HYDRAULIC

The main hydraulic system is comprised of two independent systems; system A and system B. Hydraulic power is used to power the primary flight controls (rudder, elevators, ailerons, and roll spoilers), the landing gear, the leading edge slats, the speed brakes, the nose wheel steering and the main wheel brakes. A rudder standby sub-system is installed in the aft section of the right pylon to provide redundancy for the system B power control unit (PCU) of the lower rudder. The electric motor/pump unit provides 3000 PSI to the system B (lower rudder) PCU. It is fully automatic and is powered on when the accumulator pressure falls below 2300 PSI. During normal operation, even when the standby system is not required, the motor pump runs periodically to keep the standby accumulator charged so that the system will be ready if a failure occurs. The entire hydraulic system requires servicing with hydraulic fluid specified in Section I (Limitations).

Tubing which carries full system pressure is of titanium, except in wheel well areas where it is stainless steel. Return lines carry a pressure of 50 PSI, and therefore, except for those in the wheel well area, can be made of aluminum. All of the system one-quarter inch lines are pressure lines and are of titanium or stainless steel. There are no one-quarter inch aluminum lines in the system.

Both systems are powered by engine driven pumps; one mounted on each engine accessory gear box. The pump driven by the left engine supplies pressure to the A system and the pump driven by the right engine delivers pressure to the B system. System A is the primary system and powers the landing gear, nose wheel steering, main wheel brakes, the outboard speed brakes and the outboard roll spoilers. System B powers the inboard roll spoilers and the two inboard speed brakes. Both systems independently actuate the rudder, elevator and ailerons through redundant actuators. The slats are extended or retracted using either system, since the slat control valve is a single unit with dual valves to accommodate both system A and system B pressure.

System A may be powered redundantly by two methods. In the event of a left engine or hydraulic pump failure, pressure can be restored to system A through the power transfer unit (PTU). The PTU is fundamentally a hydraulic pump driven by system B pressure. With system B operating at 3000 PSI, the PTU can generate 2600 ±400 PSI to system A. The second backup system is an electrically driven auxiliary pump that can provide 3000 PSI hydraulic pressure to all of system A. Due to low system capacity when the auxiliary pump is the only source of hydraulic power, the landing gear should not be lowered hydraulically or the thrust reversers deployed, since it would result in slow operation of other more critical systems.

The main system is equipped with pressure and return filters to ensure system cleanliness. They are located in the aft fairings and have a filtration capability of 5 microns nominal and 15 microns absolute. All filter elements are disposable and non-reusable and are equipped with indicators which pop up at 70 ±10 PSI differential. Once tripped they must be manually reset. The indicators have thermal lockouts which prevent inadvertent indication if the fluid temperature is below 85°F.

Depressurization of the nose wheel steering accumulator can be accomplished, if needed, without turning on airplane power, by pressing and holding (20 to 25 seconds) a bleed switch located in the left hand forward avionics bay, near the pressure bulkhead. In some cases activating this bleed switch will accomplish release of the airplane hydraulic system pressure, but it should not be depended upon to do so.

