Podcast 007 - Hydraulics

Today We'll be discussing the 737NG Hydraulic system and its associated controls and lights.

We have 3 systems onboard the aircraft known as the A, B and Standby system's. The aircraft Hydraulics power things such as:

Flight Controls	Leading-edge Flaps and slats	Trailing edge flaps
Landing gear	Wheel Brakes	Nosewheel steering
Thrust Reversers	Autopilots'	

Either the A or B system can power all flight controls with no decrease in airplane controllability.

Each system has a fluid reservoir located in the main wheel well area. System A and B are pressurised by bleed air with the Standby system connected to the System B reservoir for pressurisation and servicing. Pressurisation ensures positive flow to all hydraulic pumps and prevents cavitation and foaming at high altitudes. Foaming could be recognised by pressure fluctuations and intermittent activation of the Low Pressure lights along with the Master caution light and HYD annunciation.

Now the way I like to think of the systems is that the A system is for the ground and the B system for the air with a couple of things to remember on top of course! Both A and B systems run your flight controls which include Ailerons, Elevator, Rudder and flight spoilers, each system controls 2 flight spoilers on each wing. On top of this, system A, or the ground system, also controls Ground Spoilers, nose wheel steering, Landing gear movement, Reverser 1 and A is for Alternate Brakes. You also just need to remember the onside Autopilot as in Autopilot A and that System A also provides the power for the PTU which we will talk about later.

System B, or the air system, on top of those flight controls also provides power for Leading edge flaps and slats, Trailing edge Flaps, Yaw Damper, Autoslats, the Landing gear transfer unit and autopilot B. The non-airborne ones to remember for system B are B for Brakes as in normal Brakes, No2 Reverser and the alternate NWS.

The standby system is limited as a backup to four systems. Thrust Reversers, Rudder, Leading edge flaps and slats, extend only and Standby Rudder. More on that system later.

Let's talk about the hydraulic pumps. Each main system has an AC Electric motor driven pump or EMDP and an Engine driven pump or EDP. Power wise System A's EDP is energised by engine 1 and system B's EDP from engine 2. As for the EMDP's, well, System A is powered by XFR BUS#2 and system B by XFRBUS#1. This gives redundancy to the system should an engine failure occur along with Bus Tie Breaker failure. Also, just to mention here that the Standby EMDP is driven by XFR BUS #2

EDP's provide approximately 6 times the fluid volume as the related EMDP, 36 US Gallons per minute compared to 6, and are therefore more likely to give you a problem with a leak. This is the reason why you have a standpipe in system A that maintains a 20% fluid level for the EMDP should you get a leak caused by the EDP. However, if the leak was caused in the EMDP line or common components then all system fluid would escape, and system pressure would be lost.

The ENG 1 or ENG2 pump ON/OFF switch controls the EDP output pressure. Positioning the switch to OFF isolates the fluid flow from the system components. However, the EDP continues to rotate until the engine is shutdown. Pulling the fire switch shuts off the fluid flow to the EDP and deactivates the LOW PRESSURE light. Incidentally this LOW PRESSURE LIGHT would normally illuminate when system pressure drops below 1300 PSI. A reason for this LOW PRESSURE light can also be that after the loss of the associated EDP a high load is put on that system. In this case the flight control LOW PRESSURE light, the Master Caution light and the FLT CONT and HYD system annunciator lights also illuminate.

You may have wondered what the reason behind leaving the EDP switches on when we have shut everything down is? Well, it's to preserve a solenoid of course. When you turn the switch off a solenoid held blocking valve depressurises the pump so switching it off requires power from DC Bus 2 and 1.

The Elec 2, which is system A and Elec 1, which is system B, pump ON/OFF switches control the related EMDP. If an overheat is detected in either system, the related OVERHEAT light illuminates. This can be either if the case drain fluid temperature is over 107 degrees Celsius/225F OR if the built-in temperature sensor is over 113 degrees C/235F but on some NG's this limit is 99 degrees C/210F

As installed a separate temperature switch in the EMDP automatically removes electrical power from an overheated EMDP causing the LOW PRESSURE light to illuminate simultaneously.

Hydraulic fluid used for cooling and lubrications of the pumps passes through a heat exchanger before returning to the reservoir. The heat exchanger for system A is located in main fuel tank 1 and for system B in Main fuel tank 2. This leads to a limitation of the system on the ground in that there must be at least 760kg of fuel in the related main tank to run the EMDP. You can also encounter overheat problems when fuel temperature is above 32C/90F.

While we're talking about limitations there's a couple of other figures to look at. Firstly, normal operating pressure of the hydraulic system is 3000psi, we look for a minimum of 2800psi and a max of 3500psi when we pressurise the system and bring up the SYS page.

When first checking the aircraft, we also look at quantities to make sure the RF, or Refill indication isn't showing which will appear when quantity is below 76%. The RF indication is located next to the quantity percentage on the SYS page. This indication is only valid with the aircraft on the ground with both engines' shutdown OR after landing with the flaps up during taxi. It will not appear in flight.

