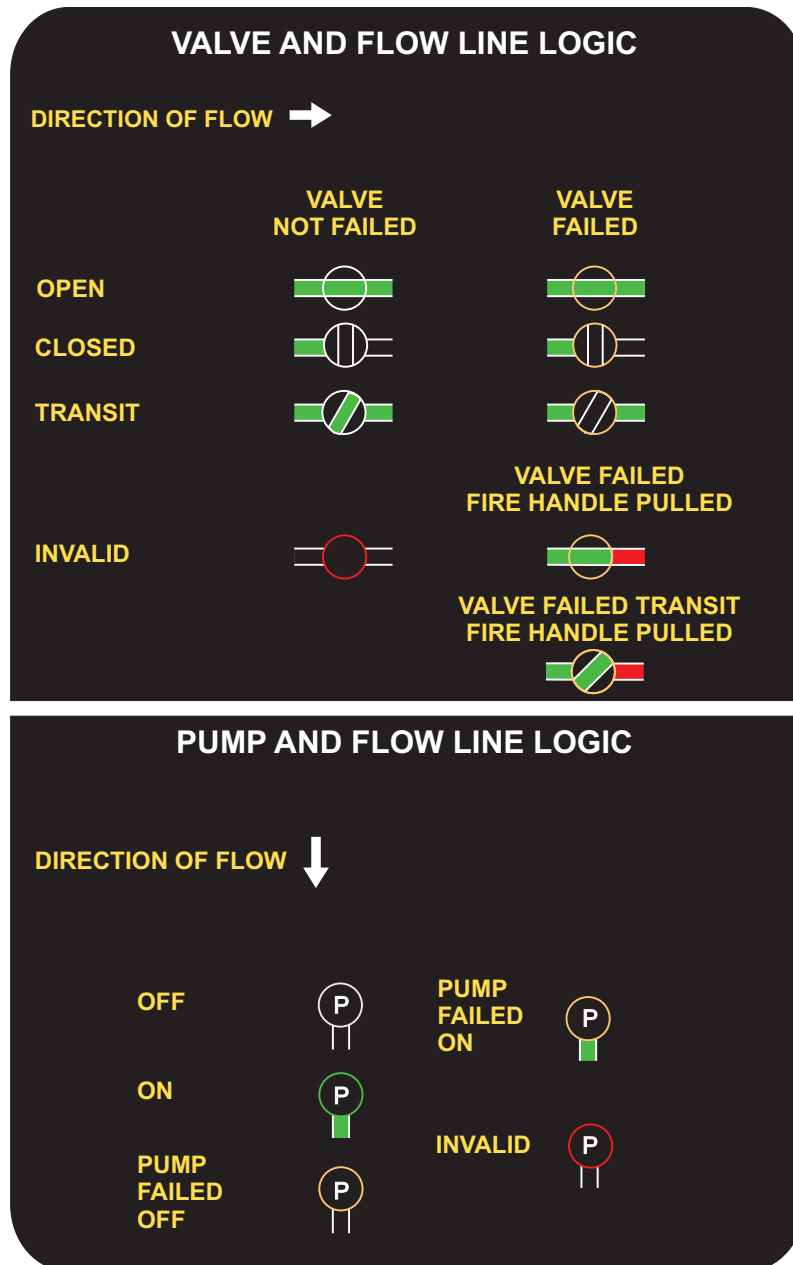
HYDRAULIC SYNOPTIC PAGE (Cont)



HYDRAULIC SYNOPTIC PAGE SYMBOLS

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

EICAS PHILOSOPHY

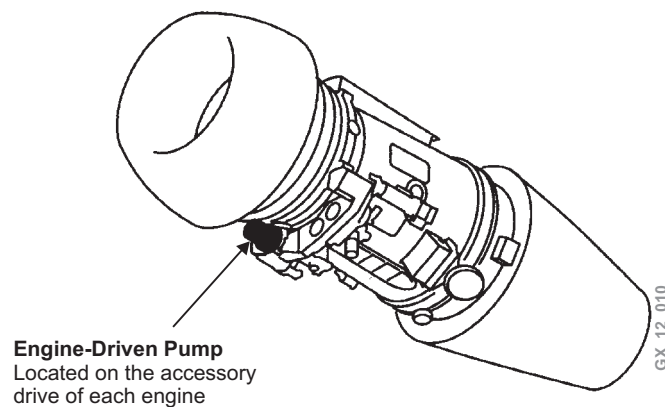


DESCRIPTION

HYDRAULIC SYSTEM 1 AND 2

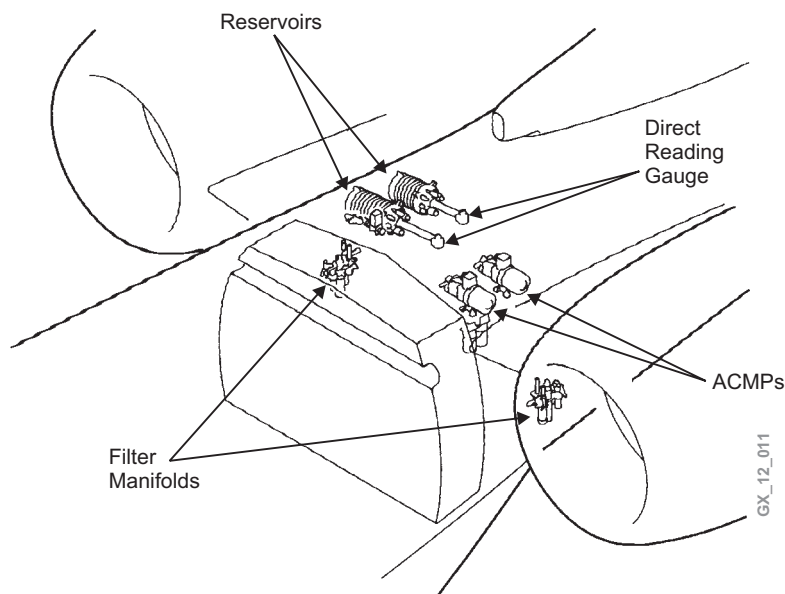
Each system comprises an EDP, reservoir, ACMP, manifolds with pressure, return and case drain filters, hydraulic shutoff valve, heat exchanger, and ground servicing panel. Hydraulic overfill bottles for system 1 and 2 are provided and located near their system components.

ENGINE-DRIVEN PUMPS



The EDPs 1A and 2A are used as primary pumps and draw fluid from the reservoirs through hydraulic shutoff valves. Fluid is delivered to the applicable manifold, filtered and distributed to the airplane's hydraulically-actuated components.

AFT EQUIPMENT BAY COMPONENTS



RESERVOIR

System 1 and 2 reservoirs are located at the top of the aft equipment bay. Fluid quantity and temperature transducers are located on the reservoir and are indicated on the HYDRAULIC synoptic page.

AC-MOTOR PUMPS (ACMP'S)

The backup ACMPs 1B and 2B pumps are normally operated in the AUTO mode and come on automatically during takeoff, approach and landing, or in support of a primary pump failure.

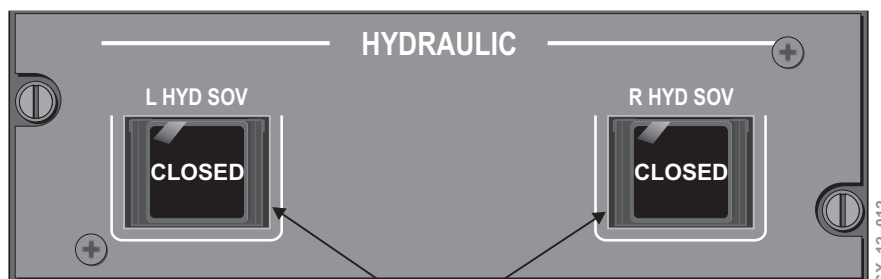
ACMPs 1B and 2B are powered from AC bus 3 and AC bus 2, respectively. Both pumps are controlled by separate toggle switches on the flight compartment HYDRAULIC control panel. Refer to External and APU Power - ACMP Operation Electrical Pump operation in this chapter for external/APU ground services.