HYDRAULIC SYSTEM

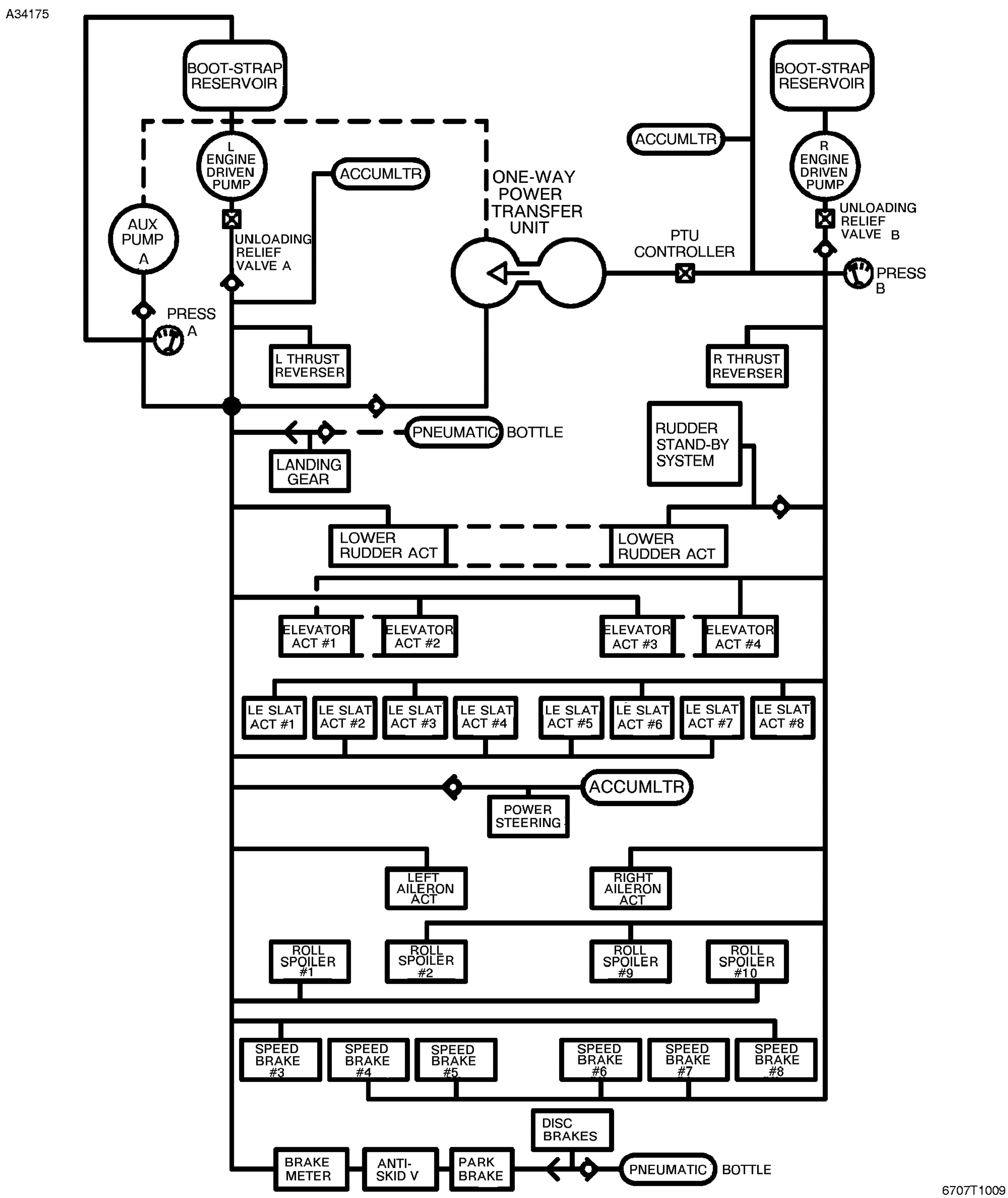

Figure 2-15

The nose gear torque links must be disconnected during towing operations or the system may be damaged. They are disconnected by removing a safety pin from the torque link shaft, by pushing a release button and pulling out the pin. The torque links are spring loaded to extend horizontally from the nose gear strut when the pin is removed.

RESERVOIRS

The fluid for the main system is contained in two cylindrical bootstrap reservoirs located in each engine pylon. Each reservoir has an internal volume of 400 cubic inches. A properly serviced system reservoir, at 3000 PSI, contains between 160 and 210 cubic inches of fluid. The reservoirs, located above panels in the bottom of the respective side engine pylons, are translucent and have indications of fluid level, which correspond to different stages of system and accumulator pressurization, marked on the bottom of the reservoir. When the bootstrap (smaller) cylinder is pressurized to 3000 PSI, the return side of the cylinder is pressurized to 50 PSI, since the ratio of the piston areas is 60 to one. The level of fluid and system pressure are transmitted by transducers and are shown in the cockpit on the engine instrument and crew alerting system (EICAS).