Part of the reason for this is that you will get varying quantity indications with aircraft configuration. Retracting the gear during take-off causes system A quantity to drop by about 15%. This fluid only returns to the reservoir when the gear is extended for landing. Flight and Ground spoiler deployment will also cause small drops in the related system as well as leading edge flaps and slats, again approximately a 15% drop for system B at FULL EXT. You will also get a drop of quantity in each system as the fluid is exposed to cold outside temperatures. This Thermal contraction usually stabilises after a couple of hours at about 10% on each system.

We already talked about the standpipe in system A which allowed 20% of the fluid for the EDMP in the event of a leak from the EDP. In system B there is no such standpipe, so if a leak develops in either system B pump, line or a component of system B the quantity decreases until approximately zero and system B pressure is lost. However, if a leak occurs about 5 litres or 1.3 Gallons remains in the reservoir and can be used for the Power Transfer Unit, or PTU as we know it. A leak in system B does not affect the operation of the standby Hydraulic system.

Let's talk about the PTU itself. The PTU is located on the main wheel well keel beam. It has two parts, a hydraulic motor which is turned by system A pressure and a hydraulic pump which receives fluid from system B supplying an alternate pressure of approximately 2600PSI to the LE flaps and slats. The two parts are connected by a common shaft. The PTU is used to supply the additional volume of hydraulic fluid needed to operate the auto slats and leading-edge flaps and slats at the normal rate when system B EDP volume is lost, most likely caused by an Engine no2 failure or a leak within system B. There is no fluid exchange involved in the process.

The PTU operates automatically when all the following conditions are met. The Air/Ground-Relay is in Flight, The TE Flaps are not up and less than 15 unless you're in a SFP 737 in which case TE flaps are not up, EDP system pressure drops below 2400PSI and the Alternate Flaps Position switch is NOT in DOWN.

Worth mentioning is the fact that as soon as the standby hydraulic system is used to extend the LED the PTU and autoslat system become redundant

Before moving on to the standby system we'll have a quick look at the Landing Gear Transfer Unit. This system provides the extra volume of Hydraulic fluid needed to raise the gear at the normal rate in the event that system A EDP volume is lost. The System B EDP provides the volume needed to operate the LGTU automatically under the following conditions. Airborne, Landing gear lever is in up position, No1 engine N2 drops below 50% and either main gear is not up and locked.

It's worth mentioning that if you were unlucky enough to have the system A EDP itself fail on take-off then the remaining EMDP may not have the output to raise the gear. One, or both main gear struts may remain down or in transit. The LGTU will not operate as all the conditions just mentioned are not met in that Engine 1 N2 hasn't dropped below 50%.

The Standby hydraulic system is provided as a backup if system A and/or B pressure is lost. It can be activated manually or automatically and uses a single EMDP again powered by XFER BUS 2. A quick reminder that the standby EMDP can power the Thrust reverses, The rudder, The leading edge flaps and slats to extend only and the standby yaw damper.

The standby system is filled through the ground servicing connection into the Hydraulic B reservoir where fluid goes first into the standby reservoir and then through the fill and balance line into the Hydraulic B reservoir. This make up does mean however that if you have a leak in the standby system you will also lose some system B fluid. System B will stabilise at around 72% in this case. You will see a low quantity light on the standby system once quantity drops below 50% and this light is always armed. I say that because the other light associated with standby system, being the Low pressure light is only armed when the standby EMDP is in operation whether that's by manual selection or automatically.

There are two ways the standby system can be manually operated. The first is by positioning either FLT CONTROL switch to STBY RUD. What does this do? Well, quite a lot so listen closely! It activates the standby EDMP, shuts off the related hydraulic system pressure to ailerons, elevators and rudder by closing the flight control shutoff valve, opens the standby rudder shutoff valve, deactivates the related flight control LOW PRESSURE light when the standby rudder shut off valve opens, allows the standby system to power the rudder and thrust reverser and illuminates the STBY RUD ON, Master caution and FLIGHT CONT lights.

The second way is to position the Alternate Flaps master switch to ARM. There's another list here of what this will do, thankfully not quite so long. This will activate the standby EMDP, close the trailing edge bypass valve, arm the Alternate Flaps position switch and allow the standby system to power the leading-edge flaps and slats and thrust reversers.

Automatic operation of the standby system is initiated when the following conditions exist. Loss of system A or B AND flaps extended AND airborne or wheel speed greater than 60kts AND the FLIGHT CONTROL switch A or B is in the ON position.

The other way in which Automatic operation is initiated is if the main rudder PCU Force Fight monitor trips as it detects opposing pressure between HYD A and B actuators. This could occur if either System A or B input is jammed or disconnected. You will get the STBY rudder light, Master Caution and FLT CONT lights in this case. With the standby PCU powered you retain adequate rudder control capability.

Automatic operation activates the standby EMDP, opens the standby rudder shutoff valve, allows the standby system to power the rudder and thrust reversers and illuminates those STBY RUD ON, Master caution and FLT CONT lights.