FILTER MANIFOLD

The filter manifold for system 1 is located on the left side of the aft equipment bay, and on the right side for system 2. Each hydraulic system accommodates pressure, return and case drain (pump lubrication fluid) filters, and a system pressure relief valve. They also contain filter “pop-up” indicators to show when the filters are clogged. Two pressure switches and a transducer are part of the pressure manifold and are used to provide EICAS displays for pump failures and loss of system pressure. Fluid quantity and temperature transducers are located on the reservoir and are indicated on the HYDRAULIC synoptic page.

HYDRAULIC SHUTOFF VALVE CONTROL PANEL

Two switches are provided on the HYDRAULIC shutoff valve panel to isolate the applicable shutoff valve in the event of a hydraulic overtemperature. These switches should not be selected closed with the engine running except for isolation in the event of system overtemperature. The engine-driven pump will cavitate and greatly reduce the efficiency and life of the pump.



Left/Right Hydraulic Shutoff Valve Switches

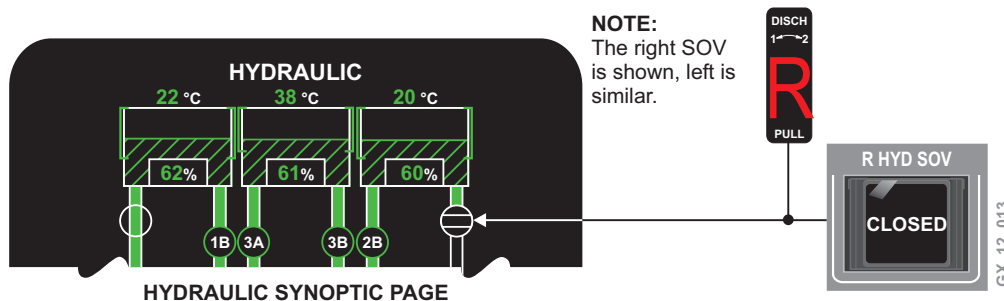
Controls the operation of the hydraulic shutoff valve in the following condition:

- CLOSED – When the switch is selected, it isolates the hydraulic fluid to the respective engine-driven pump by closing the hydraulic shutoff valve.

The purpose of isolation is to permit the fluid to cool and control the overtemperature, without having to shut down the engine. These switches operate in parallel with the switch in the fire handle to control the operation of the applicable hydraulic shutoff valve.

HYDRAULIC SHUTOFF VALVES

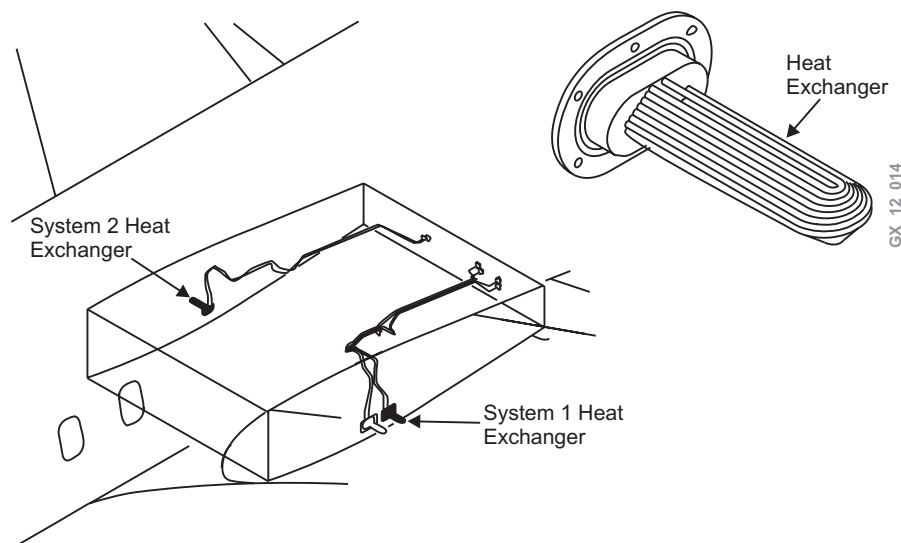
Electrically-operated shutoff valves (normally open) are installed on the suction lines for the engine-driven pumps 1A and 2A, and their position is indicated on the HYDRAULIC synoptic page.



The corresponding hydraulic shutoff valve is motored closed during an engine fire condition (fire handle pulled), or selection of a HYD SOV switch. Selection of a HYD SOV switch will illuminate a CLOSED legend on the switch to indicate the switch position. When the hydraulic shutoff valve is closed, a L or R HYD SOV CLSD white status message (described in Chapter 9, FIRE PROTECTION) is displayed on EICAS. Deselection of either the fire handle or HYD SOV switch will command the SOV open, and extinguish the message. Deselecting the HYD SOV switch will extinguish the CLOSED legend.

HEAT EXCHANGER

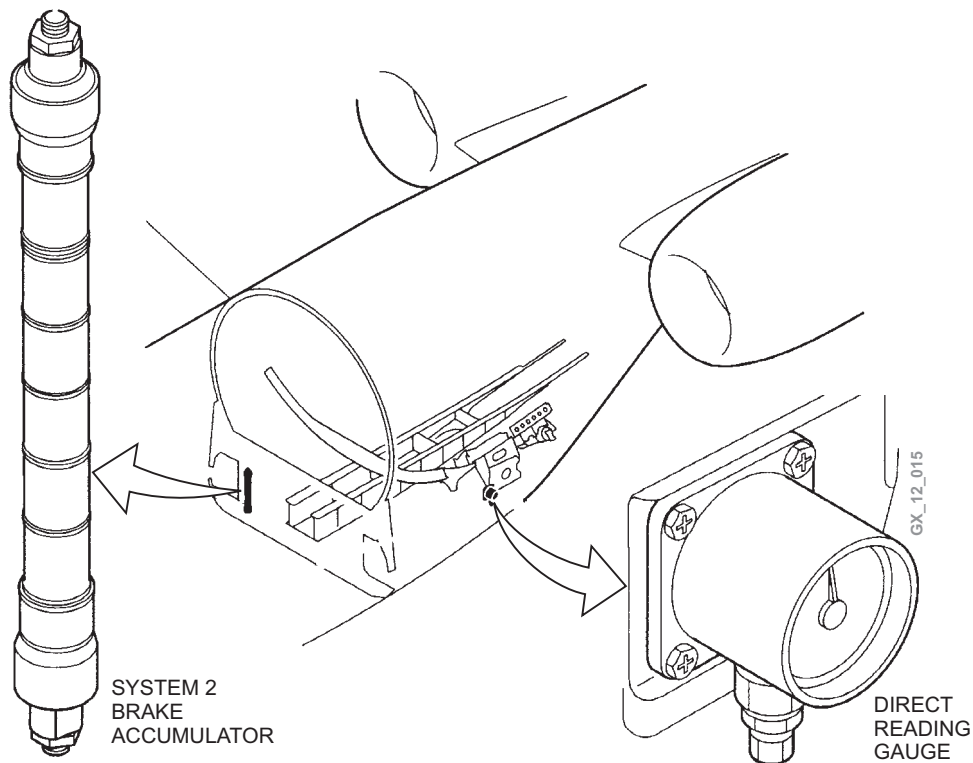
System 1 heat exchanger is positioned within the left fuel feed tank, and system 2 in the right. The purpose of each exchanger is to cool the case drain fluid (lubrication fluid within each pump), prior to returning it to the reservoir.