Servicing of the reservoirs can be checked through a door on the bottom of the engine pylons. The piston can be seen through the opaque sides of the reservoir, its position noted in relation to marked indices and compared to the servicing placard on the outside of the reservoir.

The hydraulic system reservoirs are serviced through a hydraulic service panel (pressure and return quick disconnects) located behind a door in each side of the aft fuselage, below the engine pylons. A hydraulic service cart, capable of providing fluid under pressure, is required for system servicing. Servicing is accomplished through a spring loaded manual fill valve controlled from the hydraulic system servicing panel. The valve must be held open, in order to discourage overfilling. A reservoir bleed handle, which is used to bleed air or excess fluid from the system, is also located at the service panel.

The airplane is serviced with the spoilers retracted, the thrust reversers retracted, and the system accumulators serviced to 1500 PSI. Should the system become overfilled the excess fluid will be vented overboard through the fluid overboard drain, located just below the hydraulic service panel.

If reservoir pressure exceeds 120 PSI, a reservoir over-pressure relief valve (120 PSI cracking pressure) will actuate and relieve pressure overboard.

A low limit volume switch in the reservoir will actuate when the fluid level drops below 16%. It will cause an amber (HYD VOLUME LOW A - B) engine indicating and crew alerting system (EICAS) digital message in the cockpit.

The auxiliary system has its own small reservoir of 25 cubic inches capacity. It is a spring loaded reservoir; the function of the spring is to provide slightly pressurized fluid to the rudder standby system motor pump.

SYSTEM INDICATIONS

To read the hydraulic system pressure and quantity (volume) the pilot may select FUEL HYD by pressing the bezel button so identified on the crew alerting system (CAS) display tube. NORM is the default selection which appears upon system initiation, and will display the pressures of the A and B systems (and rudder hydraulic system if the B system pressure is low) as well as the DC electrical system voltage and amperage readings. If NORM is displayed the hydraulic volume will not be shown.

The FUEL HYD selection will cause the EICAS system to show the A and B systems pressures as well as their hydraulic fluid quantities in terms of percent fully serviced. Pressure is shown in increments of 100 PSI. If the B system pressure is low (below 2200 PSI), it will display the rudder (RSS) system pressure. There will be no rudder system quantity indication. The temperature of the fluid in the A and B systems will also be shown in degrees Celsius. In this selection, the temperature of the fuel in the tanks and at the engine fuel control will also be added to the fuel display which is always present.

Normal hydraulic pressure (2600 to 3200 PSI) and quantity (16% to 100%) indications are in green. If the engines are not running, the hydraulic pressure indications will also always be in green. Pressures of less than 2600 PSI or more than 3200 PSI will be shown in amber; quantities of less than 16% will be also shown in amber. Hydraulic fluid temperatures of up to 82°C will be shown in green; 82°C or above will be shown in amber. If the engines are running and both system pressures are below 2600 PSI, the pressure indications will be in red.

There are other indications, concerning the hydraulic system (and other aircraft systems) which have not been discussed here. These are colored (green, amber, red, cyan, white) digital messages located in the crew alerting system (CAS) section of the EICAS display. For continuity and convenience, all airplane system EICAS indications are grouped together and discussed under Engine Indicating and Crew Alerting (EICAS) in this section.

PUMPS

Each engine drives a variable displacement (wobble plate) hydraulic pump providing continuous system pressure of approximately 3000 PSI. Each pump can deliver from 0 to 15.5 gallons per minute of fluid flow, depending upon system demand. The pumps are driven any time the engines are rotating; an engine speed of approximately 20% N_2 RPM will produce 3000 PSI system pressure, if system demand is not high.

The A system has for one backup system a power transfer unit driven by the B hydraulic system. This system-to-system hydraulically driven pump (no fluid is exchanged between systems) will come into operation if the A system pressure falls below the breakout point (the point at which the pump overcomes static friction). It will pressurize system A to 2600 ±400 PSI. The second A system backup is an electrically driven motor pump which can maintain 3000 PSI in the A system for emergency operation. During system operation when the auxiliary pump is the only source of hydraulic pressure, simultaneous operation of systems which could cause overloading and thereby slow operation of critical systems, should be avoided. For instance, the landing gear should not be lowered hydraulically or the thrust reversers deployed under these circumstances.

The B system lower rudder backup system also is powered by a small electric motor pump which will come on, when B system pressure drops below 2300 PSI. This pump powers the lower rudder in the B system to its regular 3000 PSI and charges the standby rudder system accumulator. It has a maximum flow capability of 0.2 gallons per minute.

FIREWALL SHUTOFF VALVES

Firewall shutoff valves, when closed, cut off hydraulic fluid (and fuel) to the engine nacelle area in the event of an engine/nacelle fire or loss of fluid through a ruptured or leaking line. The firewall shutoff valves are controlled, individually, by the corresponding left and right engine fire buttons. They operate by closing off the intake side of the pumps and are powered closed when the pilot presses the LH ENG FIRE or RH ENG FIRE button, which also arms the fire bottles. When the firewall shutoff valve closes, a white HYD FW SHUTOFF A - B annunciation will appear in the engine indicating and crew alerting system (EICAS).

THRUST REVERSER CONTROL VALVES

The thrust reverser control valves contain four internal solenoid valves. Two of the solenoids open pathways to the stow and deploy hydraulic lines. One valve routes pressure into the latch lines. The remaining valve blocks the inlet pressure port to avoid inadvertent deployment. Refer to Thrust Reversers in this section for thrust reverser operation.

HYDRAULIC ACCUMULATORS

The purpose of the hydraulic accumulators is to store hydraulic fluid under system pressure; to absorb system shock during a component cutoff, reducing the magnitude of spikes and transients, and to have instant system pressure available upon actuation of the component(s). There are four accumulators in the system; the left and right main systems, the nose wheel steering, and the the rudder backup system. The main system accumulators are 25 cubic inch units located in the aft fairings. They are the free sliding piston type and are precharged with nitrogen. There are gages in the aft fairings by which the nitrogen charge may be verified prior to flight. The main system accumulators are charged through schrader valves located inside the door of the hydraulic service panels.

The rudder standby sub-system accumulator is a 12 cubic inch free sliding piston type which is serviced with nitrogen to a pressure corresponding to the stated temperature/pressure table affixed near the service valve. The service pressure is shown on a gage in the bottom of the right engine pylon, which can be checked prior to flight.

The nose wheel steering accumulator is a 50 cubic inch free sliding piston type, which is precharged to 1500 PSIG with nitrogen. The pressure gage is located near the service valve which is mounted in a line leading to the accumulator, near the nose compartment bulkhead in the left forward avionics bay. A temperature/pressure service table is located near the pressure gage.

UNLOADING RELIEF VALVES

Both systems A and B have an unloading relief valve which protects the system from excessive pressures. The valves are manually controlled by a two-position cockpit switch (UNLOAD A/NORM and UNLOAD B/NORM). The switches, normally left in the NORM position, are used to manually depressurize the systems, if desired, or they will automatically depressurize the system(s) if pressure should reach approximately 3750 PSI, as discussed below.

If the system should fail to regulate at 3000 PSI, due to failure of the normal system pressure regulating valve, a backup regulator will attempt to maintain a system pressure of 3400 (±100) PSI; this is the cracking pressure of the backup relief valve. If system pressure does continue to climb and reaches 3750 PSI it will maintain that pressure, which represents the maximum possible flow rate. At this pressure heat buildup will be rapid, resulting in an overtemperature message, upon the appearance of which the pilot should depressurize the affected system. The fluid will then circulate in the system at a substantially lower pressure and will cool. Temperature sensing is provided to trigger an amber CAS message (HYD O'TEMP A-B) if system hydraulic fluid temperature reaches 200°F (93°C), and a red CAS message (HYD O'TEMP A-B) if system fluid temperature reaches 265 °F (130°C). If the amber overtemperature message appears, the pilot should carefully monitor system temperature. If the red CAS message appears, the hydraulic system should be depressurized, if conditions allow, in order to let the fluid cool.