If the fluid temperature is sufficiently cooled, a by-pass of the exchanger will allow the fluid to go directly to the reservoir. Fuel in the wing feed tank is the cooling medium.

SYSTEM 2 ACCUMULATOR

The brake control system uses an accumulator from hydraulic system 2 for brake operations.

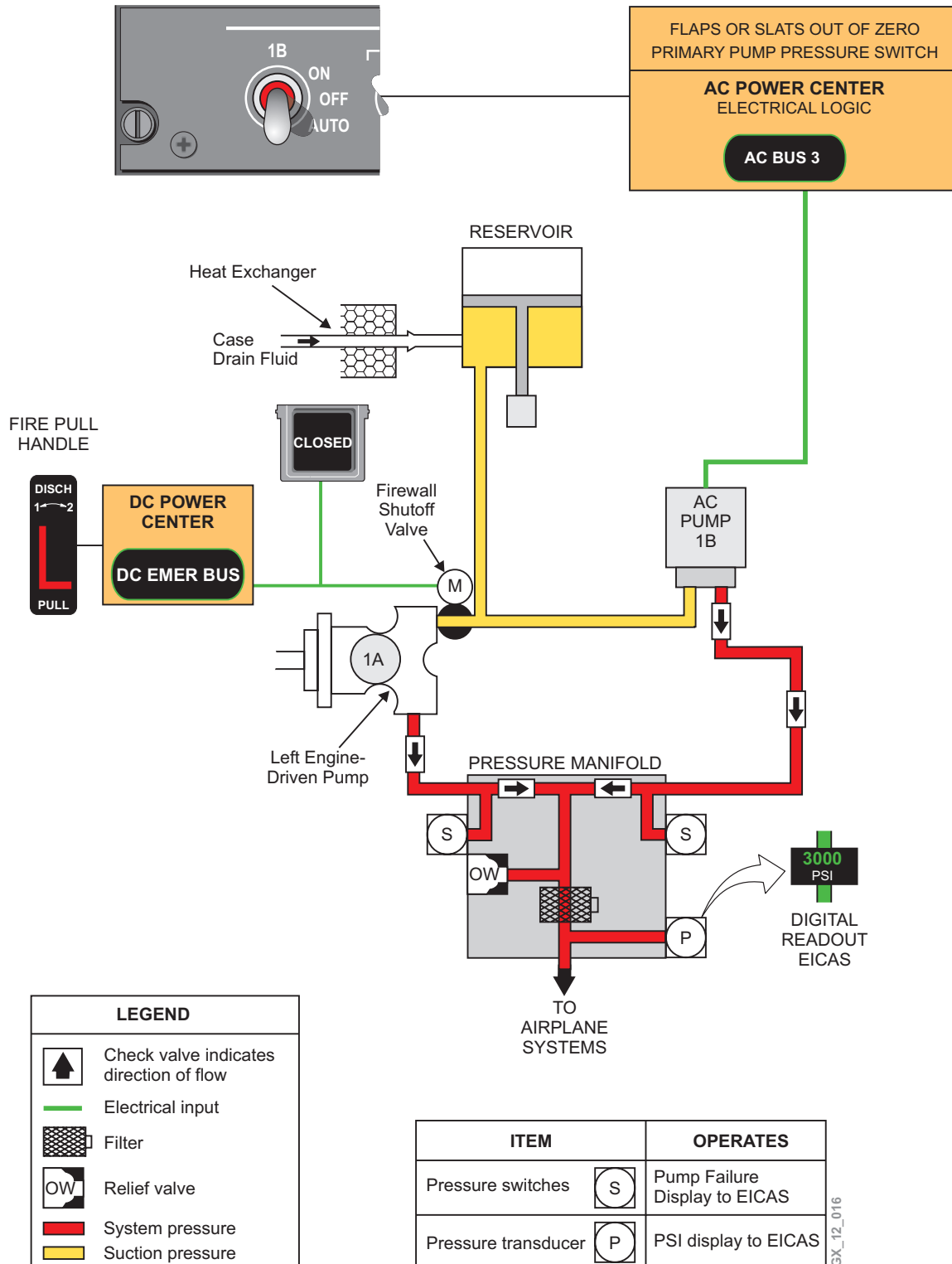


There is a direct reading gauge to check the precharge condition of the accumulator. Refer to Chapter 14, LANDING GEAR for more information on the brake and control system.

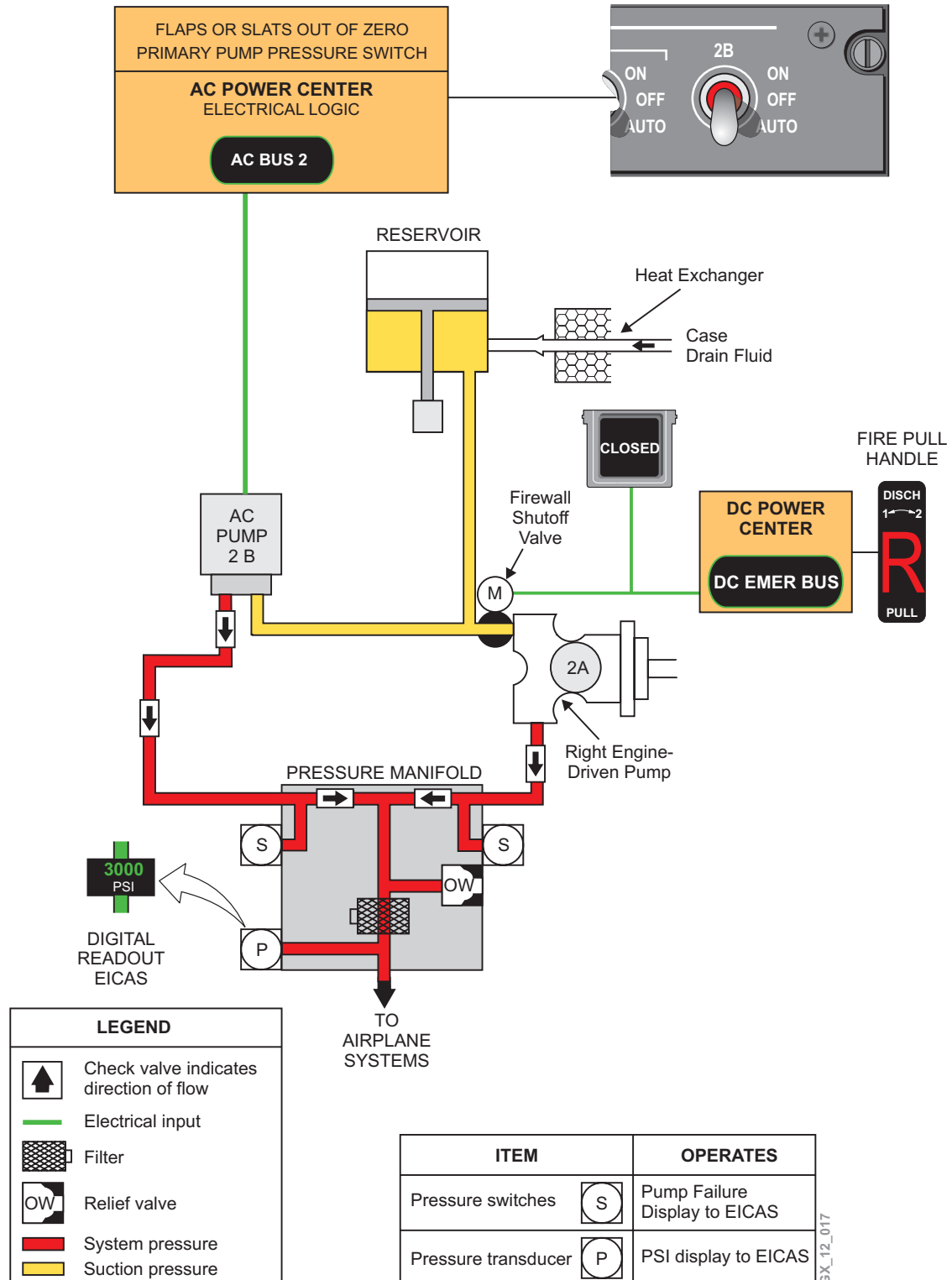
GROUND SERVICE ACCESS

The ground service access for systems 1 and 2 is located in the aft equipment bay.

HYDRAULIC SYSTEM 1 SCHEMATIC



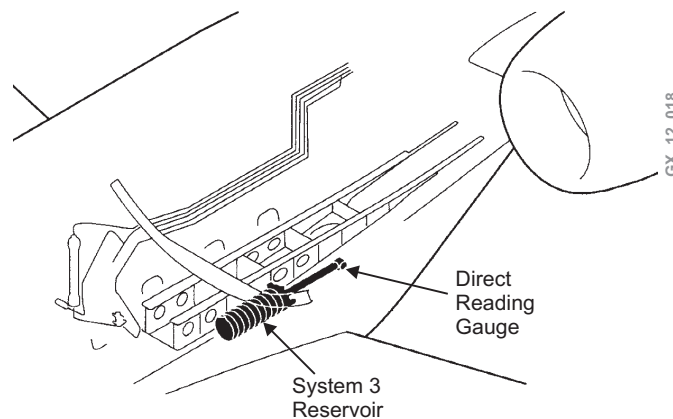
HYDRAULIC SYSTEM 2 SCHEMATIC



HYDRAULIC SYSTEM 3

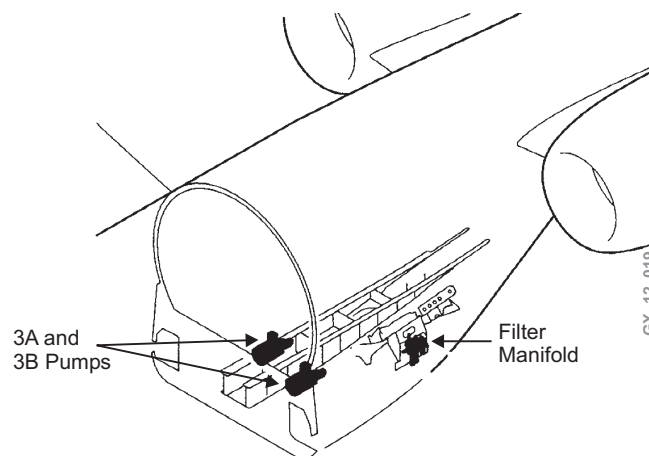
System 3 includes a reservoir, ACMPs 3A and 3B, RAT pump, manifold with pressure, return and case drain filters heat exchanger, and ground servicing panel. Hydraulic overfill bottles for the system are provided and located near system 3 components.

RESERVOIR



System 3 reservoir is located in the lower belly fairing. Fluid quantity and temperature transducers are located on the reservoir and their indications are displayed on the HYDRAULIC synoptic page.

ACMP'S 3A AND 3B



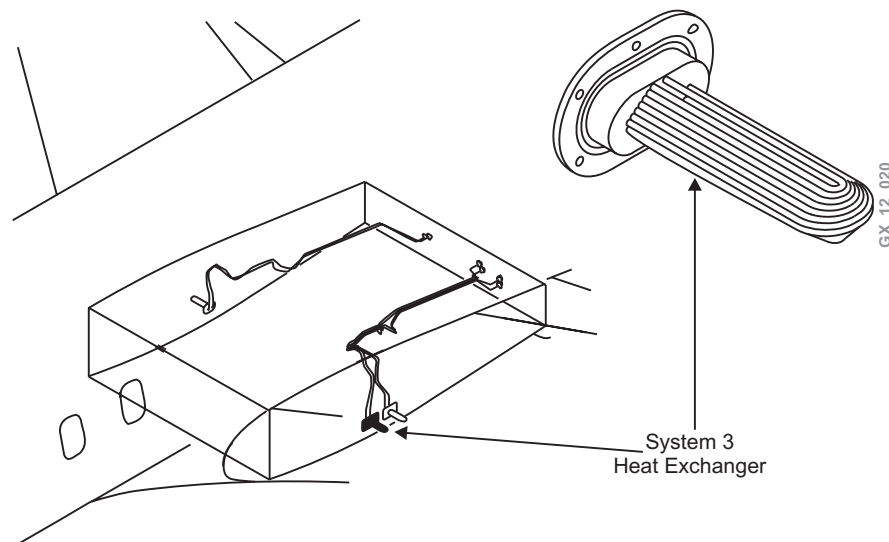
System 3 ACMPs are located in the lower belly fairing. System 3A pump is used as primary pump (runs continuously in the ON position) and 3B as the backup pump.

RAM AIR TURBINE (RAT)

In case of an emergency (example: dual-engine failure), the RAT is deployed and will power an independent hydraulic pump for system 3. Therefore, system 3 has three hydraulic pumps available to power the system.

The RAT hydraulic pump is mounted at the rear of the RAT. It uses system 3 hydraulic fluid for emergency operations. An additional feature is that the RAT pump shares a common pressure switch with ACMP 3B. The RAT operation is described in Chapter 6, ELECTRICAL of this manual.

HEAT EXCHANGER



The heat exchanger is positioned in the left fuel feed tank. System 3 heat exchanger has the same function as systems 1 and 2.

FILTER MANIFOLD

The filter manifold for system 3 is located in the lower belly fairing of the aircraft, and contains all the features of system 1 and 2.

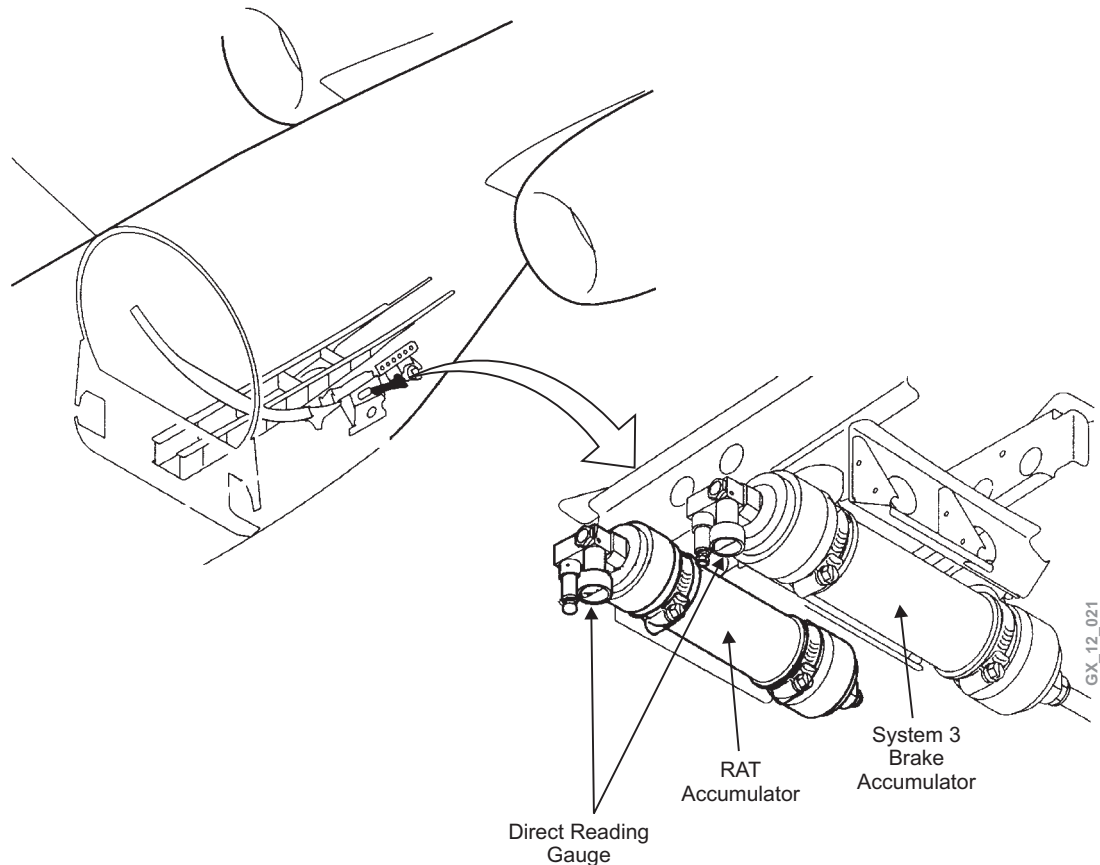
Fluid quantity and temperature transducers are located on the reservoir and their indications are displayed on the HYDRAULIC synoptic page.