The situations, discussed in the following sentences, are possible in which it is beneficial that the system(s) be unloaded. If a pump runaway should occur, caused by the swash plate going to full deflection, the pump will immediately try to deliver full capacity which cannot be accommodated in the system at normal pressure. An overpressure will ensue, and the excessive pressure will cause an overtemp condition. Upon this occurrence the system should be depressurized to allow the system to cool. Also, in case of a jammed flight control power control unit (PCU), the control surface would be jammed. Relieving the pressure by manually dumping the system pressure will free the flight control surface.

The manual relief valve (which is the only "automatic" feature of the unloading valve) will crack open at 3400 PSI (minimum) and regulate pressure, if the 3000 PSI pressure regulating system fails. This relief valve is also designed for full flow (15.5 GPM) relief at a maximum of 3750 PSI. When the manual relief valve is regulating pressure, temperature will rise rapidly and continue to rise until the pilot opens the unloading valve using the cockpit switch.

AUXILIARY SYSTEM

The auxiliary pump is located outside the boundaries of a potential damage zone in case of catastrophic engine failure. The auxiliary pump is controlled by a two-position switch on the hydraulic control panel. The pump is a variable displacement type with a maximum capacity of one gallon per minute of flow. The entire hydraulic system is serviced by the auxiliary pump, however discretion must be used if the auxiliary pump is supplying pressure for the system, due to its limited capacity. For example, the landing gear should not be lowered hydraulically when the hydraulic system is powered by the auxiliary pump, due to the fact that the other systems will operate slowly, since operating the landing gear absorbs considerable hydraulic power. The same is true of the thrust reversers. The auxiliary pump is primarily for emergency use and is also used to set the parking brakes. The control switch positions are A AUX PUMP and OFF.

In OFF position, power is removed from the motor and it will not operate; the pump does not have an automatic starting function.

When the auxiliary pump is running the EICAS system displays a white HYD AUX PUMP ON message. This message is intended as a reminder to the crew that the auxiliary hydraulic pump is in operation. The message is caused by the application of electrical power to the auxiliary pump motor.

POWER TRANSFER UNIT (PTU)

As described under the general Hydraulic System heading above, the power transfer unit (PTU) transfers hydraulic power from the B system to the A system without any exchange of fluid. The system is essentially a hydraulic motor in the B system powering a hydraulic pump in the A system. The pump is protected by a 1-amp circuit breaker (HYD B/PTU CONT) on the left circuit breaker panel. The PTU system will automatically go into operation when the A system pressure falls below a predetermined point. If it is desired that PTU system operation be prevented or stopped, the only way to accomplish it is to pull the HYD B/PTU CONT circuit breaker.

The B system has an integral flow limiter which is a part of the PTU shutoff valve and which prevents excessive power absorption from the B system if the A system has a situation in which pressure is unrecoverable, such as a line failure. The outlet of the PTU pump is equipped with a fluid filter.

HYDRAULIC SYSTEM CONTROL PANEL

The hydraulic system control panel (HYDRAULIC PUMPS) is located to the right of the landing gear control handle on the lower section of the copilot's instrument panel. It has mounted on it the unloading switches (UNLOAD A/NORM and UNLOAD B/NORM) which are used to unload (depressurize) the main systems, and the auxiliary pump control switch (A AUX PUMP/OFF) which controls operation of the A system electric auxiliary pump. All of the systems and control switches are discussed above.

In the closed (UNLOAD) position of the loading valves, fluid will flow from the pumps to the distribution lines. If the unloading valves are opened, pressurized fluid continues to flow from the pumps to the distribution lines. However, restrictions in the system will cause the fluid to flow through the unloading pressure relief valves and back to the inlet side of the pumps at a pressure of less than 100 pounds.