Two pressure switches and a transducer are part of the pressure manifold and are used to provide EICAS displays for pump failures and loss of system pressure.

GROUND SERVICE PANEL

The ground service panel for system 3 is located on the left side of the fuselage aft of the wing trailing edge.

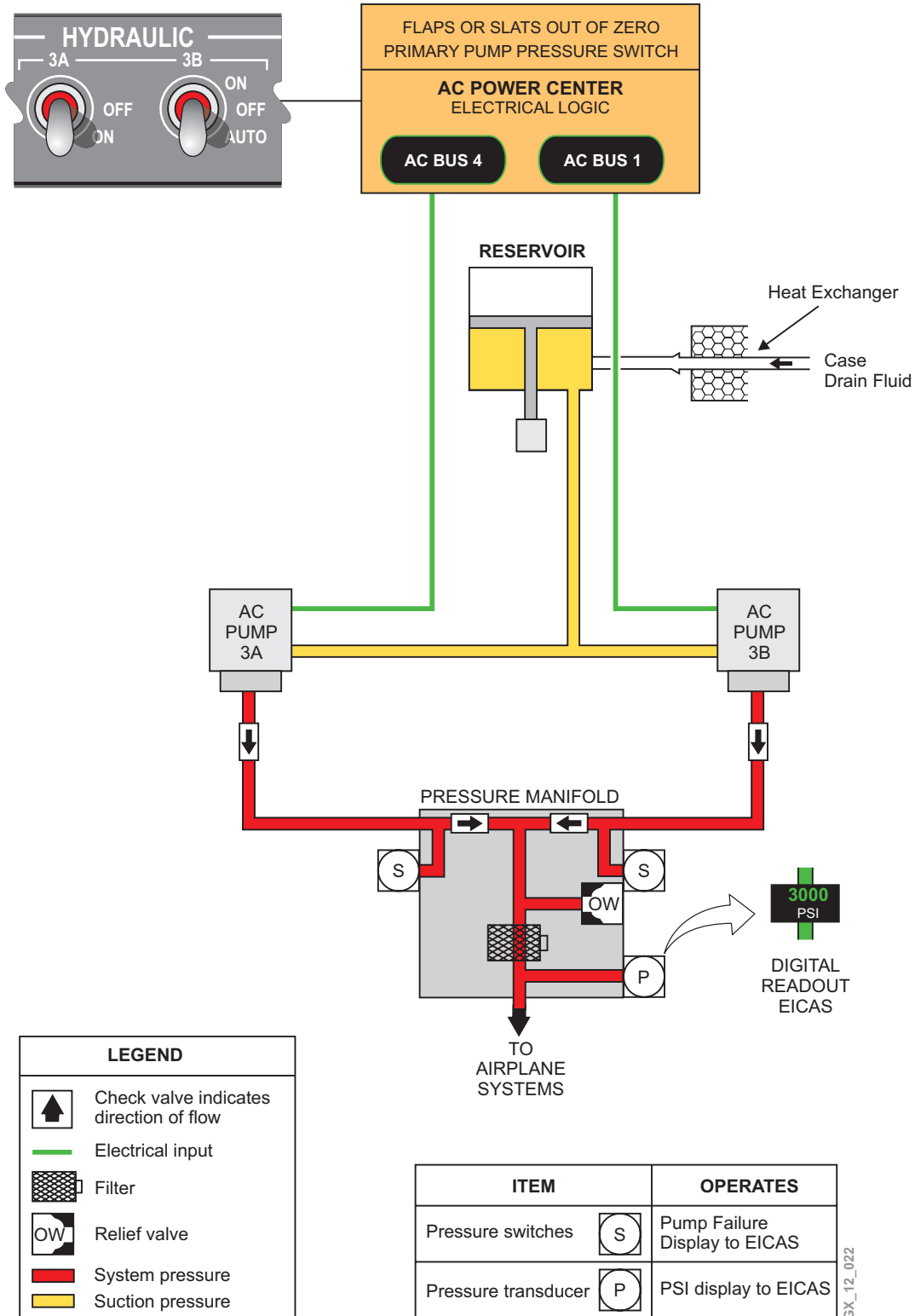
RAT AND SYSTEM 3 ACCUMULATORS



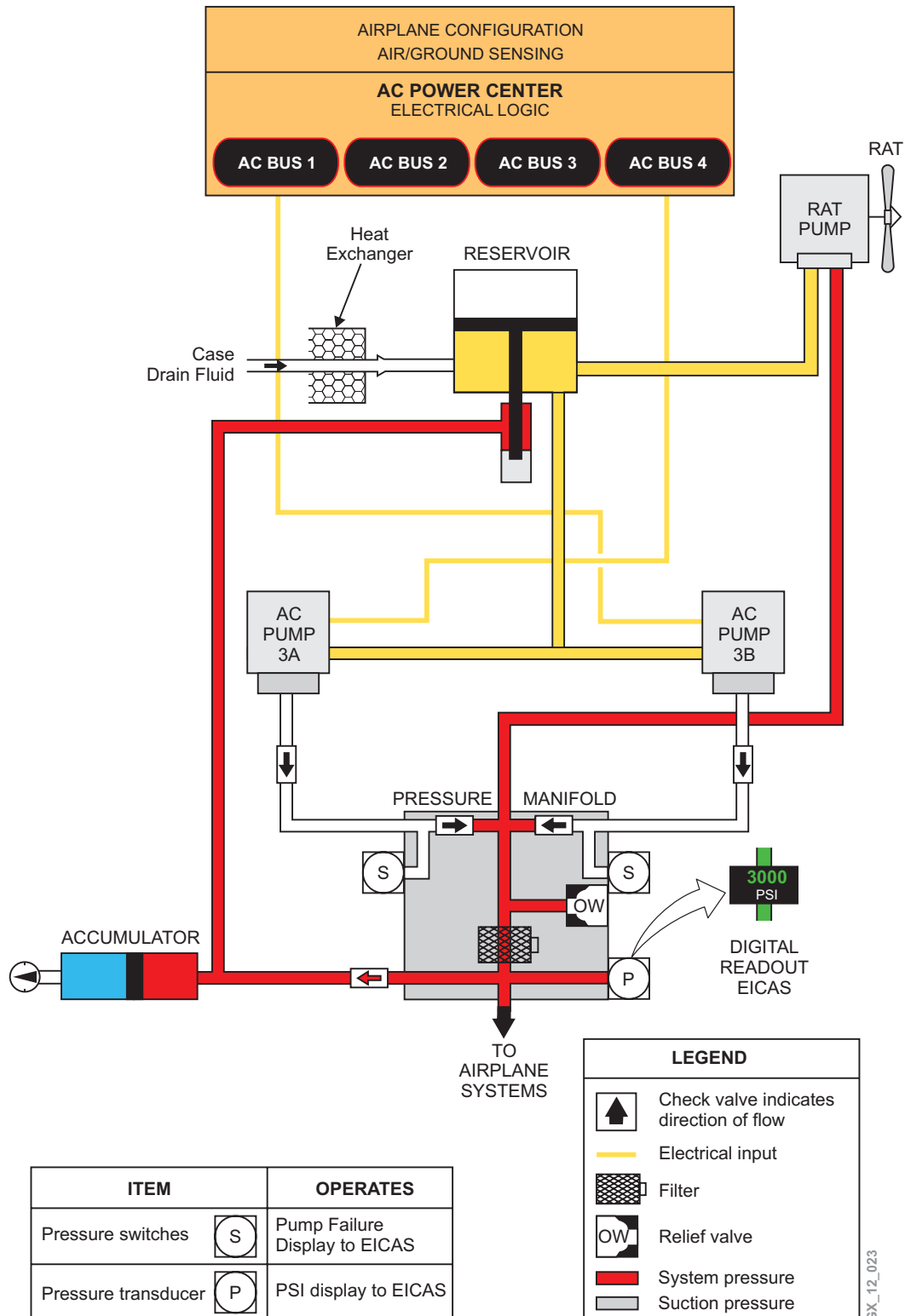
A RAT accumulator is used to maintain pressure to the reservoir when 3A and 3B ACMPs are inoperative in flight. This will provide a continuous pressure for up to 44 seconds from the reservoir suction line to the pump, enabling the RAT pump to come on line quickly. There is a direct reading gauge to check the precharge condition of the accumulator. Normal precharge pressure equals 1000 psi.

The brake control system uses an accumulator from hydraulic system 3 for brake operations. There is a direct reading gauge to check the condition of the accumulator. Normal precharge pressure of the brake accumulator equals 500 psi. Refer to Chapter 14, LANDING GEAR for more information on the brake control system.

HYDRAULIC SYSTEM 3 SCHEMATIC



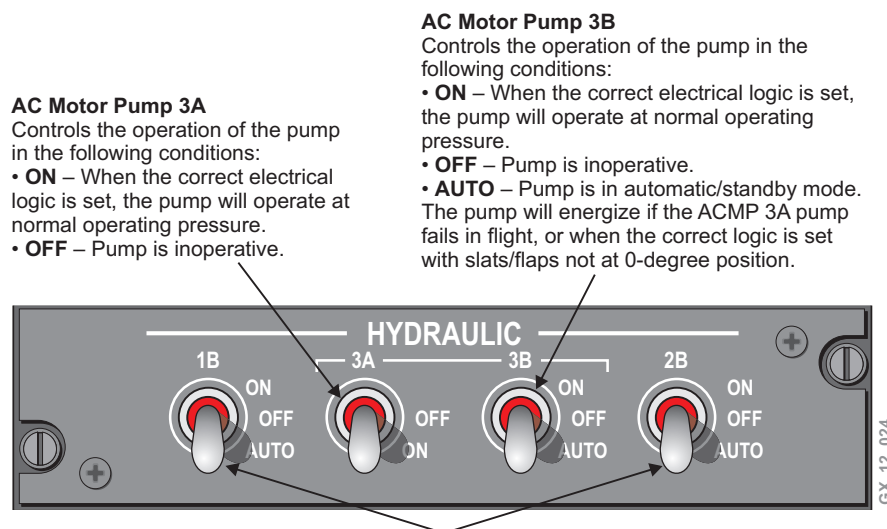
RAT DEPLOYMENT HYDRAULIC SCHEMATIC



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HYDRAULIC CONTROL PANEL

The HYDRAULIC control panel is located on the overhead panel in the flight compartment and contains the ACMP switches.



AC Motor Pump 3A
Controls the operation of the pump in the following conditions:

- **ON** – When the correct electrical logic is set, the pump will operate at normal operating pressure.
- **OFF** – Pump is inoperative.

AC Motor Pump 3B
Controls the operation of the pump in the following conditions:

- **ON** – When the correct electrical logic is set, the pump will operate at normal operating pressure.
- **OFF** – Pump is inoperative.
- **AUTO** – Pump is in automatic/standby mode. The pump will energize if the ACMP 3A pump fails in flight, or when the correct logic is set with slats/flaps not at 0-degree position.

AC Motor Pump 1B and 2B
Controls the operation of each pump under the following conditions:

- **ON** – When the correct electrical logic is set, the applicable pump will operate at normal operating pressure.
- **OFF** – Pump is inoperative
- **AUTO** – Pump is in automatic/standby mode. Each pump will energize when its system primary pump fails in flight, or when the correct logic is set with slats/flaps not at 0-degree position.

MANUAL MODE

Manual mode is accomplished by placing the respective ACMP control switch into either the OFF or ON position. The pumps will run when selected to ON and their respective bus is powered. In the OFF position each pump is inoperative for all operating conditions.

AUTO MODE (PUMPS 1B, 2B AND 3B)

When the pump switch is set to AUTO, the respective pump automatically starts under one of the following conditions:

- When the correct electrical logic is determined by the Alternating Current Power Center (ACPC), either slats or flaps are not at the IN/0° position and at least one Variable Frequency Generator (VFG) operating
- When the primary pump (EDP 1A, 2A or ACMP 3A) falls below normal system pressure (≤ 1800 psi) in flight.

GROUND OPERATION INHIBITS

When the APU is the airplane single source of electrical power, only one ACMP is allowed to run at a time to prevent overloading the APU generator. The priority for running the ACMPs are as follows:

- No. 1 priority - ACMP 3A
- No. 2 priority - ACMP 3B
- No. 3 priority - ACMP 2B
- No. 4 priority - ACMP 1B

If a lower priority ACMP is running and a higher priority ACMP is activated, the lowest priority ACMP will shut off and the higher priority ACMP will turn on automatically.

The B pump automatic start mode is inhibited when no engines are running to enhance system safety during normal maintenance operations.

The B pumps will not come on automatically (AUTO mode selected) in support of a primary pump failure on the ground.

All B pumps will be commanded on automatically (AUTO mode selected) when flaps/slats are selected out of 0° and slats motion has stopped, and a minimum of two VFGs are operating (i.e. all electrical buses powered).

FLIGHT OPERATION

The normal pump switch configuration in flight is AUTO mode of operation for pumps 1B, 2B and 3B and ON selection for pump 3A.

The B pumps will come on automatically (AUTO mode selected) in support of the applicable primary pump failure in flight. When an ACMP is commanded on **due to a low pressure condition** of the primary pump, that ACMP will remain on for a minimum of 5 minutes (including touchdown) unless ON or OFF is selected. This is required to prevent ACMP overheating due to continuous restarts if the low pressure alternates above and below 1800 psi.

During single VFG operation ACMPs 1B and 2B are load shed since their respective buses are disconnected from the remaining good generator.

RAM AIR TURBINE (RAT)

When the RAT is deployed and on-speed, it will power the AC ESS bus and the independent RAT hydraulic pump, to ensure that system 3 components are powered at all times (see hydraulic synoptic page in this chapter).

ACMP POWER AND DISTRIBUTION

Electrical power and distribution using the ACMPs are described as follows:

ACMP'S 1B AND 2B

Hydraulic systems 1 and 2 are each powered by one EDP used as the primary system pump. Each primary pump is backed up by a single ACMP (one per system) during high flow demand flight phases or failure of the primary pump in flight.

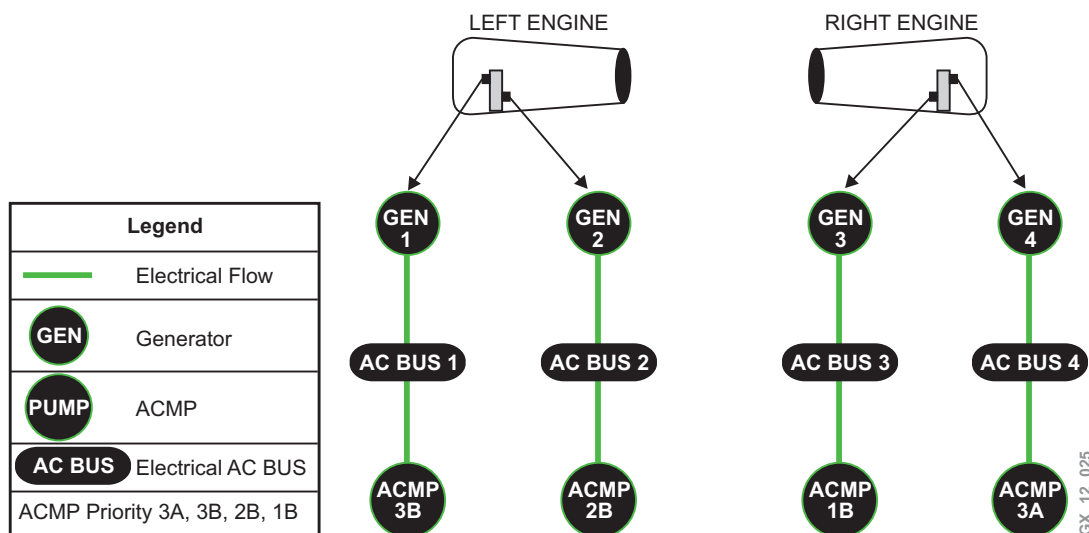
The ACMPs are also used for system ground maintenance operation with the control switch in the ON position. Each ACMP is powered by one of the electrical AC buses supplied by both an inside generator(s) and cross-side generator(s) (ACMP 1B is connected to AC bus 3. AC bus 3 is normally powered by its own generator (No. 3) but is backed up by, in priority, generators 2, 1 and APU). This will ensure operation of both hydraulic systems 1 and 2 in the case of a single engine failure.

When only one generator is operating, AC buses 2 and 3 are shed. Since their respective AC buses are disconnected during single generator operation, ACMPs 1B and 2B are automatically load shed.

ACMP'S 3A AND 3B

Hydraulic system 3 is powered by two ACMPs, 3A as the primary system pump and 3B as the backup pump. Each pump is powered by a different AC bus (ACMP 3A is connected to AC bus 4 and ACMP 3B is connected to AC bus 1). In the event of one, two or three generator failures, both 3A and 3B ACMPs will receive power from the remaining generator. AC bus 1 and AC bus 4 are both powered during single generator operation.

ACMP ELECTRICAL POWER SCHEMATIC



EXTERNAL AND APU POWER-ACMP OPERATION

External AC power has the capability to power all ACMPs for ground operation when the hydraulic control switch is selected to the ON position.

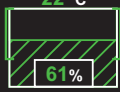
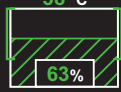
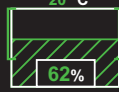
During ground operation with either the APU or external ground power as the source of electrical power, the AUTO mode of operation is not available. On ground with APU as the single source of electrical power, only one pump at a time is allowed to run with 3A, 3B, 2B and 1B in priority.

In flight with the APU as the single source of electrical power, two pumps only (3A and 3B) are allowed to run to prevent overloading of the generator.

RESERVOIR QUANTITY LIMITS

The table on the following page describes the range of values between the upper and lower fluid quantity limits for each system. The green brackets are variable in size, and in combination with the reservoir filling and digital readout represent the level of quantity in the reservoir for all airplane configurations.

The quantity indication (reservoir filling and digital readout) for systems 1 and 2 will turn amber if the displayed reservoir quantity for that system is at or below the lower limit.

	SYSTEM No. 1 	SYSTEM No. 3 	SYSTEM No. 2 
LOWER LIMIT	ON GROUND: Hydraulic Quantity Lower Limit = 34% IN FLIGHT: Hydraulic Quantity Lower Limit = 16%	ON GROUND: Hydraulic Quantity Lower Limit = 20% IN FLIGHT: Hydraulic Quantity Lower Limit (L & R gear uplocked) = 28%	ON GROUND: Hydraulic Quantity Lower Limit = 32% IN FLIGHT: Hydraulic Quantity Lower Limit = 12%
UPPER LIMIT	100%	ON GROUND: Hydraulic Quantity Upper Limit = 70% IN FLIGHT: Hydraulic Quantity Upper Limit = 100%	100%

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The quantity indication for system 3 will turn amber when the displayed quantity is at or below the lower limit or at or above the upper limit when the quantity reaches 70%.

Notwithstanding the limits stated above, the following table lists the normal quantity you should see on your walkaround or on a synoptic page.

Hydraulic System No. 1
(Sys on, spoilers down, TRs stow)
Max qty drop – pressurized = 4%

FLUID TEMP (°C)	RESERVOIR LEVEL (%)
-16 to 4	38 to 47
5 to 26	47 to 56
27 to 49	56 to 66
50 to 71	66 to 74
72 to 93	74 to 83

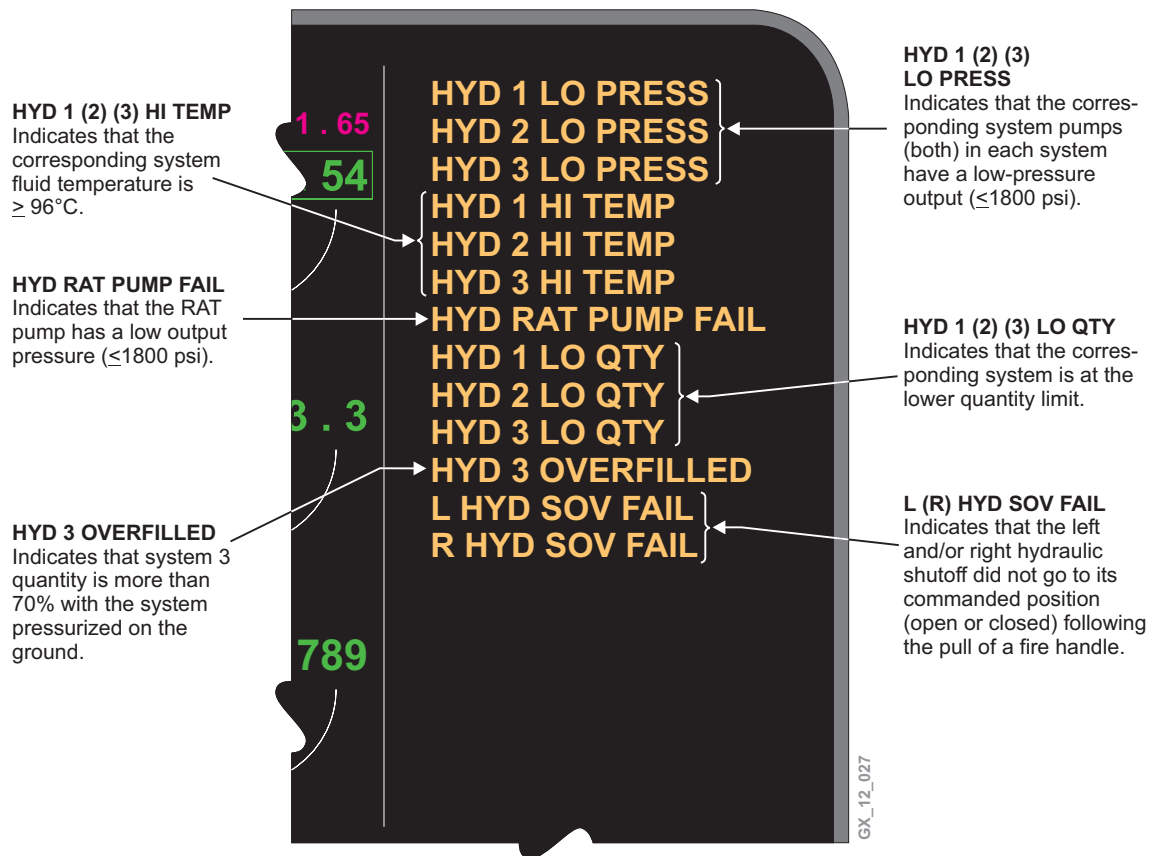
Hydraulic System No. 2 – Quantity Check
(Sys on, spoilers down, TRs stow, brakes off)
Max qty drop – pressurized = 12%

FLUID TEMP (°C)	RESERVOIR LEVEL (%)
-16 to 4	40 to 50
5 to 26	51 to 58
27 to 49	58 to 65
50 to 71	66 to 73
72 to 93	74 to 80

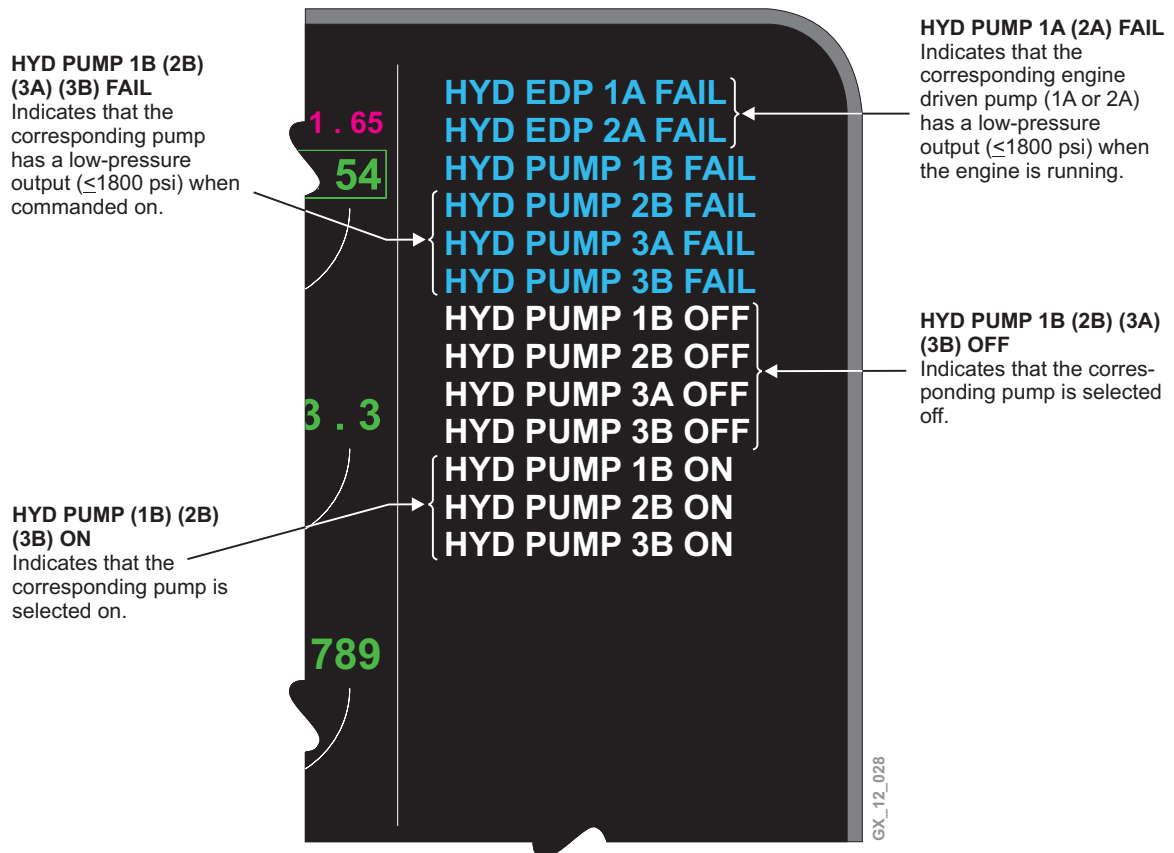
Hydraulic System No. 3 – Quantity Check
(Sys on, spoilers down, LDG doors closed,
brakes off)
Max qty drop – pressurized = 18%

FLUID TEMP (°C)	RESERVOIR LEVEL (%)
-16 to 4	30 to 36
5 to 26	37 to 43
27 to 49	44 to 50
50 to 71	51 to 58
72 to 93	58 to 65

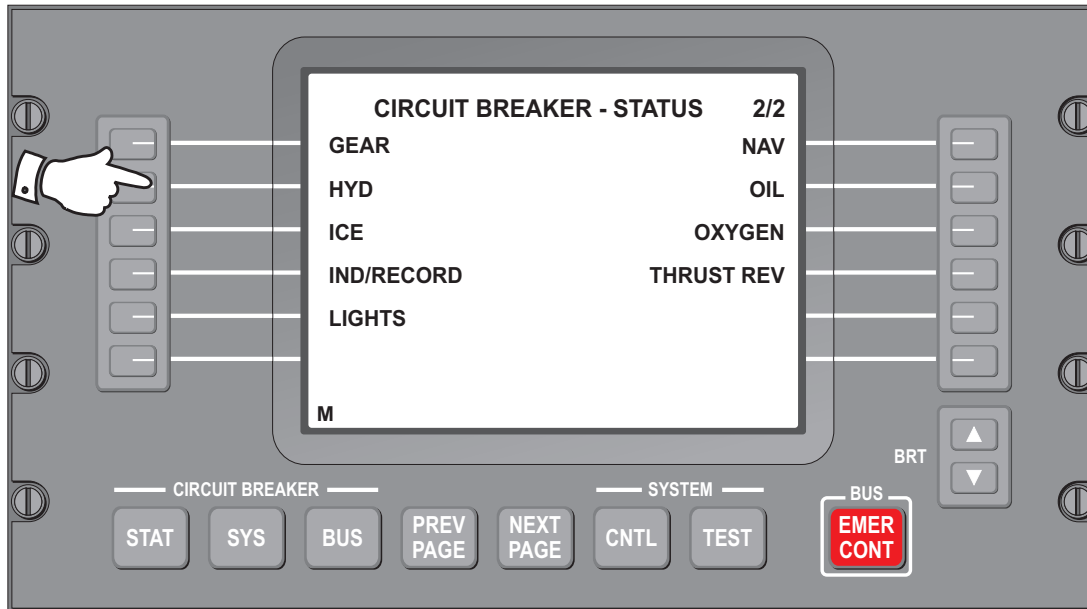
EICAS MESSAGES



EICAS MESSAGES (Cont)



EMS CIRCUIT PROTECTION



CB - HYD SYSTEM			1/2
HYD 1 PRESS XDCR	DC 1		IN
HYD 2 PRESS XDCR	DC 2		IN
HYD 3 PRESS XDCR	BATT		IN
HYD PUMP 1B	AC 3		IN
HYD PUMP 2B	AC 2		IN
HYD PUMP 3A	AC 4		IN

CB - HYD SYSTEM			2/2
HYD PUMP 3B	AC 1		IN
L HYD SOV	DC EMER DCPC		IN
R HYD SOV	DC EMER DCPC		IN

M

GX_12_029